Information Systems & Grid Technologies

Seventh International Conference ISGT'2013

Sofia, Bulgaria, May, 31 – June 1., 2013.

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Preface

This conference was being held for the seventh time in the end of May and beginning of June, 2013 in the halls of the Faculty of Mathematics and Informatics of the University of Sofia "St. Kliment Ohridski", Bulgaria. It is supported by the National Science Fund, by the University of Sofia "St. Kliment Ohridski" and by the Bulgarian Chapter of the Association for Information Systems (BulAIS). Traditionally this conference is organized in cooperation with the Institute of Information and Communication Techno-logies of the Bulgarian Academy of Sciences.

Total number of papers submitted for participation in ISGT'2012 was 56. They undergo the due selection by at least two of the members of the Program Committee. This book comprises 31 papers of 36 Bulgarian and 19 foreign authors included in one of the three conference tracks and an additional section for separate contributions. The conference papers are expected to be indexed by the digital libraries http://www.ebsco.com/ and http://www.proquest.co.uk/. They are available also on the ISGT web page http://isgt.fmi.uni-sofia.bg/ (under Former ISGTs tab).

The editors

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INFORMATION SYSTEMS

The Data Mining Process

Vesna Mufa, Violeta Manevska, Biljana Nestoroska

Faculty of Administration and Information System Management,
University "St. Kliment Ohridski" – Bitola,
Partizanska bb, 7000 Bitola, Republic of Macedonia
vesna_mufa@hotmail.com, violeta.manevska@uklo.edu.mk, nestoroska_bile@yahoo.com

Abstract. The rapidly growing amount of data exceeds the human ability to understand them without the mediation of powerful tools. In such case, the stored data are an archive material, which is rarely visited and used. Consequently, the decisions are made based on the intuition of decision makers, but not on the basis of information and knowledge extracted from the data, which are stored in databases. Data mining is the nontrivial extraction of implicit, previously unknown and potentially useful information or knowledge from large dataset. It is a carefully planned and complex process that consists of the following phases: defining the problem, data preparation, execution of algorithms and interpretation of obtained results. The individual phases, as well as the overall process are interactive. The successful data mining is due to understanding and fulfillment of each phase.

Keywords: Data, Data Mining, Algorithms, Data Extraction

1 Introduction

Data that are found in the databases, such as the most common location for their storage, reaches sizes of Giga and Terabytes, so the databases contain more than million rows, while the column's number ranges from 10 to 10 000. The storage of data imposes on their understanding and making data analysis.

The rapidly growing, enormous amount of data exceeds the human ability to understand them if there is no mediation of powerful tools. In this case, the stored data represent an archive material, which is rarely visited and used. Consequently, the decision making is based on the intuition of the decision makers, not on the basis of information and knowledge, which is extracted from the data [1].

There are many tools that allow multidimensional data analysis, but without opportunity for advanced analysis, such as the classification, the clustering, and tracking the changes to data over time. Advanced data analysis is achieved by applying the so-called data mining. Data mining is a result of the natural evolution of information technology, which aims to extract a "gold" (information or knowledge) from an "archive material" (data). Data mining is the nontrivial

extraction of implicit, previously unknown and potentially useful information or knowledge from large data set.

2 The Data Mining Process

According to some opinions, data mining consists of selection and application of computer-based tools or selection and implementation of algorithms. This belief is partly true because data mining implements methods (algorithms), but is needed to be performed several phases before algorithm's implementation on data. It is a carefully planned and complex decision-making process on that what will be the most useful and relevant. The data mining process is represented graphically in Fig. 1.

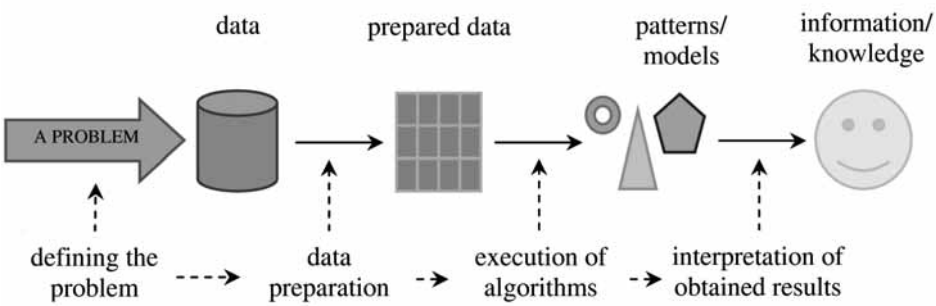

Fig. 1. The data mining process

The data mining process consists of the following phases:

- defining the problem;
- data preparation → a result: prepared data;
- execution of algorithms → a result: patterns or models and
- interpretation of obtained results → a result: information/knowledge.

The individual phases as well as the overall process are interactive.

2.1 Defining the Problem

Each data mining starts by defining the problem. The problems belong to different domains and therefore is necessary domain-specific knowledge and experience. Defining the problem means understanding the goals and requirements of domain perspective and transforms that knowledge into data mining problem with the existence of a preliminary plan.

One type of problem that can be solved by applying data mining is, whether flats that the real estate agencies will offer to their customers are good or bad offers. The goal is to construct models that the agencies will apply whenever they mediate in selling this type of real estate. If the offer proposed by a customer who

sold flat isn't in accordance with the terms that the flat has (a bad offer), agencies must state that the price should be corrected. If the offer is good, it's accepted without remarks.

In this phase is accomplished closely interaction between a domain expert (in our case, a real estate agent) and a data mining expert. This collaboration should not stop at this initial stage, but it should continue through the entire process because the domain expert should validate the results in the further phases.

Once the problem is defined, the data should be selected because they will be input into data mining.

2.1.1 Data – Inputs into Data Mining

The input into data mining is a dataset, which consists of instances (objects/ records). Because the set is presented in a tabular form, the instances are rows from the table, and the columns are called attributes. Each instance is described by a number of attributes. An attribute is defined as a data field and represent a feature of the data object [2].

Data mining divides the attributes into two groups: discrete or categorical and numeric or continuous. The discrete attributes have a finite number of predetermined possible values, while the continuous attributes have an infinite number of possible values. The type that will be used for a given attribute depends on its meaning.

Discrete attributes

Discrete attributes include: nominal, binary and ordinal attributes. They are qualitative, which means that they describe a feature of an object. The values of these attributes represent categories and integers are used to replace the categories with numbers. When replacing the category with a number, the numbers are not used for quantitative purposes, which means that the mathematical operations on values in these attributes have no meaning. But in such situations should always be careful not to execute numerical algorithms because the obtained results will be incorrect.

A nominal attribute is "name of thing". Between the values there isn't a significant order. Due to the nature of nominal attributes, the calculation of mean or median is meaningless, while finding the most common value, which is known as a mode, has meaning.

A binary attribute is a nominal attribute with only two categories or states: 0 or 1, where 0 usually means that attribute is absent, and 1 means that it is present. This attributes are symmetric if both of its states are equally important and have the same weight, which means that there is no proper logic for that which of the

values can be coded with 0 or 1. Binary attributes are asymmetric if the results from the states aren't equally probable.

An ordinal attribute is an attribute with ranked values, but the magnitude between successive values is not known. They are useful for subjective assessment on the quality that can't be objectively measured. Ordinal attributes are obtained and through discretization of continuous data. The central tendency of an ordinal attribute is represented through a mode and median, but the mean can't be defined [3].

Continuous attributes

Continuous attributes include: integer, interval-scaled and rational-scaled attributes. The attributes can accept 0 as a value and negative values. When defining the values can be set restrictions. At this type of attributes can be calculated the mean, median and mode.

Integer attributes, as values, take genuine integers. Unlike discrete attributes, which can be coded with integers, the arithmetic operations with these attributes are significant.

Interval-scaled attributes are measures on a scale with equal size of units. Because of the possibility of ranking, the values can be compared and can be measured their differences.

Rational-scaled attributes are similar to the interval-scaled attributes, but they are different in that the zero point reflects the presence of the measured characteristic. The values of these attributes can be duplicated.

The dataset of flats consists of eleven attributes: *area, rooms, region, number of terraces, floor, fitted, lift, parking space, new/old building, price* and *type of offer*. The attributes *area, rooms, number of terraces, floor* and *price* are continuous, while the other attributes are discrete. The discrete attribute *region* has three possible values (*center, settlement_1 and settlement_2*), while the other discrete attributes are binary. Attribute values of *new/old building* are labeled with *n* and *o*, the values of attribute *type of offer* are *good* and *bad*, and the values of other binary attributes are labeled with *yes* and *no*.

2.2 Data Preparation

Raw data sets that are located in databases aren't suitable for data mining. Data undergo many changes before the algorithms for data mining being executed on them [4].

Data preparation sometimes is ejected from the literature intended for data mining, or is formally cited as one of the phases of the data mining process. However, in a real application the situation is reversed and more efforts are invested in data preparation, rather than implementation of algorithms. Data preparation means an organization of data into a form suitable for execution of the algorithms in order to get the best performance.

Data preparation consists of:

- *data cleaning*, which includes filling the missing values, as well as dealing with incorrect and inconsistent data;
- *data integration*, which means collecting the data from different sources in one location;
- *data reduction*, which is a reduction of the dataset in terms of attributes and instances;
- *data transformation*, which includes normalization and aggregation of data, and
- *data discretization*, which means converting the continuous values into discrete.

The order of the steps may be different. One option that is regarded as the most effective is implementation of the steps according to previously given order. Another option is implementation of the steps in the following order: data integration, data reduction, data cleaning, data transformation and data discretization. In some situations, some of them are skipped. If data is stored in one source, there is no need for integration. If all data are discrete, there is no need for discretization. However, the cleaning, reduction and transformation are infallible steps in data preparation.

Data preparation for flats consists of: cleaning, discretiзation and transformation. Data integration and reduction are not needed because the dataset is situated in one location with an adequate number of attributes and instances. The preparation of data was done manually.

Data cleaning aims to eliminate the attribute values that vary significantly compared to the other values. It was necessary for the values of attributes: *area*, *rooms* and *price*. Their values were either too high or low. For example, the area was too high, the flat had a small area, but a large number of rooms, or the price was incompatible with the rest attributes. Such data were brought into normal form depending on the rest attributes, and by comparison with similar instances. If the area was too high or low, the rest attributes of that flat were analyzed, and they were compared with a similar instance. The same principle was applied in cleaning of the rest attributes.

In dealing with missing data, we applied three strategies:

- If the instance consisted of a large number of missing values, it was eliminated from the data set.
- If the instance contained few missing values and, if it was a continuous value, the average of the rest values for that attribute was used, but if it was discrete values, the frequent class of the rest values for that attribute was used.
- If the instance contained one missing value, the rest attributes was observed and a similar instance that contains all values was searched, whereby the

value of the attribute that was missing was taking.

Data discretiation transform continuous attributes into discrete. Data preparation ends with the transformation of data to a format readable by the tool that will be used for execution of the algorithms. Usage of the *Weka* software package requires data to be transformed into *arff format. In Fig. 2 are shown data in *arff format.

```
% ARFF file for flats

@relation flats

@attribute area numeric
@attribute rooms numeric
@attribute region {centre, settlement_1, settlement_2}
@attribute number_of_terraces numeric
@attribute floor numeric
@attribute fitted {yes, no}
@attribute lift {yes, no}
@attribute parking_space {yes, no}
@attribute now/old_construction {n, o}
@attribute price numeric
@attribute type_of_offer {good, bad}
@data
42,2,settlement_2,1,2,yes,no,no,o,26000,good
56,2,settlement_2,1,2,no,no,yes,n,30000,good
32,2,settlement_2,2,1,no,no,no,o,21000,bad
77.3.settlement 2.1.2.no.no.no.n.48000.bad
```

Fig. 2. Data display in *arff format

Once the phase of data preparation will be completed, follows the execution of algorithms on prepared data.

2.3 Execution of Algorithms

Data mining can be categorized into several tasks. When defining the problem, should be determined the category to which it belongs. In some cases, the answer to the given problem is achieved by applying a single task, while in other cases, it is necessary to be combined multiple tasks to get the solution. Each task disposes with corresponding algorithms.

The tasks of data mining are:

- *Exploratory data analysis* - The purpose of this task is an exploration of data without having a clear idea of what you are looking at the data. The available algorithms allow visualization of datasets with a relatively small number of dimensions (dimensions=attributes). As the number of dimensions grows, visualization becomes difficult and incomprehensible. If the number of data and attributes is small, the projection techniques generate useful projections of the data. The inability to visualize important details is compensated by the opportunity to summarize the data.
- *Predictive modeling* – The solution of our problem will be achieved by using

predictive modeling. The goal of predictive modeling is to build a model, which will be used to predict the value of one attribute on the basis of values of the other attributes. It involves finding a set of attributes relevant to the attribute of interest (usually through statistical analysis) and predicting the value, based on the set of similar data. The predictive models are built with use of classification and regression algorithms. In classification, the attribute that is predicted is discrete, while in regression the attribute that is predicted is continuous [5]. Because the determination of a good or bad offer is a binary classification problem, we use classification methods (algorithms) to obtain models for classification.

- *Descriptive modeling* - The aim of descriptive modeling is to describe data or the process that they generate. Descriptive models discover patterns or trends in the data that can be easily interpreted. The most famous descriptive algorithms are divided into: algorithms for clustering and association algorithms. Clustering aims to detect natural groups in data, while the associative task of data mining has two goals: finding attributes that frequently occur together and determining rules for their interconnection.
- *Time series and sequence analysis* - This analysis is intended for large sets of time series, where algorithms find certain regularities and interesting features, as well as similar sequences or sub-sequences. Time series and sequences are similar because they contain ordered data from observations. They are different in the type of data: the time series contain continuous data, while the sequences are characterized by discrete states [6].
- *Retrieval by content* - This task is used in cases when it is necessary to be found a pattern based on previously given pattern. Retrieval by content is commonly applied to datasets that consist of text or images. When is discussed about text, the pattern can be a set of keywords,a segment or a text document, and when is discussed about images, the specified pattern can be an image, part of an image or description of an image.
- *Deviation analysis* - Deviation analysis is used to find rare cases that significantly deviate from normal behavior. Most often this analysis is used for fraud detection. Standard algorithms for this task don't exist, so this task is accomplished by using algorithms for decision trees, neural networks and clustering.

The obtained results from execution of the algorithms are: patterns and models [7].

2.3.1 Patterns/Models

Patterns represent a local feature of data, which refers to several instances, some attributes or both. From all generated patterns, only a small part of them are interesting. Patterns are interesting in the following cases:

- if they can be easily understood by users;
- if they reflect their needs;
- if they are valid on new data;
- if they are potentially useful;
- if they are previously unknown and
- if they confirm set hypothesis.

The interesting pattern offers new information and represents knowledge.

Does data mining will generate all interesting patterns depend on the implemented algorithm. An ideal situation is when the algorithm generates all interesting patterns. The generation of all interesting patterns, except it is very desirable, it is effective because it eliminates the effort that users should make to identify interesting patterns. The measures for that how much the patterns are interesting are crucial in detecting valuable patterns. They are used throughout the entire process of discovery and serve as constraints.

Models, unlike patterns, are on a global level and are relevant to the entire dataset. Some algorithms explicitly generate models, while some explicitly don't generate models.

With implementation of the method of classification rules, i.e. the algorithm PART, we get a model of classification rules. On Fig. 3 is shown a part of the resulting model.

```
PART decision list
------------------

price = '(41500-inf)' AND
fitted = no AND
parking_space = yes: bad (26.0/4.0)

price = '(41500-inf)' AND
fitted = yes: bad (12.0/1.0)

price = '(-inf-41500]' AND
lift = yes: good (37.0/6.0)

price = '(-inf-41500]' AND
now/old_construction = n: good (31.0/7.0)

price = '(41500-inf)' AND
region = centre AND
lift = no: bad (10.0/4.0)
```

Fig. 3. A part from the model obtained by implementation of the PART algorithm

With implementation of the method of decision trees, i.e. the algorithm RandomTree, we get a model of decision trees. On Fig. 4 is shown the resulting model.

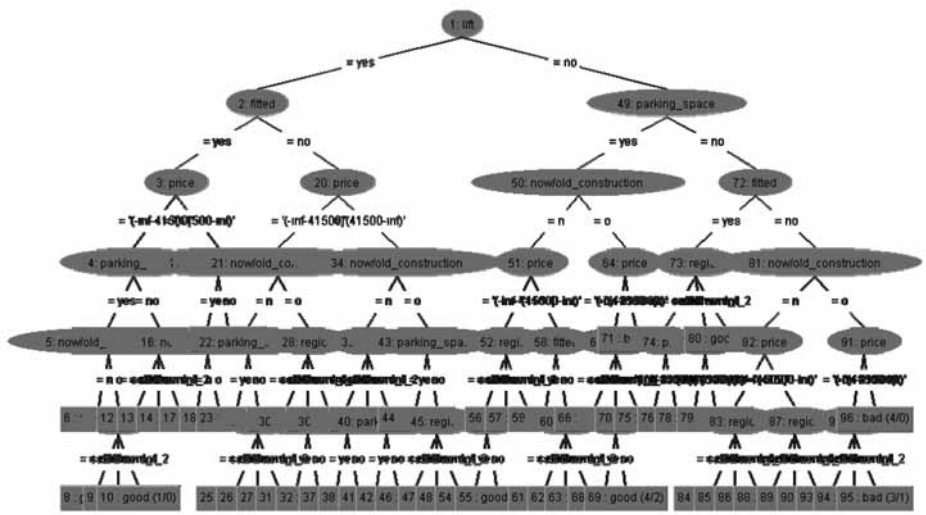

Fig. 4. A display of the model obtained by implementation of the RandomTree algorithm

2.4 Interpretation of Obtained Results

Interpretation of obtained results is the final phase of the data mining process. The patterns and models obtained as a result of the implementation of algorithms for data mining serve as a tool for decision making. Therefore, they should be interpretable, which allows their usefulness because people don't want their decisions to be based on something that they don't understand. The accuracy of the patterns/models and the accuracy of interpretation are somewhat contradictory. Most often, simple patterns/models are more interpretable, but less accurate. The modern algorithms generate concise results through high dimensional models. Therefore, the problem of their interpretation is considered as a separate phase in the overall process of data mining.

The model shown in Fig. 3. contains a set of rules. The first part is composed of conditions that are interconnected with the operator AND, while the second part, which is the part after the symbol :, contains the classification. In prediction of new instance of flat, if all conditions are met, the classification of the rule is assigned as classification of the new instance.

The decision tree shown in Fig. 4. consists of 95 nodes. The root node is labeled with attribute *lift*, suggesting that it is the most important attribute. The internal nodes are labeled with the other attributes, while the leaf nodes contain the classification. Prediction of new instance for flat starts from the root of the tree, and then move through the tree is determined by the values of other attributes and ends with the leaf node. Classification of the leaf node is assigned as classification of the new instance.

3 Conclusion

The successful data mining is a result of understanding and fulfilling of every phase. If the definition of the problem has no sense, or if the data are improperly collected or prepared, the obtained results are invalid, despite the implementation of a powerful algorithm.

With implementation of data mining methods is solved a wide range of problems. One of them is construction of predictive models that agencies will use when they mediate in selling flats. Performed data mining results in two models: classification rules and decision trees, with which it is determined whether the flat that would be sold is a good or bad offer.

Although data mining is a very powerful tool, it isn't enough alone. For successful data mining are required skilled technical and analytical specialists, who are able to define the problem, to structure the analysis and to interpret the created output.

Despite data mining identifies patterns and models, it didn't indicate their value or importance, but allows it to be done by the users. Their validity depends on the way how they are compared with the actual circumstances. This indicates that the limitations of data mining are more concentrated on the staff than the technology.

Data mining identifies relationships between behavior and/or variables, without identifying their causal relationships that is a lack when it is used in applications where causal relationships are crucial.

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Marketing Research by Applying the Data Mining Tools

Biljana Nestoroska, Violeta Manevska, Vesna Mufa

Faculty of Administration and Information Systems Management,
University „St. Kliment Ohridski“ - Bitola,
Partizanska bb, 7000 Bitola, Republic of Macedonia
nestoroska_bile@yahoo.com, violeta.manevska@gmail.com, vesna_mufa@hotmail.com

Abstract. Predictive models in data mining are used to perform prediction of data by using known results. The Bayesian method, the nearest neighbor method, the decision-making trees (J48) and the classification rules (JRIP) are used to assess which is the best model, i.e. which model is the best for describing the data from the database. In this paper, we will review these methods for marketing research.

Keywords: Methods, Predictive Models, Marketing Research

1 Introduction

Data mining is an exploratory science that deals with discovering of useful information from a large data and solves some practical problems.

The predictive models are used for making a prediction of the data values, by using previously found results. Prediction can be done by using historical data. The predictive models, despite prediction, include classification, regression and time-series analysis.

A marketing research is an oriented research activity focused on collecting, processing and analyzing of data, which are the basic resource for making decisions by the managers.

2 Definition of Marketing Research

A marketing research is a function that links the buyer, the public, the intermediaries and the company, and creates a picture of needs, goals and opportunities for them. Information gained from the marketing research are used for: define the possibilities and problems of marketing service, authentication, restoration and evaluation of marketing actions, monitoring the performance and effectiveness of the actions and understanding the marketing as a process.

2.1 The Process of Marketing Research

The process of marketing research is realized through several stages:

- *Defining the problem and goals*: The problem should be clear and should be known the reasons for the goals. The problem can be solved on the basis of data from the previous studies. The researcher should set a hypothesis, which explain certain phenomena, i.e. the reasons that caused the problems that affect the research.

- *Develop the research plan*: A research project is a plan or framework that guides the research. It contains all the details about the research process, including the methods and procedures for collecting and analyzing the required data, the time needed for the project realization and the necessary funds. After defining the problem, the goals are set that can be:

  • *preliminary or exploration research*, which is used when defining the problem and setting the hypothesis,

  • *descriptive research* that is used for describing features or functions of the market, and

  • *causal research*, which is used to examine the hypotheses about the relationships between causes and effects.

The choice of the research project depends on the research purpose, the hypotheses and the methods that are used for data collection.

- *Data collection*: The companies use secondary data from internal and external sources that are used as a statistical data or reports by governmental and commercial organizations. When is necessary to be solved a particular problem, then is used primary data. The methods of data collection depend on the conditions in which they are used. The choice depends on the problem's nature, the goal of the research, the nature of knowledge that should be getting and whether the research will discover objective or subjective elements. Most often form for data collecting is a questionnaire, composed of questions by using simple and clear language, avoiding unconditional alternatives and ambiguous issues that would confuse the respondent.

- *Present the findings - research report*: the marketing management should prepare a report, which is a written presentation of the research results. The quality of the report depends on the style of writing, objectivity, completeness, exactness, clarity and concision.

Our real problem is determining the type of car that contributes to increase the earnings in a car saloon. The data are taken from the car saloon. A part form the dataset for sold cars is shown in Fig. 1.

No.	Model of vehicle Nominal	Type of fuel Nominal	Catalyst Nominal	Average consumption (L/KM) Numeric	Price of Vihicle Numeric	Nomber of sold cars Numeric	Good Model Nominal
1	Alfa Romeo Mi....	Diezel	Yes	5,6	15990.0 Eur	59,0	No
2	Alfa Romeo Gi....	Gasoline	Yes	8,4	13540.0 Eur	51,0	No
3	BMW M5	Gasoline	Yes	10,8	25890.0 Eur	95,0	Yes
4	Mercedes e 220	Diezel	Yes	6,5	55700.0 Eur	120,0	Yes
5	Reno 19	Diezel	Yes	5,	10540.0 Eur	18,0	No
6	Hunday i35	Diezel	Yes	7,3	25990.0 Eur	59,0	No
7	Golf 5	Gasoline	Yes	9,9	35770.0 Eur	89,0	Yes
8	Audi A6	Diezel	Yes	5,9	22330.0 Eur	61,0	Yes
9	Peugeot 307	Gasoline	Yes	12,6	15000.0 Eur	18,0	No
10	Opel Corsa	Diezel	Yes	3,6	11540.0 Eur	98,0	Yes
11	BMW 525	Diezel	Yes	4,8	14510.0 Eur	81,0	Yes

Fig. 1. Display of car sales

2.2 Application of Data Mining in the Field of Marketing Research

Data mining uses two methods for the marketing research: *supervised learning* and *unsupervised learning* [1].

Supervised learning is used to predict the relationship between a group of independent variables and a group of dependent variables. The dependent variable can be categorical or continuous. The independent variable can be of any type, and it should be properly encoded. The supervised learning uses two tasks: classification and regression. Supervised learning is using the following methods: Naïve Bayes classifier, k-nearest neighbor, classification and regression trees and some other methods.

The classification is used to predict the class that belongs the dependent variable of new example, based on the results from the training database. The variable that is predicted is categorical.

The regression is associated with predicting continuous dependent variables instead of categorical variables.

Unsupervised learning is used for data mining tasks, when we want to examine the independent variables and to describe the data. The methods used in this kind of learning are: clustering and market basket analysis.

Clustering is a method used for observation of the customer subset, mutually similar, but different from another customer subset.

Market Basket Analysis is used to analyze whether customers who will buy the product A will buy and the product B. Also, this analyze is used for comparison the results from different stores, different days of the week, different seasons of the year, etc.

3 Predictive Models

Algorithms for predictive models are applied to determine the impact that prices and the number of cars sold have in earnings on sales of cars (Fig. 1). In fact, these algorithms determine which type of cars contributes to increase earnings.

Defining the predictive models: Suppose that we have a database $\mathrm{D} = \{\mathrm{t}_1, \mathrm{t}_2, \dots, \mathrm{t}_\mathrm{n}\}$ composed of a set of records and classes $C = \{C_1, \dots, C_m\}$. The classification represents a mapping $f: D \to C$, where each record t_i is labeled with a class. The class C_j contains all records that are repainted in it $\{t_i \,|f(t_i) \in C_j, 1 \leq i \leq n,\ t_i \in D\}$. Each class is predefined and it shares the database in areas, and each area is represented by a class and each record in the database belongs to one class.

The classification is implemented in two stages [2]:

1. At the first stage, the algorithms generate models from training data.
2. At the second stage, the models that are created in the first stage are used to perform classification of the records from the database with unknown class.

The classification problems are solved by using these three methods [3]:

- *specification of the area boundaries*: according to this method, the classification is performed by dividing the input data in areas, where each area is associated with one class.
- *using possibility distribution*: if the possibility $P(C_j)$ of appearing the class C_j is known, then $P(C_j)P(t_i\,|C_j)$ is used to estimate the probability that t_i belongs to the class C_j.
- using conditional probability: $P(C_j|t_i)$ is used to determine the probability of each class C_j, and new example will belong to that class which has the highest probability.

3.1 Probability Models

A Bayesian classification is an example for a probability model, which is based on the Bayes' theorem,

$$\mathrm{P}(H|X) = \frac{\mathrm{P}(X|H)\ \mathrm{P}(H)}{\mathrm{P}(X)}, \tag{1}$$

where with $P(X)$ is marked the probability of X and with $P(X|H)$ is marked the conditional probability of X if H is known. The Bayes' theorem is used to estimate the probability of a record from a database that belongs to each of the possible classes in order to solve a classification problem. According to the Bayesian classifier, each class must be conditionally independent. This is why the article $P(C_j|X)$ is replaced by the product of the probabilities [4]:

$$\prod_{\mathrm{i}} \mathrm{P}\left(A_i = x_i \middle| C_j\right). \tag{2}$$

This classifier is used to estimate the conditional probability $P(C_j) = P(C = c_j)$ and $P(A_i = v_i\ k|C_k)$ for each value c_j of the class C and for each value of attributes $v_i k$ for each attribute A_i. The conditional probability $P(C_j)$ is estimated by the number of samples $n_j = N(c_j)$ from the class c_j, divided with the total number of training data n, $P(C_j) = n_j/n$. $P(A_i = v_i\ k|C_k)$ can be calculated as a quotient between $N(A_i = v_i\ k \wedge C = c_j)$ and $N(C = c_j)$,

$$\mathrm{P}(A_i = v_i k|C_k) = \frac{N\big(A_i = v_i k \wedge C = c_j\big)}{N\big(C = c_j\big)}. \tag{3}$$

The advantages of the Bayesian classifier are: easy to use, the training data should be passed only once, easily handles with the values of missing data, gives good results when is performing the classification for simple relationships between the attributes.

By applying the naïve Bayesian algorithm on data for car sales, the obtained results are: 76% correctly classified cases and 24% incorrectly classified cases. From the matrix we can see that the number of false-positive results is 10 and the number of false-negative results is 14 (Fig. 2).

```
Correctly Classified Instances          76               76      %
Incorrectly Classified Instances        24               24      %
Kappa statistic                          0.3023
Mean absolute error                      0.2639
Root mean squared error                  0.4172
Relative absolute error                 71.6633 %
Root relative squared error             97.5318 %
Total Number of Instances              100

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 0.868     0.583      0.825     0.868     0.846      0.8      ne
                 0.417     0.132      0.5       0.417     0.455      0.8      da
Weighted Avg.    0.76      0.475      0.747     0.76      0.752      0.8

=== Confusion Matrix ===

  a  b   <-- classified as
 66 10 |  a = ne
 14 10 |  b = da
```

Fig. 2. Evaluation of the naïve Bayesian algorithm

3.2 Nearest Neighbor Method

This method is used for continuous and discrete attributes. In Fig. 3 is shown five closest neighbors. The nearest neighbors are marked with k, which can have a different number.

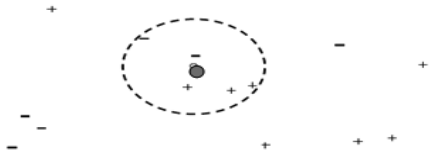

Fig. 3. Preview of the nearest neighbor method

In the circle can be seen that three neighbors are marked by the sign '+' and two neighbors are marked by the sign '-'. Because the number of positive signs is higher than the negative, the classification of the red point will be with positive sing. To calculate the distance between the two points, we use the Pythagorean theorem:

$$Dist(A,B) = \sqrt{(a_1 - b_1)^2 + (a_2 - b_2)^2}\,, \tag{4}$$

where the notation $Dist(A,B)$ is used to determine the distance between two points, i.e. the distance between point A and point B. The distance form point A to point A is zero, $Dist(A,A) = 0$. The distance from the point A to point B is the same as the distance from B to A, $Dist(A,B) = Dist(B,A)$.

According to this method, it is difficult to determine the accurate number of k. It is also difficult to handle with categorical attributes.

By using the nearest neighbor algorithm (for k=1) on data from the car saloon, the obtained results are: 81% correctly classified cases and 19% incorrectly classified cases. The matrix shows us that the number of false-positive results is 5 and the number of false-negative results is 14 (Fig. 4).

```
Correctly Classified Instances          81               81      %
Incorrectly Classified Instances        19               19      %
Kappa statistic                          0.4025
Mean absolute error                      0.1967
Root mean squared error                  0.4313
Relative absolute error                 53.4238 %
Root relative squared error            100.818  %
Total Number of Instances              100

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 0.934     0.583      0.835     0.934      0.882      0.675    ne
                 0.417     0.066      0.667     0.417      0.513      0.675    da
Weighted Avg.    0.81      0.459      0.795     0.81       0.793      0.675

=== Confusion Matrix ===

  a  b   <-- classified as
 71  5 |  a = ne
 14 10 |  b = da
```

Fig. 4. Evaluation of the nearest neighbor algorithm for k=1

If the number of nearest neighbors k is different (k=3, 5 or 10), then the obtained results are:

k=3

```
Correctly Classified Instances          91               91      %
Incorrectly Classified Instances         9                9      %
Kappa statistic                          0.7259
Mean absolute error                      0.1391
Root mean squared error                  0.2561
Relative absolute error                 37.848  %
Root relative squared error             59.9666 %
Total Number of Instances              100

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 0.987     0.333      0.904     0.987     0.943      0.961    ne
                 0.667     0.013      0.941     0.667     0.78       0.961    da
Weighted Avg.    0.91      0.256      0.913     0.91      0.904      0.961

=== Confusion Matrix ===

  a  b   <-- classified as
 75  1 |  a = ne
  8 16 |  b = da
```

Fig. 5. Evaluation of the nearest neighbor algorithm for k=3

k=5

```
Correctly Classified Instances          88               88      %
Incorrectly Classified Instances        12               12      %
Kappa statistic                          0.6164
Mean absolute error                      0.1992
Root mean squared error                  0.3014
Relative absolute error                 54.2122 %
Root relative squared error             70.5767 %
Total Number of Instances              100

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 0.987     0.458      0.872     0.987     0.926      0.922    ne
                 0.542     0.013      0.929     0.542     0.684      0.922    da
Weighted Avg.    0.88      0.351      0.886     0.88      0.868      0.922

=== Confusion Matrix ===

  a  b   <-- classified as
 75  1 |  a = ne
 11 13 |  b = da
```

Fig. 6. Evaluation of the nearest neighbor algorithm for k=5

k=10

```
Correctly Classified Instances          82               82      %
Incorrectly Classified Instances        18               18      %
Kappa statistic                          0.3608
Mean absolute error                      0.2585
Root mean squared error                  0.3404
Relative absolute error                 70.3449 %
Root relative squared error             79.6912 %
Total Number of Instances              100

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 0.987     0.708      0.815     0.987      0.893      0.894    ne
                 0.292     0.013      0.875     0.292      0.438      0.894    da
Weighted Avg.    0.82      0.541      0.83      0.82       0.784      0.894

=== Confusion Matrix ===

  a  b   <-- classified as
 75  1 |  a = ne
 17  7 |  b = da
```

Fig. 7. Evaluation of the nearest neighbor algorithm for k=10

From these results can be seen that if the number of nearest neighbors is small, the model is much better.

3.3 Decision Trees

Defining the decision tree: Suppose that we have a database $D = \{t_1, t_2, \dots, t_n\}$, a set of classes $C = \{C_1, \dots, C_m\}$ and a set of attributes $\{A_1, A_2, \dots, A_h\}$.

The decision tree has the following properties: each internal node from the tree is labeled with the attribute A_i, each leaf is labeled with class C_j, each branch is marked with a predicate that can be applied to the attribute, associated with the parent.

Advantages of the decision tree: efficient and easy to use; generate rules that are easy to interpret and understand, and trees are constructed from data that consists many attributes.

Disadvantages of the decision tree: not easy to handle with continuous attributes because the domains of attributes are divided into categories that need to be covered by the algorithms. If the domain is divided into rectangular regions, then is difficult to solve the problem about the lack of data. The decision tree can be very big, but this situation can be exceeded by cutting the tree.

By applying the J48 algorithm on data from the car salon, the obtained results for the exactness of the model and the model error are: 99% correctly classified cases and 1% incorrectly classified cases. From the matrix, we can see that the number of false-positive results is zero and the number of false-negative results is 1 (Fig. 8).

```
Correctly Classified Instances          99               99      %
Incorrectly Classified Instances         1                1      %
Kappa statistic                          0.9722
Mean absolute error                      0.01
Root mean squared error                  0.1
Relative absolute error                  2.7155 %
Root relative squared error             23.3774 %
Total Number of Instances              100

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 1         0.042      0.987      1         0.993      0.979    ne
                 0.958     0          1          0.958     0.979      0.979    da
Weighted Avg.    0.99      0.032      0.99       0.99      0.99       0.979

=== Confusion Matrix ===

  a  b   <-- classified as
 76  0 |  a = ne
  1 23 |  b = da
```

Fig. 8. Evaluation of the J48 algorithm for decision tree

The results can be visually displayed by using a tree structure:

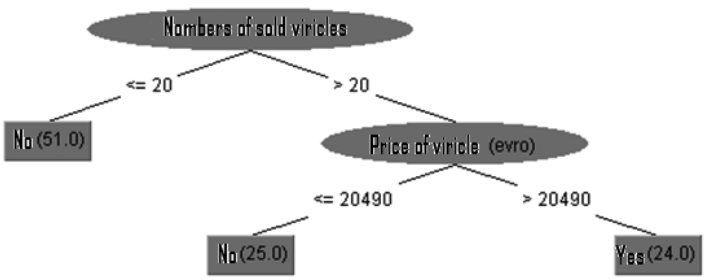

Fig. 9. Decision tree generated of the J48 algorithm

From the tree visualization can be seen that if the number of sold cars is higher than 20 and if the price of the car is higher than 20.490 €, then that model of the car is considered as a good model. The number of good car models is 24 and 25 models are bad because they price is less than 20.490 €. The remaining 51 models are not considered as a good model because the number of sold cars is less than or equal to 20.

3.4 Classification Rules

The classification rules are used to present knowledge gained through the use of algorithms for data mining. The classification rule consists a set of conditions and consequences [5]:

IF set of conditions **THEN** conclusion

The set of conditions represents the sequence of attribute tests, and the consequences determine the class that or determine the distribution of class probabilities.

$$IF\ attribute_1\ relation_1\ value_1\ AND$$

$$attribute_2\ relation_2\ value_2\ AND$$

$$\ldots\ldots$$

$$attribute_m\ relation_m\ value_m\ AND$$

$$THEN\ Class = class\ X$$

The preconditions from the set of conditions are associated with the logical function -AND, and the rule will be satisfied if all tests are satisfied. For connection of the individual rules is used the logical function -OR. When the rule is satisfied, the rule conclusion is used as a classification. If more rules with different conclusions are satisfied, this causes a conflict. Therefore, it is necessary to use classification trees, where the set of conditions is presented as a condition for each node, moving from the root to the leaf of the tree and the conclusion of the rule represents the class that defines the leaf. The rules, as well as the trees, can be pruned.

The differences between the rules and trees are: if new rules should be added to the classification rules that would not affect the existing rules, but if a new structure should be added to the classification trees, this leads to a change of the whole tree. It is very important how the rules are being interpreted and what is their interpretation order because if the order is not clear, then it's possible to get different conclusions for the same instance.

By applying the JRIP algorithm to data from the sale saloon, the obtained results for the exactness of the model and the model error are: 99% correctly classified and 1% incorrectly classified cases. The matrix shows that the number of false-positive results is zero and the number of false-negative results is 1 (Fig. 10).

```
Correctly Classified Instances          99               99      %
Incorrectly Classified Instances         1                1      %
Kappa statistic                          0.9722
Mean absolute error                      0.01
Root mean squared error                  0.1
Relative absolute error                  2.7155 %
Root relative squared error             23.3774 %
Total Number of Instances              100

=== Detailed Accuracy By Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 1         0.042      0.987     1         0.993      0.979    ne
                 0.958     0          1         0.958     0.979      0.979    da
Weighted Avg.    0.99      0.032      0.99      0.99      0.99       0.979

=== Confusion Matrix ===

  a  b   <-- classified as
 76  0 |  a = ne
  1 23 |  b = da
```

Fig. 10. Evaluation of the JRIP algorithm for classification rules

4 Conclusion and Recommendations

With use of data mining in the marketing research field, through analysis and modification of the algorithms, can be created accurate predictive models that will help the companies to make right decisions.

Modeli	NaiveBayes	Nearest neighbor	J48	Jrip	Class
TP Rate	0.417	0.417	0.958	0.958	YES
	0.868	0.934	1	1	NO
FP Rate	0.132	0.066	0	0	YES
	0.583	0.583	0.042	0.042	NO
Precision	0.5	0.667	1	1	YES
	0.825	0.835	0.987	0.987	NO
Recall	0.417	0.417	1	1	YES
	0.868	0.934	0.958	0.958	NO
F-Measure	0.455	0.513	0.979	0.979	YES
	0.846	0.882	0.993	0.993	NO
ROC Area	0.8	0.675	0.979	0.979	YES
	0.8	0.675	0.979	0.979	NO

Fig. 11. Comparison between model's performance

If we make a comparison between the results got from using different algorithms on the data for car sales, we can get a conclusion that the best models are the models that are derived from the algorithms J48 and JRIP.

Data mining techniques for marketing research are more effective than statistical analysis because with usage of a smaller data amount, we can get important information.

The data mining techniques can be used not only in sales, but also in manufacturing, industry, banking, health, education and more.

If companies want to make more profit and to place their products on the market, they need to focus on marketing research and to visit seminars that show how to use new program packages for marketing research, in order better decision making.

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CRM systems and their applying in companies in Republic of Macedonia

Natasa Milevska[1], Snezana Savoska[2]

[1,2] Faculty of administration and Information systems Management, University „St.Kliment Ohridski“ – Bitola,
Bitolska bb,
7000 Bitola, R.of Macedonia,
nmilevska@hotmail.com, savoskasnezana@gmail.com

Abstract. The development of information technology contributes companies to implement strategic information systems in their work. One of the primary objectives of the company is getting quick and accurate information for decision making. Each company needs to prepare data into information for decision making. To understand the customer behavior for businesses is the primary objective for market appeal and providing better service to its customer. Advances of technology contribute to development of a large number of systems and software that would be useful and contribute in their work. Precisely a kind of such systems is CRM systems (Customer Relationship Management). These systems have a role to understand the customer behavior which as a result would give improvement of the service to their customers as well as increase their satisfaction. The purpose of this paper is to define the benefits and importance that derives with using CRM systems by companies, as well as receiving information about customers, which represent the basis in making marketing decisions.

Keywords: CRM systems, Decision making, Customer behavior.

1 Introduction

The rapid development of technology contributes companies to require the application of information systems in their work due to their speed, cost, accuracy and reliability that provide. The role which has information systems in operation of companies is of great importance and contribution to the company.

The big changes that are happening daily imposes the need for fast and efficient operation of the company to the changes that occur in order to stay competitive in the market in which the company act (work) with his offer or service.

Retrieving information and decision making is crucial for companies, which determines the direction of the company movement and enables satisfying customer’s needs and desires. Advances in the technology have a profound impact on the behavior of buyers in the process of buying and offering new ways

for companies in the process of communication with customers and collecting relevant data for them.

Finding out more information about customers is certainly an advantage for any company, because that data has a great impact when decision making in the company is at stake. The existence of Customer relationship management enables companies to find out the buyers' behavior in the purchasing process, their needs and improving customer service. With the help of these systems provides a better way of communication between customers and the company, which derives as a result of the realization of the needs, requirements and expectations of customers.

The paper is structured in three parts. The first part take into consideration the customer relationship management (CRM) and marketing decision support systems and the second ones is dedicated to benefits arising from the use of CRM systems. The third part describes the application of CRM systems in companies in R. of Macedonia.

2 Customer Relationship Management (CRM) and marketing decision support systems

The understanding of consumer behavior is of great importance for companies in the decision making process. Marketing decision support systems allow companies to collect data coordinately, consisting of tools and techniques with supporting software and hardware, with which the company collects necessary information. They interpret information and are aiming to make marketing decisions which are crucial for the business. Indeed these systems are part of the customer's relationship management, which include marketing activities, sales as well as the communication and customer relationship. When is at stake making marketing decisions of great importance are Customer relationship management systems.

CRM is a system where the buyer puts at the center of the business process, but also represents a process of collecting and analyzing information about the company's interactions with customers, as well as the technology that enables companies to maximize profit in addition to increasing the value with complete understanding and fulfilling the needs of customers.

CRM is a comprehensive strategy and process of acquiring, retaining and partnering with selective customers to create superior value for the company and the costumers [1].

CRM systems cover all aspects relating the company's interaction with their own customers, whether it comes to sales or service. The purpose with

the CRM systems is to build long-term relationship and to be given value to the relationships that take place between the company and customers [2]. These systems make it possible to identify what customers want for automatic alignment of all processes in order to fulfill their demands. CRM systems offer the opportunity to store all information coming from clients in a central database, which provides access to it.

About CRM can to say that actually represent the company's business strategy and set of software tools and technologies that enable:

- Understanding the customer's behavior;
- Retention of existing customers, guided by experience;
- Attracting the new customers;
- Cost reduction;
- Moving to the correct direction;
- Detecting new opportunities;
- Revenue growth;

CRM integrates best practices and apply advanced technologies in order to help the companies in exercise of their targets. CRM focuses on automating and improve the institutional processes that are related with the customer relationship management in the marketing field, management communication as well as services and support [3].

CRM is an integration of sales, marketing, service and support strategies, processes, people and technology to maximize customer benefits, value, relationships and retaining customer loyalty. This data is core for the preparation of information for marketing decision making.

Term customer relationship management is used when describes business relationship management with customers, while CRM systems are used in the same way to manage business contacts, customers, realizing agreements as well as selling. The use of CRM systems enables an efficient way of working activities in the company that manages contacts, customer data, their needs and the all information needed for market appeal. It allows its users an overview of the organizational structure of the company and all data that are related with the company.

In the CRM systems a there are a number of ways for customer communication which can be implemented in order to find out information which will be helpful in the insight customer relationship. Companies are those which should be attractive to buyers or to attract buyers. Satisfying the customer's needs is the primary task of CRM systems, but also a core winning card for a successful company. The possibility of getting and keeping information offers an opportunity about making analyzes that are greatly helpful in making decisions as well as adapting to the needs of business users.

3 Benefits offered by the CRM systems

The key objective with the use of CRM systems is directing the business processes and increasing sales, which lead to greater customer satisfaction, increased loyalty to them and maximizing profits [4]. CRM allows companies to acquire competitive advantage and entering new markets. Some of the benefits provided by CRM systems are [5]:

- Data exchange - data stored in a central database, thus is seamless potential of access next to her and available to all users of the business or company;
- The opportunity to improve services to their own customers - possibility to store detailed information about each customers, allows to keeping such necessary information to improve the speed and quality of service to customers;
- Elevated buyer's satisfaction - possibility that CRM systems offering customers to feel like they are part of the sales team, increases the customer satisfaction;
- Improvement of marketing efforts - data both contained within the CRM system can be analyzed, as well as all the data that are related with the buyers can be studied as it is established which a group of buyers is best for each individual marketing campaign, also data that are the disposal with CRM systems for previous customer orders can be used to predict which type of product will be the next target the customers;
- Increased profits - a combination of enlarged and better services to its customers, effective marketing, customer satisfaction leads to an increase in sales and achieving satisfactory profit;

The benefits of the company which allow applying CRM systems are great and significant when high risk and high reward decisions are at stake.

4 Application of CRM systems in companies in Republic of Macedonia

Customer relationship management in companies in the Republic of Macedonia is relatively underrepresented in the process, in carrying out companies' work activities. Application of CRM systems by companies would bring a number of benefits. Finding out the needs, demands as well as behavior of buyers is of vital importance for the existence and survival of a business in the market. CRM systems are exactly those which would help the company about learning everything related to buyers as a kind of market research, their

advantages are obligated at the speed in operation, economically and most importantly, reliability.

In order to find out whether and how customer relationship managements are applied in the companies' operations, there was conducted research in Pelagonia -Prespa region in R. of Macedonia.

The questions that were asked to the companies was to find out whether and how big is the application of CRM systems in their companies were, related with CRM system usage by the companies in the area in addition to the data collected by these systems.

According to the results which were obtained from performed research in the region, we can say that 5.3% of the results show that companies use CRM systems in their operations, 34.2% of the results display that companies sometimes use CRM systems in their operations, 60.5% of the results show that companies do not apply CRM systems in their operations. Large number of the companies even have not heard of this software and could not answer the questions, asset declarations returned empty, explaining that no one in the company has heard of CRM systems.

Given the results from performed research on the application of CRM systems in companies in the region in R. of Macedonia, is evident that the application of CRM systems is a very small. Macedonian companies do not apply these systems in their operations. The insufficient applying of CRM systems by companies perhaps due to:

- Lack of companies' management knowledge by the existence of CRM systems and their role;
- Undersupplied knowledge of the companies' management with advantages and benefits offered by these systems using in their work;
- Lack of an appropriate IT staff that can affect their implementation and above all, the impact of management for familiarization with the need of their use;
- The impact of the company's size in which these systems are used;

Our research showed that only 5.3% of the surveyed companies use CRM systems in their operations, indicating that it is a small representation of CRM systems in operation by the companies, which requires taking of appropriate actions for more informing on companies for the existence of CRM systems. Fig.1 show graphically review of results obtained from conducted research for the application of CRM systems in the mentioned region in R. of Macedonia.

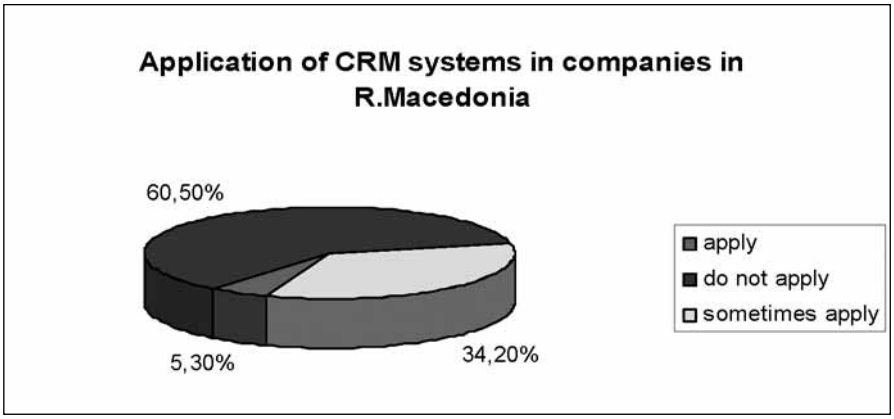

Fig. 1 Application of CRM systems

Also, needed are prerequisites to implement such a system in the company, some of the conditions are:

- the existence of organizational a culture of targeting towards customers and the environment i.e. culture focused on the purposes,
- good to know which is the objective that would be achieved by using these systems,
- having cadre in the company that will manage CRM systems,
- also of great importance is the education of managers for CRM systems as well as their role in survival in the market.

It would be realized with the presentation of CRM system, its functioning, efficiency ease of use, assistance that company would have to obtain the necessary information for buyers as well the pleasure which arises by the buyers, as a result of improved service that enables company.

8 Conclusion

According to what was previously said, we come to the conclusion that customer relationship management are systems that would have provided the buyers' data, so that would improve service towards them, on top of holding former customers and their loyalty.

Therefore it is necessary to familiarize company's managers with advantages and benefits arising from their use and it can be done with holding seminars and education of managers for the existence of the system, presenting how the system

works and the way that are facilitates the operation in companies with the help of these systems.

When it comes to CRM systems according to the research we can say that they are generally not applied by companies in Macedonia. Company managers need a better introduction of CRM systems and the benefits that would be gained from implementation but also the data which could come out with their use and when necessary, obtaining information which have a major role in decision making.

Therefore our opinion is that it have to make attempts to organize seminars for managers from the faculties to introduce in usage of these systems. Also, it has to introduce the courses with items that will familiarize students with opportunities to these and other systems that can bring competitive advantage for the company.

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Visual systems for supporting decision-making in health institutions in R. of Macedonia

Jasmina Nedelkoska, Snezana Savoska

Faculty of Administration and Information Systems Management , University „St.Kliment Ohridski“, Partizanska bb, 7000 Bitola, R.of Macedonia , www.famis.edu.mk

Abstract: everyday, managers look for better ways to access data in order to discern changes more effectively. Dashboards today are the preferred tool for managers. They offer the managers to support critical decisions with information obtained from dashboards. With them managers can follow the plan and its execution.
The aim of this paper is to show which data managers want to see in dashboards. For instance the pilot visual system for supporting the decision making in health institutions, will be demonstrated. The benefits of visual systems for managers will be presented with specific dashboards – the data of which are shown, for which type of managers and for which part of the operations they can be used, will be explained.

Keywords: Dashboards, Health institutions, Decision making.

1 Introduction

Long time ago people where aware that “a picture is worth a thousand words”. For that reason, they have been making efforts to apply visualization wherever possible. Visualization is an area that has rapidly developed in recent decades. It is a method that enables the viewing data and with its help you can discover connections and dependencies between data, i.e. to “penetrate” into the data. Visualization can be applied to data from all areas, which once again confirms its great application. With its help we can say that the thinking of people has changed and visualization has become a preferred form of getting information [1].

The effects that managers are expecting are to decrease the visualization time spent on data analysis and delve into the data, leading to better decision making process and better decisions [9].

To have a good and efficient data visualization, data should we be very well prepared. That process includes the selection of the data that will be subject of visualization and their visualization, i.e. their representation [2].

Visualization can have different purposes depending on what needs to be visualized. The most important goal is to make the “invisible visible”, i.e. obtain new understandings, effective presentation of significant features, more research

and use of data and information. Usually these dashboards are part of business intelligence systems [9].

Today there are a number of techniques that you can use in the process of visualization. Selecting the most appropriate technique depends on the types of data that will be subject to the visualization. One of the most desirable displays which are especially favored for managers is called dashboard that has made a significant impact on the decision making of managers in different areas [5].

In the first part of this paper, is introduced the problem that we solved and the term visualization. In the second part, analysis of the data that is subject to visual analysis and problems that we have solved is made. In the third part, pilot visual system to support decision-making in health institution, is described.

2 Analysis of the data that is subject to visual analysis and problems that we have solved

Data for the problems that we solved was collected in a conducted survey [4]. The collected results are derived the following conclusions. In the health institution that is the subject of research, data for drug consumption by type and by volume is stored daily. These data are coded under sections, and it is known which and what drugs are consumes by each department daily. This is still a new part in the information system, so there is no available data from previous years in electronic format. For that, there was a problem with compliance codes for drugs in the health institution and the health insurance fund, but efforts were made to overcome it. We expect this part to work correctly in the future.

For accurate records of entry and exit of staff in health institution a card reader is set. All employees have a card and there need to be accurate data for input and output of all employees. According to these data, measures need to be taken for delays in payment and etc.

There is a request for statistical processing of purchased materials (spent) and monitor their prices on an annual basis (for example, prices of food, medical supplies, etc.), yet there is no data stored in the database which will allow to make a visual system that will help with the statistical processing. For this application, first we need to create a suitable base, to input data for purchased materials and even after you have collected data that can be developed by a visual system for this part of the operation.

For comparison, between plan and implementation of the budget items, especially in the material section as well as in the organizational structure, there are some data in the database. In the pilot visual system there are parts of the budget, but there is a problem with the fact that in the previous years' data was not stored in the same format, i.e. each year data was saved in different data formats for budget and are not suitable for simple loading of data in a single database and to compare the years. But for 2012 and 2013 data are entered into a database

information system manually, with entering data for the following years, thus temporarily this problem was overcome.

The data base consists of human resources and their structure but it is not quantified. The only quantifiable data is about the performance, salary and the institution includes human resources data. The medical examinations are written down according to the ministry of health criteria. The previously mentioned information is private by the state law therefore we were not able to access it to make visual systems about it.

A hospital and a pharmacy for instance do not have network connection yet, so the managers are not able to collaborate and share information about these visual systems. Since network connection is provided in the institution then the visual systems would be available and common storage would be created so as this data could be visualized.

The consumables are kept in the database in the institution. But it should be refilled with additional information about the consumption of the materials as well as being inserted into the base according to the days so we could generate visual displays about daily, monthly and annual material consumption.

Financial condition data, partly and overall, can be seen from the realization data according to the accounts of budget. Part of the data is still in the base but consequently it will be finished and we will acquire revised and advanced visual displays in this matter.

There are procurements about the medical supplies but this data division should be expanded by the daily consumption and minus the daily consumption we get the wasted materials and the remaining ones. The requirement to align the budget with the actual needs of the institution, the information system which is in the initial stage of its operation is not in a state to offer sufficient information for this part. Therefore the data about the functioning of the institution for the previous year should be available. This data should be compared with the planned one and the differences will lead to making the budget plan for the following year.

To sum up, the information system is in its beginnings. For lots of years data is non-existent and that is the reason why we cannot do a better comparison of data. The exploring motif and the job done were from the existing data on the subject.

This thesis shows a visual system based on the available data, which is part of the basis and some of it was not available for us to use. We consider that in the future an improvement of the databases of the information system is needed in the health facilities as well as acquisition and input and store of data from the past years. This will help in gaining relevant information about the visual system which helps the managers to make decisions and it will increase their efficiency in data analysis, solving the upcoming problems which will follow with more effective decisions.

4 Pilot visual system to support decision-making in health institution

According to the managers' requirements, a visual control system which allows data view on the table Budget was made. Most of the managers have declared that the Budget is the most critical part of the operations of the institution [11]. Visualization has to help users to analyze all the data and come up with new hypotheses. In this part large data sets are analyzed, so the user first gets a full view of the data. In the view, the user identifies interesting patterns in data sets and focuses on one or more. To analyze the patterns, the user should list and start the process of exploring of the data. The visual view can be distorted in order to focus on interesting subsets of data. This may allow the allocation of a percentage of the display of the set of interest, while reducing the use of screen data that are not of interest. For the research on the set of interest, users needs drop-down capacity to observe details of the data. All these techniques are shown in the prepared visual system and can be seen in the images below. The visual system is developed by using the tool Dundas Dashboars. The completed dashboards can be used in almost all software tools like an object.

With prepared visual in place, managers will be able to choose for which account they want to open a dashboard and for which the costs are. Figure 1 shows part of the visual system that provides a view of budget expenses billed to the primary account 421 (utilities, electricity, water and utilities, trash and other utilities). In the figure, the billable expenses in denars are in the y axis, while the x axis shows the sub accounts for primary account 421. The graph shows data for all four quarters, with different types of graphs. Here are shown the data of expenses, and if we want to look for which under accounts costs are highest, we select Line area graph that is appropriate for this type of data. For all four quarters we chose different types of line graphs and charts of different colors, to faster and better see the differences. The dashboard has the filter that allows you to select and view data for a specific sub account where you can see the data for all four quarters.

If managers want to see the graphics from various quarters one to one, and they do not want them to be folded, they only need to click on the graphic of Figure 1 and a pop-up window will be opened where they can see the data for all four quarters separately (Figure 2). For all four graphics they can see such measures are set billable costs in denars, as long as the dimensions we have under account for the account 421. On this dashboard, managers can detect which quarter and which sub account costs are highest and make rapid comparisons of the amount of certain sub account in all four quarters. This dashboard can help managers in the decision making process for planning the budget for next year, and to see how big amounts billed and for which sub accounts.

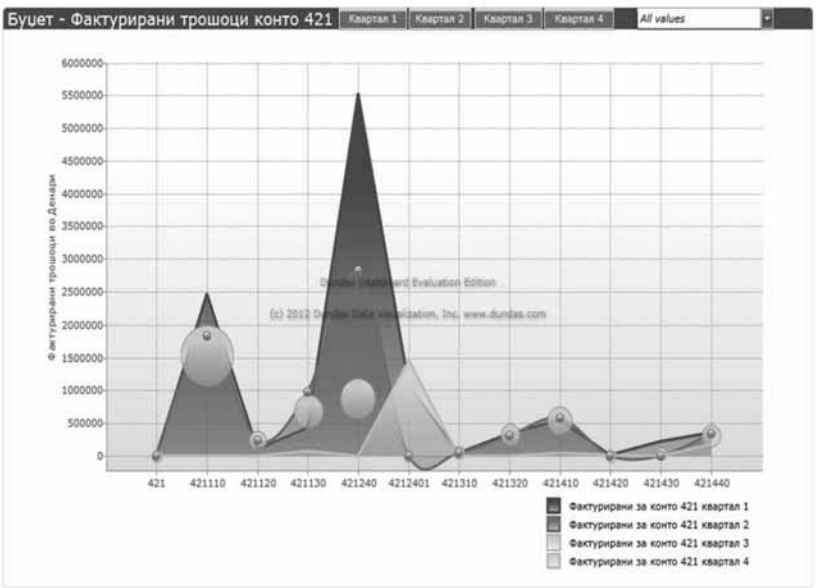

Figure 1: Line and point charts for billable expenses in denars (y axis) for the sub accounts for the account 421 (x axis) by quarters

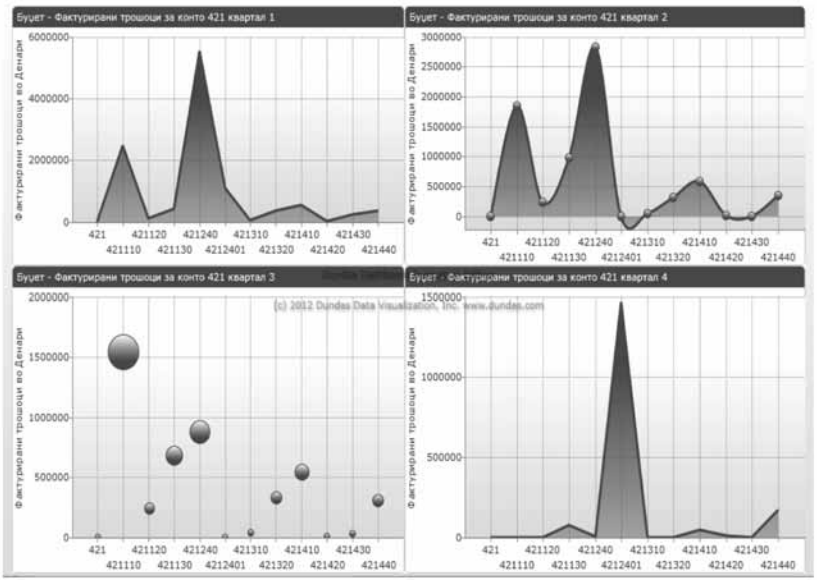

Figure 2: Line diagram and point of billed charges in denars (y axis) for the sub accounts for the account 421 (x axis) for all four quarters separately

Besides the quarters, the data can also be divided by dimension – from which

accounts come from (from which of the three accounts of the institution). According to the requirements of managers for the need of visual display of the invoiced cost of class 4, is made a visual display of synthetic account 421 for 1 account with its analytical accounts. In Figure 3, with bar diagram, the amount of billable costs for all analytical accounts for 421 synthetic account of account 1, is shown. This dashboard uses a visual bar diagram that is appropriate for displaying the data where we want to make a comparison of the amount of costs, i.e. where we compared the highest and the lowest costs [10].

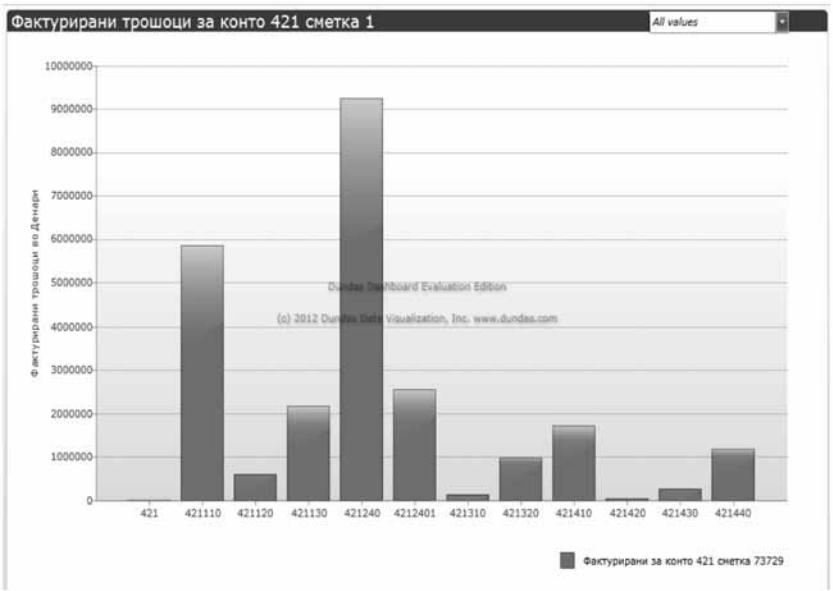

Figure 3: Bar diagram where the x axis is the sub ledger account 421, while in y axis is billable expenses in denars for account 1

Apart from the data on the budget, the options for displaying data in a visual system form i.e. in the visual system created for this purpose, we have data for revenues and expenditures. Part of the revenues data is presented in Figure 4. Here you can see the data for 2009, 2010 and 2011. Data are presented on line graphs. The blue line marks data for 2009, the green line marks revenues for 2010 and the turquoise line presents data for 2011 [12]. On the x axis we see the data for the type of revenue, while the y axis shows the values for that type of revenue.

Because the data we have received and the one we already had were not read, a very big difference in the values of revenue appeared, therefor it was necessary to apply a method for normalization of the data i.e. we applied data processing with normalization and used a logarithmic function over revenue to get more

adequate values for visualization i.e. values can be presented on a graph. An applied logarithmic function is used at transformation of the data (base 10 logarithms). And this visual dashboard allows filtering of data by a particular type of revenue.

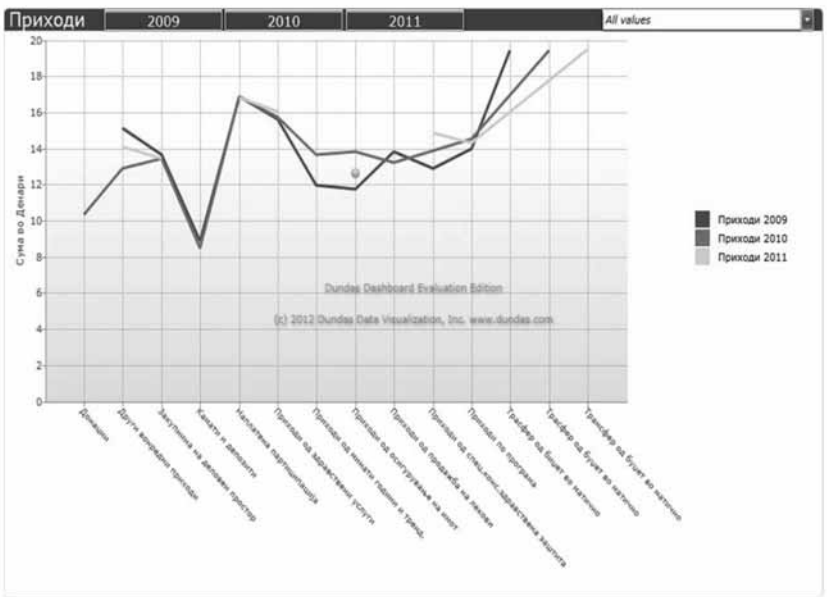

Figure 4: Line diagram of revenues for 2009, 2010 and 2011, where in the x axis we have shown income and in the y axis the amount in denars

The program for creating visual systems provides for a number of views that we can use. If on the visual dashboards we would like to display more data, line and column displays are most suitable. Fewer data will be displayed on the following visual dashboards but with slightly different visual displays that will refer to the costs in the budget.

In Figure 5 we can see the planned costs for a certain account. In the first part we showed the planned costs for the aggregated account 401-Basic salaries and personal tax for each quarter. Here managers can see the collective planned costs on account of all quarters, where we can notice that the charges of the second and third quarter overlap and they are same, and that the cost for the fourth quarter are the smallest. In the next sections present the planned costs of account 402-Contributions of pension fund and health care contribution, taxes for healthcare and employment also divided by quarters. Here the managers can see that the planned costs of account 402 for the second and third quarters are the same and they are the highest, while the costs for the fourth quarter are the lowest. In the

next part of the visual dashboard presents the planned costs of account 404-Compesations according to the four quarters. This shows that the most costs are planned for quarter 1 and the same costs have been planned for the second and fourth quarter. The last part of the visual dashboards present the planned costs of account 423-Materials, medications and other medical materials. This shows that most costs are planned for the fourth quarter, while the least for the third quarter. If with the cursor we go to a certain indicator of the planned costs the exact planned full amount will be displayed. This visual dashboard helps managers see witch accounts the most costs have been planned for and which quarter the most of the costs have been planned for. They can use this for planning costs for the next year and to have a look at the spending of resources.

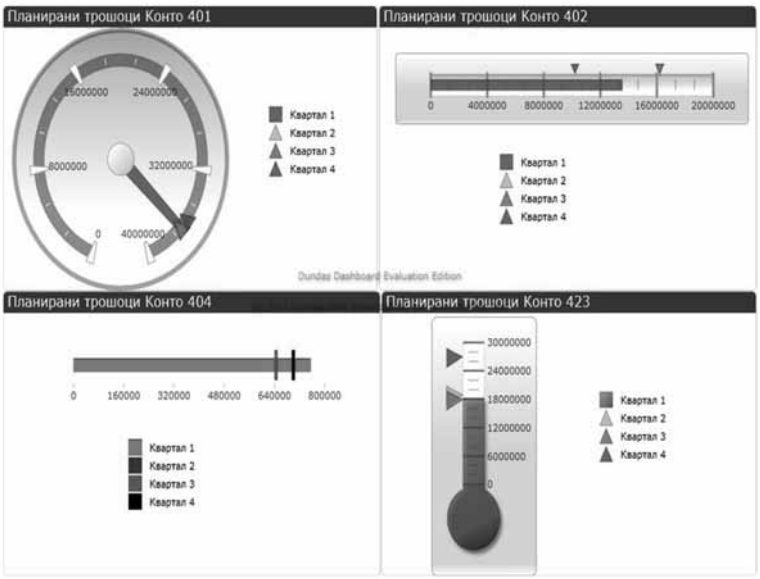

Figure 5: Planned costs for accounts 401, 402, 404 and 423 presented in 4 quarters

Beside the data for the budget, in the database we have the data for medicine consumption. On Figure 6 you can see the consumption of medicines by departments. There are more data to be seen for medicines on the visual dashboards that are important to know, so more data are presented in the data grid (table). On this visual table we have three filters and we can do data filtering by department, by group and by the name of the medicine.

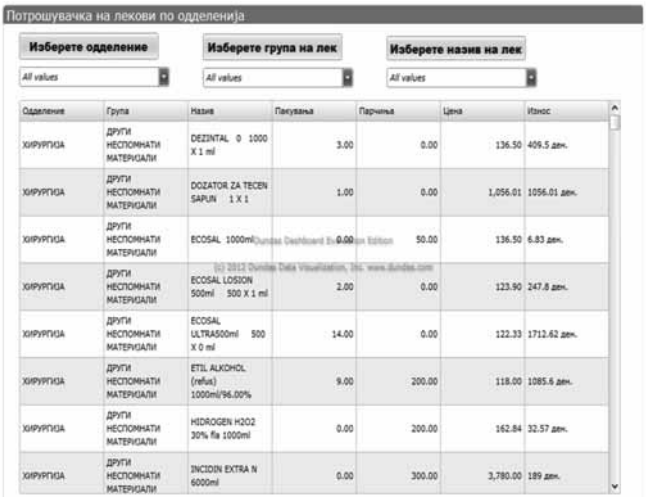

Figure 6: Consumption of drugs by departments

The possibilities for getting reports by using the visual dashboards and their combinations are endless, limited only by the imagination of users and their requirements [6]. Many different combinations are possible depending on the needs of the target manager. Here you have to work with a good strategy for deciding on the base of the real needs of the applicants' services – to effected the outcomes and to receive automated visual dashboards. It is a task on which the managers of health institutions and IT personnel need to work together, to make a system which will help managers in their decision making.

5 Conclusion

Based on the research made, we came to the conclusion that managers have constant need of obtaining quick and reliable reports, from where they can easily and visually see the changes and improve their decision making. The reports that they now receive are not sufficient for a timely registration of the changes and hence for improving the process of decision making.

The future of improving the process of decision making lies exactly in the use of these visual systems. They will improve the work of health institutions where they will improve the services and increase the profit of the health institution. If they respond on time and quickly to all changes, the health institutions will be able to save resources and with that they will get the opportunity for progress [8].

The implementation of visual systems in all of the public health institutions in Macedonia will take time and expertise from employees in the IT sector. First

they need to create dashboards that will be useful to managers and will be created for each part of the operation of the institution. Health institutions have a lot of data for all parts of the operations and for that the creation of this system will be a very hard process. But, when once it is created, it can be used in all public health institutions. The long term benefits that a visual system will bring are much larger than the time and costs for creating the system.

When the visual system is created and implemented, it is necessary to train managers for its use [3]. If managers previously understood the need and usefulness of the system, they will be motivated enough to use the system. The system is very simple for usage. Managers just need to choose which dashboards with witch data they want to see and the system will visually show them. With this the changes in the work of health institutions will be detected on time and appropriate measures will be taken in time.

In the future, we think that the concept should expand to all public health institutions in Macedonia where managers can get the data that they want to see on those dashboards. They should be applied to that part of the operations for which there is a necessity for that kind of a visual system. Once the data is collected and processed, it is necessary to expand the database so that it includes all of the data requested by the managers. But, even when we have all the data, we must create algorithms to prepare the data to be used for visualization. That means we need to create a new database that will communicate with the databases from the hospital and will take the data from there, and it build views that provide data needed for visualization. This way of connection with the databases of the actual system is not possible, but is essential for creating the visual system. It would be an excellent topic for future surveys. The next step is creating a visual system that will satisfy the needs of all managers in the health institution by the example proposed in this paper. For that visual system every manager will have password protected access and access to the visual dashboards that are of his interest. The visual system should be implemented in all public health institutions in Macedonia. At the end managers need to be trained for using the visual system, and understand the opportunities that it offers and how they can use those opportunities to improve the work of the health institution.

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Evaluation of Taxonomy of User Intention and Benefits of Visualization for Financial and Accounting Data Analysis

Snezana Savoska[1] , Suzana Loshkovska[2],

[1,] Faculty of administration and Information systems Management, University „St.Kliment Ohridski“ – Bitola, Bitolska bb, 7000 Bitola, R.of Macedonia,
savoskasnezana@gmail.com
[2] Faculty of computer science and ingeneering, Ss.Cyril and Methodius University in Skopje, Rugjer Boshkovikj 16, 1000 Skopje, Republic of Macedonia, suze@feit.ukim.edu.mk

Abstract. In this paper we evaluate the taxonomy model for multidimensional data visualization for accounting data analysis. This taxonomy takes into consideration users' intentions and also, the benefits of visualization for analysts, businessmen and managers who use financial and accounting data. We also explain the proposed taxonomy as well as the taxonomic framework which contains three groups of attributes. They are classified according to visual techniques and their capabilities. We have analyzed several multidimensional and multivariate visualization techniques, each presented in a table according to the proposed taxonomy. This table will determine their capability and capacity to solve specific visual problems.

Evaluation of this taxonomic model for visualization of multidimensional and multivariate financial or accounting data implies the possibility for introducing an automatic selection of a visualization techniques and the best visual representation.

Keywords: data visualization, taxonomy evaluation, financial and accounting data, multidimensionality

1 Introduction

Many taxonomy methods and techniques, used in data visualization start from data and used techniques. We proposed taxonomy for data and information visualization which have a different focus of interest and take in consideration the user's preferences in the process of visualization and refers of financial and accounting data. We believe that this taxonomy will be very useful to handle with everyday's data and information overflow and it's analysis for the managers and analytics. We proposed the proactive policy of gaining visual reports in the phase of data preparation and effective manner of presentation. This proposed coherent review and conceptual framework will be elaborate in this paper and will gain design classification and selection of techniques dependent of the users' intention, its capability and the benefits given to the end users. The end users can

have different level of foreknowledge which has to be taken into consideration in the process of selection. We will analyze some of the most popular visualization techniques for multidimensional and multivariate (mdmv) data visualization.

The evaluation of this taxonomy's model can help understanding the usefulness of this taxonomy for evaluations of each technique for particular user's group and specified level of foreknowledge as well as creation of user's manuals for usage of each proposed visualization techniques appropriate for end user's group. The implementation of this taxonomic model will help for more efficient, faster and better future prepared visual information and for bridging the gap between necessary and expected results for some user groups. Also, we intend to propose some strategy for selecting technique and creating multidimensional and multivariate visualization for financial and accounting end users which will be the base for some automation in the business oriented information systems.

If we analyze the taxonomies in the whole visualization area, we can say that many classifications have been made. It is assumed that from taxonomy data, which means, its characteristics, the number of independent variables, variable sets, data types (scalar, vector or more complicated structures, discrete or continuous, nominal, interval or numerical, indexes and other). But, none of this taxonomy is focused on user intention, gained effects and interaction with data. This taxonomic framework for mdmv visualization is focused on the specific user groups of financial and accounting data and its preferences.

The paper is organized as follows. The second section, after the introduction, is dedicated to the short introduction in the proposed taxonomy and its dimensions. The following section takes in consideration most used visualization techniques and the subsequent explains in detail the evaluation of the proposed taxonomy for these visualization techniques. The following section discusses results with specific usage and examples for the effects of used taxonomy. The conclusion depicts remarks for future work.

2 Explanation of the Proposed Taxonomy

The proposed taxonomic model is created for mdmv data visualization for financial and accounting data analysis. According to this taxonomy, three dimensions are created: user intention [1], effect of visualization techniques and the interaction possibility. The additional dimension refers to the user groups and each combination of these four dimensions is a single vector in the four-dimensional space.

For better understanding, we can present the taxonomy's dimensions on the axes in the 3D Cartesian system, but it is useful to make a coding of all values, which the independent variables can take all three axes. The first dimension can take discrete coded data values for: data overview, hypothesis confirmation and insight, delve into the data and make new decisions (Table 1). The second dimension is

the visualization technique effects (visibility, interpretability and delve into data -Table 2). The coding of the third dimension, visualization techniques effects are shown on Table 3. The interaction possibilities are classified according to data selection from the beginning. In the end, the fourth dimension - the user groups and its coding is presented on Table 4. Taking into consideration this taxonomic model, we can evaluate the most used mdmv techniques and gaining the results - effect with some sample of accounting and financial data.

Table 1. The first dimension coding – User intention

1	**Data Overview**	UI/DO
2	**Hypothesis Confirmation**	UI/HC
3	**Delve into (the data) and making new decisions**	U I / DID&MND

Table 2. Coding of dimension VTE -Visualization technique's effects

Visualization techniques effect	Type of variable	Variable rang	Used code
Visibility	One screen or n-screen	data are shown on one, two or n-screens	S_1, S_2 ,…. S_n
	Object selection (slider, tab or radio button, combo box, command button)	Possibility to select data with object	SL, TB, RB, CB, COM, NO
	Analytical or aggregated data	Analytical data are shown or data aggregations are shown	AN, AG
	a) Relations are visible b) Relations aren't visible	The relations between data are or are not shown	RV, RNV RELV, RELUNV
Interpretability	The level of data understanding	The data understanding is at the: Low, Middle or High level	LL,ML,HL
	Relationship understanding level	Strong capability, middle, weak or no possibility for correlation discovery	SC, MLC, WC, NoC
	The aggregation understanding	There is visible: clustering, classification, association, rule detection, there is not visible rule	NoVIS, VCLU, VCLA, VASS, VRD
Insight in data	Possibility for ordinary statistical, mathematical data analysis, no possibility	Statistical or mathematical data analysis possibility or no possibility	IDAS, IDAM, IDAN
	Possibility to discover correlation	Correlation discovering level (1-5)	ICORR 0-5
	Possibility for cluster analysis	The level of clusters (1-5)	ICLU 0-5
	Possibility for classification	Possible classification level (1-5)	ICLS 0-5
	Possibility for pattern recognition	The possibility level of pattern recognition (1-5)	IPR 0-5
	Possibility for discovering associations	Association discovering possibility	IAD 0-5

3 Overview of the mdmv techniques and its coding according to the proposed taxonomy

When it comes to the analysis of financial and accounting data, it is important to note that the techniques used for effective visualization should be classified into eight groups of requirements of the visualization [3]. They are: Overview & detail on demand, Hierarchical structures and relations, Multivariate data attribute views for a time period, Analysis of objections to the plan (or plan disagreements), Additional detail for disagreement as drill-down possibility, filtering ability (information of interest, the level on detail, subsets for data analysis, comparison sets), Ability for relation and attributes changing in time or time series for attributes and relationships as well as company graphs for accounting period following attributes or Adjusting periods for data analysis. The techniques which will be of interest for analysis for proposed taxonomy for mdmv data visualization are shown on the Table 5.

Table 3. Possibility for selection data, attributes and interaction with data

Interaction possibility	**Type of variable (Nominal, Ordered, Quantitative)**	**Variable rang**	**Used code**
Selection of subsets from the visualization dataset	With previous data preparation, In the visualization screen, No selection possibility	The visualization is prepared with already selected data set, on a whole data set and selection is enabled, Selection is not enabled	SELP, SELV, SELNO
	Enabled selection – filter for data/ There is only time filter/ Enabled with some object (slider, tab, combo or radio button)	There is data filter for all dimensions, Only for time period, Select data set with given object for data selection	SFIL 1-n, STFIL, SOBJ 1-n
	Zoom, Selection, Distortions, Linking and brushing	Data can be selected with zooming, distortion, linking and brushing or interactive filtering	SZOOM, SDIS, SLB, SIF, SNO
Selection of desired data attributes	With previous selected attribute (query or alias)	Previous prepared data set with selected attribute – number of selected attributes	SAP 1-n
	Selection of attributes on the visualization screen: Aggregated Analytic- data with drill-down possibility, Selection of attribute with object selection, Selection with slider or pointer	Embedded drill-down possibilities for aggregated data, Selection of attribute with selection of object dedicated to the desired attribute (radio button, tab, combo box or check box…), Selection with slider or pointer	SAVDD 1-n, SAVOS 1-n, SAVSP 1-n
Possibility of interaction with data in the given visualization	Possibility for selection analytical data/aggregated data/ No possibility interaction	Analytical data selection/ Aggregated data selection/ No interaction	ISAND, ISAGD, ISNO
	Only data navigation, Possibility for zooming, for linking and brushing, for interactive filtering	Possibility for: navigation only, zooming, linking& brushing, interactive filtering	INAV, IZOOM, ILB, IIF

3.1. Analysis of time histograms with displays and possibility select and zoom

The mentioned visual display may be set in the dashboards class with the "Overview & detail on demand" [3] class. It can be used as the base of many MIS, EIS, ESS and BI systems, as dashboards views for various manager's levels and business analytic staff. The number of screens is bounded with the users' demands and data visibility and clearance for the analysis. The proposed taxonomy for this visualization technique is shown on the Table 5.1a.

Table 4. User groups with specified tasks and level of information and analytical knowledge

Users' group	Specified tasks	Information knowledge	Used code
Top managers	Strategic management and planning activities	High level	SMHI, SMMI, SMLI
	Planning and control activities	Middle level	PCHI, PCMI, PCLI
	Region management activities	Low level (informational and analytical knowledge)	RMHI, RMMI, RMLI
Tactical (middle level) managers	Sector's planning and control	High level of	SPHI, SPMI, SPLI
	Management by exception	Middle level of	MEHI, MEMI MELI
		Low level of (information and knowledge)	LEHI, LEMI, LELI
Operative managers	Standard procedures control	High level of informational and analytical knowledge	SPCHI, SPCMI, SPCLI
	Operation management	Middle level of informational knowledge	OPHI, OMMI, OMLI
	Problem detection and solving	Low level of information and knowledge	PDSHI, PDSMI, PDSLI
Analytical staff	Specific analytic task	High level	SATHI, SATMI, SATLI
	Exception analysis	Middle level	EAHI, EAMI, EALI
	Perception analysis	Low level (information and knowledge)	PAHI, PAMI, PALI

Table 5 - Proposed Multidimensional and multivariate Visualization technique used for data analysis of financial and accounting data

Dashboards with time slabs – analysis using histograms, scatter plots or line plots as Ds
Parallel coordinates
Hierarchical parallel coordinates
Pixel-oriented display
Hierarchical pixel-oriented display
Glyphs
Hierarchical glyphs

Scatterplots
Hierarchical scatterplot
Dimensional stacking
Hierarchical dimensional stacking
Nodes and links techniques (cone trees, information landscapes, hyperbolic spaces etc.)
Polar coordinate – Kiviat's diagrams

Table 5.1a. Analysis according to the proposed taxonomy with the properties visibility, interpretability and insight in data

	Visibility				Interpretability			Insight in data					
Technique	I	II	III	IV	I	II	III	I	II	III	IV	V	VI
Dashboard(THWS&Z)	S2	SL	AG	RELUNV	HL	NoC	NoVIS	IDAN	ICORR0	ICLU2	ICLS0	IPR2	IAD1

The example below describes visualization with visibility defined as two windows in the screen, the first windows with slider. In the windows on the top it shows the aggregated data from database but relations between data are not visible. The interpretability is described as a high level of data understandability, no visible correlations and clusters or associations, and no rules. Insight in data property is explained as "No statistical or mathematical possibilities for data analysis". No visible correlation in some dimensions, no visible classification, and rules will only be drown based on the seasonal natures and associations, are possible only with a selected dimension – time chunks and another dimension. The possible improvements aimed in increasing the possibility for filtering with a slider or pointer [5, 6], as well as a data filter with object which can increase the number of observed dimensions [8].

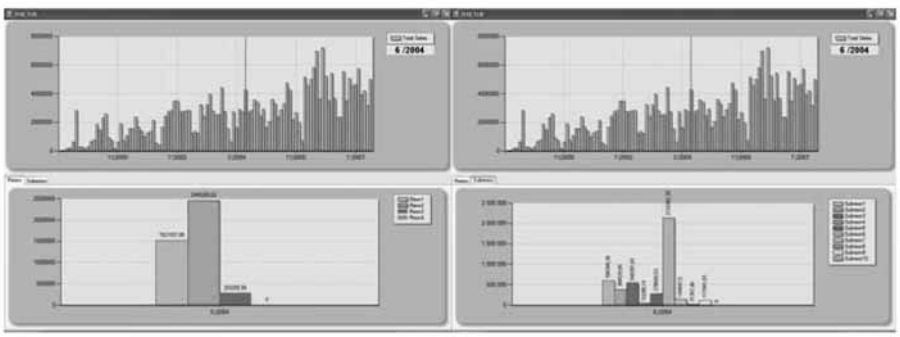

Figure 1: Time histograms with interactive selection of time unit and dimension

Next table 5.1b shows the analysis of this combination type of visualization techniques forming the aspect of interaction with data, selection of attributes which will be visualized and with direct interaction possibilities.

Table 5.1b. Analysis under the proposed taxonomy and possibility for selection and interaction

	Possibility for data selection			Attribute selection		Interaction with data	
Technique	I	II	III	I	II	I	II
Dashboard (THWS&Z)	SELV	SFIL2	SND	SAP3	SAVOS3	ISAGD	INAV/IZOOM

In this analysis, the selection possibility is on the screen in the first window, one dimension (time slab) can be selected with a slider (or a pointer) as a data selection. No direct zoom, linking & brushing or distortion or interactive filter possibility on the first window. The attribute selection is done with tabs or sliders (or radio buttons, or check boxes). The direct interaction with data is data selection from aggregated ones with the slider on the first windows in the screen. This technique only offers the possibility to navigate through data. This methodology is desirable for non informatics staff, but requires prior programming to the preparation of the data. The main purpose is that the systems are business oriented, especially for managers of a higher level and control to perform operational management tasks. By incorporating automated alert, efficiency in the operation can be improved a lot for this user group types.

3.2. Analysis of technique parallel coordinates and hierarchical parallel coordinates

The technique of parallel coordinates allows the detection of relationships between variables which are analyzed and are shown on the N-dimensional parallel axes in the 2D space. According to their purpose, we can classify them as presentation techniques of hierarchical structures to demonstrate links or Hierarchical structures and relations [3]. There are many tools for multidimensional and multivariate analysis which allows data analysis with this technique. The advantage is that all data is in the same screen and the number of sets axes are limited only by data visibility on the screen surface for data presentation. This technique actually represents the reflection of N-dimensional Euclid space in to 2-dimensinal surface. The proposed taxonomy, its application for multidimensional and multivariate visualization for this technique is shown on the Table 5.2a.

Table 5.2a Analysis under the proposed taxonomy for the technique parallel coordinates, taking in consideration visibility, interpretability and insight in data

	Visibility				Interpretability			Insight in data					
Technique	I	II	III	IV	I	II	III	I	II	III	IV	V	VI
PARCOR	S1	SL	AN	RELV	HL	SC	VCLU	IDAS	ICORR1	ICLU5	ICLS3	IPR3	IAD1
HPARCOR	S1	SL	AG	RELV	ML	SC	VoVIS	IDAS	ICORR1	ICLU0	ICLS0	IPR0	IAD0

The example described in this table is visualization with visibility as all dimensions are shown in one display, data visibility is provided with navigation through the axes with a slider and the analytical data values can be also obtained.

The relation between data is visible because of the lines which connect the axes. This visualization is high interpretable. There is a high degree of perceived correlation between data in the axes and some cluster that can be detected. Some groups of clusters can also be noticed. The awareness in data can be also explained as possible statistical analysis with hierarchical parallel coordinates, correlation in a scale of 1 to 5 is four, excellent cluster detection, middle level of possibility for classification (three) and pattern recognition possibility in the low level (one from the scale of 1 to 5).

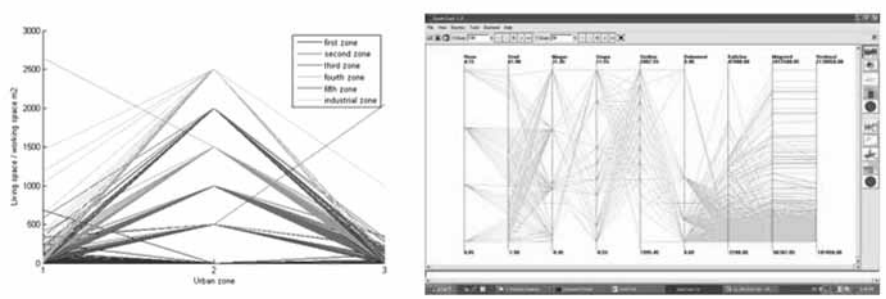

Figure 2: Parallel coordinate techniques as technique for hierarchical structures and relations presenter

If we take into consideration the hierarchical parallel coordinates, they have a decreased level of interpretability because there the means data values are shown on the display and the rules cannot visually be detected. There isn't a possibility for a high degree of discerning in data because of data aggregation [7] (Figure 2). The possible improvement can be done with increasing interpretability with introduction of colors; visual primitives for the lines [4] (dashed or dotted lines etc).

Table 5.2b. Analysis for selection and interaction possibilities of ParCor techniques

	Possibility for data selection			Attribute selection		Interaction with data	
Technique	I	II	III	I	II	I	II
PARCOR	SELP	SFIL1	S*	SAPn	SAVSP1	ISAND	I*
HPARCOR	SELP	SFIL1	S*	SAPn	SAVSP1	ISANG	I*

Table 5.3a – Analysis under the proposed taxonomy on the techniques for multidimensional and multivariate visualization – visibility, interpretability and insight in data

	Visibility				Interpretability			Insight in data					
Technique	I	II	III	IV	I	II	III	I	II	III	IV	V	VI
PIXELDIS	S1	NO	AN	REL UNV	LL	WC	VRD	IDAN	ICORR0	ICLU1	ICLS1	IPR3	IAD3
HPIXELDIS	S1	SL	AG	REL UNV	LL	NoC	VCLU	IDAN	ICORR0	ICLU6	ICLS0	IPR0	IAD0
GLYPHS	S1	NO	AN	REL UNV	LL	WC	NoVIS	IDAN	ICORR0	ICLU0	ICLS0	IPR2	2
HGLYPHS	S1	SL	AG	REL V	ML	MLC	VASS	IDAN	ICORR0	ICLU3	ICLS1	IPR3	2
SCATMAT	S1	SL	AN	REL V	HL	SC	VRD	IDAS	ICORR5	ICLU5	ICLS5	IPR5	5
HSCATMAT	S1	SL	AG	REL UNV	ML	SC	NoVIS	IDAS	ICORR3	ICLU3	ICLS3	IPR1	1
DIMSTACK	S1	SL	AN	REL UNV	LL	WC	VCLU	IDAS	ICORR0	ICLU2	ICLS0	IPR1	0
HDIMSTACK	S1	SI	AG	REL UNV	LL	NoC	NoVIS	IDAN	ICORR0	ICLU1	ICLS1	IPR1	0

Table 5.3b shows the analysis under the proposed taxonomy for data, attribute selection and direct interaction possibilities.Table 5.2b analyzes the aspect of data selection, attribute selection and data interaction for these visualization techniques. The possibility to select data is in the phase of data preparation (time – the possibility to observe the presented data in a timetable or having the possibility to see different dimensions at the same time). The column "interaction with data" shows that all known interaction types with data are available. The number of possible attributes for selection is equal with the numbers of dimensions. The selection is made with a slider or a mouse pointer. Analytical data can be selected and all of interaction types with data are available to select – from selecting and brushing to distortion and zooming. Hierarchical parallel coordinate techniques differ in the selection possibilities because only the aggregated data is shown and interaction is limited. The tools available for implementing this kind of data visualization require prior preparation of data and high level of IT knowledge.

Table 5.3b. Analysis of proposed taxonomy for multidimensional and multivariate techniques and their possibilities for selection and direct interaction with data

	Possibility for data selection			Attribute selection		Interaction with data	
Техника	I	II	III	I	II	I	II
PIXELDIS	SELP	SFIL1	S*	SAPn	SAVSP1	ISAND	I*
HPIXELDIS	SELP	SFIL1	S*	SAPn	SAVSP1	ISANG	I*
GLYPHS	SELP	SFIL1	S*	SAPn	SAVISP1	ISAND	I*
HGLYPHS	SELP	SFIL1	S*	SAPn	SAVISP1	ISANG	I*
SCATMAT	SELP	SFIL1	S*	SAPn	SAVISP1	ISAND	I*
HSCATMAT	SELP	SFIL1	S*	SAPn	SAVISP1	ISANG	I*
DIMSTACK	SELP	SFIL1	S*	SAPn	SAVISP1	ISAND	I*
DIMSTACK	SELP	SFIL1	S*	SAPn	SAVISP1	ISANG	I*

3.3. Analysis of other proposed techniques for multidimensional and multivariate data visualization

The techniques offered by the available multidimensional and multivariate visualization tools (as XmdvTool, VizDb etc.) provide multidimensional and multivariate visual displays of some data in order to improve the analyst's exploration possibility. For this purpose, we may take into consideration their capabilities under the proposed taxonomy's frame. These are the techniques

for pixel display, glyphs, scatter plot matrices, dimension stacking. All these techniques have their own possibilities for hierarchical displays, which show the statistical averages of analytical data. The advantage is the fact that all data is shown on one screen and the number of data depends on the number of records in the fields in database which are used for visualization. The proposed taxonomy, applied in these techniques for multidimensional and multivariate visualization is shown on the table 5.3a.

It is obvious from the table that the multivariate outputs of the visual display have a different level of visibility, interpretability and insight. They are ranked from techniques which have a high degree of interpretability such as scatter plot matrix to the techniques which aren't interpretable. The scatter plot matrix and its hierarchical version have a high possibility level to detect correlations between dimensions. Most of them have the capability for statistical analysis, but, the cluster, classification and association possibilities have only one scatter plot matrix technique with a high degree of usefulness. The pattern recognition capability is higher only in the glyphs and pixel oriented displays. The next figures (Figures 3 & 4) show some multidimensional and multivariate data displays explained in table 5.3a. The possible improvements are increasing interpretability with the study of glyph possibilities and controlling the arrangement of pixel-oriented displays.

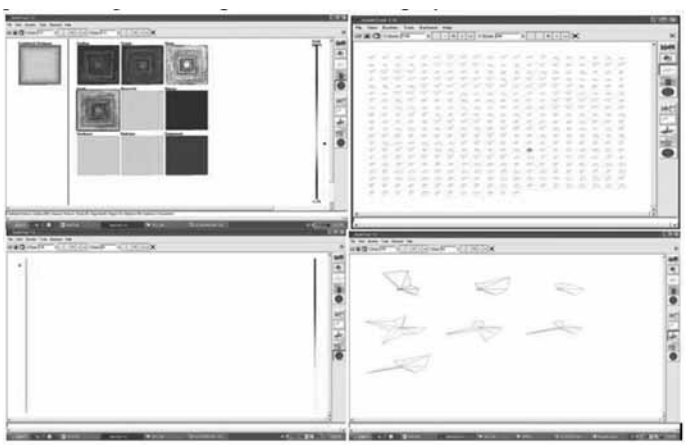

Figure 3: a) Pixel-oriented display of material-finance data b) Glyphs technique for same data c) Hierarchical pixel display d) Hierarchical glyphs

As parallel coordinate technique, these multidimensional and multivariate visualization techniques have the possibilities of data selection, but only in the phase of data visualization preparation. It is possible to set a wide variety of filters for each dimension or for their combination at the same time. All interactions with data possibilities are included. The number of possible selection attributes is equal

to the number of analyzed dimensions, and the selections are made by a pointer. The analytical (in the regular displays) as well as the aggregated (in hierarchical displays) data can be selected. It's possible to use all types of data interaction as selection, zooming, linking& brushing or distortion. Using these techniques also requires knowledge of the specific tools for data visualization of multidimensional and multivariate data and advanced data preparation. This also means a high level of IT expertise.

3.4. Analysis of the techniques nodes and links, trees, hyperbolic spaces and Kiviat diagrams

While the mentioned (nodes, links and hyperbolical displays) can be classified into hierarchical structures and relations, the Kiviat display is figure obtained in a polar coordinate system (and its possible transformations in cylindrical or spherical coordinate system). Figures themselves are obtained by connecting points of polar coordinates. This technique can be seen as the axes rotate from parallel coordinates into polar coordinates. Nodes and links are popular for displaying complex relationships in the formation of tree maps, cone tree, hyperbolic trees etc. The size of the hierarchical structure dictates the view and the techniques used to interact with the data. This representation shows all data in the techniques of nodes and links is some kind of clear drawings that can zoom in or distorts, depending on the user requirements. The Kivit figures show shapes obtained in the polar coordinate system giving information about the values of each of the axes. The proposed taxonomy used for this model of visualization is shown on table 5.4a.

Figure 4 a) Scatter plot matrix b) Dimensional stacking c) Hierarchical scatter plot matrix d) Hierarchical dimensional stacking

The example describes visualization of nodes and relations whose visibility is described only in one display shows the analytical data is from the database without object possibility selection. The arcs show the links between data and they are visible. Their interpretability is depicting as high level of data understandability which gives a high degree of dependency and understandable object classification. There are not many possibilities for statistical and mathematical analysis, but they have a great opportunity for making classifications and clustering. The insight in data possibilities is weak.

Table 5.4a. Analysis under the proposed taxonomy for the properties visibility, interpretability and insight in data

	Overview				Interpretability			Insight in data					
Technique	I	II	III	IV	I	II	III	I	II	III	IV	V	VI
Nodes, links and relations, treemap, conetree	S1	NO	AN	REL V	HL	SC	VCLA	IDAN	ICORR0	ICLU5	ICLS5	IPR 1	IAD 0
Kiviat figures	S1	NO	AN/AG	REL V	ML	WC	VCLA	IDAM	ICORR3	ICLU3	ICLS1	IPR 3	IAD 1

The Kiviat figures are usually shown in the screen without the data selection possibility. They are made from analytical as well as average data (hierarchical kiviats). The level of data understandability for this technique isn't on the highest level and the correlation detection has a low level [2]. The visible level of classification possibility is obvious. The mathematical data analysis are possible with this technique, also it has possibilities for correlation detection, medium level of pattern recognition and clustering capability, but there isn't an ability for discovering clusters and association (Figure 5). The possible improvements are aimed at increasing data filtering with the usage of a slider or a pointer as well as increasing the number of dimensions which are taken into consideration with the visualization.

The data sets selections possibilities for the technique nodes and links are made with the previous data preparation for visualization; there isn't a filter for data selection or attribute selection as well as for interactively movement through the nodes. The number of selected attributes is defined in the previous prepared static data set and there aren't embedded additional possibilities for selection with a slider or a pointer. There isn't an interaction possibility, data changing, navigation capabilities or distortion, zooming or another type of interaction. The tools used for such displays, are mostly for the engineering staff and require high former knowledge of specific software tools which normally allow visualization and simulations. First, data should be adequately prepared for visualization. Kiviat figures are created from the previous prepared data sets, without an interactive data filter or any other possibility for data or attribute selection. These tools do not allow the usage of sliders and pointers nor have opportunities for data interaction. However, the development of visual tools can change this situation. Users need to have knowledge depending on the information that needs to be presented visually and effectively.

Table 5.4b. Analysis under the proposed taxonomy of data and attributes selection and direct interaction with data possibilities

	Possibility for data selection			Attribute selection		Interaction with data	
Technique	I	II	III	I	II	I	II
Nodes, relations, treemap, conetree	SELP	SFIL0	SIF	SAPn	SAVOP0	ISNO	INO
Kiviat figures	SELP	SFIL0	SNO	SAP0	SAVSP0	ISNO	INO

The analysis of these techniques is shown on the table 5.4b in term of data and attributes selection as well as direct interaction with data.

4. The results

Proposed taxonomy, evaluated in this paper, tries to classify the user's purpose and benefits of visual analysis of the financial and accounting data based on several criteria. We estimate that this will provide the classification of data visualization techniques used for financial and accounting data to serve as a basis for automation of the choice of visualization techniques for specific purposes. The implication of such a division would provide a high degree of specification of individual visualization techniques for specific purposes and specific opportunities. In the previous examples, each attribute is encoded by a weight factor. Although is not an easy task and requires complex mathematical calculations or intelligent methods, it is still worth exploring because of the overflow of collected data and the necessity of rapid analysis.

The choice of techniques for visualization according to this taxonomic model as well as the possibilities for selection appropriate visualization techniques can automatically be incorporated in software tools which can produce faster analysts' performance, detection of exceptions etc. Such algorithms can be nested in the creation process of data visualization with HCI intensions for financial and accounting staff.

This visualization can have many goals like: creation of dashboards as system control tools, balanced scorecards etc. Although, the most important prerequisite in this case is the staff's training for usage and tool possibilities, with the purpose of effective and rapid preparation of information from databases or tabular data representation in visual representation [3].

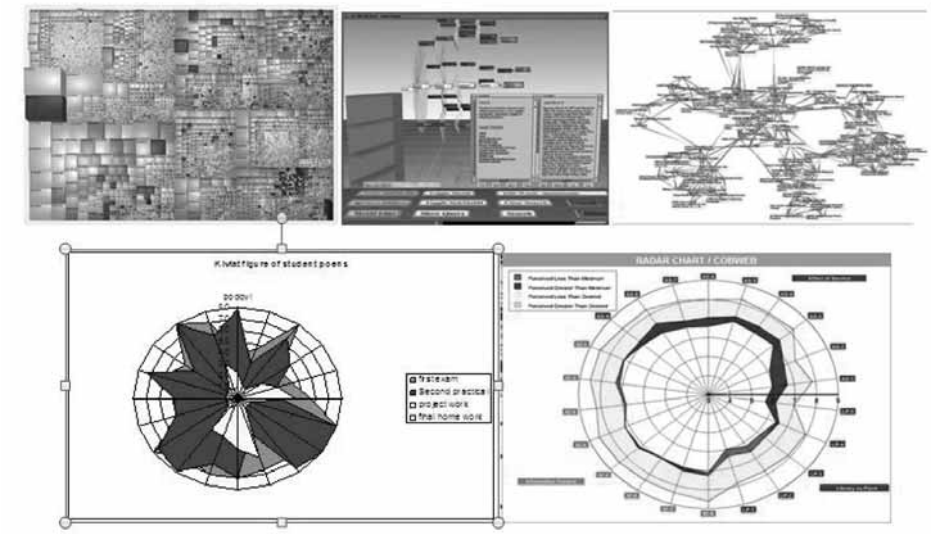

Figure 5 a) Tree maps technique for hierarchical display b) Cone tree c) Semantic network d) and e) Kiviat diagram figure

5 Conclusion

In order to evaluate the proposed taxonomy to support the creation of a coherent and comprehensive conceptual framework that can allow the user classification by users' intention and benefits of visualization for financial and accounting data, we explore the most used techniques for mdmv data analysis according to proposed taxonomy. We evaluate all of these techniques with coding of four dimensions for each technique and their possible values are provided in the given tables. They can be easily understood and used for creation of algorithms for the automation of visual representation on HCI through interactive displays. But, it should be mentioned that there is no final solution for automatic gaining visual representation that would satisfy all end users. In any attempt to automate this process, it is necessary to have the interaction for end users through selection of offered solutions, meaning system that supports decision making process for end users.

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Data Structures in Initial Version of Relational Model of Data

Vladimir Dimitrov,

University of Sofia, Faculty of mathematics and informatics, 5 James Bourchier Blvd.,
1164 Sofia, Bulgaria
cht@fmi.uni-sofia.bg

Abstract. Initial version of relational model of data is reinvestigated. Main concepts and ideas behind them are discussed. The model is formally specified in Z-notation as model elements and operations.

Keywords: relational model of data, formal specification, Z-notation.

1 Introduction

One of the greatest inventions of the last century is the Relational Model of Data. Information systems, based on this model, are used today in everyday life. Many ideas, on which relational model was created, had been implemented. Other stay in latency for many years before being recognized. Such an example are non-atomic attribute values. Initially, Codd introduced relations with structured attributes. But later on, relational algebra and data manipulation languages, based on first order predicate logic, established First normal form, i.e. atomic attributes. Moderate object-relational model turned back to the structured attributes.

It is curious to comment that first order predicate logic, as a query language in the version of relational calculus, easy generates infinite relations that is catastrophic for the finite computing systems. Manipulation of infinite relation means infinite program execution. There are more successful attempts to be created logical models based on Prolog, but this is another story. Infinite relation is not a problem in mathematics, only mathematics investigates infinity, i.e. tries to investigate the God. Informatics is grounded – it works only with finite objects.

Today commercial database systems do not use the second version of relational model of data. They are object-relational, which in reality means relational with object-oriented add-ons. There is no consistent definition of object-relational model of data. The last model is very important to the industry. Commercial implementations of object-relational model follow SQL standards, but SQL by its nature is not pure relational – it has been originally developed as an integrated data manipulation language for both relational and hierarchical models of data. SQL definition is partly based on the first version of relational


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model of data. So, there is a need for definition of object-relational model of data for further theoretical and practical developments.

From above examples, it is clear that there are many ideas behind the relational model of data that are still not exploited. One of the evergreen investigations in informatics is how to extract knowledge form data and how to represent it. After the initial representation Codd tried to capture more meaning in the model – more data semantics to represent, but these ideas had not been supported by the industry. Now days, many original ideas of relational model happen to be used in object-relational model. So, it is clear that relational model of data has to be reinvestigated and precisely specified and after that the focus can be put on the nature of object-relational model.

Results of pure relational model had been summarized every ten years by Codd. The relational model of data development can be divided on the following versions: initial, first and second. This paper is a research on the heritage of relational model of data, initial version.

In this paper, the focus is on relational data elements and operations on them. It is specified as a model but not as an abstract data type. Some topics, like data redundancy, are discussed only for consistency.

Initial version of relational model of data has been introduced by Codd in [1]. The model is founded on set theory, but it presentation is not formalized. In this paper are used definitions and examples from [1], but notation is slightly changed to be avoided contradictory interpretations. Some print errors in the original paper are corrected.

2 Basic definitions

Let S1, S2, …, Sn are n sets, which are not obligatory different, i.e. $\neg(\forall\, i, j: 1..n \bullet i \neq j \Rightarrow Si \neq Sj)$. Then R is a relation on these n sets, if R is a set of n-arity tuples, where every tuple has first component from S1, second component – from S2, etc. More formally, R is a subset of the Cartesian product of S1, S2, …, Sn, i.e. $R \subset S1 \times S2 \times \ldots \times Sn$. Sj for j=1..n is j-th domain of R. Relation R has n domains, which are not necessary different. Relation R is of n-arity by the number of its domains. Relation with one domain is unary relation, with two domains – binary, with three domains – ternary, with n domains – n-ary.

Relations can be represented as an array, but this is not part of the model. Such an array has the properties:

1. Every row is a n-arity tuple of R.
2. Rows order is not important.
3. All rows are different.
4. Columns order is important. It is the order of domains S1, S2, …, Sn, on which R is defined.

5. Semantics of the columns is partly represented by their domain names.

Example of 4-arity relation:

```
supply(    supplier, part, project, quantity)
      1     2     5     17
      1     3     5     23
      2     3     7     9
      2     7     5     4
      4     1     1     12
```

Column order is important because one domain can be used several times and every its usage can has different meaning. Column names are the domain names. The next example shows a ternary relation with duplicated domains with different meaning:

```
component(part, part, quantity)
      1     5     9
      2     5     7
      3     5     2
      2     6     12
      3     6     3
      4     7     1
      5     7     1
```

In this array every row is a tuple (x, y, z), which means that part x needs of z elements y to be assembled.

The database is a set of changeable relations. Every relation is of fixed arity. In the time, to every n-arity relation new n-arity tuples can be added, available tuples can be removed or the components of last one can be changed.

In the real case, one relation can have very many domains. For the users it is difficult to remember domain order. For this reason, Codd introduced relationships. All columns in the relationship are with unique names. Columns order in the relationship is not important. Duplicated domains in the relationship are qualified with a role to achieve column names uniquety. The role of the domains shows the meaning of the concrete usage of the domain.

Relation is more basic term than relationship. It is closer to the physical implementation. Relation has only one free dimensionality, it is set of tuples and does not depend of the concrete records order at the physical level. The file organization of the relation can be changed and tuples (records) order would be changed, but the relation remains the same. Relation is an abstraction of the different file organizations in which it is stored.

On the other hand, relationship has two free dimensionality. It does not support tuples ordering, but even more – domains ordering. Relationship represents all relations that could be generated by the permutation of all its domains.

The relation from above example as relationship is:

```
component(sup.part, super.part, quantity)
```

Introduction of relationships is motivated with the better user acceptance of the model. The user working with the database has to know relationship name, domain names and eventually the roles of last ones in case of duplications.

Relation definition here differs from its mathematical counterpart – it has columns named by its domains. In mathematics, domains are used only in the Cartesian product, after that they are not used. In that sense, relations could be closer to mathematical ones if their columns are only numerated and not named. But columns naming by the domains introduces some semantic description of the column.

The relationship is closer to the later emerged "table", but its columns are named by the domains with optional role qualification of duplicated domains. In the tables, columns are named by their usage and they are independently bounded with the domains.

Formal specification of introduced terms follows.

Basic sets are:

$$[RNAMES, DNAMES, VALUES]$$

Where RNAMES is the set of all possible relation names, DOMAINS is the set of all possible domain names, and VALUES is the set of all possible values.

The set of domains is defined as&

$$DOMAINS == \mathbb{F}\ VALUES$$

The domain is a finite set of values. DOMAINS is the set of all possible unnamed domains. Named domains are defined with the global partial function:

$$domains: DNAMES \pfun DOMAINS$$

It maps domain names to domains.

Relation schema is a finite non empty sequence of domain names:

$$SCHEMAS == \text{seq}\ DNAMES$$

This definition includes the relation without domains.

Database schema is defined with the function dbSchema, which maps relation names to their schemas.

$dbSchema: RNAMES \pfun SCHEMAS$

This is the formal specification of relations. The last ones accept domain names duplication in their schemas. Relationships with role qualifications do not permit column name duplication.

A new basic set – the set of all possible qualified domain names has to be introduced:

$[QDNAMES]$

This set contains all qualified domain names including unqualified domain names.

There is a total function from qualified domains names to unqualified domain names:

$domainName: QDNAMES \fun DNAMES$

Relationship schema is a finite set of qualified domain names:

$QSCHEMAS == \mathbb{F}\ QDNAMES$

Relationship database schema is defined with the function:

$$dbRelationshipSchema: RNAMES \pfun QSCHEMAS$$

$$\mathrm{dom}\ dbRelationshipSchema = \mathrm{dom}\ dbSchema \land$$

$$(\forall rn: \mathrm{dom}\ dbRelationshipSchema \bullet$$

$$\quad \textbf{let}\ s == dbSchema(rn);\ rs == dbRelationshipSchema(rn) \bullet$$

$$\quad\quad \#s = \#rs \land (\forall i: 1..\#s \bullet \exists_1 dn: rs \bullet s(i) = domainName(dn)))$$

For every relationship exists a relation with the same name and relation schema, which a permutation of relationship schema with de-qualified domain names. This is defined by the function invariant that postulates: dbRealtionshipSchema and dbSchema domains are same; relationship schema and relation schema are same; and for every domain name in the relation schema exists exactly one qualified domain name in the relationship schema.

2 Instance, primary key and foreign key

Relation instance is the set of all its tuple in a given moment. Database instance is the set of all instances of all its relations. Codd has not explicitly introduced these terms, but they are used in relational database world.

Not all domain values are used in the current database instance. The set of all used values from particular domain in the current database instance is called active domain. This term is a fact, but it is not used in any way.

Domain or combination of domains in a relation, whose values uniquely identify its elements (tuples) is called primary key. The primary key is minimal: it is a simple domain or it is a combination of simple domains, in the last case all domains are used for element identification. In other words, the primary key does not have a subset (different from it), which has the same property, i.e. the subset uniquely identifies relation tuples.

If there are several primary keys, only one from them is selected as primary. The primary key is important for the file organization in which the relation tuples are stored. File organizations like B-trees and hash files support only one search key. Usually, the primary key is used as a search key.

On the other hand, database design uses all (primary) keys. That is why, latter on many variations of the term has been used, like “candidate key”, “alternative key” etc.

It is very important, from navigation point of view, how relation elements reference to each other. For this purpose foreign keys are used. A domain or combination of domains from the relation R is a foreign key, if it is not primary key in R and its elements assemble primary key values in some relation S. It is possible R and S to be the same relation.

In the relation supply from the above example, the primary key is a combination of domains supplier, part and project. Every domain from the primary key is foreign key.

The definition of the foreign key requires referential constraint from the foreign key to the primary key of referred relation. Referential constraint is dominating in all definitions of initial relational model. Such examples are join and joinable defined latter here.

The foreign key is in two variants. Primary key domains can be used as foreign keys. Primary key domains by latter on terminology are called “primary attributes”. A subset of primary key domains can be a foreign key. The whole primary key could not be a foreign key.

In this definition of the foreign key, domains of the primary key and domains of the foreign key do not play any role. The foreign key domains must be mapped to the primary key domains, but there is no requirement the source and target domains to be the same. The definition simply require the foreign key value to

form primary key value in the referred relation.

In the formal specification of these new terms, first tuple and relation instance have to be specified. Tuple is a sequence of values:

$$TUPLES == \text{seq}\ VALUES$$

The tuple can be viewed as a function that maps relation schema domains to values from the corresponding domain. This interpretation is not used here, the relation definition requires tuple components ordering. The reason is that there is so called “standard order” for tuple values, which is used at physical level.

Relation instance is a set of tuples that are constructed using the relation schema. Database instance is a partial function from relation names to relation instances:

$$db: RNAMES \pfun \mathbb{F}\ TUPLES$$

$$\text{dom}\ db = \text{dom}\ dbSchema \land$$

$$(\forall rn: \text{dom}\ db \bullet \textbf{let}\ s == dbSchema(rn) \bullet (\forall t: db(rn) \bullet (\forall i: 1..\#s \bullet t(i) \in domains(s(i)))))$$

Every relation instance has its own schema. The functions db and dbSchema have the same function domain.

Now, active domain can be defined:

$$activeDomain: DNAMES \pfun \mathbb{P}\ VALUES$$

$$(\forall dn: \text{dom}\ activeDomain \bullet (\exists rn: \text{dom}\ dbSchema \bullet \langle dn \rangle\ \text{in}\ dbSchema(rn)) \land$$

$$(\forall v: activeDomain(dn) \bullet \exists rn: \text{dom}\ dbSchema \bullet$$

$$\textbf{let}\ s == dbSchema(rn) \bullet \exists i: 1..\#s \bullet dn = s(i) \land (\exists t: db(rn) \bullet v = t(i))))$$

Active domains are that ones, which are used is some relation schema. Every its element has to be tuple component in some relation instance for the same domain. It is possible active domain to be empty set.

Primary key is a subschema. Every relation has only one primary key. The primary key is specified as a list of domain indexes in the relation schema. The reason for that is the possibility of domain name duplication. If a domain participates in the primary and at the same time it is duplicated, then exact participation of that domain in the relation schema must be fixed.

$$KEYS == \text{iseq}\ \mathbb{N}_1$$

$$primaryKey: RNAMES \pfun KEYS$$

$$\text{dom}\ primaryKey = \text{dom}\ dbSchema \land$$

$$(\forall rn: \text{dom}\ primaryKey \bullet (\forall t1, t2: db(rn) \bullet \textbf{let}\ pk == \text{ran}\ (primaryKey(rn)) \bullet$$

$$(\forall i: pk \bullet i \leqslant \#(dbSchema(rn))) \land t1 \neq t2 \Leftrightarrow (\exists i : pk \bullet t1(i) \neq t2(i))))$$

Relation can have several foreign keys. In the specification foreignKey is a function from relation name and foreign key to referred relation:

$$foreignKey: RNAMES \times KEYS \pfun RNAMES$$

$$\text{ran}\ foreignKey \subseteq \text{dom}\ dbSchema \land$$

$$first\ (\!|\text{dom}\ foreignKey|\!) \subseteq \text{dom}\ dbSchema \land$$

$$(\forall fk: \text{dom}\ foreignKey \bullet (\forall i: \text{ran}\ (second\ fk) \bullet i \leqslant \#(dbSchema(first\ fk))) \land$$

$$second\ fk \neq primaryKey(first\ fk) \land$$

$$(\exists_1 map: KEYS \longrightarrow KEYS \bullet map(second\ fk) = primaryKey(foreignKey(fk)) \land$$

$$(\forall\ t1: db(first\ fk) \bullet \exists\ t2: db(foreignKey(fk)) \bullet$$

$$\text{ran}\ (second\ fk) \rhd t1 = \text{ran}\ (primaryKey(foreignKey(fk))) \rhd t2)))$$

The set of referred and the set of referring function are subsets of the database. The foreign key is defined in the referring relation, where it is not a primary key. The primary key is entity identifier and the foreign key is reference to an entity. That is why the foreign could not be a primary key.

There is only one legal mapping from foreign key domains of the referring relation to primary key domains of the referred relation. The source and target domain must not be the same. Actually, the map is mapping of foreign key domain indexes to primary key domain indexes. In other words, for every tuple in the referring relation must exist a tuple in the referred relation and the foreign key components of the source tuple must compose the primary key of the target tuple. Not every tuple in the referred relation has to be referred by the foreign key.

All foreign keys for a given relation can be retrieved from the function foreignKey. From this function, all relations and foreign keys referring given relation are easy retrieved via reverse mapping. This Z-schemas are not included here, because they have no impact and further development on the model.

3 Normal forms

The relation definition does not require relation domains to be simple. Such a requirement is enforced for key domains. Relation schema can contain structured domains. Relation schema that has at least one structured domain is not in first normal form. First normal form is very important requirement for the relation model evolution. Only object-relational model removed this constraint.

In above formal specification, there are no assumptions about domains structure.

In the initial presentation of the model, Codd used as example relation employee(name, (salary, history)), in which the second domain is a structured domain (relation). This means that every tuple that relation as a second component has an binary relation instance with domain: salary and history.

In its presentation, Codd links attribute with simple domain and repeating group with structured domain, following latter on terminology. Structured domain is a set of atomic values or a set of structures of the same type. When the domain is with simple structure (without substructures) – structure fields can be directly included in the relation schema.

Codd separated type from instance in the relational model. In the previous models such a differentiation has not been done. This means that logical structure of the database (its schema) is constructed via types system. Database instance is a set of instances of the schema types. Types system applies for relations and for domains. Relation types are constructed using relational model notation. There is no comment about domain type construction. Relational model semantics is defined by relations semantics and domains semantics. Relations are describing relationships among the domains. In terms of entity-relationship model, domains are entity sets and relations are relationships. This mapping is not true, because there are examples in Codd's presentation, in which relations do not represents relationships, but entity sets.

Codd motivated First normal form with the relational query language.

In initial version, database normalization means conversion of database relations to First normal form. This means that relations with structured domains are converted to equivalent relations with simple domains. An example of such normalization follows. Before normalization:

```
employee(man#, name, birthdate, jobhistory, children)
jobhistory(jobdate, title, salaryhistory)
```

```
salaryhistory(salarydate, salary)
children(childname, birthyear)
```

After normalization:

```
employee(man#, name, birthdate)
jobhistory(man#, jobdate, title)
salaryhistory(man#, jobdate, salarydate, salary)
children(man#, childname, birthdate)
```

Unnormalized relations are organized in a tree as shown in Fig. 1.

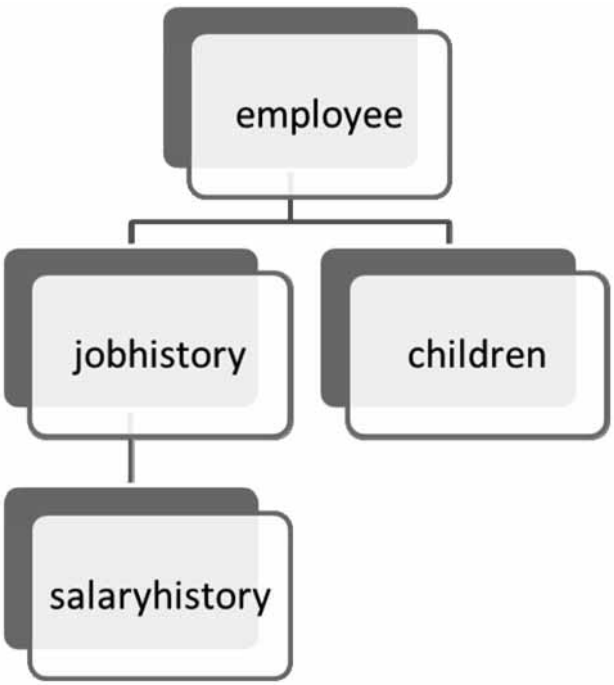

Fig. 1. Unnormalized relations tree.

Normalization process starts from the root. Primary key of the root is inserted in its children relations schemas. Key of the last one is composed of root key and its own key. Then from the root structured domains are removed. This steps are applied recursively to all subtrees.

Normalization process needs the next conditions to be enforced:

1. Relationship graph of non-simple domains is a set of trees.
2. Primary keys are composed of simple domains.

The first constraint prohibits cycles. The second constraint simplifies the normalization process. The last one is a designer intellectual endeavor and there are no ready receipts.

The relation in First normal form has the following benefits:

1. Does not contain pointers.
2. Does not have hash addressing schema dependencies.
3. Does not contains indexes or ordering lists.

In other words, relation in First normal form does not contain elements of its physical organization. If tree presentation is used as in above example, then some of above mentioned physical organization schema has to be used.

For relations in First normal form, the next naming schema is proposed: R(g).r.d, where R is relation name, g is an optional relation generation name, r is an optional role name, and d is domain name. This naming schema proposes one relation to be stored in several named generations. Idea for relation generations is only marked here and has no further development. One relation in several generations is direct access to relation archive. This idea is not implemented in any relational database system.

It is possible to interpret relation generation in another way, for example every generation is a result of concurrent transactions execution on this relation or relation generation is relation instance at given time moment, but there are no research in that direction. That is why relation generation is not covered by the formal specification.

4 Conclusion

In this paper only structure aspects of initial relational model are investigated. The leading Codd intention was "How to capture more meaning in the relational model of data". The conclusion is that balance between domains and relations semantics has to be searched. This balance has been searched yet many years from that time.

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Peopleware: A Crucial Success Factor for Software Development

Neli Maneva
Institute of Mathematics and Informatics, BAS,
Acad. G. Bonchev str., Bl.8, 1113 Sofia, Bulgaria,
neman@math.bas.bg

Abstract. The purpose of the paper is to present the current state of peopleware and to try to explain why it can be considered as a crucial success factor for software development. A context-driven human resource management is described so as to demonstrate, that some SE methods, best practices and procedures for their application can be slightly modified and use for the purposes of the peopleware. An example how the proposed approach has been accomplished in a real-life project is presented.

Keywords: Peopleware, context-driven human resource management, business rules extraction.

1 Introduction

The basic goal of the Software Engineering (SE) is to assure the efficient development, use and maintenance of quality software. In order to achieve this goal a variety of approaches with different origin and complexity can be applied – a sophisticated mixture of scientific methods, technological innovations, managerial techniques, profitable business practices, etc. Together with the methodological challenges of the interdisciplinary, each software project should be accomplished in accordance with preliminary stated constraints for time, cost, people involved, physical environment, technological and other resources. Unfortunately, the collected from real-life software projects statistical data shows the alarming tendency of increasing number of prolonged or even cancelled projects. The data analysis reveals that in many cases software projects should be carried out and completed in environment with permanently insufficient resources. Bearing in mind the rigid limitations for available money and development time, which are fixed in the contract and usually can not be re-planned and re-negotiated, it seems that one possible and feasible solution for success of the project can be to rely on potential (theoretically unlimited, but hardly predictable) power of the ***human resource***.

In this paper we will try to elucidate the leading role of the human factor for

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software industry and how its impact can be strengthened by a systematic, pure SE approach. Next section presents the basic ideas and current state of ***peopleware,*** summarizing some observations and best practices, identified as quite significant from practical point of view, i.e. it is worth to be followed in order to be successful in the field of software creation and use. Section 3 describes our approach and how it can be used for the purposes of the human resource management. Section 4 presents briefly the experimental use of the proposed approach in a real-life project. In the last section some ideas for further research and development work in this direction have been mentioned.

2 Peopleware State of the Art: Promises and Unrealized Power

Nowadays the human factor in the area of software development and use is a "hot" topic both for scientists and practitioners in the field. There are two main reasons, explaining this fact. First, the existing software intensive systems have been created by teams, comprising individuals with different physical, intellectual and psychological profiles. A thoughtful study of people's capabilities and competencies should be performed and the results obtained should be used so as to improve the work processes and productivity. Second, all software systems are used by people and the investigation of user's profile, attitudes and preferences is necessary for creation of effective, reliable and user-friendly systems. That's why the traditional pair (hardware, software) has been extended with a third element, called ***"peopleware"***. This neologism has been introduced by P. Neumann [6] to denote one of the most significant three core aspects of computer technology, supplementing the other two, already in use - hardware and software. Peopleware is a synonym of "human factor/human resource" and covers different aspects of the role of people in the development and/or use of computer systems, including (but not restricted to) such issues as human resource management (HRM), software psychology, productivity, teamwork, group dynamics, organizational factors, software ergonomics, human-machine-interaction, etc.

The importance of peopleware has not only been appreciated, but also shaped into a constructive framework by the Software Engineering Institute by developing the ***people management capability maturity model*** (PM-CMM). The proclaimed goal of the model has been "to enhance the readiness of software organizations to undertake increasingly complex applications by helping to attract, grow, motivate, deploy and retain the talent needed to improve their software development capability" [1]. In this model the key practice areas for software people have been defined: recruiting, selection, performance management, training, compensation, career development, organization and work design, and team/culture development.

The PM-CMM model introduces both theoretical and pragmatic improvements in the area of peopleware. It presents the basic HRM activities in more formal way and provides some indicators to measure the achieved level of maturity in their accomplishment. It is pity that without access to some officially published statistical data and analysis, performed to evaluate the degree of improvements in software organization HRM as a result of usage of this model, no judgment of its impact can be made.

Trying to find more up to date information about the current state of peopleware in software industry, we read the latest edition of a book [2], which is classical for the field. On the base of rich own experience gathered during long work as consultants and managers in great number of software projects, the authors of the book De Marco and Lester present their understanding of the main principles of management of human resource. They share some ideas about establishment of effective office environment, recruiting right people and constructing "jelled" teams. Different approaches and good practices in peopleware have been not only described as real-life stories, but have been evaluated in respect to their feasibility, complexity of accomplishment and results obtained. The informal style of presenting valuable knowledge and experience makes easy the adoption of the proposed ideas. The objective observations and the judgment, shared after some experiments increase the level of trust and encourage the readers with HRM-related professional responsibilities to dare to apply and examine in practice some of the suggested techniques.

After the performed study of the current state of peopleware, the following conclusions can be made:

- Software project implementation is under triple limitations - in project scope, time and cost and unfortunately, t least one of them has been permanently violated. Thus, the effective and efficient achievement of project objectives within the defined constraints requires significant managerial efforts.
- Human resource management is an important part of the overall management because the most problems, encountered during software project implementation in their essence ***are people-related: sociological, not pure technological***. So the HRM should be a set of coordinated and controlled activities, precisely defined both at strategic level - doing the right things, and at operational level - doing things right.
- Many of the existing approaches, techniques and best practices, which have been already identified as useful and promising, are not part of the established HRM programs and action plans in the most real-life software projects.
- Due to different reasons (lack of solid theoretical base, which can be further developed in a procedural form, making possible the transfer of

the main ideas to practice; high cognitive complexity; etc.) the peopleware problems are not easy issues, but trying to solve them, software people will maximize their chances of success.

- Software managers have to be educated and trained so as to develop the needed peopleware-oriented competencies - a sophisticated mixture of knowledge, skills and attitudes, which could assure professional performance at the required level.

During the last 10 years we are working on some HRM-related problems, trying to provide a theoretically justified and experimentally validated solution for hiring the best software people, team-building, soft skills training for software people. Now, taking into account the results of the resent study in the area of peopleware, we have some ideas about a context-driven HRM, which are described briefly in the next section.

3 Our Approach to Peopleware

We believe, that the main peopleware problems arise … from people, responsible for the HRM activities in software organizations. Usually these people are with technologically-oriented education, background and work experience, with no enough sociological knowledge and skills to deal properly with so sophisticated in nature, dynamic over the time and unpredictable as behavior human beings. The essence of our idea is to apply some well known and recognized as fruitful SE methods, techniques and tools so as to resolve the specific HRM problems. Next we will clarify this idea, presenting a process framework with goal-oriented modeling and use of a formal method, providing a context-driven peopleware.

3.1 Human Resource Management Process

The ***HRM process*** can be defined as a collection of activities, actions, and tasks that are performed when a human resource-related problem has to be solved. Usually the process defines *who* is doing *what, when* and *how* to reach a certain goal. So the first step is to define the "who" part of the problem. Our suggestion is to consider the participants in a software project as components of a system, for which the generic process framework for software engineering, described in [7], can be applied. This framework comprises five activities, which can be easily re-defined for the purposes of the HRM:

Communication – clarifying the stakeholders' objectives for the work that should be done and gathering requirements so as to define team members' responsibilities and functions.

Planning – determining how many and what kind of people should be included in the team(s) so as to finish the work within the planned resources**.**

Modeling - a model of the team(s) should be created, defining the number and the roles of the participants, described by a desired profile. As in the architectural software design, the relationships (interfaces) among participants should be specified. Then (as in software detailed design), some additional refinement of the models of each participant should be done, providing more details about required personal and professional characteristics. As in the model-driven software development, here also it is quite natural to create and use more than one model, depending on the preliminary stated goals.

Construction - this activity combines selecting the team members and further testing whether the created team can operate effectively. As in software testing, the adopted versions of the black-box and the white-box testing of teams and their members can be carried out.

Deployment – the constructed team (as an entirely complete group or as a core of the team, which will be further extended) starts to work. The performance characteristics of the team are evaluated and on the base of the results, some structural and/or personal changes can be made.

The analogy between software system development and team building gives the possibility to enrich the peopleware with some methods and best practices from the SE field, validated as useful. Let us present briefly such a method.

3.2 Context-driven peopleware

Introducing the above mentioned model for HRM process, we have to face the following key question, stated in [7]: *What actions are appropriate for a framework activity, given the nature of the problem to be solved, the characteristics of the people doing the work, and the stakeholders who are sponsoring the project?* In order to answer this question, we need a general, but flexible method, capable to reflect a great variety of problems, which should be solved within a specific context. As each problem solving action can be consider as a result of a sequence of decision making, we decide to use a context-driven peopleware, based on a formal method for a reasonable choice. This method, called Comparative analysis, has been created and already successfully used in many activities [4].

Comparative Analysis (CA) is a study of the quality content of a set of homogeneous objects and their mutual comparison so as to select the best, to rank them or to classify each object to one of the predefined quality categories.

The compared objects should be identified as significant for the activity under consideration. When apply the CA method, we distinguish two main players: the ***Analyst***, responsible for all methodological and technical details of

CA implementation, and a ***CA customer*** - a single person or a group of persons, who should make a decision in a given situation and wants to use the CA.

The ***context*** of the desired CA is specified through a ***case***, described by the following six elements:

case = { View, Goal, Object, Competitors, Task, Level }

The **View** describes the customer's role and the perspective from which the comparative analysis will be performed. For HRM the role of customer can play any person, having a people-related problem.

The **Goal** expresses the main customer's intentions in CA use and can be to describe, analyze, estimate, improve, predict or any other, formulated by the Customer, defining the case. This element is important, because it determines the quality content of the compared objects.

The **Object** represents the item under consideration. For each investigated object a quality model should be created – a set of characteristics, selected to represent the quality content, and the relationships among them.

According to the goal, the set C of **Competitors** – the instances of the objects to be compared – should be chosen.

The **Task**, described as an element of a case can be Selection (finding the best), Ranking (producing an ordered list), Classification (splitting the objects to a few preliminary defined quality groups) or any combination of them.

The depth **Level** defines the overall complexity of the CA and depends on the importance of the problem under consideration and on the resources planned for CA implementation.

Generally speaking, the CA method can be used in any decision making situation after specifying a case with an appropriate definition of the above mentioned elements. Let us describe briefly how the CA can be used in the field of peopleware.

The first step should be to identify the responsibilities and the typical tasks of the main players, involved (as subject or object) in some HR-related activities. In any software organization they can be classified in two groups: internal (managers at different levels of hierarchy in the organization and software people with different professional specialization) and external (current or potential users or clients, contracted projects with the organization). The following roles have been identified till now:

- CEO, HR manager, QA manager, Customer services manager;
- Project leader, a member of a functional group (e.g. developer, software engineer, tester, system administrator, technician);
- Stakeholders – representatives of organization, ordered project and/or individuals, who are going to use the project results.

The implementation of the context-driven HRM is not too difficult, because there is a procedure for CA method use, which can be followed. This general

procedure has been modified in accordance with some specifics of the HRM so as the content (as a set of mutually connected activities) of the three main phases is defined. During the ***Preparation*** phase, each HR-related problem, encountered in the current project, has been decomposed into a number of ***cases*** to support the crucial decision making. For each case the Analyst checks which case elements have already existed from previous analysis and can be subject only for modification, and which ones are new and have to be constructed from scratch.

The most difficult task in this phase is the construction of a ***quality model*** of compared objects. For the context-driven HRM these objects are some of the above mentioned typical software players, who will be studied in different situations, described by cases, giving the context. Depending on the goal of the performed analysis, the constructed Object model comprises different ***quality characteristics***, presented in a multi-levels hierarchical structure, showing the relationships among them, too. According to the prescription of the method, for such goal-oriented object modeling, an incremental approach should be applied. When a case for comparison of some software people appears, the Analyst has to create its first model, saved further as a generic (basic) model. When a request for CA with the same object arises, the generic model is found and modified so as to reflect the requirements, stated by the new context. So for each object a set of models has been maintained: one complete generic model and a number of "partial" derivative models, covering the peculiarities of the object, defined in a given case.

During the *Implementation* phase the Analyst reuses or constructs the needed object models, forms the set of Competitors, and performs the CA Task, using the available software tools, which facilitate the CA method. At the *Follow-up* phase the obtained results have been analyzed so as to create a detailed action plan to solve the problem under consideration.

4 A Case Study: Context-driven HRM in a Real-life Project

The feasibility of the approach, described above, has been examined within a scientific project "Automatic Business Rules Extraction from Programs", performed under a contract with the National Scientific Research Fund.

The usefulness of the context-driven HRM will be illustrated by its usage as a decision supported method in a situation at the beginning of the second phase of the project, when due to the significant cut off of the project's budget, the project team has to be reorganized both in size and structure. The following two HRM-problems arise:

- How to decide which team members should continue to work?
- How to redefined the responsibilities and tasks among the members of

the smaller team, i.e. to assign the most appropriate work position (Role) for each member of the reorganized team so as to complete successfully the BR-extraction project?

Analyzing the situation, in which the project budget has been decreased, but the scope of work remains almost the same, the project leader decides to compensate the smaller number of participants with a team, comprising people with higher productivity.

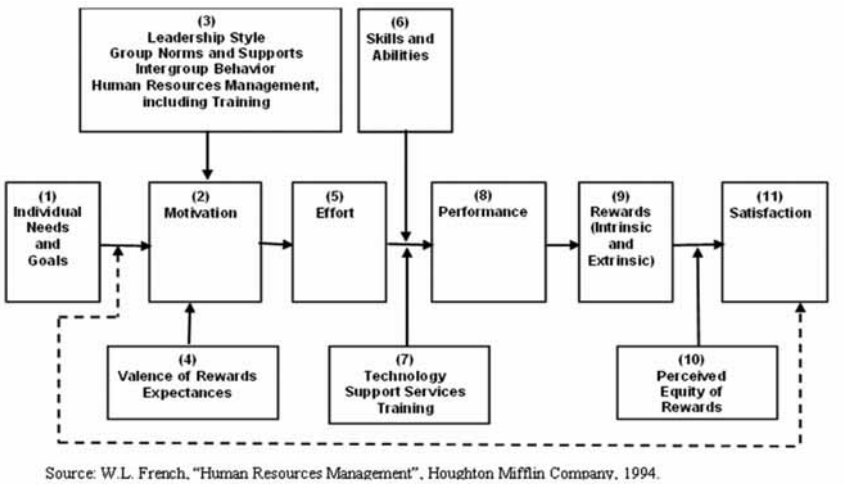

Fig. 1.

So the following case have been defined:

case = { View, Goal, Object, Competitors, Task, Level },

where the values of the elements are as follows:

- **View** – that of the project leader, responsible for the team reorganization
- **Goal** – evaluation;
- **Object** – a team member;
- **Competitors** – members of the team;
- **Task** – ranking;
- **Level** – simple.

A new quality model for the object 'member of the team" has been constructed on the base of the proposed in [3] description of factors, influencing the employee's performance (see the Fig.1).

For the second problem, how to assign the most appropriate work position (Role) for each member of the reorganized team so as to complete successfully the BR-extraction project, we have to start again with object modeling. On the basis of the Job description, a model has been created for each of the identified Roles: Business Analyst, Policy Manager, Software Architect, Software Developer, System Administrator, Policy Translator, Rules Extractor and Mediator. As

such an object have been already used in a previous case, we simply re-use the existing object model, comprising three groups of characteristics: professional competences, soft skills and experience. After that the CA has been used to produce an ordered list of candidates for each Role through comparison between the role profile and the individual profiles of team members.

5 Conclusion and Future Work

The purpose of this paper has been to analyze the current state in the field of peopleware and to show that some selected best practices and methods from software development can be re-defined and used for the purposes of the HRM. The proposed goal-oriented modeling and the context-driven CA have been examined in a small project.

Our intentions for further research in this area are:

- To continue construction of some basic and derivative models of participants in software projects with different positions and roles;
- To choose a few other best practices from SE and modify them accordingly so as to be used for the purposes of the HRM;
- To study and select validated contemporary methods and techniques, developed in the field of applied psychology, which can be used for recruiting, selection, performance management and training of software people.

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Information System for Seed Gene Bank

Ilko Iliev[1] and Svetlana Vasileva[2],

[1] Shumen University „Bishop Konstantin Preslavski“, College – Dobrich, Dobrotitsa 12, Dobrich, 9302, Bulgaria
{[1]ilko_ici, [2]svetlanaeli }@abv.bg

Abstract: This paper discusses the problems in the creation and implementation of the web-based information systems for seed gene banks. Each information system (IS) serving seed gene bank is required to provide information about the samples that are stored. Information issued by the information system is the link between scientific institutes engaged in genetics and a breeding of cultivated plants. The paper presents a web-based gene bank information system for cereals of Dobrudzha Agricultural Institute – General Toshevo municipality. For the implementation of the information system are synthesized *SQL* queries to issue information about varieties and breeding lines, origin (country), winter type or spring type variety and more. User interface of the web-based IS is developed by *Drupal* Content Management System and *PHP*.

Keywords: information system, seed gene bank, selection, cultivated plants.

1 Introduction

Every area of scientific, economic, social activity and any enterprise engaged in the production or distribution of products creates and uses information. Any interconnection and coordination of work is possible only because of the information system (IS), covering the entire manufacturing process. Automated IS, as specialized tools for efficient information processing, become a compulsory part of every activity: production, research, economic or social systems [5].

The information system also becomes an important tool for “working” communication between experts incorporating over common problems, but located far from each other. This issue is presented in the paper - creating a *web* based information system for seed gene bank. Dobrudzha Agricultural Institute (DAI) - General Toshevo municipality. DAI is one of the largest institutes in Bulgaria dealing with the selection of wheat, sunflower and grain legumes and has a collection of long-term storage in the conditions of “ex-situ”. The Institute has no information system to serve this collection and to provide data for it research area in the world. Therefore standing a problem with development of information system for the collection of genetic resources of the Institute and for exporting data of it on the Internet for better communication with other institutions involved in the genetics and a selection of cultivated plants.

Only National gene bank of the Institute of Plant Resources in Sadovo has a web-based information system. Other research institutes in Bulgaria dealing with selection do not have information systems. And, nowadays in globalized world this is a barrier for the development of the breeding science in Bulgaria. The entire work on web based information system for gene bank of DAI is the initial part of whole image building of the organization. From creating sql database up to design the site layout, design of menus and project documentation can be useful for creation of a large initiation with practical value.

To establish a *web* based information system is necessary to use certain software. Most appropriate from a financial standpoint are the content management systems (CMS) with a free license, which provide enough powerful resources needed to establish a dynamic site with a link to a database.

2 Features of Content Management Systems

Web-based content management systems are used for the preservation and publication of documents. The open systems are established, maintained and developed by many developers. Their code is publicly available for reading and editing. This provides greater flexibility, stability, and a variety of additional modules and possibility for their functionality extend. CMS allow the creators to be independent of web design companies and are able to update and modify the content of the web sites. Each CMS could be appropriate in some conditions and inappropriate for others. Choosing a CMS should be dictated by the nature and needs of the site for which it was intended.

The Content management system Drupal is a mature system with enormous opportunities. It is free, powerful and popular, and is also open. Drupal architecture allows for a complete various types of web sites, including educational sites. Existing functionality by default can be increased by connecting different extensions - “modules” in the terminology of Drupal. These additions provide a full range of features that make the system very robust and easy to use CMS.

Many authors [1], [2] and others, point the following features of the Content management systems:

- Creation of documents and multimedia materials;
- Identification of all key users and their roles in the content management;
- Ability to assign roles and rights of the different users of different types or categories of content;
- Manage workflow to create content: it is a process of creating cycles of sequential and parallel tasks, which have to be fulfilled in the content management system. For example, the author of the article content added, but it is not published until the editor does not check and the editor did not approve it;
- Ability to track and manage multiple versions of the same content;

- Ability to publish content in the mining and access to it;
- Automated templates: created by the system and can be automatically applied to new or existing content and their change affects the appearance of all pages of the site;
- Content, which was edited, immediately after the separation of the content of the visual representation of the site it is generally more susceptible to manipulation and editing. Most CMS include *WYSIWYG* tools for editing, allowing non-technical staff to create and edit content;
- Simplified adding new capabilities: Most CMS have plug-ins or modules that can be installed easily and can extend the existing functionality of the site;
- Constant updates. Most CMS usually offer such upgrades incorporating new features and support system with the latest web standards.

One of the most popular content management systems is Drupal. CMS Drupal is a free and very effective system for both the administrator and the user of the website. It's flexible and open source. This allows its easy configuration and setup, convenient for own use. Utilizing the programming language PHP and Drupal API can quickly and easily create a template that meets our criteria for own vision of the site. To act in our own in Drupal, there is PHP function called hooks. When we want to set the system at our will, we just do implementation of the hook function for which kernel checks first in installed by us files in its own theme or module. This is how to build menus with appropriate levels (heirs) so as to be suitable for our template. The separation of the web page of several sections - "regions" in the terminology of Drupal becomes from a file with the extension .info that specifies the areas in which further stage will be distributed the contents of the site.

CMS Drupal has enough power and flexibility, allowing us to create a topic that is complex enough. The system offers countless ways to deal with problems that arise, but you need to know how to work with Drupal themes so to choose the proper way. Knowing the principles of working facilitates future maintenance [6].

For the design of the queries to the database of IS for the gene bank is necessary to use the scripting programming language *PHP*.

3 Information System Components

The web based IS contains the following components: Database of the information system; Organization of storage: data access, presentation forms and management of the processing are performed by the management of the database. The user interface is used for connection between the computer and programs of the information system to its users.

3.1 Database Design

Information system of a gene bank is essentially a database of animal and plant species, it may look for different cultures of origin, species or subspecies.

The database contains four tables. The table "Varieties" contains fields describing each variety or varietal line. The table "Country" contains information about the countries from which DAI have samples of varieties/breeding lines. The table "Vid_kultura" contains information for crops, of which there are samples in the gene bank, respectively table "Subspecies" describes the subspecies. Section 4.1 has been brought PHP code, which established the cited tables. CMS Drupal "reads" the code and creates the tables and the database (into its database). In variable schema fields are described in the tables. CMS Drupal "knows" that in this variable are described tables and use the system function to realize the tables, and then to implement the described relationships between tables.

3.2 Designing the queries to Database

In an IS for gene bank customer should be able to make inquiries on a quick search and advanced search by giving query type culture, brand name/line number (breed line), origin (search state created a variety) and search by other criteria.

In Section 4.2 has been brought PHP code, which formed the queries for quick search and advanced search. The proposed solution in this module for quick search is integrated in Drupal API function ***db_query***(). It performs queries to active database. Adopting by this function parameter is a string of real SQL query. The implemented algorithm makes an initial inspection of filled search box and if it is empty the algorithm displays friendly message to its proper completion. The final result of the query is completed advantage over the proposed table of Drupal API, which we give a theme for our needs via the function ***theme***(). Originally created array $***tableHeader*** completes header of our table. All lines that are the result of our query rotate through a ***foreach*** loop and are introduced into a new array $***tableData***[ ] (return theme('table',array('header'=>$tableHeader, 'rows'=>$tableData)).

3.3 Designing the interface to perform queries to Database

Modules developed for Drupal work on the principle of so-called "hooks". The hooks are PHP functions which name is *module_name_hook_name*(), where "*module name*" is the name of the module and "*hook name*" is the name utilized the hook. Each hook has a defined set of parameters and result types. So designed functions allow the modules to interact with the core of Drupal.

Templates in Drupal separate content on the Web page in regions in which the user can sort the content according to user's needs and demands. Any content

in the region, regardless of whether it is an article, menu, etc. is wrapped in a "block", and so there is moisture. In the design module (Section 4.2) for Drupal 7, the application creates two blocks called ***plant block***, and ***advanced plant block***, which the user can rearrange in the web page at its discretion. In the applied code by the first function ("hook") we enter the primary information about the two blocs - the name of the block with which it is knowable in the system and title which is human readable and follow other settings specifying how the system treats these blocks.

Cited at the end of section 4.2 feature *plant_block_view*($ delta ='), loaded with content the already created two blocks. Embedded into system Drupal function *drupal_get_form*() returns pre-designed by us search and advanced search forms.

4 PHP code

For the realization of a complete web based information system is needed "upgrade" over the native capabilities CMS Drupal, with original codes for *MySQL* database, as well as design and implementation the queries to the database.

4.1 Program Code establishing tables of the database

The PHP module is created in [4] and [5].

Example of a Computer Program from Iliev I. (2013) PHP module for queries to the MySQL database of gene bank

```
<?php
// Realization of  hook_schema (). Description of table
//`sortove' with six fields
function plant_schema()
{   $schema[,sortove'] = array(
      ,fields' => array(
      ,id' => array(
         ,description' => ,Primary key',
         ,type' => ,serial',
         ,unsigned' => true,
         ,not null' => true,
            ),
      ,id_entry' => array(
         ,description' => Entry N',
         ,type' => ,varchar',
         ,length' => 20,
         ,not null' => true,
            ),
```

```
      ,id_culture‘ => array(
         ,description‘ => ,Genus‘,
         ,type‘ => ,varchar‘,
         ,length‘ => 100,
         ,not null‘ => true,
            ),
      ,id_vid‘ => array(
         ,description‘ => ,Species‘,
         ,type‘ => ,int‘,
         ,unsigned‘ => true,
         ,not null‘ => true,
            ),
      ,id_vid_podvid‘ => array(
         ,description‘ => ,Subspecies‘,
         ,type‘ => ,int‘,
         ,unsigned‘ => true,
         ,not null‘ => true,
            ),
      ,id_sort‘ => array(
      ,description‘ => ,Cultivar Strain / Donor
descriptor‘,
      ,type‘ => ,varchar‘,
      ,length‘ => 100,
      ,not null‘ => true,
            ),
      ,id_original‘ => array(
         ,description‘ => ,Origin‘,
         ,type‘ => ,int‘,
         ,unsigned‘ => true,
         ,not null‘ => true,
            ),
      ,acquisition‘ => array(
         ,description‘ => ,Acquisition date‘,
         ,type‘ => ,date‘,
         ,mysql_type‘ => ,date‘,
         ,not null‘ => true,
            ),
….
),
   ,foreign keys‘ => array(
      ,country‘ => array(
      ,table‘ => ,country‘,
      ,columns‘ => array(,id_original‘ => ,id_original‘),
          ),
   ,vid_kultura‘ => array(
```

```
       ,table‘ => ,vid_kultura‘,
       ,columns‘ => array(,id_vid‘ => ,id_vid‘),
         ),
   ,podvid‘ => array(
       ,table‘ => ,podvid‘,
       ,columns‘ => array(,id_vid_podvid‘ => ,id_vid_
podvid‘),
           ),
         ),
        ,primary key‘ => array(,id‘),
    );
...
// Description of the tables
//  „Country”, “Vid_kultura” and “Podvid”
 return $schema;
}
// Realization of hook_install().
// Create tables in the first turn of the module
function plant_install()
{
// Make real foreign keys.
//Foreign key relationship country - sortove
   db_query(‘
     ALTER TABLE {sortove}
     ADD CONSTRAINT {country}
     FOREIGN KEY (id_original)
     REFERENCES {country} (id_original)’);
//Foreign key relationship vid_kultura - sortove
   db_query(‘
     ALTER TABLE {sortove}
     ADD CONSTRAINT {vid_kultura}
     FOREIGN KEY (id_vid)
     REFERENCES {vid_kultura} (id_vid)’);
//Foreign key relationship podvid - sortove
   db_query(‘
     ALTER TABLE {sortove}
     ADD CONSTRAINT {podvid}
     FOREIGN KEY (id_vid_podvid)
     REFERENCES {podvid} (id_vid_podvid)’);
}
// Realization of hook_uninstall()
// Destruction of the tables when uninstall modules
function plant_uninstall()
{    drupal_uninstall_schema(‘plant’);
}
?>
```

4.2 Program Code establishing the queries to the database

The PHP module is created in [4] and [5].

Example of a Computer Program from Iliev I. (2013) PHP module for queries to the MySQL database of gene bank

```
function plant_page()
{
  $tableHeader = array(‚Entry N‘, ‚Genus‘, ‚Species‘,
‚Subspecies‘, ‚Cultivar / Strain‘, ‚Origin‘, ‚Date of
acquisition‘, ‚last increase‘, ‚input size‘
  $tableData = array();
  $url = (!empty($_GET[‚search‘])) ? urldecode($_
GET[‚search‘]) : ‚‘;
  $id_country = ‚‘; $id_vid = ‚‘; $id_podvid = ‚‘;
  $ime_country = ‚‘; $ime_vid = ‚‘; $ime_podvid = ‚‘;
  if(!empty($url)){
//Checking question mark by country
   $result_country = db_query(„SELECT * FROM {country}
WHERE ime_country = :url“, array(‚:url‘ => $url))-
>fetchAll();
   foreach($result_country as $country){
      $id_country = $country->id_original;
      $ime_country = $country->ime_country;
   }
// Checking question mark by genus
   $result_kultura = db_query(„SELECT * FROM {vid_
kultura} WHERE ime_vid = :url“, array(‚:url‘ => $url))-
>fetchAll();
   foreach($result_kultura as $kultura){
     $id_vid = $kultura->id_vid;
     $ime_vid = $kultura->ime_vid;
   }
// Checking question mark by subspecies
   $result_podvid = db_query(„SELECT * FROM {podvid}
WHERE ime_podvid = :url“, array(‚:url‘ => $url))-
>fetchAll();
   foreach($result_podvid as $podvid){
     $id_podvid = $podvid->id_vid_podvid;
     $ime_podvid = $podvid->ime_podvid;
   }
// This is the query that fills the rows in the table
   $result = db_query(„SELECT * FROM {sortove} WHERE
id_entry = :url OR id_culture = :url OR id_vid_podvid
```

```
= :podvid  OR id_vid = :vid  OR id_sort = :url OR id_
original = :country“,  array(,:url‘ => $url, ,:country‘
=> $id_country, ,:vid‘ => $id_vid, ,:podvid‘ => $id_
podvid))->fetchAll();
    foreach ($result as $record) {
   if(!$ime_country){
// If it is not sort by country we enter it name
   $result1 = db_query(„SELECT * FROM {country} WHERE id_
original = $record->id_original“)->fetchAll();
   foreach($result1 as $ime1){
     $ime_country = $ime1->ime_country;
   }
 }
if(!$ime_vid){
//If it is not demanded by genus, we fill its name
   $result2 = db_query(„SELECT * FROM {vid_kultura} WHERE
id_vid = $record->id_vid“)->fetchAll();
   foreach($result2 as $ime2){
     $ime_vid = $ime2->ime_vid;
   }
 }
if(!$ime_podvid){
//If it is not demanded by subspecies, we fill its name
   $result3 = db_query(„SELECT * FROM {podvid} WHERE id_
vid_podvid = $record->id_vid_podvid“)->fetchAll();
   foreach($result3 as $ime3){
     $ime_podvid = $ime3->ime_podvid;
   }
 }
  $tableData[] = array($record->id_entry, $record-
>id_culture, $ime_vid, $ime_podvid, $record->id_sort,
$ime_country, $record->acquisition, $record->last_
multiplication, $record->entery_size);
$ime_country =‘‘;$ime_vid = ,‘; $ime_podvid = ,‘;
//wipe the variables
   }
   if($tableData){
return theme(,table‘,array(,header‘=>$tableHeader,
,rows‘=>$tableData, ,sticky‘ => FALSE, ,attributes‘ =>
array(,class‘ => array(,mytable‘))));
    }else{
         return no_result_page() ;
          }
         }
//close if empty search box
```

```
     else{
           return empty_search_box();
           }
}
function plant_block_info()
//adding a new block by hook_block_info
{   $blocks = array();
    $blocks['plant_block'] = array(
      'info' => t(' Search Form in Plant Bank'),
// name of the block
      'cache' => DRUPAL_CACHE_PER_ROLE,
// Mode cache.
   );
   $blocks['advanced_plant_block'] = array(
    'info' => t('Advanced Search Form in Plant Bank'),
// name of the block
    'cache' => DRUPAL_CACHE_PER_ROLE, // Cache mode
   );
   return $blocks;
}
// Displaying blocks of the site.
function plant_block_view($delta = '')
{
   $block = array();
    if($delta == 'plant_block')
    {
      $content = drupal_get_form('my_search_form');
// We attach a function that returns the form
   $block = array(
    'subject' => t('Search in Plant Bank '),
    'content' => $content,
          );
    }
    if($delta == 'advanced_plant_block')
    {
      $content = drupal_get_form('my_advanced_search_
form');
//We attach a function that returns to the form
      $block = array(
        'subject' => t(''),
        'content' => $content,
       );
   }
   return $block;
}
```

5 Realization of web site of the Information system

Fig. 1 shows the homepage of web based IS for gene bank of DAI. The fields for quick search and advanced search are in the left panel.

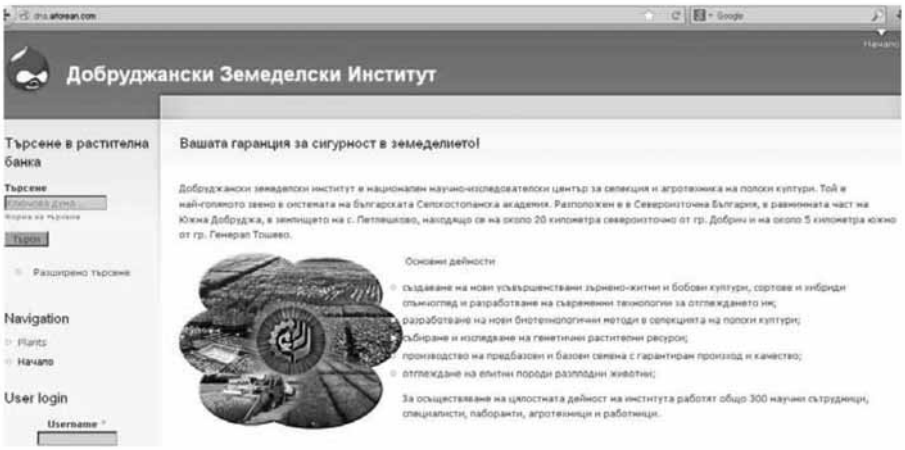

Fig. 1 Home page of the information system for the seed gene bank.

Fig. 2 shows an example query execution for fast keyword search "*triticum*".

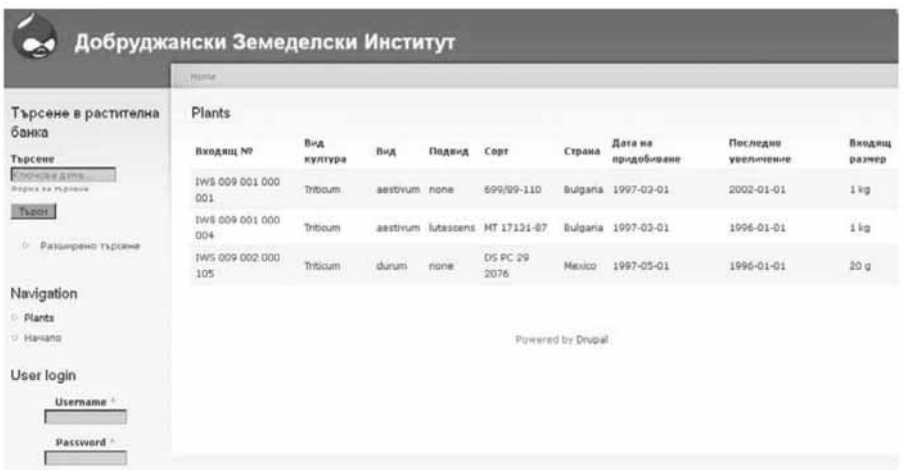

Fig. 2 Window with the results of a quick search in the information system for seed gene bank.

Fig. 3 shows an example with execution of an application for advanced search by criteria: Genus - "*triticum*"; Species - "*durum*"; Origin - "*Mexico*".

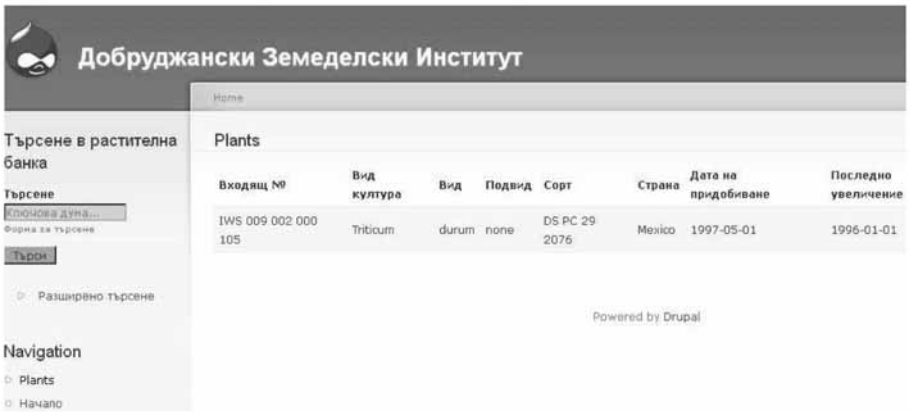

Fig. 3 Window with results of an advanced search in the information system for seed gene bank.

6 Conclusion

CMS Drupal is a very proper choice of functional and professional platform for building Web site information system for gene bank of scientific institute.

Work on the design and implementation the site of IS for gene bank of Dobrudzha Agricultural Institute - General Toshevo municipality showed multiple and "friendly" tools of CMS Drupal for creation a well-structured and coherent web based information system for gene bank.

Created in such a way IC for description of germplasm of scientific institute dealing with genetics and selection is wide and promotes successful collaboration between scientists from around the world engaged in breeding and seed production.

Future work on the web-based system includes bilingual or English only version of the site, inclusion in the database genetic resources DAI information about other cultures that the Institute deals with. For the development of selection science in Bulgaria it is necessary to create such kind of sites for gene banks.

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Validation of the Collaborative Health Care System Model COHESY

Elena Vlahu-Gjorgievska[1], Igor Kulev[2], Vladimir Trajkovik[2], Saso Koceski[3]

[1]Faculty of administration and information systems management, University "St.Kliment Ohridski", Bitola, Macedonia
[2]Faculty of Computer Science and Engineering, University "Ss Cyril and Methodious", "Rugjer Boshkovikj" 16, P.O. Box 393 1000 Skopje Macedonia
[3]Faculty of Computer Science, University "Goce Delcev", bul. Krste Misirkov bb. 2000 Stip, Macedonia
elena.vlahu@uklo.edu.mk, {igor.kulev, trvlado}@finki.ukim.mk, saso.koceski@ugd.edu.mk

Abstract. Collaborative health care system model COHESY allows monitoring of users' health parameters and theirs physical activities. This system model helps its users to actively participate in their health care and prevention, thereby providing an active life in accordance with their daily responsibilities at work, family and friends. Recommendation algorithm, which is part of the social network of the proposed model, gives recommendations to the users for performing a specific activity that will improve their health. These recommendations are based on the users' health condition, prior knowledge derived from users' health history, and the knowledge derived from the medical histories of users with similar characteristics. In this paper we give validation of the proposed model by using simulations on generic data.

Keywords: Personal healthcare systems, recommendation algorithms

1 Introduction

Advances in communication and computer technologies have revolutionized the way health information is gathered, disseminated, and used by healthcare providers, patients and citizens. The collaborative health care system model COHESY [1] gives a new dimension in the usage of novel technologies in the healthcare. This system model uses mobile, web and broadband technologies, so the citizens have ubiquity of support services where ever they may be, rather than becoming bound to their homes or health centers [2]. Broadband mobile technology provides movements of electronic care environment easily between locations and internet-based storage of data allows moving location of support [3]. The use of a social network, in

COHESY, allows communication between users with same or similar condition and exchange of their experiences.

COHESY has simple graphical interfaces that provide easy use and access not only for the young, but also for elderly users. It has many purposes and includes use by multiple categories of users (patients with different diagnoses). Some of its advantages are scalability and ability of data information storing when communication link fails. COHESY is interoperable system that allows data share between different systems and databases.

The recommendation algorithm, which is part of the social network in COHESY, is based on the dependence between the values of the health parameters (e.g. heart rate, blood pressure, arrhythmias) and the users' physical activities (e.g. walking, running, biking). The basic idea is to find out which physical activities affect change (improvement) of the value of health parameters. This dependence continues to be used by the algorithm to recognize the same or similar health situations found in another user with similar characteristics. If there is information in the users' history that after performing some physical activity their health condition has improved, the algorithm accepts this knowledge and proposes the activity to other users with similar health problems.

The usage of the social network and its recommendation algorithm are the main components and advantages of COHESY which differentiates it from other health care systems. These components provide a new perspective in the use of information technologies in pervasive health care and make this system model more accessible to users. COHESY bridges the gap between users, clinical staff and medical facilities, strengthening the trust between them and providing relevant data from a larger group of users, grouped on the basis of various indicators.

2 Collaborative Health Care System Model COHESY

Simple overview of COHESY is shown in Fig.1. System model is deployed over three basic usage layers. The first layer consists of the bionetwork (implemented from various body sensors) and a mobile application that collects users' bio data and parameters of physical activities (e.g. walking, running, cycling). The second layer is presented by the social network which enables different collaboration within the end user community. The third layer enables interoperability with the primary/secondary health care information systems which can be implemented in the clinical centers, and different policy maker institutions.

The communication between the first and the second layer is defined by the users' access to the social network where the user can store their own data (e.g. personal records, healthcare records, bionetwork records, readings on physical activities). The social network allows communication between users based on collaborative filtering techniques, thus connecting the users with the same

or similar diagnoses, sharing their results and exchanging their opinions about performed activities and received therapy. Users can also receive average results from the other patients that share the same conditions in a form of notifications. These notifications can vary from the average levels of certain bio data calculated for certain geographical region, age, sex, to the recommendation for certain activity based on the activities of other users. Collaborative filtering can be used to achieve different recommendations in these contexts.

The communication between the first and the third layer is determined with the communication between patient and health care centers. The patient has 24 hour access to medical personnel and a possibility of sending an emergency call. The medical personnel remotely monitors the patient's medical condition, reviewing the medical data (fatigue, blood pressure, heart rate) and responds to the patient by suggesting most suitable therapy (if different from the one that is incoded in the mobile application) as well as sending him/her various notifications (e.g. tips and suggestions) regarding his/her health condition.

The second and the third layer can exchange data and information regarding a larger group of patients, grouped by any significant indicator (region, time period, sex, type of the activities) which can be later used for research, policy recommendations and medical campaign suggestions.

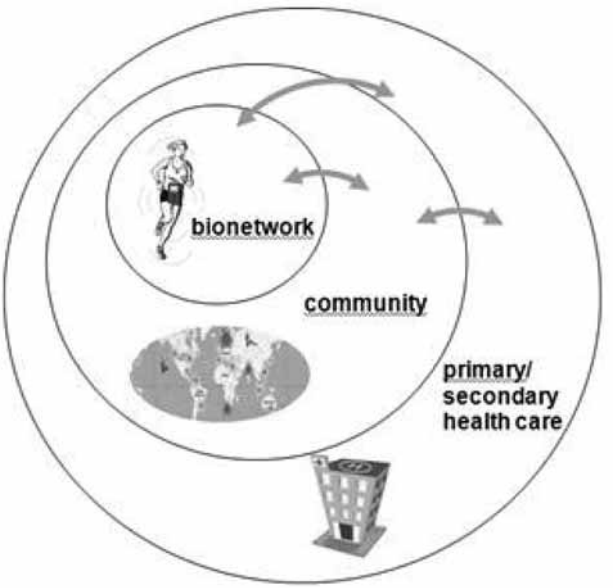

Fig. 1. System Layers

The second and the third layer can exchange data and information regarding a larger group of patients grouped by any significant indicator (region, time

period, sex, type of the activities) which can later be used for research, policy recommendations and medical campaign suggestions.

COHESY uses different techniques and protocols that guarantee security and privacy of users' data [4, 5, 6]. It has own security and privacy statements that explain how the system protects the users' privacy and confidentiality and the way in which their personal information will be treated. Every user can choose which information can be private or public. The user can choose his records to be public: (a) for medical purposes, (b) to all visitors of the Social network, (c) to the users in his category, (d) to none. In order to have medical support the user has to agree to share personal information with clinical centers and medical databases, whose data are also protected. According to user's agreement policy, those data information would be exchanged through the system.

2.1 Recommendation algorithm

The recommendation algorithm is part of the second level in COHESY (the social network). It is implemented as a web service and its purpose is to recommend the physical activities that the users should carry out in order to improve their health. The algorithm uses the data read by the bionetwork, the data about the user's physical activities (gathered by the mobile application), the user's medical record (obtained from a clinical centre) and the data contained in the user profile on the social network (so far based on the knowledge of the social network).

The main purpose of this algorithm is to find the dependency of the users' health condition and the physical activities they perform. The algorithm incorporates collaboration and classification techniques in order to generate recommendations and suggestions for preventive intervention. To achieve this, we consider datasets from the health history of the users and we use classification algorithms on these datasets to group the users by their similarity. The usage of classified data when generating the recommendation provides more relevant recommendations because they are enacted on knowledge from users with similar medical conditions and reference parameters.

There are a number of parameters that might be used to characterize a person such as: body mass index, age, blood pressure, heart rate, blood sugar levels. All these characteristics are essentially continuous variables and they are measured with (near) continuous resolution. On the other hand, the bio-medical parameters and phenomena are often too complex and too little understood to be modeled analytically. Because of its continuous nature, the fuzzy systems are very close to the medical reality and at the same time, fuzzy sets allow natural description of bio-medical variables using symbolic models and their formalisms, avoiding the analytical modeling [7]. Therefore, in this algorithm, fuzzy sets and fuzzy discretization are considered as a suitable approach that can bridge the

gap between the discrete way reasoning in the IT systems and the continuity of biomedical parameters. For every health parameter, several discretization intervals are considered. Each person has a corresponding membership factors for each of those intervals, depending on his/her parameter value.

This algorithm uses three levels of filtering, as shown in Fig.2. The first step is classification. All users belong to some diagnosis class (normal diabetes, heart problems). All users with different diagnosis from the diagnosis of the given user are filtered out. This step is important because some activities may be harmful for a particular group of people e.g. running may have much different effect on people with heart problems as opposed to people which are physically active.

The second level of our recommendation algorithm is the collaborative filtering. Every user has its own history of health conditions (health profiles) and it is important to find similar users to the given user which at some point of time in the past had similar health condition to the health condition of the given user at the moment. The technique that is used here can be considered as a collaborative filtering technique where items are equal to health profiles.

When the similar users are chosen, we use all their health condition history and the history of performed activities to find the influences of each activity on the change of the health parameters. Now we come with a fairly good approximation of the potential effect of the activity on the health condition for the given user. Here we use the characteristics of the activities in order to get good recommendations. In other words, we explore the content of the activities and use content-based filtering techniques to find the best matching activities. User preferences in our context are the desired values for the health parameters (normal range). The chosen activities would potentially improve the health condition of the given user towards the desired values.

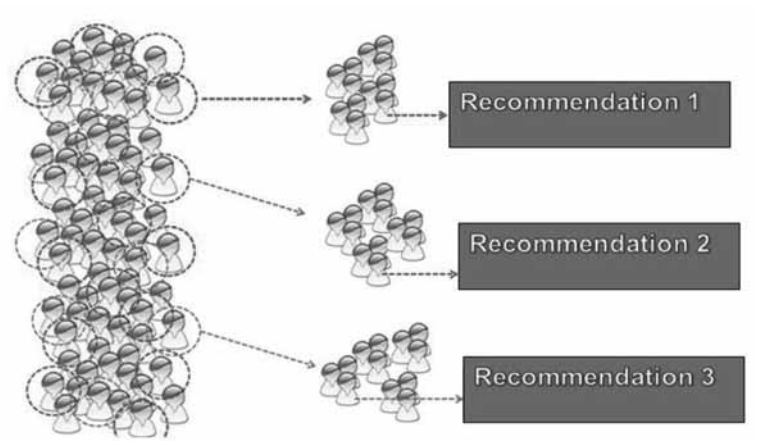

Fig. 2. Levels of filtering in COHESY recommendation algorithm

3 Simulation results and discussion

In this section we give a validation of the proposed model by using simulations on generic data. Three simulations are made and in all of them, two types of activities are generated: a positive activity (activity whose performance increases the value of a given parameter) and negative activity (activity whose performance reduces the value of a given parameter). Each activity has individual influence to the global parameter change and it is presented by a function whose shape is similar to a Poisson probability mass function. The graphs of the influences of the positive and negative activities in the time period [0, 3000000] are shown on Fig.3.

In the first simulation 25 activities were generated. Each activity begins at a randomly chosen time point between 0-th and 3000000-th second and it is positive or negative by a random choice.

Each activity carried out before a certain point in time affects the value of the parameter at that point. Our assumption is that the maximum impact of the activity takes place in a relatively short time after its execution. There are 25 generated activities that begin and end at different time points and they all affect the global parameter change. The global parameter change is a sum of all (25 generated activities) individual influences and it is presented in Fig.4.

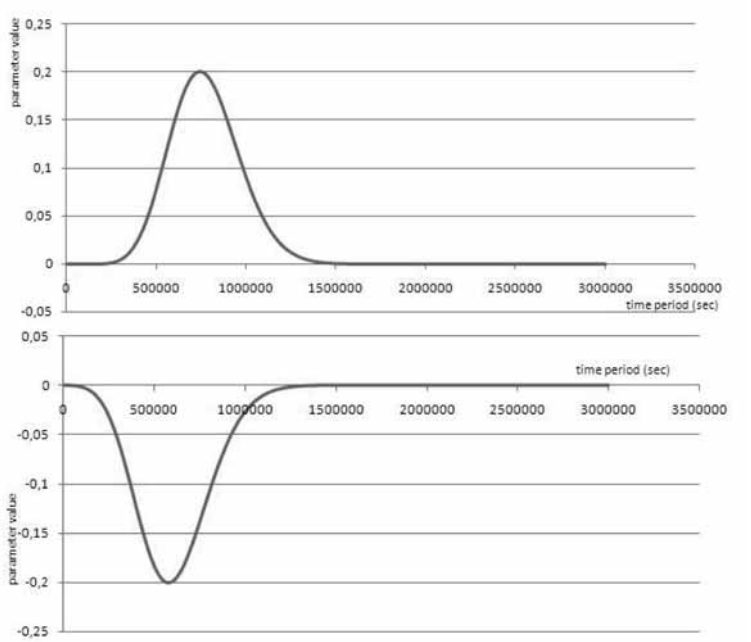

Fig. 3. Graphs of the influence functions for a positive and a negative activity

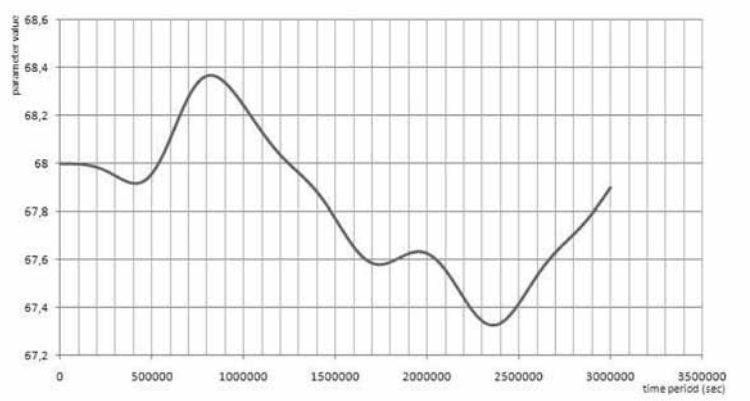

Fig. 4. Graph of the global parameter change in the first simulation

To evaluate the effectiveness of the COHESY using the proposed recommendation algorithm, in the first simulation 28 recommendations in 28 different (random) time points were generated.

In the second simulation 56 activities were generated. Each activity begins at a randomly chosen time point between 0-th and 5000000-th second. The graph of the global parameter change in the second simulation is presented in Fig.5. In this simulation, 45 recommendations were generated in 45 different (random) time points

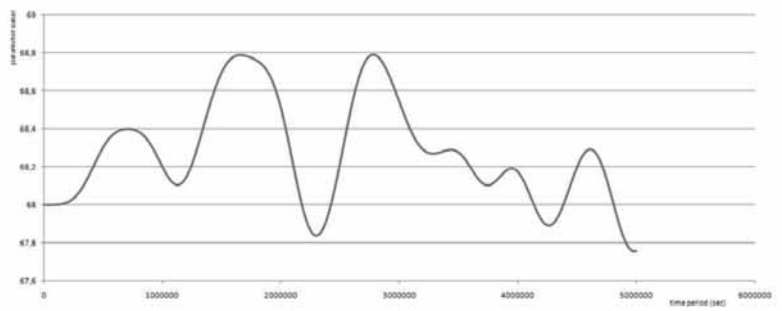

Fig. 5. Graph of the global parameter change in the second simulation

Seventy activities were generated in the third simulation. In this simulation, each activity starts at a randomly chosen time point between 0-th and 7500000-th second. The graph of the global parameter change in the third simulation is presented in Fig.6. In this simulation, 58 recommendations were generated.

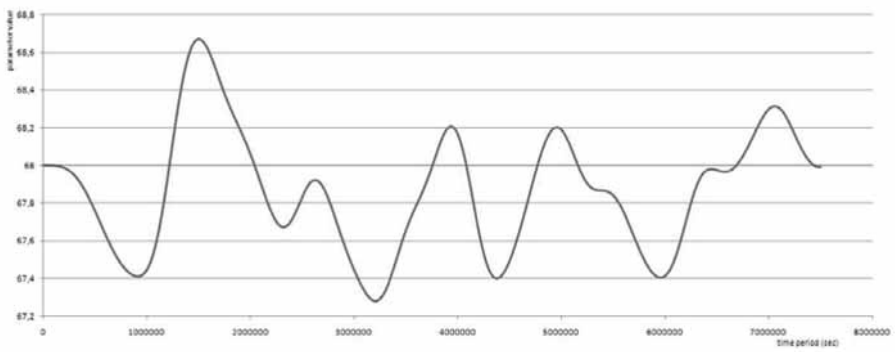

Fig. 6. Graph of the global parameter change in the third simulation

To avoid borderline cases when the value of the parameter is in the normal range, the normal range value of the parameter in the simulations is from 85 to 95. From the presented graphs in Fig.4, Fig.5 and Fig.6 we can see that the value of the parameter in all simulations ranges from 67.2 to 68.8 which is much below the lower limit of the normal value of the parameter. So, the algorithm generates the appropriate recommendations only if the recommendation relates to a positive activity.

From the results we can conclude that the recommendation algorithm in the first simulation generated appropriate recommendations with 82.14% accuracy. In the second simulation, the accuracy of the generated appropriate recommendations is 84.44%, while the percentage of appropriate recommendations generated in the third simulation is 91.38%.

These percentages show that as the number of activities increases and the time period extends, so does grow the percentage of appropriate recommendations generated by the algorithm.

Analyzing the results obtained in all the three simulations, it can be concluded that the time periods, during which the algorithm generates inappropriate recommendations, correspond to the initial period. Because all three simulations use the same algorithm and the same types of activities, it is expected that the time of adaptation or learning period of the algorithm is roughly the same in the three simulations. But while in the first and the third simulation the period in which improper recommendations are generated is about the same length, that period is almost as twice as long in the second simulation.

To discover the reason for the varying length of the period in which inappropriate recommendations are generated, we have analyzed the number and the type (positive and negative) of generated activities in the simulations individually.

Table 1. Percentage of generated activities by type (positive and negative)

	I simulation			II simulation			III simulation		
	no. a.	**% p.a.**	**% n.a.**	**no. a.**	**% p.a.**	**% n.a.**	**no. a.**	**% p.a.**	**% n.a.**
1/3 of activities (33%)	8	62,50	37,50	19	73,68	26,32	23	39,13	60,87
1/2 of activities (50%)	13	46,15	53,85	28	71,43	28,57	35	40,00	60,00
2/3 of activities (66%)	17	35,29	64,71	37	70,27	29,73	47	40,43	59,57
total activities	25	40,00	60,00	56	62,50	37,50	70	45,71	54,29

Table 1 illustrates the percentage of positive and negative activities for the three simulations by periods of generating activities. Considering the number and the type of the top 33%, top 50% and top 66% generated activities for each simulation.

The analyses show that in the initial period in the second simulation mostly positive activities are generated, while the number of generated negative activities is significantly lower. In the first and in the third simulation, the number of generated positive and negative activities is not much different. So, it can be concluded that if the number of generated positive and negative activities in the beginning of the simulation is not approximately the same, the period in which inappropriate recommendations are generated increases. This is the case in the second simulation where the period in which inappropriate recommendations are generated is almost twice longer than in the first and third simulation.

Because in the initial period of all three simulations the algorithm generates inappropriate recommendations, the conclusion is that in the proposed algorithm the problem of a cold start occurs. This is a common problem in collaborative algorithms [8]. A possible solution to this problem is to generate prior knowledge before the following simulations. This will also avoid the elongation of the period which generates inappropriate recommendations as well as the issue of a cold start.

4 Conclusion and future work

In this paper a collaborative health care system model and its validation are presented. The proposed model COHESY represents a tool for personal health care by generating various recommendations, comments and suggestions to its users.

COHESY is a complex system composed of mobile application, social network, information systems that are used by the medical personnel, medical databases and additional services. It provides monitoring of health parameters

and tracking of the users' physical activities, communication between users, automatic data transfer, data exchange between medical centers and databases. But what distinguishes the COHESY from the rest and its main advantage is the communication and exchange of data between the various components.

Validation of the proposed model is made by evaluating the effectiveness of the recommendation algorithm using generic data. The analysis of data obtained from the simulations of the recommendation algorithm on generic data show that the algorithm generates appropriate recommendations with an accuracy of 82% to 92%. As the time period and the number of activities extends, so does the percentage of appropriate recommendations generated by the algorithm increases.

However, the analyzes showed that the proposed model has deficiencies such as the *cold start* problem and the extension of the initial period in which inappropriate recommendations are generated, which should be treated with more attention in future.

The performed simulations are only an introductory step in the process of evaluating the effectiveness of the recommendation algorithm and the proposed model. In the future, the evaluations of the effectiveness of the proposed model should be done with simulations that will validate the behavior of the algorithm in different conditions (different values of the parameter, more types of activities) and with simulations with real data in order to make a quantitative and qualitative analysis of the behavior of the system.

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A graph representation of query cache in OLAP environment

Hristo Hristov, Kalinka Kaloyanova

Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", 5 James Bourchier blvd., 1164, Sofia, Bulgaria
christo_christov@yahoo.com , kkaloyanova@fmi.uni-sofia.bg

Abstract. This paper concerns the optimizations of Data Warehouses queries. Some open issues of query management in OLAP environment are discussed. A graph representation of query cache is proposed. The proposed approach uses the queries for statistical information and the graph modeling.

Keywords. Query optimization, cache, graph, OLAP

1 Introduction

Improving query response time is one of the constant issues facing scientific and business organizations working with databases. Different approaches are discussed in sources [2], [7], [8], [12], [13] and others. A possible direction to reduce the time and resource needs in processing queries is to increase the efficiency of the process. Inefficiency can appear when the same action is performed several times instead of reusing the results produced during the first time run.

Usually the results from subqueries are released immediately after query has finished its work and just part of them can stay in the form of data blocks cache maintained by DBMS. Instead of losing this data and the effort for their calculation, the information could be used for other queries helping not to recalculate again and again the same intermediate results of the queries. Creating a cache for intermediate results from the queries calculation process is a possible approach. Appropriate structure of the cache, which presents elements and relations between them, could be a graph which nodes present the queries together with their subqueries. Nevertheless the problem is too complicated in the common case, some specific characteristics of Data Warehouses could be used to reduce the complexity of the cache management.


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The goal of this paper is to find an intuitive and easy for implementation form of the graph that helps the identification of frequently needed parts of queries and which if available in advance is possible to provide overall benefit for improvement of query execution performance and cost. Oriented graph structure is proposed to be used, in order to help keeping the linkages between different queries and their subqueries. The proposal is addressed to Data Warehouse environment, where the maintenance cost of materialized views is lower than in OLTP environments. Also the specifics of the database schema and query workflow of users of OLAP environments are found to be appropriate to the characteristics of the proposed graph.

The rest of the paper is organized as follows. Section two briefly describes the major achievements up to now in the areas of research topics of materialized view selection and answering queries using views familiar to the authors. Section three presents the general idea for the graph proposed together with the preliminary conditions assumed and describes the specifics of the different levels in the graph one by one. In section four some aspects of operations with the graph are discussed. Section five provides examples and conclusions end the paper in section six.

2 Previous work

In [4] lattice of views and greedy heuristics algorithms for selection of optimal set of views for materialization are presented. The paper concerns views in cubes based on grouping characteristics of the fact joined to all dimensions. No selection and projection clauses expressions applied are examined. Further works develop the main concept in details and show some variants - for example in [1] are overseen more specifically defined problems and heuristics that solve the problems constrained by maximum number of views to be materialized and maximum space available for materialization. Also in [10] caching as a single cube (one fact table) is introduced and as a first step the query is presented in canonical form following the approach presented broadly in [9]. Based on the interactive and navigational nature of OLAP query workloads, the subqueries are presented in a hyper-rectangle and the dimensional structure itself. The cost calculation for each query is shown. [13] has proposed a model for characteristics OLAP query patterns based on Markov Models and corresponding OLAP queries prediction algorithms. Based on the current behaviour of the user in its session the queries for which there is a high probability to be used on the next step are calculated before the user really issues them. In [12] is presented a cache model aiming to increase the performance of ad hoc queries to data warehouse. The subsumption problem as summarization of query containment and query minimization problems are

presented also. The ideas here are very close to the current paper, but the focus is on flat query cache without linkage between subqueries of the user query. Despite that this research could be used to enforce selection-projection nodes similarity and linkage detection presented in the current paper. In [11] could be seen the notion of AND-OR graph and example of directed acyclic graph usage as a structure for query presentation. In [14] the focus is on the user access patterns generated on set of user access events. User access graph is generated and it represents query execution order. Interesting approach is shown in it that each node in the access graph has support value for the frequency of usage (confidence of the node) so the noise requests are eliminated. Mining user access patterns involves user session identification. In [16] can be seen the proposal for placing weight on different queries and approach to materialized view selection problem with consideration of this weight. [7] presents broad overview of the approaches for view selection methods and diversity of solutions proposed are summarized and classified. Another problem related to the topic is to answer queries using the materialized views and it is summarized in [3] and also further researched for example in [6].

Nevertheless a lot of research has been made on the area of query caching in the form of materialized views, the problem is not solved. Different proposals are presented and each of them has some positive aspects but does not cover the topic entirely, leaving room for more suggestions and research in different directions. This paper will present a combination of the directed acyclic graph and query cache proposal in a new graph structure not met in the previous works. The proposed approach is more intuitive and less complicated compared to the works so far, which makes it easier for practical implementation.

3 Graph of queries elements

As described in [15] the query processor takes three steps - parsing, logical query plan creation and physical query plan creation. It is expected some parts of the logical plan to appear as part of the logical plans of other queries issued to the database of the data warehouse. The goal is the logical query plan calculated for a query to be replaced with another one, which will produce the same result, but in a cheaper way because smaller relations already calculated as physical result from another query are used. It is known from the step of query parsing and from the step of logical query plan generation of the user's query what relations are needed, what join conditions are applied, what projections are applied and what grouping and aggregation functions are used. This information can be kept in the form of a graph which nodes present the components of the logical query plan. Search in the graph will help to match the queries issued further and to find the nodes in the graph corresponding to specific subparts (or the whole query).

As already presented in the previous section, the problem has been reviewed from different angles. The current paper will try to propose an approach, which has not been proven to give optimal solution in the context of choosing the best view set for materialization, but will make the graph of common subqueries closer to users' understanding of the query and calculated subsets. This will give possibility of the users and data warehouse administrators iteratively to change some parameters of the graph incorporating in that way the knowledge they have for the usage in the future of the system and in that way to achieved better performance.

Some conditions are assumed to be true in this setup. It is supposed that the joins between relations are always inner and actually the join conditions between any two relations are predefined. Such assumption will work fine for a dimensional structure used in data warehouses, because usually in the queries the facts are joined to the dimensions by their artificial identifiers serving as primary keys. Another assumption is that the selections are usually based on simple predicates using operators like =, <, >, >=, <=, IN, BETWEEN and one of the operands is constant. Also it is supposed that there is no self joins. In the queries all aliases of relations and attributes are replaced with their original names. These assumptions will simplify the research on this stage without limitation for further enrichment of the proposal towards more general conditions.

It is assumed that there is predefined order of all relations and of all attributes of the relations. For example this could be alphanumeric order of their names. The parts from the logical plan in the graph nodes will always be represented in uniform manner based on the predefined order of its elements and operations. This will impose similarity in query processing and resolving each part of the query in predefined order will be helpful when trace of the graph took place to identify the nodes related to the user's query.

All queries have to be matched against a graph of logical query plans parts presenting already issued queries or their subqueries. The graph is a set of nodes N which definition is given below and edges Edg = (Nc, Np), where Nc is the child node in the graph and Np is the parent node and means that the two nodes could be part of same query or child could be calculated from the results in the parent. Several types of nodes in the query graph are defined. Each type of node is allocated to specific parts of a query. Different types of nodes are referred here as levels. The nodes of the different levels have different notation and representation. Each node is defined as N = (L, E, M, S), where L = {J|S|A|Q} is the level of node where J stand for Join, S stands for Selection/Projection, A stands for Aggregation and Q is the type for whole query. The component of the node E presents expression for level definition, which will be defined later in detail. M is flag whether the node is materialized or not. The component S presents an array of statistics collected for the node and is defined as S = (NA, FT, LT, SZ, TC,

AH, IM). NA presents the number of access attempts to the node during queries logical plan generation. FT is value presenting when the node was accessed for the first time (actually it is the time of the node creation). LT is the last time when the node was accessed. SZ is the size of the nodes. The size could be presented as number of rows or number of blocks or some other metric. In case the node is materialized the exact value of the size is known. Otherwise estimation of the size could be made. Example how it could be achieved is presented in [4]. TC is the time for calculating the node (estimation or last calculation time for execution of this node is stored here or estimation). AH is complex structure keeping the actions history log where each action with this node is stored – accessing queries with their execution time and duration, materialization choices, excluding from materialization set etc. IM is value presenting the factor of importance the query has and is intended to be defined by the administrators or the users of the system. The statistics monitored could be more or less – here are included those which are considered to be most useful. Following is description of each level and its expression.

3.1 Join Level

Join level (J level) is the set of graph nodes which present the join operations in the query. It could be assumed that there are only theta join of relations as other types of joins could be presented as theta joins. The other parts of the queries like selections or projections are not presented in join level nodes. They are left to be defined in the rest of the nodes which will be discussed further. The join conditions are predefined and there is no need for them to be included in the graph node definition. In OLAP environment the joins are usually between the facts and dimensions and the join conditions present equations of primary keys of the dimensions to the foreign keys to these dimensions in the fact table. With that assumption in the join nodes could be placed only the names of the relations to be joined. The relations are presented as a list sorted according to their preliminary defined order and this is actually the expression of the node. Formally $E = (R_1, R_2, \ldots, R_n)$, where $R_1, R_2, \ldots, R_n$ are relations from the database schema listed according to the uniform predefined order.

3.2 Selection/Projection level

Selection/Projection level (S level) will present part of the selection and projection operations in the query. The S graph nodes are linked with those nodes in J level, which present the join of all relations in the query. The conditions which relate to joins are indirectly presented in J level. That's why S graph nodes represent

conditions over their tuples with predicates only on single relations. It is allowed a S node S_1 to be linked with edge to other S node S_2 instead of link to J node, if S_1 is subsumption of S_2. S_1 is considered to be subsumption of S_2 if S_1 is contained in S_2 as defined in [3]. In that case the edges of S_2 to J level nodes are in force for S_1 also. S_2 can be connected from its side to another S level node and so on the chain to continue till it is reached a S level node which is linked directly to J level node. The same principle for inheritance of J level node links is in force recursively for all these S level nodes. To simplify the graph in this level are presented also the projection clauses of queries as adding predicates which are true for all tuples in the relations but including the attributes met in projection parts of the queries but not presented in any selection predicate. The expression E here is defined as $E = (C_1, C_2, \ldots, C_n)$, where $C_1, C_2, \ldots, C_n$ are conditions in the form of $C = \{At_i$ Op Cnst | At_i IN $(Cnst_1, Cnst_2, \ldots, Cnst_n)$ | At_i BETWEEN $Cnst_1$ AND $Cnst_2\}$, where At_i is attribute of relations R_i from J level, Op = { = | < | > | >= | <=} is simple operation and $Cnst_i$ is a constant. Projection clauses presented here do not include expressions over one or several relation attributes, but only definition of all needed attributes for final query calculation. The definition of statements over these attributes is left for the higher levels of the graph.

3.3 Aggregation level

In aggregation level (A level) the nodes are linked with nodes in S level and present the grouping on subset of attributes and applying aggregation functions on the other attributes. All attributes used in the definition of this node level should be presented in S level. A special notation ø is added, which presents that the query has no grouping at all. Aggregation level expression contains two parts - the list of attributes on which a grouping is made and the calculations of expressions applied over the other attributes. Formal definition is E = (GL, AGG), where $GL = (a_1, a_2, \ldots, a_n)$ and a_i is attribute of some relation R_i. For each a_n and a_m, if $n < m$, then R_n either is same as R_m and a_n is lower in attribute order than a_m or R_n is different than R_m and R_n lower in the relations order than R_m. AGG = $(Expr_1, Expr_2, \ldots, Expr_x)$, where $Expr_x$ is SQL expression with relation attributes and constants and aggregation operations like MAX, SUM, COUNT.

3.4 Query level

To present uncovered queries which cannot be matched entirely to J, S or A levels it is included a level of nodes for exact query matching, which will “cover” the cases of more complicated queries. This level also will serve like simple query cache if no benefit could be found from the lower levels J, S or A. In that way if

some query is very popular, it will still have the chance to be cached even if it is more complicated and does not fit to the assumptions in this paper. Also the statistics and query usage history collected will be useful in the case of future work of extension of the idea here with more levels. Expression E for Q level will contain the SQL query issued from the user as it is (or with transformation in order to unify it and to improve the chance for cache hit of same but written in alternative way queries – for example replacement of aliases with original names, reordering, etc.)

4 Graph populating and materializing

When a query is issued to the Data Warehouse database some specific actions should be taken in order to change the graph in response. First the logical query plan is generated (meaning that parsing phase is passed also). But instead of relying on the logical plan generated by the data base management system, a parallel logical plan is generated for each query in respect of the nodes of the graph defined above. Expressions for each of the levels are recognized. A separate graph – a single query graph is generated for this particular query in isolation from the graph constructed up to now.

Initially only the nodes representing the relations in the database itself are presented in the graph. For each query issued this graph and the newly generated single query graph are merged. Each query will add more nodes and edges between the nodes in cases when there is no appropriate node existing for specific part of the query. On this stage the nodes generated from the single query which are subsumptions of the nodes in the graph are identified and linked with graph edge. Also generation of new nodes is made on this stage, which will identify common parts of two or more nodes after search for matching parts of definitions of two nodes. Then these matching parts form a new node and edges should link it to its parent nodes and to the respective child nodes.

After all nodes are identified, a check should be made if some of the nodes are materialized (their result is pre-calculated in advance). If yes - the nodes which are closest (have shortest path in the graph) to the node representing the query in Q level should be chosen and the query should be rewritten to use them for the query answering. After that the parameters of each inspected node should be changed so to keep the appropriate statistics which will help the choice of nodes for materialization on the next refresh cycles.

During the refresh cycle of the Data Warehouse nodes should be chosen to be materialized in advance as they are expected to reduce mostly the cost of future queries. For this purpose it is used the collected statistics – for example how many times each node is checked for materialization, how many times it is

used in modified logical query or as direct cache hit. Many of the algorithms for choosing materialized views proposed in the literature can take advantage from the collected statistics to limit the set of views appropriate for materialization and to take better decision which of them to be chosen.

5 Graph construction examples

Two examples will be shown to illustrate the J, S and A query levels as the principles for generation are different and specific for each of them.

5.1 Join level example

In Table 1 is presented a summary of a workload from a real data warehouse system working in a telecom company with a total size of near 10TB and having multiple fact and dimension tables concerning customers, their accounts, usage events, billing information and so on. For simplicity only queries which took more than 120 minutes for a period of one day are used. Relations which took part in the workload are named as R1, R2, .. , R15. Queries are presented as rows in this table along with the duration of each. In the cross-cells with X is marked if the respective relation appears in the join part of the relation the row is for.

Table 1. Experimental Results

Query #	DURATION	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15
1	190	X	X	X												
2	180				X	X										
3	280						X									
4	200			X					X	X	X					
5	200			X						X	X	X				
6	180			X						X	X	X				
7	260				X	X										
8	350	X	X	X												
9	1590		X	X			X									
10	1680		X	X			X									
11	350						X						X	X		
12	160							X								
13	1550		X	X											X	X

After applying the rules for graph generation the graph on Fig. 1 is received. Execution of query 1 will create node J1. Query 2 will result with J2 node and respectively query 3 will generate J3 and query 4 will generate J4. J5 will generate node J5 but also will identify common queries with J4 – these are R3, R9 and R10. They will form node J51. Query 6 will not add new nodes as it joins same relations as query 5. Same is in force for query 7 in couple with query 2 and query 8 in couple with query 1. Query 9 will generate node J6, but common part with J1 node will result in the node J61. Query 10 is similar to query 9. Queries 11 and 12 will form new nodes J7 and J8. And finally query 13 will generate J9, but it will be linked to already existing node J61.

Let's apply one very simplistic algorithm to choose nodes for materialization. It is to choose those join nodes which are with top 5 duration sum – the sum of durations of queries used them. Then nodes J61, J6, J9, J51 and J1 would be chosen with an algorithm with complexity not more than some sort algorithm. After that as these nodes represent actually queries of views they can be materialized or the set for materialization to be chosen between them.

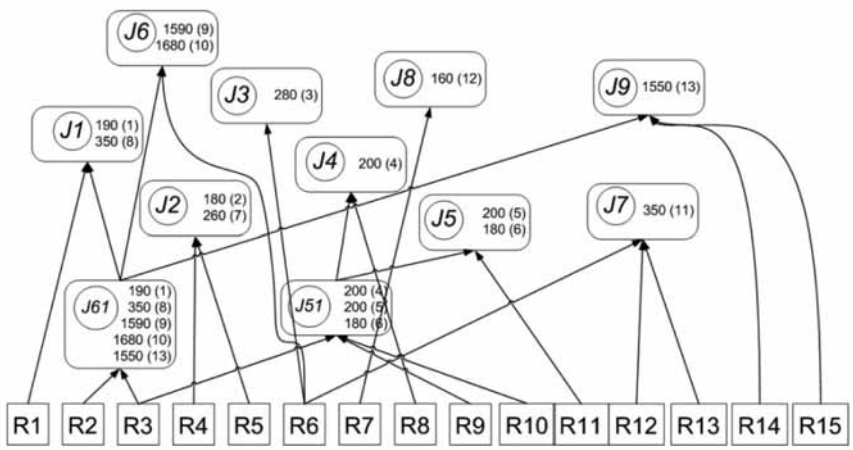

Fig. 1 Join level nodes on experimental results

5.2 Selection and aggregation level example

In order to illustrate generation of selection and aggregation levels, it will be used several queries over simple schema as presented in Fig. 2

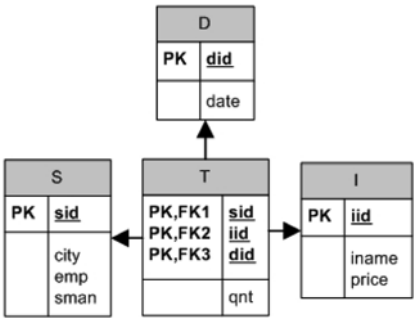

Fig. 2 Schema for selection and aggregation levels demonstration

The schema in Fig. 2 presents relations for stores S, items I, date D and transactions with the items in stores – T. Items relation I have attributes for item name – iname and the price of the item – price. Each item has identifier presented as attribute iid. Stores relation has attributes for the city where it is located, the number of employees in the store and the name of the store manager. Date relation is simply the identifier and the date itself. The relation of the transactions is actually the fact table in a star schema having foreign keys to the other relations described, which are dimensions. The fact in T is qnt, which presents the quantity sold in specific store for specific item on specific day. Let several queries presented in Table 1 are executed and have to be included in the graph.

Table. 2 Examples of issued queries

Query 1	Query 2	Query 3
SELECT I.iname, sum(T.qnt) FROM T join I on (T.iname = I.iname) WHERE T.qnt > 100 GROUP I.iname	SELECT I.iname, sum(T.qnt) FROM T join I on (T.iid = I.iid) WHERE T.qnt > 200 GROUP BY I.iname	SELECT S.city, I.iname, sum(T.qnt), max(T.qnt*I.price) FROM T join I on (T.iid = I.iid) join S on (S.sid = T.sid) WHERE S.emp > 5 GROUP BY S.city, I.iname

Query 1 and Query 2 will result respectively in nodes S1 and S2. Node S2 will be connected with edge to S1 as S2 is identified to be subsumption of S1. Query 3 will result in S3. In Fig. 3 could be seen the resulting part of the graph. For aggregation level as example in Fig. 3 is included the node A1, which will be result from Query1 and is used from Query 2 also. The grouping attributes are presented above the line and the expressions – below it. Query 3 will generate A node A2.

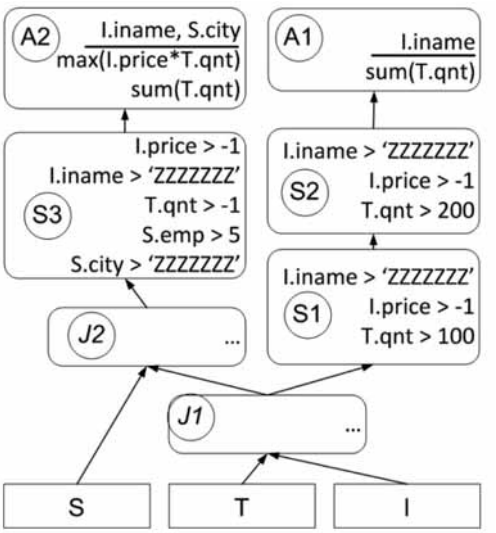

Fig. 3 Selection level nodes on experimental results

6 Conclusion

In this work an approach for caching of queries in the form of a graph structure under specific assumptions has been presented. These assumptions imply some limitations suitable for Data Warehouse environment. General presentation of the idea has been made. Many aspects of the proposal have to be developed further. For example experiments with the usefulness of statistics like the history of access of the nodes or resources concerning materialization like size, time for calculating or history of materializations should be made. Another direction is to be made experiments with known algorithms for materialized view selection as to be found if they will be appropriate for the proposed structure and if the graph can be beneficial to them. The graph is useful for prediction of future query needs based on the statistics collected. It is presented in examples that the users could be helped with GUI for presenting the collected cache and this will give possibility for the users and system administrators to have an overview and to change the weights of some nodes in order to impact the algorithm for materialization. Changes of the graph could be tracked, thus helping to collect knowledge for users' behavior. It is also possible to look for an extension of the SQL operations allowed. Some data mining methods [5] could be applied for clustering, associations or sequential pattern mining in order to achieve better prediction of the future needs of the users.

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Development of Educational Application with a Quiz

Marija Karanfilovska, Blagoj Ristevski

Faculty of Administration and Information Systems Management - Bitola
University "St. Kliment Ohridski" - Bitola, Republic of Macedonia
[1]marija.karanfilovska@gmail.com, [2]blagoj.ristevski@uklo.edu.mk

Abstract. In this article, a developed educational application with a quiz intended for children/pupils aged 6 - 9 years is described. The purpose of this interactive application is children to learn through a game with animals and birds from near and wild environment and then through a quiz to determine what they have learned. The application is divided into two parts: educational part and quiz. In the first part of this application, children can find useful data for domesticated and wild animals and birds in different data formats: text, image and audio. While in the second part (the quiz), the same information are used particularly to test the children knowledge and at the end, the quiz result shows how many points the participant has. The target audience is children aged 6 to 9 years, because the participants should be able to read and write to use this application.

Keywords: application development, educational application, quiz, database

1. INTRODUCTION

Developed application named ZUZU follows the current needs and trends for the development of an educational application. The main motivation for this task is to make concepts in detail for development of application and its connection to the database. Based on the performed research, it was noticed that additional education methods for young children education are needed in terms of learning about animals and birds. In the new textbooks for the subject "Nature" for the 1 - 4 classes in Republic of Macedonia, different species of animals and birds are covered, but their basic features and screams that they emit are not highlighted at all. To validate the impact of developed application among children, a questionnaire was attached. The poll covered 20 children aged 6 to 9 years and it was concluded that they receive too much information from the textbooks, while the children are not able to memorize all of it and usually after 2 years, they forget the learned information. Educational application with a quiz ZUZU allows children from 6-9 years to gain knowledge regarding wild and domesticated animals and birds and to test the gained knowledge. Educational interactive application for the young children looks just a simple game in which they need to find and guess the right

animals and birds. Children's role is to click on the animals/birds, to hear their screams and to read the text in the background. After that, children should be able to recognize these animals/birds.

To develop this application with a quiz, several software packages were used: Microsoft Visual C # 2010, Microsoft SQL Server 2008, Adobe Photoshop CS6 and Audio Recorder. In order to use the recorded audios in C#, recorded audios were converted from WMV to WAV. For that purpose WMV to WAV converter was used.

This article is organized as follows. In the introductory section, the concepts of educational application and quiz are introduced. In the second section, the main window and the main menu of the application are described. In the following section, the educational part of the application is described. All three consisting parts of ZUZU: introduction to the educational part, domesticated and wild animals and the component of domesticated and wild birds are depicted in this part. In the fourth section, the quiz is depicted as well as its connection to the database. The final section presents the results and conclusions about the benefits that come from using this application.

2. MAIN WINDOW AND MENU OF ZUZU

When application starts, the first window that opens is the "parent" of all other windows. While application works, this window is active all the time. When the child will leave, any other application window will be face with this window. While this window is open, the child listen the screams of different animals and birds, hence a child has a feeling that is found in the enviroment surrounded by animals and birds whose screams is listened to. The main menu is located in the upper part of the window, where child can login to another application window.

The main menu consists of four categories. The first category is the "**Instructions**" and by choosing this category a new window opens with instructions for the educational part. Second category is "**Discover the animals**". This category has two submenus: "**Domesticated animals**" and "**Wild animals**". By choosing one of these submenus, a new image opens for the corresponding animal. The third category is "**Discover the birds**". This category has two submenus: "**Domesticated birds**" and "**Wild birds**". By choosing one of these submenus, a new image for the corresponding bird is opening. The last category is "**What did you learn**". By selecting this category, a new window-quiz opens.

The structure of the application is shown in the Fig 1.

3. EDUCATIONAL PART OF THE APPLICATION

3.1 Instructions

By choosing this category, a new window with instructions for the educational part is opening. When this window will be open, each audio is deactivated. The aim of that is the child to remember each instruction. When the child will close this window, the main window will appear.

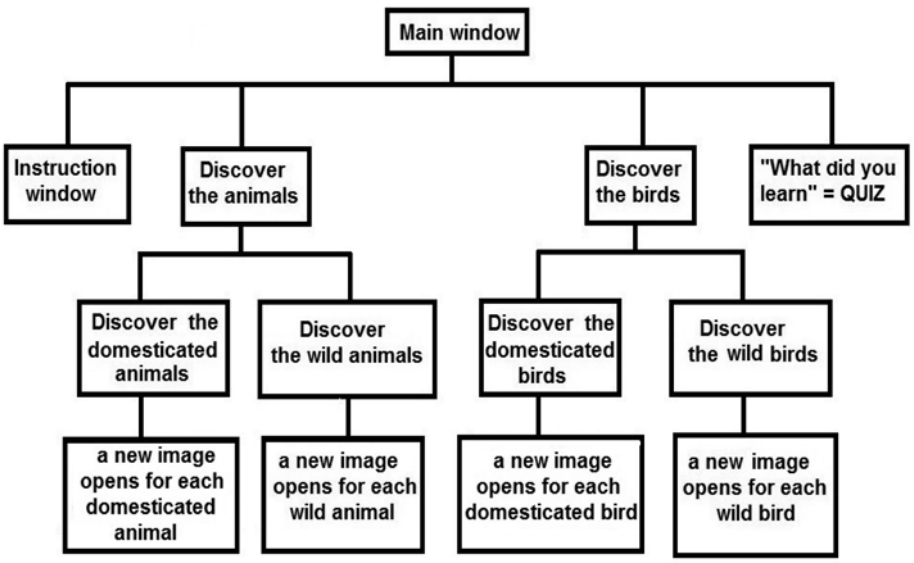


Figure 1 - The structure of the application “ZUZU”

3.2 Animals

The educational part of the animals is divided into two categories, domesticated and wild animals. This division was made in order to child can distinguish domesticated and wild animals. When the child will learn which animal in which category belongs, it will know which products are useful for the people.

3.2.1 Domesticated animals

This category includes many domesticated animals: cat, dog, horse, sheep, goat, pig and cow. Various data formats for the animals (text, image and audio) were provided. The text includes information about: what is the difference between that animal and other; what kind of food that animal eats and what the people

use of that animal. When the child will choose submenu “Domesticated animals” from the category “Discover the animals,” a new window containing an image with screams of domesticated animals is opening. There is an image and audio of domesticated animals. In this window, the child should discover which animal can be clicked. When the child will click to an animal, it can read some data, can see the image of the animal and can hear the corresponding scream. Returning to the previous window is enabled by clicking anywhere on the already open window.

3.2.2 Wild animals

This category includes several wild animals: zebra, wolf, bear, lion, deer, elephant, tiger, monkey, fox, rabbit and giraffe. Various data formats (text, image and audio) were provided for these animals. The text includes information about: what is the difference between that animal and other; what kind of food that animal eats and where it lives. When the child will choose submenu “Wild animals” from the category “Discover the animals,” a new window containing a image and screams of wild animals is opening. There is a image and screams of wild animals. In this window the child should discover which animal can be clicked. When the child will click to an animal, it can read some text data, can see the image of the animal and can hear the corresponding scream. Returning to the previous window is enabled by clicking anywhere on the already open window.

3.3 Birds

The educational part of the birds is divided into two categories of domesticated and wild birds. This division was made in order to child can distinguish domesticated and wild birds. When the child will learn which bird in which category belongs, it will know which products the people use of that.

3.3.1 Domesticated birds

This category includes many domesticated birds: hen, rooster, turkey, ostrich, goose and duck. Various data formats for the birds (text, image and audio) were provided. The text includes information about: what is the difference between that birds and other; what kind of food that bird eats and what the people use of that bird. When the child will choose submenu “Domesticated bird” from the category “Discover the birds,” a new window containing an image and screams of domesticated birds is opening. There is an image with screams of domesticated birds. In this window the child should discover which bird can be clicked. When the child will click on the bird, it can read some information, can see the image of the bird and can hear the corresponding scream. Returning to the previous window is enabled by clicking anywhere on the already open window.

3.3.2 Wild birds

This category includes many wild birds: stork, swan, flamingo, tukan, woodpecker, owl, eagle, peacock, swallow and parrot. Various data formats for these birds (text, image and audio) were provided. The text includes informations about: what is the difference between that birds and another, what kind of food that bird eats and where it lives. When the child will choose submenu “Wild bird” from the category “Discover the birds,” a new window containing an image with screams of wild birds is opening. In this window, the child should discover which bird should be clicked. When the child will click on the bird, it can read some information, can see the image of the bird and can hear the corresponding scream. Returning to the previous window is enabled by clicking anywhere on the already open window.

4.THE QUIZ

By choosing the category “What did you learn” from the main menu the window with QUIZ is opening. When this window opens, the audio is deactivated. This quiz is designed for children to test their newly acquired knowledge. The quiz covers all kinds of animals and birds. It contains questions with text and audio. When this window opens, the child should write down his/her name and click on the button “Insert”. After clicking, the button “Insert” opens the section for instructions for the quiz.

Quiz contains 23 questions: 13 questions with text and 10 questions with audio. From 13 questions with text, 3 questions regarding to the domesticated animals, 6 to wild animals, 2 to domesticated birds and 2 to wild birds. From 10 questions with audio, 2 questions are related to the domesticated animals, 4 to wild animals, 1 to domestic bird and 3 to wild birds. For each question, the child has three choices (options) and it can choose just one option. Clicking on any of the images of animals or birds it gives the answer and passes to the next question. Depending on whether the answer is correct or not, its points can increase. After switching to the next question, it is impossible to turn back. At the end of the quiz, the numbers of correct answers are shown. This score is recorded in the database.

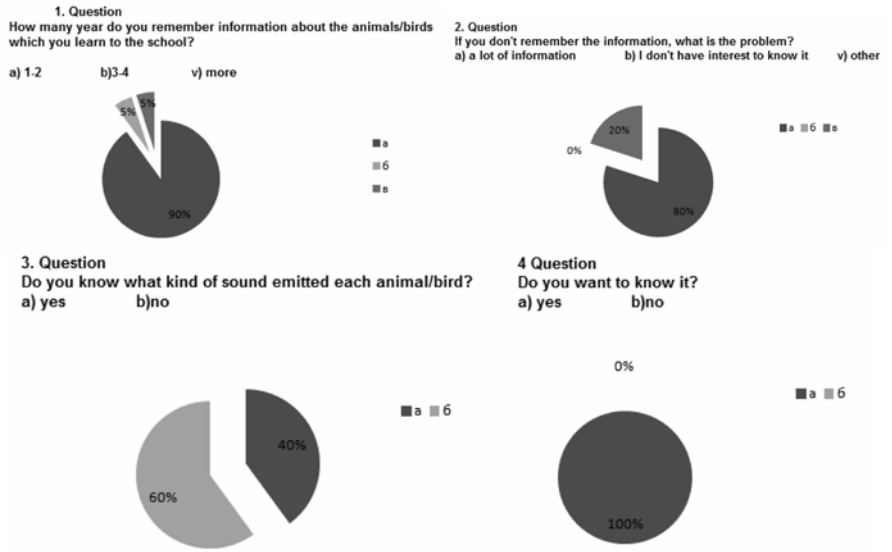
5. RESULTS AND CONCLUSIONS

The application “ZUZU” serves as an educational tool for children aged 6 - 9 years. It can be very useful application - supplement of the subject “Nature”. Educational process is carried out using images, text including basic features for each animal and bird and corresponding screams. ZUZU is developed for children to become more familiar with the attributes of animals and birds and to remember them on long term. Application “ZUZU” can be used as a part of regular classes in primary schools and other educational centers. To validate the

developed application with quiz, a poll was conducted at the primary school "Elpida Karamandi" - Bitola. Based on the results of the poll, the following can be concluded. Most of the surveyed children were aged 8 years, living in an urban environment, thinking that they have enough knowledge about animals and birds. But, often this knowledge lasts only 1-2 years. This knowledge is short-term due to too many unnecessary facts that textbooks for the subject "Nature" provide to children/pupils. They know wild birds at least, and they almost do not know the emitted sounds from the animals and birds, but they have a great desire to hear. This application was tested in the same primary school.

By opening the first window of this application, pupils were amazed by the audios they heard and by the different colors displayed on the window. They managed to read all the instructions, to remember them, and then to apply them. It was shown great satisfaction regarding the educational part. They were interesting in to continue interaction with this application The clustering of animals and birds in domesticated and wild animals and birds was helpful for the pupils easy to remember them. Regarding the quiz, the children had showed great interest in gained points and they were competitive about who is the winner with the highest score. The charts 1- 4 bellow show the results of the last four questions of the conducted survey.

Application ZUZU can be easily upgrading an extending in the future.



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Performance Study of Analytical Queries of Oracle and Vertica

Hristo Kyurkchiev, Kalinka Kaloyanova

Faculty of Mathematics and Informatics, Sofia University, 5 James Bourchier blvd., 1164, Sofia, Bulgaria

{hkyurkchiev, kkaloyanova}@fmi.uni-sofia.bg

Abstract. Analyzing and mining transactional data straight from the DBMS has become increasingly more popular, provoking research in read optimization for RDBMS. One branch of such research – column orientation claims significant improvement in read performance in comparison with row oriented DBMS. Having previously looked into the strengths and weaknesses of both approaches we take on studying the performance of commercial grade DBMSs, which employ the two views. The first step in this is examining their data models. We then develop a benchmark, which is subsequently used to measure each DBMS's performance. Evaluating the results we draw conclusions about each DBMS's suitability and main advantages over the other.

Keywords: Relational databases, Database systems, Data warehouses, Column stores, Performance evaluation, Analytical query load, Oracle, C-Store, Vertica

1 Introduction

Codd's relational database model [3] has dominated the database world for the last couple of decades due to its atomicity, consistency, isolation, and durability properties and ease of use even for non-IT specialists [4]. It is used by most traditional database management systems (DBMS) not only as a logical data model, but also as a physical one. As a result, the data tuples in them are stored contiguously on the disk [13]. This approach is usually denoted as the N-ary storage model (NSM). Column-stores also use the relational model as a logical data model. They, however, use the decomposed storage model (DSM) for physical data storage [1]. Having previously examined both ways of treating relational data [7] in general, we look into concrete, commercial grade DBMSs e.g. Oracle and Vertica to see how these abstract models affect the performance in practice. We start by first analyzing the data models and performance optimizations of both systems. Next we develop a performance benchmark, which we then use to quantify the performance differences between employing row, or column


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orientation. Based on these results we draw conclusions about each DBMS's suitability for different setups and query loads.

2 Architectural overview

Both Oracle and Vertica use as a logical model the relational data model [3]. There are certain architectural differences between the two DBMSs, however, which make them perform differently in certain conditions. In order to find why that is so and what these performance differences are with regard to analytical queries we start by examining the architectures of both DBMSs.

2.1 Oracle's architecture

Physical database structure. We use Oracle 11g to gain more information about Oracle's architecture, as this is the version later used in the tests. As every other Oracle DBMS it uses the relational model as the logical representation of the values in the database, although it also features extensions for object-oriented modeling [9]. Each implementation of a relational DBMS (RDBMS), however, specifies how the data is physically stored on the hardware. In Oracle's case the datafiles are stored in tablespaces, with each datafile being in only one tablespaces and each tablespace containing multiple datafiles [5, 9]. Other important structural components of an Oracle database include control files, redo log files, archived logs, block change tracking files, Flashback logs, and recovery backup (RMAN) files [5]. Essentially the datafiles, control files and redo log files physically represent the database on the disk [5].

For us the most important in structural regard is the datafile as it contains the real data [5, 9]. It is composed of Oracle database blocks (between 2KB and 32KB), which are in turn composed of operating system blocks [5]. The datafiles also have a logical organization of three levels – data blocks, extends and segments [5]. Bellow the structure of a typical datafile is shown. It is important to note that in the datafile header there is a checkpoint structure, which is in the form of a timestamp and is used to determine when the last changes to the file were written.

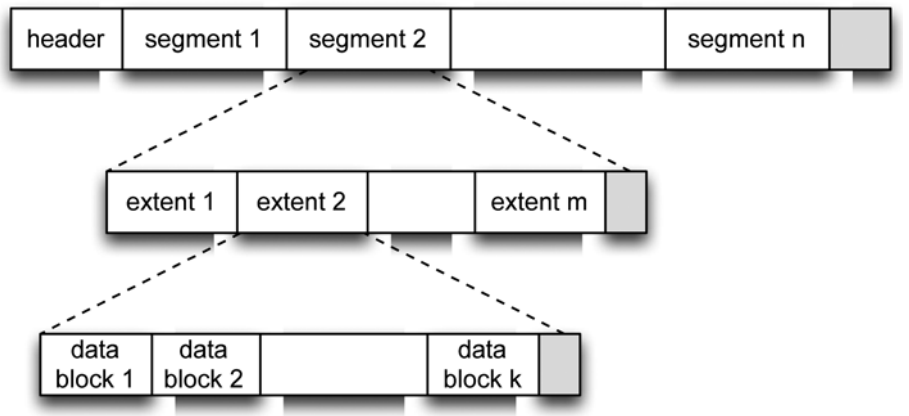

Fig. 1 Structure of a datafile

Each table has its own segment and the data in the table is stored in the segment's extents [9]. Thus the tables are stored in segments and their rows are separated between the extents of a segment. It is worth noting that the rows are usually stored with each column in the order, in which they are defined by the CREATE TABLE SQL statement [14].

Read optimization. Oracle provides a set of features to optimize read performance - query optimizer, indices, parallelization, materialized views, etc.

The key database component that enables Oracle's customers to achieve better performance is Oracle Query optimizer, which consists of four major elements [12]:

- SQL transformations, based mostly on heuristic and cost-based query transformations;
- Execution plan selection (different joint methods, indices, parallel execution);
- Cost model and statistics (object level, system, user defined, etc.);
- Dynamic runtime optimization focused on effective management of the hardware resources, especially memory and CPU.

Oracle uses two main index architectures - b-Tree indices and bitmap indices and some their variations like cluster indices, bitmap join indices, function-based indices, reverse key indices, text indices, etc.

2.1 Vertica's architecture

Vertica is essentially the commercialization of C-Store [8]. Thus it resembles the original column-oriented database greatly. Since in prior research [7] the main architectural traits of C-Store were outlined, and since Vertica resembles C-Store

in most of them, only the differences are analyzed, while the other characteristics are just briefly mentioned.

Logical database structure. Like C-Store, Vertica stores the relations by first decomposing them into **projections**. It also supports pre-joined projections to be defined, just like C-Store. However, it is a requirement that every table should have at least one *super projection* associated with it [8]. This means easier storage and lifts the necessity to implement another of C-Store's features – the **join-indices.**

Compression is another of C-Store's architectural characteristics, which made its way to Vertica. Vertica implements a slightly different list of compression methods, however, which can be found bellow [8]:

- *Auto:* the system automatically selects the compression type;
- *RLE:* the system replaces all occurrences of a single value with one pair *<value, # of occurrences>*;
- *Delta Value:* the system represents each value as a difference from the smallest value in the data block;
- *Block Dictionary:* the system replaces each value with an index in a dictionary built based on all of the distinct column values in the data block;
- *Compressed Delta Range:* the system replaces each value as a difference from the value that precedes it in the column.
- *Compressed Common Delta:* the systems stores indices in a dictionary built based on all the deltas in the data block using entropy coding.

Partitioning and **segmentation** are also supported in Vertica, as in C-Store. Both notions have evolved further with Vertica supporting intra-note and inter-node partitioning [8].

Physical database structure. Since Vertica, like C-Store consists of a Read Optimized Store (ROS) and a Write Optimized Store (WOS) there are two different ways to store the data, as each store has its own type of container [8]:

- *ROS container:* it contains a number of complete tuples sorted by the projection's sort order and stored as a pair of files per column. Each column is stored in two files – one with the actual column data and one with a position index. The position index represents important data that can speed up performance, e.g. minimum and maximum value of the column, information that can improve tuple reconstruction speed, etc. The data within the ROS container is identified by its position within it, e.g. its ordinal position within the file.
- *WOS container:* the data in these containers is solely in memory, where

its orientation (row or column) has little importance. Thus it is of little use for this study.

Read optimization. Prior research of C-Store has shown that the following features are the main reasons for its performance benefits [7] and since Vertica employees all of them it is only natural to conclude that they play a significant part of its read optimization.

- Separate read-optimized and writable store;
- Projections;
- Compression and data encoding;
- Block iteration;
- Late materialization strategies;
- Invisible joins.

To these we can also add [15]:

- Column-orientation;
- Ability to exploit multiple sort orders;
- Parallel shared-nothing design on off-the-shelf hardware.

3 Experiment setup and results

In this section the main aspects of the experiment such as the hardware and software, the database schema, the benchmark, and the measuring tools are discussed. Only a part of the original database schema is presented, as it is proprietary information.

3.1 Setup description

Hardware setup. All performance benchmarks have been done on a server with 4 Intel Xeon processors each with 4 cores each clocked at 2.4 GHz, 128 GB of RAM and 4 TB of hard disk storage. The DBMSs themselves were run as virtual machines on top of VMWare ESXi software. Each virtual machine was equipped with 2 CPU cores, 6 GB of RAM and 16 GB of storage.

Database setup. No specific tweaks have been performed on each database to improve performance, except the standard ones:

- Oracle 11g SE One was used as the Oracle instance with primary key constraints on all of the surrogate keys (which means implicit indices), as well as indices on all of the foreign keys.
- HP Vertica Community Edition was used as the Vertica instance (available as a free download from HP) with super projections on each table.

Database schema. The same database schema and data were imported into both DBMSs. They are derived from a real production configuration. The schema below features only a subset of the original columns, partly because of confidentiality and partly because of space requirements as the original schema includes much more columns (e.g. mainly for the *Trips* table, which has around 500 columns).

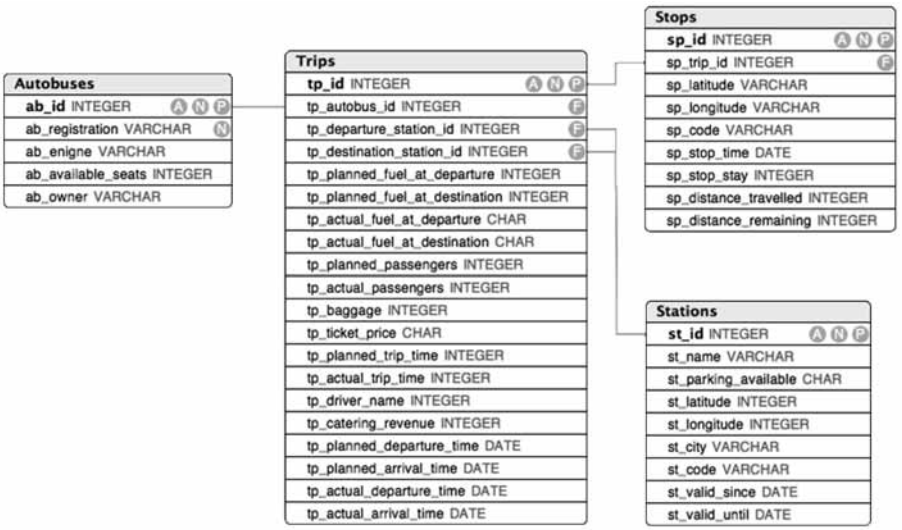

Fig. 2 Sample database schema

The data concerns autobus trips from a travelling agency. It includes autobus data (~ 50 records), station data (~ 5000 records), trips data (~ 100000 records), and stops data (~ 1750000 records).

3.1 Benchmark

Benchmark overview. Since most performance studies of C-Store [2, 6, 13] use the TPC-H benchmark or the commissioned by Vertica Star Schema Benchmark (SSB), which is derived from TPC-H [10], we decided to model our own benchmark. Another reason for doing this is that the schema that we use for testing purposes greatly differs in its properties (e.g. number of records, interconnectivity, etc.) from the ones used in the above-mentioned benchmarks. Modeling our own benchmark also allows us to include queries that are of different nature than the ones in SSB and TPC-H benchmarks.

We structured the benchmark into two sets of flights of queries:

- General queries – one flight of queries, which measures the performance of simple queries such as single row inserts, updates, deletes, and querying

data for non-analytical purposes;

- Analytical queries – four flights of queries, which measure the performance of different analytical types of queries against the above schema.

Flights of queries. As already mentioned there are four flights of queries. Most of them are inspired by the already mentioned SSB [11], except the first flight of queries, however, is completely new and not a part of either SSB or TCP-H benchmarks. All of them are described below.

The purpose of the ***first flight*** of queries is to test the common operations in transactional DBMSs, e.g. insert, update, etc. It includes:

- Q1 simple inserts:
  insert into autobuses values('ABCD', 'XY12ZT3', 45, 'S');
- Q2 simple updates:
  update autobuses set registration = 'XYZT' where id = 1;
- Q3 simple deletes:
  delete from autobuses where id = 1;
- Q4 simple selects:
  *select * from autobuses [where id = 1];*

The flight essentially consists of twenty queries[1], each of the queries Q1 to Q4 run four times – one for each of the schema's tables, so that we can measure if the number of columns in a table has some effect on the performance.

The ***second flight*** includes queries, which restrict the fact table by one dimension. Such queries have the form:

```
select avg((tp_fuel_at_departure - tp_fuel_at_destination)/tp_actual_trip_
time) as average_fuel_cost_per_trip
from trips, autobuseses
where tp_autobus_id = ab_id and
      ab_registration = [REGISTRATION] and
      tp_actual_trip_time between [TRIP_TIME] – 1 and
      [TRIP_TIME] + 1 and
      tp_paying_passengers > [PASSENGERS];
```

The query was repeated three times with different registration, trip time and passengers values so that different numbers of records are yielded.

The ***third flight*** includes queries, which restrict the fact table by two dimensions. Such queries have the form:

```
select sum(tp_actual_passengers * tp_ticket_price), ab_registration, st_
name
from trips, autobuses, stations
where tp_autobus_id = ab_id and
```

[1] For the 4th query two options were used with and without a *where* statement.

```
        tp_destination_station_id = st_id and
        ab_registration = [REGISTRATION] and
        st_city = [CITY]
    group by ab_registration, st_name
    order by ab_registration, st_name;
```

The query was repeated three times with different registration and city values so that different numbers of records are yielded.

The ***fourth flight*** includes queries, which restrict the fact table by three dimensions. Such queries have the form:

```
    select sum(tp_catering_revenue), ab_registration, st_name, sp_code
    from trips, autobuses, stations
    where tp_autobus_id = ab_id and
        tp_destination_station_id = st_id and
        tp_id = sp_trip_id and
        ab_available_seats = [AVAILABLE_SEATS] and
        st_valid_since > [DATE] and
        sp_distance_travelled > [DISTANCE]
    group by ab_registration, st_name, sp_code
    order by ab_registration, st_name, sp_code;
```

The query was repeated three times with different available seats, date and code values so that different numbers of records are yielded.

Since the dimensions in our schema are with greatly varying sizes, by choosing the dimension(s) and the values of the parameters we can provide a wide range of result sets from small (e.g. bellow 5%) to large (e.g. around 50%).

4 Read queries performance comparison

All measurements were done with Aqua Fold's Aqua Data Studio software. The query loads is separated into two sets – general and analytical. The general queries include simple inserts, updates, and deletes, as well as querying data for general reporting purposes. The analytical queries include typical data warehouse queries with aggregations and joins, usually with low column selection (bellow 10%).

4.1 General queries performance

The results of the general query performance can be seen in the table below.

Table 1. Flight one results - Oracle

	Q1	Q2	Q3	Q4.1†	Q4.2[2]
Autobuses	14 ms	10 ms	8 ms	5 ms	1 ms
Stations	15 ms	10 ms	9 ms	943 ms	1 ms
Trips	80 ms	10 ms	8 ms	3 m 20 s	1 ms
Stops	25 ms	10 ms	11 ms	5 m	1 ms

Table 2. Flight one results - Vertica

	Q1	Q2	Q3	Q4.1†	Q4.2†
Autobuses	30 ms	45 ms	27 ms	3 ms	1 ms
Stations	30 ms	45 ms	32 ms	922 ms	1 ms
Trips	235 ms	451 ms	53 ms	5 m 50 s	1 ms
Stops	30 ms	40 ms	29 ms	3m	1 ms

It should be noted that multiple operations were performed and the results were averaged. Also, with Oracle the first execution of each statement was significantly slower than the subsequent ones, while with Vertica there barely was any difference.

It is evident that Oracle is better when data manipulation language statements (safe from *select*) are concerned:

- For both updates and deletes of a single record, it is more or less independent of the number of columns or records in the underlying table;
- When inserts of a single record are considered, the number of records and the number of columns have some impact on the performance, with the number of columns having a higher one.

The query performance when selecting a single row is uniform across all tables; hence it is independent of table size and schema. The same does not apply, however, to selecting the whole table. In Oracle's case the number of records has a higher impact on the query execution time (e.g. the *select* for the Stops table took longer than the one for the Trips table). Naturally, it can be assumed that the number of columns would affect the performance as well, provided the number of records stays the same.

Vertica lags significantly behind Oracle for single row inserts, updates and deletes. The gap between the two gets wider with the increase of the number of columns in the table, which is to be expected considering the physical data models that both systems use. The inserts and updates take the highest performance hit,

[2] For the 4th query two options were used, Q4.1 refers to the query without *where* and Q4.2 refers to the query with *where*.

with the update of the Trips table being around 45 times slower than the same with Oracle. This can be explained by the fact that this is the table with the largest number of columns and considering Vertica's architecture it is to be expected that inserts, updates and deletes would be slower than with traditional RDBMSs like Oracle. Although having optimized the write performance with a separate write store [13], Vertica still cannot match the typical RDBMS when insert, update, and delete statements are concerned. The results for selecting single records and an entire table show that with Vertica the performance is dependent on the size of the result set in megabytes, and is rather independent of the number of columns. The comparison between the two systems when the whole relations are queried shows an interesting result – Vertica outperforms Oracle in the case of a large result set for a table with a relatively small number of columns (the Stops table).

4.1 Analytical queries performance

The rest of the flights of queries test the performance of both systems when analytical loads are concerned. They are separated into three flights measuring the performance of the RDBMSs when restricting one, two or three dimensions.

Second flight of queries. The second flight of queries has an original result set of around 100000 records. From it, by changing the values of the *[REGISTRATION]*, *[TRIP_TIME]*, and *[PASSENGERS]* parameters three different result sets were produced – with 800, 1500 and 3500 records. Using the average function one record was generated from the above result sets.

Table 3. Flight two results

	Q1	Q2	Q3
Oracle	605 ms	669 ms	700 ms
Vertica	171 ms	174 ms	192 ms

The results show that both DMBSs perform uniformly across the different queries in this flight with only slight slow downs when the number of records grows larger. Further a significant performance benefit from using the column store architecture is indicated. Judging by the measured response times Vertica is up to 3.65 times faster than Oracle when performing the single dimension restriction queries. The performance benefits are uniform across the selectivity, which varies from 0.8% to 3.5% for this flight. This confirms our previous findings [7] of column store's performance for analytical queries.

Third flight of queries. The third flight of queries has an original result set of around 100000 records. From it, by changing the values of the *[REGISTRATION]* and *[CITY]* parameters three different result sets were produced – with 150, 350

and 750 records. Using the sum function three records were generated from the above result sets (i.e. the group by statement produced three groups).

Table 4. Flight three results

	Q1	Q2	Q3
Oracle	627 ms	697 ms	789 ms
Vertica	207 ms	258 ms	267 ms

Again here we see that on small sets both DBMSs perform relatively the same regardless of the increasing number of records in each set. The reason most likely being the relatively small result sets in this group.

Varying the selectivity to lower the number of records in the original results sets to 0.15% - 0.75% shows that on such smaller results sets and more groups Vertica's performance benefit is slightly overcome, when compared to the previous flight of queries. It is still, however, around 3 times faster than Oracle in all the tests in this flight. It is interesting to compare Q3's results with the ones for Q1 from the previous test, as the result sets are almost equal, meaning that the difference in performance could be attributed to the restriction on two and not on one dimension. The comparison shows that the performance is being significantly impacted (0.6 times) by the restriction of both dimensions instead of just one.

Fourth flight of queries. The fourth flight of queries has an original result set of around 1750000 records. From it, by changing the values of the *[AVAILABLE_SEATS]*, *[DATE]* and *[DISTANCE]* parameters three different result sets were produced – with 35000, 160000 and 870000 records. Using the sum function 3000, 8000 and 12000 records respectively were generated from the above result sets (i.e. produced by the group by statement).

Table 5. Flight four results

	Q1	Q2	Q3
Oracle	4 s	13 s	32s
Vertica	750 ms	1 s	1 s

In this flight we observe a large range of selectivity – between 2% and 50%. These results are very important, as they are more representative for typical data warehouse queries. Even the 50% selectivity, however, stays well within the limits of our previously discovered performance threshold of 80% [7].

When comparing the results for a single DBMS a uniform behavior throughout this flight for Vertica is seen. The situation for Oracle, however, is different with its performance degrading with the increase of the size of the result sets.

The results confirm the superiority of Vertica over Oracle for queries targeting

data analysis; with the performance reaching a 32 fold gain for the highest selectivity query. The observations clearly show that the higher the selectivity, the larger the gap between Vertica and Oracle. Comparing the results from the second flight of queries where the selectivity is close to 2% (Q2 and Q3) with the one for Q1 from this flight indicates that the size of the result set plays a significant role when the performance is considered, with the performance advantage of Vertica growing 1.5 times.

5 Conclusion

The purpose of this paper is to analyze the performance of analytical queries on commercial grade DBMSs - Oracle and Vertica. As a first step in this some aspects of the data models and the query execution optimizations of the two are discussed.

Next, in order to make the performance comparison itself a new benchmark inspired by the SSB, is modeled. This allowed the inclusion of new queries, which are not part of the original benchmark and the usage of different, commercial data. Performing this new set of test flights gave interesting results for the performance of both systems. It can be concluded that the main disadvantage of a column store system in the face of Vertica is single row DML manipulations, safe from selects, as well as queries of non-analytical type – with large number of selected columns and rows. When analytical queries are considered, however, Vertica has a constant performance benefit of around 3 folds, which grows higher with the result sets that are to be processed to reach 32 times the performance of Oracle for certain queries. Having that in mind we believe that Vertica is the better candidate for data warehouse solutions, as they are usually bulk loaded with records on a predefined period of time and are mostly used for read queries where it has significant advantages over Oracle. For traditional transactional loads with lots of single row DML statements being issued constantly Oracle has superiority over Vertica and is our recommended DBMS.

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Intelligent Systems

Knowledge Management Software Application and Its Practical Use in the Enterprises

Ana Dimovska, Violeta Manevska, Natasha Blazeska Tabakovska

Faculty of Adminstration and Information Systems Management,
University „St. Kliment Ohridski“ - Bitola,
Partizanska bb, 7000 Bitola, Republic of Macedonia
ana.dimovska12@gmail.com, violeta.manevska@uklo.edu.mk, natasabt@gmail.com

Abstract. The aim of this paper is to contribute for raising the awareness of the enterprises for using knowledge management software application in order to improve their organization and to achieve greater success in their work. After the theoretical research, the practical research will be done in the enterprises in the Republic of Macedonia. The main research goal is to get a perception of familiarity and use of the knowledge management software applications in these enterprises. The expected results are that enterprises of the Republic of Macedonia are using knowledge management applications, but they are not paying enough attention on the importance and benefits which can get with this kind of application. This is the main hypothesis, we will see if this hypothesis is true after getting and processing the results.

Key words: Knowledge Management, Knowledge Management Software, Enterprises

1 Introduction

1.1 Knowledge Management Software Application

Knowledge in an enterprise is a set of people, skills, experiences, data, information, documents, routine behaviors, practices, norms and cooperation between members of the enterprise. An enterprise should properly manage all of these things in order to have efficient and effective execution of its tasks and that can be done with the help of knowledge management.

There is no universally accepted definition of knowledge management. But there are numerous definitions proffered by experts. Simply put, knowledge management is the conversion of tacit knowledge into explicit knowledge and the process of sharing it within the organization. More technically and accurately, knowledge management is the process through which organizations generate value from their intellectual and knowledge based assets [1].

An enterprise's ability to learn and to change, more important- to learn faster than other enterprises and turn the things learned into action, is the biggest advantage that

an enterprise can possess [2]. Other advantages of an enterprise are to collect, to store, to share, to distribute and to update all new knowledge in the enterprise. On this way, knowledge management process can work properly in order enterprise to achieve bigger success in their work.

Nowadays more and more enterprises are turning to modern and advanced operations. All of the working processes in the enterprises are increasingly computerized in order to obtain faster, simpler and accurate execution of the activities. In addition to business processes and activities, enterprises are beginning to computerize the knowledge they possess as well. This can be done by using appropriate software that helps enterprises to use their intellectual capital effectively. The knowledge management software application can distribute and maintain knowledge in an enterprise. The basic principle of knowledge management software application is to transfer knowledge in appropriate and easy to use format to the appropriate person, and this transfer to be made just in time for the goal of performing a given task.

Proper knowledge management software application should contribute for proper management of the whole enterprise, in a way that will be suitable for all members of an enterprise. By using a knowledge management software application, an enterprise should be able to identify, define, organize, build and distribute all the knowledge in order to have a progressive and successful work.

What kind of knowledge management software application the enterprise will use depends from the size of the enterprise, the size of its activities, its business tasks, number of employees, and other factors which affect the daily execution of the tasks.

1.2 Need for Knowledge Management Software Application

Knowledge management is an audit of "intellectual assets" that highlights unique sources, critical functions and potential bottlenecks, which hinder knowledge flows to the point of use [3].

An enterprise that wants to use knowledge management software application needs to know what goals it wants to achieve by introducing this kind of software. If an enterprise starts using the software, that means that the enterprise realized how precious is the its intellectual capital and the knowledge which it possesses. Then the purpose of the enterprise is to handle properly with the resources it possesses and improve their performance.

Other need for using the knowledge management software application is the need to transfer the knowledge and improve the process regarding meeting the requests of the clients and to perform successful and on time executions of the daily tasks and operations. When enterprises have successfully working and proper execution of the tasks that means that the cooperation between all the employees is at a very high level.

Also enterprises have need for storing and sorting the big amount of information, data and documents. During their daily work, enterprises get many email messages, documents, articles, electronic newspapers, and new data for: clients, products, requests, information etc. Enterprises spend many hours for sorting, filtering, answering and managing with all these things. In order to avoid all these activities, enterprises can start using knowledge management software application.

Knowledge management software application can be used for storing and updating all the necessary information for employees- permanent and potential; for storing and updating information for the clients, the purchases, the clients' requests and how their requests are changing in time. The same applies for the other data and information that comes from the internal and external environment. On this way, an enterprise can protect all the information and documents from loss, and managing with them can be done much easier and much faster. Also knowledge management can be used for achieving greater control over all operations and over all deadlines for completing the appropriate tasks. This software can be used for doing analysis, graphs and comparisons in order an enterprise to have a better understanding of the activities which happen in the enterprise. All of the things mentioned, and many others which can arise from the daily executions of the tasks and other factors, can be executed with the help of knowledge management software application.

1.3 Types of Knowledge Management Software Applications

Technology is a powerful enabler of knowledge management objectives [4]. New technology represented by software applications can be in the best service of knowledge management process in the enterprises, a process which without any doubt could be considered as one of the hottest research topics of the past decade [5]. Regarding innovation of the term and importance of the process of knowledge management, until now many knowledge management software applications are developed by software companies. Already developed software applications can be used in the enterprises, but also other enterprises can develop their own knowledge management software applications regarding their needs.

The knowledge management software application is not a software application with standard size, shape, look and actions that perform the same processes. Knowledge management software applications in different enterprises can differentiate very much one from another. This is due to the different activities of the enterprises and different intellectual capital that enterprises posses. Despite all the differences, knowledge management software applications in all enterprises can provide documentation of all the knowledge that enterprises poses for that knowledge to be used by authorized users across all the sectors and departments

of the enterprise. Knowledge management software application in the enterprise should support the generation, storage, update and distribution of knowledge.

International companies that produce knowledge management software applications are: Oracle, Kana, IBM, Apple, Google, EMC, SAS, Coveo, HP / HP Trim HP Enterprises services, ASG Software solutions, eTouch, Rivet Logic, Nuxeo, Bridgeway Software etc. [6].

Some knowledge management software applications that are developed from mentioned companies are:

- PHPKB (PHP Knowledge Base Software) is produced by PHP and it is leading software for knowledge management that offers assistance to clients through support and management of their knowledge databases. PHPKB software application provides statistical analysis of the knowledge that is crucial for making decisions regarding databases of the clients and provides professional manner using charts and diagrams where information and links between them can be easily seen. PHPKB software is one of the best softwares for location, selection and share of information. This software is suitable for enterprises that work with a lot of information. Despite databases in which much information can be stored, this software allows proper research that provides easy location of the searched information.
- SEM knowledge management software application is produced by software company Kana and it enables access to all databases in the enterprise, as well as other external databases. Another characteristic of this software is the contextual research that can be done in the internal and external databases.
- Smart Support software is produced by Safeharbor and it is software that can connect people with the proper answers. The software is intuitive, easy to integrate into web-based environment and offers advanced tools that can easily be managed. Also it can regulate and update the knowledge base.
- Novo Knowledge Base Software is produced by Novo Solutions. This software allows quick and safe access to the entire knowledge in the enterprise. This software is intended for enterprises that want to have a central repository of knowledge to which all employees can access. Also, service for training the employees is implemented in this software.
- Dezide Advisor software is produced by Dezide and it is web based software that is constantly in the service of their employees and customers. If employees have any questions or customers have requests, this software provides multiple solutions and answers to the questions. This software gives information, advices and answers to the requests and questions of the employees and customers, regarding data and information in its databases.
- Traction Teampage software is produced by Traction Software and it

enables easy communication, collaborative work, quick finding of the data etc. This software allows monitoring of activities, discussion and collaboration between different sectors in the enterprise and controls the execution of the activities of employees.

- XaitPorter software is produced by Xait and it commonly recommended for project activities. With this project management software, the team can constantly have full control over workflow and deadlines. This software can organize all activities and documents during the project. Enterprises can save 70 % of the time for doing documents, reports etc. by using this software.

These software applications satisfy different kinds of enterprises and their different daily problems and needs. Knowledge management is an interdisciplinary research issue. Thus, future knowledge management developments need integration with different technologies, and this integration of technologies and cross-interdisciplinary research may offer more methodologies to investigate knowledge management problems [7].

2 Practical Research

2.1 Research in an Enterprises in Republic of Macedonia

Through this research should be perceived the situation in the enterprises in the Republic of Macedonia, regarding familiarity with the term of knowledge management and the presence of the knowledge management software applications in the enterprises and their use. Besides receiving results, the research should emphasize the importance and needs of using knowledge management software application in the enterprises.

This research is done with questionnaires in 50 enterprises in Macedonia. The results are processed with SPSS statistic software application. The main hypothesis is that enterprises in the Republic of Macedonia are not familiar with the term of knowledge management and do not know what knowledge management software applications can be used in the enterprises. The sub hypotheses are that they store and update their information with software tools but they are not aware that that is part of the knowledge management software applications. Also they think that they need proper software tools for managing with their information, documents and other intellectual capital, i.e. they do not know that those tools are part of a knowledge management software application. Also they think that they will get improvement of their work if they have on disposal all necessary information, documents and have good collaboration between employees.

The research was done in 20 enterprises with number of employees from 1-9, 20 enterprises with 10-49 employees and 10 enterprises with 50-100 employees.

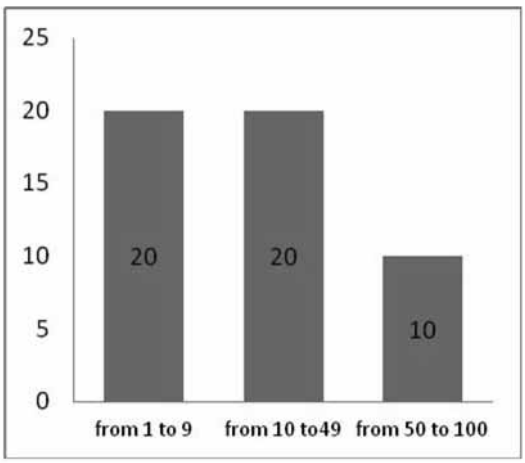

Fig. 1. Number of employees in the enterprises

More than a half declared that they connect knowledge with education, skills and experience of the employees. That means that enterprises do not know that all things mentioned above create the knowledge in the enterprise.

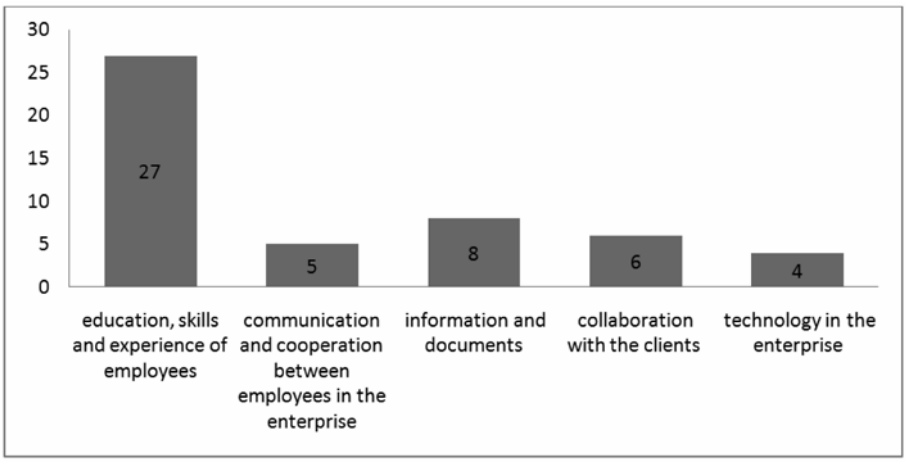

Fig. 2. What do you connect knowledge in the enterprise with?

30 of the responded enterprises declared that they store and update their knowledge with some software tools- this proves that the first sub-hypothesis is correct.

Almost all- 48 of the enterprises declared that it is necessary for an enterprise to manage with its information, documents and other intellectual capital with software tools in order to have success. Thus, the second hypothesis is correct too.

Just 10 of the responded enterprises have heard of knowledge management and knowledge management software applications, and 5 of the enterprises that had heard of knowledge management and software know what the term of knowledge management is and why the knowledge management software application in the enterprise can be used.

From this we can see that the main hypothesis is correct because most of the required enterprises are not familiar with knowledge management and do not know what knowledge management software application can be used for.

	Do you know what knowledge management is and why KM software application can be used?	Have you heard of KM and KM software applications?
Yes	5	10
No	5	30
Total	10	40

Fig. 3. Have you heard of KM?/Do you know what knowledge management is?

35 of the responded enterprises declared that if the employees share their knowledge, the cooperation in the enterprise will be in much higher level.

And almost all, 46 of the enterprises, declared that the availability of all the information for the environment, clients and requests of the clients can help the enterprise to increase its work.

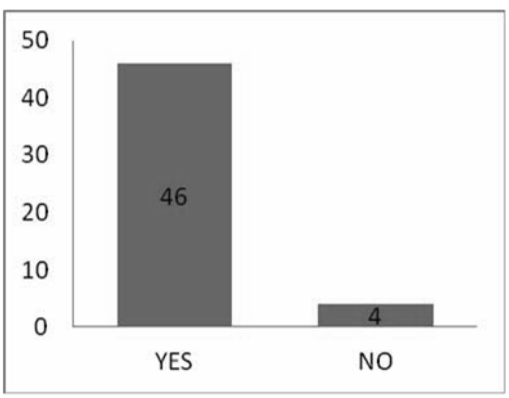

Fig. 4. Availability of all the information for the environment, clients and request of the clients can help the enterprise to increase its work

3 Conclusion

Regarding theoretical and practical research we can conclude that using knowledge management software applications in the enterprises is from crucial meaning for successful working and efficient managing of all daily activities.

Knowledge management software applications can be used for storing the data, information, documents, articles, etc., for making analysis and comparisons, for answering the questions and requests of the employees and clients, for organizing all daily work and many other things. Different kinds of knowledge management software applications can execute and can be specialized for different kinds of actions.

Regarding the results from the research, many enterprises in the Republic of Macedonia haven't heard about knowledge management and how knowledge management software applications can be used in the enterprises. Also, it is an interesting fact that enterprises are using some software tools for storing and updating the information and documents, but they do not know that these tools are part from knowledge management software application. Also they think that if they have on disposal proper software tool for managing the intellectual capital and organizing their work, they will get improvement of their work, but they do not know that these things can be executed with the help of knowledge management software application.

In conclusion, we can state that the awareness of the importance of using knowledge management software applications should be increased in the enterprises in the Republic of Macedonia. Increasing the awareness can be done with some initiatives that can be undertaken by software companies that can offer these kinds of software to the enterprises. Also initiatives can come from consultant companies and non-governmental organization which through trainings can contribute for raising the awareness of the importance of using knowledge management software application and relief the execution of the enterprises' daily activities. Also these actions can be stimulated by Ministry of Information Society and administration through advising the enterprises for using these kind of software in order they achieve better performance and to have bigger success in their work.

We can concur that the future and the progress of one enterprise is found exactly in the suitable understanding and managing of the knowledge, which is one of the most valuable intellectual capital resources of an enterprise. Proper understanding and managing of the knowledge can be done more efficiently by using knowledge management software applications.

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Personalisation, Empowering the Playful, The Social Media Cloud

Mícheál Mac an Airchinnigh

Department of Computer Science,
School of Computer Science and Statistics
University of Dublin, Trinity College,
Dublin 2, Ireland
mmacanai@cs.tcd.ie

Abstract. Beyond the Cloud? It is easy to forget that the majority of humanity is not Cloud-included; indeed most are already beyond the Cloud. To be precise they have never, and will never be part of this thing we call the Cloud! The Cloud is Amazon; the Cloud is Apple; the Cloud is Google, the Cloud is…! In other words although the Cloud is, it is rarely present is most people's consciousness. On the other hand, there are those, the technologically savvy folks, who have a private life enriched by the Internet and, of course, more generally by the Web. Everyone likes to have fun, even the scholarly folks. To see a play, to watch a movie, to listen to music, is part of everyone's Digital Cultural Heritage, in 2013. To annotate, to investigate, to write about these experiences, is the classical activity of remembrance, enshrined nominally in the professional class of the Historian. Everyone who is Web-connected, and fully engaged in the social media, will want and need to remember, to record, the social experience. In this paper, the focus is on the Digital Access to Film/Video as viewed through the media of the open access Web sites, YouTube and VBOX7. A humanistic humanitarian perspective is defined to be those digital tools that permit the recording on suitable media for future recall, remembering, of past experience. Much of these Film/Video experiences must be freely available (Creative Commons License) if the people are to be rightly served with respect to their own culture, and more importantly, to embrace the culture of another. To be definite, one must present recognizable examples, not only in one's own culture, but also, at the least, in the linguistic culture of another. Examples of said Film/Video material are given in Bulgarian and Italian Culture.

Keywords. Google goggles, IMDb, ontology, social media cloud, Wikimedia

1. Introduction

Let there be a fixed point, an anchor, a place from which we can explore something of the nature of connected human experience with respect to commonplace entertainment? In olden times, this might have been a Theatre, a Library, a Cinema, a Sports arena, a School, and especially & exceptionally, an **I**nstitution of **U**ltimately **R**ecognized **I**mportance, (acronymed **IURIU),** such as a **U**niversity (viz. University of Dublin, Trinity College, in Ireland & University of Sofia, Bulgaria) or **T**echnological **I**nstitution (acronymed **IT**) (viz. Dublin

Institute of Technology DIT [1] & Technical University of Sofia [2]). Space is of the premium in publication. Each reader, of whatever culture, will naturally nominate equivalences of similar kinds of Institutions!

In this paper we continue our research in the general field of Digital Cultural Heritage [3], and extend our focus to the individual *personal* online "art curator." Naturally, everything is underpinned ontologically [4], in both English and Bulgarian. By Art, we include the traditional Plastic Arts [5], and by necessity the prominence of the more general category of the Visual Arts, which cover photography, video, and film-making [6]. In our times, the latter embraces both YouTube [7] and VBOX7 [8].

Let us imagine that the current paper is built on earlier published work? Let us imagine, that in said previous work a photo taken from Flickr at that time was used to illustrate "The Bridge on the Drina?" [9]. That photo is no longer accessible (to the author alone?) Naturally, one suspects that either the contributor has not renewed the Flickr subscription, or the contributor has decided to try to monetarise it, or… A general Flickr search or even a Google Search or a Wikipedia Search will provide suitable alternative images [10]. But such a change requires not only the update of publication references but also the current ontology. Such updating in not automatic (yet).

Let us imagine that one is passionate about Bulgarian films, or Italian films, or Irish (Gaelic) films, of a certain time and place? Do you, the reader, have a passion for such films? If you are Italian, are you interested in Anglo-American film? In Anglo-Irish film? In Bulgarian-Italian film? If your culture is narrowed to your birth language, what do you think of, and experience, the Culture of the Other, in film? Watching a film is easy. To understand what is going on, is a little bit more difficult, culturally. Trying to ontologize a film is extremely hard. Naturally, there are available all the obvious ontological terms (in the corresponding natural languages). But for the film genre, the ontologization is much more difficult than that of, say, the still photograph. Specifically, whereas each photograph is unique, one is obliged to select certain stills from a film that captures something of its essence. What are the criteria for the choice of stills? For example, one might choose a classic photograph from the 1950-60 period in Bulgaria [11]. How shall this be ontologized? As a photograph? Certainly? As to the persons shown and location, it will take a little bit more research.

In practice, to ontologize a film, one must be very familiar with it. Not only must one have watched it (perhaps several times), but more importantly, studied it carefully. The actors appear regularly, but with different makeup, dressup, scenario settings, such as swimming pool, bedroom, dinner table, dancing floor, and so on. To do this ontologization formally, one uses stills from a film (for the visual record), one records both the actor's name and the corresponding role name, one uses a Web database facility such as Amazon's Internet Movie Database (IMDb) (in English, French, German, Italian) [12]. In particular, it turns

out that Wikipedia (with the corresponding Wikimedia) is undoubtedly one of the most import resources, especially with respect to the use of Google Goggles for visual recognition and identification.

To capture the essence of the procedure of selecting a small number (5?) of stills to categorize (and ontologize) a film, one suggests considering a preliminary analysis of still photography, covering in particular, images of Art. Furthermore, it seems advantageous to exploit the image recognition technology proved by Google Goggles, or similar.

1.1 Gathering the Information

Consider an artefact such as a colour poster of Ahinora 1925, painter Ivan Milev (1897—1927), the original of which is located in the Art Gallery of Kazanlak, done in tempera on cardboard, 86/66. The actual dimensions of the image on said poster are 40/30 cm. The original hangs like any other painting in the Gallery, except for one peculiar feature: it is covered with transparent glass. An excellent exhibition of the painting is available on Europeana [13]. A small grey scale picture developed from the original in Europeana is shown in Fig. 1. It is *important* to note that the original is seen by *reflected* light. The version on Europeana "looks much better" because it is seen by *directly transmitted* light through the "Electronic Image." Use of Google Goggles [abbreviated GG] correctly identifies the painting in question, even if (and maybe because) it is in gray scale. On the other hand, use of GG on the poster also identifies Ahinora. However, upon checking details, one notes that GG (usually?) takes us to the Wikimedia Commons [14]. In this particular case, it is the Ahinora 1922 which is displayed. Ahinora 1925 does not appear in Wikimedia Commons?

Figure 1. Ahinora, 1925 [GG +]

In this paper success of GG is denoted [GG+]. Failure is denoted [GG-]. But how is one to know whether or not GG has been successful? The author is already familiar with the original Ahinora in the Kazanlak Art Gallery, has a reasonably good poster reproduction hanging on his wall, and naturally can verify the success of GG. But one must remember that GG's success is due to, in this case, the availability of the English Wikipedia (in the first instance)? Specifically, (in this case) it is the Wikimedia Commons wherein lies the resolution of images? One might also consider a ternary rather than a binary GG. Specifically, if the image found is not what was expected (neither [GG+] nor [GG-] but in some sense GG-surprising or GG-interesting, then one might introduce [GG?]). This middle way (of a ternary logic) is a breakout for research, for new possibilities. GG?

One needs to document one's research, if only for personal use, the better to be able to recall the issues in the search and their meaning. Traditionally, the author has recourse to the formal ontology resource Protégé [4] in the first instance. The Core Terminology is provided by the CIDOC Conceptual Reference Model [15], and ISO standard since 2006. In particular, it is the Erlangen implementation that is used in our research [16].

1.2 Experiment: finding a good representative image of Ahinora

This specific problem of finding a good representative image of Ahinora has already been resolved and exhibited above, that particular one present in Europeana. But Ahinora is a common (female) name in Bulgaria. For example, a search will bring up many interesting results, one of which is "Nora Nova," real name "Ahinora Konstantinova Kumanova" [17], a picture of whom can be seen online in the LostBulgaria.com website [11]. A search for "Ahinora" on Wikipedia will not lead directly to Ivan Milev's painting. Nor will a search for "Ivan Milev" on Wikipedia reveal "Ahinora." A general search will, of course, find it [18, 19].

Ahinora has green eyes, as painted by Ivan Milev. But "green"("зелено" [**Error! Hyperlink reference not valid.**]) is a universal colour name. There are many "shades of green." Which one did Milev use? In Ireland, there are said to be "forty shades of green." If memory serves right, Milev used metallic bronze in the artwork, which will oxidize to green if exposed to the air; hence, the reason for the covering of glass over the mixed-media painting?

1.3 Experiment: To find a good representative image of a person of significance.

Let us turn our attention to a similar problem: that of attaching images to a book in which there are none. For this task subject, the famous work "The Master and Magarita" by Mikhail Bulgatov, is chosen. For illustration, let us choose the

writer himself [Fig.2], and his first wife Tatyana Lappa [Fig.1]. To ontologize these two portraits is a straightforward. Since the images are in Wikimedia, then Google Goggles recognizes them instantly. After Bulgatov divorced his first wife (1924), he married Lubov Evgenevna Belozerskaya. There does not seem to be a picture of her in Wikimedia. However, there is a small portrait of her on a Ukrainian website (Kiev). Finally, he married a third time: Elena Sergeevna Shilovskaya [21]. Google Goggles is successful in recognizing the image, undoubtedly due to the Russian version of Wikipedia [22].

Fig. 1. Tatyana Lappa, 1910 [GG +]

Fig2. Mikhail Bulgakov, 1930-39 [GG +]

2. Ontologizing Film/Video

In modern times, our times, electronic times, nothing seems to be beyond our reach! Let us now focus on the "Personal Curation" of the "Electronic Publication" of Film/Video, as currently exhibited by major and currently freely accessible "Cloud services" such as VBOX7 [8] and YouTube [7]. [Naturally, nothing is free! To access VBOX7 and YouTube requires some sort of Internet Connection, and for Quality of Video Service, one really must pay, even if it be a wired-up Coffee Shop!]. Commercial Film/Video services are deliberately excluded for the simple reason that, in academic articles such as these, there is always concern that one might infringe copyrights, even if the fair use convention is applied. A second reason is obvious. The author is familiar with, and uses, both VBOX7 [8] and YouTube [7], and these are (currently?) free (subject to the normal Internet Subscription).

However, given the nature of the struggle of owners to protect their rights and the users who prefer to pay nothing, there is no certainty of access to Film/Video. For example, the author has already published reflections on Soap Operas such as the Bulgarian "Забранена любов (Forbidden love)" available on VBOX7 [8]. This particular Soap Opera was available for a time on YouTube [7] and subsequently

removed for "alleged copyright infringement, brought, presumably," by the owner Nova Television. It is still accessible by direct connection to VBOX7 [23].

It is not easy to find suitable "Copyright free" images to illustrate the potential of GG with respect to Film/Video. But is is possible. For example, there is a Wikipedia article available for the actress Omella Mutti, illustrated in Fig 3. [24]. The image is freely available because the photographer Rita Molná took it in Cannes, 2000, and contributed it to Wikipedia. Consequently, Google Goggles recognizes it.

Figure 3. Ornella Mutti (2000) [GG++]

There is another image of Ornella Mutti, accessible in the IMDb [**Error! Hyperlink reference not valid.**]. Naturally, the next task to determine to what extent GG will recognize images in a still of a film wherein Ornella Mutti plays a part. To date, this have proved futile!

The author has already published reflections on Soap Operas such as "Swimming Pool, 2003" which is listed in the IMDb [12]. Let us focus first on the (universally not well known) actress, Ludivine Sagnier who plays the role of Julie. The really famous actress, of a certain maturity, can be readily identified! To spell out the detail would be counter-productive to the theme of this article. Once recognized and/or identified, the key information is then entered into a specific structure, EndNote (or similar structure), in the form of an electronic article:

(1) Author: IMDb (The definitive (English, French, German, Italian resource).
(2) Title: "Film: Swimming Pool 2003" [26]. In this case, it is the well-known (in English circles) key actress who is listed, rather than the film title and details.
(3) Person: Ludivine Sagnier [Людивин Санье][BG included
(4)

2. Observation on Significance of Wikipedia

One of the modern ways to ascertain the state/status of a key technology is to determine whether or not is has a significant article presence on Wikipedia. If it does have such a presence, then one further investigates the activity of the Wikipedia editors with respect to refreshing the text. What do the readers think about the article? For example, using our test case "Ahinora" we get…

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Intelligent Approach for Automated Error Detection in Metagenomic Data from High-Throughput Sequencing

Milko Krachunov[1], Maria Nisheva[1], and Dimitar Vassilev[2]

[1] Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria
[2] Bioinformatics group, AgroBioInstitute, Sofia, Bulgaria

milkok@fmi.uni-sofia.bg

Abstract. Metagenomics is a new, rapidly developing and largely unexplored field that is focused on the study of genetic material collected from heterogeneous environmental biological samples. Due to the nature of the data acquired from these samples, metagenomic research is very sensitive to the quality of the data. Sequencing errors can have a particularly large impact in studies dealing with rare mutations. Unfortunately, most error detection algorithms in NGS are intended for homogeneous datasets like those found in de novo genome sequence, and as such are not suitable for metagenomics without modifications. Our work is focused on the development of an improved error detection approach intended for metagenomics that is based on the use frequencies weighted by local sequence similarity, and the generalisation of the same measures for use in machine learning.

Key words: Metagenomics, Error detection, Artificial neural networks, Genomic sequence workflow

1 Introduction

1.1 Problems in metagenomics

Metagenomics deals with the study of mixed genetic material collected in samples of heterogeneous biological environments such as soils, water basins and the insides of various macroorganisms. The microbial communities in all these environments remain largely unexplored, presenting the researchers with both research opportunities and technical challenges. [12, 9, 10]

Comparative analysis of such microbial communities is crucial for the study of issues ranging from human health [7] to bacterial and viral evolution. [5] Results from metagenomic studies can have an effect on our understanding of the history of the biosphere as well as dealing with potential future threats. Micro-organisms are the most rapidly mutating agents in nature, which makes them the largest factor in unexpected disease outbreaks. At the same time, the rapid mutation rates provide an unique insight on evolutionary processes.

The sequenced metagenomic samples are comprised of digital data about a large number of organisms from a variety of species, a large portion of which are presently unknown or understudied. The data lacks any inherent reference points or a standard for validation, which further exacerbates the computational and methodological challenges associated with it, a large part of which are yet to find well-established solutions.

Error detection and correction is still one of the main problems, as reading errors are inevitable and the heterogeneous nature of the data makes the direct use of de-noising methods from high-throughput *de novo* sequencing very difficult. At present, researchers have to deal with these deficiencies in the quality, and often resort to the exclusion of any data that is suspected to contain errors. A software solution to reliably flag the potential errors, estimate their probability and correct them when possible will dramatically increase the useful data for many research studies, and will improve the quality in the rest.


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1.2 Our project and goal

The goal of our project is the development of a new error detection method suitable for metagenomic data. Like canonical de-noising and consensus sequence construction methods, we utilise the frequency counts of the different bases to estimate the possibility of an error at a given position. Unlike them, however, we introduce a measure of the local sequence similarity to account for the heterogeneous nature of the data, which can often contain distinct sequences coming from various species that are all sequenced correctly. The similarity can be used to distinguish between other instances of the same sequence, highly preserved homologous sequences and totally unrelated sequences.

We are working on two approaches to take local similarity into account. We have implemented a purely analytical method, which uses the frequency of each evaluated base weighted by a measure of the local similarity in a window around the evaluated position. We are also working to identify and summarize the information about sequence matches and local similarity used in this approach to construct an artificial neural network. Our work in progress is focused on splitting the match data into similarity bins which aim to provide a good trade-off between computational tractability and loss of relevant information.

The greatest challenge in the development of new error detection methods has been the validation. It is difficult to obtain a pristine metagenomic test data set that is representative of a real-world one, which makes direct validation difficult. To deal with this, we have proposed two methods for indirect validation of the results. One uses artificially simulated errors inside a two-phase procedure with repeated application of error correction, and the other uses a very large dataset and its subset. During preliminary tests, the validation procedures have confirmed the viability of our analytical approach.

The ability to apply them on freshly sequenced data makes these methods suitable not only for simple verification of the proposed analytical approach, but also for the training of an artificial neural network and machine learning solutions in general, which would be difficult if only small number of verification data sets were available.

In the development process, we are also working on a genomic workflow software package to help us with the neural network implementation and training, as well as be used for other metagenomic and genomic computational experiments.

The nature of genomic data, with its many unstructured relationships, makes the task of error detection a suitable one to apply and use machine learning algorithms, and in particular neural networks which can be used to infer the correctness of the data from the sets of data that are otherwise difficult to navigate.

2 Material and methods

2.1 The input data

16S RNA is very popular for metagenomic analysis, because it is highly conserved and thus largely similar across a great deal of species, while at the same time it contains hypervariable regions that are helpful for identifying distinct species, individual organisms as well as finding their evolutionary relationships. [11]

The sample datasets for our experiments contain short reads between 300 and 500 bases in length, divided in sets of tens of thousands of sequences between 20000 and 50000 after filtering them by length and quality. All our sample dataset were sequenced using the Roche 454 platform, which produces reads of length suitable for metagenomic experiments.

2.2 Analytical approach for error detection

After the data has been aligned and before it is ready for computational studies, reads or positions containing errors have to be filtered out to ensure high-quality results. To filter them out, sequencing equipment errors and biological errors during amplification need to be differentiated from mutations which can be found in correct reads.

An analytical approach to error detection is outlined below and described in more detail in [4, 3].

The naïve approach. A common approach to distinguish mutations from errors is to measure their frequency of appearance. Errors have a higher probability of being unique, while mutations will have either reproduced in other organisms or will appear in other reads from the same organism. This means that erroneous bases will be found at lower rates than mutations. The naïve way to use this is to count the rates of occurrence of each base in each column. The bases that appear less often than a threshold that was established beforehand can be considered errors.

To achieve this, we define a $\mathrm{score}(r, k)$ function that evaluates to the frequency of occurence of the base r_k from read r at position k in the remaining reads $R \setminus \{r\}$ in the set R.

To extend this to error correction, one needs to simply replace the bases deemed incorrect with the base that would get the highest score. The newly constructed error correction will be nearly identical to consensus construction during de novo sequencing or resequencing of genomes, which relies on always selecting the bases that appear most often. [14]

Similarity-based approach. The naïve approach is not suitable for a dataset containing multiple distinct organisms. To take into account the heterogeneous nature of the data and deal with such rare sequences and competing options, we propose an improved method that extends the naïve one. In our proposal, we will still count the frequencies of each base, but we take the context around each base into account by estimating the similarity between the sequence pairs.

Our proposal for similarity-based evaluation tries to give precendence to mismatches between similar reads over mismatches between dissimilar reads by making the importance of a mismatch proportional to the similarity. This similarity is calculated in a proximity of the evaluated position. These goals and the premise they were based on will be used as a starting point during the design of the artificial neural network described later in the article.

Fig. 1. Exponentially-decreasing similarity by position weight

We create a window around each evaluated position, and we calculate a similarity score inside the window for all $n(n-1)/2$ pairs of sequences. In the similarity, the positions away from the centre of the window are added with an exponentially decreasing position weight. This score is then used as a similarity weight during the calculation of a weighted frequency of occurence, getting the following "similarity" score:

$$\sum_{r=0}^{n,r\neq p} \overbrace{\left(\sum_{i=w_s}^{w^e, i\neq k} \underbrace{q^{|k-i|}}_{\text{position weight}} \frac{[r_i = p_i]}{W(i)} \right)}^{\text{similarity weight}} \frac{[r_m = p_m]}{N(r)} \tag{1}$$

The parameter q is experimentally evaluated, w is the size of the window, and $N(r)$ and $W(i)$ are normalizing functions ensuring that the respective sums would yield 1 if the nominators were replaced with 1.

To extend the similarity-based approach to error correction we can simply apply the score formula (1) for all potential replacement bases for the given position.

2.3 Approaches for error validation

As mentioned earlier, it is difficult to obtain a reliable test metagenomic dataset that is verified and that is a representative of a real set that would come out of the sequencing equipment. Machine learning in particular requires larger amount of test data which further increases this difficulty. To go around this difficulty, we are presenting two indirect methods for validation. The rationale for the need and choice of such roundabout methods is described in [4, 3].

Validation through repeated application approach. It is difficult to reliably simulate sequencing runs, but it is simple to simulate errors in a similar pattern to the ones that produced by the sequencing equipment. You can estimate the error patterns by sequencing sets of known sequences and comparing the sequenced to the known ones. We will call the record of this pattern an *error profile*.

Using simulated errors, one can indirectly validate an error detection approach and compare it against another. The goal to create a *better* error detection approach can be stated as the goal to create an error detection with *less false positives for the same amount of false negatives*. In other words, the better error detection approach should flag less correct data as incorrect under the settings with which it properly identifies the same number of real errors.

Given an error profile $\mathcal{E}$ and an error detection method φ we can use the similated errors for validation in the following way. We acquire a fresh dataset 0_e, correct it with φ, producing the corrected dataset 1. We artificially introduce errors according to $\mathcal{E}$, producing a second base dataset 1_e which we correct for a second time with φ to produce the final set 2. We evaluate the corrections done in $0_e \to 1$ and $1_e \to 2$, including the missed simulated errors in the latter.

This procedure yields two useful figures. If the error profile $\mathcal{E}$ is correct, the comparison between 1, 1_e and 2 gives an accurate estimate of the false negatives. The amount of missed simulated errors should be roughly the same as the amount of missed real errors. At the same time, the difference between dataset 0_e and dataset 1 gives you the total amount of corrections made.

These two figures can be used to indirectly measure and compare the false positives of two approaches. If the *better* approach under validation leads to the same number of false negatives yet makes less corrections overall, this means that the number of false positives must have also decreased, and indeed our *better* approach meets the goal to produce *less false positives for the same amount of false negatives*.

Validation through a subset approach. One difficulty in obtaining a test dataset in metagenomics is the difficulty in resampling the exact same sample again. If you could sample the same data over and over, you would end up with enough data to correctly identify all the sequences present. Similarly, if you have more data about a sample, the information that you have is closer to being confirmed than if you have less data. One way to estimate the reliability of an error detection would be to see how it performs with less data, if more data does not happen to be available.

2.4 Extending the analytical approach and validation to a neural network

The formulaic dependency between the data and the resulting error flagging decisions and the presence of many hidden factors in the input data that are difficult to asses make the problem suitable for exploring a solution using an artificial neural network. The largely unexplored sets of data with their many unknown relationships make the large inference capabilities of neural networks a very appropriate choice for a machine learning instrument. The very chaotic, tangled and unstructured relationships inside genomic data, are not always easy or even possible to map using analytical methods.

The availability of a validation method that can be applied to any sequenced dataset opens the possibility for training machine learning systems, in particular neural networks, to discover errors. To make use of this opportunity, we are working on the implementing a neural network design that extends the ideas on which our analytical approach is based.

Data input. To design a neural network that performs the task of error detection in a spirit similar to our analytical approach, we need to summarize the information for sequences in each column or window in a way that's both suitable for neural network input and retains the characteristics that are necessary to find the errors. If we provide too little input, our neural network would be doing little more than finding a threshold, if we provide too much input, we end up with a huge variable-input network that's both impossible to train and extremely unreliable.

Input generalised by similarity. Our reasoning thus far has been that two similar sequences are more likely to confirm each other than two different sequences. Directly applying this to our neural network design, we would split the match rate into bins classified by the rate of local similarity in the window. This, however, has a significant downside the measure for similarity won't be part of the machine learning, which would render the entire machine learning process much less useful.

Input generalised by similarity and offset. To account for this and make the similarity part of the learning process, we introduce match bins for the separate offsets as seen on figure 2. As our original measure for similarity was weighted by the offset, for each offset we provide three separate input bins for the similarity at that offset. The first three inputs contain the match rate (of the evaluated position) in sequences that have 0, 1 or 2 differences at offset 1, the next three inputs contain the match rate in sequences that have 0, 1, or 2 differences at offset 2, and so on.

This has the downside that the similarities at different offsets are now independent, and the neural network can't utilise information about chains of dissimilarity.

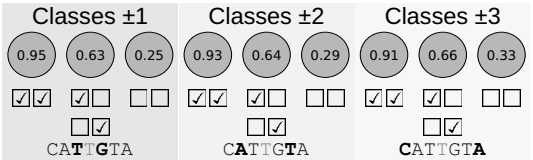

Fig. 2. Example neural network input

Non-standard topology If we look closely at (1), we can see that in our analytical approach we apply the same transformation on each independent window pair, and that our parameters are much fewer than the total input size as most inputs share the same parameters. This is unsuitable for making a summary as it would lead to the same input as the input generalised only by similarity, however it provides grounds to experiment with a neural network of a non-standard topology.

As such networks are neither supported by the neural network library we are using, nor are backed by solid theory, building one won't be our priority, but we will explore it as grounds for solving the issue with offset independence.

Cost function. Using the repeated application validation approach, we will be able to estimate when false negatives been produced by the neural network i.e. when the network does not flag an error that's already known to the validation procedure. This makes the creation of a cost function that penalises encountered false negatives straightforward. However, as we do not have any indication of false positives, we are forced to utilise an approximation that penalises any corrections at places where the validation does not identify any known error.

As we have only one output p which is an estimate for the probability of an error, we utilise

$$E(p) = \begin{cases} (1-p)^2, & \text{known error} \\ (p-p_G)^2, & \text{no known error} \end{cases}, \tag{2}$$

where p_G is the estimated global error rate.

Topology. Initially, we will use a feed-forward neural network with a single hidden layer and error back-propagation with mean squared error. The input layer will have $3 \cdot w$ neurons (w being the window radius, and 10 being the initial choice for w), $4 \cdot w$ hidden neurons and a single output neuron. As the input and cost function are settled, we will experiment with varying the rest of the parameters of the network.

2.5 Building the processing workflow

The preparation, de-noising, validation and neural network training steps described thus far can represent a part of parametric metagenomic workflows which describe computational experiments used, for example, for the confirmation of various de-noising procedures.

Often similar workflows can require on-the-fly changes, improvised modifications, which would often need to be performed by people who are not programmers. The availability of a tool for managing, running and distributing these workflows would greatly reduce the amount of manual work required to perform them, and might also help with tasks such as parallelisation.

We intend to wrap all utilised methods and middleware into a free software package that can be extended to a package aimed at the execution of such workflows.

An example of such execution is shown on figure 3, which is a slightly advanced version of the workflow presently utilised to process the data.

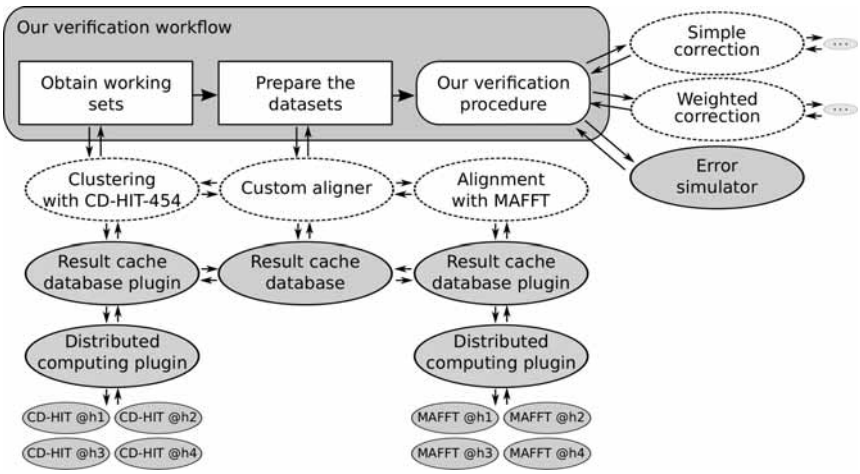

Fig. 3. Example workflow

3 Results and discussion

3.1 Experimental results

On a test run of 4540 sequences, we performed both correction with the similarity-based approach and correction with the naïve approach. The naïve approach produced 673 corrections, while the similarity-based produced only 607, or 66 less, which is a 10% decrease.

We then simulated errors using our estimated error profile, and then ran the error correction approaches again. As seen on figure 4 in the set initially corrected by the naïve approach, the false negatives were 34 for both, while in the set initially corrected by the similarity-based approach, the false negatives were 33 for both.

This result is consistent with our expectation for a decrease in the number of overall corrections for the same number of false negatives.

During the second correction we had a counter of the false positives as well. There were virtually no false positives on the set initially corrected with the naïve approach which is to be expected if you assume that it had already corrected all the correct data possible on the first run. The set initially corrected with the similarity-based approach had 67 new errors introduced by the naïve one the potential 66 false positives that it created on the first run, while only 18 new false positives were created by the similarity-based approach.

It is clear that more computational experiments are required for the comparison between the two approaches to be really significant, which is what our workflow library is intended to facilitate, together with the training of the artificial neural network that is being developed.

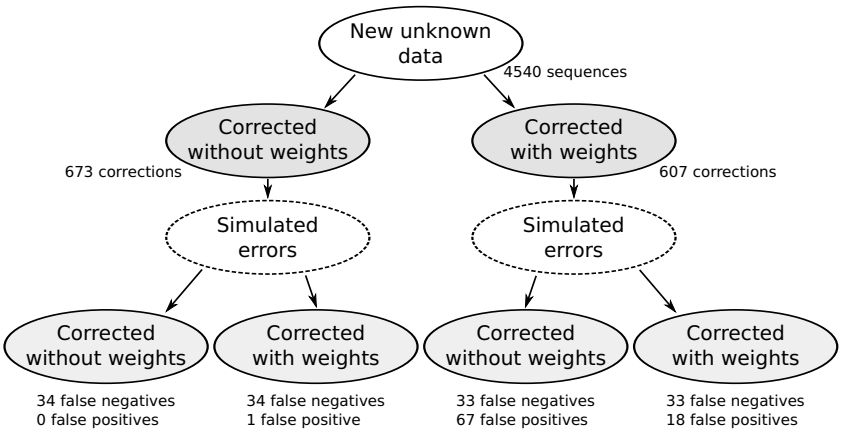

Fig. 4. Repeated application validation approach

The results from running the subset approach on small datasets proved to be inconclusive showing the need of much larger datasets.

3.2 Software package

The tasks of preprocessing, error detection and correction, validation, and neural network training are handled by a software package written in Python. The middleware that is used to start the tasks and execute external software is presently being rewritten to use the Twisted networking framework. [13]

For the processes of sequence clustering and alignment, the software package is interfacing with the CD-HIT-454 [6] clustering software. and the MAFFT [2] and MUSCLE [1] alignment software packages.

The neural network is being developed using the Python FANN library. [8] The YAML markup language is intended to be used for workflow descriptions.

4 Conclusions

The suggested method for improvement of error detection, during our experimental validation, showed results consistent with our expectations in case of an improvement in the quality. This would suggest that the use of sequence similarities is beneficial to error detection.

The core of the workflow library in development would allow the execution of multiple validation experiments that would lead to a more significant confirmation of this result. It will also provide the means for the training of an artificial neural network as another means to approach the problem of error detection. The neural network will also provide a comparison for the quality of the results of our analytical approach.

The nature of the data, being largely inter-related yet not well explored, as well as the need to define a formulaic dependence between the input data and the error determinations, make neural networks a suitable instrument to approach the problem.

The workflow library core can be used as a basis for a general-purpose workflow library that would have an useful utility in many metagenomic and other genomic computational studies.

Acknowledgements

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Semantic Digital Library with Bulgarian Folk Songs

Maria Nisheva-Pavlova, Pavel Pavlov, Dicho Shukerov

Faculty of Mathematics and Informatics, Sofia University St. Kliment Ohridski
5 James Bourchier blvd., Sofia 1164, Bulgaria
{marian, pavlovp, shukerov}@fmi.uni-sofia.bg

Abstract. The paper discusses some results obtained within the work on a project aimed at the development of technologies for digitization of Bulgarian folk music and building a digital library with Bulgarian folk songs presented with their music, texts and notes. This library provides digital preservation of the sound recordings, lyrics and notations of more than 1000 Bulgarian folk songs and tools for various types of search and analysis of the available resources. The presentation is focused on the main features of the discussed library describing it as a semantic one – the subject ontology especially developed for the occasion and its application in the implementation of a tool for intelligent search in the lyrics of songs.

Keywords: Semantic digital library, metadata, ontology, search engine, document retrieval.

1 Introduction

One of the most promising directions of research in Digital Libraries of late years is related to the development of semantic digital libraries.

Semantic digital libraries [1 – 4] are digital library systems that apply semantic technologies to achieve their specific goals. Ontologies play a major role to overcome the variety of problems caused by the structural differences of existing systems, the semantic differences of metadata standards and the necessity to support intelligent search and information retrieval tasks. Within the context of semantic digital libraries, ontologies can be used to:

- organize bibliographic descriptions;
- represent and expose document contents;
- share knowledge amongst users.

Ontologies are used in building *semantic annotations* of the information resources available on the Semantic Web.

The support of functionalities for *intelligent search* [5, 6], also known as *semantic search*, is one of the main features of semantic digital libraries. Ontologies play a key role in this kind of search.

Together with the considerable results within the last decade, the developers

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of semantic digital libraries and means for access to their content are still faced with a number of challenges. A significant challenge continues to be the provision of most precise and rich in content results of the user queries. A next serious challenge is the necessity of development of search methods and techniques which will be appropriate for sets of materials containing documents of different types and multiform content, available in various electronic formats. There are lots of open questions concerning the applicability of ontologies in building semantic search engines, some undecided personalization issues, etc.

The paper discusses some results of the activities within a project aimed at the development of technologies for digitization of Bulgarian folk music and building a semantic digital library (named DjDL) with Bulgarian folk songs presented with their notes, text and music. DjDL serves as a platform for digital preservation of the sound recordings, lyrics and notations of a multitude of Bulgarian folk songs and to provide adequate access to them. The emphasis of the presentation falls on the provided tool for semantic (ontology-based) search in the lyrics of songs.

2 Objectives

The discussed project is aimed at the development of methods, technologies and corresponding software tools intended to satisfy some of the IT needs of researchers of musical folklore in the fields of linguistics, ethnology, ethnomusicology, etc. To realize these objectives, an IT environment for digitization of music notations, especially adapted for the notation of Bulgarian national music, and a heterogeneous database with notations, lyrics and music have been developed [7]. The notations, texts and field recordings of approximately 1100 folklore songs from the Tracia region have been digitized [8].

The research activities of the authors of this paper have been oriented to:

- study of the key features of the domain and development of proper functional model of a digital library with Bulgarian folklore music;
- development and application of information technologies for building digital libraries, methods and tools for search (in particular, semantic search) in heterogeneous digital libraries.

As a result, a prototype of the semantic digital library DjDL was created. DjDL preserves Bulgarian folk songs presented with their notes, text and music and provides adequate access to the treasured digital content.

3 Main Characteristics of the Library Resources and Software Architecture of the Digital Library System

Currently DjDL contains a collection of over 1000 composite digital objects which represent a considerable part of the unpublished archive manuscripts of Prof. Todor Dzhidzhev.

The functional structure of DjDL is shown in Figure 1.

The library (metadata) catalogue consists of short descriptions in XML format of the folk songs included in the repository. As typical examples of metadata about folk songs we could mention: the title of the song, the song genre in accordance with different classification schemes, the region of folk dialect, the informant (the person who conveyed the song to folklorists), the folklorist who gathered the song, the singer(s), the date and place of record, etc.

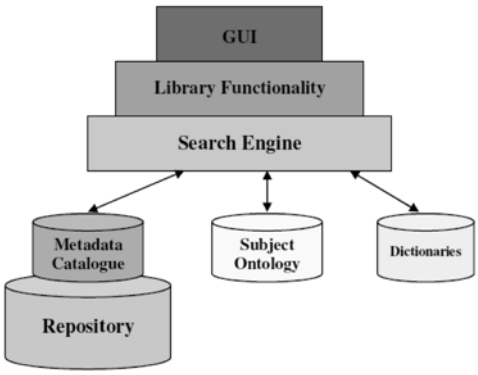


Figure 1. Functional structure of DjDL

The repository of DjDL includes composite digital objects which present Bulgarian folk songs. The single components of these objects contain respectively:

- the lyrics of songs;
- the notations of songs in the text format supported by LilyPond [7];
- musical (MP3) recordings of the authentic performances of the songs;
- musical (MIDI) files generated with the use of LilyPond from the notations of the songs.

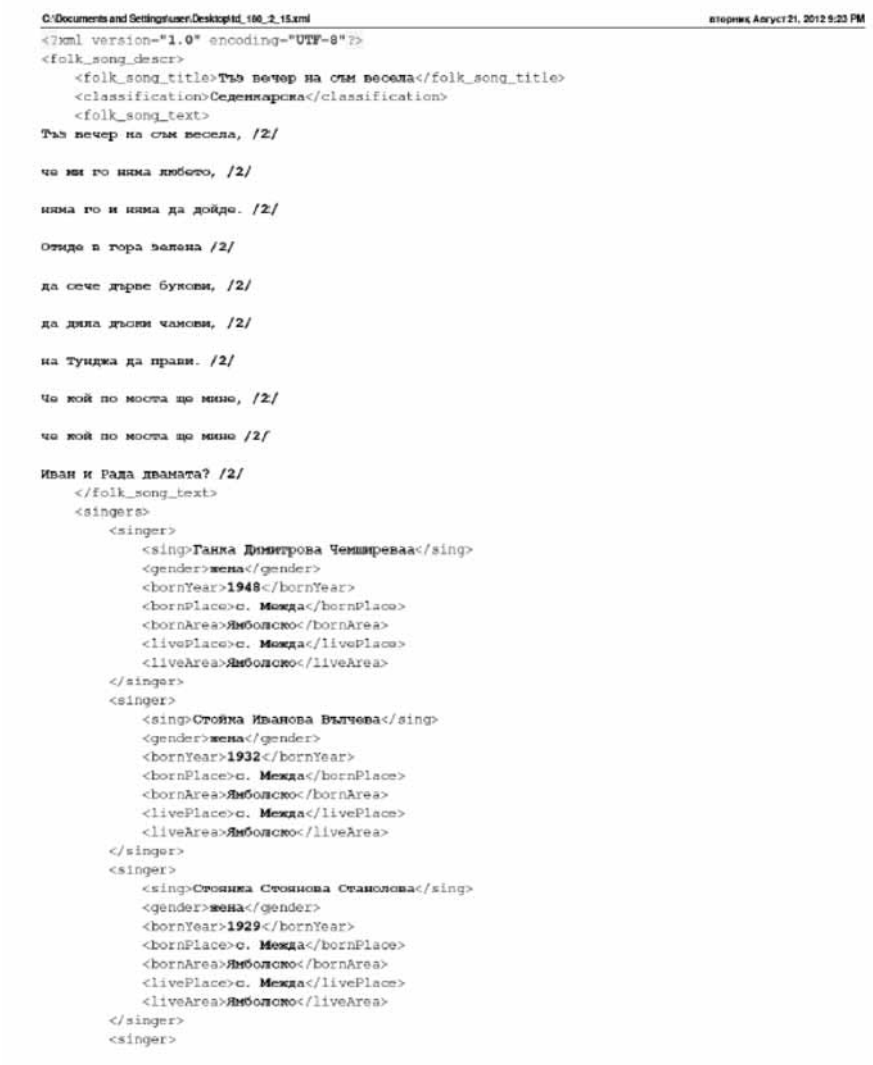
The subject ontology consists of several interrelated subontologies which play a significant role in the implementation of the full functionality of the search engine. It includes concepts of different areas relevant to the contents of the lyrics of songs, with description of their properties and different kinds of relationships among them. It plays a significant role in the implementation of the full functionality of the search engine.

The purpose of the search engine is to provide adequate access to the variety of resources stored in the repository of DjDL. Its current version supports two kinds of search in the lyrics of songs: keywords-based and semantic search. The search engine of DjDL also uses two proper dictionaries available in digital (XML) format – a dictionary of synonyms and a dictionary of obsolete and dialect words.

4 Metadata and Catalogue Descriptions

The set of metadata about folk songs used in DjDL was determined in accordance with the requirements of some international standards (the Text Encoding Initiative (TEI) and the Encoded Archival Description (EAD)) and classification schemes in combination with the characteristics of the national tradition. According to the EAD standard, each catalogue entry contains the text (i.e., the lyrics) of a particular song accompanied with the corresponding metadata.

Figure 2 illustrates the catalogue description of a song performed by a group of three singers.



C:\Documents and Settings\user\Desktop\fd_100_2_15.xml вторник, Август 21, 2012 9:23 PM

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<?xml version="1.0" encoding="UTF-8"?>
<folk_song_descr>
    <folk_song_title>Тъв вечер на съм весела</folk_song_title>
    <classification>Седенкарска</classification>
    <folk_song_text>
Тъв вечер на съм весела, /2/

че ми го няма любето, /2/

няма го и няма да дойде. /2/

Отиде в гора зелена /2/

да сече дърве букови, /2/

да дяла дъски чамови, /2/

на Тунджа да прави. /2/

Че кой по моста ще мине, /2/

че кой по моста ще мине /2/

Иван и Рада дваната? /2/
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    <singers>
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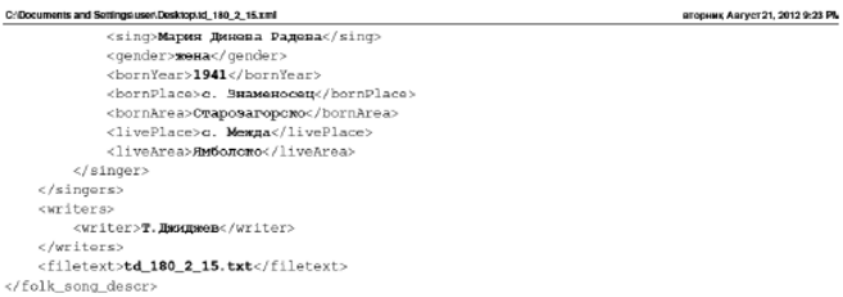

Figure 2. Catalogue description of a song performed by a group of singers

In conformity with their thematic focus, the songs are divided to three groups according to [9]:

- ceremonial songs;
- festal songs;
- labour songs.

The catalogue description of a given song contains also the available data about the date and place of its field record and the corresponding data about the singer (each particular singer): her/his name, gender, year and place of birth, migration, residence, etc. The appropriate data about the informant(s) and some technical data about the files with the notation and musical (MP3 and MIDI) recordings of the song are included as well.

It is possible to include as values of particular elements of the catalogue descriptions some informant's notes with explanations of various circumstances concerning the field recordings and short dictionaries of unknown words heard in the lyrics of songs or used by the singers.

5 Subject Ontology

The subject ontology describes a proper amount of knowledge in several domains, relevant to the lyrics of Bulgarian folk songs (with definitions of the main concepts, their properties/relationships and representative instances). It consists of several interrelated subontologies needed by the search engine of DjDL and developed especially for the occasion:

- ontology of folk songs – includes various genre classifications of folk songs (e.g. by their thematic focus – historical, mythical, etc.; by the context of performance – Christmas folk songs, harvest songs, etc.; by their cultural functions – blessing, oath, wooing, etc.);
- ontology of manner of life and family (clothing, professions, instruments, typical places, ties of relationship, feasts, traditions and rites, etc.);
- ontology of impressive events and natural phenomena;

- ontology of social phenomena and relationships (exchanges/transactions, elections, unrest, etc.);
- ontology of historic events;
- ontology of mythical creatures and demons;
- ontology of administrative division – combines the current administrative division of Bulgaria with the one from the beginning of XX century.

Most concepts of the subject ontology are constructed as defined OWL classes, by means of necessary and sufficient conditions defined in terms of proper restrictions on certain properties.

The properties "synonym" and "form" provide the search engine with suitable synonyms and grammatical forms of the terms used as names of ontology classes.

The folklore lyrics uses lots of similes, metaphors, embodiments, idioms and other sophisticated or language-dependent stylistic devices. Therefore it is expedient to combine the use of proper ontologies with other Artificial Intelligence tools to provide more adequate support for the semantic search.

In this sense we defined a set of proper patterns of typical stylistic or thematic constructs that can be matched with relatively large parts of the texts of folklore songs and have certain meaning as e.g. an expression of "unfaithfulness", "jealousy", "discontent", "sedition", etc. We call them *concept search patterns*. A set of special symbols that may be used in these patterns and the corresponding pattern matching rules were defined as well.

For example, the pattern

<< друг$? <любим_а> $? зал?б$? >>

matches successfully a number of phrases like "друго либе залиби", "друго любе залюби", "друго любе жъ залюбя", "друго либе шъ залюбиш" etc., that are oftentimes used in the lyrics of folk songs to express real or possible or future love infidelity. Therefore it may be considered as a search pattern of the concept "love infidelity". Here "?" and "$?" are used as wildcard symbols (the question mark "?" matches any letter at the corresponding position and the symbol "$?" matches any corresponding sequence of zero or more letters) and the angle brackets "< >" enclose the name of an ontology concept (the concept "любим_а" in the subject ontology means "beloved" in English).

6 Search Engine

The search engine of DjDL supports two main types of search: keywords-based and semantic (ontology-based) search. Its current version realizes some facilities for search in the catalogue metadata and the lyrics of songs only. The design of this search engine is based on some results and ideas from [10]. The functionalities supported at present were specified after a careful study of the requirements of the typical user groups (specialists and researchers in ethnomusicology and verbal folklore, philologists, etc.) [9].

6.1 Keywords-based Search

The user queries for keywords-based search contain arbitrary numbers of words or phrases that are searched for in the lyrics of songs and/or in the catalogue metadata. The user is asked to specify the proper logical connectives between these words or phrases: conjunction (and) or disjunction (or). The user also indicates the search source(s) – search in the lyrics of songs, search in the metadata or combined search in the lyrics of songs and catalogue metadata.

As a result of the user query processing, a list of links to the discovered catalogue files with metadata and lyrics of songs has been properly displayed. This list may be ordered according to various criteria. When the user clicks on the name of a chosen song, the text of this song is displayed in a new window. An access to the preserved musical (MP3 and MIDI) recordings of the corresponding songs has been given as well.

As typical examples of queries for keywords-based search one may indicate the following:

- search and retrieval of songs whose lyrics contain specific words or phrases;
- search (and retrieval) of songs with distinct thematic focus or context of performance;
- search of songs performed by a given singer;
- search of songs performed/recorded in a particular settlement;
- search of songs performed by singers from a given place.

6.2 Semantic Search

Currently the semantic (ontology-based) search tool in DjDL can process only "atomic" user queries containing single words or phrases. The user defines the particular query and indicates the search sources (the lyrics of songs or specific metadata). The search engine provides a set of additional facilities for augmentation of the user queries – automatic query reformulation according to the available explicit domain knowledge (the subject ontology and the dictionaries mentioned in Section 3). The user may refine the resulting augmented queries. When possible, proper concept patterns are applied during the search process.

The most considerable knowledge source for augmentation of the user queries is the taxonomy (the *is-a* hierarchy) of concepts/classes which serves as the basis of the subject ontology. During the augmentation of the user query, first of all an exhaustive breadth-first search in the graph representing the "is-a" concept hierarchy is performed, starting from the node which corresponds to the original user query. The names of the visited nodes that are in fact the respective more specific concepts included in the ontology, are added to the one given by the user. The resulting list of concepts if properly visualized and placed at user's disposal for further refinement (see Figure 3).

Within the next step of query expansion, the search engine adds to the newly constructed set of queries some derivatives and synonyms of the main terms found as values of their "form" and "synonym" properties in the subject ontology or found in the available dictionaries. The corresponding property values from the definitions of all concepts included by that time in the expanded user query and the existing instances of these concepts are added to the query as well. Finally, the values of such properties of the newly included instances that have been explicitly specified as significant for their classes with respect to the semantic search, are included in the resulting augmented query (an example in this sense is the property "participants" of the instances of "historic event").

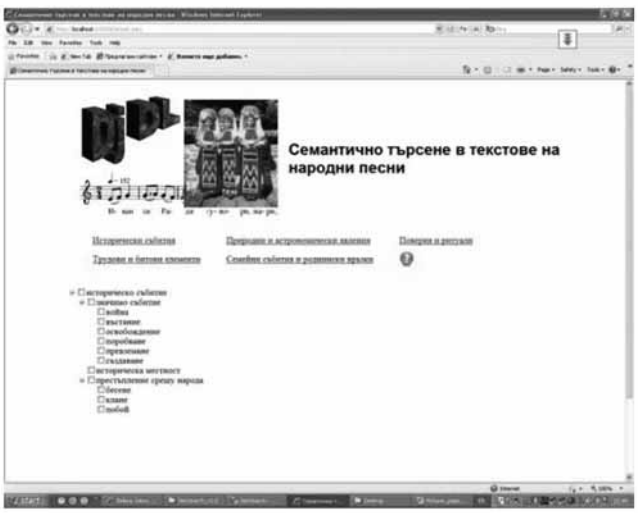

Figure 3. Construction of a user query for semantic search (step 1) [11]

Thus the user query is augmented as far as possible in terms of the subject ontology and in fact it has the shape of a disjunction of all included forms of concepts and instance names. In this form the resulting query is ready for further refinement (see e.g. Figure 4) and processing.

If the search activities have been realized in the lyrics of songs and there is a concept in the augmented query provided with appropriate search pattern(s), the pattern matching module performs an additional search for each of these patterns. Figure 5 illustrates some search results for a user query containing the phrase "love infidelity".

As example queries for semantic search being of interest for folklorists (according to [9]), that can be executed by the search engine of DjDL, we could indicate the queries for search and retrieval of:

- songs devoted to (or mentioning) significant historic events;
- songs in which exciting natural or astronomical phenomena are described or mentioned;

- songs in which typical (or typical for a certain region) folk beliefs or rites are described;
- songs in which elements of country work and life are described or mentioned;
- songs in which significant family events or human relations are mentioned.

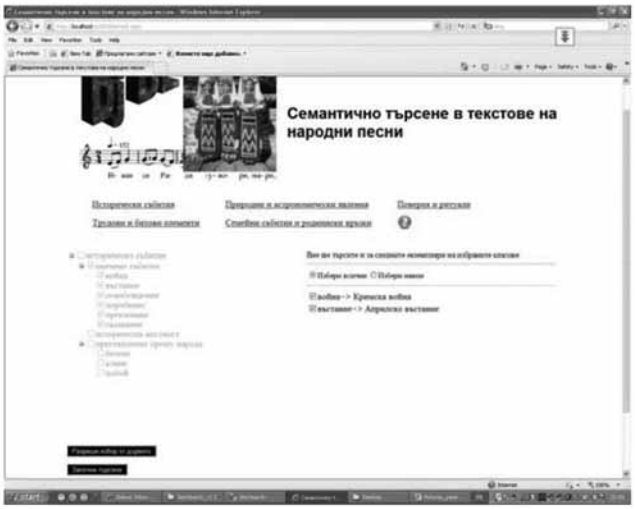

Figure 4. Construction of a user query for semantic search (step 2) [11]

Figure 5. Search results for a user query containing the phrase “love infidelity”

The search engine of DjDL [11] provides also some facilities for processing of user queries presuming examination of equality or specific types of inequality. For example, it is possible to formulate and execute queries for search of:

- songs performed alone/in a group;
- songs performed by men/women only;
- songs performed by one and the same singer;
- songs performed by singers, born in one and the same settlement or region;
- songs performed in settlements to the west/east/north/south of a specific settlement/region;
- songs performed in one of the same region (grouped by regions of performance).

Let us suppose for example that the user defines a query for semantic search in the lyrics of songs which concerns the concept "historic event" ("историческо събитие" in Bulgarian). During the execution of this query, first of all it is augmented and refined with the assistance of the user as shown on Figure 3 and Figure 4. Then a consecutive search in the catalogue descriptions of songs follows. As a result, all documents with <folk_song_text> element values containing phrases that are juxtaposed with at least one element of the augmented user query, are extracted. A list with the titles of the discovered songs is properly visualized on the user screen (see Figure 6).

Figure 6. Search results for a user query containing the phrase "historic event" (level 1)

When the user clicks on the name of a chosen song satisfying the augmented query, the text of this song is displayed in a new window. The discovered words and phrases that match (are semantically related to) the query, are highlighted.

Figure 7 shows some search results for the example user query containing the phrase "historic event".

The search engine of DjDL holds up some additional functionalities which enable the user to combine the search and retrieval of documents with a kind of sentiment analysis of their texts. For that purpose some of the subject ontology classes are associated with proper positive or negative numbers which play the role of sentiment estimates of the corresponding concepts.

The sentiment of a song is currently defined in accordance with the sum of the sentiment estimates of the particular words in the lyrics of this song (see Figure 8). The specializations of ontology concepts and all their forms and synonyms inherit the sentiment estimates of the corresponding concepts.

Figure 7. Search results for a user query containing the phrase “historic event” (level 2)

Figure 8. Some results of semantic search in combination with sentiment analysis

7 Conclusion

We presented in this paper an approach to the implementation of a tool for semantic search and document retrieval in an academic digital library that corresponds to most requirements and expectations of the typical users of this library.

Our current activities are directed to evaluating the performance of the search engine of DjDL (in particular, computing a tentative value of its average precision)

The next step will be to extend the functional facilities of the search engine with a proper tool for semantic search and knowledge discovery in the notes of songs. The main goal in this direction will be to build a software tool supporting the further study of some musical characteristics of Bulgarian folk songs (e.g., their melodies and rhythms) with the aim to discover similarities of songs according to various criteria.

In this way the final version of DjDL will be developed with the aim to provide a complete set of tools which will be useful for a series of further studies in folkloristics, philology and musicology.

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Knowledge Representation in High-Throughput Sequencing

Ognyan Kulev[1*], Maria Nisheva[1], Valeria Simeonova[1], Dimitar Vassilev[2]

[1] Faculty of Mathematics and Informatics, Sofia University, Bulgaria

[2] Bioinformatics group, AgroBioInstitute, Sofia, Bulgaria

*Corresponding author: okulev@fmi.uni-sofia.bg

Abstract. Bioinformatics emerges to be a very important circle of tasks for the contemporary high-throughput genome sequencing. The next generation sequencing (NGS) technologies produce at high speed enormous amounts of data that cannot be processed manually in a reasonable time. For these reasons, automatic approaches for NGS data analyses are mostly required and welcomed by the biological society. On the other side, custom designed bioinformatics applications comprising methods and software solutions for NGS data analysis are elaborated very often for the purposes of different tasks and projects.

The major task in high-throughput sequencing technologies and the conducted bioinformatics is the detection of different type of mutations. This is a vast and new space for research and development and has also certain technological limitations. This large pool of tasks including NGS data noise detection, and mutations assessment makes possible the utilization of artificial intelligence techniques application, appropriate for the processing of such data.
Knowledge representation is a domain of artificial intelligence that allows inference and reasoning over data. The use of knowledge representation in NGS bioinformatics is an objective of this study. The particular tasks of the study comprise the possible file formats, their convertibility, and the possible use of ontologies as an advantage and potential opportunity for automatic annotation. The complex and tangled data of next generation sequencing as well as its multi-level nature bear the beneficial application of ontologies in analysis of such data.

Keywords: knowledge, knowledge representation, ontology, file formats, bioinformatics, next generation sequencing, high-throughput sequencing.

1 Introduction

High-Throughput Sequencing technology produces vast amounts of raw data and the burden of processing them and getting meaningful biological results is a real challenge for bioinformaticians. Analysis of genome sequencing data is a multi-step process and these activities of steps that depend on each other are methods and protocols that continuously refined and developed. In high-throughput

sequencing (HTS), at the starting end of bioinformatics software pipelines are millions of short reads (each 50-200 nucleotide bases) of a genome. At the other of the pipeline, the output is usually annotation of the genome instance under study. All recognized regions of the genome instance are annotated with metainformation what genomic feature they represent.

The major phases of processing that data are: error detection, alignment (mapping), assembly of this large "space" of pieces (short reads), variant calling (specific sites detection), annotation and visualization. The most important result is variant calling – annotation of differences between individual genome and reference genome or detection of new sites in *de novo* sequenced genomes.

Next generation sequencing (NGS) allows retrieving genome data at high speed and changed significantly the way genome research is conducted. While this provides vast amounts of data, it added new challenges in processing these data. First, not the whole genome sequences are provided but many short reads at random locations. These short reads may contain errors and this have to be taken into account. By aligning all short reads and using methods from statistics, suspicious short reads can be removed from subsequent processing.

Assembly of short reads used for constructing long contiguous sequences called contigs. Since there is no metainformation in short reads about their location or relation to other short reads, the only way to construct longer sequences is by searching for overlaps between short reads. These overlaps build a graph between short reads and by traversing the graph, contigs can be built. This is not as easy as it seems because this specific problem is NP-complete and requires a lot of memory. Assembly is a real computational challenge in NGS data analysis.

The most common way of getting representation of studied genome is by mapping short reads onto reference genome for it species. Naturally there will be many small mismatches in mapping but these variants of the genome are important in sequencing. The process of finding these variants is called variant calling and it is followed by the process of annotation. Genome annotation deals with description of biological meaning concerning the structure, function and variants in assembled genome sequences.

The amounts of data generated from HTS are enormous and analyzing it requires a lot of storage and computational resources. Thus algorithms efficiency and information technology play a crucial role. They are only one of the pillars of modern bioinformatics though. The second pillar is statistical and heuristic methods for scoring, evaluating, predicting and validating. The third pillar is the new advancements in artificial intelligence and all connected computer sciences like data mining and machine learning. The software solutions for all these methods for NGS data analysis are practically implemented in a large number of separate tools or managed in processing pipelines.

The application of machine learning techniques for data mining purposes recently increase its obvious potential of direct application for annotation and in particular for extracting and presenting knowledge from biological HTS data. The extraction of new knowledge from potentially large biological datasets often calls for automated techniques that aim to find new structures, or important connections between different entities. Data mining and machine learning techniques are ideally suited to extract such knowledge for specific biological and bioinformatics tasks. A recurring aspect of machine learning based data mining techniques is the ability to gain more insight in the underlying processes by examining important features, and their relations in the scope of efficient annotation and generation of new knowledge.

In previous studies and practices, a lot of efforts have been applied in the context of gene prediction and genome annotation, incorporated in expert systems for *ab initio* gene prediction, and developing predictors that can identify the major functional elements of a gene. Recent advances in genome sequencing, such as the next generation sequencing technologies are now revolutionizing the field of genome annotation. These new techniques call for new approaches to gene prediction, and new intelligent systems for genome annotation. Among the major tasks related to these new sequencing technologies in the scope of the rapid development and application of AI methods the efforts are oriented towards development of scalable machine learning techniques that are able to generate knowledge from these huge amounts of sequence data.

More recently, data mining and machine learning techniques have been identified as key components in systems biology, where data mining is both used for knowledge discovery in identifying single components, as well as connecting different components through data integration. An interesting new development in the integration of different types of data comes from the application of data and text mining techniques to the scientific literature. Therefore the major role of the implementation of machine learning techniques in next generation sequence data analysis pipelines is focused to generation of knowledge from gene prediction, automated annotation and text mining.

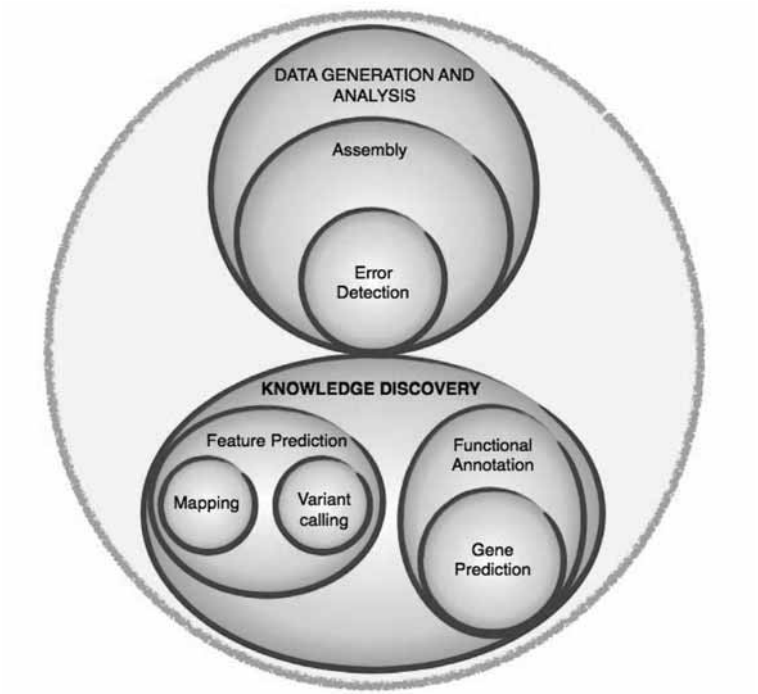

Fig. 1. Data analysis and knowledge discovery in bioinformatics.

2 Information features and file formats

The implementation of machine learning techniques for knowledge discovery in the analysis of HTS data has contributed the importance of the use of ontology for annotation purposes. It was recognized early that it will be beneficial for machine processing to have ontology for genomic features.

Annotation needs ontology in order to be useful for any machine processing and to allow interoperability between software systems. All recent developments in annotation representation use ontologies to describe genomic characteristics. Major ways for storing annotations are relational databases, XML files and text files. Since the beginning of bioinformatics, text files are used for representing data and they are still the most frequently applied. Simple and complex machine processing of annotation is easy with text files and they are very suitable for manual modification using simple text editors.

The Gene Ontology Consortium was established in 2000 as a collaborative effort to address the need for consistent descriptions of gene products in different databases and since the beginning it was decided that just using controlled vocabularies (ontologies) is not enough [1]. Gene terms are described in their

relationship and form complete ontology in the field thus allowing reasoning over gene data. There are three separate aspects to this effort: first, the development and maintenance of the ontologies themselves; second, the annotation of gene products, which entails making associations between the ontologies and the genes and gene products in the collaborating databases; and third, development of tools that facilitate the creation, maintenance and use of ontologies. Annotation data is submitted to the GO Consortium in the form of gene association files, or GAFs. This file format creates a background for determining a necessary standard for information specification concerning both the databases relations and the annotation extension which implicitly leads to a platform for presenting a new annotated knowledge.

2.1 File Formats for genome annotations

Generic Feature Format (GFF) is text file format for universal genome sequence annotation. Due to its popularity, several incompatible versions made by different bioinformatics groups gained traction. Ultimately, GFF version 3 (GFF3) by Sequence Ontology Project [2] became the most widely used for new projects. Using ontology is one of the major features of GFF3 and certainly one of the main reasons for the success of GFF3. Structural annotations can be precisely described using GFF3 but there are still weaknesses in variant calling representation. Genome Variation Format (GVF) is an extension of GFF3 that address this issue and allows all visualization and other processing software that accepts GFF3 to also work on GVF [3].

GVF format is text file with nine tab-delimited columns in each line. Chromosome identifier is in the first column, source (application or algorithm) is the second, and type of sequence alteration – in the third. Reference sequence is not in the GVF file but is referenced using chromosome identifier (column 1) and region (columns four and five that contain start and end position of the annotated region in reference chromosome). Column six contains score value but GVF specification doesn't specify semantics of this number, only recommends Phred quality score to be used [4]. Column seven is strand ("+" for forward or "−" for reverse) on the chromosome, if this is applicable, or just ".". Column eight is legacy from GFF that is not used in GVF and should be ".". Column nine contains the annotation and is represented as a list of tag/value pairs separated by ";" character. Tag name and value are separated by "=" and multiple values can be separated by ",". An example of simple SNP annotation follows, where the ninth field is split into multiple lines for clarity.

```
chr16 samtools SNV 49291141 49291141 . + .
 ID=chr1:SOAP:SNV:15883;
 Variant_seq=G,C;
 Reference_seq=C;
 Genotype=heterozygous;
 Variant_reads=17,16;
 Total_reads=33;
 Dbxref=dbSNP_137:rs77417897;
 Variant_effect=nonsynonymous_codon 0 mRNA NM_345,NM_210;
```

Reference sequence in this region of one nucleotide base is "C" and in annotated genome at this place there are two variants "G" and "C". The first is supported by 17 short reads while the second is supported by 16 reads, totaling in 33 short reads that cover this location. Database reference to an entry that describes the variant is provided with "Dbxref" tag. The effect of this variant is encoded in the last tag using Sequence Ontology terms and references to other data. ID is a required tag in the ninth field. Many other kinds of annotation are possible with GVF.

Variant Calling Format (VCF) is an alternative to GVF. It was developed by 1000 Genomes Project for representing human genetic variations and it is usually used only for human genome [5]. Major difference with GVF is that descriptive terms don't use ontology thus limiting the usefulness of the file format.

Chado [6] is a relational database schema for representing bioinformatics data, including annotation data. Representation of biological knowledge is one of its design goals. Many utilities and application programming interfaces are included to aid in utilizing Chado databases. It's a part of Generic Model Organism Database (GMOD) project [7] that also develops the GVF file format. Chado database employs the subject-predicate-object triple pattern as used in RDF but it is less generic and triples may include additional information thus it's not as strict as RDF.

In table 1, the most frequent file formats used in genome sequencing studies are shown. They could be specified in two groups: as (raw) sequence formats (FASTQ, FASTA, SAM/BAM) and annotation file formats (GTF, BED, GFF, GVF, OBO). These formats are related mainly through the idea of presenting new knowledge from the NGS data.

File format	Function	Application	Relation to other formats
FASTQ	Contains short reads	Sequence machines output FASTQ files that contain short reads and base quality scores.	NGS pipelines start with this file format or FASTA.

FASTA	Contains nucleotide sequences	DNA sequences without annotation.	NGS pipelines start with this file format or FASTQ.
S A M / BAM	Mapping of reads	Result of mapping short reads onto reference genome. Doesn't contain sequences, only location and CIGAR (transformation description for reads).	Short reads are in FASTA or FASTQ format. Reference genome is in FASTA.
GTF	Gene locations in reference genome	Auxiliary file used in differential expression analysis.	Simple annotation needed for counting reads by genes.
BED	Sequence annotation	Defining regions in annotation track in visualization of genome.	Annotated sequence is in FASTA.
GFF3	Genome annotation	Representing structural annotation using Sequence Ontology.	Annotated sequence is in FASTA.
GFF2	Genome annotation	Representing structural annotation.	Older version of GFF3 that doesn't use Sequence Ontology.
GVF	Representation of sequence variants	Result of variant calling analysis.	Extension of GFF3.
OBO	Ontology representation	External controlled vocabulary for software.	Sequence Ontology and Gene Ontology are represented in OBO.

Table 1. File Formats.

Software tool	**Web address**	**Description and features**
AUGUSTUS	http://bioinf.uni-greifswald.de/augustus/	Fully automatic annotation pipeline for genome-wide gne predictions
EUGENE	http://eugene.toulouse.inra.fr/	Gene prediction with ability to integrate arbitrary sources of information
GeneID	http://genome.crg.es/software/geneid/	Fast and accurate gene prediction
GLIMMER	http://ccb.jhu.edu/software/glimmer/	Microbial gene finder
mGene	http://mgene.org/	Genome-wide prediction of protein coding genes
SNAP	http://www.broadinstitute.org/mpg/snap/	SNP annotation for human genome

Table 2. Gene finders.

The main spread of software tools for annotating of genome sequencing information are listed in Table 2. The have different aims and features – definitely the general

purpose is the generation of new knowledge from the analyzed HTS data based on automated annotation of newly discovered and predicted structures of genomic information. These software tools are not related directly to the generation of knowledge by the methods of machine learning. The new generation software solutions with similar functional objectives will be based on the use of upgraded data formats able to provide more suitable environment for the development of the specific custom designed software tools for extracting and presenting new knowledge from HTS data analysis.

3 Extracting and presenting knowledge from HTS data analysis

The potential of representing sequence annotation using ontology is still heavily underused. By not using hard-coded feature list but ontologies instead, software systems can offload importing and maintaining terms. Moreover, it allows true interoperability with other software that uses standard ontology. Even if other software doesn't use the same ontology, one of the important properties of ontologies is that there are software tools for automatic mapping between ontologies. Another beneficial outcome of using ontology instead of feature list is that adding new terms to ontology and using these terms in new annotations does not affect old software. When unknown term is detected, it may gracefully be degraded into more general term that is understood by old software and results to still be sensible. Here the role of soft computing in terms of using different algorithmic solutions for extracting knowledge from HT sequencing is much promising. The recent achievements in pipelining of NGS data analysis is providing a real challenge for integration of different algorithmic methods and their software implementations in a common environment for knowledge based analysis. The developing of correct method and its software solution for extracting, presenting and generating knowledge from HTS data is quite not a trivial task and a lot of problems could arise in getting the right answer. As regards the specificity of the certain tasks comprising the knowledge discovery by annotating new data from the large genome studies, the role of data mining and related problems are of crucial importance. The possible application of AI methods is an obvious solution of such problems.

More general problem than handling an unknown term is metric for similarities of terms that can be used in search queries. It is helpful to have inference rules between ontology terms and even procedural knowledge for high-throughput sequencing domain. Although in artificial intelligence there are many methods for representing such knowledge, there are no bioinformatics databases that can be used in such way.

Representing sequence variants is only the first step in generating knowledge for a genome. Variants are interconnected and there are large differences in

significance between individual variants. Selecting variants for grouping and interpreting the meaning of specific combination is a challenging task that is usually performed manually by biology specialists. It is a tedious and very time-consuming work that can be greatly sped-up by using methods from the field of artificial intelligence. There is a lot of research in using these methods but application to bioinformatics domain is still lacking.

The functionality of integrating such methods is given in a general sense in Figure 2. The presented relations and interceptions of integration of different algorithmic methods and IT solutions can provide a platform for updating the already existing and developing new methods for knowledge discovery from the NGS data.

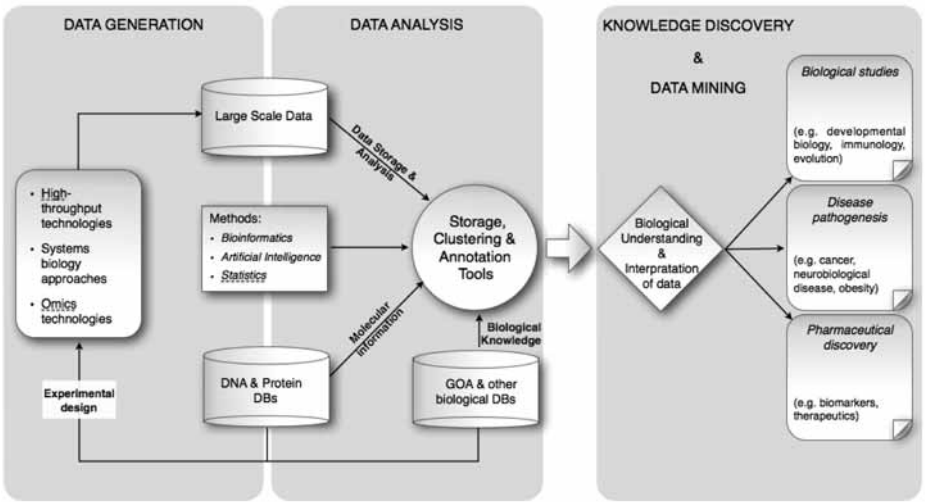

Fig. 2. Knowledge discovery in NGS data.

4 Future Trends and Conclusions

The future trends in the elaboration of contemporary methods for knowledge representation and discovery in HT genome sequencing research can be regarded in several aspects:

- the use of more advanced and custom-oriented technologies for HTS data analysis in the scope of developing suitable formats for building semantic vocabularies (ontologies) and annotations of newly discovered and predicted genome information;

- the direct and integrated use of machine learning methods for prediction, annotation and validation of newly sequenced genomic information;

– upgrade and integration of the existing information resources and software tools for discovery, prediction and annotation of sequence information;

– use of soft computing for elaborating a flexible set of algorithmic solutions and software tools for the purposes of presentation of knowledge from the growing mass of HT genome sequencing information.

As a major outcome from our work it could be concluded that the raw NGS raw data currently are aimed to be processed in a specific environments like customized software pipelines in order to handle the major operational steps of the analysis (error detection [8], assembly, alignment, variant calling [9], annotation, structural and functional discovery. All this workflow necessary for the analysis of HTS data can be upgraded by new methods of extraction, presentation and generation of new knowledge.

Variant calling is the process of finding differences between genome sequences and reference genome sequence. Exactly how these variants affect phenotype is a complex task with no definite answers. Statistics is not enough since we are not just judging by scoring and numbering but we really have a complex knowledge base that have to be taken into account. Artificial methods are developed precisely for such situations but are still underused in bioinformatics. We have shown the bioinformatics tools are starting to be directed towards use of ontology-based data bases that have potential for utilizing AI methods. Although bioinformatics knowledge representation is firmly entrenched into modern bioinformatics pipeline, inference and reasoning based on bioinformatics knowledge bases is still in infancy.

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Model of Knowledge Management System for Improvement the Organizational Innovation

Natasha Blazeska-Tabakovska[1], Violeta Manevska[1]

[1] Faculty of Administration and Information Systems Management
University"St. Kliment Ohridski"
Bitola, Republic of Macedonia

Abstract. Organizations consider the knowledge as a very important resource in recent years, so they have been using a different information technologies and techniques in aim to improve their knowledge management processes in terms of effectiveness and efficiency. This results with a competitive advantage. Some information technologies and techniques don't lead to the preferred effects. This paper analyses the influence of the model on the one organization effectiveness criteria, the improvement of the number of innovation.

Keywords: knowledge management, knowledge management system, information technologies, information techniques, organizational innovation

1. Introduction

Some of the trends, as globalization of the economy, changes in organizations working environment today, large amount of information in decision-making on the one hand and dealing with large amounts of information on the other, and the fluctuation of employees, impose the need for a different way of managing the organization and its processes.

Today organizations puts their focus on organizational knowledge rather than on material resources and increase their efforts to maximize knowledge utilization in order to cope with global trends, improve its business processes, make effective decisions, improve the quality of their products/services and increase their effectiveness. The successful management of organizational knowledge leads organizations one step further in their work and it is an important factor in gaining and maintain a competitive advantage. According to Liebowitz knowledge management "is the process of creating value from intangible organizational capital" [Liebowitz, 1998]. In most cases the goal of knowledge management is to combine customer knowledge and processes knowledge (know-how). Knowledge management focuses on several key elements: acquiring new knowledge from external sources; generating new knowledge in the organization; standardizing of existing knowledge in the form of procedures and protocols; transforming individual knowledge into collective; facilitating its use and its incorporation in business processes. It is a complex activity consisting of many processes. According to Alavi and Leinder [Alavi & Leidner, 2001] knowledge management consists of four processes:

(1) Capture and Creation
(2) Storing / retrieval
(3) Transfer
(4) Application

These processes can be facilitated and supported by various information technologies and techniques. Various information technologies and techniques applied in order to support knowledge management processes gives a different effects in improving various indicators of organizational effectiveness. Dimitrov points the need of the information technologies to be result of the business processes and to understand business terminology. This new method will prove their value and meaning, giving the desired business results [Dimitrov, 2012]. Some of the benefits are immediately visible, others are perceived with its long-term use. Some of the benefits are: increased innovation by encouraging the free flow of ideas, improved customers services, retention of employees by recognizing their knowledge through their reward, improved operations and reduce their costs by eliminating the required procedures. This paper proposes a model and analyzes the impact of the proposed model on increasing the number of innovations. Analysis of the impact of this model resulted in recommendations for integrating the solution into a model of knowledge management information system, a multimedia design of knowledge management system which is based on metadata.

2. Method of model testing

The research was conducted on the territory of the Republic of Macedonia and it included organizations from both the private and the public sector, small, medium and large organizations, as well as national, multinational and global.

The analysis applied several statistical methods: Descriptive and Frequencies to describe the analyzed sample; Correlation to determine the strength of dependence between two variables; ANOVA test to compare dispersions (variability of results) between different groups and dispersion in each group[1], i.e. ANOVA test help to determine if some information technology or technique or stage of development / application of knowledge management program have an impact on increasing the number of innovations (one of the indicators of organizational effectiveness) whether an individual or their interaction.

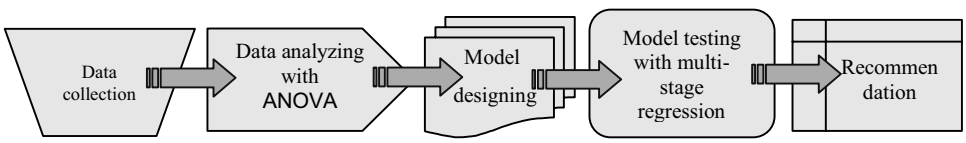

Figure 1. Knowledge Management System building methodology

[1] The groups are forming based on stage of development/application of knowledge management program and/or applying of information technology or technique

After determining the group of information technologies or techniques that have a positive impact on the number of innovations a model is proposed. The model is testing by using of multistage regression. This help us to analyze its impact on the increasing number of innovations. (Figure 1).

3. Model definition

The data analysis showed that the oragnizations apply a different rate of information techniques and technologies. We define different groups of organizations depending on stage of development/application of knowledge management program and/or applying of information technology or technique, to determine their impact on the number of innovations. Depending on the stage, it was defined 5 groups of organizations: 1 - organizations that survey their needs and conditions of introduction the program; 2 - organizations in the planning phase; 3 - organizations in introduction phase, 4 - organizations which review the program; 0 - organizations that do not consider such a program or can't see the benefits of it. Depending on whether particular organizations apply information technology or technique it was defined two groups: 1 - organizations that apply; 0 - organizations that do not apply. The dispersion between different groups and dispersion in each group (varity of results) were compared by two-factor ANOVA.

On increasing a number of innovations, the analyses show that:

- **The interaction** of stage of development/application of knowledge management program program and application/non-application of some information technologies and techniques **has a strong influence**;
- The stage of development/application of knowledge management program **has a strong separately** influence, and the impact is greatest when the program is under review;
- The application of some information technologies and techniques constitute a **strong positive impact** on increasing the number of innovations. The strongest impact has: extracting processes knowledge in order to improve operations, collection and publication of learned lessons, and extracting customer knowledge to improve products/services.

The results of the ANOVA test were used as a foundation for model definition of proposed model, which includes: extracting knowledge about customers in order to improve products/services; extracting knowledge about processes in order to improve operations; applying expert address book; the practice of creating and using a database of good practices and learned lessons and application of wiki pages. (Figure 2).

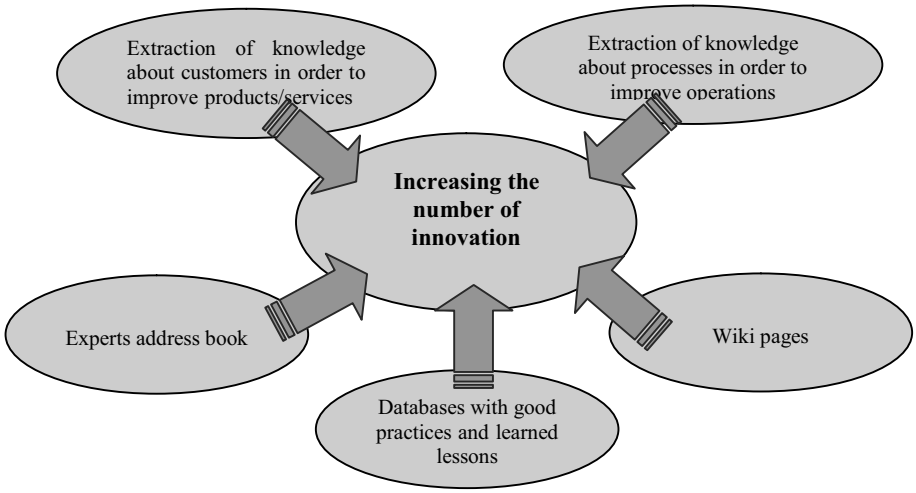

Figure 2. KMS model

In addition, we tested the impact of this model on ***increasing the number of innovation*** in organizations. To test the defined model it was applied multistage standard regression. This statistical tool helps us to determine predictive power of each of the variables in the model, i.e. how much each of them will improve the model.

4. Model testing

Before we start with further analysis or model testing, first we need to determine if the preconditions are achieved for the implementation of multi-standard regression. According to the formula given by Tabachnik and Fidel [Tabachnick & Fidell, 2007] [2] the number of independent variables is five, which impact on dependent (the number of innovation) is examined. Independent variables are not multi collinear, between them there are not strongly correlation[3]; independent variables are non singular i.e. each of the independent variables can't be represented as a combination of other variables; there are not atypical points i.e. there aren't very large or very small values of the results; the residuals (difference between accounted and predicted values of the dependent variable) are normally distributed about the predicted value; and the dispersion of the residuals around the predicted value of the dependent variable is approximately equal for all specified values.

According to meted conditions, the usage of the multistage standard regression, can move to further testing of the model.

[2] $N>50+8*m$, gives the relationship between simple size (N) and the number of independent variables (m). According the research simple witch cover 103 organization (from both public and private sector), the number of independent variables in the model is five

[3] The correlation is strong if $r\geq 0,9$

The model valuation. The analysis shows that the proposed model supports 30.5% of the increase in the number of innovations, i.e. 30.5% of the increase in innovation is explained by the application of the five proposed techniques and information technologies: experts address book, data bases with good practices and learned lessons, data mining for extraction of knowledge about customers to improve products/services, extraction knowledge about processes to improve operations and wiki pages. The results of the analysis are shown in Table 1. It can be seen that the optimistic figure of coefficient of determination is $r^2 = 0,34$. Better estimate gives a parameter Adjusted r square = 0305, so this value is taken as an indication of model support for increasing the number of innovation.

Table 1. Model summary review

Model	r	r Square	Adjusted r Square	Std. Error of the Estimate
1	,583	,340	,305	,354

The Table 2 - Test ANOVA shows the results from the statistical significance check. The value of p = 0,000 (p <0,0005) shows statistically significant of the data.

Table 2. Model testing-ANOVA

ANOVA					
Model	Sum of Squares	df	Mean Square	F	p
Regression	6,190	5	1,238	9,873	,000
Residual	12,037	96	,125		
Total	18,227	101			

Evaluation the particular impact of variables from the model. In order to determine the impact of each independent variable in the model, it was made further analyses. It helps us to determine how each individual variable contributes to the prediction on increasing the number of innovations.

Further analyzes help us to test how much the impact is of each independent variable in the model and how each individual contributes to the prediction of an increase in the number of innovations. The analysis showed that the extraction of knowledge about customers in order to improve products/services, has particularly the most contributed explanation on the increasing of the number of innovation (0.37). Also a significant particular contribution has use of databases of good practices and learned lessons (0,24). These data are shown in Table 3. The values p = 0,000, and p = 0.006 (p <0,05) lead to the conclusion that these independent variables (extraction of knowledge about customers in order to improve products/services and the use of

databases with good practices and lessons learned) has a particular and statistically significant contribution to predict the increase of innovation.

Table 3. Particular impact of the different information technique and technology on the increasing number of innovation

Model	Standardized Beta	t	p
extraction of knowledge about processes in order to improve operations	,005	,051	,960
databases with good practices and learned lessons	,242	2,800	,006
extraction of knowledge about customers in order to improve products/services	,373	3,880	,000
experts address book	,164	1,758	,082
wiki pages	,055	,646	,520

From earlier presented analysis it can be concluded that the model that includes: extraction of knowledge about processes in order to improve operations; databases with good practices and learned lessons, extraction of knowledge about customers in order to improve products/services, experts address book and wiki pages, supports 30% of the increase in the number of innovations. The largest particular contribution gives *the extraction of knowledge about customers in order to improve products/services*, which has particularly the most contributed explanation on the increasing of the number of innovation (37%) and *the use of databases with good practices and learned lessons* (24%). (Figure 3).

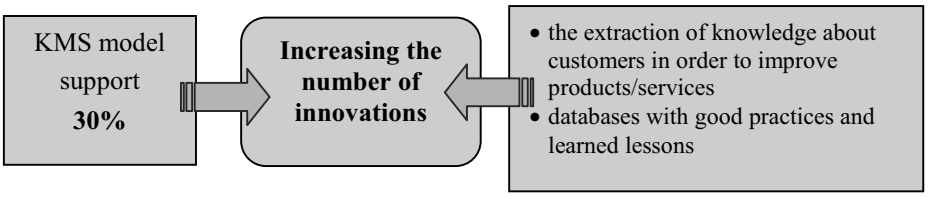

Figure 3.Impact of the different information technique and technology on the increasing number of innovation

5. Knowledge management system model

The data obtained above are the result of a comprehensive research and analysis and we propose to incorporate them into one comprehensive platform whose focus is

system's customer orientation. The proposed model of knowledge management system by Jay Liebowitz [Liebowitz, 1999] we used us a base.

We suggest multimedia knowledge management system design. The system would imply information techniques and technologies of the model which testing has shown a positive impact on increasing the number of innovations. Also the system is based on metadata such as: metadata for users of the system [a_{ij}], metadata for good practice [b_{ij}] and metadata customer [c_{ij}]. Pavlov and Pavlova Nisheva-emphasize the categories of the metadata are designed in order to facilitate, locating the requested knowledge using search machine [Pavlov & Nisheva-Pavlova, 2008]. The metadata creation will enable rational reasoning i.e. computer's conclusion. The each user of the system is necessary to provides feedback. This enables audit and dynamics of the system.

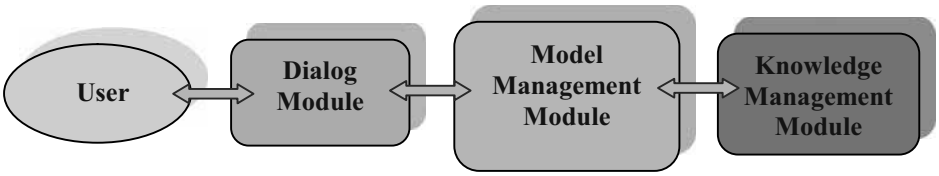

Figure 4. Knowledge management system model

The models of knowledge management system content three modules (Figure4):

• Dialog Module - the highest layer in the architecture, tasked to provide interaction with the user. The effectiveness of this layer is the major determinant for the extent of usage of the system.

• Model Management Module – This module is charged for semantic access both to the user profile and to other content. From the **set** of different content by use of content-structuring the knowledge is extracted in the context of a specific request. The extracted knowledge is presents on the preferred way. This module consists an intelligent layer and a transport layer.

• Knowledge Management Module – This module provides: data for intelligent stage, data access and environment for selection of data according to predefined criteria. The module contains data, information and knowledge that are created specifically for the knowledge management system or for other databases.

In order to increase the system functionality some of the metadata are static and the others are dynamic. The static metadata for system's user are defined by the user of the system during its registration. The static metadata for good practices and for customers are defined by the one which creates or modifies the specified content (Figure 5). The other part of the metadata are generated dynamically by the system, based on: the total number of visits of the content, the total spent time, overall evaluation of the feedback provided by the content's user (Figure 6).

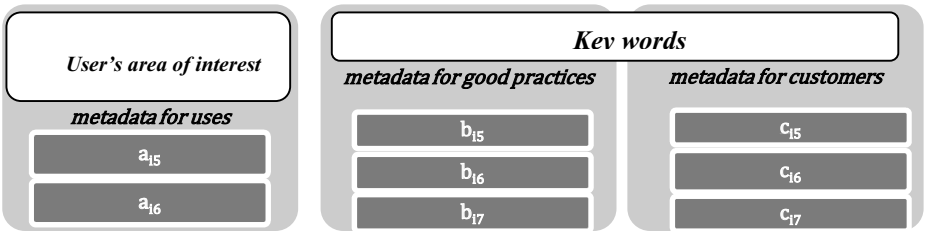

Figure 5. Static metadata for system's users, for good practices and for customers

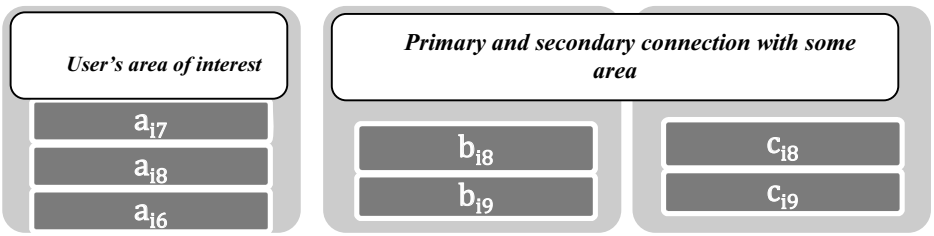

Figure 6. Dynamic metadata for system's users, for good practices and for customers

6. Conclusion

The above offered model can be incorporated into existing organizational knowledge management information systems or in the process of planning for implementation of a new information system. Such an information system would have positive effects on organizational effectiveness, and increase the number of innovations. The model includes: extraction of knowledge about processes in order to improve operations; databases with good practices and learned lessons, extraction of knowledge about customers in order to improve products/services, experts address book and wiki pages. Metadata for system's users, for good practices and for content for customers has enabled extraction and display of good practices and content for customers. The extraction is based on user's profile and content classification according to the profile. Thus users of the system would be kept informed for new content or changes made in the system, which are the subject of their interest. This type of information can change the whole way of system's user operation. The system facilitates the system's user work without they lose unnecessary time.

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Towards application of verification methods for extraction of loop semantics*

Trifon Trifonov

Faculty of Mathematics and Informatics, Sofia University

ACM Classification Codes: D.2.5, D.2.7.

Keywords: Static Analysis, Loop Invariants, Program Semantics

Abstract. There exist a variety of methods, techniques and tools for verifying properties of procedural programs. Formally, such methods provide a language for expressing properties $A(x, y)$ and means to prove $A(x, P(x))$ for a given program. Morgan and Back have demonstrated how one of these methods (Dijkstra's predicate transformers), can be extended to a method for automatic program synthesis, i.e, given a predicate $A(x, y)$, to construct a program $P(x)$, such that $A(x, P(x))$. The goal of this paper is to explore the reverse approach for loops, i.e., given a loop program $P(x)$, attempt to construct a predicate $A(x, y)$, which is as strong as possible and $A(x, P(x))$ holds by applying methods for automatic generation of loop invariants.

1 Introduction

One of the main features of programs written in a procedural style is their inherent imperativity. The most natural semantics of such programs are the low-level operational ones, which provide little insight in the high-level properties of the program. A usual approach to bridge this gap is to "inject" meta-instructions and hints to the human programmer in the form of indentation, comments, variable and function naming conventions, and supporting documentation. This allows for intuitive reasoning about properties of the program, for example, when viewed as a mathematical function.

The popular object-oriented paradigm moves this idea one step further by employing various techniques to map operations performed by the program and data manipulated by it onto a business domain model. Examples of such methods include logical grouping of data and associated operations into classes and modules, which represent consistent and integral parts of the business problem being solved. There are obvious advantages to having such a mapping: it aids reasoning about the program, simplifies the validation of the software system

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against the business requirements and reduces maintenance effort, i.e., correction of problems and accommodation of change requests.

Nevertheless, the presence of all supplements mentioned above is in fact not mandatory for the correct functioning of an already developed system. Moreover, there are overheads associated with the development and maintenance of this assisting layer, not only in terms of human effort, but also in terms of runtime performance and efficiency of the program itself. These factors induce a temptation to neglect or even fully omit such meta-information supporting the source code of the system. Following this path usually means that the information is kept implicit in the memory of the developers of the software system and gradually erodes and deteriorates with time until it mostly disappears. This can be considered as a first sign of a transformation into a *legacy system* [BLWG99]. If the problem solved by the system indeed becomes irrelevant, then the code could simply be deprecated. Even if the addressed problem is still of relevance, but it does not undergo significant reformulations or changes, then this might not become an obstacle for a prolonged period of time. However, during this period costs of maintenance and inter-operability of a legacy system could significantly rise, while in the same time development and growth of the associated business could also raise the business of the system and the cost of its removal. As a result, the legacy system would eventually need to be replaced with a modern functionally equivalent system.

One of the approaches "modernize" a legacy system is to partially recover, or reverse-engineer, the business model and business logic encoded in it, so that they can be reimplemented using modern approaches and technologies. This would usually involve "discovery" of the intended high-level semantics of the program in a convenient form. The definition of a suitable language for expressing business logic is one of the goals of the Business Rules Project [Hay00]. The present paper is a part of research effort to extract business rules from existing legacy source code. Our approach is based on static analysis and employs techniques such as analyzing possible paths in the control flow graph of the system [MMH12] and applying transformations to obtain a form of the code, which is declarative rather than imperative [MT12]. One of the most problematic pieces of the extraction of business rules from procedural programs is the treatment of loop-like control structures.

The present paper suggests an approach based on formal program verification. We use Hoare logic as the base system for expressing and proving properties of procedural programs. The standard use case for establishing semantics is to decompose a given program to simple statements and then enrich it with annotations, which are usually formulas of a fixed logical system. These properties need to be chosen in such a way that they express assertions for the variable values, which are valid at the respective points of the disected program. The case of loops is handled by a special kind of property, called a *loop invariant*, which needs to hold before the first execution of the loop, and after each execution of the loop body.

Following this approach, axiomatic *predicate transformer* semantics of procedural program can be defined, as proposed by Dijkstra [Dij75]. These semantics are complete in a sense that they capture comprehensively the meaning of the program. Morgan and Back [Bac88, Mor90] have extended this approach further by demonstrated a semi-formal method to generate procedural programs in parallel with the proof of its correctness with respect to a given precondition and postcondition. We explore the possibility of reversing this approach, i.e., given a program to generate a pair of precondition and postcondition which describe the behaviour of the program.

2 Loop invariants

Our approach builds on the well-known Hoare logic [Hoa69]. Statements of this logic are triplets of the form

`{Precondition} Program {Postcondition}`

with the intended semantics "Whenever `Precondition` holds, `Postcondition` should hold after `Program` is executed." Proofs in Hoare logic are trees built from axioms and rules described in Figure 1.

$$\{P\}\ ;\ \{P\} \qquad \text{(empty operator)}$$

$$\{P[x := E]\}\ x = E;\ \{P\} \qquad \text{(assignment)}$$

$$\frac{\{P\}\ S\ \{Q\} \qquad R \to P}{\{R\}\ S\ \{Q\}} \qquad \text{(strengthening)}$$

$$\frac{\{P\}\ S\ \{Q\} \qquad Q \to R}{\{P\}\ S\ \{R\}} \qquad \text{(weakening)}$$

$$\frac{\{P\}\ S\ \{R\} \qquad \{R\}\ T\ \{Q\}}{\{P\}\ S;T\ \{Q\}} \qquad \text{(composition)}$$

$$\frac{\{P \wedge B\}\ S\ \{Q\} \qquad \{P \wedge \neg B\}\ T\ \{Q\}}{\{P\}\ \textbf{if}\ (B)\ S\ \textbf{else}\ T\ \{Q\}} \qquad \text{(conditional)}$$

$$\frac{\{P \wedge B\}\ S\ \{P\}}{\{P\}\ \textbf{while}\ (B)\ S\ \{P \wedge \neg B\}} \qquad \text{(iteration)}$$

Fig. 1. Hoare logic axioms and rules

We will focus our attention on the iteration rule, which specifies how loop properties are established. The premise of the rule has a specific feature, which is not present in any of the other rules: the postcondition P is also a part of the precondition. Similarly in the conclusion of the rule, P is a precondition, which is also part of the postcondition. Traditionally, P is referred to as the *loop invariant*, because it specifies a condition, which is true in the following three situations:

– before the loop is executed,
– after the execution of every loop step, and
– after the loop execution completes.

Proving a property about a loop requires building a proof of the triple

```
{Precondition}
while(Condition)
  Statement
{Postcondition}
```

In order to proceed with the proof, we need to apply the iteration rule. However, this could only happen if `Postcondition` is **exactly** the conjunction of `Precondition` and the negation of `Condition`. Unfortunately, in practical cases, this very rarely holds, as can be seen from the following simple example:

```
{x == 0 && i == 1}
while(i != n) {
  x += i;
  i++;
}
{x == n*(n - 1)/2}
```

In such a case, our only hope is to attempt to bridge the gap between `Precondition` and `Postcondition`. In Hoare logic, this can be done by applying the strengthening and weakening rules. Our goal is to replace `Precondition` with an equivalent or weaker formula, and, respectively, replace `Postcondition` with an equivalent or stronger formula so that it can fit the template of the iteration rule. One example how this can be done is shown below:

```
{x == n*(i - 1)/2}
while(i != n) {
  x += i;
  i++;
}
{x == n*(i - 1)/2 && !(i != n)}
```

It is clear that if `x == 0` and `i == 1` then obviously `x == n*(i-1)/2`. Similarly, if `x == n*(i-1)/2` and `i == n`, then trivially `x == n*(n-1)/2`. Unfortunately, this is not sufficient to prove the validity of the triplet. The problem is that the new `Precondition` needs to be sufficiently strong so that whenever both `Precondition` and `Condition` hold, then `Precondition` should continue to hold after the execution of `Statement`. In our case, we have chosen an unsuitable weakening of `Precondition`, because now we are unable to prove the triple

```
{x == n*(i - 1)/2 && i != n} x += i; i++; {x == n*(i - 1)/2}
```

The reason why we cannot proceed is the following. Our only possibility here is to apply the composition rule and the assignment axiom, with possible application

of the logical strengthening or weakening rules. This would amount to proving that `x+i == n*i/2 && i+1 != n` implies `x == n*(i - 1)/2`, which would hold if `n == i/2`, and certainly not for an arbitrary `i`.

The correct invariant in this case clearly is `x == i*(i - 1)/2`. It still follows from the original `Precondition` and implies the original `Postcondition`, but now also we can prove the premise of the iteration rule, namely the triple

```
{x == i*(i - 1)/2 && i != n} x += i; i++; {x == i*(i - 1)/2}
```

Finally, it should be noted that Hoare logic provides means to prove partial correctnes of loop programs, i.e., that if `Precondition` holds, then `Postcondition` is true after the program execution, if it completes. The proof of a triplet asserts nothing in case the program does not terminate. For example, the above program will not terminate if `n == 1`, but this fact does not impact its partial correctness. Hoare logic could be extended to also assert loop termination by appointing a non-negative expression, which provably decreases after each loop step (sometimes called the *loop variant*). However, in the present paper we will only consider partial correctness.

3 Using invariants for extracting loop semantics

The process of discovering the invariant Section 2 was not formal and automatic. We had to find a condition, which "fit" the rules of the Hoare logic. This could be denoted by an annotation of the following form:

```
{Precondition}
while(Condition)
  {Invariant}
  Statement
{Postcondition}
```

By discovering an appropriate `Invariant`, we have unveiled a piece of information about the semantics of the loop. In particular, we have discovered a property, which remains valid regardless of the dynamics of the loop execution. In addition, we have established the following three connections between the values of the variables [MT12]:

- Whenever `Precondition` holds, then `Invariant` should also hold.
- `Condition` holds and `Invariant` holds, then `Invariant` should also hold after `Statement` is applied.
- Whenever `Invariant` holds and `Condition` does not hold, `Postcondition` holds.

The above statements can be seen as high-level information, which we have extracted form the low-level program. Thus, the discovery of a loop invariant can be considered as a process of reverse-engineering of the program. For a given loop there are many possible invariants, which capture the meaning of the program

to a different extent. As an example, `i > 0 && x >= 0` is a valid invariant for the example in Section 2. Nevertheless, it gives very little information about the semantics of the loop. Therefore, discovering a valid invariant by itself might not suffice to provide complete insight about the problem. The invariant we discovered was strong enough, because the discovery process was driven by the need for consistency with the provided pair of precondition and postcondition. It could be argued that it is precisely this pair of properties that defines the meaning of the loop, and the invariant merely serves as a witness to the validity of these properties. Indeed, this is precisely the case when our goal is to verify whether a given program S possesses a given property $P \to Q$.

However, a deeper look reveals that in fact Hoare logic exposes a much more profound connection between the program and its properties, which can be used to obtain results with less information initially available. This was first noticed by Dijkstra, who defined program semantics based on Hoare logic [Dij75]. The semantics expresses the connection between the components of the triplet precondition-program-postcondition by imposing a high order view of programs as predicate transformers. As an example, every program S can be viewed as a function transforming a postcondition Q to the *weakest possible precondition* P, which needs to hold before the execution of S, so that Q holds after its execution. We will not present the details here, but will note that the predicate transformer semantics of a program is independent of any external factors, such as the postcondition. Nevertheless, the definition of loop semantics still requires finding a suitable invariant for every given postcondition.

Dijkstra's intention of the weakest predicate semantics was practical and at the same time foundational: he suggested an approach to develop programs, which are correct by design by turning the programmer's attention from the operational to the denotational properties of program statements [Dij68, Wir71]. This approach can be viewed as "top-down" construction of programs starting from the final property which the programmer is seeking to achieve and gradually introducing program statements in a directed fashion, transforming the goal property accordingly. A formalisation of this scheme was introduced by Back [Bac88] and called *refinement calculus*, later extended by Morgan [Mor90]. Effectively, the programmer is **given** from a pair of precondition P and postcondition Q and **generates** a program S, together with a proof in Hoare logic of $\{P\}\ S\ \{Q\}$. In particular, the refinement calculus suggests various techniques for generating invariants based on the precondition and postcondition.

In the present paper we turn our attention to the exact opposite of the above approach, namely, **given** a program S **generate** a pair of precondition P and postcondition Q, together with a proof of $\{P\}\ S\ \{Q\}$. Focusing on loops, the approach would amount to the generation an invariant I for a loop program **while** (B) S, since then the program would satisfy the postcondition $I \wedge \neg B$. In the next section we present a survey of methods for invariant generation and highlight those which would be suitable for recovering high-level semantics of loops.

4 Methods for generation of loop invariants

The introduction of Hoare logic laid the foundations for practical verification of procedural programs. This research area advanced significantly and the question for fully automatic verification was posed. Two main challenges were identified: the need for tools of automatic establishing of first-order theorems (a problem, which is proven to be not generally solvable) and the need to generate auxiliary assertions about programs, such as loop invariants [BLS96]. Therefore, the first developed techniques for invariant generation were specifically designed to address the practical problem of program verification. Many of these methods included heuristics, such as trying various symbolic manipulations of the precondition or the postcondition until an assertion is reached for which the Hoare iteration rule can be applied (examples of these can be found in [BLS96]).

The introduction of Dijkstra's predicate transformer semantics revealed a deeper meaning of the loop invariant: it could be viewed as a fixed point of a predicate transformer, such as the *weakest precondition* (`wp`) or the *strongest postcondition* (`sp`) [Dij75]. This approach revealed a direct theoretical definition of an invariant. It can be shown that for every loop there is an invariant of the form $\exists k\ I_k(x)$, where I_k is the application of the k-th iteration of a predicate transformer over an arbitrary initial invariant candidate I_0. Unfortunately, this definition is too abstract to be directly utilized for program verification, as the repeated iteration of predicate transformers leads to overly complicated formulas, which cannot be handled efficiently by theorem provers. This definition is also not very useful for extracting high-level semantics, since its form is too convoluted for revealing the intended meaning of the program.

Fortunately, the fixpoint interpretation of loop invariants provides a very simple and intuitive algorithm for their generation, described in detail in [BBM97]. The algorithm is as follows: choose a simple invariant candidate (e.g., the precondition or the postcondition) and iteratively calculate new invariant candidates by applying one of the predicate transformers, until the newly generated invariant candidate is equivalent to the previous one. If this happens, the obtained invariant candidate is a fixed point of the predicate transformer, and hence a valid loop invariant. If the precondition is chosen as an initial invariant candidate and `sp` is used as the predicate transformer, the process is called *forward propagation*, and the dual case, where `wp` is repeatedly applied on the postcondition, is referred to as *backward propagation* [BBM97]. The process could be summarized by the following pseudocode:

```
Predicate generateInvariant(program, candidate) {
  invariant = wp(program, candidate);
  while(invariant <=/=> candidate) {
    candidate = invariant;
    invariant = wp(program, candidate);
  }
  return invariant;
}
```

An important downside of this approach is that the predicate transformers are not guaranteed to be continuous, hence propagation might not terminate, i.e., the fixed point might not always be found in a finite number of steps.

Among the reasons for possible non-termination is the complexity of generated formulas. The final invariant (if found) will be complete, but its syntactic form might not be at all simple. To solve this problem research in the area focused on finding invariant candidates, which are simpler and more likely to stabilize quickly. Two of these techniques are *abstract interpretation* and *predicate abstraction*, outlined below.

Abstract interpretation is an approach for partial reconstruction of the semantics of the program by imposing an abstract view of the program statements and the manipulated data and simulated partial execution of the obtained abstract program [CC77]. Examples of applications of abstract interpretation are the control flow graph and data flow graph of a given program. Using an abstract interpretation of a program and combining it with forward or backward propagation allows to generate simpler invariants by hiding unnecessary complexity and preserving essential information about the program.

There are many possible ways to utilize an abstract interpretation to generate loop invariants. One specific abstract interpretation is *predicate abstraction*, in which properties of data are abstracted by means of booleans, which keep track of predicates over the data [FQ02]. The technique uses a theorem prover to aid the generation a loop invariant built from a set of potentially useful predicates. As a consequence, the problem of invariant generation is reduced to generation of atomic formulas (predicates), from which the invariant is to be constructed.

Several approaches have been suggested towards the practical use of predicate abstraction. Some of them include: utilizing a user-provided library of predicate templates [BHMR07b, GR09], in particular linear constraints, which are produced using constraint-solving techniques [CSS03, BHMR07a], quantifier elimination [Kap04], generation of indexed predicates [LB04], counterexample-guided predicate generation [DD02, KW06]. Even though predicate abstraction is a major step towards the automation of invariant generation, in most cases it still requires some form of input, in addition to the program. The type of user input usually includes one or more of the following:

- precondition and postcondition,
- predicate libraries,
- predicate templates,
- guidance during the generation process.

Our goal is to utilize loop invariants to reverse-engineer a legacy system, i.e., to recover its intended semantics. It is safe to assume that we will have extremely limited preliminary information about the program. Therefore, we focus our attention to approaches which require the minimal amount of additional input. This seems to be a promising direction, since there exist a few loop generation techniques, which have evolved from algorithms supplementing automatic or semi-automatic program verification to self-sufficient methods for uncovering

meaning of programs. Such approaches do not require *any* form of user guidance, and operate solely on the source code.

One of these approaches is described in [KV09], where the authors suggest deriving a collection of properties for the loop variables from the operations performed on them in the body on the loop and using a saturation theorem prover to combine those properties and produce a loop invariant. The derivation of properties is performed via well-known techniques, such as recurrence solving and quantifier elimination. One of the novelties of [KV09] is the generation of the so-called *update predicates*, which describe the changes performed to an array within the body of the loop. This allows shifting the attention to the essentials of the loop and avoiding performing unnecessary reasoning for the whole array. Most importantly, the application of a theorem prover for invariant generation could be seen as a major conceptual shift for the application of verification techniques for semantics extraction, an approach which is also advocated in the present paper. In this particular case the engine of a saturation theorem prover for directed generation of consequences of a set of formulas is used to generate invariant candidates. The generation is not random: the theorem prover is fed with a specific reduction strategy, which is focused at eliminating auxiliary symbols in formulas.

The practical aspects of this approach are explored in [HKV11a, HKV11b]. The authors demonstrate that their approach successfully generates meaningful invariants for several simple loop programs involving arrays, such as initialization, copying, shifting, partitioning, and search. The application of saturation theorem provers for invariant generation is also explored by other researchers, e.g., [McM08]. Other lines of research are directly focused on discovering properties of loop programs involving arrays [GRS05, HP08]. These could be combined with invariant generation techniques to allow extraction of semantics of more complicated programs, e.g., involving nested loops.

5 Conclusion

We explored the extent to which program verification techniques could be successfully applied for recovering the intended semantics of procedural programs, and more specifically, of programs containing loops. Our main thesis is that the discovery of a suitable loop invariant is a valid approach to unveiling high-level information about a procedural program. In addition to revealing logical properties of a program loop, a generated invariant would also be *verified*, i.e., it would posses a certain guarantee for correctness, since its definition is very closely related to the predicate transformer semantics of the program.

We have summarized a number of approaches for invariant generation and have highlighted a research trend [GRS05, HP08, McM08, KV09, HKV11b, HKV11a] which aims at discovering program properties without any additional user input. Our conclusion is that the practical exploration of the applicability of such approaches towards recovering business rules about legacy systems is a promising direction of future research.

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DISTRIBUTED SYSTEMS

Field Fire Simulation Applying Hexagonal Game Method

Stefka Fidanova and Pencho Marinov

Institute of Information and Communication Technologies, Bulgarian Academy of Sciences, Acad. G. Bonchev str. bl25A, 1113 Sofia, Bulgaria
{stefka, pencho}@parallel.bas.bg

Abstract. The field fires are a big problem for countries with dry climate. The Mediterranean region, south part of the USA, Australia are highly affected. In this work we propose a model of field fire spread. We apply Game Method (GM) which is a kind of cellular automate. In our application the cells are hexagonal, which is closer to the circle (the form of fire spread) than the square cells. In this work we describe the simplest cases, without wind and slope. We test our simple model on several scenarios and the results looks realistic.

1 Introduction

Every year a lot of hectares of forest are burn in Europe. Especially south part of Europe where the climate is hot and dry during the summer. Last decades with a climate change this part of the Europe becomes dryer and increase of the field fires is observed. The same problem arise in northern America. A model field fire spread can have several applications. The prevision of the fire front can help the fireman to optimize their work, and to reduce the damages. Another application is prevention. Possible scenarios can be played and the computer model can show the dangerous places.

Existing models are fare to be satisfactory or they are very complicate and slow to be used in real time.

The empirical models are based on empirical correlations found in actual fires and on characteristics of different vegetations types. Among them is one developed by Rothermel [9], used in most North American models [6]. These models predict the position of the fire front, but many relevant physical variables of the fire are unknown. Because they use correlations coming from real situations, their use with different physical conditions is hard.

Combustion models intend to keep track of the real physical variables involved in a fire. They are usually posed on a bidimensional domain. These approaches are based on describing the processes with a system of differential equations. Several important physical effects like wind, moisture, tilt or radiation are evaluated [4, 7, 8]. The initial system of differential equations is complex and some authors try to simplify it. These methods model the fire propagation more close to the real fire spread, despite of the simplification they are very slow and hard to be use in real time computations.

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The game method is a kind of cellular automate. The main idea is to represent the area with cells and to define transition rules between cells. Thus we can describe the fire propagation and we hope that this approach is faster. In existing application of the game method [2] the cells are square and they form a square grid. In our application the cells are hexagonal.

The rest of the paper is organized as follows: in section 2 we describe the game method and it application on field fire propagation; in Section 3 we test our algorithm on variety of situations; at the end we draw some conclusions and directions for future work.

2 Game Method

The game method for modeling is introduced by K. Atanassov [1]. The idea comes from the Conway's Game of Life [3]. The game method is a kind of cellular automate. The process is iterative. Every cell is related with several parameters. The parameters are changed during the time steps. There are rules describing the change of every parameter. The number of parameters and the rules depends of the modeling process. The cells can have different forms, it depends to the application. In most of the existing applications the cells are square.

One of the first applications of the game method is for simulating some aspects of forest dynamics [5]. The used cells in this applications are square. Other application is for simulating oil transformation in the marine environment [10]. In this application the cells are square too. Other application with square sells is for simulating Brownian-like motions [2]. Game method for construction of Voronoi's diagrams uses triangular cells [2]. Other applications are solving variants of Steiner-Rosenbaum's problem [2] and simulation of development of forest fire [11]. In the both applications are used square cells.

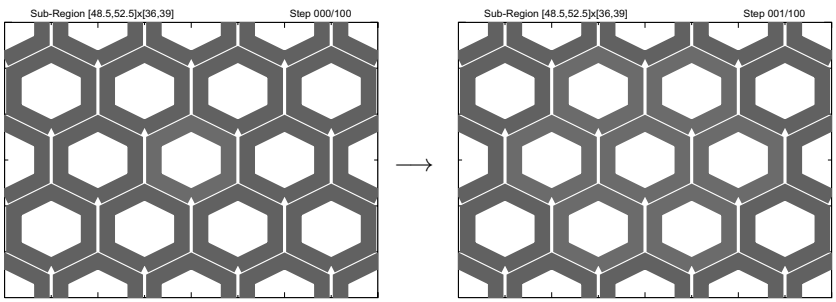


Fig. 1. Hexagonal sells

In our application, considered area is represented by hexagons (see Figure 1). The hexagonal cells have two main advantages comparing with square. All neighbor cells have side contacts. There are not corner neighbors, which can provoke

problems and deformation of the results. The hexagon is closer to the circle, which is the real fire spread without wind. The problem is very complicated. Therefore we start our modeling with the most simple case when the area is flat and without wind. In this stage in our model there is only two parameters: the how long the material burns (burning duration) and how much time it need to start to burn (speed for ignition). For example if the speed for ignition is 2 and the burning duration is 5, the cell will start to burn if during 2 time steps some neighbor cells burn and the cell will totally burned 5 time steps after ignition. We suppose that the size of the parameters and the size of the cells are fixed in advance. If the material in the cell is unburned, than the burning duration and the speed for ignition are equal to 0.

The rules for our application of game method are:

1. In the initial time step the fire starts from fixed cells (one ore more);
2. Every time step the burning duration decrease with 1 till it becomes 0 (totally burned);
3. If some of the neighbors of the cell burns, the speed for ignition decreases with 1;
4. If the speed for ignition of the cell is equal to 0 the cell starts to burn;
5. The process continues until no other change of the parameters is possible, otherwise go to 2.

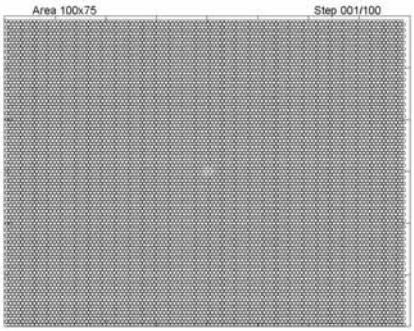
One of the advantages of our model is that the fire can start from one ore more point (cells) or from developed fire front. Comparing with WRF Fire model [6] the fire starts from a straight line.

3 Numerical Simulation

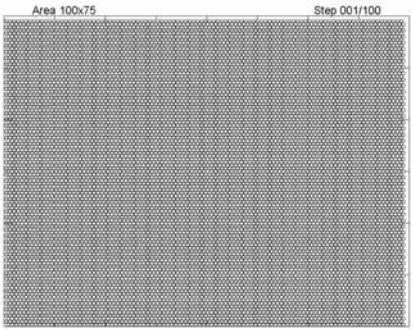
In this section we test our model on several scenarios. Our model is two dimensional. The number of cells in every of two directions, the time steps and the cells parameters are input data for our software. In our representation the cells in the rows are neighbors and the cells in columns are not neighbors. In our test examples the area consists of 100×100 cells, but because in the row the cells are not neighbors, the area is rectangular.

First we test area where the burning duration of all the cells is 9 time steps and the speed for ignition is 1.The fire starts from the center, the cell $(50, 50)$. On Figures 2a, 2b and 2c we show the fire spread on first, ninth and third time steps. We see that the fire is propagate like circle as is expected. On ninth iteration all area inside the fire front burn. On iteration 30 there is totally burned area and the circuit burning front. On Figures 2d, 2e and 2f we show the fire spread on first, ninth and thirteen time steps. The burning duration of all the cells is again 9 time steps, but the speed for ignition is 3. We observe that the fire is propagate slower, comparing with the previous case. On both examples the is same kind of vegetation in all cells.

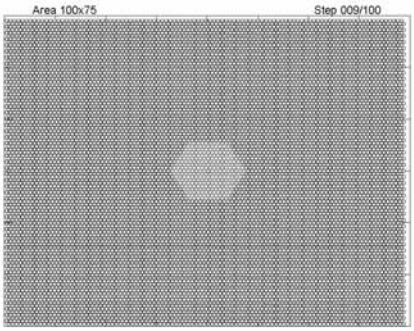
On Figures 3a, 3b and 3c we show example with two kind of vegetations. Most of the cells have speed of ignition 1 and burning duration 2 and there are



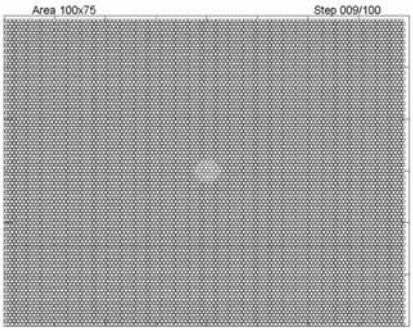
2a.



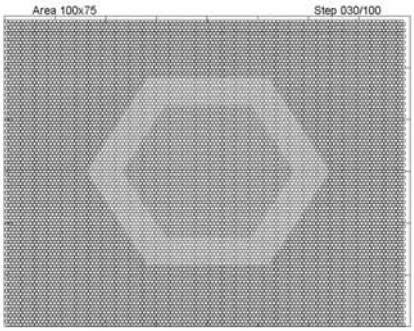
2d.



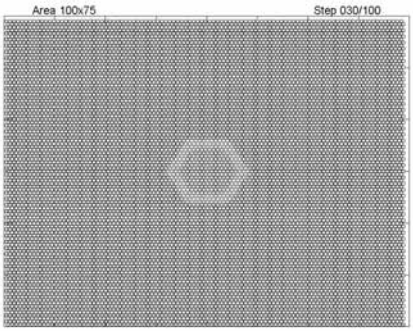
2b.



2e.



2c.



2f.

Fig. 2. Fire propagation in homogeneous area, ignition speed 1 and 3

group of cells, in the left of the center with burning duration 9 and speed for ignition 4. Let imagine that it is a grass region and there is small forest inside. The fire starts again from the cell (50×50). We observe that on time step 16 the fire surrounds the forest without the forest start to burn because the speed for ignition of the forest is high. In time step 29 one of the corner of the forest start to burn, because it has 4 grass neighbors cells which burn consecutively and thus the speed coefficient becomes 0 and the cell start to burn.

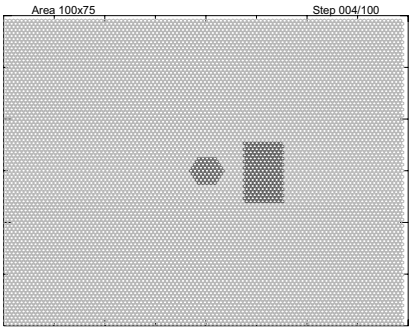
On Figures 3d, 3e and 3f we show an example similar to previous one, but in this case the burning duration of the grass is 4 and the speed for ignition of the forest is 3, or the speed of ignition of the forest is less than the burning duration of the grass. In this case the grass succeed to ignites the forest and we observe the difference of the burning front in this and previous case. On the figures are shown the iterations 4, 16 and 39. On figure 3f we see that in iteration 39 all area around the forest is burned only the forest continue to burn, because its burning coefficient is higher.

On Figures 4a, 4b and 4c 4d we show the case when on the area there are three types of combustible material. Lets think that they are big grass area, small forest and streak of bushes on the left of the forest. The speed of ignition of the grass is 1 and burning duration is 2, the speed of ignition of the bushes is 2 and the burning duration is 5 and the speed of ignition of the forest is 4 and the burning duration is 9. On the figures we observe that the burning grass ignite the bushes. The bushes decrease the speed of the fire, thus the burning grass start to surround the forest. The forest is ignited by the bushes from the left and later it is ignite from the right corners by the grass. Thus from time moment 34 the forest burns from left to the right and from right to the left.

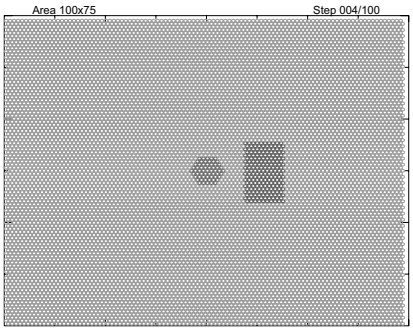
The last scenario which we have prepared is area with the same speed of ignition equal to two and non-burning area with form of Π. We can think that it is rock area or lake. We show the fire spread in this case on Figures 5a, 5b, 5c and 5d. We observe that the fire surround the non-burning area and in the time step 68 all surrounding of the rocky area is burned or burning and there is a small area inside the Π which is unburned. In time step 80 all surrounding of the rock is burned and there is a small area inside the Π which continue to burn.

4 Conclusion

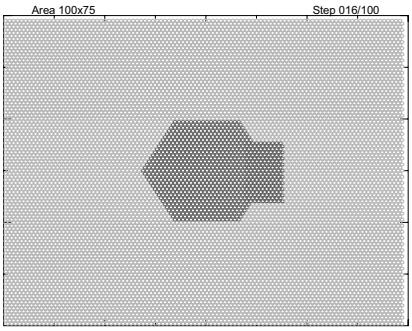
On this paper we present a field fire model based on the game method. On our approach we use hexagonal cells for area representation. We apply the model on flat area without wind, which is one of the simplest applications. We prepare several scenarios to test the model. The achieved fire fronts look realistic. In a future work we will include wind and slope. We will try to contact developer of existing models and to compare with their results. We will try to find real data and to compare the spread modeled by our model with the real fire spread.



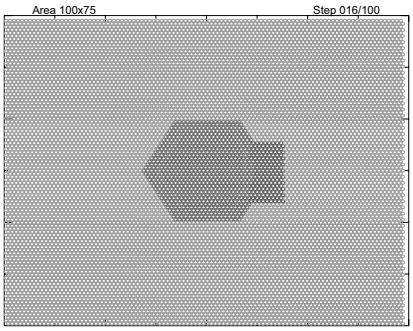
3a.



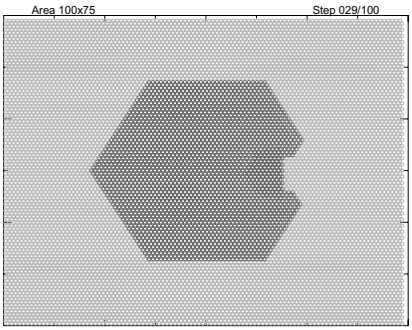
3d.



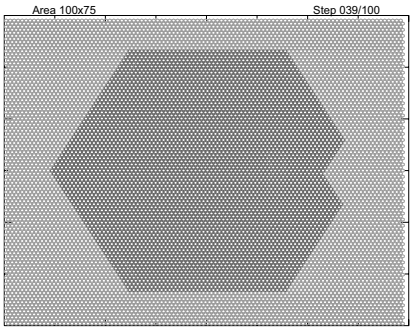
3b.



3e.



3c.



3f.

Fig. 3. Grass and forest, case one and case two

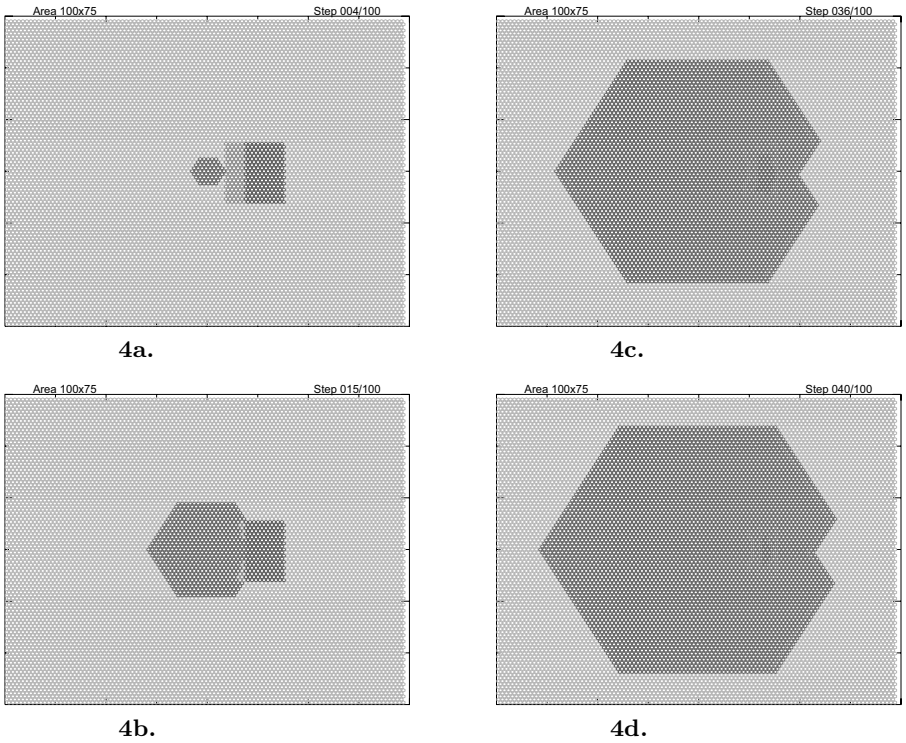


Fig. 4. Grass, bushes and forest

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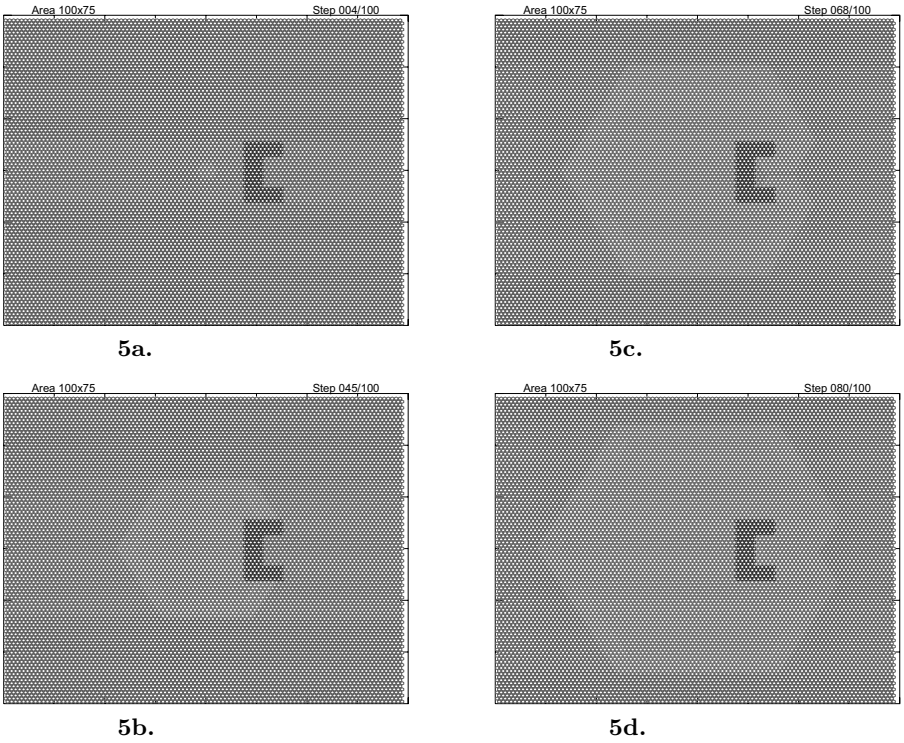

Fig. 5. Grass and rock

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USING CLOUD COMPUTING IN HIGHER EDUCATION

Josif Petrovski[1], Niko Naka[2], Snezana Savoska[2],

[1] Faculty of education, University „St.Kliment Ohridski" – Bitola, Vasko Karangelevski bb, 7000 Bitola, R.of Macedonia, thejosif@yahoo.com
[2] Faculty of administration and Information systems Management, University „St.Kliment Ohridski" – Bitola,
Bitolska bb, 7000 Bitola, R.of Macedonia,
naka_niko@yahoo.com, savoskasnezana@gmail.com

Abstract. Information Technology today is becoming an integral partner in modern higher education. We are witnessed of the changes that occurred by using of this technology in the classroom. But, despite the constant improvement of performance and price, the total cost of IT is still going upwards, mostly because of the need of teachers and students of the newer and more powerful machines, and audio-visual aids. Working in times of financial crisis and in conditions of steady growth needs, universities are facing with difficulties in providing necessary information technology (IT) to support education, research and development activities. In these conditions educational institutions very quickly embraced cloud computing strategies and acceded to their implementation to their own needs. Although there are still obstacles to the full implementation of the cloud model, the potential benefits greatly outperform other risks that arise. Changes that occur require a new way of managing with information technology and also staff with responsibilities. As this model is developed and the risks are lower, most institutions are more intensely to adopt and implement according to their needs and conditions. The purpose of this paper is to present alternatives to the use of information technology in order for university to improve the overall educational process by reviewing the methods of using the model in higher education.

Keywords: information technology, cloud computing, higher education

1. Introduction

In these modern times the expression "Cloud computing" is being used a lot, but there is a lack of clarity about what cloud computing is. A study by McKinsey [12] found that there are 22 possible separate definitions of cloud computing [9, 19]. In fact, no common standard or definition for cloud computing seems to exist. Most of us are using the cloud on everyday basis without even realizing that this is the case [2,7]. Using our Gmail or Hotmail accounts, or uploads a photo to Facebook, we are using the cloud. The potential benefits and risks, however, are more visible [17]. The cloud can be described as on-demand computing, for anyone with a network connection. Access to applications and data anywhere, anytime, from any device is the potential outcome. In practice, cloud

computing as implemented is substantially more complex than the user perspective of it suggests, and many of the potential benefits of the cloud actually stem from this. Many of the perspectives on the cloud adopt a 'layers' view to describe it MIT Technology Review briefing [15].

In the last couple of years the concept of cloud computing has emerged as a practical and promising resolution to the challenges in the reduction of IT budgets and the growing of IT needs. Journals, conferences, consulting firms, and service providers dedicated to cloud computing services and strategies have sprung up virtually overnight which has increased exposure, attention and promise to address IT budget deficit. Despite this creation of cloud computing resources and interest in such resources, for some IT leaders and institutional administrators, the solution is still far away [6, 8]. Most of the concerned sides say that there is too much propaganda but not enough adequate research and convincing case studies to fully commit resources and funding to move in this direction. Others are more troubled about the security and data protection [14]. The commitment to this model fundamentally will change the way of working of IT groups in universities, their power and influence, and their function and view of assessment within the institution.

In many terms the primary advantages the cloud brings are to do with cost and efficiency, which are closely observed. The capital costs of computing can be resolved if an organization relies on the public cloud, buying virtual server time and storage space on demand. Expenditure on IT becomes operational, rather than capital. Moreover, the physical space required for tiers of servers is no longer essential and the organization no longer acquires energy costs for running and cooling its servers. For many start-up businesses, cloud computing offers access to computing power that would otherwise be beyond their reach. The entry barrier for large-scale computing task is effectively removed by the cloud. As costs are incurred on a per use basis, the risks of committing to large capital purchases are removed. Scalability allows the organization to add capacity as and when it's needed and to scale down as well as up, driven by demand [17].

Even if ditching all physical servers is seen as a step too far, building a private cloud with virtualized servers, even if the organization owns and maintains the physical infrastructure, can deliver large efficiency gains. A McKinsey survey cited by The Economist [12] suggests that, without virtualization, on average only 6% of server capacity is used. However, the kinds of economies of scale that large cloud providers can take advantage of will typically be absent. Nonetheless, in this private cloud approach an organization can still take advantage of the on-tap computing power in the public cloud. 'Cloud bursting' is a service that provides 'overflow computing' for dealing with spikes in web traffic or processing load [15]. Flexibility, as well as cost, is another compelling advantage of the cloud. As Erik Brynojolfsson [1] of MIT states, "The ability to be agile in your infrastructure is what separates the winners from the losers… cloud computing is one of the most important technologies that affect the ability to maintain that level of flexibility". The paper is structured in two parts: theoretical and practical. The theoretical part presents the importance of the cloud computing in higher education and its benefits. In practical part we present our 3 types of learning management systems which are implemented in our faculty.

2. Cloud Computing In Higher Education

The Higher education around the globe is constantly evolving, generally as a result of important challenges arising from efforts to adopt new technologies and pedagogies in their classrooms. This is mainly as a result of a new genre of students with learning needs vastly different from their predecessors, and it is increasingly recognized that using technology effectively in higher education is vital to providing high quality education and preparing students for new challenges.

Many technologies that were previously expensive or unavailable are now becoming free when using the World Wide Web. This is true for all web sites, blogs, video sharing, music sharing, social sharing, collaboration software, editing/presentation and publishing, and computing platforms in the "cloud". Students are already using many of these technologies in their personal lives. In the professional world, the trend of discovering and using technologies in our personal life is called "consumerization" [6]. This means we should demand and consume the required services. Our education system should take advantage of this situation, which will improve student's education and reduce the spending of the academic institutions. Universities should identify and control technologies that are cost-effective, and try hard to offer realistic and reasonable access to technology for students and staff. The need for hardware and software isn't being eliminated, but it is shifting from being on-premises to being in the cloud. All that is needed is a cheap access device and a web browser, internet connection in the facilities, perhaps wireless hotspots.

According to the CDW 2011 Cloud Computing Tracking Poll [3], 28 percent of organizations use some form of cloud computing. By industry, 37 percent of large U.S. businesses employ cloud computing strategies followed by 34 percent of higher education institutions in the U.S. This latter figure may not be accurate as another 2011 survey which revealed that as many as 63 percent of those completing the survey representing higher education reported that they were confused regarding the differences between cloud computing and virtualization [18]. Regardless, a growing number of higher education institutions in the U.S. are adopting some form of cloud computing for various reasons and only 5 percent are not considering it in the near future [3]. Many of the researchers [11] in this filed identify 10 important features of cloud computing in higher education with respect to on demand services:

1. Increasing access to scarce IT expertise and talent.
2. Scaling IT services and resources.
3. Promoting further IT standardization.
4. Accelerating time to market through IT supply bottleneck reductions.
5. Channeling or countering the ad hoc consumerization of enterprise IT services.
6. Facilitating the transparent matching of IT costs, demand and funding.
7. Increasing interoperability between disjoint technologies within and between institutions.
8. Supporting a model of a 24 x 7 x 365 environment.
9. Enabling the sourcing of cycles and storage powered by renewable energy.
10. Driving down capital and total costs of IT in higher education.

Institutions will gain the benefits of cloud computing in varying degrees upon their

level of operation and degree of service models. As institutions become further engaged in cloud computing, they will be able to realize greater advantages, such as increasing access to scarce IT expertise and talent, promoting further IT standardization, the transparent matching of IT costs, demand and funding, and increasing interoperability between disjoint technologies within and between institutions. Using a scalable 24 x 7 x 365 model can drive down the capital and total costs for IT. The utility model is a pay-as-you-go model of cloud computing and is a welcome strategy and cost-saving measure for institutions of higher education in the face of rising IT costs and decreasing IT budgets. Services and computing resources are deployed in the cloud on a pay-per-service basis, thereby avoiding capital costs and internal operational expenditures. This way institutions can make adjustments every time they file like to increase or decrease capacity. There are numerous examples of when institutions need IT cloud resources scaled to meet temporary needs. For example:

- Enrolment of students;
- Organizing conferences and provide IT support and Internet access for conference participants;
- Distance learning support;
- Final examination period when thousands of students simultaneously need access to computing resources and exams;

3. The Challenges Of Cloud Computing In Higher Education

Despite the growing acceptance of cloud computing and documented cost savings made possible by cloud computing in higher, concerns about the vulnerability to security breaches are the biggest obstacles to cloud computing adoption in higher education [10, 18]. The most important of these security risks includes the loss of authority, lock-in issues, isolation failure, compliance risks, management interface compromise, data protection, incomplete or insecure data deletion and malicious insiders [2]. In addition, concerns regarding privacy, data integrity, intellectual property management, regulation issues (e.g. HIPAA and FERPA), and audit trails are significant barriers to adoption of cloud-based solutions [4, 5].

Consequently, risk assessment becomes a critical task, although some argue that many of the risks related to cloud computing is transferred to the cloud vendor/service provider [16]. To help diminish these risks for higher education institutions, several organizations have emerged in the last few years. The Cloud Security Alliance was launched in 2009 as a non-profit organization tasked with conducting research in cloud security and offering information and resources about best practices in security protection in cloud computing [4, 5]. The Higher Education Information Security Council, a subgroup of EDUCAUSE, provides membership, comprehensive resources and engages members in an ongoing dialogue and issues, challenges and solutions in this area. As noted above, EDUCAUSE [4] also has a dedicated area on its website for cloud computing issues in higher education complete with publications, presentations, podcasts, blogs and news feeds.

Similar to computer security programs, cloud security involves the same general concerns: maintaining the integrity of data, ensuring access is limited to authorized users and maintaining the availability of data and services [4, 5]. With cloud computing, the

data and services are external to the campus and therefore controlling and protecting these assets becomes a much more complex and challenging proposition. Data encryption, e-discovery, frequency and reliability of data backups and recovery of data, the long-term viability of the cloud vendor and laws regarding storage and access to data all become critical issues. Typical service level agreements that cloud vendors provide are not specific and detailed enough to meet college and university requirements. Fortunately, through the Higher Education Information Security Council, a toolkit called the Data Protection Contractual Language is available to provide guidance and languages to assist institutions in crafting appropriate SLAs and contracts to meet their specific needs. This is an evolving area, and although much progress has been made, much more is needed before colleges and universities can place their complete trust in these third party cloud vendors. As increasing numbers of institutions move to the cloud, their collective bargaining power will help them create appropriate policies and contracts to meet their needs.

4. The Alternatives Of Cloud Computing In Higher Education

NIST [13] also describes three service models: Cloud Software as a Service, Cloud Platform as a Service and Cloud Infrastructure as a Service.

The differentiators among these three service models are the nature of the service and the level of customer-vendor control and engagement. Furthermore, it should be noted that these models are not mutually exclusive; organizations can and do employ different cloud service models on varying scales for different departments within the organization based on specific needs.

In model Cloud software as a service (SaaS), the vendor provides, manages and controls the underlying cloud infrastructure, including individual applications, network, storage, servers, operating systems, etc. The customer is able to fully access the vendor‘s applications in the cloud via a variety of devices (e.g. cell phone, laptop, PDA). SaaS examples include MyErp.com, Salesforce.com and Workday.com. Google Docs, Twitter and Facebook also fall into this category.

In the Cloud platform as a service (PaaS) model, similar to SaaS, the vendor provides, manages and controls the cloud infrastructure, except for applications, which the customer has control over. The vendor provides tools and resources allowing the customers to create and/or acquire applications to meet their specific needs. PaaS vendor examples include Wolf Frameworks, Dell-Boomi Atmosphere, Heroku, Google App Engine and Microsoft‘s Azure [20].

Cloud infrastructure as a service (IaaS) model means that vendor provides, manages and controls the general cloud infrastructure but provides the customer control over operating systems, storage, processing, and networks on demand. IaaS vendor examples include Flexiant‘s Flexscale, Rackspace and Amazon‘s Elastic Cloud Compute (EC2) and their Simple Storage Service (S3).

The case study we take in consideration is the implementation of learning management system – efront in the classes of web programming course in our faculty. The software is installed on the faculty’s server as intranet solution, but it can be installed also on the web environment as cloud. In the fig.1 the used screens are shown and we can see the possibilities of the proposed solutions.

Fig. 1. Efront screen shoots: Home page, administrator dashboard, professor dashboard, student dashboard and screen for editing lessons of the intranet platform

Also, we implemented another two different platforms, SaaS with Google site possibility and IaaS with creation of own e-learning system with usage of own content management system.

The Google site is created for the needs of students which learning course of Analysis and design of information systems in our faculty. This site can be created with templates offered by the provider and it is restricted on the given possibilities. Design of created site is shown on screen shoots in the fig.2.

Fig. 2. Creating a new Google sites, screen shoots with lessons and editing the lessons

The third possibility which we used is creation of own e-learning system, created for specific purpose of final bachelor work. It is some kind of content management system, created in PHP with MySQL database which can be uploaded on dropbox. We can use it as the repositories which will content the course's lessons. For all users (professors), the usernames and passwords can be created and they can put their lessons on the site. Students can have a free assess or restricted, depends on the contraction with the professors. The lessons can be protected with passwords or with lessons' entry codes. The screen shoots of this solution is shown on the fig.3.

Fig. 3. Creating a own content management system, uploaded on dropbox, form user login, staff menu and the appearance of the posted lessons

This proposed solution has own benefits – we can design the site as we want, without restrictions of proposed solutions as in the Google sites or with efront solution. Design of this kind of solution depends only of the programmer's invention and knowledge or the users' demands. We can use all of three concept separate or integrated depends of the courses, number of students on the courses or the demands of professors or students. Each of them has advantages and disadvantages accompanying with some specific form of learning as the practical work or task solving, communication possibilities or mutual work and depends on these reasons the solution can be selected.

5. Conclusion

Cloud computing is an emerging computing paradigm which promises to provide opportunities for delivering a variety of computing services in a way that has not been experienced before. It was demonstrated in this article how educational institutions are already taking advantage of the benefits which this technology is bringing, not only in terms of cost but also efficiency and the environment. It was argued in this article that educational establishments are likely to embrace cloud computing as many of them are bound to suffer from under-funding due to the global economic crisis. In some parts of the world, such as our region, cloud computing is emerging as an empowering tool that is being used to advance the cause of education in the Balkan countries. Conventional perception dictates that cloud computing, as explained in this article, is unlikely to be suitable for education. However, recent research and real-life examples suggest that this view may no longer be valid. Like many new technologies and approaches, cloud computing is not without problems. There are many concerns relating to its security and reliability.

However, before that stage is reached, more work is required in order to address the concerns that currently prevent some organizations from embracing cloud computing.

We can use different approaches of the usage of cloud computing in the higher education process, depends on the professors' and students' needs and the type of courses and way of learning. All of these solutions have advantages or disadvantages which are associated with the level of practical work or possibilities of problem solving in the courses. Selection of the solution is specified with the preferences of the specific course.

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Implications of Data Security in Cloud Computing

Dimiter Velev[1] and Plamena Zlateva[2]
[1]University of National and World Economy
UNSS – Studentski grad, 1700 Sofia, Bulgaria
dgvelev@unwe.bg
[2] Institute of System Engineering and Robotics – Bulgarian Academy of Sciences
Acad. G. Bonchev Str., Bl. 2, P.O.Box 79, 1113 Sofia, Bulgaria
plamzlateva@abv.bg

Abstract. The cloud computing services provide for numerous benefits to the users. However, there are potentially significant security considerations that should be taken into account before collecting, storing, processing or sharing data in the cloud. The paper tries to give a short overview of potential problems and their eventual solutions for providing data security in cloud computing regarding confidentiality and privacy, data leakage, business continuity, legal issues of data manipulation in cloud computing services.

Keywords: Data, Security, Cloud Computing

1. Introduction

Internet has always been a dangerous place for malicious activities. The cloud computing offers a tempting target for cybercrime for various reasons. To maintain data integrity, many providers require all of their customer's data to be placed in cloud which means that if compromised all data is available to attackers. Leading cloud providers such as Google and Amazon have existing infrastructure to deflect cyber-attacks, but this could not be the case with all providers. The cloud architecture is such that it has interlinks with multiple entities and compromise with any one of the weakest links would compromise all the linked entities.

The cloud community services analyses the cloud activities constantly to detect and prevent newly injected viruses and malicious activities. Active participation of many organizations will help curb the malicious activities more effectively.

There are many clouds available in the market and the enterprises will start using different clouds for different operations. Eventually there will be a situation where the cloud integration services would be required which again would require a different approach of security implications. There is no single regulatory organization which regulates the standards for cloud security.

2. Cloud Computing

Cloud computing is an on-demand service model for IT provision based on virtualization and distributed computing technologies [1], [2], [3]. Typical cloud computing providers deliver common business applications online as services which are accessed from another web service or software like a web browser, while the software and data are stored on servers. The abstraction of computing, network and storage infrastructure is the foundation of cloud computing. The infrastructure is a service, and its components must be readily accessible and available to the immediate needs of the application stacks it supports. Cloud computing removes the traditional application silos within the data center and introduces a new level of flexibility and scalability to the IT organization.

The following cloud computing categories have been identified and defined in the process of cloud development:

- Infrastructure as Service (IaaS): provides virtual machines and other abstracted hardware and operating systems which may be controlled through a service Application Programming Interface (API). IaaS includes the entire infrastructure resource stack from the facilities to the hardware platforms that reside in them. It incorporates the capability to abstract resources as well as deliver physical and logical connectivity to those resources. IaaS provides a set of APIs which allow management and other forms of interaction with the infrastructure by consumers.
- Platform as a Service (PaaS): allows customers to develop new applications using APIs, implemented and operated remotely. The platforms offered include development tools, configuration management and deployment platforms. PaaS is positioned over IaaS and adds an additional layer of integration with application development frameworks and functions such as database, messaging, and queuing that allow developers to build applications for the platform with programming languages and tools are supported by the stack.
- Software as a Service (SaaS): is software offered by a third party provider, available on demand, usually through a Web browser, operating in a remote manner. Examples include online word processing and spreadsheet tools, CRM services and Web content delivery services. SaaS in turn is built upon the underlying IaaS and PaaS stacks and provides a self-contained operating environment used to deliver the entire user experience including the content, its presentation, the applications and management capabilities.
- Multi-Tenancy: the need for policy-driven enforcement, segmentation, isolation, governance, service levels and billing models for different consumer constituencies. Consumers might utilize a public cloud provider's service offerings or actually be from the same organization, but would still

share infrastructure.

The cloud services can be implemented in four deployment models:

- Public Cloud. The cloud infrastructure is made available to the general public or large industry group and is owned by an organization selling cloud services.
- Private Cloud. The cloud infrastructure is operated entirely for a single organization. It may be managed by the organization or a third party, and may exist on-premises or off-premises.
- Community Cloud. The cloud infrastructure is shared by several organizations and supports a specific community. It may be managed by the organizations or a third party, and may exist on-premises or off-premises.
- Hybrid Cloud. The cloud infrastructure is a composition of two or more clouds (private, community or public) that are bound together by standardized or proprietary technology that enables portability of data and application.

The cloud computing environment usually consists of the following components:

- Servers - Hosting servers in the cloud using the corresponding services means operating those servers a safe distance from any disaster. Cloud hosting providers generally have more redundancy of network connections, mirrored sites and other precautions to ensure access under adverse conditions.
- Applications - People that use cloud-based applications like Google Apps or Microsoft Office 365 can log in and be productive from virtually anywhere and any mobile device.
- Online data - Users will tend to keep their data stored remotely in the cloud. It is available from everywhere, and like cloud applications and it can be accessed from any device capable of connecting to the web.
- Cloud backup - Many companies fail to backup critical systems on a periodic basis at all, but it is even more severe when an organization has taken the time to create the backups, but the backups end up getting destroyed at the same time as the servers and data their backing up. Using a cloud-based backup solution provides for rebuilding the systems and resuming normal operations.

Under some circumstances, virtual appliances or virtual machine images of existing workloads can be created in the data center and stored in a cloud data center. In the event of a failure of the former, the virtual machines serve as recovery mechanisms that can be reactivated in the cloud.

3. Implications of Data Security in Cloud Computing

While cloud computing services have numerous potential benefits, there are

also potentially significant privacy and security considerations that should be accounted for before collecting, processing, sharing, or storing institutional or personal data in the cloud. Consequently, institutions should conduct careful risk assessment prior to adoption of any cloud computing service.

The different models for cloud service delivery (IaaS, PaaS, SaaS) have different requirements of the customer when it comes to security. The less control is exercised, the greater rely on the security practices of the provider. Understanding where the lines are drawn and who is responsible for what is vital before moving anything valueable to a cloud. Private clouds arevnot necessarily free of the security concerns that plague public offerings. While a private clouds may seem more secure, they may introduce new threats and vulnerabilities that need to be understood. Even a locally hosted private cloud represents a potentially high concentration of data and services, which may have been far more distributed in the past. While the benefits of cloud may be that organizations need to worry less about how computing resources are provided, there are no free passes when it comes to compliance and legal responsibility. Cloud presents a way for business units to quickly provision systems and services, utilize resources, and de-provision those same systems so quickly that traditional approaches to good governance, security and due diligence are unlikely to keep pace. Cloud is a huge opportunity to redefine the way security and business units interact. While the technology may have been around a while, the way it is going to be used is new.

Specific risks and challenges to consider include [4], [5]:

- Vendor transparency and inadequate or unclear service level agreement;
- Privacy and confidentiality of personal, sensitive, or regulated data and information;
- Legal and regulatory compliance;
- Cyber security and support for incident forensics;
- Records preservation, access, and management;
- Service availability and reliability.

The security components involved in protecting data in cloud environments could include a long list of items [4], [6]:

- Encryption - To guarantee the privacy of information hosted on servers in cloud, the information could be encrypted which can only be decrypted at the client level with a key.
- Intrusion Detection and Prevention Systems - Providing security for cloud computing requires more than authentication using passwords and confidentiality in data transmission.
- Antivirus - Antivirus scanning can be done on the cloud to reduce the risk of malicious activities. It is an expensive operation and doing it once ahead of time for benefit of many could be advantageous, and with the power of cloud more anti-virus engines can be employed to make more efficient.

- Firewall - Firewalls could be implemented as a virtual machine image running in its own processing compartment or at the hardware level.
- Security Threat - The communication between cloud services and consumers can be secured using SSL. Since the technology is too familiar, users usually ignore the warning which can be exploited by attackers. In SaaS model, the developer should always assume that intruders have full access to the client as anyone including intruders can buy the software.
- Authentication and Access - There are different authentication mechanisms for different services.
- Data Security - The organizations using cloud computing should maintain their own data backups even if the providers backs up data for the organization. This will help continuous access to their data even at the extreme situations such as data providers going bankruptcy or disaster at data center
- Legal Issues - The key legal issues in cloud with respect to sourcing arrangements are DPA (Data Protection Act of 1998), duties of confidentiality and database right.

Detailed cloud computing security considerations have been already developed through in the world by many government agencies [4, 7]. Detailed list of security considerations that agencies can discuss both internally and with vendors that are transparent about their security measures. Questions are provided to provoke thought and discussion, rather than to be used simply as a checklist. Answers to these questions will assist agencies to develop a risk assessment and make an informed decision regarding whether the agency's proposed use of cloud computing has an acceptable level of risk. It is unlikely that any single vendor will provide suitable answers to all of the questions, so agencies should decide which questions are most relevant based on the agency's intended use of cloud computing. Answers to the following questions can reveal mitigations to help manage the risk of business functionality being negatively impacted by the vendor's cloud services becoming unavailable [5], [7]:

- Business criticality of data functionality - are business critical data or functionality moved to the cloud?
- Could vendor's business continuity and disaster recovery plan be comprehensively reviewed and could they cover the availability and restoration of both my data and the vendor's services that I use?
- What is the data backup plan and what will be its cost?
- What is the network connectivity to the cloud?
- What is the vendor's guarantee of availability? Does the Service Level Agreement (SLA) guarantee that the vendor will provide adequate system availability and quality of service, using their robust system architecture and business processes? Availability may be affected by technical issues such as computer and network performance and latency, hardware failures and faulty

vendor software. Availability may also be affected by deliberate attacks such as denial of service attacks against me or other customers of the vendor that still affects me. Finally, availability may also be affected by configuration mistakes made by the vendor, including those resulting from poor software version control and poor change management processes.

- What is the impact of outages? The vendor may have numerous long scheduled outages, including emergency scheduled outages with little or no notice to customers that do not result in a breach of the SLA. Vendors with distributed and redundant computing and network infrastructure enable scheduled maintenance to be applied in batches while customers are seamlessly transitioned to computing and network infrastructure that is still available and not part of the outage.
- What is the level of data integrity and availability? How does the vendor implement mechanisms such as redundancy and offsite backups to prevent corruption or loss of my data, and guarantee both the integrity and the availability of my data? This problem affected data in the vendor's multiple data centers, highlighting the importance of having offline backups in addition to redundant data centers.
- How is data restoration performed?
- What is the level of scalability? How much available spare computing resource does the vendor provide to enable my usage of the vendor's services to scale at short notice?
- How will the problem of changing vendor be solved**?** If a client wants to move his data to a different vendor, or if the vendor suddenly becomes bankrupt or otherwise quits the cloud business, how does he get access to his data in a vendor-neutral format to avoid vendor lock-in?

4 Conclusion

It is evident that the cloud computing by itself is in evolving stage and hence the security implications in it are not fully complete yet. Achieving complete solution for legal issues is still a question. With this level of issues in cloud computing, the decision to adopt cloud computing in an organization must be carefully assessed well in advance.

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Contemporary Concurrent Programming Languages Based on the Actor Model

Magdalina Todorova, Maria Nisheva-Pavlova, Trifon Trifonov,
Georgi Penchev, Petar Armyanov, Atanas Semerdzhiev

"St. Kliment Ohridski" University of Sofia, Faculty of Mathematics and Informatics
Sofia 1164, Bulgaria

Abstract. This article briefly reviews some of the contemporary languages for concurrent programming that are based on the message-passing paradigm with the Actor model as a formal model for concurrency. The Actor model is briefly described and its implementations are reviewed in all included languages: Elrang, Scala, Ptolemy, Io and SALSA.

Keywords: programming language, concurrent programming, actor model

1 Introduction

Two models of concurrency are widely recognized - the one with shared memory (shared memory) and the one based on the exchange of messages (message passing). Most concurrent programming languages use the shared memory approach. A small number of modern programming languages, including Erlang, Scala, SALSA, Io, Ptolemy, Occam, Oz, Pict, Stochastic Pi Machine, PiLib, among others, apply the model based on the exchange of messages.
The message passing model implies multicomputer architecture with a multitude of processors each having a local memory. There is no shared memory and all the calculations are carried out by isolated processes. The established known mathematical models of the message passing approach are the Actor model [1] and the Pi calculus [2].
This article is focused on the general purpose programming languages, based on the Actor model.

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2 Actor Model

2.1 Definition

In [3] Gul Agha, one of the authors of the Actor model defined it as follows:

Actors is a model of concurrent computation for developing parallel, distributed and mobile systems. Each actor is an autonomous object that operates concurrently and asynchronously, receiving and sending messages to other actors, creating new actors, and updating its own local state. An actor system consists of a collection of actors, some of which may send messages to, or receive messages from, actors outside the system.

2.2 Historical aspects

This model is influenced by the programming language Lisp, Simula 67 and Smalltalk-72, as well as the ideas for Petri nets, capability-based systems and packet switching. A more detailed overview of the historical development of this model can be found in [4]. Initially, the concept was developed by Carl Hewitt in [5] where the actor "referred to rule-based active entities which search a knowledge base for patterns to match, and in response, trigger actions". Further development of the model was done by Carl Hewitt, Peter Bishop, and Richard Steiger, who initially regarded actors as agents of computation, and later as a model of concurrent computing. The Actor model used today was proposed by Gul Agha in 1985 and defines the actors through a simple operational semantics [1].

2.3 Key features

In the actor model, each object is an actor that receives and processes messages. The order of the processing of the messages is not relevant to the actor, although some implementations, for example Scala, have introduced the concept of a message queue. The absence of preference in the selection of messages to process allows the actor to work with messages in parallel.

The Actor is an entity that has a name and behavior which determine its actions. Messages can be exchanged between actors, which will be buffered in the mailbox. The actions that an Actor can execute in response to a received message are:

- Create some new actors;
- Send some messages to other actors;
- Assume new behavior for the next message to be received;
- Migrate to another computing host.

Fig. 1 illustrates this.

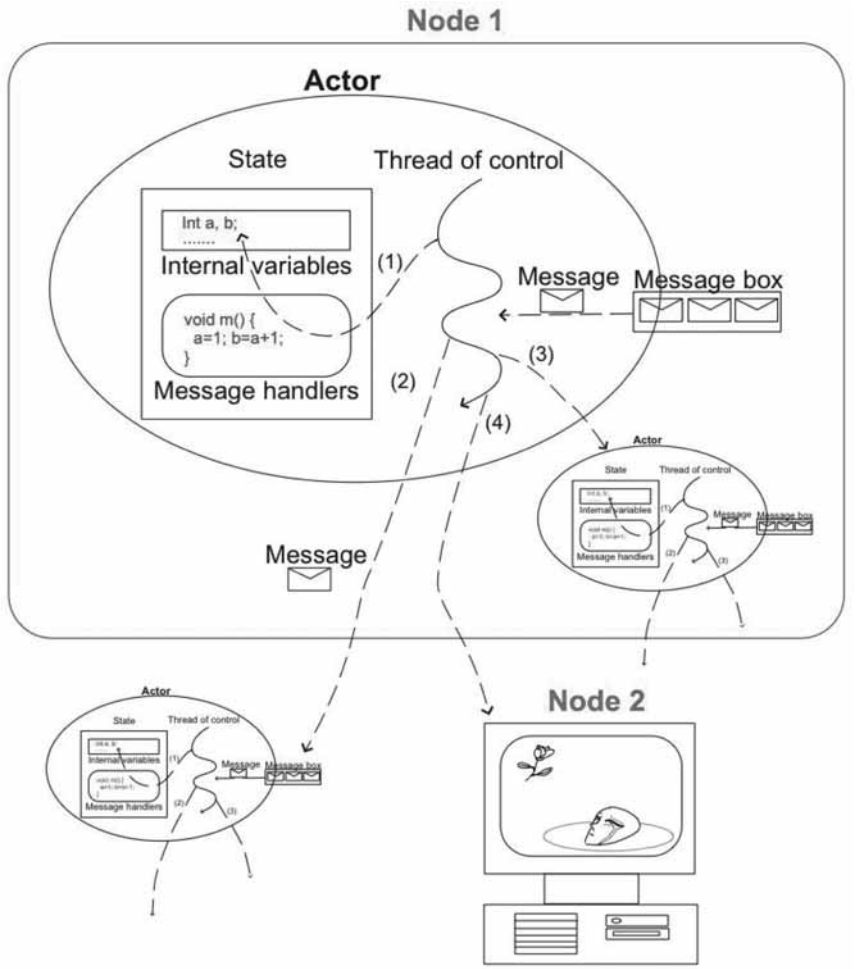

Fig. 1. Actors are reactive entities. In response to a message, an actor can (1) change its internal state, (2) send messages to peer actors, (3) create new actors, and/or (4) migrate to another computing host.

The interaction between actors is mainly asynchronous. This means that the player that sends a message does not wait for the receiver of the communication to process it, and continues to perform its internal calculations instead.

Unlike previous models, combining consecutive processes, the actor model is suitable for parallel and distributed processes. The main new element is the introduction of the term “behavior”, formally defined by a mathematical function that represents the actions of actors in the processing of messages. By means of the “behavior” component the concurrency can be formalized as a mathematical model.

It's not necessary for actors to receive messages in the same order in which they have been sent. All messages received by an actor are buffered in its mailbox before being processed. Communication between actors allows an actor that is constantly in a state of readiness to process messages from their mailbox to process all messages sent to it. An actor may interact with another actor if it has a reference to the latter. Since actors can create other actors, the model supports unlimited concurrency.

2.4 Programming with Actors

According to [1] a program in an actor language consists of: *behavior definitions*; *new expressions*; *send commands*; *receptionist declaration*; *external declaration*.

In the text that follows, we use the Backus-Naur meta-language syntax.

2.4.1 Defining Behaviors

The behavior definitions simply associate a behavior schema with an identifier (without actually creating any actor). They are templates for actor behaviors. A behavior definition is expressed as a function of the incoming communication. Two lists of identifiers can be used for the definition: the first list (the acquaintance list) corresponds to the parameters that need values assigned to them upon actor creation; the second list (called the communication list) is a set of parameters that are bound to data from the incoming messages (communications). When an actor is created and it accepts a communication, it executes commands in the environment defined by the bindings of the identifiers.

The syntax of a *behavior definition*:

<*behavior*_definition> ::=
def <behave_name> (<acquaintance_list>) [<communication_list>]
    <command>*
end def

The <behave_name> is an identifier.

2.4.2 Creating Actors

Quoting [1], actors are created by means of *new expressions* which return the mail address (i.e., actor reference) of a newly created actor. A new expression is defined as follows:

<new_expression> ::= **new** <behave_name> (expr {, expr}*)

The <behave_name> is an identifier bound to a behavior given by a declaration by means of a behavior definition. A new actor is created with the behavior implied by the behavior definition and its parameters are instantiated to the values of the expressions in the parenthesis.

2.4.3 Creating Tasks

The syntax of a command that would create tasks is as follows:

<send_command> ::= **send** <communication> to <target>

where a <communication> is a sequence of expressions (perhaps empty). The expressions may be identifier constants or the appropriate functions of these. The <target> is the mail address of the actor to which the communication is sent.

2.4.4 Declaring Receptionists

The receptionists are those actors that can receive messages sent from outside the system. The dynamic and open nature of the actor systems implies a dynamic character of the set of receptionists.

Receptionist declaration lists actors that may receive communications from the outside.

2.4.5. External Declaration

The external declaration lists actors that are not part of the population defined by the program but to whom communications may be sent from within the configuration.

2.4.6 Commands

Commands determine the set of actions that have to be executed. The minimal palette of the most used commands in the programming languages based on the actor model can be described in the following way:

<command> ::= **if** <*logical_expression*> **then** <command>
{ **else** <command>} **fi** |
become <expression> |
<send_command> |
<let_bindings> { command } |
<behavior_definition> | <command>*

This briefly overviews the expressions for creating new actors (new) and the commands for creating new tasks (send) and for defining behavior (behavior

definition). The if-fi command is similar to the if-else operator in the imperative programming languages.

In the following command:

become <expression>

<expression> is bound to a mail address. The actor simply forwards all its mail to the actor at the specified mail address. This command serves as a behavior change.

The syntax for *let bindings* is as follows:

<let_bindings> ::= let id = <*expression*>
(and id = <*expression*>)*

where *id* is an identifier. Using *let* allows for assigning shorter names to some expressions.

The following syntax:

<command>*

denotes a sequence of commands.

The programs that apply the actors model are a sequence of behavior definitions followed by a command:

<program> ::= <behavior_definition$_1$> … <behavior_definition$_n$> <command>

2.5 Applications of the Actor model

The model has been used both as a framework for a theoretical understanding of concurrency, and as the theoretical basis for several practical implementations of concurrent systems.
With the rise of parallel and distributed computation platforms, such as multicore architectures, sensor networks, cloud applications, etc., the number of applications of the Actor model has also risen. It can be successfully applied in modelling parallel programs that involve distributed computation: e-mail, web services, semaphore objects, cloud computing. Actors can be used for modelling functional, procedural or object-oriented systems.
Many actor languages and frameworks have been defined. Some of the first actor-based languages were: Act 1, 2 and 3, Acttalk, Ani, Cantor, Rosette, ABCL, ConcurrentSmalltalk, POOL, ACT++, CEiffel, HAL. Modern languages based on this model are: Erlang (from Ericsson) [7], Scala (from EPFL) [8], Ptolemy (from UC Berkeley) [9], SALSA (from UIUC and RPI) [10], Charm++ (from UIUC) [11], ActorFoundry [12] (from UIUC), the Asynchronous Agents Library

(from Microsoft) [13], Axum [14] (from Microsoft), Orleans framework for cloud computing (from Microsoft) [15], etc.

The ideas of the actor model are universal and simple but their literal implementation is ineffective because of the lack of determinism in the model. Thus every language based on it implements it in its own specific way. For example, in Erlang the processes (actors) can interact asynchronously, but the interaction inside a process is synchronous.

3. Programming languages based on the actor model

3.1. Erlang

Erlang (http://www.erlang.org/) is a programming language designed at Ericsson Computer Science Laboratory. It is a general-purpose programming language which utilizes concepts of functional and logic languages. Erlang was originally designed to support distributed, fault-tolerant, soft-real-time, non-stop applications. Its main advantage is the support for concurrency. It is a purely functional language enabling the use of single assignment variables, which leads to the absence of side effects. There is no concept of shared memory and there are no locks. Processes communicate only by exchanging messages.

Erlang processes are lightweight processes which are managed by an internal scheduler. There is no shared state between them and communication is done by an asynchronous message passing system. Concurrency in Erlang is achieved by using three language constructs: **`spawn`**, **`send`** (**`!`**) and **`receive`**.

`spawn`(<function>) creates a new concurrent process that evaluates <function>. The new process runs in parallel with the calling one. **`spawn`** returns a *process identifier*.

<Pid> **`!`** <message> sends <message> to the process with identifier <Pid>.

`receive ... end` is used to retrieve messages that match specific patterns. The **`receive`** command has the following syntax:

```
receive
   Pattern1 [when Guard1] ->
      Expressions1;
   Pattern2 [when Guard2] ->
      Expressions2;
   ...
   after Timeout ->
      ExpressionTimeout;
end
```

Each process has a mailbox which contains a queue of messages sent by other processes which have not been carried out yet. The `receive` command checks all the messages inside the process' mailbox against the sequence of patterns. If a match is found, the message is deleted from the mailbox and the process execution is resumed. Otherwise, the process blocks until new messages are delivered.

The behavior of the `receive` command depends on the particular value of the `Timeout`. If no timeout is specified, or the timeout value is equal to infinity, `receive` blocks until new messages are put into the mailbox. If a value between 0 and infinity is specified, `receive` waits for the specified amount of time and if no messages arrive, the `ExpressionTimeout` is executed. When the timeout value is 0, `receive` tries to match the messages in the mailbox against the patterns and if no match is found, the `ExpressionTimeout` is performed.

3.2 Scala

Scala (http://www.scala-lang.org/) is a programming language which provides both object-oriented and functional programming styles. It was designed at EPFL in Lausanne, Switzerland, in order to be scalable in correspondence with the needs of its users. Scala is fully interoperable with the Java language, which allows developers to use Java legacy objects and all Java libraries within Scala.

In contrast to Erlang, two kind of concurrent programming models can be exploited in Scala: *shared memory*, provided by means of threads, and *distributed memory*, using asynchronous message passing provided by the actor model. Actors in Scala are not a language construct, as in Erlang, but implemented in a library. The Scala Actors library defines the actor type and three operators: **!** (**send**), **receive** and **react**. The first two have practically the same syntax and semantics as in Erlang. The explanation of the **react** operator needs some information about the way actors are implemented in Scala.

There are two types of programming models for concurrent processes: thread-based and event-based. Within the thread-based implementation, each actor is executed by a thread. The execution state of a concurrent process is maintained by the corresponding *thread stack*.

In the event-based implementation, an actor is described by a proper set of event handlers. The execution state is maintained by an associated *record of object*.

Actors in Scala unify both programming models. The **react** operator is a semantic equivalent to **receive** but while the latter is based on the thread-based model, the former implements the event-based one. Thus **receive** blocks the actor, actually suspending the corresponding thread, if there are no messages in the mailbox. In contrast, **react** just detaches the actor from the active thread.

It is shown in [16] that it is possible to unify these programming models by using a threads pool of executing actors. During the execution of an actor, tasks are generated and submitted to a thread pool for execution. A task is generated in three cases: spawning a new actor, calling react when a message can be immediately removed from the mailbox, sending a message to an actor suspended by a react that enables the actor to continue. The thread pool approach could cause deadlocks if its size is fixed [16], therefore the thread pool may be re-sized in case of necessity.

3.3 Ptolemy

Ptolemy is a programming language whose goals are to improve a software engineer's ability to separate conceptual concerns. In particular, Ptolemy's features are useful in case of modularization of crosscutting concerns. A key difference between Ptolemy and other technologies to separate conceptual concerns such as AspectJ is that Ptolemy strives to balance separation of crosscutting concerns and modular understanding and reasoning about concerns. Its motto states that: "one shall not have to choose between modular reasoning and separation of crosscutting concerns." [17]. It has been created under the Ptolemy project frame, conceived in the University of Berkley, California, under the guidance of professor Edward A. Lee. The development of the language passed through a few phases: Gabriel (1986-1991), Ptolemy Classic (1990-1997) and Ptolemy II (1996-). Ptolemy II is a complex of programs, libraries of Java classes and other mechanisms aimed at building and exploring models of different heterogeneous computing systems (mostly embedded systems), as well as at scientific research in the modeling domain.

To fulfil this goal, Ptolemy II supports a wide array of computational models among which: CI (component interaction) – a computational model with a "push/pull" interaction between components; CT (continuous time) – models with continuous time; DE (discrete-event) – models with discrete events; DDE (distributed discrete events) – systems with partially ordered sets of discrete events; FSM (finite-state machines) – finite automata (lacking the concept of time); GR – supporting 3-D graphics; PN (process networks) – networks of Kahn processes (Kahn); SDF (synchronous dataflow) – models for representing systems for signal processing (lacking the concept of time); DDF (dynamic dataflow) – an extensions to SDF, that allows for components to change the quantity of used and created data for one iteration during the execution of the model; HDF (heterogeneous dataflow) – an extension of SDF that allows to preserve the static architecture and some other features of the models; DT (discrete time) – analogous to SDF, but with the concept of time; SR (synchronous-reactive) – a synchro-reactive computational model; CSP (communicating sequential processes) – interacting

sequential processes; Wireless – a computational model for systems with wireless communication.

Many of these computational models support the actor-based model as a basis of the architecture. Unlike the object-oriented based architectures, the actor-based one focuses on parallel computing that naturally emerges in modeling some processes.

In *Ptolemy II* (http://ptolemy.eecs.berkeley.edu/ptolemyII/), actors are software components that execute concurrently and communicate through messages sent via interconnected ports. They can be viewed as atomic functional signal transformers. Their behavior is implemented in Java. Every actor is an object of a Java class that can be extended during modeling. This interface does not take into consideration the internal state of the actor and only provides rule for interaction between the actor and its environment. The interface includes ports that serve as connection points to the actor, and parameters that serve to fine tune the behavior of the actor.

Actors can have a hierarchical structure (they can be containers for other models). Ptolemy II has a huge library of actors, arranged by the kind of the transformations they can execute. Polymorphism is a key feature of Ptolemy II. It concerns the computational models, as well as the data being processed. The language also supports Higher-order components (actors). The standard library includes actors that allow user input, interactive shell, input, output and processing of signals and images, including video signals in real time; file input and output; access to internet-based resources; integration with other tools and languages.

3.4 Io

Io is a pure object-oriented programming language inspired by Smalltalk, Self, Lua, Lisp, Act1, and NewtonScript. Io has a prototype-based object model similar to the ones in Self and NewtonScript, eliminating the distinction between an instance and a class. Like Smalltalk, everything is an object and it uses dynamic typing. Like Lisp, programs are just data trees. Io uses actors for concurrency [18]. The language has very simple syntax and semantics. There are two basic structures: objects and messages. They serve as building blocks for all other concepts in the language. There are no classes, only objects. An object can be cloned and changes so that a new object is created (prototyping). Every object contains its own meta-information and can change to an arbitrary type of an object. All data types, values, etc., are objects of the language.

Io uses the mechanism of active objects (actors) for parallel programming. An Actor is represented by an object-oriented stream. Each object can be sent an asynchronous message by prepending "@" or "@@" in front of the message name. When an object receives an asynchronous message, it stores it in its own internal

queue, unless the latter is empty. If there was no queue defined for the object, a coroutine is invoked to process the message. The queued messages are processed in FIFO order. Calling "yield" can transfer the control to another coroutine. The result of an asynchronous "@" message can be obtained by using the Future method. This result can then be sent to another object using sendResultTo().

3.5 SALSA

The SALSA programming language (Simple Actor Language System and Architecture) is an actor-oriented programming language that uses concurrency primitives beyond asynchronous message passing, including token-passing, join, and first-class continuations. It also supports distributed computing over the Internet with universal naming, remote communication, and migration of linguistic abstractions and associated middleware [19]. The language was created to introduce the benefits of the actor model while keeping the advantages of object-oriented programming. It can be viewed as a Java dialect. Furthermore, SALSA provides automatic local and distributed garbage collection. It is often used for building systems involved in grid computing, mobile computing, and internet computing applications.

A SALSA program consists of universal actors that can be migrated around distributed nodes at run-time. Fig. 1 shows an actor and the main actions an actor can take in the SALSA language. The internal state of the SALSA actors can be described in terms of Java objects or primitive types. It is completely sealed, i.e. it cannot be shared with other actors. The main form of communications of SALSA actors is the asynchronous message passing. A SALSA message handler is similar to a Java method. The language provides three approaches to coordinate the behavior of actors: token-passing continuations, join blocks, and first-class continuations.

SALSA supports the following concurrency programming mechanisms:

- New actors can be defined with the *new* keyword. Creating an actor returns its reference.
- Sending messages to other actors happens via the <- operator.

Once created, actors process all incoming messages one by one.

Distributed SALSA programming involves universal naming, theaters, service actors, migration, and concurrency control.

4 Conclusion

The development of computer science and its applications in practice leads to the emergence of new tasks that the old programming languages are poorly fit to solve. In turn, this leads to the creation of new programming languages. Concurrency is a fundamental problem in recent years. The goal of this article is to briefly introduce some modern languages targeted specifically at concurrent programming based on the message-passing concurrency model with the actor model formalism.

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Software Integration Platform for Large-Scale Genomic Annotation of Sequences Obtained in NGS Data Analysis

Deyan Peychev[1*], Atanass Ilchev[1], Ognyan Kulev[2], Dimitar Vassilev[1]

[1]Bioinformatics group, AgroBioInstitute, Sofia, Bulgaria
[2] Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski"

*Corresponding author: deyan.pey@gmail.com

Abstract. Genome annotation is important part of process of de-novo sequencing of genomes. It provides ability to identify patterns of similarity between genes from different organisms, and probably to predict function of de-novo explored genes. In last few years, NGS technology has provided a huge amount of data, which are most commonly hard to interpret and to be added as knowledge input for further investigations. Many tools are available for sequence data manipulation like aligners, assemblers, mappers, annotators but still hasn't exists platforms providing integrated runtime environments which are easy to use for researchers. They should acquire some special skills to execute appropriate tools, to interpret intermediate results, and convert data to suitable input formats for next stages in their research pipelines. Our work is focused on applying of multi-platform, generic software integration platform for easy construction of pipelines which are able to combine multiple implementations for sequence data manipulation. Current use case is specially adopted for clustering and filtering of assemblies from de-novo sequenced RNAseq short reads obtained from bread wheat (*Triticum aestivum)* genome. CCIL platform (Content Classification and Inter-Linking) is represented as solution to integrate appropriate tools and data standards to handle interoperability and scalability problems in NGS data analysis.

Version 1.0 of CCIL is available for download at http://sourceforge.net/projects/ccil

Keywords: Annotation, Software solution, Next Generation Sequencing

1. Introduction

High-throughput sequencing (HTS) or Next-generation sequencing (NGS) technology was boosted by the massive implementation of new sophisticated bioinformatics tools, specifically designed to make the NGS possible. Not only new software has been developed for a range of novel applications and types of data analysis, but new algorithms have also been developed for giving new solutions to old problems such as sequence alignment, de-novo assembly, functional annotation with the only objective to manage with the real deluge of data generated from the new sequencing platforms.

Key bioinformatics challenges created by NGS data comprise either aligning (mapping large number of reads to a reference genome or de novo assembly of novel genomes (transcriptomes), multiple alignment of large number of reads, contig matching in de novo sequencing projects, detection of rare variants and annotating them using new file formats and computational resources for efficient management of the multi-terra byte sequence data files.

1.1. Problems in annotation

Ideas for new concepts of gene structure and function emerge constantly from the biological and medical research. The major objective of genome annotation is to provide an accurate and up-to-date coding reference for biological and medical research. This annotation is a very important background for the development of other genomic research technologies such as expression studies, epigenetics, generation of knowledge based on functionally important mutations.

By it sense genome annotation for NGS data is a multi-step process based on the: information for the gene model (EST library or protein database), building evidence-based gene models, training the gene prediction program with collected evidence, predict gene models and the genome features, and assign gene names and report annotation accuracy. All these steps can be considered as a unite knowledge generation process providing and information with new quality [1, 6, 7].

Technically, every particular NGS workflow includes many stages for data manipulation and interpretation. At first time the sequencer output must be formatted in way, depending of subsequent processing specifics. Subsequent steps can be different filtering algorithms, nucleic sequence aligners, database lookups and more. At each step specific implementations may require different input-output formats and incompatible metadata sets. In most cases genome annotation applications are running in different process containers, and researcher must configure and start every stage of analytical workflow separately. This may cause more errors in components configuration, input data selection and loss of data. Researchers should acquire some special skills to execute appropriate tools, to interpret intermediate results, and convert data to suitable input formats for next stages in their research pipelines. Furthermore sometimes they need to change one algorithm implementation with another one to achieve better performance and scalability, but most commonly this affects efficiency of entire research and possibly leads to radical changes in research pipelines. The problem in general is that separate programs in genome annotation workflow require additional efforts for proper communications between them. Good existing solution is Blast2GO program [2] which provides sequence alignment, database lookup and search in one integrated and easy configurable process. But problems of genome annotation often falls back to scalability and annotation process operates with really huge amount of data. In NGS data analysis the “short reads” input is composed of

millions of nucleic sequences to be analyzed. The most effective way to operate with such kind of large-scale input is to build study-specific pipelines with high-level control over used components in way to increase efficiency and decrease the cost of the study.

1.2. Project and goal

The goal of current work is to develop integrated platform for nucleic sequence data manipulation. This platform is based on CCIL platform (http://sourceforge.net/projects/ccil) and it is organized in way to integrate existing tools for sequence analysis, data transformations and storage in pipelines. Every pipeline stage (particular tool in this context) can be configured autonomously according to researcher's particular needs and also can be replaced with alternative implementation without any considerable changes in pipeline itself. The solution is a framework at the same time, because it provides ability to build analytical applications with shifting and reconfiguring of a set of predefined tools, custom client implementations and third-party libraries. Such kind of integration is achieved defining common base interfaces between all stages in way to interpret communications and data handling at more abstract and transparent level.

CCIL platform provides more granular task distribution and possibility to use alternative technologies for data transformation, data mining and store. In some cases researchers takes different decisions about the work direction at all – machine learning or statistical approaches, relational databases or XML-based data stores etc. One of the most important things in that study is development of common data flow standard for communication and data propagation between every particular pipeline stage to achieve high-scalable and flexible infrastructure for NGS data analysis.

In current study we discuss preliminary results produced by using of CCIL framework (Content Clustering and Inter-Linking) to build pipeline for retrieving, clustering and storage of genome assemblies from *Triticum aestivum.* Integrating some base data mining technologies, we produce clusters of sequence similarities which are suitable for filtering of irrelevant noisy contigs produced by short reads assembly.

2. Material and methods

2.1. Input data

Our experimental object is dataset containing RNAseq short-read assemblies between 300 and 3000 base pairs in length. They are obtained from several de-novo sequenced regions from bread wheat *(Triticum aestivum)* genome, including:

1. Transcriptome part – coding mRNA reads from three different development stages of wheat.
2. Exones part – coding DNA reads linked with short poly-A fragments.

Short-reads are assembled using Trinity and Abyss. The produced assemblies are serialized in FASTA format and take approximately 45GB disk space. Length properties of assemblies are represented into the following table:

	Trinity			**Trans-ABySS**		
	2CFG	**CFB**	**CFD**	**2CFG**	**CFB**	**CFD**
Contigs count	51012	59280	54521	31152	356787	33820
Mean length	357	364	361	304	280	298
Median length	333	336	335	267	257	262
Max length	2928	1934	2513	2211	1460	2124

Table 1. Contigs for three developmental stages assembled by Trinity and Trans-ABySS. The two algorithms were run out with default parameters.

2.2. Software platform

CCIL platform is originally developed as service-oriented software integration solution for information retrieval and semantic indexing over large-scale of web resources. It's designed to construct pipelines composed by stages, all of them performing simple task over the data. These stages use common interface for message and data exchange and can be arranged on different ways, depending of specific needs to produce custom data analysis. Initially the platform is distributed with small number of built-in stages including data collectors (crawlers and parsers), filter and indexers providing ability to analyze document similarities and phrases-to-document relevancy in the context of particular domain. Stages are custom classes which extends single Java base type – CCIL Stage Base. Base class provides simplest interfaces between stages – row data which is populated with one row per iteration, assigning label for every object passed to data flow or initializing key-value map of features for every row object. This is suitable for mapping of particular sequence with relevant metadata and passing them to the next stage. Actually the stage is custom inheritor of CCIL Stage Base and can invoke third party objects and manipulate the data in study-specific manner. Configuration of the stages is designed to use "contexts". Context is set of

parameters which are specific for stages and defines a pipeline to be executed. Contexts are serialized in two files. First one describes actual implementations of the stages. It is serialized in TTL format and affects entire platform. Example lines are as follows:

```
      @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-
ns#>.
      @prefix entity:     <https://sourceforge.net/projects/
cybercore/entities#>.
      @prefix service:    <https://sourceforge.net/projects/
cybercore/services#>.

      service:collect-rdb       rdf:type      entity:service ;
            entity:implementation      "com.ccil.collect.rdb.
RDBContentProvider" ;
            entity:classpath           "" ;
            entity:arguments           "" .
```

First three lines are prefixes declaration for namespaces used in configuration. Remaining part describes that "collect-rdb" is entity of type "service", and it's implementation has fully qualified name "com.ccil.collect.rdb. RDBContentProvider". Following two lines describes that this implementation has no additional classpath dependencies and takes no arguments directly from data flow.

Second configuration file is serialized in key-value properties file and defines context-specific parameters distribution of each stage. It also defines the pipeline itself:

```
      context.collector.pipeline = RDB, BUILDSV

      RDB = collect-rdb
      RDB.connection = jdbc:mysql://localhost/ccil
      RDB.query = SELECT id, sequence FROM contigs
      RDB.user = isgt
      RDB.password = conference
      RDB.lucene = lucene

      BUILDSV = index-sv
      BUILDSV.lucene = @lucene
      BUILDSV.termfile = termvectors.bin
      BUILDSV.docfile = docvectors.bin
      BUILDSV.dimension = 200
      BUILDSV.seedlength = 10
      BUILDSV.docindexing = inmemory
      BUILDSV.contentsfields = @contentfield,metadata
      BUILDSV.docidfield = @docidfield
```

First row describes pipeline and order of stages insight. Pipeline is composed by two stages – RDB and BUILDSV. Next few lines are for parameters of both stages. This particular example configures a pipeline that means the following:

Collect all sequences from MySQL database named “ccil” executing query (RDB.query parameter) and store collected data in Lucene document store. Then start to build SemanticVectors store using following parameters (BUILDSV parameters).

For *Triticum aestivum* – NGS *de novo* RNA seq annotation study, a specific pipeline were designed. It includes custom FASTA parser, SemanticVectors indexer and custom vector search component. Vector search is actual component which looks up for sequences similarity and builds the similarity clusters. Finally, cluster results are stored to relational database. Case-specific pipeline is described in the following section.

2.3. Pipeline model

Analytical pipeline includes following stages: parsing of assembled contigs, loading to document store, vector indexing and clustering. Nucleic sequences with assigned metadata are represented as labeled textual resources with unique inner identifiers.

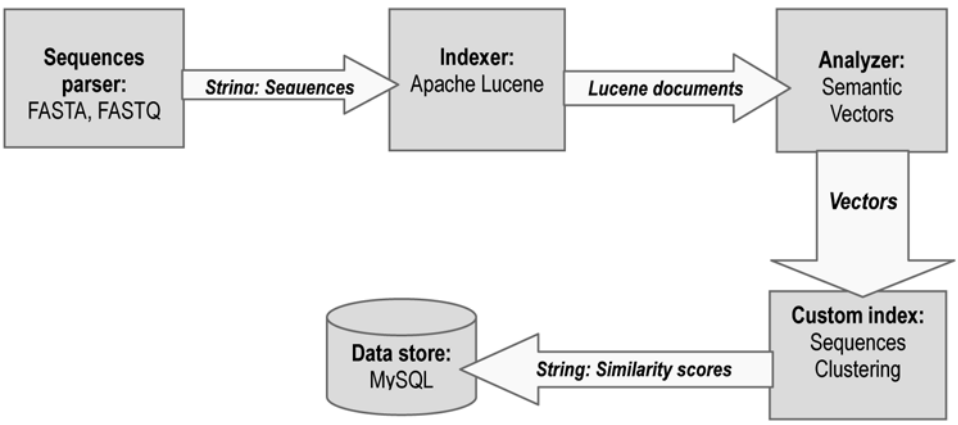

Fig 1. Current CCIL pipeline for building of similarity clusters between assembled contigs. Rectangles are components, arrows are interfaces

2.3.1. Parsing stage

First stage uses custom parser component that reads text files in FASTA or

FASTQ format. The component loads sequences in memory as simple key-value row objects. Keys are unique identifiers for sequences and document labels as well.

2.3.2. Indexing and clustering stages

Once loaded in memory, contig sequences are serialized in Apache Lucene *(http://lucene.apache.org)* document index. Lucene is able to store large-scale labeled documents and retrieve them in high-efficient way. It is base indexing layer for further stages of the pipeline. More specific indexing layer integrated over Lucene is SemanticVectors [3]. This library was used to interpret nucleic sequence documents as vectors. Vector space model [4] is our approach to load sequence objects in non-finite linear models and to set them key features representing objects behavior in multitude. Our idea in using vector representation models is that similarities between sequences is tendency of best matches occurrence between specific strand regions rather than number of best matches between strands itself. In current *Triticum aestivum*-NGS study, features selection for building of vector model is based on frequency of occurrence of nucleotide bases on any particular position into the sequence. Clustering stage compares deviation of angles between all documents in the vector store. Angle deviations are calculated as Cartesian product of entire document set. Every particular vector is a query towards all other vectors in the store. Similarity score is function that can be described with equation:

$$\cos\theta = \frac{\mathbf{d_2} \cdot \mathbf{q}}{\|\mathbf{d_2}\| \, \|\mathbf{q}\|}$$

Fig. 2 depicts vector space model representation of nucleic sequences. **d1** and **d2** are document vectors in the store, **q** is query vector. The cosine of angles between vectors gives the scoring values of distances between vectors.

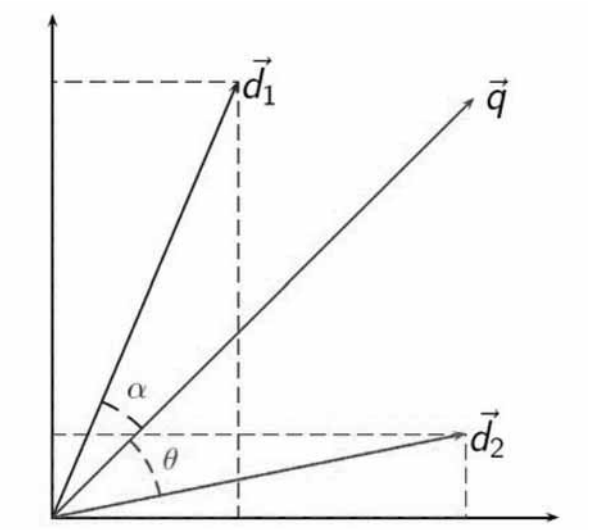

Fig 2. Vector Space Model representation and distances query

Each vector in the store is served as a query vector in a particular iteration of the clustering algorithm used by clustering stage of the pipeline. By its similarity scores, after calculation all vectors are distributed in clusters of similarity. Each vector participates in cluster of vectors with highest values of similarity scores. In the current *Triticum aestivum*-NGS study, clusters of similarity are stored in relational database tables, represented by sequence identifier (document label) and score of similarity towards all other sequence identifiers.

3. Results

At the time of ISGT conference, the process of contigs clustering using CCIL is still ongoing. The process is now running on Linux Debian Wizzy servers with 128GB RAM and 48 cores at the Joint Genomic Centre and AgroBio Institute – Sofia, Bulgaria. Preliminary results show that good clustering can be achieved with setting of similarity threshold upper the 0.75. All sequences with similarity rate (score of the vector spaces) between 0.75 and 1 are good candidates to build similarity cluster. For now, number of candidate clusters is more then 6700. Additional evaluation is needed to estimate the quality of clustering and to give proper tendency of parameter settings for components involved in the pipeline. Final results of the clustering of the contigs will be published in further articles, specially intended for *Triticum aestivum*-NGS study of bioinformatics group at AgroBio Institute and Joint Genomic Centre.

4. Discussion

In our initial step of this study we discovered that nucleic sequences are excellent candidates for web resource-like interpretation as input. CCIL was initially designed for data mining in the field of natural language analysis. Thus the platform serves capabilities for cross-domain usage and adaptation of common solutions between text and sequence analysis assays. Many of existing technologies used in text analysis provide numerous of useful functionality and they can be reused in genome analysis. Text processing resources like parsers, tokenizers, stemmers and classifiers are suitable to process nucleic sequences as well. But very important thing is, that natural text and nucleic sequences "text" has very different lexical characteristics and text processing engines components should take different feature settings when they are used in genomic research. For example tokenization process in natural languages has very clear principles to interpret words and phrases as tokens. If one very long nucleic sequence requires tokenization as part of gene-prediction study, token interpretation may vary in most of its heuristic principles. For instance, transcription initiation sites, terminators of transcription, short repeats and more elements may takes a role in feature selection for toikenizers. Using of tokenization process in prediction or annotation of *de-novo* sequenced genomes or transcriptomes is important step considering that nucleic sequences are extremely long objects and they can not be easy correlated with words. In our early analysis we avoid that problem, just interpreting entire sequences as labeled documents. Thus we can evaluate similarity tendencies between sequences at all, but not providing inline analysis of specific regions inside the sequences.

5. Future trends and conclusions

Genome annotation is a time consuming and multiple stage process. Neither individual *ab initio* nor more sophisticated computational tools are able to predict the gene model for a genome with an accuracy more than 50 %. The community based effort has become more and more important for better genome annotation. The GENCODE Consortium and other collaborating team (e.g. GMOD) have created a genome annotation framework for multiple model organisms which have benefited from the continuous in depth annotation expert curators and technology advances in both next generation sequencing and software tools innovation. The NGS technology has not only made genome sequencing faster and cheaper but allows researchers to generate transcriptomics evidence or genetic event related evidence much more efficiently. Recent research has shown that the new technology provide further evidence based annotation - as a platform for knowledge generation about the gene model of particular genome. Future

work will be focused mostly over application of CCIL platform in functional annotation of wheat genome. One of most important future tasks is to build integrated data warehouse containing already explored genes from different species. This warehouse must be populated with databases of structural and functional annotations previously sequenced genomes. One of the central roles as data set is given to GeneOntology [5] consortium projects providing functional annotation of coding genes from several model genomes. Second steps are related to building of post-assembly CCIL pipelines to find similarities between assembled contigs and genes from integrated warehouse. Thus we will make attempt to find functional characteristics of de-novo sequenced wheat genes.

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Models of Quality of Cloud Services

Radoslav Ivanov, Vasil Georgiev

University of Sofia, Faculty of Mathematics and Informatics,
5 James Bourchier blvd., Sofia 1164, Bulgaria

Abstract. Cloud computing is providing on demand access to shared pool of resources hosted in data centers of cloud providers. While it is offering effective and cost efficient utilization of resources, as well as scalability and comfort for consumers of cloud services, cloud computing is also raising concerns regarding quality of service guarantees in such multi tenant environment. This paper is addressing the need for providing quality of service guarantees and provides an overview of quality of service attributes and various mechanisms that could be applied for maintaining certain levels of quality of service parameters.

Keywords: Cloud Computing, Quality-of-Service (QoS), Service Level Agreements (SLAs), Resource Provisioning.

1 Introduction

Cloud computing is rapidly developing segment with rising adoption among companies and organizations. It is promising increased efficiency, cost savings, high scalability and access to services from any place with internet access.

In cloud computing resources and services are virtually unlimited and are provided on demand. Users pay only for the resources they use and they can dynamically request and release resources based on their current needs.

This is possible through heavy use of virtualization, metering and dynamic resource allocation to end users using models like Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

Resources themselves are centralized and hosted in remote data centers, where they are distributed and shared among users. Since the resources are shared and controlled by the cloud providers, this is rising concerns regarding performance, availability, balanced distribution and reliability of the resources. These are factors that are affecting the overall quality of services provided to the users.

This paper will explore the different aspects of quality of service (QoS) in cloud computing and the mechanisms used to guarantee that quality of service parameters are maintained at certain levels required for satisfying user needs.

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2 Problem Description

Core concept of cloud computing is on demand access to shared pool of resources with the intent of cost savings and better utilization of computing resources through virtualization and automation technologies.

In cloud computing resources reside in data centers of cloud providers. Infrastructure is virtualized and can be provided as a service or used as a base for other higher level services and thus computing resources are shared. Higher degree of sharing provides fewer guarantees for performance.

The end users have control to some degree on the purchased services but they have limited or no access to underlying infrastructure or services and no control over them. It is provider's responsibility to maintain and control the underlying infrastructure and services. This provides comfort to end users but also raises concerns about the risks of outsourcing services to third parties. Even when the cloud is private for the organization, there is still need for guarantees that services meet certain requirements for availability, performance, security, etc.

Here comes the need of defining explicit quality of service requirements in order to provide users certain performance guarantees. In addition service delivery methods should apply mechanisms that guarantee that the agreed service levels are provided to the user.

3 Quality of Service Attributes

This section will review the major attributes that are affecting quality of service in cloud computing. These attributes can be used as base for defining quality of service requirements. This is important since quality of service guarantees should be based on well defined requirements and measurable artifacts. Following QoS attributes will be reviewed:

- Availability
- Performance
- Cost
- Reliability
- Security
- Privacy and legal compliance

3.1 Availability

High availability is a key attribute of enterprise applications and mission-critical services and for many customers system downtime can lead to serious consequences. When customers rely on cloud environments for hosting their services, cloud providers need to address their expectations regarding availability and uptime.

3.2 Reliability

Outsourcing infrastructure and services in the cloud increase dependencies of users on cloud providers. When users are hosting mission-critical services and applications in the cloud, they need certain guarantees about availability and uptime of underlying cloud infrastructure and services as well as disaster recovery options.

3.3 Performance

Cloud computing is heavily relying on virtualization and resource sharing. This means that even that there is certain level of isolation between resources dedicated to different users, these are still often sharing common hardware. This may cause some interference that is affecting performance. Such situation should be handled properly in order to provide users certain performance guarantees for covering their needs.

3.4 Cost

Cloud computing offers dynamic resource allocation, pay per use model and virtually unlimited resources. Customer costs depend on resource usage and prices vary depending on QoS guarantees given by the service provider. Provider costs depend on effective utilization of data center resources. Ensuring proper balance between cost and other quality of service parameters is essential for both sides.

3.5 Security

In cloud computing data and services are located in remote data centers managed by service providers. This raises privacy and security concerns. Storing confidential or sensible data in the cloud requires certain guarantees that data is stored securely and is accessible only by authorized users. Depending on the sensitivity of the data additional requirements may be in place regarding backup and recovery of data. Services should be secured as well to prevent unauthorized access and guarantee availability and resistance to attacks.

3.6 Privacy and Legal Compliance

User data may be scattered across multiple data centers that could be located in different countries. Cloud providers should comply with the legal requirements of the countries where they operate thus user data falls under different jurisdictions depending where it is stored. On other hand customers may also need to meet certain regulatory requirements that are putting limits on exporting customers

data abroad or where data can reside. Other issues that need to be addressed are ownership of the data and liability of cloud providers in cases of data loss or misuse.

4 Quality of Service Definition

As already mentioned, different users may have different requirements regarding performance, availability, security, etc. In cloud computing services are provided on a large scale. Here providing the same quality for all users is not a feasible option. This is why we will suggest and use the following definition for quality of service in cloud computing:

Quality of Service (QoS) in cloud computing is the ability to provide users the desired levels of QoS attributes, that satisfy their needs and to have mechanisms to maintain and guarantee this service levels.

5 Service Level Agreements

Defining QoS attributes is essential part of quality of service but customers need certain QoS guarantees in order to meet their objectives and perform normally their operations. Consumers rely on cloud providers to supply resources for satisfying their computing needs. Since user needs vary, providers have to meet different QoS levels, depending on consumer requirements. These need to be negotiated and guaranteed by a formal contract between provider and customer that defines the obligations and consequences when the concerned parties don't comply to what have been agreed. Here comes the role of service level agreements:

Service Level Agreement (SLA): Written agreement between a service provider and customers that document agreed service levels for a service [1].

SLA records the guaranteed levels of quality of service attributes. It can define metrics and service level objectives as well as penalties in case of non-compliance of the SLA.

Once service levels are negotiated, continuous monitoring and measuring of QoS attributes is necessary to enforce SLAs. Monitoring and SLA enforcement may use various control and provisioning mechanisms in order to guarantee desired service levels.

6 Control and Provisioning Mechanisms

In cloud environments workloads and demand for resources are constantly changing. Resources are allocated and released dynamically in order to achieve good balance between performance, costs and quality of service. This requires constant monitoring and correction mechanisms in order to ensure compliance

with SLAs and satisfaction of user needs. This section will review various control and provisioning mechanisms that may be applied in order to provide necessary resources and achieve desired QoS levels.

Several research works consider SLA based mechanisms to guarantee QoS in cloud environments. Buyya et.al. present challenges and architectural elements of SLA-oriented resource management and propose architecture for flexible SLA-based resource provisioning in clouds that supports integration of marked based provisioning policies and virtualization technologies [2].

Serrano et.al. propose a cloud model that integrates QoS and SLA into the cloud. It aims to provide SLA-oriented cloud reconfiguration and SLA governance by allowing users to select QoS attributes and desired metrics through SLA non-functional interface that are further used for autonomic cloud reconfiguration in order to provide performance, dependability and cost guarantees for online cloud services [3].

Another method for resource allocation is proposed by Awano et.al. [4]. By selecting the minimal resources that satisfy QoS requirements, it aims to make possible meeting more future requests later. The proposed method targets multiple heterogeneous resource attributes by identifying the key attribute having highest impact on resource allocation and selecting resource centers with lowest capacity that can provide desired QoS so future request with higher requirements can still find available resources.

Beloglazov et.al. propose energy-aware allocation heuristics for resource provisioning [5] that improve energy efficiency of data center and thus decrease cost, while still delivering the necessary quality of service. They discuss the challenges of energy-aware resource management, resource provisioning and allocation algorithms and develop autonomic and energy-aware mechanisms for resource management by using dynamic consolidation of virtual machines and energy-efficient mapping of virtual machines to cloud resources.

Zissis and Lekkas are addressing cloud security issues by using cryptography and in particular public key infrastructure (PKI) [6]. They are suggesting usage of PKI in combination with single-sign-on and directory services to ensure the authentication, confidentiality and integrity of data and communications.

Cloud security is also addressed by cloud providers and various organizations that are providing guidelines and recommendations for securing cloud services and infrastructure [7, 8, 9, 10]. They are addressing the security challenges and control mechanisms in different cloud models as well as related topics like availability, data protection, privacy and legal compliance.

The reviewed control and provisioning mechanisms are addressing various aspect of quality of service and help improving one or more quality of service parameters. Further research of the topic should investigate the possibilities of combining different approaches for achieving overall quality of services guarantees.

7 Conclusion

Cloud computing offers effective utilization of computing resources by extensive use of virtualization and resource sharing mechanisms. Centralization of infrastructure and resource sharing are providing comfort and decrease operational costs but also raise concerns regarding quality of service guarantees in such multi tenant environment.

This paper provides an overview of the various aspects of quality of service in cloud computing, QoS attributes and service level agreements. It addresses the need for providing QoS guarantees and performs a review of some control and provisioning mechanisms that could be applied for maintaining certain levels of quality of service parameters.

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Contemporary Concurrent Programming Languages Based on the Communicating Sequential Processes

Magdalina Todorova, Maria Nisheva-Pavlova, Atanas Semerdzhiev, Trifon Trifonov, Petar Armyanov, Georgi Penchev

"St. Kliment Ohridski" University of Sofia, Faculty of Mathematics and Informatics
Sofia 1164, Bulgaria

Abstract. This article gives a brief synopsis of some of the modern languages for concurrent programming, which are based on the Communicating Sequential Processes (CSP) formal model. A short description of the CSP model is presented. For each of the languages, we present the main characteristics of the CSP model, as implemented by the language.

Keywords: programming language, concurrent programming, communicating sequential processes

1 Introduction

In the field of Informatics, a number of mathematical theories have been developed, in order to describe the interactions between programs. Some of these are known as process algebras or process calculi. Some of the most widely used among them are:

- *Communicating sequential processes* (CSP) [1], created by the famous Mathematical Logic specialist C.A. Hoare. In this theory, interaction between processes is done via messages. Hoar's algebra formalizes the term process, describes it through protocols and also offers axioms, which describe interaction between processes.

- *Calculus of communicating systems* (CCS) [2], proposed by R. Milner. The rendezvous mechanism lies in the foundation of this theory, in which interaction between processes happens instantly.

- *Algebra of communicating processes* (ACP) [3], developed by Jan Bergstra and Jan Willem Klop. ACP is fundamentally an algebra, in the sense of universal algebra. This algebra provides a way to describe systems in terms of algebraic process expressions that define compositions of other processes, or of certain primitive elements.

In this article we present the CSP mathematical theory and the concurrent programming languages OCCAM, Go and Limbo, which apply CSP as means of implementation of concurrency. We focus on the specifics of implementing concurrency through CSP for each of the languages.

2 Foundations of Communicating Sequential Processes

In [1], the main goal of research is described as a search for the simplest possible mathematical theory, which has the following properties:

1. It should describe a wide range of interesting computer applications, from vending machines, through process control and discrete event simulation, to shared-resource operating systems.
2. It should allow for an efficient implementation on a variety of conventional and novel computer architectures, from time-sharing computers through microprocessors to networks of communicating microprocessors.
3. It should provide clear assistance to the programmer in his tasks of specification, design, implementation, verification and validation of complex computer systems.

CSP is a formal language for description of concurrent systems, as well as a mathematical theory, which can be used to describe the behavior of such systems [4]. CSP describes the behavior of systems through building algebraic models of components (processes), in which the more complex forms of behavior are made up of simpler ones, with the help of a set of operators. The language is action-based. This means that the components of the systems, which are being described, communicate directly (through events) rather than indirectly (e.g. through shared variables). Communication events are synchronous. The language has capabilities for parallel composition, non-determinism and hiding of events.

Primitives

The process algebra of CSP offers two classes of primitives: events and primitive processes. Events represent communications or interactions. Primitive processes represent fundamental behaviors: examples include *STOP* (the process that communicates nothing, also called deadlock), and *SKIP* (which represents successful termination) [4].

Processes

The basic component of the language is the process. In [1], the word “process”

is used to denote *the behavior pattern of an object, insofar as it can be described in terms of the limited set of events selected as its alphabet*.

Let *e* be an event and *X* be a finite set of events. With the help of BNF, by applying the main operators, a process can be incompletely defined, in the following way [4]:

Proc ::= STOP | SKIP	
| e → Proc	(prefix)
| Proc ; Proc	(sequential composition)
| Proc \ X	(hiding)
| Proc □ Proc	(deterministic choice)
| Proc ⊓ Proc	(nondeterministic choice)
| Proc || Proc	(parallel composition)
| Proc ||| Proc	(interleaving)

***Prefix* (operator →)**

The simplest form of sequencing in CSP is the prefix operator. If *a* is an event and *P* is a process, then $a \rightarrow P$ (called a prefix) is the process which is initially willing to communicate *a* and will wait indefinitely for this *a* to happen. After *a,* it behaves like P [1].

***Sequential composition* (operator ;)**

The semi-colon operator is used to specify that two processes are executed sequentially.

***Hiding* (operator \)**

If *X* is a finite set of events, which have to be hidden, then P \ X is a process, which behaves similarly to *P*, with one difference – all events from *X* are hidden.

CSP supports operators for deterministic and nondeterministic choice.

***Deterministic choice* (operator □, or |)**

If P and Q are processes, then P □ Q is the process which is willing to communicate the first events of P or of Q and then behaves accordingly. For example, if *a* and *b* are separate events, then the process (a→P') □ (b→Q') describes an object, which initially participates in one of the events *a* or *b*. The next behavior of the object is described by the process *P'*, if the event *a* occurred first, or the process *Q'*, if the event *b* occurred first. As *a* and *b* are separate events, the choice between *P'* and *Q'* is determined by which event occurs first – *a* or *b*.

***Nondeterministic choice* (*operator* ⊓, *or* ⊢|)**

If P and Q are processes, then P ⊓ Q is the process, which behaves like either P or Q. In this case, the choice between P and Q is random. This operation allows us to take into account the stochastic effects of external factors or effects from other objects, which interact with the system.

***Parallel Composition* (*operator* ||)**

If P and Q are processes, then P || Q is the process, which executes P and Q in parallel, i.e. it has the behavior of a system, which is composed of the P and Q processes and in which their interactions are synchronized. The parallel composition ends when each of the processes finishes its execution.

***Interleaving* (*operator* |||)**

The notation P ||| Q is used to unite processes with identical alphabets for parallel execution. During the execution, no direct interactions or synchronization of the processes takes place. In this case, each action of the system is an action of exactly one of the processes. If one of the processes cannot finish its execution, this must be done by the other process. If the same action can be performed by both processes, the choice between them is nondeterministic.

For each of the operators, which are introduced in [1], a thorough research has been made, to study the laws that they satisfy.

Communication

Communication is an important element of CSP. In order to execute communication, we need mechanisms for output from a channel and input into a channel.

We use

$$(c\ !\ v \rightarrow P)$$

to denote a process, which outputs *v* from the channel *c* and after that has behavior similar to that of *P*.

We use

$$(c\ ?\ x \rightarrow P(x))$$

to denote a process, which initially is ready to input a random value *x*, passed through the channel *c*. After that, it has behavior similar to that of *P(x)*. For

example, the recursive definition:

COPY(left, right) = left?x -> right!x -> COPY(left, right)

is used to define copying of values from the channel *left* into the channel *right*.

The command is a basic construct in CSP. In [5], the syntax of a command is defined and can be expressed as:

<command> ::= <simple_command> | <structured_command>
<simple_command> ::= <null command> | <assignment> | <input> | <output>
<structured_command> ::= <alternative command> | <repetitive command>
| <parallel command>
<null command> ::= skip
<command_list> ::= { <declaration>; | <command>; } <command>

A full description of the SCP language based on BNF can be found in [5].

3 Programming Languages Based on Communicating Sequential Processes

3.1. OCCAM

OCCAM [1, 6] is a programming language for concurrent programming, based on CSP process algebra. It was developed by David May and researchers at INMOS, a British semiconductor company (1978 – 1994), under Hoare's guidance. The language was created to address the needs of transputer microprocessors, developed by INMOS. The development of transputers led to constant development of the language. It was brought closer to high-level languages and the circle of problems, that can be solved with the help of OCCAM, was expanded. The most popular versions of the language are OCCAM 1, OCCAM 2 (2.1) and OCCAM-π.

The language is imperative and similar to Pascal. The first versions of the language contained just one type of composite data – one-dimensional arrays. OCCAM-2 and OCCAM -π offer two- and three-dimensional arrays. Defining them is similar to that in Pascal.

As a concurrent programming language, OCCAM belongs to the group of imperative programming languages that are designed for this purpose, as opposed

to being simply extensions of general-purpose languages. A basic component of the language is the process (primitive, composite or named). Named processes can have formal parameters. The latter are implemented through lists and the following keywords can be put before the parameters: VALUE (passed by value), VAR (passed by name) and CHAN (for a channel). Processes interact among themselves through channels. They do this using operations for input and output that work with channels.

Output process

channel ! expression – passes the value of *expression* through *channel*.

Input process

channel ? variable – extracts a value from *channel* and assigns it to *variable*.

Processes are executed either sequentially or in parallel.

Sequential processes

They can be defined by using the SEQ keyword and a list of processes, which follow it. For example:

```
SEQ
  P
  Q
  R
```

This corresponds to the (P ; Q ; R) process.

The next example [1] defines a named process, which copies values from the channel *left* into the channel *right*.

```
PROC copy(CHAN left, right) =
  WHILE TRUE
    VAR x :
    SEQ
      left ? x
      right ! x:
```

The execution of sequential processes often involves assigning values to variables. In this case, assignment has a syntax similar to that of Pascal:

variable := expression

We can also use the conditional process IF. It implements a choice between the executions of several processes. For this purpose, it seeks and executes the first process, which is related to a condition which has a value of TRUE.

Parallel processes

For their definition, we use the keyword PAR, followed by a list of processes. For example:

```
PAR
  P
  Q
  R
```

This corresponds to the (P || Q || R) process.

Example: By using [1]

```
CHAN mid :
  PAR
    copy(left, mid)
    copy(mid, right)
```

we define a double buffer.

Choice of process to be executed with ALT

In OCCAM we can make a choice between the executions of several processes, depending on other processes. This can be done by applying the ALT process. For example:

```
ALT
  c ? x
  P
  d ? y
  Q
```

This corresponds to the (c ? x $\rightarrow$ P $\square$ d ? y $\rightarrow$ Q) process.

3.2 Go

The Go programming language [7] was created in 2007 by Robert Griesmer, Robert Pike and Kenneth Thompson from Google Inc. It was officially published in 2009. The language integrates a few different conceptual paradigms: imperative, structured, concurrent and compiled. The language has features brought from the C language (simple structure and syntax), Java (inheritance by means of "Interface"), C#, Java (package definition), Oberon (extensible structs and their attachable procedures), Limbo, Newsqueak (concurrency mechanism, based on Tony Hoare's Communicating Sequential Process theory), Javascript, Ruby (polymorphism, independent of inheritance).

The main characteristics of the language are briefly presented in [7, 8, 9] and, in more detail, in [10]. R. Pike, one of the language authors, defines the main

features of Go as follows [9]: a feel of a dynamic language with the safety of a static type system; compile to machine language so it runs fast; real run-time that supports garbage collection; concurrency; lightweight, flexible type system; has methods but is not a conventional object-oriented language.

Go is a language for concurrent programming. Concurrency in Go is not based on a library. Instead, the language uses two constructs – goroutines and channels. The theoretical model of Go is based on CSP. We will give here a brief synopsis of the mechanisms used by Go to activate parallel processes, implement process interactions and their synchronization

Activation of parallel processes

For this purpose the go keyword is used. For example:

```
go l.sort();
```

A function, which is activated in such a way is called a *go-routine*. The author of Go describes the go-routine as follows:

"*A go-routine has a simple model: it is a function executing in parallel with other go-routines in the same address space. It is lightweight, costing little more than the allocation of stack space. And the stacks start small, so they are cheap, and grow by allocating (and freeing) heap storage as required*."

Implementation of interactions between processes

Interaction between processes in Go is done through channels. The creators of the language believe that the use of channels is the way to overcome the main problem of contemporary parallel programming – its difficulty.

Channels in Go are modeled after ideas from CSP [1]. In Go, they serve as both data store and synchronization mechanism between go-routines. Channels are ordinary objects, which are created with the help of the *make* function. For example:

```
c := make ( chan int, 50 );
```

creates a channel *c*, which can be used to transmit integers and which has a volume of 50 messages (in this case – integers). The operator <- is used to implement input and output operations. „The <- operator specifies the channel *direction*, *send* or *receive*. If no direction is given, the channel is *bi-directional*. A channel may be constrained only to send or only to receive by conversion or assignment. [11]"

For example

```
c <- 35;
```

transmits the integer 35 through the channel and

```
int i := <- c;
```

pulls an integer from the channel *c* and stores it in the *i* variable.
Channels in Go can be function parameters, including goroutines.

Synchronization of parallel processes

Channels are a primary means of synchronization in Go. The essence of the synchronization mechanism derives from the limitations of the internal queue of the channel. If the queue is full, then the process, which attempts to send a message through it, gets blocked. If the size of the internal queue of a channel is 0, then the process, which sends a value down the channel, is blocked until a read command is submitted by another process.

The Go language possesses another synchronization mechanism – the *select* operator.

Select statement

In [11] the syntax of the *select* operator is defined as:

```
SelectStmt = “select” “{“ { CommClause } “}”
CommClause = CommCase “:” StatementList
CommCase  = “case” ( SendStmt | RecvStmt ) | “default”
RecvStmt  = [ ExpressionList «=» | IdentifierList «:=» ] RecvExpr
RecvExpr  = Expression
```

The operator picks which communication from a given set should be executed. In the example given below, the operator must choose which of the two communications should be executed. To do this, it pauses until a message is received from one of the two channels – *s* and *q*. This will either result in executing go run (req) (in the case of receiving a message from *s*), or ending execution (return).

```
select {
   case req := <- s:
      go run ( req );
   case <- q:
      return;
}
```

3.3 Limbo

Limbo [12] is a concurrent programming language, developed by Sean Dorward, Phil Winterbottom and Rob Pike in 1995. It can be used to implement distributed systems. It is also the language used to develop applications for *Infermo* – a compact operating system designed for building distributed and networked systems on a wide variety of devices and platforms.

The language is under the influence of C, CSP and Alef. It also inherits certain traits from predecessors such as Modula 2, Oberon and Ada. From C, Limbo inherits compactness and expressiveness. The modules and the syntax for data type definitions come from Modula 2. From Oberon, the language inherits the built in abstract data types.

A large quantity of libraries have been created for Limbo. They enable working with graphics, mathematics, databases, etc. The language supports data types such as: integer (byte, int, big, real), lists, array (with slicing), string, tuple (ordered collection of types), channel (for inter-process communication), adt (abstract data type), pick (discriminated union type), module. Limbo is a strongly typed language with limited means to operate with pointers.

Concurrency in Limbo is based on CSP and using threads. Each process represents one or more streams that are executed concurrently. Synchronization and isolation are implemented by a virtual machine.

Spawning new processes is done by the *spawn* operator. A thread can be split into several independent threads. For example, the following code [13, 14] implements an application, which splits a thread into 10 threads, each of which executes the hello function:

```
init(nil: ref Draw->Context, argv: list of string) {
   sys = load Sys Sys->PATH;
   for (i:=1; i<=10; i++) {
         spawn hello(i);
   }
}

hello(i: int) {
   sys->print(”Hello from thread number %d\n”, i);
      }
```

Threads communicate with each other by sending messages over a nonbuffered, two-way channels. Coordination between processes is done with the help of channels.

Channels

Channels (chan) can be used for communication between local processes, which exchange atomic objects of a given type. They look like pipes in the UNIX command interpreter. Channels are created with the help of the *chan* keyword and the standard syntax for variable declarations. For example:

```
c := chan of int;
```

The code above creates a channel *c*, over which integers can be transmitted. Input and output are done with the help of the <- operator. For example, the code below submits the value 35 through the channel *c*:

```
c <- = 35;
```

The sample below retrieves an integer from the channel *c* and assigns it to the integer variable *i*:

```
i : int;
i = <- c;
```

There is also an option to retrieve and ignore a value from a channel. For example:

```
<-c;
```

Destroying a channel is accomplished through:

```
c = nil;
```

Channels can also be buffered. The size of the buffer is specified in the same way in which an array size is specified:

```
d := chan [10] of int;
```

The buffer works as a queue. After filling it up, sending data into the channel blocks the caller.

Channels in Limbo are used for data exchange, as well as thread synchronization. The alt operator can be used for choosing between channels. It is similar to the case operator, but it is intended to work on channels. In an alt statement, each alternative must be an expression, which contains the <- operator, or it must be *.

The semantic of alt is as follows: if alt has an alternative, which can be executed without blocking, it is executed. If there is no such alternative and no * alternative, alt is blocked, until at least one channel is ready for I/O. If alt contains a * alternative, its block gets executed.

4 Conclusion

The article contains a short synopsis of the CSP theory and its application in certain modern languages for concurrent programming. From its description, one may conclude that CSP is a powerful tool for creation of computer and program models. It has a high level of expressiveness, which allows for recording and proving theorems. CSP is powerful and unambiguous and it can also be applied as a programming language, as well as for creating programming languages. The article presents its applicability in the modern concurrent programming languages OCCAM, Go and Limbo. Elements of CSP are applied to implement concurrency in Haskell, Python, Verilog, SystemVerilog, Joyce, SuperPascal, Ada and others. For this language, the model checker FDR has been defined, through which formal models based on CSP can be verified.

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SEPARATE CONTRIBUTIONS

Parsing "COBOL" programs

Krassimir Manev[1], Haralambi Haralambiev[2], Anton Zhelyazkov[3]

[1] Department of Informatics, New Bulgarian University, 21 Montevideo str.,
1618 Sofia, Bulgaria, kmanev@nbu.bg
[2] Musala Soft Ltd., 36 Dr. Tzankov blvd. 1057 Sofia, Bulgaria,
haralambi.haralambiev@musala.com
[3] Faculty of Math. &Comp. Sciense, Sofia University, 5 J. Bourchier blvd.,
1164 Sofia, Bulgaria, iyi.blade@gmail.com

Abstract: Legacy software systems, obviously, are successful, stable and helpful. That is why it is worth to transform them to modern platforms, preserving the built in knowledge and business logic. If the source code of the legacy system software is available, the analysis of this code is obligatory for modernization of the system. Analysis of the code is helpful and necessary in many other cases too.

Parsing of the source code is unavoidable first step of any code analysis. Unfortunately, in the case of legacy software, most of the used programming languages are not maintained nowadays (COBOL, 4GL, RPG, etc.). That is why parsing of source code for purposes of the analysis of legacy software could be true challenge. This paper describes our experiments with parsing the programs of a real-life legacy system, written in a dialect of the programming language COBOL. The used parsing approaches are presented as well as the surmounted difficulties and unsolved problems.

Keywords: source code analysis, parsing of formal languages, COBOL, COBOL dialects, abstract syntax trees.

1 Introduction

Now a day, the quantity of the software running all over the world is very large and the necessity to look inside the program code of different software systems became more and more frequent. In particular the necessity to look inside the programs code of so called *legacy systems* – written in old fashioned programing languages and on old fashioned platforms that are not maintained more. Recently, a set of activities, related to the *analysis of programs' code* [1] is mentioned as *software archeology* [2]. One of the serious reasons to do code analysis is the challenge of the process of modernization of the legacy systems. Because in many cases the program code is the only available form of "documentation" of the system, its analysis could help the process of modernization [3].

But this is not the only reason for analyzing programs code. Systems for code analysis could be very helpful in process of development of new code. Especially, to control the production of not experienced programmers and for general control of the quality of produced code. Something more – systems for code analysis could be used in the process of education of programmers – being an interactive

component inside the development environment and helping students for escaping bad programming practices.

Inevitable first step of the process of automated code analysis is the *parsing* of the code and transforming it into some *language independent presentation*. It seems that parsing is a well-studied (as research object) and routine (as a practical activity) process. We will show below that in case of legacy software such assertion is discussable. Working on a project for extraction of business rules from the source code of a legacy system we had to perform parsing of the code written in a dialect of the programming language COBOL (mentioned in the source code as COBOL 2). This paper describes our experience gained by two attempts to parse the legacy COBOL code. The used approaches are presented as well as the surmounted difficulties and unsolved problems.

Section 2 introduces some basic notions, necessary for understanding the essence of our work. In Section 3 we describe so called *incremental parsing* – one attempt to manage in the jungle of languages collected under the label "COBOL" implemented with ANTLR. Then, in Section 4 we discuss another approach based on the LegStar technology for transformation of COBOL programs tht could be redesigned to a business rules extractor from COBOL programs. Section 5 contains conclusion and some directions for future work.

2 Notions and concepts

The Generally speaking, the tasks arising in the process of modernization of a legacy system through usage of the source code of its software are from the Theory of the formal languages and translation. Let us remind some basic notions of this theory [4], relevant to the subject under consideration.

Basic for the theory is the notion of *formal language*. Any formal language L is subset of the set Σ^* of all *words* (or *strings*) over some *alphabet* Σ such that is *generated* by some *formal grammar* Γ_L. The grammar puts some constraints over the words of the language—in order to belong to L a word $\alpha \in \Sigma^*$ has to poses some *structure*. We say that the grammar defines the *syntax* of the language. The main task of the theory is *recognition* of a language: for a given grammar Γ_L of the language L and a word $\alpha \in \Sigma^*$ to decide whether the word α is a word of L or not.

Formal languages are the principle instrument of informatics. Everything that we ask to be done by the computer has to be expressed in some formal language. The *machine language* is the only language that computer understands; most of applications are written in high level *programming languages*, communication of the users with the operation system and applications is done by very high level *command languages* and so on.

In order to make a formal language operational, to each word of the language

(i.e. a syntactically correct string) is assigned some change of the computer state—called *semantic* of the language. Let us denote by $\sigma_L(\alpha)$ the semantic of the word α. The reaction of the computer to a word α of the language L is to change its state as specified in $\sigma(\alpha)$.

Because each computer understands only its own machine language M, each word of a formal language has to be *translated* in a form, understandable by the computer. One of the possible forms of translation is the *compilation*, i.e. the translation $\kappa : L \rightarrow M$, such that $\forall\alpha\in L,\ \sigma_L(\alpha) = \sigma_M(\kappa(\alpha))$. *Interpretation* is a specific form of translation when α is given as an input of a program-interpreter, which performs directly the changes defined by $\sigma_L(\alpha)$.

Parsing (*syntax analysis*) is an obligatory first step for each form of translation. It checks the syntactic correctness of the analyzed word. If the translated word is syntactically correct, it is transformed to some *inner structure,* syntactically equivalent to the word, but more appropriate for the next steps of the process – *syntax tree*, for example. Next steps of compilation are not object of this paper.

3 Incremental parsing

For the first experiment the instrumental tool ANTLR was chosen [5]. ANTLR is a modern implementation of a classical parsers generator tool (in the stream of good traditions of `lex/yacc` couple) with all facilities provided by the modern technologies. ANTLR get as input one formal grammar of the language and produce lexical and syntax analyzer of the corresponding formal language that work in cooperation – we call the couple of these two analyzers *parser.*

The parsers, generated by ANTLR, read and analyze a piece of code written in the target formal language, asserting that the piece is syntactically correct or to stop with a negative answer, pointing the place in the code that does not fit to the grammar. For each case of correctly recognized construction the developer could provide piece of code – let us call it *parsers reaction* – which the parser will execute when the corresponding syntactical construction is recognized in the analyzed code. A standard reaction that ANTLR could produce is generating of a data structure, which is syntactically equivalent to the parsed piece of code – a *syntax tree*. That is why it is very appropriate for the purposes of code analysis and especially for our project for extracting the business logic from the programs code of the legacy software. It gives us the possibility to build business rules, starting from syntax trees and does not matter which was the programming language of the software.

In order to build our parser we had to use a formal grammar of the language “COBOL”. The name is written in quotation marks because, by our opinion, no such programming language. Indeed, now a day COBOL is not a programming language but a programming conception implemented in tens different languages

– some of them mentioned as *standards* (ANSI COBOL 1968, ANSI COBOL 1974, ANSI COBOL 1985, etc.), some of them as *dialects* (HP3000 COBOL/II, COBOL/2, IBM OS/VS COBOL, IBM COBOL/II, IBM COBOL SAA, IBM Enterprise COBOL, IBM COBOL/400, IBM ILE COBOL, Unix COBOL X/ Open, Micro Focus COBOL, Microsoft COBOL, Wang VS COBOL, etc. – the list is not a complete one at all) [6].

As it is easy to see there is no COBOL 2 in the lists of standards and dialects. There are COBOL/II and COBOL/2 but is one of them equivalent to our COBOL 2 and if there is one – which of them. So, from our particular case raised many practical questions: when a customer provides a legacy "COBOL" code for some analysis, how to recognize the dialect used in the source? If we are able to find the grammar of particular dialect, is it worth to build a separate parser for each specific grammar? What is the probability that we will have to analyze more projects written in the same dialect? And so on.

Trying to find some reasonable solution of the raised problems, in the discussed here project [7] it was proposed an approach for building parsers which, by our opinion, is new or, at least, not very popular. We called this approach *incremental* building of a parser. The essence of the approach is to start with an *empty grammar* that does not recognize a language construction at all. Then the *syntax rules* of the different constructions are appended to the current state one by one, in the order they are met in the analyzed program.

Applying incremental parsing we start with the formal grammar of arbitrary dialect that is available. If a syntax rule of the used dialect does not fit to the syntax rule of the parser we obtain a set of operators (at least one) as counter examples and guess the correct rule of the dialect. When all constructions of analyzed program(s) are recognized we obtain, in parallel with the working parser, a formal grammar of a *subset* of the used in the analyzed system dialect. By different reasons, obtained subset could be much simpler than the dialect itself. So the parser will be simpler too.

Latter, when we have to analyze another system written in some unknown dialect, we will first try the already built parsers and if one of these parsers could recognize the code then the programs was written in some of the processed earlier dialects and the task is solved. Else we will take one of the most promising of the existing parsers and will try to modify it. When some of the used in such parser rules are not appropriate for the analyzed code, than we could *decrement* the grammar with these rules and to start incrementing it again, guiled by the not recognized to the moment constructions. Unfortunately we did not applied true decrementing phase yet because of lack of appropriate program code. It will be an object of future research.

The approach based on repetition of steps *decrement the grammar—guess new rule—increment the grammar* is not, of course, the ideal for processing the

large families of dialects. It could be used only in the beginning. The stable and most promising approach will consist of a hierarchy of grammars of the languages of the family and building of corresponding *hierarchical parser* which is able to parse arbitrary dialect included in the hierarchy. This is not a trivial task and also will need a serious preliminary research.

4 LegStar parsing

The second experiment was performed with an instrument that was used by the authors for other projects that include static analysis of the code (test data generation, software metrics evaluation and searching of anti-patterns). LegStar [7] is a tool for integrating legacy systems written in Cobol for Mainframe with modern Java and SOA (Service Oriented Architectures) technologies. LegStar project was developed in different directions, the most interesting of which for the considered here problem is the generation of *Cobol transformers*.

LegStar Cobol Transformers Generator (LCTG) generate transformers from COBOL to Java. Input of the transformer is a XML Schema equivalent to the syntax structure of the COBOL program. A special instrument is developed to extract the XML Schema from the source code of the COBOL program by static analysis of the code. This is the particular instrument of LegStar project that could be used as a base for developing the analyzer for extraction of business rules. So let us describe it briefly.

The mentioned instrument is the program cob2xsd. It is totally independent from the other instruments of LegStar and extracts the structure of the COBOL program in form of XML Schema. For the purpose cob2xsd use a grammar of subset of COBOL language. Fig. 1 schematically describes the architecture of a COBOL parser and abstract syntax tree generator cob2xsd:

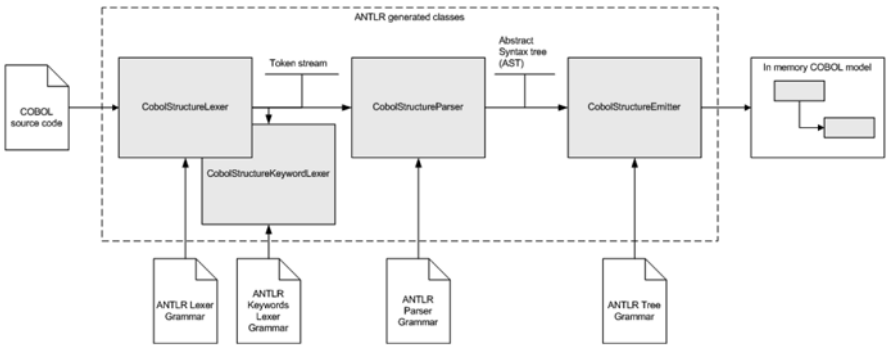

Fig. 1. COBOL parser and abstract syntax tree generator cob2xsd.

CobolStructureLexer and CobolStructureKeywordLexer execute the lexical

analysis of the program (separate COBOL keyword parsing simplifies significantly lexical analysis because of large number of keywords in languages of the COBOL family) CobolStructureParser is the syntax analyser of the program. It receive list of *tokens* from the lexical analysis and if it is syntactically correct then build the AST equivalent of the analyzed code. Especially interesting for us is the CobolStructureEmitter which close the sequence of steps of producing some model of the COBOL program. If we take as a model of the COBOL program the embedded in it business rules [8] then cob2xsd has precisely the architecture of the extractor of business rules from program code as we imagine it.

Another very attractive element of this instrument is that all formal definitions (grammars) are provided to the program as ANTLR inputs. This make very easy passing the grammars built by our incremental parsing approach to the input of our rules extractor. The only negative element of architecture of the instrument is that it is able to interpret only subset of the full COBOL structure. So the main efforts will be dedicated to rewriting these parts of cob2xsd that rely on the limitation put on the grammar.

5 Conclusion

The process of extracting business rules from legacy COBOL source code is just one of the many interesting tasks of the software archeology. There are many aspects of the task that need a serious research (see for example [9,10,11]). But it is possible also to modify well known approaches and technologies for the purposes of the extraction. The paper demonstrates how not very large modifications of the classical parsing of context-free languages and the program cob2xsd could facilitate creation of a business rules extractor from COBOL programs. The proposed modifications are in the last stage of its implementation and will be finished to the mid of 2014.

Crucial moment in the implementation will be transformation of not totally formal business rules description to ANTLR rules which is also in progress. The approach will be much more attractive if a hierarchy of grammars of as many as possible dialects of COBOL be built. We suppose that when the implementation for COBOL programs is finished its application to code written in some other legacy programming language will be easier.

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Verification of Java programs and applications of the Java Modelling Language in computer science education

Kalin Georgiev and Trifon Trifonov*
Faculty of Mathematics and Informatics, Sofia University,
email: {kalin,triffon}@fmi.uni-sofia.bg

Abstract

We suggest an application of the automatic verification platform Why in the education on theoretical computer science. The proposed approach is intended as a practical extension of the course "Semantics of Programming Languages" taught at Sofia University. We provide a set of exercises to demonstrate the application of the Java Modeling Language (JML) and the Krakatoa tool for verifying correctness of Java programs using Floyd's method. The examples range from simple numeric algorithms to nested cycles with special attention on the comparison of iterative and recursive implementations. The proposed exercises discuss the specifics of the Why/Krakatoa system and some of its limitations. We outline the potential benefits of enriching the curriculum with hands-on lab exercises.

1 Introduction

The "Semantics of Programming Languages" course in Sofia University is giving important theoretical computer science background by teaching the students formal methods for arguing about program semantics [SD96]. A substantial part of this course are practical exercises in proving partial and total correctness of iterative and recursive programs [SN03]. We suggest an extension of the course with lab exercises, which utilize automatic verification

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tools to aid the students through the gradual process of refining the logical statements about the program.

We chose Java as the language to base our exercises on as it is a widely spread language with considerable availability of programming tools. Furthermore, since Java is a modern programming language with extensive practical use, students are already familiar with it and the course will not need to be extended with a tutorial on the language itself. JML [BCC+05, LC] is a natural choice for annotating Java programs.

Among the several available tools for JML (see [CKLP05]) we chose the Why/Krakatoa platform [FM07, why], because it provides an interface to a rich set of automatic and interactive theorem provers, and can be applied for programming languages different than Java, for example C.

Our goal is not to present the student with ready solutions and let them draw conclusions themselves. For example, when presenting an exercise to students we intentionally "miss" some of the conjuncts of the conditions and after the system fails to prove correctness, prompt the students for a suggestion what the problem is.

A good way of finding out what is "missing" is to conduct a manual proof and carefully make note of *any* fact, as simple as it may seem to students. They need to understand that even simple arithmetic statements might require simple, general or even nested induction. Moreover, first-order arithmetic is an area in which automatic provers are notoriously ineffective. In our opinion, it is instructive to explain the students which facts are "easy" to prove, because they follow by propositional logic from the axioms and lemmas, and which require more complicated reasoning.

The proposed exercises rely on the important assumption that students are already familiar with Hoare's method for verifying program correctness and completeness [Hoa69, Flo67]. Furthermore, each of the examples needs to start with at least an idea for a manual proof. General limitations of the automatic verification tools require students to be able to increase the level of detail of their proofs and determine the auxiliary assumptions and lemmas needed for each deduction step in order to aid the provers, for example by strengthening the invariant clauses.

Teaching students to work with an automatic prover is not only a benefit because it demonstrates the practical application of the method. In our opinion, the sole attempt to aid a prover when it fails stimulates students to uncover those aspects of the proof, which they otherwise tend to overlook. This helps to capture mistakes and validate that a proof is indeed correct.

2 Formal setup

Students are often confused by the concept of program verification and ask questions such as "What exactly needs to be proven to assert that a program is correct?", "How detailed should the proof be to make sure it is correct?", "What guarantees do we have about the program when we finish the proof?". What is especially difficult to comprehend is that in order to prove that a program calculates a certain function, this function needs to have a formal mathematical definition, sometimes very similar to the program. Thus we need to make the general setup clear from the start: on one side we have a language in which programs are expressed (*program syntax*) equipped with a language for annotating the programs with desired properties (*annotation syntax*) and on the other we have a formal system, in which we state and prove purely mathematical properties (*verifying system*).

The source of ambiguity is usually the fact that the systems above are usually very close syntactically, but are different in nature. Using a condition generator such as Why helps to explain the usually implicit translation between the two worlds. The conditions, which are obtained from an annotated program, demonstrate how the question of verifying the result of its execution (its operational semantics) can be brought down to a completely abstract mathematical problem (its denotational semantics).

In fact, not only one, but several translations take place in order to transform the original JML annotated Java program into a set of conditions. Krakatoa is the interface between Java/JML and Why's internal syntax for programs and annotations. Caduceus and Frama-C are a similar interface for annotated C programs. However, the essential generation of verification conditions from annotations happens in Why.

The Why system provides additional features for validating the overall program robustness by the safety checks. These include loop termination, null pointer dereferencing, range checking for variable values and array indices, division by zero. Since the "Semantics of Programming Languages"course uses an infinitary model for representing memory, we pay attention only to verifying total correctness of the program by proving termination of loops. In Krakatoa this is implemented by the `loop_variant` annotation, which should be a non-negative term decreasing with each step of the loop.

3 Arithmetic example: quick power

We start our exercises with the iterative variant of the quick power function. This example is not trivial to prove both manually and automatically. We assume that the student is capable of proving the correctness of the algorithm manually and our goal is to explain the steps of verifying the proof with the help of the automatic tool.

```
public static int qpow (int x, int y)
{
    int res = 1;
    int mult = x;
    while (y > 0) {
        if (y % 2 == 0) {
            mult *= mult;
            y /= 2;
        }
        else {
            res *= mult;
            y--;
        }
    }
    return res;
}
```

In order to prove correctness of *qpow* we need to have a model of the power function in the verifying system. The easiest way to introduce a model of a function in Krakatoa is by the use of the `axiomatic` syntax. It allows to declare the signature of a function and equality axioms for it. The new function is introduced into the system only as a syntactic entity and the axioms act as rewrite rules. Note that there is no guarantee of axioms consistence or completeness. The model is assumed correct by definition.

```
axiomatic Power {
    logic integer powf(integer x,integer y);
    axiom powf0 : \forall integer x; powf(x,0) == 1;
    axiom powf_mult : \forall integer x, integer y;
        y>=0 ==> x * powf(x,y) == powf(x,y+1);
}
```

The postcondition of the program is natural: we simply express the fact that *qpow* models the *powf* function. The precondition just expresses the domain of *powf*.

```
requires y >= 0;
ensures powf(x,y) == \result;
```

We will not herein discuss how the loop invariant is constructed as this is a part of the theoretical background of the "Semantics of Programming Languages"course. Intentionally omitting the $y \geq 0$ conjunct would allow Why to prove that the invariant holds initially and is preserved, however, the postconditions would not be deduced. Students can easily see the need of the conjunct if they follow a manual proof of the program correctness.

```
loop_invariant
    powf(x,\at(y,Pre)) == res * powf(mult,y) && y >= 0;
```

The first obstacle students encounter is already with proving that the invariant initially holds. It is easy to explain that the lemmas *mul1x* and *mul1y* are needed for that.

```
lemma mul1y: \forall integer y; 1 * y == y;
lemma mul1x: \forall integer x; x * 1 == x;
```

The next step is to prove invariant preservation. We have four properties to prove, because we have two cases in the loop body and two conjuncts in the invariant. However, the proof is more involved, as it requires arithmetical properties of the power function in the model. It is easy to explain that for the case of y being odd, associativity of multiplication is required. For the even case we need a separate helper lemma for each conjunct. To prove preservation of $y \geq 0$ we need to prove a lemma that dividing by a positive integer does not change the sign (*divgt0*).[1]

```
lemma assoc_mult:
    \forall integer x, integer y, integer z;
        (x*y)*z == x*(y*z);
lemma divgt0:
    \forall integer x, integer y;
        x >= 0 ==> y > 0 ==> x / y >= 0;
```

A more complicated argument is needed to prove the preservation of the essential conjunct in the even case. The lemma states that raising x to the even power y is equivalent to raising the square of x to the power of half y. The proof of this lemma requires general induction and consequently Why is not able to prove it automatically.

[1] In fact only division by 2 is sufficient for the considered example.

```
lemma powf_2 :
    \forall integer x, integer y;
        y % 2 == 0 ==> powf(x*x, y/2) == powf(x, y);
```

4 Array example: selection sort

Having discussed the challenges of proving a single loop specifically involving non-trivial arithmetic, we consider next the selection sort algorithm. The implementation is more complex because of the nested loop. The lack of arithmetical expressions, however, considerably simplifies the task of the automatic provers and this allows us to focus on the nested loop aspect.

The implementation of the selection sort algorithm is straightforward.

```
public static void sssort (int[] a)
{
  int i=0, j=0, iMin = 0, tmp = 0;
  for (i = 0; i < a.length-1; i++)
  {
      iMin = i;
      for (j = i+1; j < a.length; j++)
          if (a[j] < a[iMin])
              iMin = j;
      tmp = a[i];
      a[i] = a[iMin];
      a[iMin] = tmp;
  }
}
```

The precondition requires a non-empty array of integers and the postcondition ensures that each next element is greater or equal than the previous one.

```
requires a != null && a.length > 0;
ensures
  \forall integer i; 0 < i < a.length-1
      ==> a[i] <= a[i+1];
```

The loop invariant of the outer cycle is fairly easy to construct due to the nice property of the selection sort algorithm that the first i elements of the array are sorted after the i-th iteration. It is also important to state that

the elements with indices greater than i are all not smaller that those with indices less or equal to i.

We also specify a range for i to allow the prover to combine it with the loop exit condition and conclude that i is equal to the array length when the cycle finishes.

```
loop_invariant
    0 <= i &&
    i < a.length &&
    (\forall integer k; 0 <= k <= i-2
          ==> a[k] <= a[k+1]) &&
    (\forall integer left, integer right;
        (0 <= left < i && i <= right <= a.length-1)
            ==> a[left] <= a[right]);
```

The goal of the inner cycle is to find the minimum of the elements in the "right part" of the array.

```
j >= i && j <= a.length && iMin >= i && iMin <= j &&
(\forall integer k; i <= k < j ==> a[iMin] <= a[k])
```

The inner cycle invariant should also "copy" the outer invariant so that we are able to prove that operations in the inner cycle preserve the properties of elements with indices less than i. The last conjunct

```
\forall integer k; 0 <= k <= i-1 ==> a[k] <= a[iMin]
```

states that whatever the value of $iMin$ is, the element at that position is always greater or equal than all elements "to the left" of i. Although this property is intuitively derivable from the rest of the statements, the provers fail to verify that after swapping the $iMin$ and i elements the property of being sorted extends to include the i-th element.

5 Recursive example: quick power

In order to compare verification for recursive and iterative programs, we will examine a recursive version of the quick power algorithm, described in Section 3. In fact, a recursive program is much more natural, since it takes advantage of the execution stack and does not need additional variables.

```
public static int qpow (int x, int y)
{
    if (y == 0)
        return 1;
    else if (y % 2 == 0)
        return qpow(x*x, y/2);
    else
        return x*qpow(x, y-1);
}
```

We reuse the function *powf* as a model, and keep the exact same pre- and post-conditions, which we had in the iterative program. However, the loop invariant is now redundant. Furthermore, this removes the need for all lemmas from Section 3 except *powf_2*. The latter statement is completely sufficient for most automatic provers to complete the correctness proof of the program.

The quick power algorithm is very instructive and is usually used to demonstrate to students how recursive algorithms can be both natural to write and efficient. In the light of the current paper it has yet another advantage: we can use it to illustrate clearly that the lack of variables and assignment makes the program easier both for annotation and verification.

6 Conclusion

The examples discussed here are far from being a complete tutorial for computer lab exercises. A useful set of materials would also include a set of demonstrative homeworks, as hands-on activities are, in our opinion, especially important for practical classes. The purpose of the present paper is to highlight important aspects and challenges which should be considered when engaging students in automated practical program verification. The field of automatic program verification is undoubtedly large and compelling; our proposed exercises touch only a tiny piece of it and there are many directions in which interested students can be encouraged to investigate.

For example, a more sophisticated method for describing models in the verifying system are inductive definitions. They are an extension of the axiomatic approach in the following sense. The axioms for *powf* state that the function is a fixed point of the corresponding equations, while an inductive definition would state that it is the least fixed point of the same equations. In Why we can define inductive predicates rather than recursive functions, so we are able to define a predicate, which describes the graph of the *powf*

function. Even though the inductive predicates produce more precise models, the automatic provers seem not to be able to cope that well in proving conditions involving inductive definitions. We have not been able to produce satisfactory annotations with inductive definitions for any of the examples above.

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Evaluation metrics for Business Processes in an Academic Environment

Kristiyan Shahinyan[1], Evgeniy Krastev[2]

[1] ComSoft Ltd., 47, Knyaginya Maria-Luiza blvd., floor 1, 1202 Sofia, Bulgaria [2] Faculty of Mathematics and Informatics, St. Kl. Ohridski University of Sofia, 5 James Bourchier Blvd., 1164 Sofia, Bulgaria

[1] k.shahinian@comsoft.bg, [2] eck@fmi.uni-sofia.bg

Abstract. This paper proposes a formal approach for business process improvement by extending a BPMN model with evaluation metrics for the purpose of simulation and monitoring the respective business process in the context of the Six Sigma methodology. The activities during the DMAIC phases of this methodology are being described in terms of a realistic case study in an academic environment. Appropriate KPIs and evaluation metrics are introduced at the definition stage of the BPMN model. The thus formalized model allows measuring and analyzing both the static and dynamic properties of the business process performance. Techniques and tools employed in social network analysis and business activity monitoring are presented for the purpose of the identification of deficiencies and proposals for improvement of the business process.

Keywords: Business process, Evaluation metrics, KPI, Business Process Modeling, BPMN, Business Process Monitoring, Business Process Simulation

1 Introduction

The evaluation of business processes plays an important role in improving the total quality of the services offered by a business organization. In particular, this means raising profitability, increasing market share and improving customer satisfaction. Several Business Process Improvement (BPI) methodologies like Six Sigma [1-2], the PDCA/PDSA Cycle [3-4] and Statistical Engineering [5] have been adopted for quality management. Recent research on business process improvement focuses on standards and tools for modeling, analyzing, monitoring and simulation of business processes. There are two major standards for developing business process models, the Business Process Model Notation (BPMN) [6] and the Event- driven Process Chain (EPC) [7], that are used in these investigations. Both quality management and business process improvement employ measurement of quality indicators in one or another way.

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In practice it is essential to introduce quality indicators [8- 9] as part of the business process model itself. The selection of appropriate quality indicators for processes running in an academic environment is not well investigated. Usually research in this area identifies Key Performance Indicators (KPIs), Key Result indicators (KRIs), Critical Success Factors (CSF) or Performance Indicators (PIs) related to non- academic, administrative support units [10]. In some cases KRIs or PIs are wrongly interpreted as KPIs [11]. Furthermore, there is no commonly accepted set of measurements for business process in an academic environment, although there are detailed descriptions of educational criteria for performance excellence [12]. Finally, unlike a typical business environment with strictly established structure of relationships and subordination among the employees, the academic environment includes a lot of elements of a social network, where the lecturers and the researchers are organized, communicate and make decisions in groups of academic interests. In addition to their direct job description, faculty members have to interact with non- academic supporting units in the organization. Therefore the existing methodologies for BPI cannot be directly applied in an academic environment.

This paper considers the use of evaluation metrics in business process modeling, simulation and improvement in the context of methodologies for quality management. An approach to identify evaluation metrics in relation to a selected KPI and to analyze the selected metrics is illustrated by a realistic BPMN model of a business process in the academic environment at Sofia University.

2 Problem statement

Nowadays more and more academic organizations make serious efforts to manage the available resources in a better way in accordance with their mission and vision goals. For this purpose it is natural to adopt methodologies used in business organizations for BPI and Total Quality Management (TQM). Some of the frameworks most frequently used in the latest years in business organizations for BPM and TQM are Six Sigma [1], the Deming cycle [4] and Statistical Engineering [5]. In this paper we follow the DMAIC (Define/Measure/ Analyze/ Improve/Control) [3] methodology in combination with Statistical engineering methods to implement Six Sigma in an academic environment.

At the *Define phase* the goal of the project has to be defined. This includes a clear definition of the KPIs, KRIs, CSFs and PIs of the academic organization, for instance, by following the strategy of Parmenter [11]. Sample strategic goals for a university are [12]:

- Enhance quality of faculty
- Enhance quality of degree program
- Enhance quality of graduating students

The following may serve as sample KPIs for an academic organization:

- the graduation rate of students
- the enrolled rate of students
- the number of publications with impact factor
- the average time lecturers spend in teaching
- the average time lecturers spend in administrative procedures

Accordingly, the scope of the processes relevant to the improvement of these indicators has to be outlined. Pareto analysis or Statistical engineering methods could be used to describe this set of processes in terms of their boundaries, resources, as well as, the expected deliverables.

The *Measure phase* requires designing the business processes, defining appropriate evaluation metrics and evaluating the current level of process performance in terms of the indicators specified in the Define phase. The BPMN model is an open standard and therefore it is preferably to use it at this phase instead of the EPC model. On the other side, BPMN allows integrating seamlessly parameters for monitoring [13] and simulation [14] of a process execution and thus enabling the process performance evaluation.

Definition: *Evaluation metrics* is the type of measurement of a property of an indicator for business process performance in terms of a selected measurement scale.

The following are some of the important characteristic of an evaluation metrics:

- must reflect an important University-wide performance dimension
- must influence PIs
- can be communicated and understood by a wide audience
- can be computed and correlated to existing standards
- the units accountable for providing the data can be identified
- must be sustainable over a period of years
- the resources needed to collect data are justifiable

The business process performance depends on the model adopted for its execution, as well as, on values of the indicator properties obtained during the process execution. Thus, evaluation metrics can serve to estimate both the *static* properties related to the structural complexity of the model and the *dynamic* properties determining the quality of the execution of the current process model. Since a BPMN model can be converted into a directed graph, then certain properties obtained by Network analysis techniques[15] of that graph can serve as static properties of the business process and according evaluation metrics can be defined [8- 9]. A similar approach has been proposed for EPC models for the purpose of identifying structural errors in such diagrams on the basis of studying evaluation metrics of statistical properties of the resulting graph [7]. Evaluation metrics for static properties of the structural complexity of business processes in an academic environment provide indication for levels of hierarchies of roles and

documents, as well as, social network properties such as *closeness*, *centrality* and *betweeness centrality* [15] among various resources and activities in the business model.

The dynamic properties provide information about the current level of business process performance. An important role in defining evaluation metrics in this case plays the evaluation metric "cycle time".

Definition: *Cycle time* evaluates the time spent on completing an assigned activity.

Cycle time is closely related to the computation of important evaluation metrics and thus it indirectly influences the established KPIs and CSFs. For instance, the cycle time is used to compute the sigma level in the Six Sigma methodology [1]. The business model must be executed or monitored in order to obtain evaluation metrics about dynamic properties of the model. In previous research [14] it has been demonstrated how the BPMN model can be extended in an Activiti framework [16] for the purpose of simulation and monitoring of evaluation metrics.

The *Analyze phase* comprises activities aiming to estimate the influence of changes in evaluation metrics measurements over the selected indicators for quality of the business process and its sub processes subject to investigation. For this purpose it has to be established the dependency of these metrics on management of basic resources of the business process. Pareto analysis and What-if analysis may be used to limit the set of evaluation metrics to include only those elements that have the greatest impact on the quality indicators.

During the *Improve phase*, recommendations for the process improvement are being made on the basis of possible structural changes in the BPMN or better management of the business process resources. The implementation of these recommendations takes place in the last phase of the here considered methodology, the *Control phase*. This entails regular reviews of the implemented measures and their impact over the established KPIs.

3 Case Study

We have selected a realistic process in the Sofia University where the *Academic life cycle of part-timers* is being described in order to illustrate the above presented methodology. Accordingly, we define KPIs and evaluation metrics, introduce appropriate metrics in the BPMN Process diagram, analyze the process for weaknesses, and give some recommendations about the process.

In the Define phase of Six Sigma we consider the commitment to "Enhanced academic quality of the graduating students" as one of the strategic goals of the university. This KPI is related to all six balanced scorecard perspectives [11] (financial results, customer satisfaction, learning and growth, internal processes,

staff satisfaction, as well as, community and environment). These perspectives allow us to define appropriate PIs and related evaluation metrics for each one of them as follows:

- The number of students attending each course allocated to the lecturer;
- The average number of students in the courses allocated to the lecturer;
- The total hours a lecturer teaches each term
- Part-time lecturers' recruitment rate per term;
- The total time lecturers spent in administrative procedures per term;
- Part-timers' rank of assessment by the students;
- Students' graduation rate.

During the *Measure* phase we focus on the business process model and develop a respective BPMN diagram (Fig. 1). This way it is has been established that an employee from the Record Keeping is generating a form for a part-timer contract in the beginning of each term and prepares a weekly sign-in book. The contract contains information describing the part-timer, for example, the names, the address and other personal identification data, as well as, the terms of the contract. Accordingly, there is information about each course the part-timer is taking, namely, the number of students expected to register in each course (although in many cases this number is not yet confirmed), how many hours per week are the classes (although this number is already defined in the teaching program documentation and respectively, known in advance).

On the other hand when a course starts the part-timer is supposed to fill-in and sign a report of the teaching hours he has completed every week. This is executed for every course, taught by the part-timer. At the end of the course, the part-timer prepares a final report, containing the same personal information as the contract, where the number of students in his courses has been updated with the exact number of students, attending the course and the students taken the end of term exam. He also provides a declaration for the payment check and an exam protocol, approved by this Admission Department. After gathering all part-timers' contracts, a Record Keeping employee sends a payment request in the Rectorate, where the payment gets approved and sent back to the Finance Department. Finally every part-timer receives his paycheck.

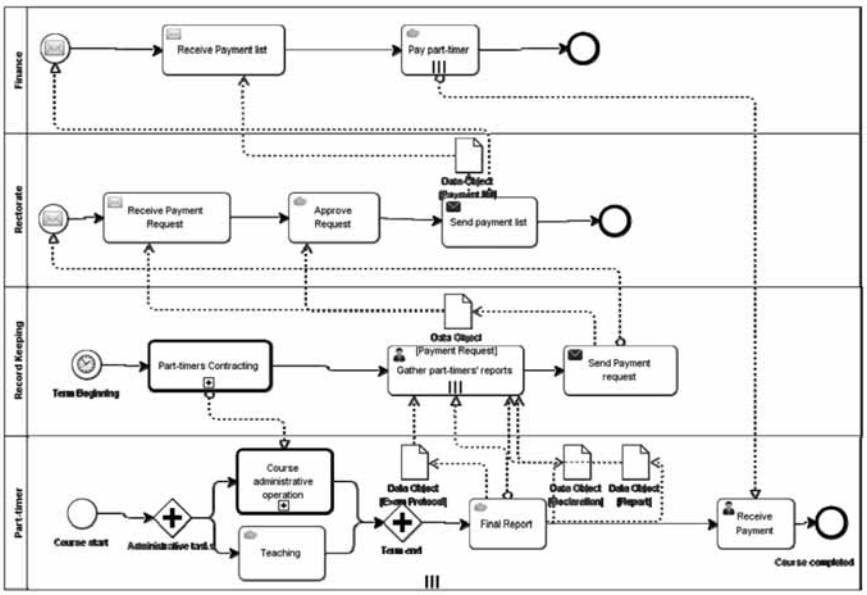

Fig. 1. Academic life cycle of part-timers and related subprocesses.

Static evaluation of various resources and activities involved in the business model the BPMN diagram (Fig 1) shows that certain important nodes like part-timers contracting, reporting of various activities are displaced in the peripheral of the business process. Thus, the business process suffers of the *eccentricity* in the displacement of important activities and the lack of *betweeness centrality* among these activities. As a result the part- timer's contract contains redundant data or data that cannot be validated at the time the contact gets signed.

An appropriate execution engine [16] is required to evaluate the dynamic properties of the BPMN model by interpreting the process diagram for the purpose of simulating the business process, implementing the automated process analysis and monitoring the production environment. The set of components employed in our investigation are displayed in the UML component diagram on Fig. 2:

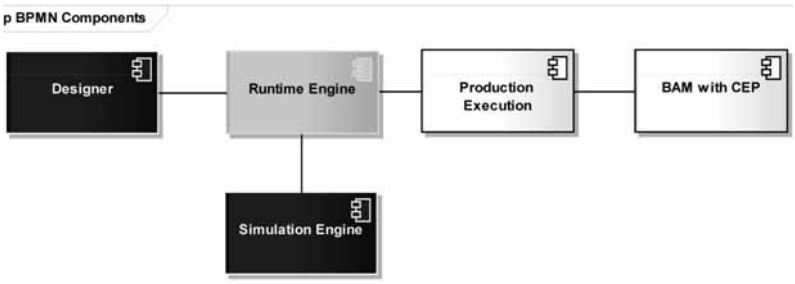

Fig. 2. Components for implementing and managing a business process

- Designer, a BPMN designer for creating and/or modifying BPMN diagrams.
- Simulation Engine, it has been used for simulation of user tasks in the BPMN diagram.
- Runtime Engine, it has been used for the execution of BPMN processes. It has a direct connection to both the Designer and the Simulation Engine.
- Production Execution, it extends the Runtime Engine in order to provide a scalable and production ready environment for real users. Configuration of such an environment and its maintenance is a project on its own;
- Business Activity Monitoring (BAM) with Complex Event Processing (CEP) it is usually being used to supply online data from the Production Environment. It is typically used for real-time monitoring and long-term data analysis.

Once these components have been setup, the evaluation metrics introduced in the *Define* phase can be included as part of appropriately selected activities in the BPMN model by means of the Designer. The selected activities are encircled on Fig. 3 and thus the BPMN model gets extended in a seamless way with evaluation metrics [14].
It allows us to measure PIs related to *cycle time* for the purpose of analyzing and improving the business process.

4 Analysis and improvement of the business process model

The analysis of the business process shows that there are a lot of time consuming manual tasks. This may cause serious process execution problems as there is no formal approach to errors management. Examples of redundant data and lack of interfaces with external information sources for data validation are the following:

- The part-timer is entering personal data several times
- The Record Keeping employee checks every course and fills in some additional data without any means for data validation
- The part-timer provides a bank account multiple times, fills in data in the report that without validation

The issues of key interest are encircled on Fig. 3.

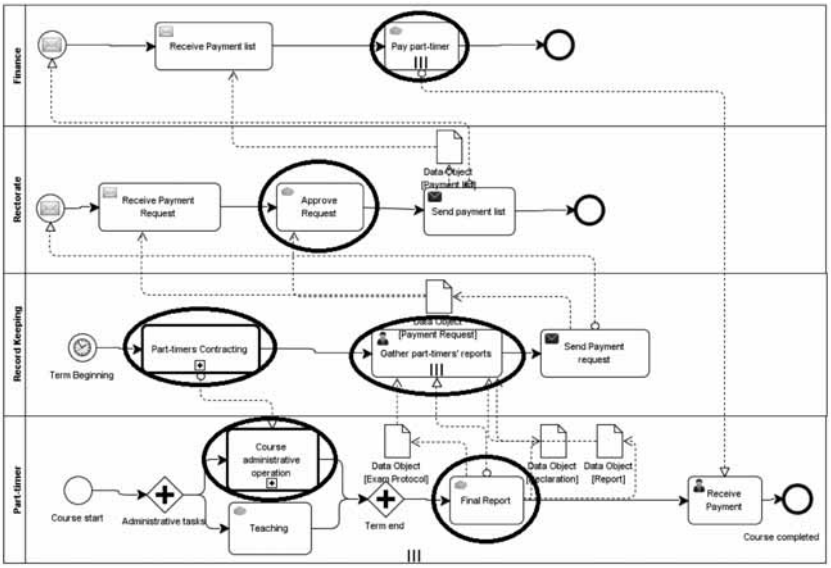

Fig. 3. Critical aspects in the execution of the BPMN model

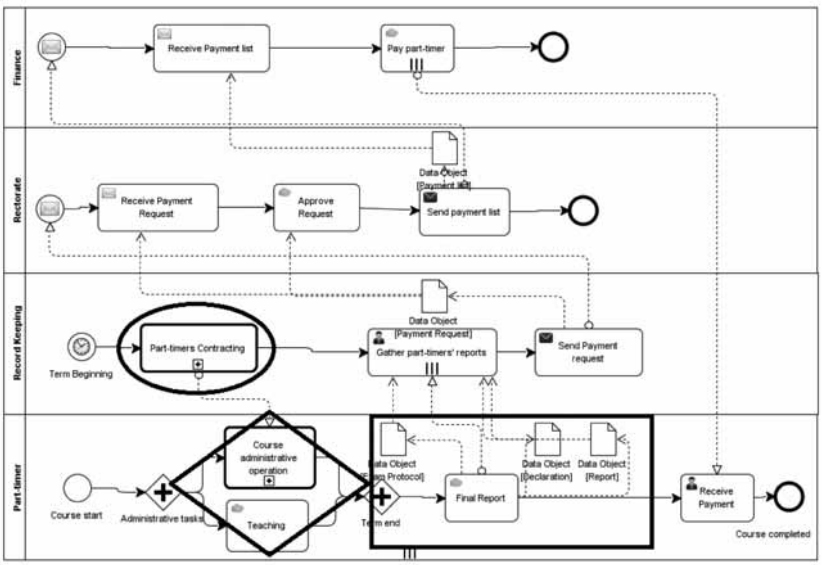

Fig. 4. Selecting tasks that influence evaluation metrics

As part of our investigation we have analyzed simulation data obtained by extending the definition of the BPMN model activities denoted on Fig. 4 with the following evaluation metrics:

1. The enrolled rate of students- marked by an ellipse (based on prediction). The selection of an appropriate initial value at the time the contract is signed is approximate, because the process of student enrollment is not incomplete at the time of the contract signing.
2. The average time lecturers spend in teaching- influenced by the activities, marked by a rhombus
3. The average time lecturers spend in administrative procedures during the term- influenced by the activities, marked by a rhombus and rectangle. This metrics be should periodically optimized and minimized.

The obtained data involves computation of the *cycle time* in terms of the proposed set of components on Fig. 2. All this metrics can be analyzed both by monitoring the business process execution and by feeding the Production execution with simulation data. Furthermore, this approach allows us to extend the BPMN standard in a natural way with evaluation metrics making it possible to execute the thus obtained BPMN model for the purpose business process monitoring or simulation [13- 14].

The results of the *Analysis* phase provide a basis for recommendations at the *Improvement* phase, as well as, guidelines for monitoring the process execution and the analysis of other evaluation metrics during the process execution.

5 Conclusion

In this paper we have made an overview of the Six Sigma methodology. The Define, Measure, Analysis and Improve phases of this methodology have been illustrated by a realistic business process at Sofia University, where a KPI and appropriate evaluation metrics have been investigated.

We have made a proposal for infrastructure, where we can model, analyze, simulate and execution in real-time a business process, based on BPMN. We have shown a diagram of the components we need in order to build an environment based on this infrastructure. These components can be kept in mind as separate modules that can be integrated into existing software, frameworks or even environments. Using this environment we can monitor the process execution and its KPIs. Following the Six Sigma methodology we can give concrete proposals for optimizing the business process execution and its performance by monitoring or simulation of variations in the evaluation metrics.

Acknowledgement

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Monte Carlo Simulations: Interest rate sensitivity of bank assets and liabilities. What will happen if interest rates change by a certain amount?

Milko Tipografov, Peter Kalchev, Adrian Atanasov

Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", 5 James Bourchier blvd., 1164, Sofia, Bulgaria

Abstract. In this paper, we research the interest rate sensitivity of a bank's loan portfolio using the Monte Carlo-simulated portfolio Value-at-Risk (VaR) model as a theoretical background and Oracle Crystal Ball as a main analytical tool.

Keywords. Monte Carlo-simulations, Value at Risk (VaR), Crystal Ball

1. Introduction

We explore the following two main points of interest:

- Possible portfolio values and returns taking into account **all possible interest rate changes**.
- Possible values of the liabilities and their interest rate based on the results above.

A similar model can be applied to a bank's liabilities and hence, to encompass all items on the bank's balance sheet.

2. Background theory

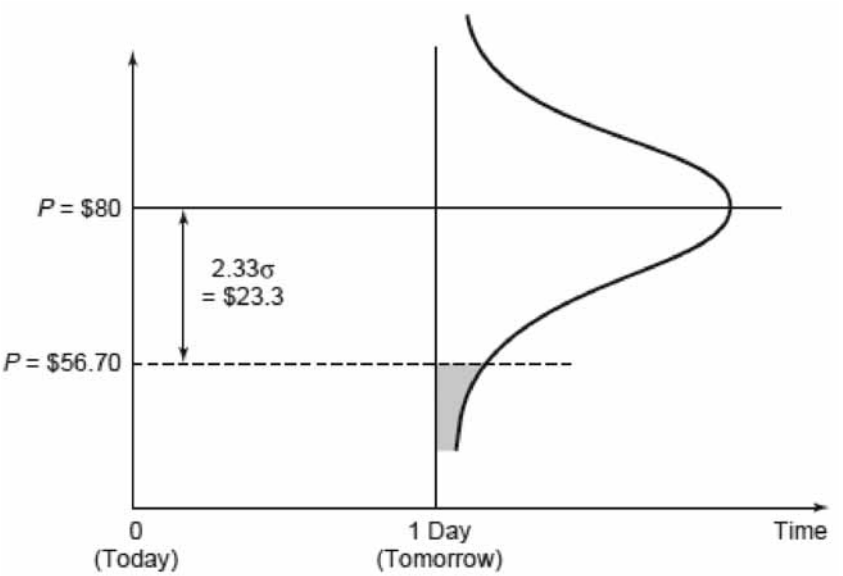
2.1. The concept of Value at Risk (VaR)

Essentially, value at risk **(VaR)** models seek to measure the maximum loss in value of a given asset or liability over a given time period at a given confidence level (e.g., 95 percent, 97.5 percent, 99 percent, and so on.). The key inputs in calculating the VaR of a marketable instrument are its current market value ***(P)*** and the volatility or standard deviation of that market value ***(s)***. Given an assumed risk horizon and a required confidence level (e.g., 99 percent), the VaR can be directly calculated.

Suppose the market price (P) of a share today is $80, and the estimated daily standard deviation of its value (s) is $10. Because the trading book is managed

over a relatively short horizon, a trader or risk manager may ask: "If tomorrow is a 'bad day,' what is my VAR (size of loss in value) at some confidence level?" Assume that the trader is concerned with the value loss on a bad day that occurs, on average, once in every 100 days, and that daily asset values (returns) are normally distributed around the current share price of $80. Statistically speaking, the one bad day has a 1 percent probability of occurring tomorrow. The area under the **normal distribution** carries information about probabilities. We know that roughly 68 percent of return observations must lie between +1 and –1 standard deviation from the mean, 95 percent of observations lie between +2 and –2 standard deviations from the mean, and 98 percent of observations lie between +2.33 and –2.33 standard deviations from the mean.

With respect to the last, and in terms of dollars, there is a 1 percent chance that the value of the share will increase to $80 + 2.33s (or above) tomorrow, and a 1 percent chance it will fall to a value of $80 – 2.33s (or below). Because s is assumed to be $10, this implies that there is a 1 percent chance that the value of the share will fall to $80 - 23.30 = $56.70 or below. Alternatively, there is a 99 percent probability that the equityholder will lose less than $23.30 in value; that is, $23.30 can be viewed as the VAR on the equity share at the 99 percent confidence level. Note that, by implication, there is a 1 percent chance of losing $23.30 or more tomorrow. Because asset values are assumed to be normally distributed, the one bad day in every 100 can lead to the loss being placed anywhere in the shaded region below $56.70.



If daily returns are used, it follows that the resulting risk measure is a daily one. However, a different time horizon could be selected. The standard deviation

σ_T for the period T can therefore be obtained from the daily one σ_D as:

$$\sigma_T = \sigma_D \sqrt{T}$$

Once standard deviation has been "scaled", VaR over a risk horizon of T days can be expressed as a multiple of the "new" standard deviation at T days.

$$VaR_T = VaR_D \sqrt{T}$$

2.2. VaR for a portfolio

When one wants to shift from an individual position to a **portfolio of multiple positions**, not only the volatilities of individual returns, but also their covariances need to be taken into account. The **portfolio's VaR** is given by a function which contains all the VaRs of the individual portfolio positions and the correlation coefficients among the relevant risk factors.

2.3. Monte Carlo-simulated portfolio VaR

The Monte Carlo Simulation technique is particularly useful because it can potentially encompass a very large number of assets or asset classes, each with its own specific characteristics which cannot be described by a single number (as is the case with standard deviation or volatility, for example). The return on each asset class is simulated according to a probability distribution of returns, preferably determined by examining the actual empirical distributions of assets, or asset class returns over a sufficiently long historical period.

The **Monte Carlo-simulated portfolio VaR** is an advanced model used for calculating the risk characteristics of the entire portfolio. Basically, the following building blocks are underpinning this model.

2.3.1. Returns of risk factors vs asset returns

Two possible approaches are possible – **taking into account the returns of the risk factors** influencing the instruments in the portfolio (in case of a portfolio of options these can be the market indices upon the options are based) or **taking into account the returns of the assets within the portfolio** themselves. We will undertake the latter approach here.

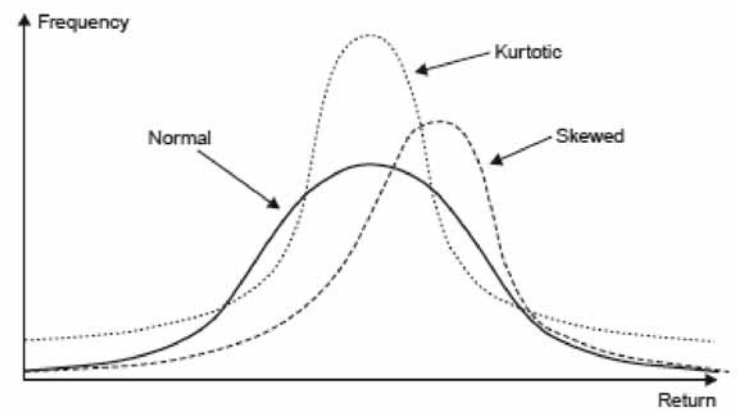
2.3.2. Historical data for the assets in question

Historical data for the asset returns should be gathered – the more data

available, the better will the model perform in a statistical sense. Data for the asset allocations within the portfolio is also needed.

2.3.3. Return distributions

Statistical properties of the historical returns are to be examined – this step is crucial as incorrect distributions will lead to incorrect results. Contrary to common wisdom (and practice), asset returns **are often *not*** normally distributed. Most often returns are skewed to one side or the other, and furthermore they often exhibit more extreme market events than is predicted by the normal distribution, which gives rise to so-called *kurtosis* or 'fat tails' (shown below).



Expected probability distributions can be based on historically observed frequency distributions as well as more or less subjective expectations about future distributions of returns. There are three main statistics that are used for ordering the distributions:

- Anderson-Darling
- Chi-Square
- K-S

The choice of the best distribution depends on its use in the model and the judgement of a subject matter expert (SME). Thus, the Monte Carlo approach leaves the risk manager free to select the distribution which is thought to be most suitable.

2.3.4. Correlations

Correlations between the returns are defined so that the joint distributions of the variables are specified. Without correlations, the model is unrealistic as thus it

is assumed that there is no relation between the variables which is obviously not true in the real world. The correlations are assumed as being constant – this is definitely not true in the long run; however we can safely assume that these correlations are relatively stable over shorter periods of time.

2.3.5. Simulation

For each asset/asset class returns are drawn based on the joint statistical distributions specified above. We draw quasirandom returns from asset class return distributions according to the specified correlation matrix. The value of the portfolio and the return on the portfolio is re-calculated for each trial. The end result is many portfolio values corresponding to each random return and a portfolio return distribution. It is then possible to calculate VaR based on the desired percentile – both in absolute and percentage terms.

Monte Carlo can also be used for asset allocation and portfolio optimisation
- ***Quasi-Random Monte Carlo Simulated Asset Allocation (QRMCSAA)***
– possibly a future project.

2.3.6. Drawbacks of the Monte Carlo model

- The correlation matrix is assumed as being constant.
- Monte Carlo simulation does not model serial correlations.
- Just like all other risk-management tools, it is only as good as its inputs, and Monte Carlo only works if the probability distributions are accurately estimated or predicted.

3. Empirical study

3.1. Applicable Tools

We will use the **Crystal Ball add-in for Excel** from Oracle (http://www.oracle.com/us/products/applications/crystalball/Crystal-Ball-product/overview/index.html), which is one of the leading tools for Monte Carlo simulations. An alternative tool that might be used is **@RISK** from Palisade Corporation (http://www.palisade.com/risk/).

3.2. Initial Data

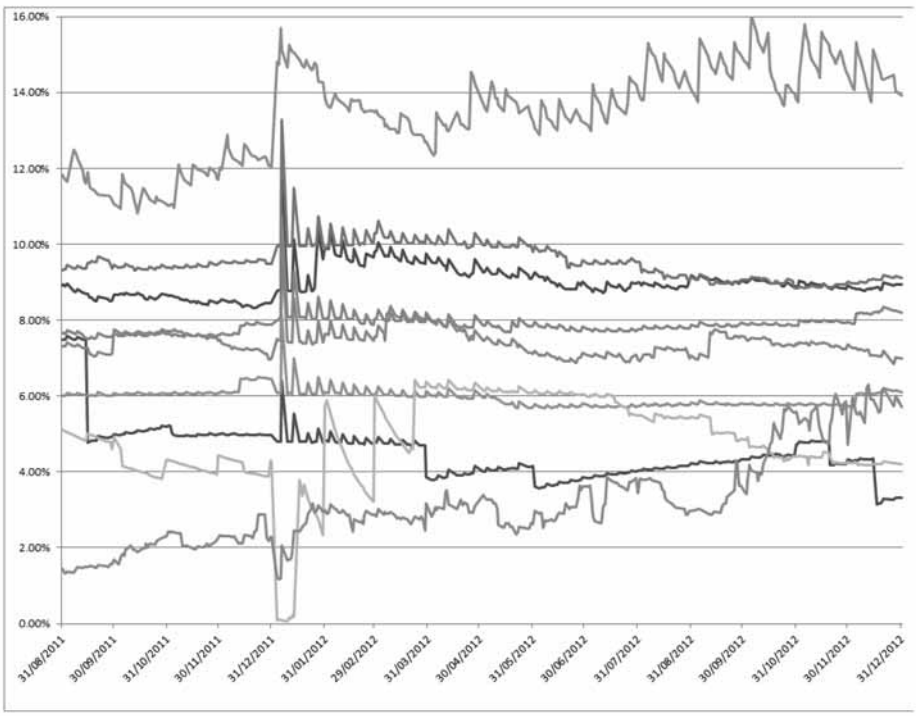
We have the following raw data on hand:

- Interest rates (returns) for 9 categories of loans on a daily basis (31.08.2011

– 31.12.2012) – not shown here, but available upon request.

- Composition of the loan portfolio as of 31.12.2012 (shown on the figure below).
- Value of the interest bearing liabilities as of 31.12.2012 – 674 109 833.35
- Gap between the interest bearing assets and interest bearing liabilities as of 31.12.2012 – 18 437 013.60.
- Net interest margin as of 31.12.2012 – 2.63%.

Statistics for each of the 9 time series



3.3. Return distributions

From first sight it is obvious that:

- All asset classes are non-normally distributed.
- Most asset classes show a positive skew (returns skewed to the right).
- All but 1 asset classes show a positive kurtosis (relatively peaked distribution).

Crystal Ball has built into its distribution-fitting procedure the algorithms to estimate parameters and assess the goodness of fit between the empirical distribution function (EDF) of your dataset and the cumulative distribution function (CDF) of each applicable continuous distribution in its distribution gallery. The fitting and selection is nearly automatic, although it does require some judgment and subject matter knowledge to use most effectively. In situations for which we know that there is a limit on how large or small a generated value can be, we can set a limit on our generated values for any distribution with a **truncation limit** in Crystal Ball. The Batch Fit procedure of Crystal Ball also considers correlations between the time series. The **Pearson's coefficients** given above do not generalize easily to all distributions, so Crystal Ball uses the **Spearman rank correlation coefficient** instead of the Pearson. The Spearman correlation coefficient is the Pearson correlation coefficient calculated for the ranks of the observed values of *X* and *Y*.

Results from the fitting procedure are summarised below (p-values for the statistics are not provided here):

Asset Class	**Fitted Distribution**	**Anderson-Darling Statistic**	**K-S Statistic**	**Chi-Square Statistic**
Business customers - large exposures	Student's	10.6573	0.1482	187.9765
Business customers - corporate	Gamma	1.2165	0.0480	32.4000
Business customers - small and medium businesses	Lognormal	1.8893	0.0668	56.5412
Retail banking - loans to purchase homes	Max Extreme	4.7591	0.1171	166.6294
Retail banking - consumer loans	Max Extreme	3.0783	0.0899	76.4353
Retail banking - overdrafts	Weibull	10.0112	0.1631	326.3412
Credit cards	Beta	4.1356	0.0521	30.7235
Interest income on securities management	Student's t	6.7194	0.1097	183.0588
Interest income from placements of FI	Lognormal	3.2115	0.0900	94.3176

The correlation matrix presented by Crystal Ball is as follows:

1.0000	0.4165	-0.3973	-0.0068	-0.1557	0.6421	-0.4092	-0.6531	-0.5929
0.4165	1.0000	0.3331	0.3071	0.1655	0.4243	-0.1697	-0.1335	-0.2464
-0.3973	0.3331	1.0000	0.4108	0.5468	-0.1920	0.3575	0.4860	0.3484
-0.0068	0.3071	0.4108	1.0000	0.1930	0.3211	-0.3180	0.2345	-0.4174
-0.1557	0.1655	0.5468	0.1930	1.0000	0.2298	0.5645	-0.1209	0.4489
0.6421	0.4243	-0.1920	0.3211	0.2298	1.0000	-0.3561	-0.5333	-0.4432
-0.4092	-0.1697	0.3575	-0.3180	0.5645	-0.3561	1.0000	-0.0008	0.6710
-0.6531	-0.1335	0.4860	0.2345	-0.1209	-0.5333	-0.0008	1.0000	0.2017
-0.5929	-0.2464	0.3484	-0.4174	0.4489	-0.4432	0.6710	0.2017	1.0000

3.4. Defining assumptions

We will use the fitted distributions as assumptions for the model as below and will truncate all distributions that allow negative values at 0, since interest rates cannot be negative.

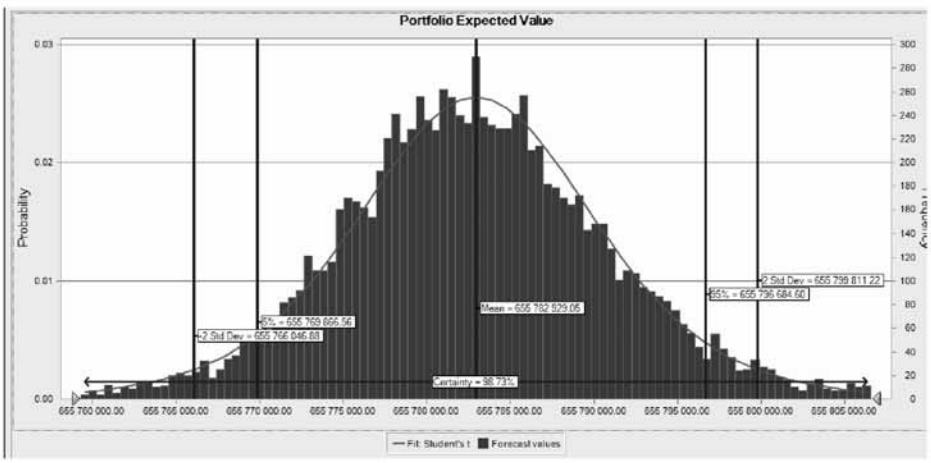
Asset Class	**Fitted Distribution**	**Mean**	**Standard Deviation**
Business customers - corporate	Student's	0.0453683765355653	0.00710205784068987
Business customers - corporate	Gamma	0.0741839206775967	0.00335368634077826
Business customers - small and medium businesses	Lognormal	0.0899185541254804	0.00411585247069061
Retail banking - loans to purchase homes	Max Extreme	0.0953965463390321	0.0047961603379285
Retail banking - consumer loans	Max Extreme	0.0786650429901828	0.00219933306743806
Retail banking - overdrafts	Weibull	0.059565033964636	0.0023119675848071
Credit cards	Beta	0.134767395238086	0.012354478124047
Interest income on securities management	Student's t	0.0479895153727406	0.0116488916780078
Interest income from placements of FI	Lognormal	0.0316948002562221	0.0121898869866307

3.5. Simulation of the loan portfolio value, portfolio return and VaR

We define as forecasts in Crystal Ball the value of the portfolio and the portfolio return. Results based on 10 000 trials are summarised below:

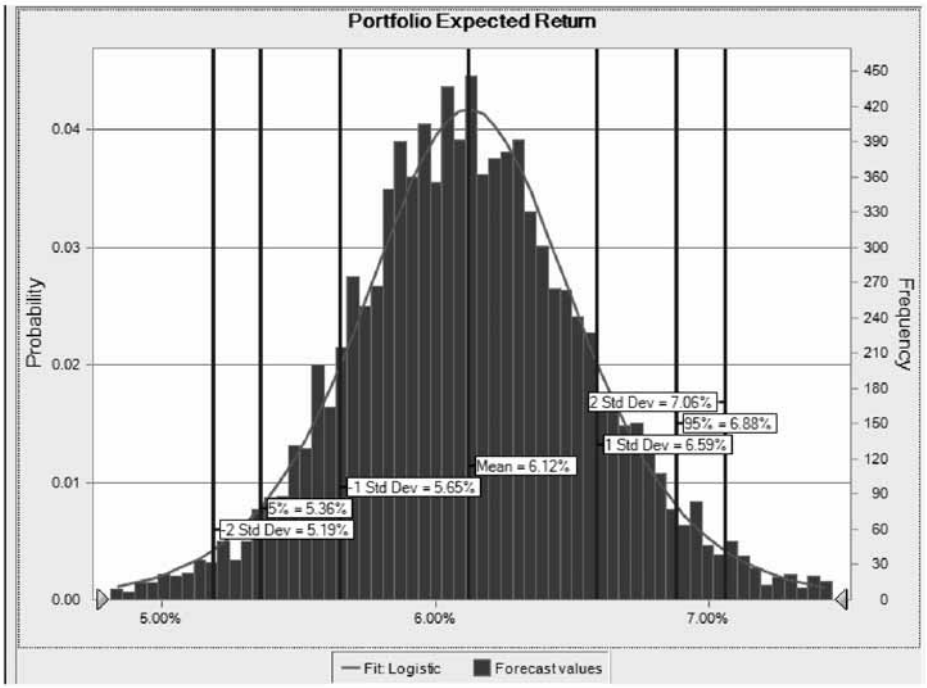
Indicator	**Expected Portfolio Value**	**Expected Portfolio Return**
Mean	**655 782 929.05**	**6.13%**
Standard Deviation	**8441.09**	**0.47%**
Minimum	655 749 880.64	4.29%

Maximum	655 838 152.64	9.20%
Fitted Distribution	Student's t	Logistic
0% Percentile	655 749 880.64	4.29%
10% Percentile	655 772 953.68	5.57%
20% Percentile	655 776 387.99	5.77%
30% Percentile	655 778 713.12	5.89%
40% Percentile	655 780 756.24	6.01%
50% Percentile	655 782 685.99	6.12%
60% Percentile	655 784 618.75	6.22%
70% Percentile	655 786 668.34	6.34%
80% Percentile	655 789 353.98	6.49%
90% Percentile	655 793 313.49	6.71%
100% Percentile	655 838 152.64	9.20%
VaR at 97.5% for 1 day[1]	**19 667.74**	**1.10%**
VaR at 97.5% for 5 days[2]	**43 978.40**	**2.46%**



[1] Calculated as: 2.33 x 8 441.09 = 19 667.74 and 2.33 x 0.47% = 1.10%

[2] Calculated as the above times sqrt(5).



Thus, we can be 97.5% confident that the loan portfolio will fluctuate in a negative direction from the means (**655 782 929.05 and 6.12%)** by not more than **19 667.74** in absolute terms and **1.10%** (on an annual basis) in relative terms during the next business day. For the next 5 trading days, these numbers are **43 978.40** and **2.46%** respectively. **As strictly speaking interest rates on loans cannot be negative, the portfolio will not decrease in value, but rather may bring lower than expected absolute and relative returns.**

3.6. Simulation of interest bearing liabilities value and interest rate

Assuming that the gap between interest bearing assets and interest bearing liabilities remains constant and that the net interest rate margin is constant as well (both are thus assumed fixed as of 31.12.2012), we now simulate the probability distribution of interest bearing liabilities values and interest rates.

We define as forecasts in Crystal Ball the value of interest bearing liabilities, the interest rate on these liabilities and the absolute change in the value of the interest rate liabilities. Results based on 10 000 trials are summarised below:

Indicator	Expected Value of Interest Bearing Liabilities	Expected Return on Interest Bearing Liabilities	Expected Change in Interest Bearing Liabilities
Mean	**674 219 942.65**	**2.86%**	**110 109.30**
Standard Deviation	**8441.09**	**0.47%**	**8441.09**
Minimum	674 186 894.24	1.02%	77 060.89
Maximum	674 275 166.24	5.93%	165 332.89
Fitted Distribution	Student's t	Logistic	Logistic
0% Percentile	674 186 894.25	1.02%	77 060.90
10% Percentile	674 209 967.29	2.30%	100 133.94
20% Percentile	674 213 401.59	2.50%	103 568.24
30% Percentile	674 215 726.72	2.62%	105 893.37
40% Percentile	674 217 769.85	2.74%	107 936.50
50% Percentile	674 219 699.60	2.85%	109 866.25
60% Percentile	674 221 632.35	2.95%	111 799.00
70% Percentile	674 223 681.95	3.07%	113 848.60
80% Percentile	674 226 367.58	3.22%	116 534.23
90% Percentile	674 230 327.10	3.44%	120 493.75
100% Percentile	674 275 166.25	5.93%	165 332.90

As assets and liabilities are linked, expected changes in assets are translated into expected changes in liabilities – the bank needs to match collected funds against attracted funds. Thus, in order to meet the expected values of the loan portfolio and its return during the next business day, the bank should consider the following:

- Interest bearing liabilities have a mean value of **674 219 942.65**.
- Interest bearing liabilities pay a mean interest rate of **2.86%.**
- Interest bearing liabilities are to increase by **110 109.30.**

4. Conclusion

Monte Carlo simulation can be effectively used when analysing the interest rate sensitivity of a bank's assets and liabilities. Simulating returns can help management in directing the bank's policy in relation to granting loans and attracting new funds. In this case study with the particular dataset in question, we demonstrated that for the next business day the following is expected:

- The value of the loan portfolio will be 655 782 929.05 and there is a 97.5% chance that it will not fluctuate by more than 19 667.74. The return on the loan portfolio will be 6.12% and there is a 97.5% chance that it will not fluctuate by more than 1.10%.
- With the above considered and other things being equal, interest bearing liabilities should increase by 110 109.30 and pay an interest rate of 2.86%.

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Classification of Events in the EPC Standard

Ivaylo Kamenarov,

Department of Informatics and Information Technologies, University of Ruse,
8 Studentska Str., 7017 Ruse, Bulgaria
ikk@ami.uni-ruse.bg

Abstract. This paper presents the necessary terms assuring the EPC diagrams correctness. Four types of composite events, represented as a combination of events and connectors, are discussed. Links between them are approved using the formal definitions of EPC standard.

Keywords: Business Process Models, Event-driven Process Chain.

1 Introduction

Nowadays, a dynamically changing industry requires corporations to continuously adapt and change their activities. It imposes on corporations to describe and manage the overall activities through business process modeling. Modeling of business processes should be implemented by a standardized approach to define specific criteria for the process description.

Standard EPC (Event-driven Process Chain) allows business processes modeling by graphical diagrams, which present the workflow of business processes. The EPC is developed within the framework of Architecture of Integrated Information System (ARIS) by Prof. Wilhelm-August Scheer in the early 1990s. Over the years, the standard has improved and established as a powerful tool for modeling, analysis and transformation of business processes and it is used by many organizations. The main elements of the standard are functions, events, connectors and connections between them.

This paper presents the necessary terms for the correctness of EPC diagrams and types of composite events, that can be composed by connectors and events. Using the formal definitions of the EPC standard the presented arguments are approved.

2 Correctness of EPC diagrams

The EPC diagrams are sequences of functions, events and connectors that represent the workflow of business processes. But not every such sequence is correct EPC diagram. It must correspond to certain conditions that accurately represent a business process model.

Formulations of restrictions in the EPC standard are required to implement precise approach for business process modeling. It improves modeling, comprehensibility and usability of the created business processes models and


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thus, standardizes and facilitates the work of business analysts, developers and all those who uses business processes models.

In Fig. 1 two sequences of EPC elements are shown, which are models of two almost identical business processes. The difference between the two sequences is that the left diagram is not correct EPC diagram and does not respond to the requirements, while the right diagram is correct and satisfies all requirements. Left sequence does not satisfy the following requirements:

- Every business process must have at least one triggering event and at least one terminating event (after $\mathbf{f}_3$ there must be an event, which is terminating for entire business process);
    - Between each two function, there must be an event ($\mathbf{f}_1$ can't be connected directly to $\mathbf{f}_2$, also $\mathbf{f}_2$ to $\mathbf{f}_3$);
    - Between two events, there must be a function ($\mathbf{e}_1$ can't be connected directly to $\mathbf{e}_2$).

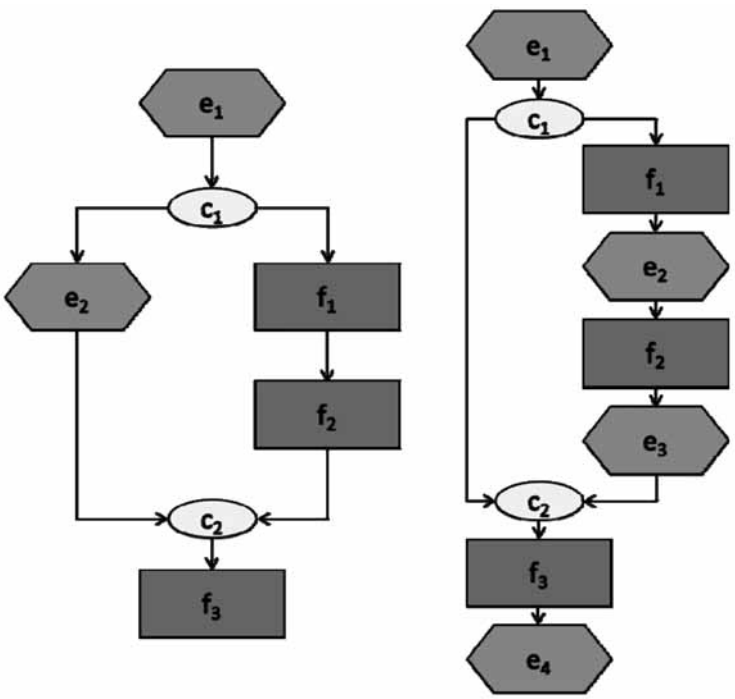

Fig. 1. Not correct and correct EPC Diagrams

Fig. 1. Not correct and correct EPC Diagrams

To specify all the requirements of the EPC standard it is necessary to define three formal definitions [1].

- **Definition 1**:

- EPC is a five-tuple (**E**, **F**, **C**, **l**, **A**);
- **E** is a finite (non-empty) set of events;
- **F** is a finite (non-empty) set of functions;
- **C** is a finite set of logical connectors;
- **l** C { , XOR, } is a function which maps each connector onto a connector type;
- **A** (**E** × **F**) (**F** × **E**) (**E** × **C**) (**C** × **E**) (**F** × **C**) (**C** × **F**) (**C** × **C**) is a set of arcs.

- **Definition 2:**

- Let EPC = (**E**, **F**, **C**, **l**, **A**)
- ***N*** = **E** **F** **C** is a set of nodes of EPC;
- For **n** **N**:
- **n** = {m | (m, n) **A**} is a set of input nodes;
- **n** = {m | (n, m) **A**} is a set of output nodes;
- $\mathbf{C_J}$ = {**c** **C** | | **c**| ≥ 2} is a set of join connectors;
- $\mathbf{C_S}$ = {**c** **C** | |**c** | ≥ 2} is a set of split connectors;
- A directed path **p** from a node $\mathbf{n_1}$ to a node $\mathbf{n_k}$ is a sequence {$\mathbf{n_1}$, …, $\mathbf{n_k}$} such that ($\mathbf{n_i}$, $\mathbf{n_{i+1}}$) **A** for 1 ≤ i ≤ k-1;
- $\mathbf{C_{EF}}$ **C** such that **c** $\mathbf{C_{EF}}$ if and only if there is a path **p** = {$\mathbf{n_1}$, $\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$, $\mathbf{n_k}$} such that $\mathbf{n_1}$ **E**, $\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$ **C**, $\mathbf{n_k}$ **F** and **c** {$\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$};
- $\mathbf{C_{FE}}$ **C** such that **c** $\mathbf{C_{EF}}$ if and only if there is a path **p** = {$\mathbf{n_1}$, $\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$, $\mathbf{n_k}$} such that $\mathbf{n_1}$ **F**, $\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$ **C**, $\mathbf{n_k}$ **E** and **c** {$\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$};
- $\mathbf{C_{EE}}$ **C** such that **c** $\mathbf{C_{EF}}$ if and only if there is a path **p** = {$\mathbf{n_1}$, $\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$, $\mathbf{n_k}$} such that $\mathbf{n_1}$, $\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$ **C**, $\mathbf{n_k}$ **E** and **c** {$\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$};
- $\mathbf{C_{FF}} \subseteq \mathbf{C}$ such that $\mathbf{c} \in \mathbf{C_{EF}}$ if and only if there is a path **p** = {$\mathbf{n_1}$, $\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$, $\mathbf{n_k}$} such that $\mathbf{n_1} \in \mathbf{F}$, $\mathbf{n_2}$, …, $\mathbf{n_{k-1}} \in \mathbf{C}$, $\mathbf{n_k} \in \mathbf{F}$ and $\mathbf{c} \in$ {$\mathbf{n_2}$, …, $\mathbf{n_{k-1}}$};

- **Definition 3:**

- EPC = (**E**, **F**, **C**, **l**, **A**) satisfies the following requirements:
- The sets **E**, **F** and **C** are pairwise disjoint, i.e. **E** **F** = ∅, **E** **C** = ∅ and

F **C** = ∅;

- for each $\mathbf{e} \in \mathbf{E}$: $|\mathbf{e}| \leq 1$ and $|\mathbf{e}| \leq 1$;
- there is at least one event $\mathbf{e} \in \mathbf{E}$ such that $|\mathbf{e}| = 0$ (triggering event);
- there is at least one event $\mathbf{e} \in \mathbf{E}$ such that $|\mathbf{e}| = 0$ (terminating event);
- for each $\mathbf{f} \in \mathbf{F}$: $|\mathbf{f}| = 1$ and $|\mathbf{f}| = 1$;
- for each $\mathbf{c} \in \mathbf{C}$: $|\mathbf{c}| \geq 1$ and $|\mathbf{c}| \geq 1$;
- $\mathbf{C}_J$ and $\mathbf{C}_S$ partition $\mathbf{C}$, i.e. $\mathbf{C}_J \cap \mathbf{C}_S = \emptyset$ and $\mathbf{C}_J \cup \mathbf{C}_S = \mathbf{C}$;
- $\mathbf{C}_{EE}$ and $\mathbf{C}_{FF}$ are empty, i.e. $\mathbf{C}_E = \emptyset$ and $\mathbf{C}_{FF} = \emptyset$;
- $\mathbf{C}_{EF}$ and $\mathbf{C}_{FE}$ partition $\mathbf{C}$, i.e. $\mathbf{C}_{EF} \cap \mathbf{C}_{FE} = \emptyset$ and $\mathbf{C}_{EF} \cup \mathbf{C}_{FE} = \mathbf{C}$.

Types of events

In the EPC standard the events are passive elements and serve as a link between the different functions of the business process. They are divided into simple and composite. Simple events are single items and composite events combine together several events (possibly also composite) through connector. Each process (function) is preceded by a triggering event and ends with a terminating event, where the triggering and terminating events can also be composite.

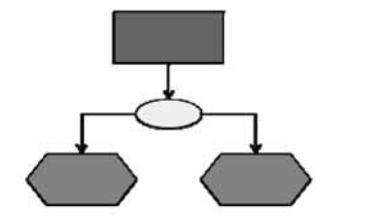

Fig. 2 Terminating Composite Splitting Event

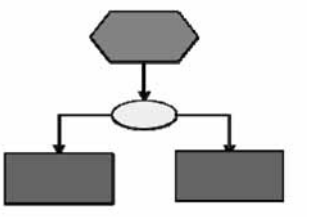

Fig. 3 Triggering Composite Splitting Event

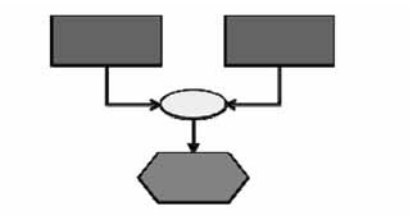

Fig. 4 Terminating Composite Joining Event

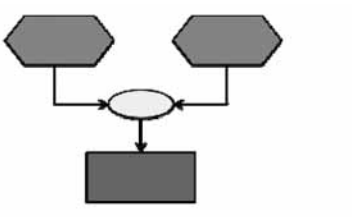

Fig. 5 Triggering Composite Joining Event

The composite events are divided into two groups according to the connector: splitting and joining. The composite events are divided into: triggering and terminating depending on whether they precede or follow process. It is not possible for a composite event (**c** **C**) to serve as both triggering and terminating, because it must have an input node function ($\mathbf{p}_1$ **F**) and an output node function ($\mathbf{p}_2$ **F**) then **c** $\mathbf{C}_{FF}$ ($\mathbf{C}_{FF}$ is empty set - Definition 3). Therefore composite events are four types: terminating splitting (end composite splitting **ECS**), terminating joining (end composite joining **ECJ**), triggering splitting (start composite splitting **SCS**) and triggering joining (start composite joining **SCJ**) events.

- Terminating composite splitting event (**ECS**) is shown in Fig. 2. The connector type of this composite event can be AND, XOR, OR: l(c) = { , XOR, } [2].

Let us consider the terminating composite splitting event **c** (a type of **c** is **ECS**). Then **c** combines related events {$\mathbf{e}_1$, …, $\mathbf{e}_k$}, which should be more than one (**k** > 1), so that a connector of the events is splitting. The composite event **c** must be terminating for only one function. It is possible $\mathbf{e}_i$ (for each **i** from **1** to **k**) to be a simple event as well as a composite event. If the event $\mathbf{e}_i$ is composite, then its type is **ECS** (Fig. 6) or **ECJ** (Fig. 7), i.e. it is also a terminating event. Because if $\mathbf{e}_i$ is a triggering event, then there is a path ($\mathbf{f}_1$, **c**, $\mathbf{e}_i$, $\mathbf{f}_2$), where ($\mathbf{f}_1$, **c**) **A** and ($\mathbf{e}_i$, $\mathbf{f}_2$) **A**, i.e. **c** $\mathbf{C}_{FF}$, but $\mathbf{C}_{FF}$ is empty set (by Definition 3). Therefore it is not possible $\mathbf{e}_i$ to be a triggering event. The composite event **c** may be considered as a root of a tree, and $\mathbf{e}_1$, …, $\mathbf{e}_k$, as its inheritors. If $\mathbf{e}_i$ is a simple event then it adds a leaf $\mathbf{e}_i$ to the root of the tree. If $\mathbf{e}_i$ is a composite event, then it adds a subtree of composite event $\mathbf{e}_i$ to the root of the tree.

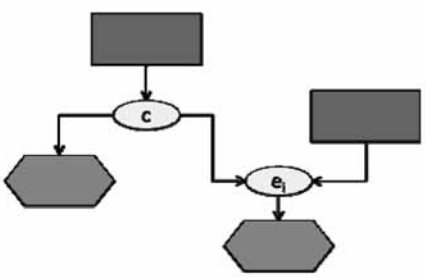

Fig. 6

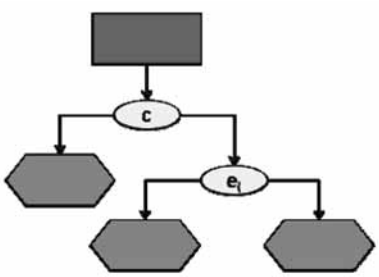

Fig. 7

- Terminating composite joining event (**ECJ**) is presented in Fig. 4. The connector type of this composite event can be AND, XOR, OR: l(c) = { , XOR, } [2].

Let us consider the terminating composite joining event **c** (a type of **c** is **ECJ**). Then **c** combines just one related event **e** and it is a simple or composite event. The event **e** must be terminating for more than one function, so that a connector

of the event is joining. If the event **e** is composite, then its type is **ECJ** (Fig. 8) or **ECS** (Fig. 9), i.e. it is also a terminating event. Because if **e** is a triggering event, then there is a path ($\mathbf{f}_1$, **c**, **e**, $\mathbf{f}_2$), where ($\mathbf{f}_1$, **c**) A and (**e**, $\mathbf{f}_2$) **A**, i.e. **c** $\mathbf{C}_{\mathbf{FF}}$, but $\mathbf{C}_{\mathbf{FF}}$ is empty set (by Definition 3). Therefore it is not possible **e** to be a triggering event. If **e** is a simple event, then the tree of events for this case consists of only one leaf with **e**. If **e** is a composite event, then the tree of events is a tree for event **e**. In both cases event **c** misses as a node in the tree.

- Fig. 3 shows a triggering composite splitting event (**SCS**) . The connector type of this composite event can be only AND: l(c) = { } [2].

Let us consider the triggering composite splitting event **c** (a type of **c** is **SCS**). Then **c** combines just one related event **e** and it is a simple or composite. The event **e** must be triggering for more than one function, so that a connector of the event is splitting. If the event **e** is a composite, then its type is **SCS** (Fig. 10) or **SCJ** (Fig. 11), i.e. it is also a triggering event. Because if **e** is a terminating event, then there is a path ($\mathbf{f}_1$, **e**, **c**, $\mathbf{f}_2$), where ($\mathbf{f}_1$, **e**) **A** and (**c**, $\mathbf{f}_2$) **A**, i.e. **c** $\mathbf{C}_{\mathbf{FF}}$, but $\mathbf{C}_{\mathbf{FF}}$ is empty set (by Definition 3). Therefore it is not possible **e** to be a terminating event. If **e** is a simple event, then the tree of events for this case consists of only one leaf with **e**. If **e** is a composite event, then the tree of events is a tree for event **e**. In both cases event **c** misses as a node in the tree.

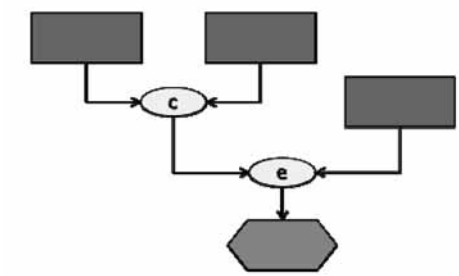

Fig. 8

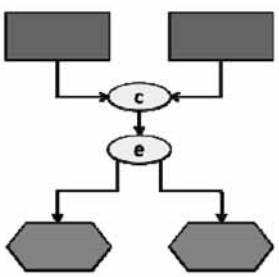

Fig. 9

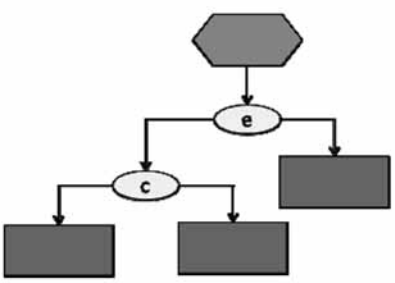

Fig. 10

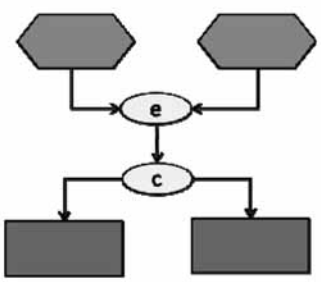

Fig. 11

- Fig. 5 presents triggering composite joining event (**SCJ**) . The connector type of this composite event can be AND, XOR, OR: l(c) = { , XOR, } [2].

Let us consider the triggering composite joining event **c** (a type of **c** is **SCJ**). Then **c** combines related events {$\mathbf{e_1}$, …, **ek**}, which should be more than one (**k** > 1), so that a connector of the events is joining. The composite event **c** must be triggering for only one function. It is possible $\mathbf{e_i}$ (for each **i** from **1** to **k**) to be a simple event or composite event. If the event $\mathbf{e_i}$ is a composite, then its type is **SCJ** (Fig. 12) or **SCS** (Fig. 13), i.e. it is also a triggering event. Because if $\mathbf{e_i}$ is terminating event, then there is a path ($\mathbf{f_1}$, $\mathbf{e_i}$, **c**, $\mathbf{f_2}$), where ($\mathbf{f_1}$, $\mathbf{e_i}$) **A** and (**c**, $\mathbf{f_2}$) **A**, i.e. **c** $\mathbf{C_{FF}}$, but $\mathbf{C_{FF}}$ is empty set (by Definition 3). Therefore it is not possible $\mathbf{e_i}$ to be a terminating event. The composite event **c** may be considered as a root of a tree, and $\mathbf{e_1}$,…, $\mathbf{e_k}$ as its inheritors. If $\mathbf{e_i}$ is a simple event then it adds a leaf $\mathbf{e_i}$ to the root of the tree. If $\mathbf{e_i}$ is a composite event then it adds a subtree of composite event $\mathbf{e_i}$ to the root of the tree.

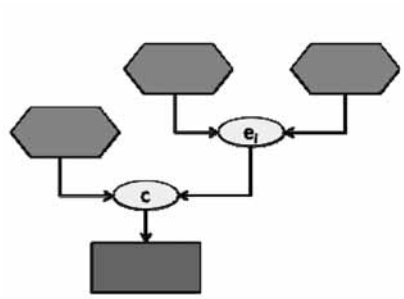

Fig. 12

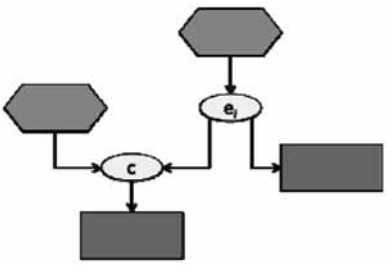

Fig. 13

Considering each of the four composite events types, it can be concluded that for each composite event a tree of events is formed. The leaves of this kind of tree contain only simple events. If a function has a triggering event which is composite, using its tree of events, the all simple events can be found. Similarly, if a function has composite terminating event, using its tree of events, the all simple events can be found.

CONCLUSION

The description of composite events is presented by a tree of events. The concept of formal function (process) definitions is extended by description of its input and output nodes. For each function two trees of events are added, which

represent its input and output. Trees of events as well are used to define the triggering and the terminating events of the function.

By the described method whole fragments could be built. For each function the corresponding fragment includes the function itself and all events (triggering and terminating). Relationships between functions are established by the events included in the function fragment. The role of these fragments is to facilitate the work of business analysts and managers in business process modeling. They improve the usability of already modeled business processes and support the modeling of new business processes by reusing fragments of existing business processes.

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