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ICT AND MANAGEMENT

USE OF TEMPORAL CONCEPTS IN TRANSACTIONAL DATABASES

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Abstract: *The last quarter-century, a number of researchers and experts are engaged in the study of temporal concepts in databases. Justification of a large number of research papers is that conventional DBMS are not able to respond to some of the tasks imposed by the modern business environment. These tasks are related to tracking the state in real system on one hand, while on the other hand they are related to tracking the state of database itself. Furthermore, the study of information systems, as one of its goals, is to make better description of the real system and the problems that need to be addressed. The consequence of this is to enrich the semantic data models with brand new or older and expanded concepts and represent real system in better way. This paper aims to present a brief overview of temporal concepts and to show their application in one of the proprietary transaction DBMS, IBM DB2 10.5.*

Keywords: *Temporal databases, SQL:2011 standard, transactional databases*

1. INTRODUCTION

History of the temporal concepts in databases is long, complicated and with a lot of controversy. In short, there are two main periods. The first period is 1986-2011 and is called SQL/Temporal. Significant research works in this period are: (Snodgrass, 1986), (Snodgrass et al., 1994), (Snodgrass, 1994), (Darwen & Date, 2006). The second period is 2008-2011 and it is characterized by the fact that temporal concepts become part of the SQL: 2011 standard. Temporal concepts in SQL: 2011 standard is largely based on the SQL/Temporal, but there are significant differences (Kulkarni & Michels, 2012).

The rest of this article is organized in the following way: Section 2 gives an overview of temporal concepts and focus on temporal features defined in SQL:2011. Section 3 provides examples of temporal concepts in transactional database in IBM DB2 10.5. The last section gives conclusions and discusses future work.

2. BASIC TEMPORAL CONCEPTS

The problem that occurs in conventional databases is that only current state is memorized. Therefore, they are referred as snapshot database. We insert new data, change or delete existing data, but state before change is not memorized. Thus, a conventional DBMS are memoryless systems (Patel, 2003).

The problem can be solved using temporal concepts. In practice there is need to implement them, but information system designers, programmers, database administrators, users in one word, ignore and simplify that fact, because of the complexity. Application were required to implement support for temporal concepts were developed for a long time with a lot of code and proved to be incomplete. As an example, IBM made research in which they compared the implementation of temporal concepts in three possible ways (Saracco et al., 2012). The first is to incorporate them directly into the database. The second is implementation by using stored procedures and triggers. The third realization consists of triggers and application logic written in Java programming language. Result of the research is that the built-in support for temporal concepts is the best solution that can reduce the size of the program code up to 45 times.

Time in temporal database is viewed as ordered sequence of points in granularity which is determined by application. For example, if we need to develop application for HR, which task is to track period of time in which employee has worked in department, minimal granularity should be one day. This means that employee in one day can do his job only in one department. In reality, every day is flow of time, not a point, because it consists of hours, minutes, seconds etc. Chronon is term in literature that is used to describe this minimal granularity of application. The consequence of defining minimal granularity, for example a day, is that events that take place in this day are simultaneous events, although in reality it does not have to be.

There are two types of temporal information (Elmasri & Navathe, 2010). First group are time series. In that situation, event is connected with one point in a time in some granularity. For example, stock value of some

company at August 15, 2013. was 50$. In practice, to process these types of information companies are using dedicated software systems – time series database server (TSDS). They are not subject of this paper.

Second group are duration events, or facts and they are referring to specific time period in database. For example, employee may have worked in financial department from August 18, 2012 until January 1, 2014. Time period is represented by its start and end time points, for example [2012-08-18, 2014-01-01]. This time period can be represented as the set of all time points from its start-time to end-time, in the specified granularity (Elmasri & Navathe, 2010). If the granularity is day, then the defined period is the sum of all days from August 18, 2012 to January 01, 2014.

Temporal concepts links time of event, or a fact with time point in database. If an event has occurred in the real world, or fact proved to be true or valid and has its conjunction with time in the database, then the time is referred to as the valid time. Transaction time is the time to indicate that the information is valid in the database, ie. in the system itself. If database has support to each of these time dimension, it is indicated as bitemporal database. These basic concepts are described, from point of SQL/Temporal. There is a slight difference in terminology between SQL/Temporal and SQL:2011 standard. It is shown in the table 1.

Table 1: SQL/Temporal vs SQL: 2011 difference in terminology

SQL/Temporal	SQL:2011
valid time	application time
transaction time	system time
validtime table	application time period table
transactiontime table	system-versioned table
bitemporal table	system-versioned application time period table

2.1. Application time period tables

Application time period table contains PERIOD clause, whereby the user can define the name of the period. These tables contain two columns: one to store the initial time of period, and the other to store the end time of period. The values in these columns are defined by user. Additional syntax is provided for users to specify primary key/unique constraints to ensure that no two rows with the same key value have overlapping periods. Application time period table stores valid time, and they suggest when a fact or event is valid in the real world. Because user defines values for initial and end time of period, changes in database can be applied before they come in real world. That is proactive update, and it reflects state of table in a future. In addition, there is a retroactive update, where changes are entered into the database after they have occurred in the real world.

This temporal concept can be used to solve the following business requirements (Saracco et al. 2012):
1. A client challenges an insurance agency's resolution of a claim involving a car accident. The agency needs to determine the policy's terms in effect when the accident occurred.
2. An online travel agency wants to detect inconsistencies in itineraries. For example, if someone books a hotel in Rome for eight days and reserves a car in New York for three of those days, the agency would like to flag the situation for review.
3. A retailer needs to ensure that no more than one discount is offered for a given product during any period of time.

2.2. System-versioned tables

In contrast to regular tables, system-versioned tables preserve old versions of rows as table is updated. Table contains two additional columns where start time and end time of period is stored. Values in these columns are set by system. Users are not allowed to supply values for these columns. These tables keep all changes of state of table, so user can logically returns on some state of database. Because of that database with this time can be referred as rollback database (it isn't related with rollback operation of transaction) (Elmasri & Navathe, 2010). System-versioned tables contain PERIOD clause, with predefined name of period SYSTEM_TIME, and specified WITH SYSTEM VERSIONING. Rows whose periods intersect the current time are called current system rows. All others are called historical system rows. Only current system rows can be updated or deleted. All constraints are enforced on current system rows only.

This temporal concept can be used to solve the following business requirements (Saracco et al., 2012):
1. An internal audit requires a financial institution to report on changes made to a client's records during the past five years.
2. A pending lawsuit prompts a hospital to reassess its knowledge of a patient's medical condition just before a new treatment was ordered.

2.3. System-versioned application time period table

If database should store application and system time at the same time, in that situation we use combined approach, system-versioned application time period table.

This temporal concept can be used to solve the following business requirements (Saracco et al., 2012):
1. A client inquiry reveals a data entry error involving the three-month introductory interest rate on a credit card. The bank needs to retroactively correct the error (and compute a new balance, if necessary).

3. TEMPORAL CONCEPTS EXAMPLES ON IBM DB2 10.5

IBM DB2 10.5 version implements all previous mentioned temporal concepts. It should be borne in mind that concepts that are described by SQL:2011 standard have different names in IBM DB2 terminology. The differences are shown in Table 2.

Table 2: terminology differences between SQL:2011 standard and IBM DB2 10.5

SQL:2011 Standard	IBM DB2 10.5
application time period tables	tables with business time
system-versioned tables	tables with system time
system-versioned application time period tables	bitemporal tables

Temporary concepts are going to be presented in following examples. That will be done using Product table. In one point of time, discount for only one product should be enabled.

3.1. Tables with business time

Creation of table with business time in IBM DB2 is done using following command:

```
CREATE TABLE Product(
id INT NOT NULL,
name VARCHAR(20),
price DECIMAL,
discount INT,
bus_start DATE NOT NULL,
bus_end DATE NOT NULL,
PERIOD BUSINESS_TIME(bus_start, bus_end),
PRIMARY KEY(id, BUSINESS_TIME WITHOUT OVERLAPS)
)
```

In IBM DB2 implementation of temporal concepts, user doesn't have the possibility to define the name of the period. It is predefined as BUSINESS_TIME. Bus_start and bus_end columns present start and end time. Optional command BUSINESS_TIME WITHOUT OVERLAPS is used for primary key limitation. That means that 2 versions of the same product, which are valid in one same point of time, cannot exist. Inserting rows into Product table is shown in the following example:

```
INSERT INTO Product
 VALUES(1, 'Black Shoes', 150, 10, '2012-12-25', '2013-01-10'),
       (1, 'Black Shoes', 150, 5, '2013-01-10', '2013-01-31'),
       (1, 'Black Shoes', 150, 0, '2013-01-31', '9999-12-30'),
       (2, 'Moccasin', 100, 5, '2012-09-01', '2013-04-01')
```

Table 3: table with business time after INSERT statement

id	name	price	discount	bus_start	bus_end
1	Black Shoes	150	10	2012-12-25	2013-01-10
1	Black Shoes	150	5	2013-01-10	2013-01-31
1	Black Shoes	150	0	2013-01-31	9999-12-30
2	Moccasin	100	5	2012-09-01	2013-03-01

If we tried to execute following SQL statement:

```
INSERT INTO Product VALUES (1, 'Black Shoes', 150, 10, '2013-06-06', '2013-07-07')
```

An error would occur because of defined limitation for Period temporal data. Syntax for UPDATE command is expanded with FOR PORTION clause that supports temporal data. This clause is used to specify a period of time for which update is going to be done.

The result of next UPDATE statement, used for Table 3, is shown in Table 4:

```
UPDATE Product
   FOR PORTION OF BUSINESS_TIME FROM '2013-06-01' TO '2013-09-01'
SET discount = 20
WHERE id = 1;
```

Table 4: table with business time after UPDATE FOR PORTION

id	name	price	discount	bus_start	bus_end
1	Black Shoes	150	10	2012-12-25	2013-01-10
1	Black Shoes	150	5	2013-01-10	2013-01-31
1	**Black Shoes**	**150**	**0**	**2013-01-31**	**2013-06-01**
1	**Black Shoes**	**150**	**20**	**2013-06-01**	**2013-09-01**
1	**Black Shoes**	**150**	**0**	**2013-09-01**	**9999-12-30**
2	Moccasin	100	5	2012-09-01	2013-04-01

Two rows are processed with UPDATE command for product 1. Each of 2 original rows will split into 2 rows, as shown, because the command includes a part of period inside these 2 rows in the table.

For removing data from table with business time, operation can be limited to specific part of the time, by specifying FOR PORTION OF BUSINESS TIME clause. If a row should be deleted, and data are not fully included in that part of time, DB2 would provide that row information is saved.

Result for the following command executed over Table 4:
```
DELETE FROM Product
 FOR PORTION OF BUSINESS_TIME FROM '2012-09-01' TO '2013-01-01'
WHERE id = 2
```
is shown in Table 5.

Table 5: table with business time after DELETE FOR PORTION

id	name	price	discount	bus_start	bus_end
1	Black Shoes	150	10	2012-12-25	2013-01-10
1	Black Shoes	150	5	2013-01-10	2013-01-31
1	Black Shoes	150	0	2013-01-31	2013-06-01
1	Black Shoes	150	20	2013-06-01	2013-09-01
1	Black Shoes	150	0	2013-09-01	9999-12-30
2	**Moccasin**	**100**	**5**	**2013-01-01**	**2013-04-01**

It is possible to make temporal and non-temporal queries over table with business time. Non-temporal queries are classic SELECT commands that are also written for DBMS that don't support temporal concepts. Following 3 temporal conditions can be included in temporal queries:
- FOR BUSINESS_TIME AS OF . . . – enable the execution of query over data in specific point of time
- FOR BUSINESS_TIME FROM . . . TO . . . – enable the execution of query with condition from start to end time defined. IBM DB2 uses inclusively-exclusive approach, so end time is not taken into count
- FOR BUSINESS_TIME BETWEEN . . . AND . . . – data are selected from specific to specific time. Condition is inclusively-inclusive, which means that start and end point are included in condition for selection.

If following query is used with Table 5:
```
SELECT discount
FROM Product FOR BUSINESS_TIME AS OF '2013-03-20'
WHERE id = 1
```

The operation result is 0.

If we want to list conditions for buying product 1 in period from 2013-03-01 to 2013-07-01, following query can be made. The result is shown in Table 6.
```
SELECT *
FROM Product FOR BUSINESS_TIME FROM '2013-03-01' TO '2013-07-01'
WHERE id = 1;
```

Table 6: result of SELECT statement with condition FOR BUSINESS_TIME

id	name	price	discount	bus_start	bus_end
1	Black Shoes	150	0	2013-01-31	2013-06-01
1	Black Shoes	150	20	2013-06-01	2013-09-01

3.2. Tables with system time
Creation of table with system time is going to be shown. In IBM DB2 database, old rows are kept in history table – table that is separated from table with current data, with the same structure (Saracco et al., 2012). For IBM DB2 database table creation is done in 3 steps:

1. Create the base table for current data – it contains 3 TIMESTAMP columns, 2 for start and end point of system time and one for transaction start time. (In DB2 this column is used to follow the first execution of data changing command). These three columns can be specified with GENERATE ALWAYS, so on INSERT, UPDATE or DELETE command new values will be generated in database. Optionally, you may define these columns as IMPLICITLY HIDDEN so they won't show up in SELECT * statements.
2. Create the history table - this table has structure identical to the table that contains current data. This is easy step with CREATE TABLE . . . LIKE statement.
3. Alter the current table to enable versioning and identify the history table.

Now we will see these 3 steps. First is to create base table. We can do it with command:

```
CREATE TABLE Product(
id INT PRIMARY KEY NOT NULL,
name VARCHAR(20),
price DECIMAL,
discount INT,
sys_start TIMESTAMP(12) GENERATED ALWAYS AS ROW BEGIN NOT NULL,
sys_end TIMESTAMP(12) GENERATED ALWAYS AS ROW END NOT NULL,
trans start TIMESTAMP(12) GENERATED ALWAYS AS TRANSACTION START ID IMPLICITLY HIDDEN,
PERIOD SYSTEM_TIME (sys_start, sys_end)
);
```

Now we will create related history table.

```
CREATE TABLE Product_history LIKE Product
```

The last step is to enable versioning:

```
ALTER TABLE Product ADD VERSIONING USE HISTORY TABLE Product_history;
```

Suppose now that the following command was executed on April 13, 2012. Results are displayed for current row is in table 7, and history rows in table 8.

```
INSERT INTO Product(id, name, price, discount)
VALUES (1, 'Black Shoes', 150.00, 10);
INSERT INTO Product(id, name, price, discount)
VALUES (2, 'Moccasin', 100.00, 5);
```

Table 7: Product table after INSERT statement

id	name	price	discount	sys_start	sys_end
1	Black Shoes	150	10	2014-04-13 17:53:25	9999-12-30 00:00:00
2	Moccasin	100	5	2014-04-13 17:53:25	9999-12-30 00:00:00

Table 8: Product_history table after INSERT statement - empty

id	name	price	discount	sys_start	sys_end

For each row in database TIMESTAMP VALUES are generated for system time, and transaction start time. Value in column SYS_END is set to December 30, 9999. This means that these rows are current.

If we run UPDATE command on current rows, old versions of rows will be memorized in history table. Suppose now that the following command was executed on April 15, 2014.

```
UPDATE Product
SET discount = 30
where id = 1;
```

Row that keeps current data is updated and copy of old row is moved to history table as shown in table 10.

Table 9: Product table after UPDATE statement

id	name	price	discount	sys_start	sys_end
1	Black Shoes	150	30	2014-04-15 12:53:25	9999-12-30 00:00:00
2	Moccasin	100	5	2014-04-13 17:53:25	9999-12-30 00:00:00

Table 10: Product_history table after UPDATE statement

id	name	price	discount	sys_start	sys_end
1	Black Shoes	150	10	2014-04-13 17:53:25	2014-04-15 12:53:25

If data is going to be deleted, they are moved to history table. END_TIME of deleted data is time of the transaction. Suppose the following command was executed on April 20, 2014.

```
DELETE FROM Product WHERE id = 2;
```

Tables that show current and history rows are shown in table 11 and table 12.

Table 11: Product table after DELETE statement

id	name	price	discount	sys_start	sys_end
1	Black Shoes	150	30	2014-04-15 12:53:25	9999-12-30 00:00:00

Table 12: Product_history table after DELETE statement

id	name	price	discount	sys_start	sys_end
1	Black Shoes	150	10	2014-04-13 17:53:25	2014-04-15 12:53:25
2	**Moccasin**	**100**	**4**	**2014-04-13 17:53:25**	**2014-04-20 12:13:45**

Conducting the temporal queries in tables with the system time is functioning on the same way as they functioning in table with business time. The only difference is that the result can contain history rows.

Before we represent bitemporal tables, there is overview which compares the key characteristics of system time and business time (Mathias, 2012).

Table 13: key characteristics of system time and business time

Characteristics of system time	Characteristics of business time
Captures the time when changes happen to data inside DB2 database.	Captures the time when changes happen to business objects in the real world
Maintains a history of updated and deleted rows, generated by DB2	Maintains application-driven changes to the time dimensions of business objects
History based on DB2 system timestamps	Dates or timestamps are provided by application
DB2's physical view of time	Your application's logical view of time
Spans from the past to the present time	Spans past, present, and future time
System validity (transaction time)	Business validity (valid time)
Supports queries such as: "Which policies were stored in the database on June 30?"	Support queries such as: "Which policies were valid on June 30?"

3.3. Bitemporal tables

Next example shows how to create bitemporal table:

```
CREATE TABLE Product(
id INT NOT NULL,
name VARCHAR(20),
price DECIMAL,
discount INT,
bus_start DATE NOT NULL,
bus_end DATE NOT NULL,
sys_start TIMESTAMP(12) GENERATED ALWAYS AS ROW BEGIN NOT NULL,
sys_end TIMESTAMP(12) GENERATED ALWAYS AS ROW END NOT NULL,
trans_start TIMESTAMP(12) GENERATED ALWAYS AS TRANSACTION START ID IMPLICITLY HIDDEN,
PERIOD BUSINESS_TIME(bus_start, bus_end),
PERIOD SYSTEM_TIME (sys_start, sys_end),
PRIMARY KEY(id, BUSINESS_TIME WITHOUT OVERLAPS));
```

Once the table is created as bitemporal, it is necessary to make a copy of the same table. After that it is necessary to link created tables, and allow versioning. Complete procedure is explained in the previous section.

For example, assume that product 1 is created by user on 19 Apr 2014 with discount of 10%. Discount is set to go into effect on 01 May 2014.

```
INSERT INTO Product(id, name, price, discount, bus_start, bus_end)
VALUES(1, 'Black Shoes', 150, 10, '2014-05-01', '9999-12-30');
```

Suppose that on 20 April 2014, someone change the terms of discount for product 1. Discount is set to go into effect on 01 June 2014 and discount increases to 20%.

```
UPDATE Product
 FOR PORTION OF BUSINESS_TIME FROM '2014-06-01' TO '9999-12-30'
SET discount = 20
WHERE id = 1;
```

Because of simplifying the display instead of TIMESTAMP data type for the system time we will show only the date part. Tables Product and Product_history look like Tables 14 and 15 respectively.

Table 14: Bitemporal table Product

id	name	price	discount	bus_start	bus_end	sys_start	sys_end
1	Black Shoes	150	20	2014-06-01	9999-12-30	2014-04-20	9999-12-30
1	Black Shoes	150	10	2014-05-01	2014-06-01	2014-04-20	9999-12-30

Table 15: Bitemporal table Product_history

id	name	price	discount	bus_start	bus_end	sys_start	sys_end
1	Black Shoes	150	10	2014-05-01	9999-12-30	2014-04-19	2014-04-20

Now let's look at an example showing the advantages of the bitemporal concept. Customer calls contact center on 15 July 2014 and complains about the bill. Customer thinks that value of discount is not adequate and requires all changes in price and discount in the last year.

Database administrator can set following query:

```
SELECT *
FROM Product
 FOR SYSTEM_TIME FROM '2013-07-15' TO '2014-07-15'
WHERE id = 1;
```

Result of this query is presented in Table 16.

Table 16.

id	name	price	discount	bus_start	bus_end	sys_start	sys_end
1	**Black Shoes**	**150**	**20**	**2014-06-01**	**9999-12-30**	**2014-04-20**	**9999-12-30**
1	**Black Shoes**	**150**	**10**	**2014-05-01**	**2014-06-01**	**2014-04-20**	**9999-12-30**
1	**Black Shoes**	**150**	**10**	**2014-05-01**	**9999-12-30**	**2014-04-19**	**2014-04-20**

Bitemporal tables can implement temporal queries with 3 types of conditions: conditions with business time only, conditions with system time only and conditions with combination of business time and system time. First two types are already mentioned when we talked about system-versioned tables and application time period tables. Third type of temporal queries combine conditions of these two groups.

Following 6 temporal conditions can be included in temporal queries:
- FOR BUSINESS_TIME AS OF . . .
- FOR BUSINESS_TIME FROM . . . TO . . .
- FOR BUSINESS_TIME BETWEEN . . . AND . . .
- FOR SYSTEM_TIME AS OF . . .
- FOR SYSTEM_TIME FROM . . . TO . . .
- FOR SYSTEM_TIME BETWEEN . . . AND . . .

Suppose that tables Product and Product_history are presented with data in Table 14 and Table 15.
Result of following query, which is combination of conditions with business and system time, is presented in Table 17.

```
SELECT *
FROM Product
 FOR BUSINESS_TIME AS OF '2014-05-01'
 FOR SYSTEM_TIME FROM '2014-04-19' TO '9999-12-30'
```

Table 17: Resulting query which is combination of conditions with business and system time

id	name	price	discount	bus_start	bus_end	sys_start	sys_end
1	**Black Shoes**	**150**	**10**	**2014-05-01**	**9999-12-30**	**2014-04-19**	**2014-04-20**
1	**Black Shoes**	**150**	**10**	**2014-05-01**	**2014-06-01**	**2014-04-20**	**9999-12-30**

4. CONCLUSION

Temporal concepts in transactional databases enable users to implement tracking the state in real system and tracking the state in database itself, and combination of both concepts. Using temporal concepts we can remove basic problem of these systems. Temporal concepts, specified in SQL:2011, simplify the logic of applications, stored procedures and triggers, which would be used if we want to implement tracking the state of tables in database. IBM DB2 10.5 is commercial solution that fully supports temporal concepts. Future directions should consider joins with temporal condition - temporal joins.

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PERFORMANCE EVALUATION OF TEMPORAL FEATURES DEFINED IN ORACLE 12C DATABASE

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Abstract: *Conventional relational databases represent state of the business entity at a moment. Although, data changes over time with insertion of new records, update of previous records or deletion of not needed records, these changes present a modification of the state of business entity. However, there exist applications where previous state of database should be kept. In conventional relational databases the attributes involving time are manipulated mainly by the application programs, with help from the database management system (DBMS). Therefore, a need to shift time manipulation from application to DBMS is identified and implemented in SQL:2011 standard. This research aims to evaluate performance of traditional relational DBMS (RDBMS) and temporal databases. Performance comparison is conducted in controlled, experimental environment using Oracle 12c DBMS.*

Keywords: *Temporal databases, SQL:2011 standard, DBMS, performance comparison*

1. INTRODUCTION

In majority of database systems time dimension of event (record) present one of the most important attributes in its application. This is especially true for analytical database such as data warehouses (Golfarelli & Rizzi, 2011). Every event important for operation of enterprise occurs at specific point of time. Also, object and relationships between two or more objects exist only for some interval point of time. Therefore, ability to model time of real world is one of the most important subjects in many applications such as financial application, medicine (Mahmood et al., 2013), web traffic (Mokbel et al., 2013) and geographical information systems (Siabato et al., 2014).

Traditional relational databases present state of enterprise at a current point of time. In other words, previous states of object or relationship between objects (after update or delete of some record) cannot be fully retrieved. However, historical data is needed in order to gain insightful knowledge from history and thus make better decision. In most applications this problem is solved on computer application side, which resulted in expensive development. Since this can pose a serious threat in real-time transactional systems need to mitigate this problem to DBMS is identified. In 1995, the ISO SQL committee initiated a project to create a language extension to support temporal features in SQL standard. A set of language extension based on TSQL2 (Snodgrass, 1995) were submitted for standardization at that time, but unfortunately these proposals generated considerable controversy and failed to get adequate support from the ISO SQL committee's members. In addition, there were no indications that key DBMS vendors were planning to implement temporal extensions in their products. Darwen & Date (2005) criticized TSQL2 language extension, which proved this language extension was not mature enough to be applied in real world systems. First, in each temporal table there were unnamed timestamp columns which are hidden from the user. Thus, user could not access this column through traditional relational theory simply referring to the columns by name. This property is inconsistent with the principles of relational database theory. It needed to include new syntax for expressing temporal queries and modifications. Additionally, new features were needed in the catalog in order to describe tables with temporal support. Second, statement modifier are said to be flawed because syntax for queries needed to change dramatically (adding VALIDTIME prefix before SELECT statement) which is not intended in relational theory to be used as statement operator. Finally, lack of generality was stated. Defined temporal intervals failed to include support for operations on intervals in general. Also, lack of generality is seen in question whether, if it is reasonable to use hidden columns for valid times and transaction times, would it not be equally reasonable to use hidden columns for other kinds of data. Eventually, the work on extending SQL language with temporal features was cancelled in 2001.

Second attempt to implement temporal features in SQL standard started in 2008, as proposal for system-versioned tables was accepted by INCITS DM32.2 and ISO/IEC JTC1 SC43 WG3. Additionally, application-time period tables were included. In 2011, a new set of language extensions for temporal data support were submitted and accepted by the ISO SQL committee. These language extensions are now part of SQL:2011

Part 2, SQL/Foundation (ISO/IEC 9075-2:2011, 2011) as T180 – System-versioned tables and T181 – Application-time period tables, instead of appearing as a new part (Zemke, 2012).

The goal of this paper is to test whether there is significantly different decrease in performance of temporal features compared to traditional relational databases in elementary functions (INSERT, UPDATE and DELETE). Tests are executed in controlled, experimental environment using following software setup: Oracle 12c DBMS and Windows 7 Ultimate (x64) operating system, and hardware setup: computer with 4GB of RAM memory and Intel(R) Core(TM) i5 M460 processor.

To best of our knowledge only few researches were made in this field. First research, conducted by Kaufmann et al. (2013), performed benchmark analysis of non-temporal and temporal queries (defined with SQL:2011 standard), where several combinations of selection of data was performed. In this research, based on provided schema, only SELECT statements were evaluated. Similar research, done for benchmark of bitemporal tables, was performed by Kaufmann et al. (2014). They came to conclusion that existing temporal database systems highlight significant optimization potential and insufficient support for common application use case. Testing was done on Oracle 12c DBMS. Temporal query processing in Teradata was performed by Al-Kateb et al. (2013). They discussed in depth the pros and cons of the rewrite and native implementation approaches. So far it seems that most of temporal features were implemented by IBM DB2 DBMS, which is presented in white paper by Saracco et al. (2012).

The remainder of the paper is structured as follows. Section 2 gives an overview of temporal features defined in SQL:2011 standard. In section 3 design of experiment, used for performance comparison of these two systems, is introduced. Section 4 provides experimental results for traditional table and temporal tables and results analysis. Section 5 provides conclusion and further research directions.

2. TEMPORAL FEATURES IN SQL:2011 STANDARD

Time itself is very complex concept. First, measuring of time is depended of application. In astronomy time is measured in eons and solar days, in production on daily level, in sales on day and time level and in chemistry can be on nanoseconds. Second, total order relationship cannot be fully developed, which means that one time element can have more higher level and lower level of granularity (i.e. for month, lower levels of granularities are week and day, while higher levels of granularities are semester and year). Third, time carries inherited inaccuracy (indeterminacy property). (Snodgrass, 1986)

2.1. Temporal concepts

In order to explain temporal features included in SQL:2011 standard several temporal concepts are going to be explained. These concepts are defined by (Anselma et al., 2013).

Definition 1: Chronon (time quantum or moment) c is basic inseparable time unit, defined on domain TC. Mathematically, $c \in TC$.

Chronon is the simplest time unit which cannot be divided to smaller units of time. It is defined on time domain TC called timeline, which is an ordered set of chronons $\{c_1,…, c_i,…, c_j,...\}$, where $c_i < c_j$, $\forall i < j$.

Definition 2: Temporal element TE is a set of chronons, defined on domain TC. Mathematically, $TE = \{tc_1,…,tc_n\}$, $tc_i \in TC, i=1,…,n$.

Disjunctions of temporal elements are a natural way of coping with time indeterminacy, in which each temporal element models one of the alternative possible temporal scenarios, where any one of which could be valid.

Determinate times can be modeled through a disjunctive temporal element (DTE) containing just one temporal element (called singleton DTE). As a result of this, any determinate temporal element can be modeled with a singleton DTE.

Although, event (fact) can relate to temporal element of one record in database interpretation of that event can vary. Jensen (2000) defined two types of interpretation. First, if temporal element presents time or period of event in real world, then this point is *valid time* temporal element. Events of this type could present time in past, present or future. If database uses this concept it is called valid time database. On the other hand if time or period presents point of time where information was entered into database then this time or period is *transaction time* temporal element and databases which use this concept are called transaction time databases. However, there exists one more type of temporal elements, besides valid and transactional,

which is called *user defined* temporal element. In this case user defines semantic and meaning of temporal element. If table contains both valid time and transactional time then this table is called *bitemporal* table. Each of temporal features can be explained through following definition:

Definition 3: Given a schema $(A_1, A_2,…, A_n)$ of non-temporal attributes defined on the domain $A_i \in D_i$, $i=1,…,n$ temporal relation r is an instance of the schema $(A_1, A_2, … , A_n \mid T)$, where T is temporal attribute. Then, r is defined on the domain $D_1 \, x \, … \, x \, D_n \, x \, TC$ in which empty temporal element and value equivalent tuples are not admitted.

With this definition expressiveness property is satisfied. This formalism allows one to express (i.e., to associate with each tuple) any combination of possible scenarios (i.e., any subset of the lattice of scenarios). Based on value of temporal element T, different types of temporal databases are presented. Each tuple $x=(v_1,…, v_n \mid d) \in r$, where d is a DTE, is termed a valid-time tuple. If d is DTE which presents current (system) time stamp then this tuple is termed transaction-time tuple.

2.2. System-versioned tables

In SQL:2011 standard system-versioned tables are tables that include system timestamp and, therefore, correspond to transactional time. They must include PERIOD statement with two predefined columns and WITH SYSTEM VERSIONING statement. System-versioned tables must have two and only two additional columns, one for beginning and another for end SYSTEM_TIME period. These new columns cannot be changed by the user. In other words, system can only add or change values of these fields. As additional property of system-versioned tables history is saved. This means that with UPDATE statement close end time of updated record and creates new record with start time of current timestamp. Additionally, terminology for records that intersects with current time is called *current system rows*, while others are called *historical system rows*. Finally, only current system rows can be updated or deleted and every constraint can be applied only on these records.

In Oracle system-versioned tables are implemented through temporal validity feature which allows data that is older or no longer valid or not yet valid to be hidden from queries. In other words, only active data returned by queries. These features are achieved with FLASHBACK DATA ARCHIVE option, not needing to specify anything else on table level. With this feature user can query date as of some time and between some times (and this is defined in FROM part of statement). For this purpose, in this research, PERIOD has been created with hidden columns for start date and end date. User can access them (if he/she is SQL proficient), but cannot change values.

2.3. Application-time period tables

Application-time period tables are defined in SQL:2011 standard and relate to valid time or user defined temporal elements, since user defines and controls periods. These kinds of tables are defined with PERIOD statement with two predefined columns, one for beginning of period and another for end of period. In order to prevent user to create two or more records with same value, PERIOD can be included as primary key. Data manipulation (INSERT, UPDATE and DELETE statements) are executing in same manner as ordinary tables. In other words, user controls dates and times of PERIOD columns. Since user manipulates date and time columns, user can refer to any date and time (past, present or future). Additionally, one constraint is added, which disallows creating a record where end time is lower than beginning time. For UPDATE statements additional syntax is defined which allows row splitting. Row splitting means that if there exists record with period P and UPDATE query is updating subset of P then existing record will be updated (from records beginning time to UPDATE statement beginning time) and two additional rows will be created (one record from UPDATE statement beginning time to UPDATE statement end time and another from UPDATE statement end time to records end time) in order to maintain integrity of data. Also, for DELETE statements is defined additional syntax which deletes records that satisfy time period condition, but inserts additional two rows (one from records beginning time to DELETE statement beginning time and another from DELETE statement end time to records end time).

In Oracle DBMS application-time period tables are designed in similar fashion. Only difference is that start and end of period must be defined. Therefore, user can access and manipulate with period. Feature that disallows creation of overlapping period does not exist in Oracle 12c. Therefore, user must control insert and update of records.

3. EXPERIMENTAL SETUP

In the real world business applications can and should use a lot of temporal dimensions at the same time. However, for every data model additional temporal dimension increases the complexity. It is up to user (software developer) to make decision which database features to use. Therefore, in this research performance, in terms of execution time, of temporal features implemented in Oracle 12c is tested. If there is too much difference in execution time, then it will be unreasonable to use these features, but if there is no big difference a lot of benefits can be made. First, validation of data insertion is transferred to DBMS, which reduce possibility of human error in software design and speed up execution. Second, every record from past can be retrieved and used. Therefore, final user can, even if accidentally deletes or updates record see previous state of that record. Third, historical data can be used for analytical purposes, which can lead toward new business insights. On the other hand, if there are many data operations (many insertions, updates and deletes), then there is a reasonable doubt that database will grow much faster than ordinary, memory-less database. The goal is to inspect whether there exists statistically significant difference between execution time of INSERT, UPDATE and DELETE statements between these three groups. In this research comparison of execution time between two temporal and ordinary tables is made. Temporal tables used in this paper are system-versioned table, where transaction time is saved and application-time period table where valid time is saved. Ordinary table is table without temporal features included but having two additional attributes with timestamp data type, which are controlled through application. Experiments are conducted on Oracle 12c DBMS on Windows 7 Ultimate (x64) operating system in controlled environment on computer with 4GB of RAM memory and Intel(R) Core(TM) i5 M460 processor.

SELECT statement is omitted from this research since temporal databases will eventually generate more records and therefore execution time will surely be greater. Also, SELECT statement allows new features which are usable in different way and some of them cannot be recreated through ordinary SQL query. Analysis of SELECT statement in temporal databases is explained in detail in (Kaufmann et al, 2013; Kaufmann et al., 2014).

Oracle 12c adopted many temporal feature defined in SQL:2011 standard, but implementation is incomplete. First, a temporal data manipulation language (DML) API, temporal integrity constraints, temporal joins and temporal aggregations are missing. Also, support for multiple application-time period tables are missing too. On the other hand, Flashback Data Archive (system-versioned tables) allows user to go to history and check which record was active at a point in time. This feature is used with Temporal Flashback Query.
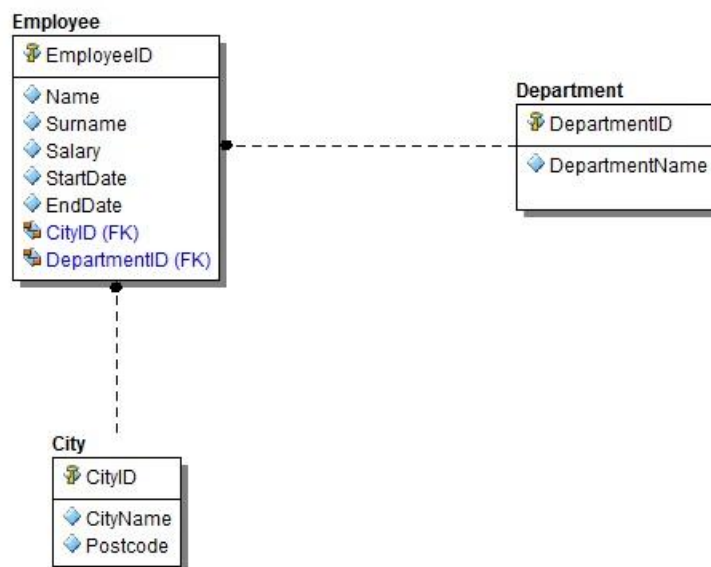

Figure 1: Idef1x schema of database

On Figure 1 Idef1x schema which is used for this research is presented. This model is used to keep records of changes of employee salary, city where employee lives and department. Columns *StartDate* and *EndDate* are temporal features. In case of system-versioned table these two columns are system times, while in case of application-time period table these columns are not overlapping time periods. SQL data definition language (DDL) for creation of tables is given below. First, ordinary table is created.

```
CREATE TABLE EMPLOYEE (
```

```
    EMPLOYEEID      NUMBER(38,0) NOT NULL,
    NAME            NVARCHAR2(250),
    SURNAME         NVARCHAR2(250),
    SALARY          NUMBER(38,2),
    STARTDATE       TIMESTAMP (6) NOT NULL,
    ENDDATE         TIMESTAMP (6) NOT NULL,
    CITYID          NUMBER(38,0) NOT NULL,
    DEPARTMENTID    NUMBER(38,0) NOT NULL,
    CONSTRAINT PK1 PRIMARY KEY ("EMPLOYEEID") )
```

Second, SQL code for system-versioned table is presented below. Since, system-versioned tables are implemented through Flashback Data Archive no need for any modification of SQL statement for creation of ordinary table, but in this paper PERIOD is created in order to get temporal validity features in transactional time. For system-versioned tables to work DBMS_FLASHBACK must be applied to tablespace. Since transactional time should not be changed start and end timestamp are marked as hidden, so it would not appear in SQL query. As a result of PERIOD part of statement, new constraint is added.

```
CREATE TABLE EMPLOYEE_SYS (
    EMPLOYEEID      NUMBER(38,0) NOT NULL,
    NAME            NVARCHAR2(250),
    SURNAME         NVARCHAR2(250),
    SYSTEM_START    TIMESTAMP(6) DEFAULT sysdate INVISIBLE,
    SYSTEM_END      TIMESTAMP(6) DEFAULT to_date('01-01-9999', 'dd-mm-yyyy')
INVISIBLE,
    PERIOD FOR SYSTEM_TIME(SYSTEM_START, SYSTEM_END),
    SALARY          NUMBER(38,2),
    CITYID          NUMBER(38,0) NOT NULL,
    DEPARTMENTID    NUMBER(38,0) NOT NULL,
    CONSTRAINT PK11 PRIMARY KEY ("EMPLOYEEID"),
    CONSTRAINT SYS_TIME1 CHECK ((SYSTEM_START<SYSTEM_END) and (SYSTEM_TIME>0))
ENABLE )
```

Finally, application-time period tables are implemented as temporal validity feature in Oracle 12c DBMS (in same manner as system-versioned table defined above). For system-versioned and application-time period visibility of data in tables with temporal support, DBMS_FLASHBACK_ARCHIVE.enable_at_valid_time procedure must be used.

```
CREATE TABLE EMPLOYEE_APP (
    EMPLOYEEID      NUMBER(38,0) NOT NULL,
    NAME            NVARCHAR2(250),
    SURNAME         NVARCHAR2(250),
    VALID_START     TIMESTAMP (6) NOT NULL,
    VALID_END       TIMESTAMP (6) NOT NULL,
    PERIOD FOR VALID_TIME(VALID_START, VALID_END),
    SALARY          NUMBER(38,2),
    CITYID          NUMBER(38,0) NOT NULL,
    DEPARTMENTID    NUMBER(38,0) NOT NULL,
    CONSTRAINT PK111 PRIMARY KEY ("EMPLOYEEID"),
    CONSTRAINT VALID_TIME1 CHECK ((VALID_START<VALID_END) and (VALID_TIME>0))
ENABLE )
```

For every table, defined above, following SQL command applies.

```
ALTER TABLE EMPLOYEE (
    CONSTRAINT FK1 FOREIGN KEY (CITYID) REFERENCES CITY (CITYID),
    CONSTRAINT FK2 FOREIGN KEY (DEPARTMENTID) REFERENCES DEPARTMENT
(DEPARTMENTID) )
```

For this experiment it is expected that temporal tables have slightly inferior performance since it needs more operations to process than ordinary table on all three tests. On the other hand, system-versioned tables should have better performance than application-time period tables since timestamps for start and end of period are not included (they are generated by default).

4. EXPERIMENTAL RESULTS

After conduction of 1000 INSERT statements, for three types of tables, results, shown in Table 1, were gathered. It can be seen that system-versioned tables performed the best with average of 8.21 milliseconds per insert, while application-time period tables performed the worst with 9.58 milliseconds insert on average. Also, each type had at least one long insert, which lasted over 100 milliseconds.

Table 1: Descriptive statistics of INSERT experiments

	Default			System-versioned tables			Application-time period tables		
	Mean	Max.	St. Dev.	Mean	Max.	St. Dev.	Mean	Max.	St. Dev.
Time	8.41	122.00	3.66	8.21	101.00	3.59	9.58	137.00	7.09

Since goal of this paper was to identify whether there exists statistically significant difference between execution time of insertion of data of different types of tables analysis of variance (ANOVA) test was conducted (since time execution have normal distribution). Results are shown in Table 2. Value of F statistic between groups is 21.351 with significance of 0.000, which means that there exists at least one statistically significant difference between groups. In order to see that information Levene homogeneity of variance test will be conducted followed by post-hoc analysis of variance.

Table 2: ANOVA test for INSERT statement

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1089.549	2	544.774	21.351	0.000
Within Groups	76469.835	2997	25.515		
Total	77559.384	2999			

In Table 3 homogeneity of variance test is shown. Value of Levene statistic is 48.370 with 2 and 2997 degrees of freedom and significance 0.000 which means that variance between groups is different and therefore Games-Howell post-hoc test will be used.

Table 3: Levene statistic of homogeneity of variance

Levene Statistic	df1	df2	Sig.
48.370	2	2997	0.000

Table 4 shows that application-time period tables performed statistically significant worse with both ordinary and system-versioned tables, which leads that this type of tables requires more computer resources, but allows using temporal features.

Table 4: Games-Howell ANOVA post-hoc analysis

(I) Type	(J) Type	Mean Difference (I-J)	Std. Error	Sig.
Default	System-versioned tables	0.20100	0.16215	0.430
	Application-time period tables	-1.16600[*]	0.25227	0.000
System-versioned tables	Default	-0.20100	0.16215	0.430
	Application-time period tables	-1.36700[*]	0.25131	0.000
Application-time period tables	Default	1.16600[*]	0.25227	0.000
	System-versioned tables	1.36700[*]	0.25131	0.000

Second type of experiment was conducted for UPDATE statements using same settings as for INSERT statement. In other words every group had 1000 executions. Time execution, in milliseconds, is presented in Table 5. As in INSERT statements experiment, system-versioned tables have shown the best performance with average 7.9 milliseconds of execution time. Similar execution time had nontemporal table with 7.94 milliseconds of execution time. Since standard deviation is low, it can be concluded that results are stable. It

is worth to notice that application-time period table had worse result, but not by far with 8.03 milliseconds average execution time.

Table 5: Descriptive statistics of UPDATE experiments

	Default			System-versioned tables			Application-time period tables		
	Mean	Max.	St. Dev.	Mean	Max.	St. Dev.	Mean	Max.	St. Dev.
Time	7.94	183.00	5.64	7.90	30.00	0.94	8.03	26.00	1.52

In order to conclude whether there are statistically significant differences between groups ANOVA test is conducted. Results are shown in Table 6. Value of F statistic is 0.368, which is explained through significance of difference execution time between groups. Since significance is 0.692, it can be stated that there are no statistically different groups, which means that execution time is approximately the same. Because of that post-hoc test should not be executed.

Table 6: ANOVA test for UPDATE statement

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.579	2	4.289	0.368	0.692
Within Groups	34917.788	2997	11.651		
Total	34926.367	2999			

Third part of experiment refers to difference in execution time of DELETE statement. Time execution, maximum deletion time and standard deviation are presented in Table 7. Ordinary and system-versioned tables have shown the best performance with average execution time 0.27 milliseconds, but since standard deviation of system-versioned table is lower it can be stated that this deletion was more stable. Application-time period table was, again, the worst with average execution time 0.57.

Table 7: Descriptive statistics of DELETE experiments

	Default			System-versioned tables			Application-time period tables		
	Mean	Max.	St. Dev.	Mean	Max.	St. Dev.	Mean	Max.	St. Dev.
Time	0.27	30.00	1.08	0.27	2.00	0.51	0.33	2.00	0.57

In order to inspect whether there are differences between execution time ANOVA test was performed. Results are shown in Table 8. Since difference in time execution between groups is not significant, it is 0.141 which is greater than 0.05, it can be stated that there are no statistically significant differences between execution times between default, system-versioned table and application-time period table.

Table 8: ANOVA test for DELETE experiments

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.275	2	1.137	1.960	0.141
Within Groups	1739.317	2997	0.580		
Total	1741.592	2999			

Finally, difference between default table and system-versioned table was not statistically significant, but system-versioned table have shown better performance. Therefore, this kind of temporal table have shown that temporal feature is capable to improve software development, since developer does not need to develop date time validation before insert, update or delete of records. Additionally, database administrators can perform history checkup of data, which can be useful in many data analysis applications. On the other hand, application-time period performed slightly worse with statistically significant slower execution time in data insertion, and slower but not statistically significant execution time in update and delete statements. Since difference was a little greater than 1.5 millisecond, it is up to user to calculate whether application will perform slower with DBMS controlling data validation or not. It is worth to state temporal features requires intuitive upgrade of SQL skills, which can be learned easily. On the other hand, Oracle 12c does not have implemented as much temporal features as IBM DB2 database, which can explain execution time performances. One possible usage of temporal features is in analytical databases, especially for slowly changing dimension (dynamic hierarchy) type 2, where ETL process could be carried out with less chance for error.

5. CONCLUSION

Experiment have shown that there exists statistically significant difference between application-time period tables and other types of tested tables, where application-time period tables have shown worse results in execution time. These results are gathered on execution time of 1000 insert statements of each type (total of 3000 records) for each of three experiments.

Conclusion can be made on two levels. First, since there are no statistically significant difference between system-versioned table and ordinary table and execution time of system-versioned tables were faster or with same execution time in every test (INSERT, UPDATE and DELETE) than ordinary tables it is better for software developers to use temporal features of database for several reasons. First, complexity of tedious validation of data is transferred to database level and it is concern of DBMS. This provides better time execution and more reliable data in organization. Second, every historical event can be reconstructed using temporal queries, which can be used for analytical purposes. As application-time period tables is concerned no grounded conclusions can be made, since performance for INSERT was statistically significant worse and for UPDATE and DELETE were just worse. It is up to user to measure whether time execution or data validation and historical information are more important. Second, it must be stated that implementation of temporal features of SQL:2011 standard is incomplete (temporal DML API, temporal integrity constraints, temporal joins and temporal aggregations are missing) and theory about temporal dimension is still in development. Also, it seems to be that Oracle did not want to cope with complexity of time dimension (support for time integrity constraint does not exist) and help software developers to build better software. It does not transfer data validation fully on DBMS. One possible explanation for the lack of temporal features is speed of execution, which we tested here. Therefore, in order to get full picture of performances of temporal features defined in SQL:2011 these experiments should be conducted on other DBMS vendors which implemented temporal features defined in SQL:2011 standard. Compared with DB2 (Saracco et al., 2012) it seems that IBM have made more work on temporal support in database with features like history table in system-versioned tables and ability to create application-time period tables for record without overlapping.

In a future, plan is to inspect other DBMS and compare performances and possibilities each of DBMS vendors. Also, it would be interesting to evaluate different performance of other statement and see whether there is correlation between them. Finally, experiment can be performed on different, much more data intensive, data models and compare performances and evaluate how much database grows (primarily, to compare whether size of database will become unpractical to use compared to memory-less databases).

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AUTOMATIC GENERATION OF EXECUTABLE UI PROTOTYPES USING SILABREQ LANGUAGE

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Abstract: *The subject of this paper is the identification of correlations between the use case model, data model and the desired user interface. Since use cases describe the interaction between the users and the system, implemented through the user interface with the aim of changing the state of the system, the correlation between these three components should be considered at the software requirements phase. Software requirements must somehow be formalized to accomplish the goal to be automatically processed and analyzed. On the other hand, these requirements need to use notation that is understandable for all participants in the software project. We strongly believe that controlled natural language with simple grammar can achieve this goal. Thereby, we have developed SilabReq project. This project includes SilabReq Language, SilabReq Transformation and SilabReq Visualization components. Using SilabReq components it is possible to establish the meta-model of software requirements which enables not only the design and implementation of the user interface, but also the automation of this process. In order to prove the sustainability of this approach, we have been development a software tool which performs the transformation of the model to an executable program code. As a final validation and verification, SilabReq project and the software tool for automation the user interface implementation process has been used for the Kostmod 4.0 project, which was implemented for the needs of the Royal Norwegian Ministry of Defense.*

Keywords: *use cases, use case specification, executable specification, user interface, user interface generation, prototype*

1. INTRODUCTION

The requirement specification, which is commonly represented by the use case model, should be detailed enough to provide the information necessary for the design and implementation of all elements of the software system - starting with the user interface, through application logic which encapsulates domain structure and system behavior, to data storage. However, the requirements specification often lacks the information required to design certain aspects of the system. In those cases, it is left to a programmer to interpret requirements and find solutions, which can often lead to results which do not meet the user's needs, e.g. when considering the user interface, one will find that the requirement specification rarely provides information about its appearance, content, types of components to be used, and so on.

The phases included in the software life cycle are the collection and specification of user requirements, analysis, design, implementation and testing. The design of the user interface starts only after the requirements phase has been completed, or even after the design of application logic.

Contrary to that, another approach to development exists - one which suggests designing the user interface parallel with the requirement specification. This approach is based on the way the user sees the software system, which can be summarized by saying that the user interface is the system! [Vliet, 2008] The reason for that is that the user is not familiar with the structural details and the ways in which the system is implemented. The requirement specification explains how the user wishes to execute a certain task using the software system. The execution of such a task entails an interaction between the user and the system, which forms a particular structure. According to this approach, the user interface should follow this structure so as to attain a higher level of software system usability. The early phases of creating a user interface often do not result in a fully functional user interface, but a prototype whose main goal is to emphasize the questions and presumptions that might not have been clarified using other approaches in requirements engineering. [Pfleeger and Atlee , 2006)]

A very important aspect in software development is the cost of a completion of software project. Given that the production of software is a series of intellectual and technical activities performed by highly-educated engineers, it becomes clear that the cost of the system greatly depends on the time and effort required for its production. The development of the user interface presents a significant part of such a process. [Kennard and Leaney,2010]. A survey [Myers and Rosson, 1992] found that 48% of a software system's programming code is related to the user interface, with about 50% of the entire development time being used for its implementation. Other research in this area has produced similar conclusions [Kivistö, 2000], regardless of the fact that tools which hasten this process and make it easier are utilized in development.

Due to the fact that the user interface represents a direct link between the user and the system, the user often alters the requirements regarding its appearance and structure during the development process. These

alterations occasionally cause changes to be made to the implemented system and often result in the discarding of the interface developed until that point. This means that the entire process must be started again. However, the user may find that even the new solution fails to meet their needs, as they often find it difficult to precisely define the requirement specification.

All these facts impose a need for the automation of the process whose goal is to devise a solution to speeding up the development of the user interface and cutting its costs. This tool would make a more efficient requirement specification process available. The user would then be able to quickly identify deficiencies in the requirement specification and remove them, resulting in the system which meets their needs as closely as possible.

The resulting user interface must be based on user requirements. The significance of software requirements in software development is best illustrated by the research which demonstrates that half of the factors which influence the success of a software project are linked specifically to software requirements. [6] Thereafter, this paper pays a great deal of attention to the process of collecting and specifying of software requirements.

The most widely used techniques for the collection of user requirements today are use case specification, [Cockburn,2000],[Jacobson et al.,1993] and user stories [Cohn, 2004]. The use case specification and user stories share certain characteristics (they are based on scenarios and user's aim oriented), but also differ in a number of ways (they vary in structure, the range of requirements covered, integrity, feasibility, and how detailed they are) [Stellman, 2009] [Cockburn, 2000] [Cohn, 2004]. The goal of both techniques is to specify the intent of the user - what the user wishes to achieve through a desired functionality. By considering the two aforementioned techniques for the collection and specification of user requirements, we can conclude that the use case specification presents a more acceptable solution than the user stories, especially when we wish to achieve automated development of certain software elements. The reason behind this is their structure, integrity, as well as the possibility of including additional details significant to different system aspects. The literature often suggests the use cases as the best choice when using the MDA (Model Driven Architecture) approach. [Fatolahi, Somé and Lethbridge, 2008].

Choosing a technique for the software requirements specification does not solve all the problems which can occur during this process, and which can later have significant consequences. One of the most common problems which occur during the use case specification process is the existence of ambiguities in use cases [Wiegers, 2006] [Silva et al., 2007]. All ambiguities in software requirements must be identified and removed as early as possible in order to avoid additional effort and save time [Frost and Campo, 2007]. Should ambiguity only occur once the implementation phase has been already reached, the necessary changes must be made, which is often very complex, time-consuming, and hard to trace [Lin, Prowell and Poore,2009].

In literature we can find a thesis: If ambiguous requirements are the enemy, the domain model is the first line of defense! [Rosemberg and Stewphens, 2007]. The literature [Cox and Phalp, 2010][Fortuna,Werner, and Borges, 2008] suggests the integration of the use case and the domain model as one way of ensuring validity of software requirements.

This paper will present the results of research whose goal has been to develop a model for the software requirement specification which would be semantically rich enough to enable the automation of the user interface implementation process.

The paper is organized as follows. In the next section, we present an overview of the Silab project and its main characteristics. Section III describes SilabReq project with emphasizes of its main component (SilabReq Language component). In Section IV, we present an overview of the SilabUI project. Finally, Section V concludes the paper and outlines some future works. The specification of the *Register new invoice* use case from the *Point of Sale System* is given in the Section III, while executable Java desktop UI prototype for this use case is shown in the Section IV.

2. AN OVERVIEW OF THE SILAB PROJECT

Silab Project was initiated in Software Engineering Laboratory at Faculty of Organizational Sciences, University of Belgrade in 2007. The main goal of this project was to enable automated analysis and processing of software requirements in order to achieve automatic generation of different parts of a software system.

At first project has been divided in two main subprojects SilabReq [Savic, Antovic, Vlajic, Stanojevic and Milic, 2011] and SilabUI projects that were being developing separately. SilabReq project considered formalization of user requirements and transformations to different UML models in order to facilitate the analyses process and to assure the validity and consistency of software requirements. On the other hand, SilabUI project considered impacts of particular elements of software requirements and data models on resulting user interface in order to develop a software tool that enables automatic generation of user interface based on the use case specification and the domain model.

When both subprojects reach desired level of maturity, they were integrated in a way that some results of SilabReq project can be used as input for SilabUI project.

As a proof of concept, Silab project has been used for the Kostmod 4.0 project, which was implemented for the needs of the Royal Norwegian Ministry of Defense. After finishing this project we have analyzed the results and we calculated that user interface for approximately 75% of total number of use cases have been

completely implemented using the Silab project, and other 10% needed minor manual development adjustments. For other 15% of use cases some parts of UI is also generated using Silab project, but it required much more manual development.

3. AN OVERVIEW OF THE SILABREQ PROJECT

It has been mentioned earlier that one of the advantages of the use case specification over other techniques for the collection and specification of requirements is its structure. This structure is not strictly defined, and different authors present the use case specification in different forms (templates).

Today's literature lists many different formats or templates for use case specification. [Malan and Bredemeyer, 1993][Bittner and Spence, 2003][Cockburn,1997][Coleman,1998.][Jacobsonet al.,1998] These templates primary provide guidelines for structuring use case description. They are a result of the need to standardize the use case specification, in order to ensure that the specification is complete and that the communication between team members in charge of the specification is comfortable.

The use case specification templates describe structural elements that each use case should contain. However, none of the those templates describes in detail the structure of the main scenario or the structure of scenario steps, except for some templates which recommend the numeration of the steps or the separation between the actions performed by the user and the ones executed by the system. The one of the key problems with use cases is their semantics, especially precise notation for specification of the use case actions. Because their semantic are poorly defined, it make them difficult to automatically process and analyze.

The authors [Cockburn, 2000] [Rosemberg and Stewphens, 2007] suggest that all steps in a scenario should be written in active voice, and in sentences with a Noun-Verb-Noun structure. The first noun signifies the doer - the user or the system as the subject of the sentence (depending on whether the action is performed by the user or the system), the verb represents the predicate of the sentence and denotes the action being executed, while the second noun marks the object of the action being performed.

The one of the key problems with use cases are their semantics, especially precise notation for specification use case actions. In his paper [Som´e, 2009], Some defines the abstract syntax of a textual presentation of the use case. The author emphasizes that certain elements (formalisms) of the UML languages such as actions, activities are formally defined through the meta-model (or the corresponding meta-class). On the other hand, UML has not formally defined meta-model for a textual description of the use cases, although text-based notation is a primary notation for the use case description. Therefore, the author defines the meta-model to describe the interaction between system users and systems. Jacobson has described steps in a use case as representing a transaction. He has identified four types of transactions:

- The primary actor sends request and data to the system.
- The system validates the request and the data.
- The system alters its internal state.
- The system replies to the actor with the result.

Even though Jacobson identified different actions in use cases the specification of these actions are left undefined in UML. In his work, Williams uses 4 basic actions (Input, Output, Computation, and Exception Handling) and 4 flow-of-control actions (Selection, Iteration, Inclusion and Extension) for use case specification [Williams, Kaplan, Klinger and Paradkar, 2005] In additional, in [Genilloud, Frank and Génova, 2006] authors were explained limitations of the graphical notation for use case specification and emphasize that use case specifications in natural language should describe the actors' actions of entering data, selecting an option, etc., and so that they can be easily read by system users and other stakeholders.

The SilabReq project includes SilabReq Language, SilabReq Transformation and SilabReq Visualization components. These components are shown in Fig. 1.
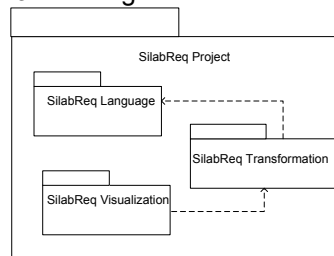

Figure 1. SilabReq main components

Because semantic of use cases are poorly defined, it make them difficult to automatically process and analyze. The goal of the SilabReq Language component is to solve these problems. The SilabReq Language component presents our SilabReq controlled natural language for use case specification [Savić, Silva,Vlajić,Lazarević, Antovic, Stanojevic and Milić, 2012]. It uses textual concrete syntax for definition of the use case context.

In order to accomplish goals SilabReq language is presented as a model. Thus, use cases can be automatically processed and analyzed. We have identified four different types of use case actions and we

have categorized them in two groups: actions which are executed by the user and actions which are executed by the system. Actor executes two types of the use case action:

- Action *Actor (user) Prepares Data for System Operation execution* (first type of user's action - APDSO)
- Action *Actor Call system to execute System Operation* (second type of user's action ACSO)
  On the other hand, system executes two types of the use case action:
- Action *System Executes System Operation execution* (first type of system's action – SESO)
- Action *System Returns Results of system operation execution* (second type of system's action - SRR)

We have developed grammar for all of these actions and integrated them into SilabReq language. SilabReq is developed under XText framework. [XText] This framework is based on openArchitectureWare generator [oaW] framework, the Eclipse Modeling Framework (Eclipse Modeling Framework) [EMF] and Another Tool for Language Recognition (ANTLR) parser generator [ANTLR].

The SilabReq Transformation component is responsible for transformation software requirements into different models. Currently, we have developed transformations which transform SilabReq model into an appropriate UML model.

All of these transformations are defined through Kermeta language [30] for meta-modeling. Kermeta is the model-oriented language. Kermeta meta-model is fully compatible with Essential OMG Meta-Object Facility (EMOF) meta-model and Ecore meta-model, which is part of the Eclipse Modeling Framework (Eclipse Modeling Framework EMF).

The SilabReq Visualisation component is responsible for visual presentation of the specified software requirements. Currently, we have developed only UML presentation of these requirements. So, we can present SilabReq use cases through UML use case, UML sequence, UML activity or UML state-machine diagram.

The SilabReq Language component is the base component for the SilabReq project as well as the whole Silab project. Its main part is SilabReq language. The aim of this language is to be used for functional specification of the software requirements in use case form.

The abstract syntax of the SilabReq language is defined by meta-model, while SilabReq grammar is used to define concrete syntax of the language. One of the most import goals of the SilabReq project is to produce domain model [Larman, 2004] from use case model. In order to accomplish this goal we identified actions in use case which contain semantics that can be used to determine initial domain model of the system. In this section we present the meta-model of the SilabReq language and point out the part of this meta-model which is used to determine initial domain model. Fig. 2 shows the meta-model for SilabReq use case model.

We use SilabReq use case model (SilabReqUseCaseModel meta-class) to describe software requirements for particular software system. SilabReq use case model contains the users of the system (Actor meta-class), set of identified use cases (UseCase meta-class) and set of identified domain entities (DomainConcept meta-class). We have designed SilabReq language so that each domain entity that is determinate in use case specification must be declared firstly. Thus, we have reduced the possibility to use synonyms as well as homonyms in use case specification. Fig. 3 shows the meta-model for SilabReq use case.
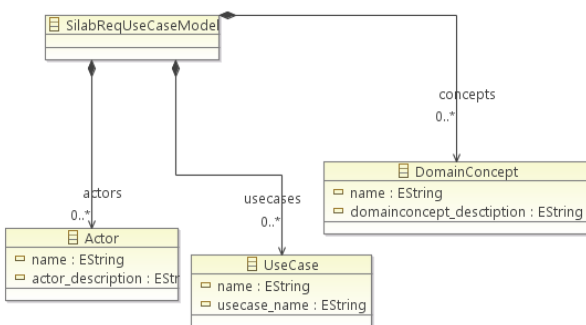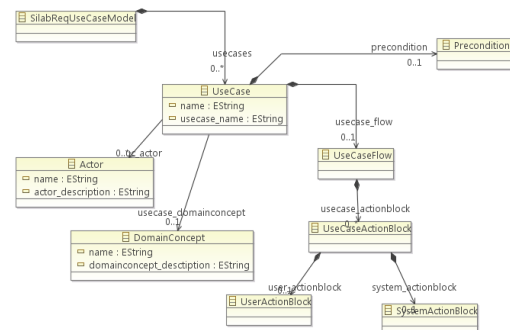

Figure 2: Meta-model for SilabReq use case model

Figure 3: SilabReq use case meta-model

The following part of this section contains the specification of the *Register new invoice* use case from the *Point of Sale System* (Fig.4)*. This use case includes *Find customer* use case. Both of them are executed by the actor with Worker role.

Actor: Worker
Domain concept: Invoice
Domain concept: InvoiceItem
Domain concept: Product
Domain concept: Customer

UC: UC_FindCustomer "Find customer"
 Actors: Worker

Use case domain concept : Customer
USE CASE FLOW
USER ACTIONS:
 apdso: «1» Worker ENTERS data for search Customer "ID" or Customer
   "firstName" or Customer "lastName"
 acso: «2» Worker **calls system to** find customer
SYSTEM ACTIONS:

RESPONSE:
  SUCCESSFUL RESPONSE
    Data: SHOWS Customer AND ALL CUSTOMER Invoice
  END SUCCESSFUL RESPONSE
  EXCEPTIONS
    "System did not found customer" **action** "end use case"
  END EXCEPTIONS
  END RESPONSE
 END SYSTEM ACTIONS
 END USE CASE FLOW
END USE CASE

UC: UC_SaveInvoice "Register new invoice"
Actors: Worker
Use case domain concept : Invoice
 Precondition:
  Domain concept: Customer
  constraint description: "must be register in the system"
 End precondition
 USE CASE FLOW
 USER ACTIONS:
  include: UC_FindCustomer
  acso: «1» Worker **calls system to** create new invoice
 SYSTEM ACTIONS:
 RESPONSE:
  SUCCESSFUL RESPONSE
    Message: "Invoice is created"
    Data: THE LAST CREATED Invoice
  END SUCCESSFUL RESPONSE
  EXCEPTIONS
    "Invoice is not saved" **action** "go to action 1"

END EXCEPTIONS
END RESPONSE
END SYSTEM ACTIONS

 USER ACTIONS:
  apdso:«1» Worker ENTERS Invoice "date" when the Invoice is created
   iterate
    apdso:«2» Worker CHOOSES Product which want to put on InvoiceItem
    apdso:«3» Worker ENTERS InvoiceItem "quantity" per each Product
    acso: «4» Worker **calls system to** add invoiceitem on the invoice
   end iterate
  acso: «5» Worker **calls system to** save invoice
 SYSTEM ACTIONS:
 RESPONSE:
  SUCCESSFUL RESPONSE
    Message: "Invoice is saved"
    Data: THE LAST SAVED Invoice
  END SUCCESSFUL RESPONSE
  EXCEPTIONS
    "Invoice is not saved" **action** "interruped use case"
  END EXCEPTIONS
  END RESPONSE
  END SYSTEM ACTIONS
  END USE CASE FLOW
END USE CASE

Figure 4. Use case specification in SilabReq language

The use case flow for the *Register new invoice* use case contains two pair of the user and the system blocks. The first block of actions is used by the actor to find an appropriate customer and to create new invoice. The second one is used by the actor to enter data for that invoice (actions form 1 to 4 in the second block).

4. AN OVERVIEW OF THE SILABUI PROJECT

The goal of SilabUI project is the identification of impacts of particular elements of software requirements and data models on resulting user interface in order to develop a software tool that enables automatic generation of user interface based on the use case specification and the domain model.

We can often find the recommendation to omit information about the user interface from the use case specification. [Larman, 2004] As one of the most common mistakes in the use case specification, authors mention existence of details related to the user interface. This recommendation comes from the legitimate concern that details related to the user interface can distract the stakeholders from the essence of the problem being analyzed when specifying software requirements. Information about the user interface is of no importance when describing the goal and the aim of the user, while the user's goal and aim are essential for use cases. However, the fact that information about the user interface is so often found within use case specification testifies to the necessity of establishing clear relations between the user interface design and the interaction between user and system as described by use cases. [Sinnig, Chalin, and Rioux, 2005]

A single use case can be realized through different templates [Antović, Vlajić, Milić, Savić and Stanojević, 2011]. By using the tools for automatic user interface generation created for the purposes of this research, it is possible to quickly and easily obtain a completely different user interface for the same use case by making simple adjustment of the selected template in the model. This way, the stakeholder can try out different templates during user requirement specifications, and decide which one suits their specific use case best. Templates are designed in such a way that they can be combined, which means that different templates can be used for a single use case and its parts.

The following part of this paper will provide an example of combining different templates into multiple depth levels. This example demonstrates one of the solutions, attained by automatically generating a user interface by utilizing a developed code generator, for a highly complicated use case which processes the entity in four levels of depth. The example shown is a part of the user interface designed for the project Kostmod 4.0, which was implemented for the needs of the Royal Norwegian Ministry of Defense. Even after familiarizing them with the potential problem, the customer decided not to deviate from their original plan. In the end, the problem was solved by combining a number different user interface templates (Fig. 6). The diagram shows a simplified data model - the part of the data model to which the aforementioned example refers to (Fig. 5).
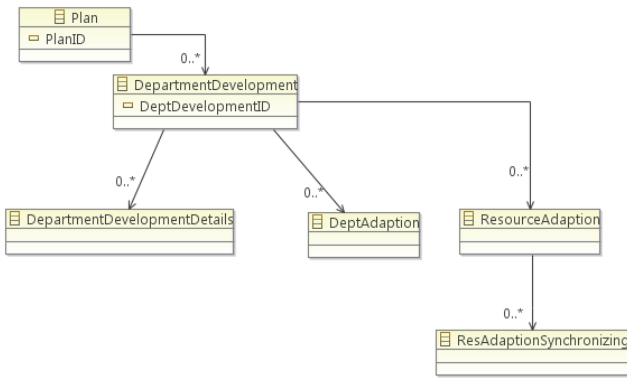
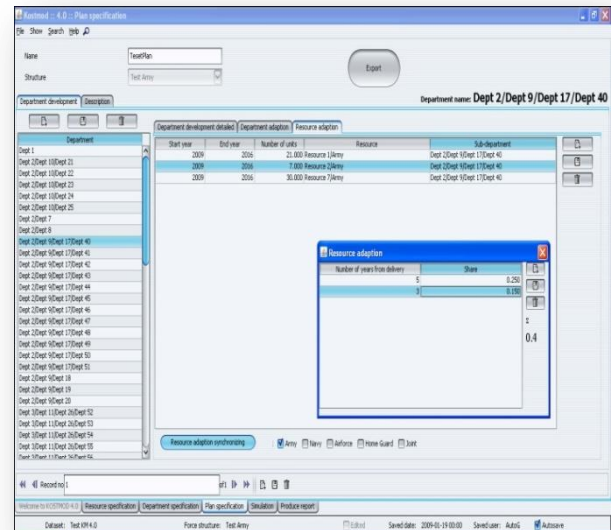Figure 5. The part of the data model illustrating the example of combining different UI templates

Figure 6. An example of combining different user interface templates with four levels of depth

The goal of SilabUI project was to develop a model for the specification of software requirements which would be semantically rich enough to enable the automation of the process of implementing the user interface. The basis for defining such a model are the relationship between the use case model, the data model, and the desired user interface, which were noted in the previous chapters. Considering how use cases describe the interaction between the user and the system, which is realized via the user interface and whose goal is to change the state of the system, the connection between these three components must be represented appropriately, so as to enable the automation of the user interface implementation. When defining a model, one must take care that the model follows good practice in the specification of software requirements, which means that it should provide a frame for the specification of requirements which will be understandable to all of the interested parties that take part in this process - from the engineers, to the final users.

The software requirement specification is supposed to contain information about the goal and aim of the user when executing certain system functions, and should not include implementation details, such as details about the user interface or the realization of other parts of the system. In order for the specification to remain completely in the domain of the problem, and not in the domain of the solution, it is necessary to split these two domains through a model, and make the problem domain independent of the solution domain, which usually contains one or more possible ways of realization. As the development of the model is based on the relationship observed among the use case elements, the data model, and the graphical user interface, a SilabUI meta-model has been developed. In order to enable the automatic generation of user interface through a model based on the illustrated meta-model, this model must be defined in a form which is suitable for manipulation by a Java program which will be used to realize a generator, but which is also readable and understandable by all the stakeholder during the process of requirement specification. XML is usually listed as the most suitable format for this purpose, as this language with a simple syntax is legible for both humans and computer programs.

In order to separate the specification of software requirements and information about the user interface, the user interface creation model would be specified using two separate XML documents. The first XML document represents the use cases, and part of the data model to which the use case relates, and this data is stored in the UIReq.xml file. This file can be manually created, but it can also be automatically created using SilabReq Transformation component from SilabReq project. The second XML document contains information about the elements of the graphic user interface, and every element of this document refers to a particular element from the defined UIReq.xml file. The content of the second document is specified in the UIReqExtension.xml file. The existence of the second document is not mandatory. In case the second document is not created, the default user interface elements (such as user interface templates and graphical components) will be used for displaying the use case described within UIReq.xml file. Should the requirement be that the user interface differs from the implied settings, these settings are specified in the UIReqExtension.xml file.

In order to prove the sustainability of this approach, a software tool – SilabUI generator was devised to conduct the transformation of the defined model into executable programming code. This will enable the creation of a user interface in the early phase of the software's life cycle. The figure bellow (Fig. 15) presents generated executable prototype the *Register new invoice* use case. This, in turn, gives the possibility to validate and verify user requirements, and reduces the time and effort required to implement the user interface. This software tool enables the generation of executable programming code for the interface of a

Java desktop application. The application can be used to perform basic operations on data from a relational database for a defined use case which, according to some research, includes up to 80% of all use cases describing a software system [Nakatani,Urai, Ohmura and Tamai, 2001].
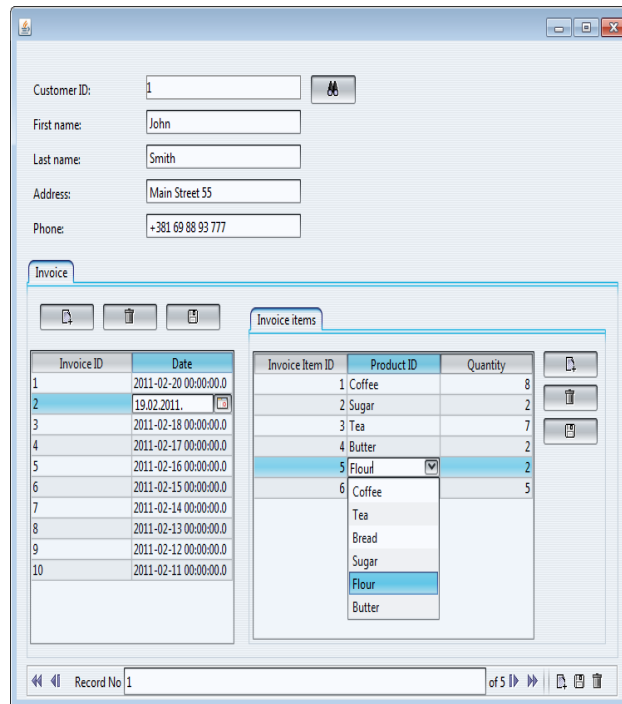

Figure 7. The prototype of the *Register new account* use case

5. CONCLUSION

This research considered the relationship which can be observed among the elements of the use case specification, the data model, and the user interface. Based on these perceived connections, a meta-model of software requirements had been developed - one which considers the elements of all three aforementioned system aspects. Using this meta-model, we can create a software requirement model which enables not only the formal specification of the user interface but the automation of this process as well. This process is supported through Silab project.

Potential further research in this area could relate to: (1) The examination of the applicability of the meta-model to various technologies and platforms (desktop applications in different technologies, web applications in different technologies and so forth), (2) The enrichment of the meta-model and generator so as to ensure support for the realization of various architectures of the resulting application, (3) The enrichment of the model with the possibility to specify more complex validation rules, (4) Ensuring the adaptability of the user interface (5) Generating different types of the automated tests.

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SOFTWARE DELEGATES AS A METHOD OF CODE ORGANIZATION WITHIN CONTEXT ORIENTED PROGRAMMING ENVIRONMENT

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Abstract: *This paper will present a new approach in organizing elements and entities according to the specific demands of the Context oriented programming (COP) method in software engineering. Context oriented programming is defined by dynamic elements within the communicative organization of multiple entities and, as such is in contradiction with the usual software organization in programming languages with static type checking. After dealing with the mentioned problem for several years and existing published solutions created in the Software Engineering Laboratory at the Faculty of Organizational Sciences, the authors are presenting a new method of communication between entities and describe the outlines of reaching the solutions. In this way, advantages of Context oriented programming paradigm are presented in the modern static type checking programming languages, primarily C# which was used for the practical application of the presented model.*

Keywords: *software, software development, software pasterns, Context oriented programming, software engineering*

1. INTRODUCTION

Software engineers and architects community worldwide is constantly occupied with the search of better and more wholesome methods of describing real environments in computer software development. This search is fueled mostly through pressure of making quality software more efficient but also through the personal curiosity and challenges within the community. Context oriented programming is among newer methods of software development and presents an abstraction of context within software development. Context is a central place where all the executives of the practical tasks meet, scenario by which the task can and should be completed and finally, the skills required to solve the task successfully.

The paper will further examine all the entities that are taking place in developing COP software and will also include a short presentation of the application which authors use as a proof of the sustainability of the presented model. It will also include a theoretical overview of programming code organizations which influenced the implementation of the presented method of program structures. The paper will also describe the step-by-step solution for the problem at hand in detail.

In the next section will be introduced key elements and entities of COP model; the third section is about MixIn and Trait principle of organizing programming code; the forth section is about dynamic change of entities during the execution time; the fifth section is about the delegates' impact on the software design; the sixth section is about lambda expressions, anonymous methods and their place in method application; last sections, seventh and eighth, are dedicated to case study and application in practice.

2. KEY ELEMENTS AND ENTITIES IN THE PRESENTED COP MODEL

Within the suggested paradigm, context takes up the central place due to the fact that it determines the behavior of executive parts of the problem's solutions. In other words, different contexts require different behavior from the same executives in order to solve a context-defined problem successfully [1]. The paper will explore an example of the possibility of the same executive behaving in various solutions as well as the method by which it was applied in the suggested model. What is new and highly interesting is that the executive entity bears no knowledge of the ways to solve the problem prior to reaching the environment of the problem itself. Skills and knowledge required to solve a problem are only being awarded to the executive entity within the problems context, and in the end, upon solving the problem, the executive entity leaves the problem are with no saved knowledge of steps that brought it to

the solution. Each and every time the same entity encounters the same problem, it will receive the information all over again.

This method allows the entity to exist on a very simple level as it only bears information about itself, Changing the skills required to solve a problem, which is certainly a legitimate situation within software development, no changes will be required for the entity itself. It is protected in it's own ignorance (dumb entity) which in turn makes it simple and easy to maintain. Although the concept itself seems simple and logical, static type check languages have no easy solutions for the described method. Simply put, static checking types within those languages have to be fully described and formed prior to the execution time in order to pass the check during compiling. Workaround methods circumventing the static type check for the purpose of accomplishing the described functionality have been of interest to the authors of this paper for several years now and, after publishing other solutions we present a new way of solving the problem [2]

As already mentioned, COP model solution described in this paper contains several required elements:

- Context
- Scenario
- Skill
- Role

The following sections will further explore each of the mentioned elements:

2.1 Context

Context is the environment of the complete software process. Context is a singleton, there can only be a single one during the time of executing the application [3]. That's the place where roles meet their tasks. Context has no information of roles or tasks. It is externally initialized, mostly by the software's user and most often by the user's GUI. External initialization in the specific example means that the Scenario's name will be forwarded to the Context. Context has access to the catalog of scenarios which lists the known scenarios and related roles and skills. Engineering-wise, the catalog can be conceived in numerous ways, from a relational database entry to a simple text file. Application used as the example uses JSON (Java Script Object Notation) document as a catalog Based on the received Scenario name, context initializes the surrounding. Within our application, context uses the reflection space of the name and the possibility of dynamic creating of class instances in order to instance the already built Scenario. Scenario, further on, posses information about roles and required skills to complete the tasks successfully,

2.2 Scenario

Scenario bears information of the required tasks, it's executioners and the skills required for the task to be completed successfully. Scenario will instance all objects required for the completion of the task. Each scenario inherits the joint interface within the environment which acts as a contract that ensures a common collection of functionalities that are of interest for the environment. This allows for the coexistence of all scenarios. Scenario has the highest level of importance compared to other objects and also has the highest level of knowledge of other objects included in the process. Once instanced, scenarios does not communicate with context in any way.

2.3 Skill

Skill is the description of the algorithm used to solve a specific problem. It embodies the knowledge, the skill that the executioner has to possess in order to complete the task. The executioner is irrelevant for the skill meaning that anyone can execute the solution since the knowledge is in no way connected with it specifically. Executioner receives the required knowledge once it is required. In the same way, it 'forgets' it once the task is completed. Within COP, the knowledge is dynamically injected to the executioner during the executing time. Methods of injection the knowledge are the basis of interest of the paper's authors for quite some time and this paper is a result of exploring this specific problem. The methodology itself will be explained in more detail later in the text.

2.4 Role

Role or the executioner is the last required entity within the presented software model. The concept that the authors follow within their research is very well described by Koplin and Bjørnvig. According to them, the role entity should be knowledge-free or 'dumb', that is only the description of the entity and it's traits, not a description of the functionality. [4] Of course, in order for the executioner to complete the assigned tasks, there has to be a place where it will receive the necessary knowledge and also a way to activate that knowledge in order to complete the work. In the example application, each executioner inherits the Role interface that obligates each child object to implement the public method "DoIt" which is the place where the knowledge is provided and which can start the execution of the specific task.

This concludes the listing of the types of entities that form the presented model of Context oriented programming environment. This would also be a required minimum. The number of individual examples of each entity is not limited by anything other than the domain described by the software. Authors that wish to apply the model can implement other entities according to the needs of the software application they're writing. The authors of this paper themselves use other entities which do not fall strictly within the listed categories but are entities that further describe the domain that's being realized. The organizational model described in this paper is completely open to such independent objects.

3. PROGRAMMING INFLUENCES USED IN THE PROJECT

Software engineers are trying to fulfill the need for a different organization of the object oriented code for quite some time now, using different, more or less successful solutions. A distinct direction in new solutions is the tendency to compose objects out of different elements using a 'has a' rather than 'is a' approach. Suggested solutions which are explored in this and previous papers are Mixin and Trait objects which will be further explored.

3.1 Mixin principle of organizing programming code

Mixin objects are classes in object oriented programming that are ready to be 'mixed' with methods form other classes [5]. This allows for the avoidance of class inheritance thus following the Composition over Inheritance principle which, as a result, produces a readable code that can be used in multiple ways. [6] As per the original idea, Mixin delays the 'mixing' moment until the execution time. That way, Mixin also counters the primary idea behind the static type checking languages. This contradiction is being solved differently depending on the language used. C# can implement the Re-mix library (http://remix.codeplex.com/) which solves the basic problem of changing the class during execution time.

3.2 Trait principle of organizing programming code

Trait is by definition a "collection of methods used as a simple conceptual model for structuring object oriented programs" [7]. Trait is a simple group of methods that serve as building blocks for classes and are the basic element for code reuse. Scala programming language has trait usage implemented. Trait uses different language tricks, depending on the specific programming language in order to effectively and dynamically compose multiple classes into one. C# has no built-in ways to purely implement Trait concept. That way, Trait can only be seen as an influence while looking for original solutions within C#.

4. DYNAMIC CHANGE OF ENTITIES DURING THE EXECUTION TIME

The problem being considered here is directly connected with the basic characteristics of procedural programming languages. Among a number of different classifications, here, we're interested in the differences based on the built-in type checking mechanisms. In this respect, it's possible to isolate two major groups:
- Static type check languages
- Dynamic type check languages

Languages with static type check presume that each variable must be explicitly declared according to the type it belongs to because the type check will be completed prior to compiling, i.e. the compiling won't be possible if there's any doubts about the data type of each variable. This means that it's not possible to compile a program that includes a variable that can't be precisely attributed to a certain data type. The most widely used languages of

this kind are certainly Java and C#. The relation between dynamic and static type checks is of key significance for this research. Dynamic executive entity change during the execution time is the prerequisite for context oriented programming. This, of course, opens up the issue of implementing the paradigm in the static type check languages[8]. Previous papers we published explore several methods for dynamically changing user defined types during execution time. Some of the solutions presented directly stem from the evolution of C# itself. There's several possible ways of dynamically changing data types using new built-in language possibilities and that's by using:

- Type extensions
- Dynamic libraries

Both methods are the result of the Microsoft's DotNet Framework division's efforts in trying to bring C# closer to dynamic languages. The most probable reason is the growing popularity of web applications and languages such as JavaScript And Python [9]. It's a fact that a number of programmers today gains their first coding experiences using these languages and the goal is to bring C# closer to their way of thinking. It should be noted that after these changes, C# can't be easily classified as strictly a static type check language and the developer's tendency to make it more like dynamic languages must be taken into account.

Implementing dynamic entity characteristics using the Weaving method is not a part of built in C# capabilities but the result of the programming community's efforts to enable the Aspect oriented programming paradigm [10] in a DotNet environment. Weaving method is more of a brute force approach but is remains an effective form of changing user defined objects during execution time. [2]

5. DELEGATES, PRINCIPLES AND EXPLANATION OF THE SOFTWARE PARADIGM.

Delegates are not a new concept in OOP. They're not always called the same in different languages but all the relevant object oriented languages have a similar concept in place. In software engineering, the delegates influence the design to have each object delegate the assigned task to it's attached object, instead of doing it itself. That way, the responsibility of the software object is removed. Delegated object doesn't have to inform the delegator of the task completion.

In C#, the delegate is a type of data. It's a very important characteristic. The delegate is also a type with it's own signature in the form of a parameter list and the expect type of the return information.

Based on this, it's logical to expect that delegates in C# point to a method in a certain way. This is not a new concept either and has existed since C++ which had the concept of variable's function pointer which could be forwarded to a different entity as a parameter. Delegates in C# can also be forwarded as parameters to a different known instance. Delegate can activate each available method as long as the signatures' are appropriate i.e. as long as the elements of the parameter list are ordered by the same type and the expected result is of the same type as well. A typical delegate in C# would look like this:

public delegate int Calculate(int x, int y)

Calculate delegate can activate any operation that has two normal numbers as parameters and that expects two normal numbers as results as well. This way, it's possible to have a whole sequence of operations such as:

```
public int Add (int x, int y)
{
        return x+y;
}
```

or

```
public int Subtract (int x, int y)
{
        return x-y;
}
```

and of course, further on, the multiply method and many others as well, proved that the method signature is the same. It's obvious that, in this way, the concept of delaying the decision until the execution moment is possible, deciding on the specific method that has to

be called upon. Specifically, if during the execution, based on a dynamic condition two numbers need to be added, method Add will be called in the following way:

Calculate add = Add;

add(2,4);

The system will receive the return information as the sum of 2 and 4 (6). In the same way, if the conditions point to the need of subtracting the numbers, the Subtract method would be called in via Delegate in a similar way:

Calculate subtract = Subtract

subtract(2,4)

with the system receiving the value of -2 as the result.

What's even more interesting is the possibility to forwarded the method via delegate as a parameter. This way, the following method would be legitimate:

```
public int DistinctProcedure(Calculate operation)
{
        return operation(2,4)
}
```

and we could activate it from any available part of the application as:DistinctProcedure(add) orDistinctProcedure(subtract) etc.

This shows the general concept of placing the information during execution time into a different object which is the subject of this paper as well. A similar concept has been used in the example application and will be further explained.

The advantage of the method shown is the possibility to use the built-in capabilities of C# without the need for external libraries or complicated language tricks. Concept is known and used since the existence of C# as well.

6. LAMBDA EXPRESSIONS, ANONYMOUS METHODS AND THEIR PLACE IN METHOD APPLICATION

Lambda expressions have found widespread usage in numerous scientific and technical areas and their explanation in full overstretches the boundaries and possibilities of this article. In software engineering, lambda expressions have been used since the very first theoretical beginnings, Turing's universal machine and Turing's theory. C# borrows lambda expression elements on a large scale from mathematics, also with the theory of anonymous functions. The possibilities of lambda expressions in C# are relatively new and are present since version 3.0. What's written down in math as:

$$(x, y) \rightarrow x \times x + y \times y$$

can be written in C# as:

(x,y) =>{x*x+y*y};

The system will know to forward the values of the sorted couple to the anonymous function x*x+y*y and that it can await for the result of the function. Incorporating lambda expressions turned out to be a huge step forward for C#'s flexibility and compatibility. Anonymous functions also have their own technical specifications meaning that the system has no instanced method in memory, and thus, no references for the method either. Anonymous function has complete in-line execution - when the program flow encounters it, it executes the method and after execution there is no trace of it in the system until the next execution - that way, there's also no need to clear the system from methods or stack keeping etc. What's interesting for our research in regards to lambda expressions is the possibility (available since C# 3.0) to attach a lambda expression to the previously described delegates. This results in an encapsulated variable that carries with it complete information about the method being executed and, as such, can be forwarded as a parameter into any available part of the application. In the code itself, it's possible to write:

delegate int Calculate(int x,int y) = (x,y)=>{x+y;};

and to forward such a delegate as a parameter containing all the necessary information in regards to the execution of the required method. Even more compact, it's possible to make anonymous delegates and forward them as the method parameter. Since C# 3.0, special types of delegates have been introduced:

- Action (delegate with the return value of the void type)
- Func (delegate with the return value)

which make writing the previously mentioned expression as:

$$\text{Func<int, int, int> calculate = (x,y) => x + y;}$$
and forwarding it as a parameter in function:
$$\text{DoIt (calculate, x, y);}$$
which allows for a very compact way of information transferring which was of the prime interest for the research at hand.

In order to encapsulate functionalities in scenarios, authors use the Action<T> delegate type incorporated in C# which is a void type, meaning it sends no results back. Technically, there's no obstacles to do it via the Func<inT,outT> type and ultimately, there's no obstacles in using the delegates in the same way they were used prior to 3.0. It is necessary to adjust the scenario logic in those cases requiring return information.

7. DESCRIPTION OF THE APPLICATION USED AS A STUDY EXAMPLE:

The application used to confirm the theoretical model is created using solely C# 4.0 programming language. The development environment used was Microsoft VisualStudio 2012 (http://www.visualstudio.com/). Application's front end was developed using the WPF (Windows Presentation Foundation) technology but could also be completed using any other technology, bearing in mind that it's completely separated from the applications logic itself.
The idea was to create multiple scenarios which:

- don't have to be connected in any way
- share certain elements or entities

It's necessary to check the applications functionality in such conditions. That's how the following scenarios were created:

- Text manipulator
- Money transfer
- Square root computing using the Newton method
- Account cash payments

Scenarios' names themselves point to the fact that two of them share certain domain similarities and those are the money transfer and cash payment scenarios. It's also obvious that there's two additional scenarios that are in no way connected to the previous two. In this way, the application can be tested to solve a certain problem in three unrelated domains where each domain bears all the necessary elements that were described above but that there's also a domain that has all the elements but two scenarios solving independent problems as well. This domain proves the idea that a certain Role entity can be infused with different information and that it can successfully complete tasks requiring that information.
Meanwhile, there's no changes to the Role entity itself, as will be shown.
Each of the listed scenarios has it's individual characteristics. Most obvious ones would include the number and the type of parameters required to complete a task - the text manipulator requires the text to be edited, Money transfer has the accounts and money amount etc. A problem with unifying entities with different types and number of parameters is shown. This problem was solved in a way that has been present in C# for a long time and that's the making of a sequence of objects and using keyword params in order to inform the method that there's a possibility of no data showing as an argument[1]. This method itself is not particularly elegant since there's the need to convert the received parameters in the required data type. Still, it's efficient and simple enough for a junior programmer to use. Similar method is applied to the Main method in the command promp (console) of C# applications. The method is built in in the automatic creation of Console application projects within Microsoft Visual Studio environment. This makes the explained method familiar for most programmers using C#. This is probably the biggest compromise required for the survival of the entity consistence in the observed organizational model. Specifically, Role entity received a DoIt method that looks like this:

```
public override void DoIt(Action<object[]> action, params object[] args)
{
    action(args);
}
```

Skill entity now has an Action type property wit the following signature:
Action<object[]>
in order to be compatible with the DoIt method in the Role entity types.

---

[1] http://msdn.microsoft.com/en-us/library/w5zay9db.aspx

7.1 Text manipulator:

The text manipulator is the first scenario in the application. This is the simplest one, both logically and technically and it's purpose was solely to prove the concept on the simplest example. The scenario will be described since specifically due to it's compact and simple nature.

The task of the scenario is a menial one, inverse writing of the given text. The execution flow follows:

- User requests the context with the scenario's name text bia GUI
- Context looks for the Scenario within the catalog, based on the name given as a parameter
- Context creates the scenario and starts it's execution
- Context has no interaction with the started scenario anymore, it waits for the next new scenario request.
- Scenario knows who is included in the text manipulation and creates new TextManipulator instances, the Role type entity and instance TextManipulationSkill which is the skill type entity.
- It forwards the information to the TextManipulator in the form of an Action delegate with all the the necessary text transformation logic, as well as the text that needs to be changed as a second parameter of an object sequence type (object []).
- TextManipulator bears the DoIt method that was previously described. As soon as it receives the necessary arguments, DoIt method is executed using logic received as skill and application writes the inverted text at the user's screen.
- After executing the logic, all the entities from the TextManipulation scenario dissappear from the application's execution area automatically.
- Application is ready to execute a new scenario.

The same steps are used for all the other listed scenarios, the logic and the data is different but the sequence, being also the main algorithm of the system does not change with different scenarios. This results in a Context oriented programming environment as requested by this research.

8. TRANSFERRING MONEY AND CASH PAYMENTS, TWO SCENARIOS OF THE SAME ROLE

These two scenarios are no different to the already described Text manipulation scenario, in respect to the execution flow. The reason for explaining these two scenarios is the implemented realization of two scenarios with a single role. Both scenarios have the same executioner, a user type, class Accountant

that's being provided with different information for both of the scenarios and that can successfully complete the required tasks. This is in essence the proof of the concept described in regards to the Mixin organizational principle that speaks about creating a software code that requires no inheritance but works based on composition and valorizes composition over inheritance.

The usual way of creating a business application via Object oriented programming would be creating an Employee class and than a whole sequence of classes which would implement the Employee and provide it with one or more extensions in order to cover all the possible positions of the employee that are of interest to the application. In an average business informational center, this would very soon result in a huge number of classes which would complicate the understanding of the system and it's maintenance.

On the other hand, the shown model would contain the Employee class and than a sequence of skill classes which by themselves would be algorithms required for completing certain tasks. When needed, the Employee class would be provided with the required skills during execution time. We firmly believe that this would result in a more logical and easily understandable system, making it more simple to maintain as well.

Another observation is worth noting, in regards to these two scenarios. At the very beginning of this paper, we allowed for the possibility of enhancing the observed model with other entities, aside from the required ones. These entities would further describe the domain. In these scenarios, the Account entity is present - although not a pre required one, it is necessary for the domain's full description. This shows that the application works with no problems with additional user defined types, regardless of their form.

9. CONCLUSION

The goal of this paper was to point out to different possibilities of organizing large, mostly business applications written in C#. The paper describes one such system and the technical ways of making a functional solution possible. The described method is fully supported with built-in C# capabilities and requires no language tricks, external libraries or other exotic solutions. It only requires a slightly advanced understanding of the language and the good will to use according to the way shown. Applying this method in practice, however, is highly limited due to the established and worked-out solutions that are first of all satisfactory and also thoroughly backed up with literature, examples and experiences of the programming community. With this in mind, the authors bear no illusion that the suggested methodology would influence the practice significantly but they hope to contribute to the overall corpus of knowledge within the community by presenting and explaining an alternative concept which greatly differs from the mainstream solutions.

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SERAPHIM: LINUX KERNEL MODULE FOR RESOURCE MANAGEMENT AND COMMAND EXECUTION

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Abstract: This paper presents the ability to monitor the performance and usage of a target computer system running on the GNU/Linux operating system and predefined command execution using Seraphim, open-source Linux kernel module. Seraphim's primary target audience are business users. It provides the vital ability to answer the following question: „Who has asked for which resource, and at what time did he ask?". Seraphim can also be used for various other puproses, for example in education purposes. It has a modular structure and is easily extendable. Seraphim is published as an open-source project, under the GNU/GPL license.

Keywords: Linux, security, monitoring, kernel, module, system programming

1. INTRODUCTION

In the previous years there has been an increased number of cyber attacks on operating systems based on the Linux kernel (Sophos Security Threat Report 2013, 2013). Considering the reasons that the number of computers and handheld devices running Linux is on the rise (The rise of Android: from 32% to 65% in two years, n.d.), there is an increased need for security and resource monitoring. Therefore, there is also a need for adequate software tools specially suited for such a task. Seraphim was created to aid in the prevention of Linux based operating systems (such as GNU/Linux and Android) abuse by providing an interface to keep track of specific Linux resources and execute specific commands. Its target audience are business users; however it can be used for various other purposes, for example in education.In the next section, problem statement and motivation for developing Seraphim are given. Section three provides with three use cases for Seraphim in its different configurations, while section four gives a review of existing tools for Linux resource management and command execution. In the Section five, Seraphim structure and subroutines are described. Following section contains information about kernel communication. Section seven describes Seraphim logging facilities, while Section eight presents the command execution feature. At the end of the paper, conclusions and suggestions for future work are given.

2. PROBLEM STATEMENT

Looking at the usage of Linux in business (Linux Adoption Trends End User Report 2013, 2013), one can conclude that security and continuous control are a necessity. In these turbulent times, the ability of knowing who asked for which resources and at what time is of vital importance, also activities such as auditing and user provisioning are important parts of an identity and access management system (Milenković, Šošević, & Simić, 2012). At the moment, there is no adequate tool on the market that could provide these features effectively. Consequently, there is definitely a need for tool which would allow business users to effectively track their resource usage and execute predefined commands to aid overall security of the system.

Furthermore, such software can be used in education, specifically in computer security training, where it could provide insight into key resources defined before compilation, allowing the user to see how the system is responding to a given training scenario. Another notable usage would be in the field of Electrical and Computer Engineering, providing a safe and redundant solution to tracking resources while testing new software and hardware configurations, without having to attach an external debugger.

The software that is the topic of this paper, Seraphim, tends to provide the ability to monitor Linux kernel resources, execute commands and keep logs of given actions. The software is provided as open-source, under the GNU/GPL license. (Ţivadinović, n.d.)

3. USE CASES

Seraphim may be used:
- as an intrusion detection and prevention tool,
- as a hardware and software configuration testing tool,
- as a resource monitoring tool,
- to avoid memory dumping for analysis,
- for honeypot computers, and honey networks,
- for tracing scripts,
- as an educational tool.

In this paper we present use cases for the first three possible applications of Seraphim.

Considering Seraphim's usage in detection of intrusions, assume the situation where a crucial computer system has been compromised by the means of infiltration by unauthorized users. In this specific case, Seraphim can generate a report of resources compromised with the dates and times of them expressing unusual behaviour, and, if programmed, execute sanitation and prevention commands that would reinfore the security of the computer system while preventing the malicious user from further action against the target computer system. Without specific software for the detection and prevention of intrusions, the computer system is left vulnerable to infiltration and exploitation, both internal and external.
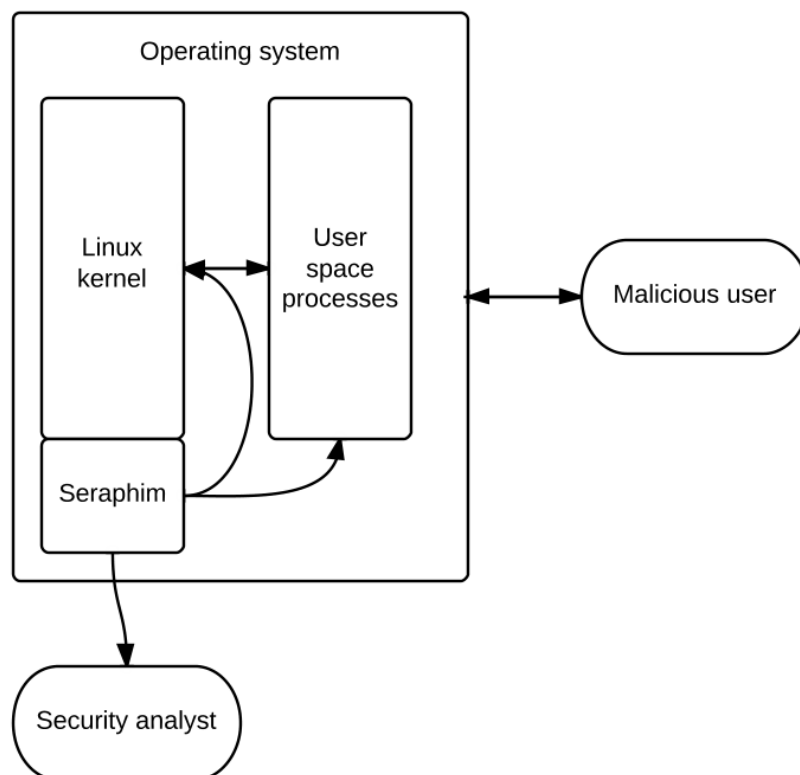
Figure 1: Usage of Seraphim as an intrusion detection and prevention tool

It is also noted that Seraphim can be used in the field of Electrical and Computer Engineering as a tool to track resources while testing new software and hardware configurations. The first step in using Seraphim for this purpose is to compile it with the list of resources that need to be tracked and, if required, commands that should be executed. After that, the person that is testing new software and hardware configurations must load Seraphim into the kernel before the testing begins. During testing, the person performing the tests can have direct access to predefined resources, vastly simplifying the cost and time required for testing with alternate tools, such as JTAG debuggers.
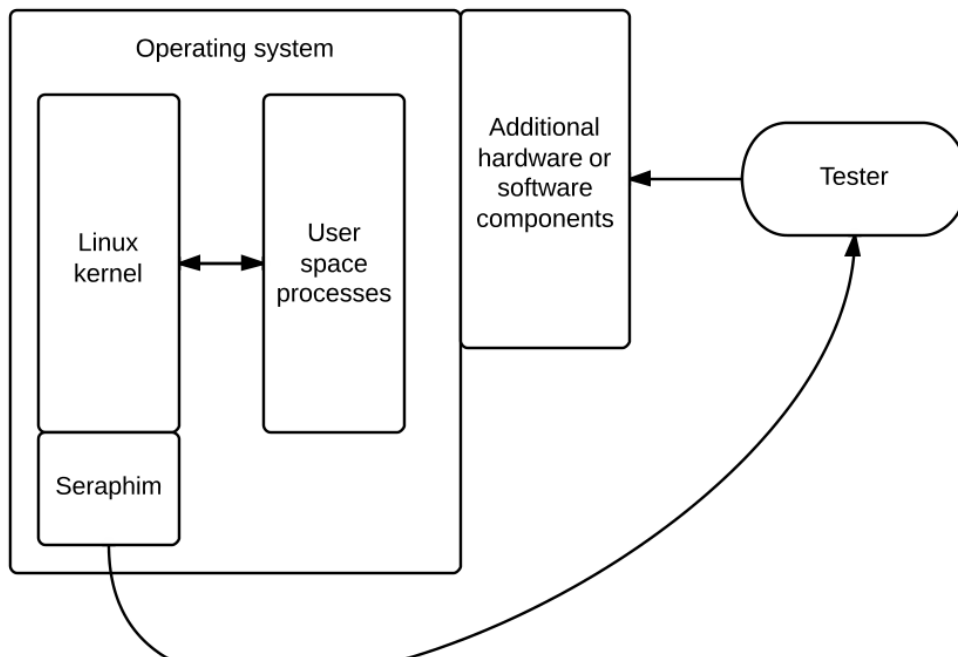
Figure 2: Diagram of Seraphim in the role of a hardware and software configuration testing tool

Another use case for Seraphim would be for constant resource monitoring with the goal of optimizing the target computer system, thus improving overall business performance. Employment of Seraphim as a resource monitor with the ability to generate periodical reports is similar to the last two use cases and requires the person gathering data for further analysis to predefine the resources that should be monitored and the required time intervals on which reports should be generated. These reports can later be aggregated and analyzed to show adequate steps to further optimization and improvement of business performance.
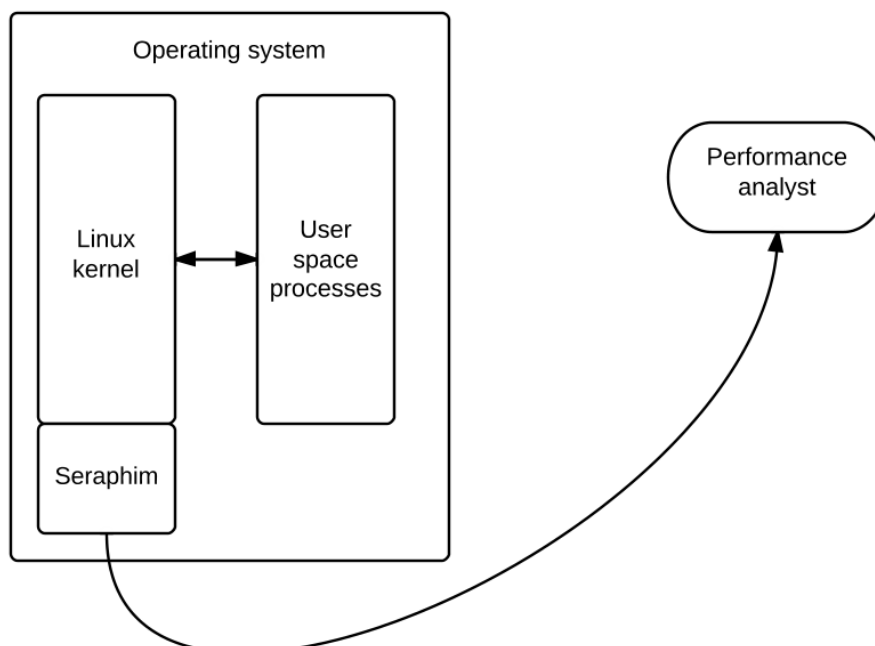
Figure 3: Usage of Seraphim as a resource monitoring tool by a performance analyst

4. EXISTING TOOLS

Currently, there is no adequate open-source tool on the market for Linux resource management and command execution via kernel module routines. Several years ago there were tools that fit the specification, but they were created for malicious purposes (Attack Sneaks Rootkits Into Linux Kernel, n.d.). Other tools, such as Nagios (Nagios, n.d.) and Tripwire (Tripwire, n.d.), which are proven solutions and industry standards, have become products with a large amount of legacy and archived code, considering they have been in use for more than a decade (Nagios History, n.d.). Some of them (like Knark (Intrusion Detection FAQ: Knark: Linux Kernel Subversion, n.d.)) which could have been implemented as tools without a

malicious purpose have been out of date for several years due to the advancement of the Linux kernel and the lack of development.

If implemented correctly into a target computer system, Nagios provides monitoring of computer resources and system metrics, including a powerful scripting API to modify Nagios to specific needs of the target computer system. Such integration allows the generation of detailed reports about security incidents, with the ability to extend the reporting system. (Nagios - Nagios Features, n.d.). Seraphim draws inspiration from several segments of Nagios, especially the extendable API and a report generating system.

Even though Knark hasn't been developed for several years, it still poses a threat to operating systems running the Linux 2.2 and Linux 2.4 kernel (Information about the Knark Rootkit, n.d.). Knark's attack vector is defined by the ability to hide TCP or UDP connections, perform system call injection, hide files, directories and processes and change the UID and GID of a process, just to name a few of its features (Intrusion Detection FAQ: Knark: Linux Kernel Subversion, n.d.). The distinguishing part of Knark is that it is implemented as a Linux kernel module, giving it automatically an advantage over other tools (such as Nagios and Tripwire) since it has access to the same resources as if it were the Linux kernel itself. Such design was a primary trigger for the development of Seraphim, considering that, as a Linux kernel module, it would have an amount of features not accessible if it were created as a regular, user space application.

Tripwire functions by defining policies, upon which are generated reference points of target computer resources (file systems, databases, virtual systems to name a few). Later ongoing integrity checks compare the current state of target computer resources with the reference points and, upon policy restrictions, can act if the modifications were unauthorized. (Tripwire Enterprise FAQs, n.d.). The predefined policy based system is a feature that was implemented in Seraphim as a set of commands defined in the application itself prior to compilation.

There are, in fact, tools that have adapted to the development of the Linux kernel and the need for adequate monitoring and system control (such as Nessus (Nessus Vulnerability Scanner, n.d.)), with the main drawback of price (Nessus: Tenable Store, Unified Security Monitoring, n.d.) and proprietary code.

5. SERAPHIM STRUCTURE

Seraphim consists of several subroutines, each providing a specific purpose. The main reason for making the features of the software atomic is the ability to easily extend it using a crude API.
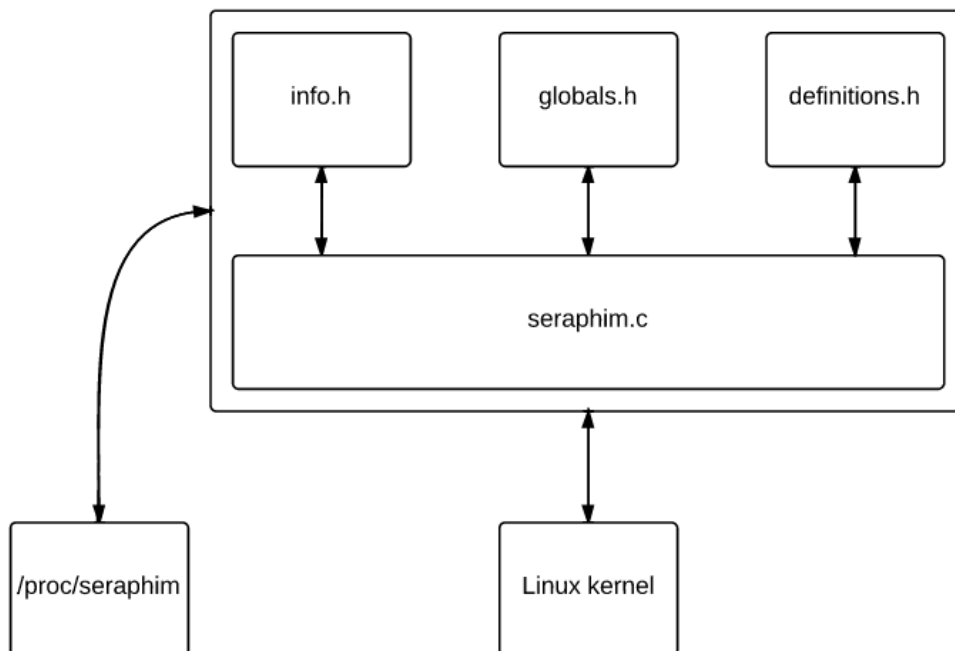

Figure 4: Block diagram of Seraphim structure and connections

To start the application, one must compile it on the target system (or a viable alternative) and then insert the kernel module into the Linux kernel using adequate system provided commands.

The entry point of the application is the file "seraphim.c" which is an aggregation of several files which provide adequate kernel communication and logging facilities. Kernel communication and logging facilities do not exist on their own, they are supplemented by several secondary subroutines which provide the actual interface into the Linux kernel. Secondary subroutines are defined in the file "globals.h". Primary subroutines exist in the file "definitions.h". The file "info.h" contains necessary author and licensing information.

Primary subroutines of Seraphim provide the implementation of secondary subroutines into forms that the Linux kernel can execute. The main part is the infinite loop that provides the execution of primary and secondary subroutines. Primary and secondary subroutines are duplicated at several places due to the fact that disk writing operations are categorized as slow operations, hence they were sometimes dropped from the Linux kernel process execution queue. After defining adequate primary and secondary subroutines, it is required of the programmer who is extending Seraphim to include the subroutine calls in the infinite loop so that they could be executed.

```
static void printString(char *string) {

    struct tty_struct *tty;

    tty = get_current_tty();

    if(tty != NULL) {

        (tty->driver->ops->write) (tty, string, strlen(string));

    }

    else
        printk(KERN_ALERT "TTY equals zero.\n");
}
```

Figure 5: Example of a secondary subroutine "printString" which prints the given string to the terminal console

Before the execution of the main loop, Seraphim registers itself to the kernel and provides an input/output interface under the /proc filesystem which allows an authorized user to manipulate the flow of the application.

6. KERNEL COMMUNICATION

Before each run, kernel modules must be loaded into the kernel. This is usually done with the command "insmod". After they are loaded, kernel modules start their execution. The process of loading a kernel module implies that the kernel module is being added to the Linux kernel, forming an integrated entity between the raw kernel and the kernel module. Considering this, it is safe to conclude that Seraphim runs in the kernel space, a region in memory where the Linux kernel runs and provides defined services (Kernel Space Definition, 2005), unlike most other resource monitoring applications, which run in user space, a memory segment where user processes reside (User Space Definition, 2005).
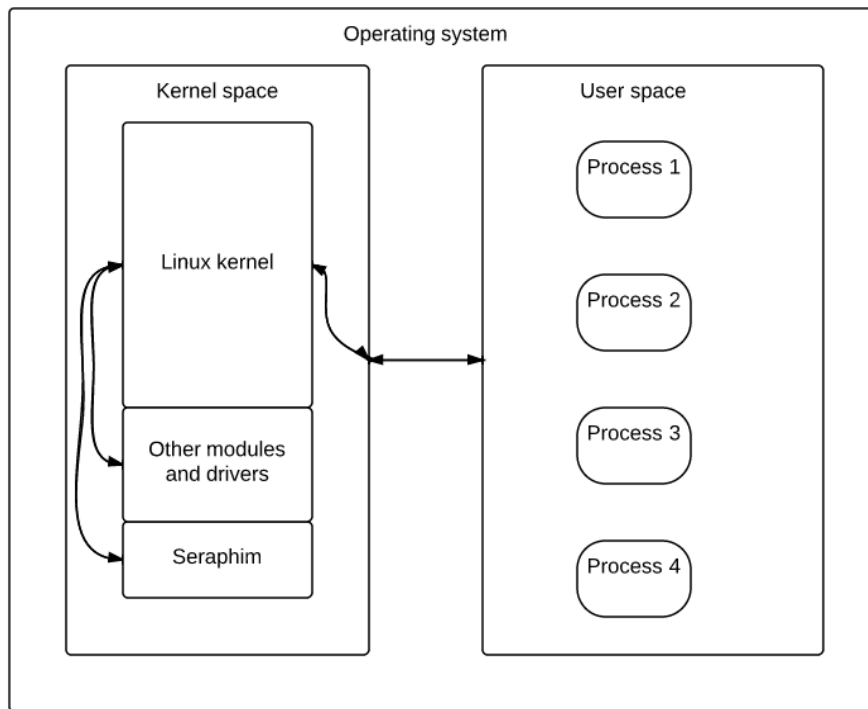
Figure 6: Seraphim integration within the operating system with four running processes; inter-process communication and communication with the user space kernel communication provider is abstracted

As defined earlier, the primary subroutines are defined in the file "definitions.h" and they are supplemented by secondary subroutines in the file "globals.h". The main part of these subroutines, both primary and secondary, provide communication with the kernel. Kernel modules communicate with the kernel by having access to subroutines not normally available to user space applications due to the fact that kernel space applications (in this case kernel modules) are compiled against the Linux kernel itself, instead of compilation against the GNU Standard C library.

Communication with the kernel is defined on several fronts. One of them is the usage of existing teletype interfaces to provide the piping of data through the kernel to the end user, allowing real time monitoring from the teletype interface from which Seraphim was loaded into the kernel.

The most important part of Seraphim is the ability to execute system commands automatically as an administrator. That feature is provided by the "runner" subroutine which utilizes the kernel functions for string concatenation and memory management, creating a construct which is then called by the kernel and executed after passing the Linux process execution queue.

One of the other places where the kernel communication is extensively utilized is for the creation of adequate files under the /proc filesystem, providing a user interface for kernel communication, and the ability to log executed commands and the status of resources predefined before the compilation.

Commands used for communication with Seraphim are inspired by the BASIC programming language and consist of a single string which is then parsed inside of Seraphim to determine its meaning. Currently, the only implemented command is the command "STOP" which halts the execution of Seraphim.

7. LOGGING FACILITIES

The ability to log targeted resources and their states and also the results of executed commands from Seraphim is of vital importance to the security and integrity of the targeted system. Monitoring of resources is done several times per iteration of the main loop, providing redundancy in case of dropped statements from the Linux kernel process execution queue. Both the results of monitoring and command execution are logged in the messaging facilities of the kernel, from which they can be extracted for further analysis.

The process of monitoring and logging is done by executing a specially crafted command embedded inside a subroutine, which is modified before execution with the resource from the /proc filesystem that we wish to monitor. The location of the file where the log should be saved is predefined as a macro and can be changed prior to compilation and execution. Furthermore, the event of monitoring is logged in the kernel message device, along with a timestamp providing the system analyst with information at what time and which state was the system in when there was an unplanned event.

Each executed command is logged in the kernel message queue and in the adequate files on disk defined before the compilation of the kernel module. Furthermore, subsequent command executions are marked in the files on the disk. Timestamps of resource monitoring and command execution are written in the kernel message queue, allowing qualified persons to determine at which time since the start of the system has there been a breach of monitored resources or the execution of unauthorized commands.

8. COMMAND EXECUTION

As it was noted above, Seraphim provides the execution of commands under administrative privileges using the "runner" subroutine, providing a simple interface to execute additional commands to the system for maintenance and extended security monitoring which isn't encompassed by Seraphim.

Similar to the logging facilities, command execution is encapsulated in a specific subroutine, which takes two parameters, first one being the command that is supposed to be executed and the second one which represents the location on the file system where the result of the execution will be written. The key component of this subroutine is "call_usermodehelper" (Linux Manual Documentation, n.d.), a subroutine which allows the calling of predefined commands as a superuser, having access to all components of the operating system. It is worth mentioning that both the logging facilities and command execution are based on the same principles and subroutines.

Using the ability that Seraphim can execute commands defined before compilation, one can theoretically infinitely extend and integrate Seraphim into the target system, using it as a hub for continuous monitoring and security activities, supplemented by its own integrated subroutines providing a low-level approach to the Linux kernel and operating system which applications running in userspace cannot achieve.

9. CONCLUSION

In these tempestuous times, the ability to have up to date logs of crucial data on your target systems is the primary concern, as is the execution of commands to mitigate attacks against the monitored system or simply the execution of commands to reinforce the system on which they are being run. A large number of solutions on the market simply do not provide the necessary features required for low level system monitoring or the management of computer resources and command execution.

Seraphim, at this current state, provides the answer to these problems by monitoring predefined files and executing predefined commands, without the need for external control. Furthermore, Seraphim is modularly built, allowing further expansion before compilation.

Further course of Seraphim development is porting the source code to the Microsoft Windows operating system, with the same or even greater features, and later, implementing additional features such as system call injection and scripting to the original Seraphim for the Linux kernel. Considering the alternate tools (Nagios, Tripwire and Nessus) and the man hours spent developing them, one can conclude that Seraphim, even though has a fraction of their possibilities, is a worthy contender, despite the fact that it was developed with a lot less man hours than its main competitors.

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THE ARCHITECTURE OF INTEGRATED IDENTITY MANAGEMENT AND MULTIMODAL BIOMETRIC SYSTEM

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Abstract: Identity management systems are used in different types of organizations. Most of them have remote users who access the organization's resources through the Internet. It is crucial to prevent frauds and unauthorized access to data. Techniques for authentication that are used in today's identity management systems are vulnerable when they are used over the Internet. Identity management systems integrated with multimodal biometric systems could build a more secure environment in which to perform critical operations. In this paper, we present the architecture of a prototype of an integrated system of identity management and multimodal biometrics. Special attention was given to how to integrate multimodal biometrics into existing identity management system.

Keywords: identity management system, authentication, multimodal biometric, single sign-on, open source

1. INTRODUCTION

Modern information technologies have enabled information infrastructure to connect remote entities around the world by using large networks, relying on application level protocols and web services. The advantages of computing resources, which are available on the Internet via cloud computing and virtualization technologies, are being used by the companies to an increasing extent. Given that the number of online users is growing daily and approaching the actual total count of people, the issue of digital identity management arises in order to protect privacy and retain liabilities in transactions and interactions in accordance with the regulatory controls. Digital identity can be defined as the digital representation of information about a particular person or organization. Digital identity has a finite, but also an unlimited number of attributes. Digital identity may include attributes of a person such as: name and surname, personal identification number (PIN) or passport number. Additionally, it can obtain biometric data such as the iris of the eye or a fingerprint, as well as the information about the users' activities, including web searches and transactions during Internet purchase. Biometrics is a relatively new field, but today, in the process of verifying users' identity, multimodal biometrics is its greatest asset. In multimodal biometrics, different modalities are taken simultaneously in order to determine users' identity. Therefore, the probability of verifying an identity is high.

The identity management and access control involve several fundamental parts, such as: user identification, authentication and authorization. These three activities are strongly connected and, in fact, we can say that they form a chain of interdependence. Authorization depends on authentication, and the authentication itself is based on identification (Lynch, 2011). There are lots of other activities that are important for identity management, but particular emphasis is put on managing user accounts and monitoring of the system user activity.

In order to respond to current trends, a prototype system for identity management needs to be developed. It is necessary that this system fulfils requirements for identity management, policies and monitoring of the system user activities. In accordance with these requirements, a system has been designed for identity management based on FreeIPA solution for digital identity management and MMBio framework for multimodal biometrics.

2. IDENTITY MANAGEMENT

Identity management can be defined as the creation, management and use of digital identities. Identity management implies safe management of the entire digital identity's lifecycle, from its creation (registration of a digital identity), through maintenance (implementation of organizational policies with regard to the

access to electronic resources) and, eventually, the termination of digital identity. It allows efficient and safe access to data and applications.

Three key elements of identity management are: policies, processes and technology. Policies refer to limitations and standards that need to be followed in order to be in compliance with regulations and business practices, as FreeIPA allows by defining the policies. Processes describe the sequence of steps that lead to the completion of business tasks or functions. Technologies are automated tools that help achieve business goals more efficiently and accurately with regard to all limitations and guidelines outlined in the policy.

Identity management system of an organization does not remain stagnant over time. New technologies will be introduced into the system, new business models and limitations will change the processes and management type. Once one of the elements undergoes a change, a new balance needs to be established (Kong, 2011).

Three key elements of identity management are:
- Data access service
- Access control
- Identity life cycle management

Basic concepts of digital identity are:
- The subject, entity
- Resource
- Digital identity
- Authentication
- Authorization
- Federation
- Integrity
- Single sign-on (SSO)

The subject or an entity is a person, group of people, an organization, a virtual object (e.g., computer process, application, text file), tangible object (e.g., electrical appliances and computers) or any other entity that requires access to a particular resource.

A resource can be a specific data in the database, a remote server or a website, and what is common to all the resources is the access, i.e., the entity refers to its own digital identity when accessing the resource.

Digital identity, the very concept of it, represents an experience of one's own identity, the identity of other people and things in the aspect of digital technologies (Prasad and Rajbhandari, 2011). The definition of digital identity consists of the following parts:
- Identifier
- Credentials
- Key attributes
- Context-specific attributes

The identifier or the key is a part of the information that uniquely identifies the object in a particular context. Examples of identifiers are email addresses, user names or the unique identification number that every person possesses.

Credentials are private or public data that could be used as proof of identity authentication.

Key attributes represent data that help describe identity. Key attributes can be used in a variety of different business and application contexts. For example, addresses and phone numbers are common attributes used in a variety of business application.

Context-specific attributes are data that help describe the identity, but these attributes are used only in specific contexts.

Authentication is a process of verifying the identity of the user, devices, or other entity in a computer system, which is often a prerequisite for gaining access to resources in the system.

Authorization is an approval given to the user, application program or a process to accesses a particular object or group of objects. Authorization is often resolved through the mechanism of roles. It is possible to

assign a specific role or group of roles to one user or a group of users. The role may consist of other roles, which together make up a set of privileges at the disposal of the authorized entity.

Federation enables secure sharing of information with external systems that need to manage the identities of foreign customers. Without this functionality, administrators would have to maintain a separate folder for all foreign users and manually update data about them (Williamson, Yip, Sharoni, and Spaulding, 2009). Identity Federation represents a circle of trust and allows users from one domain to access resources in another domain without any additional introduction.

Integrity is a guarantee that the content of the received message was not altered in respect to the content of the original message sent.

Single Sign-On (**SSO**) is a process of authentication that allows a user to access one or more resources within single security domain. SSO is a common procedure in Enterprises, where clients logs in once and gain access to different resources connected to a local area network (LAN), without the need to re-enter log-in credentials.

3. MULTIMODAL BIOMETRIC SYSTEMS

Problems that occur with previous methods of identification could be solved by recognition of a person based on something he or she is, by using biometric identification. In this way, issues with password memorization and safety of the object are resolved, and the identification of a person is enabled without external data or objects (Hermans and Valkenburg, 2009). This is particularly significant once we take into consideration the fact that distance communications are expanding. Throughout the Internet people use services such as electronic commerce and administration, they perform business transactions, study and maintain personal contacts. In all of the above mentioned situations it is crucial to establish the identity of the person performing a transaction, or the person with whom communication is maintained. This way frauds and unauthorized access to data are being prevented.

Similarly to the Internet technology, the first implementation of biometrics was for military purposes. Academic institutions have directed their efforts adequately with the more evident need for biometric technologies. Progress in the technology development, specifically in biometric sensors of affordable price, has enabled the implementation of biometric technology in new areas (O'Gorman, 2009). Now, even the smaller development teams with limited budget can afford the costs of procurement of appropriate equipment used for development and testing. This technology development trend has assisted the emergence of open source biometric solutions, developed by the open-source community. Systems that integrate multiple different biometric modalities, e.g., face and fingerprint, voice and the iris, are called multimodal biometric systems. Integral parts of multimodal biometric systems are methods for fusion of information concerning various modalities.

Multimodal biometric systems imply several processes:
- Acquisition of biometric data
- Biometric data processing
- Characteristics extraction
- Comparison and decision making

Each of these processes involves working with a multimedia database of multimodal biometric data. Depending on where the above processes are deployed, we can distinguish between distributed and centralized architecture of multimodal biometric system. In a centralized architecture all biometric processes are located on one host. Distributed architecture implicates the distribution process in several different places (machines), where they must have the ability to communicate through the network.

Potential users have at their disposal numerous commercial as well as open-source solutions. Commercial solutions often make up closed units, with all the advantages and disadvantages of this approach. Some of the open source solutions enable the development of flexible systems, which can have the same use value as commercial solutions in certain situations, but with much smaller financial investments. Also, the use of biometric authentication is not generally in the forefront and is offered as an optional possibility with some of the commercial producers' solutions (Bogicevic, Milenkovic and Simic, 2012).

The solution offered by Microsoft, Active Directory Services (ADS), includes an integrated identity management system. Ever since the Windows server 2003 R2, Active Directory Federation Service (AD FS) is an integral part of the ADS and is being used to create connections between organizations. This is

possible by user authentication through Active Directory which represents an identity provider. Moreover, AD FS issues tokens that are used in the authentication process. In addition to ADS, Microsoft has also developed MIIS-Microsoft Identity Integration Server, which has changed names, but in the year 2010 was presented as FIM – Forefront Identity Manager. FIM was developed in order to integrate with Active Directory and Microsoft Exchange solutions.

IBM offers an identity management system, which is a part of Tivoli and is called Tivoli Identity Manager, based on policies and roles. It provides a hierarchy of roles, web self-services, group management and synchronization of user data with different repositories. The advantage is in the possible synchronization of Tivoli with ERP systems. Furthermore, there is a possibility of using biometrics as an authentication method.

The imposed open source solution is the FreeIPA solution that allows creation of identity storages, centralized authentication, domain control for Kerberos and DNS services and authorization policies, and all this on Linux systems using the native Linux tools. Basically, the FreeIPA is a domain controller for Linux and Unix systems. FreeIPA defines the domains through control of the servers and reported client machines. That provides a centralized structure that was previously unavailable in Linux/Unix environments, and all this through the use of native Linux applications and protocols.

A suggested technical solution is based on FreeIPA and MMBio solutions. Identity management is done with the help of FreeIPA system, while MMBio framework for multimodal biometrics is responsible for working with biometric data. Data acquisition is done with the help of kerberized application for acquisition which uses functionalities of the FreeIPA solution.

A multimodal biometric application has been developed together with the use of framework. Within the application, three different open source solutions have been integrated and each of them works with different biometric modality. The modalities used are: fingerprint, face and voice. Although each of the open source solutions has lower accuracy than commercial solutions available on the market, when different modalities were combined, the accuracy of the system was at a considerably higher level than it was with any unimodal solution individually.

4. MMBIO – FRAMEWORK FOR MULTIMODAL BIOMETRICS

In order to build a multimodal biometric system from unimodal open-source solutions, several challenges have to be solved. It is necessary to establish communication between open-source unimodal solutions, acquisition sensors, biometric database and multimodal fusion algorithms. Also, this communication has to be implemented in accordance with the system distributed nature, as different system components can be deployed on various platforms. Moreover, biometric data management has to be implemented, with special focus on supplying data in accordance with unimodal biometric solutions specifications. Finally, framework has to support component reusability in new, different context.

MMBio framework for multimodal biometrics was developed to overcome these challenges (Milovanović, Minović and Starčević, 2012). Communication between different system parts is based on MMBio communication protocol. Communication protocol is used rather than object serialization because communication protocols are platform independent. However, unimodal solutions and acquisition sensors often support only nonstandard, solution specific communication methods. In such situation, it is necessary to develop a communication adapter in order to translate protocol commands to solution specific ones.
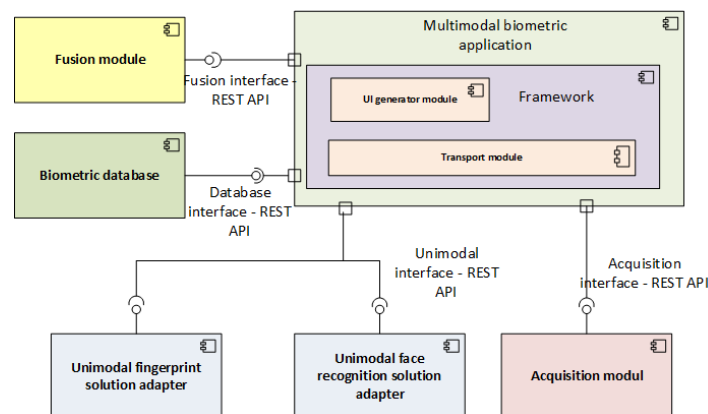

Figure 1: Multimodal biometric system architecture

MMBio framework supports different multimodal database work modes. It is possible to use either centralized or distributed database. Also, biometric data associated with an identity can significantly differ from one biometric system to another. In a multimodal biometric database, a person can have data about several different biometric modalities, and each modality may be represented by several data instances. Biometric data can be in raw form, or stored as biometric characteristics. Each type of biometric data can be stored in different file formats, and some file formats are solution specific. MMBio communication protocol has been designed to comply with different biometric database models, and supports different use case scenarios.

Figure 1 shows architecture of multimodal biometric system developed with MMBio framework. System components are biometric application, biometric database, acquisition module, and unimodal solutions (Milenković et all, 2013). Communication adapters are used for protocol message translation. Each component reports its functionalities to multimodal system during the initialization process. Communication between components is synchronized, based on request/response paradigm. In this use case, MMBio protocol is implemented by using REST (Representational State Transfer) services. Protocol messages are sent over HTTPS protocol. An example of protocol message is shown on Figure 2

```
POST /NBIS/resurs/match HTTPS/1.1
Content-Type: image/jpeg
User-Agent: Jersey/2.2 (HttpUrlConnection 1.7.0_25)
Host: 10.10.1.176:8080
Connection: keep-alive
ServiceName: NBISFingerprint
UserID: 1120
Timestamp:09.09.2013. 14:54:03
Modality:Fingerprint
Biometric-Sub-Type: index finger
Biometric-Sample-Type: raw image/bmp
Content-Length: 277921

PGh0bWw+CiAgPGhlYWQ+CiAgPC9oZWFkPgogIDxib2R5PgogICAgPHA+VGhpcyBpcyB0aGUg
  Ym9keSBvZiB0aGUgbWVzc2FnZS48L3A+CiAgPC9ib2R5Pgo8L2h0bWw+Cg==
...............................................................
```

Figure 2: Protocol message example

HTTPS request line contains information about web service location. Example shows a biometric data match request which is being sent to a unimodal biometric solution. Header fields are used to describe request in detail. User ID, information about biometric modalities and sample types, content type are contained in the request header. Biometric-Sample-Type field describes whether biometric data is raw or processed. Payload contains extracted biometric characteristics that are to be verified. In the example, Jersey framework was used to implement REST web services.

5. FREEIPA

In theory, Identity management (IdM) describes the management of individual principals, their authentication, authorization, and privileges within or across some boundaries with goal of increasing security and productivity while decreasing cost, downtime and repetitive tasks. In practice, what this means? IdM manages over the following data, functions and processes:
▪ Identities (principals): users, machines, services and/or applications
▪ Authentication: password, biometry, 2 Factor Authentication (2FA)
▪ Authorization: Polices, ACLs, DAC, MAC

FreeIPA is built as a set of services over a single domain to achieve this goal. Its mission is to facilitate the management of the domain, the identity of the users, client machine, and configured services. Services used by FreeIPA are:
▪ Authentication: Kerberos KDC, Dogtag Certificate System
▪ Data Storage: 389 Directory Server
▪ Server/Client Discovery: DNS
▪ Management: NTP

FreeIPA itself defines a domain, a group of machines that have shared configuration, policies, and identity stores. This shared configuration allows the machines (and users) within the domain to be aware of each other and operate together.

Sharing configuration is done through a client-server paradigm. This means that FreeIPA have a client part. It must be installed on the machine before it can join to the domain.

For FreeIPA a client is simply any machine, which is configured to operate within the FreeIPA domain, using its Kerberos and DNS services, NTP settings, and certificate services. That is an important distinction: a client does not require a daemon or (necessarily) an installed product. It requires only system configurations that direct it to use FreeIPA services.
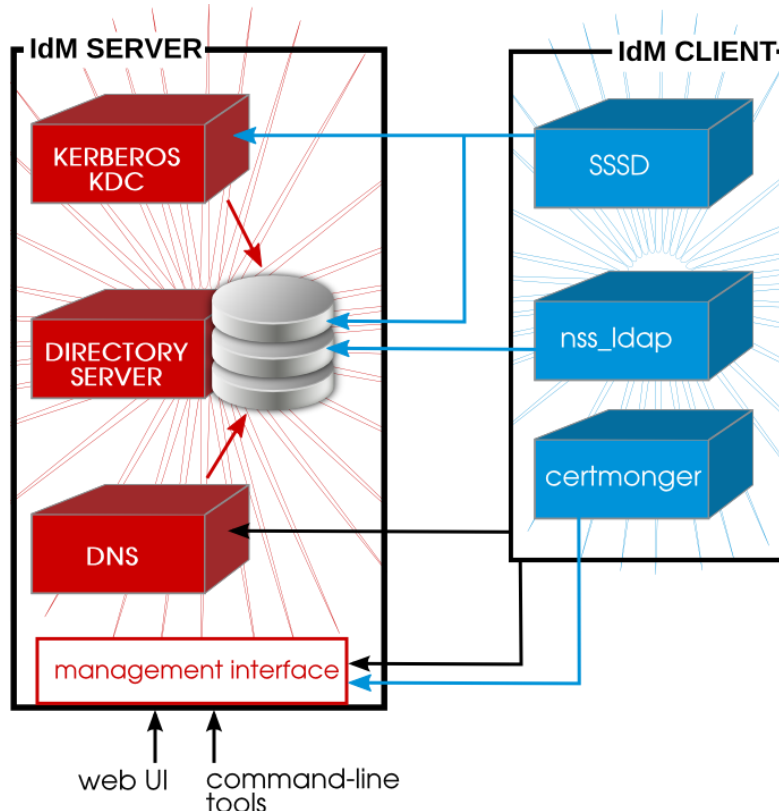

Figure 3: FreeIPA Architecture

IdM uses the local storage (cache) on a client to improve performance in a few ways:
- Store IdM information when the machine is offline.
- Keep information active beyond its normal timeout period if the client cannot access the central server. The cache is persistent even after rebooting the machine.
- Reduce the round-trip time of requests by checking information locally before looking at the server.

Information is stored either in an LDB database (similar to LDAP) or the local filesystem (as XML files), depending on the type of information. There is a two type of information: Identity information (about users, machines, and groups) and policies which are set globally on the server and then are propagated to the clients.

As Figure 3 shows that FreeIPA client uses two native daemons to interact with the IdM server:
- SSSD provides the user authentication for the machine and enforces host-based access control rules.
- Certmonger monitors and renews the certificates on the client. It can request new certificates for the services on the system, including virtual machines.

When a FreeIPA client is added to the domain (enrolled), its SSSD and certmonger are configured to connect to the IdM server and the required Kerberos keytab and host certificates are created. The host certificate is not used directly by IdM; it may be used by other services, such as a web server or any other local or remote applications.

6. ARCHITECTURE OF PROTOTYPE

Current operating systems use text password for user authentication. Almost everyone knows the weaknesses of this method of user authentication. The main objective of the proposed prototype is to extend the current one-component method of user authentication. As shown in Figure 4, a prototype extends FreeIPA authentication with a biometric sample of the user. During process of authentication it sends standard credentials of the current user together with biometric sample. Standard FreeIPA server does not know how to handle this request for authentication. Therefore, we added MMBIO server to FreeIPA services and diverted sending the request for authentication to it. MMBIO server extracts biometric sample from request and sends it to the MMBIO search engine (Multimodal Biometric Matcher). Also it must send standard request for authorization to the FreeIPA. Process of authorization can be counted as successful when both have got positive responses. MMBIO server sends back to the client consolidated response.
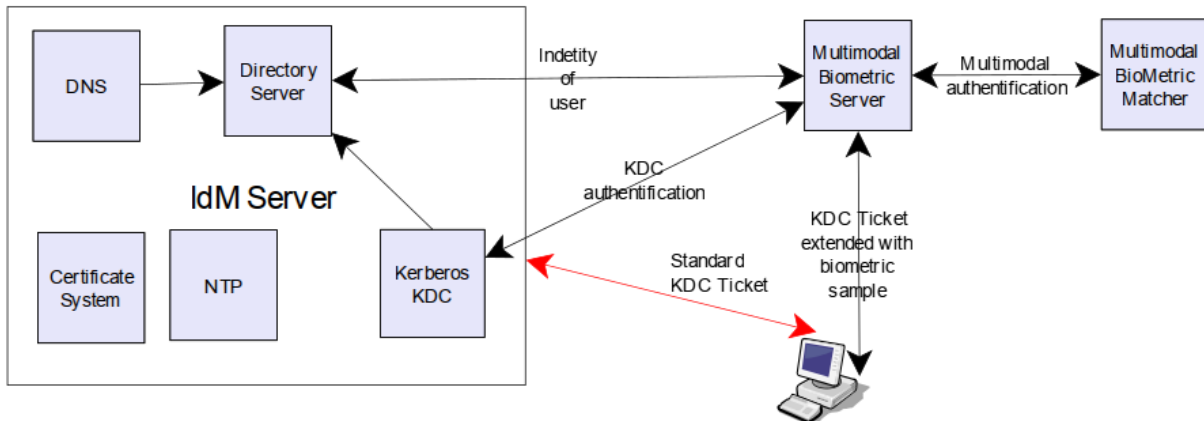

Figure 4: Prototype Architecture

It should be noted that it is necessary to pair the identities stored in the FreeIPA server and the MMBIO server due to different ways of storing user information. MMBIO server needs to know which identity from FreeIPA repository has biometric samples in its database and vice versa. In this way, communication between FreeIPA and mmbio server transmits a minimum set of data sufficient to unambiguously determine the identity of a user during authentication process.

MMBIO Matcher uses unique identifier MMBIOHashID to determine identity of the user. The process of adding users in MMBIO base is process of taking the biometric samples. Upon completion of the acquisition of samples it is necessary to bind MMBIOHashID to the identity of a user in FreeIPA storage.

On the other hand, the process of adding a new identity in FreeIPA environment includes creating a user profile and binding it to a MMBIOHashID. We have two scenarios:
▪ Newly created user does not have enrolled biometric samples in MMBIO database,
▪ Newly created user is already enrolled in MMBIO database

The second scenario is trivial. We need to bind the user identity with existing MMBIOHashID. In the first scenario we need to take biometric samples from the user and upload them to the MMBIO database.

During process of authorization, on the client side, key part is SSSD (System Security Services Daemon). It allows to any application, on the operating system which use NSS (Name Service Switch) for identity and PAM (Pluggable Authentication Module) for authorization, to use biometric sample along with standard password mechanism (shown in Figure 5.). An SSS Client Application is unaware that it is communicating with an SSS Client Library. It simply calls a standard NSS or PAM function, which is mapped by the NSS/PAM runtime to a module-specific function name, and which is then delivered to an SSS Client Library.
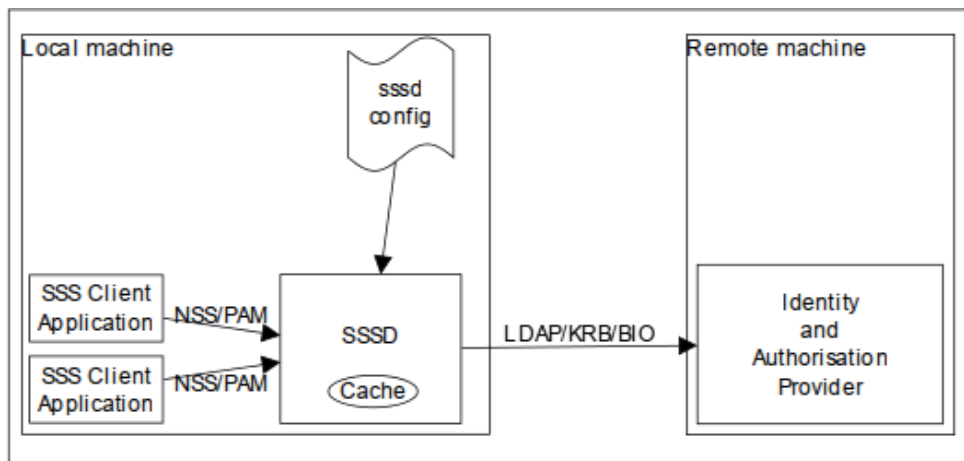
Figure 5: Multiple SSS Client Applications

Key features from SSSD are:
- NSS and PAM interface to the operating system
- Pluggable back-end system to connect to multiple different identity sources.
- Offline authentication

With SSSD it is possible to create multiple domains of the same, or of different types of identity provider. SSSD maintains a separate database file for each domain. This means that each domain has its own cache, and in the event that problems occur and maintenance is necessary, it is very easy to purge the cache for a single domain.

7. CONCLUSIONS

In this paper various important aspects of the Identity Management Systems and Multimodal Biometrics functionalities are revised. Most of Identity Management Systems allows Single Sign-on feature. With remote users and communications made through the Internet, the possibility of fraud and unauthorized access to data increased. Securing the authentication process is today's the biggest concern. Therefore, allowing the use of biometric data of one user in the process of authentication for access to critical data, it reduces the chance of fraud and unauthorized access.

Developed prototype confirms possible integration of identity management and multimodal biometric systems. During implementation of the prototype, some new issues concerning communication between client and server have risen, and they should be further investigated. Moreover, challenges connected to the acquisition of the biometric data and its upload to the MMBIO database are of great importance, and they are going to be an important part of future work on this topic.

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METHODS FOR BIOMETRIC DATA CONNECTION IN MULTIMODAL SYSTEMS

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Abstract: *Multimodal Biometric Systems in Identity Verification use statistical data on anatomical and physiological characteristics of humans and they always carry a dose of certain amount of uncertainty with regards to the accuracy of results. At some important social activities, like security, healthcare or finance, the accuracy of certain biometric systems becomes questionable as singular mismatches could cause irreparable damage harm to an individual person or the community. In recent years, in order to achieve a more reliable identification, there has been intensive application of multimodal biometrics systems, namely application of fusion of independent biometric data. Analyses that were conducted in recent years have shown numerous advantages in relation to the accuracy and the efficiency of implementation of biometric fusion. However, in order to accomplish this, attention must be paid to ways that data, in multimodal biometric systems, are connected.*

Keywords*: Biometric systems, methods for biometric data, biometric fusion, multimodal biometrics*

1. INTRODUCTION

The process of globalization is strongly connected to the issue of security and identity recognition and validation, due to which attention is paid to international connection of security mechanisms based on multimodal biometric systems. Biometric identification is becoming sophisticated because it combines different biometric modalities and techniques, and, in return, it gains higher accuracy or it notably reduces the effort of users in the process of identification. In recent years, there have been large amounts of data in literature about research in the field of multimodal biometrics, but the impact of certain combination of biometric modalities, the available methods of processing biometric data and the influence of the size of the biometric database on the system's overall performance hasn't been significantly analysed. This paper analyses multimodal biometric systems for identity verification that simultaneously use several biometric modalities i.e. a fusion of independent biometric characteristics. Special chapter of this paper refers to ways of connecting biometric data in multimodal biometric systems, because the method of data connection directly influences the overall system's performance in the realistic conditions of use.

2. MULTIMODAL BIOMETRIC SYSTEMS FOR DETERMINATION OF IDENTITY

When only one biometric characteristic is used for identification, or when several characteristics of a single mod are used, then some parts of the procedure for determining identity become critical with regards to the accuracy of the data for processing, i.e. their precision so errors occur more frequently in the work of the system compared to procedures that use a fusion of several independent biometric characteristics – specific mode of operation used for identification. Then we say that we are talking about multimodal biometrics i.e. multi-biometric system for identity recognition and verification with multiple biometric characteristics.

In order for multimodal systems to be more precise than unimodal, but also fast enough, it is important to find an efficient combination for the fusion of biometric characteristics. As mentioned, the first multimodal systems were those created by combining biometric characteristics of voice and face lines.[1] The aim of their application was to overcome the aforementioned limitations that appear in unimodal systems, which increased not only the precision of work but also the reliability of the process of identification, the overall number of implemented biometric systems as well as the number of different applications in the society[2]. Those multimodal biometric systems are showing significant advantage in prevention of abuse of biometric technologies because they provide a greater level of security of the system having in mind that they require a user to be physically present during data collection.

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[1] A. Ross, K. Nandakumar, A. K. Jain, (2008).

[2] A. Nagar, K. Nandakumar, A. K. Jain, (2012). Technical report: Multibiometric Cryptosystems, vol. 7, NO.1.

The essence of multimodal systems is seen in the use of several independent procedures in a process of calculation of a degree to which the biometric data entered match to those stored in the database (Y.Xu, D.Zhang, J.Yang, 2010). This way, the number of components that in case of failure or malfunction could endanger the overall functioning of the system functioning is eliminated or significantly reduced. The collected intermediate results of independent system components are then adjusted for final process of decision making. The principle method of work of a multimodal system is illustrated in picture No.1.

By all means, the identification becomes more sophisticated and expensive as different techniques of biometric identification are combined, thereby gaining on reliability in precision and deduction while allowing the level of the requested effort on a side of a user in the process of identification to be influenced as well.

It should be emphasized that, in recent years, a more intensive application of multimodal systems is in use, so the results achieved in the field of testing the accuracy of certain multimodal combinations can be found in literature, but without data that refer to the performance of such systems. More importantly, the influence of the amount of data stored in database is in direct relationship with the system's performance.
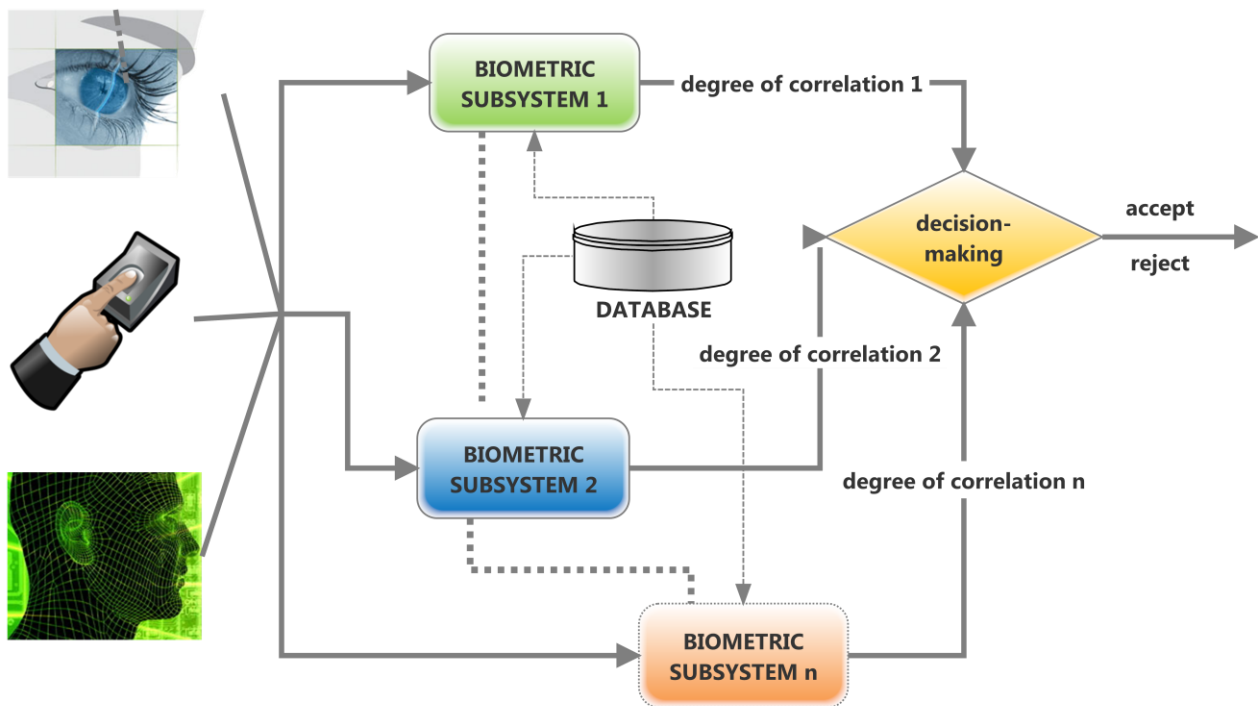
Picture 1: The principle method of work of a multimodal system

According to the available sources, there is no simple way to choose biometric methods to be used in a multimodal system. However, we could still say that, in majority of different scenarios, the best results are achieved through a combination of biometric methods that, even in unimodal systems, offer a great level of accuracy, as expected, while satisfactory results are achieved by combining techniques that each, for itself, provides the average accuracy of the work of the system. The techniques most frequently used in multimodal biometrics include techniques that work with fingerprints, face lines and iris images.

A safer biometric system can be built if a larger number of the aforementioned methods are used. In practice, it is desirable to combine physical and behavioural characteristics, since it reduces the possibility of fraud of a biometric system in the process of the identification or verification. It is already mentioned that these methods are in use at border crossings to control passenger entry or exit, to control access to a certain area, the network protection etc.

Multimodal biometrics could also be used as a support to standard procedures of identity control when, from standard documents and papers, it is not possible to acquire a sufficient number of data that would describe a person... Therefore, due to the risk of abuse, it is recommended to use both standard protection mechanisms as well as biometric data. One of the examples is a fake fingerprint. If only one biometric technique is used, and the person possesses a fake fingerprint, which is used for authentication, on behalf of a person, it could result with abuse. However, if the verification is based on face recognition, or, better yet,

on iris detection or vein position check, it is possible to ascertain, with greater level of certainty, whether or not it is the person in question or it is an attempt of identity theft.

Multimodal systems have numerous advantages over unimodal ones. In case when one biometric characteristic is common to several persons, the presence of the other method prevents a scenario of wrong acceptance. System frauds are drastically limited by existence of larger number of methods that are used during identification.

3. METHODS FOR BIOMETRIC DATA CONNECTION IN MULTIMODAL SYSTEMS

Efficiency and precision of multimodal systems are greatly influenced by methods and means of interconnecting several biometric data and their respective fusion. The process of unification of biometric data itself can be accomplished using different logical processing levels. As the main task of biometric system is acquiring biometric samples, the first possible level at which the fusion could take place is the level where a process of acquiring samples is completed. The result of fusion, at this level, is an aggregated sample obtained by combining multiple samples acquired. For instance, aggregated sample is a combination or raw data obtained from several fingerprints of a single person.

In the second stage of processing, based on the acquired, raw biometric sample certain characteristics are derived and placed into a pattern, so fusion, at this level is conducted by unifying several formed patterns into a one unique pattern which is then recorded into the database. In the next, the third phase of processing, matching of the derived characteristic, with the existing one in the database, is tested where, in multimodal systems, matching is done among several derived characteristics or mods which are compared with equivalent recordings in the database, and results are, by fusion, combined in terms of similarity in order to get a unique result a scalar, as a measuring unit of similarity. Finally, in the last, the fourth stage of processing, a decision should be made whether or not the system determined or failed to determine the identity of the analysed person. The fusion of data, on a decision level, is made easy as decision is made for each tested biometric mod individually, and after that, the final decision is made by the means of majority selection (A. Hicklin, B. Ulery, C. Watson, 2006).

The most important preconditions for efficient and precise running of multimodal systems are related to the functioning of input sensors. Those sensors need to be designed in such a way that they are cost effective and able to rapidly collect biometric data and store them into the system, without an error. Apart from this, keeping in mind the possibilities of sensors and chosen combination of biometric characteristics, it is important to conduct the needed analyses of several possible levels of data fusion, in order to choose the level that is, under given conditions, the most precise and efficient. At present day, a large number of sensors as well as groups of acquired biometric data are available, therefore, it is necessary to find the best solution for each application.

Biometric fusion is used in processes of identification as well as in procedures of user verification. The task given to the system for identification is, of course, far more challenging than the one for the system of verification. Experiences in the application of such systems have shown that the best results are achieved by using biometric modality of fingerprint. The multibiometric systems which use combination of several fingerprints for identification, like AFIS does should be highlighted. Also, it is concluded that fusion on the level of characteristic comparison, so far produced the best results (A. Ross, A. K. Jain, 2004).

The analyses conducted in several cases, have shown that the two largest advantages that can be expected if biometric fusion is applied, are precision and efficiency. However, based on a fact that the fusion process is processing several aggregates of data, unlike in unimodal systems, it leads us towards demands for stronger computing systems and thereby higher expenses. Apart from this, more time is required to complete the task considering that more biometric data is being collected. Keeping in mind challenges that biometrics pose with regards to the right to privacy, we can say that the demand for collection of multiple data on a particular person does create a greater danger to violate one's privacy right.
Instead of a conventional approach to the location of potential combining of multimodal biometric data, Sanderson and Paliwal divided levels of fusion to two basic groups i.e. (A. Ross, K. Nandakumar, A. K. Jain, 2008): fusions prior to comparison and, fusions made after the comparison.

Approach to later fusions could be based on the concept of ranking of results or assigning points i.e. scores to comparison results. In terms of identification mode of work, the system's output result can be viewed as a ranking of identities entered into a database. In this case, the output result indicates a group of potential identities by sorting obtained matching scores, in a descending manner.

The goal of the method of fusion at this level is a consolidation of output rankings of singular biometric systems in order to obtain a common ranking for each identity. The ranking offers a better insight into a decision making process, but it reveals less information than the result represented in points, i.e. scores. Unlike scoring, ranking offers a possibility to compare the work of multiple biometric systems. Because of this, in this particular case, normalization of scores obtained is not needed (A. Ross, K. Nandakumar, A. K. Jain, 2008).

Normalization is an important phase with fusion technologies in multimodal biometrics. The goal of normalization is adjustment of parameters that refer to the location and scale of distribution of comparison results, scores, at the exit point of a separate module for comparison, in order to bring the results obtained from multiple modules, to the same level in order to allow further comparison (A. Ross, K. Nandakumar, A. K. Jain, 2008).

The picture No. 2 shows the taxonomy of possible techniques of unification of data in multimodal systems, according to *Sanderson* and *Paliwal*.
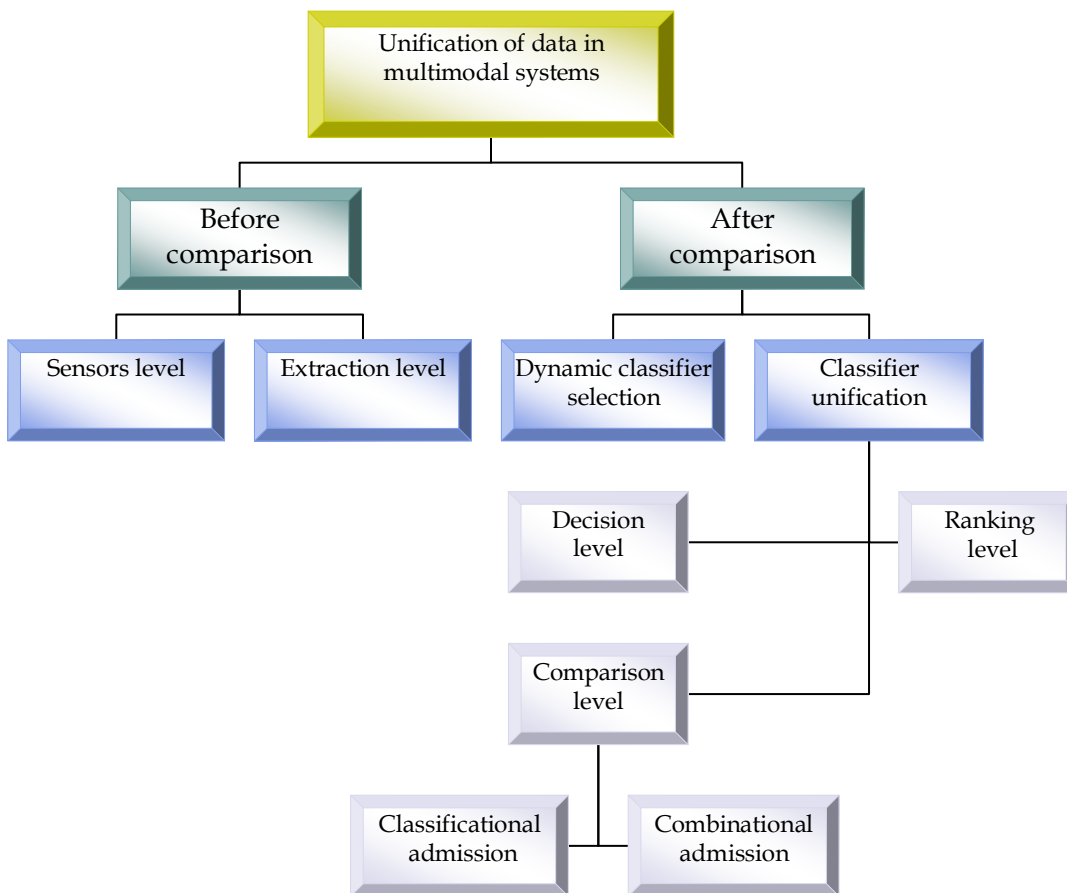
Picture 2: Taxonomy of possible techniques of unification
of data in multimodal systems

The first group of techniques, prior to comparison, includes sensor and unification level fusions of the derived characteristics (a characteristic vector), while the second group includes match score and decision level fusions (A. Ross, K. Nandakumar, A. K. Jain, 2008).

4. CONCLUSION

Analysing the relationship between the group of techniques that belong to the model of earlier fusion, compared to those belonging to a later fusion, it can be concluded that techniques that belong to the model of earlier fusion, generally, have an advantage because the earlier fusion's algorithm does not include only biometric data, but their relationships, as well, which reduces the entropy of the system in question. As an

illustration of the expressed position, we can say that biometric characteristic contains more information on a concrete biometric modality than what we get at the exit of the comparison module (I. Milenković, D. Starčević, S. Paunović, 2011). The analysis of papers that deal with the problem of fusion, on all the aforementioned levels, indicate that the largest number of advantages is gained with unification at the level results of characteristic comparison because the previous results of processing of modalities within the system are relatively easily combined. The shortcoming of the fusion at the early stage of processing can be seen in the demand for compatibility of biometric data, which is not always easy to accomplish. As far as the fusion at a later stage is concerned, for example, decision making level, the research have indicated shortcomings of the fusion at this level because the possibilities for integration are very rigid as they possess a lesser number of information, unlike previous levels.

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INTEROPERABILITY PROBLEM IN MULTIMODAL BIOMETRIC SYSTEMS

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Abstract: *The increasing utilization of biometric technologies in a variety of institutions and organizations requires constant research and improvement of biometric systems performance and precision. In such circumstances, combining several biometric technologies (multimodal approach) stands out as a possible solution. Using different biometric modalities and different biometric sensors and solutions developed by various companies, reveals the interoperability problem in multimodal biometric systems. This paper describes the aforementioned issue and lists currently available standards that address this issue. Also, a set of biometric communication protocols implemented in MMBIO framework that try to solve this problem are briefly presented in the paper.*

Keywords*: biometric systems, multimodal biometrics, MMBIO framework, interoperability, communication protocols*

1. INTRODUCTION

Utilization of biometrics for identification purposes dates from 1858. when Sir William Herschel, who worked for the Civil Service of India, recorded a handprint on the back of a contract for each worker in the organization (Komarinski, 2005). He used the recorded samples to distinguish real from fake employees when payday arrived. This is thought to be the first systematic capture of hand and finger samples that have been used for identification purpose. Later, in 1965. North American Aviation developed the first signature recognition system (Mauceri, 1965). In 1994. The Immigration and Naturalization Service Passenger Accelerated Service System (INSPASS) biometric system has been implemented which allowed travellers to bypass immigration lines at selected airports in US. Authorized travellers received a card with their hand geometry information (Wayman, 2004). They presented their cards along with approaching their hand to a biometric sensor. Upon authentication, passenger could proceed, thus bypassing the long lines. This system was discontinued in 2004.

One of the milestones in application of biometrics in organizations and institutions was also the so-called PIV (Personal Identity Verification) of federal employees and contractors (United States Department of Veterans Affairs, 2004). In August 2004. USA President Bush issued Homeland Security Presidential Directive 12 (HSPD-12) for a mandatory, government-wide personal identification card that all federal government departments and agencies will issue to their employees and contractors requiring access to Federal facilities and systems. The PIV for federal employees and contractors, specifies the technical and operational requirements for the PIV system and card. Also, in the same year several USA states established state-wide palm print databases that allow law enforcement agencies in each state to submit unidentified palm print samples in order to be searched against each other's database of known offenders. Biometric passports (Wikipedia), which contain biometric data about the passport owner, are also a mentionable milestone in biometric systems application in organizations and institutions. The biometric data is stored on a special chip, which contains information needed for face, fingerprint and iris recognition. Many developed European countries, but also a vast number of other world countries have implemented biometric passports, including Norway (2005), Japan (2006), Australia, USA (2007), Serbia, Montenegro (2008) and also Bosnia and Herzegovina (2009) .

All of aforementioned milestones show that implementation of biometric systems can improve authentication, security and identity management inside an institution in general. However, besides obvious opportunities and advantages of using biometrics in organizational settings, existing limitations must also be taken into account. As standard biometric system is not effective on its own, it must be improved in some manner. Usually, it is combined with a smart card system, but the cost of implementing both systems is significantly large (Nadir Blog, 2008). Also, lack of reliability of standard unimodal biometric systems is a mentionable disadvantage. Biometric devices can be fooled; if fingerprints or some other physical modality are compromised, they can't just be replaced like passwords or smart cards.

A possible solution for presented disadvantages could be the usage of multimodal biometric system, that uses several biometric modalities and in that way has improved performance and reliability. Also, by using different biometric solutions or devices, including those that are open-source, the cost of implementing such system could be drastically lower. However, combining those components and making them work together in a reliable manner is an issue that needs to be addressed. This issue is known as multimodal biometric system interoperability problem.

In the next chapter, the term interoperability is defined and also the problem that this paper tries to solve is stated. Currently available biometric standards that solve the problem of interoperability in biometrics are listed in third chapter and also each of presented standards is briefly described. In the fourth chapter, the solution that is used in MMBIO framework in order to solve the interoperability problem is briefly described. Conclusions, shortcomings and future work regarding the presented biometric communication protocols are defined in the last chapter.

2. INTEROPERABILITY IN BIOMETRIC SYSTEMS

This chapter presents the interoperability problem in biometrics research area. Afterwards, different formal definitions of interoperability, that are currently available in literature, will be listed.

In the research area of biometrics, several definitions of interoperability are present. (Wikipedia) defines the interoperability as an "ability of making systems and organizations to work together (inter-operate)". In (Microsoft, 2012), Microsoft states that "interoperability allows disparate information systems from multiple vendors to readily work together and exchange data". As for the software, term interoperability is used to explain the ability of various programs to:
- exchange data using some of standard formats for data exchange
- read and write same file formats
- use same protocols.

Term interoperability is most frequently used to annotate functioning of different biometric sensors in a number of IT environments (Biometric Web Services, 2012). On the other hand, within the ISO/IEC 2382-1:1993 standard (International Standards Organization, 1993), term interoperability is defined as "The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units".

The problem of interoperability in biometric systems can be divided into a number of specific tasks. It is necessary to provide a communication tool between biometric solutions (both, open source and proprietary), biometric sensors and biometric database. One of the fundamentally important tasks is enabling communication and standard way of data exchange between biometric system and various types of biometric sensors, as well as acquisition devices. In this way, problem of dependence on a single manufacturer, also known as "vendor lock-in" is being solved. Last, but not the least important task in solving the problem of interoperability in multimodal biometric systems is standardization. In order to provide a wider application field of multimodal biometric systems, standardizing each segment of the system, especially communication, is of great importance. Also, it is necessary to include existing standards and allow their use within the system.

3. STATE OF THE ART

In this chapter, currently available biometric standards that solve the problem of interoperability in biometrics are listed and several most significant institutions in this research area are presented. Also, each of presented standards is briefly described.

There are several important standards which deal with interoperability problem between different biometric solutions, such as:
- MBARK
- BioAPI
- CBEFF
- ISO/JTC1/SC37
- FBI Wavelet Scalar Quantization
- Web Services for Biometric Devices
- OASIS/BIAS

Most of listed standards are not public. However, one of major problems is that none of available standards fully defines communication protocols required for network communication between all parts of a multimodal biometric system. In addition, these standards are mainly dealing with only one part of biometric system, usually the acquisition or data storing processes. Some of most important institutions in the world engaged in biometrics research field are:

- National Institute of Standards and Technology (NIST)
- International Organization of Standardization (ISO)
- International Electrotechnical Commission (IEC)

Tool for multimodal biometric application development MBARK (Multimodal Biometric Application Resource Kit) (Biometric Clients Group, Image Group, Information Access Division, Information Technology Lab, 2009), developed by the National Institute of Standards and Technology (NIST) tends to reduce complexity in the development of biometric applications. MBARK is open source software and it is available to public. It has valuable features, such as: consistent user interface, flexible user configuration and sensor interoperability. MBARK uses plug-in mechanism that enables real sensor interoperability based on mutual API. This API is used for integrating camera, fingerprint and iris scanners.

BioAPI (BioAPI Consortium, 2008) is a complete biometric standard that defines two application programming interfaces: interface for application programming (API) and interface for service programming (SPI). API enables application to utilize BioAPI framework functionalities, while SPI enables the framework to use biometric functionalities. Main goal of BioAPI standard is to enable communication between the application and biometric technologies independently from the manufacturer.

CBEFF is a standard for exchanging biometric data between different systems and organizations. It is adopted by ISO. This standard describes a structure and set of metadata elements necessary to support exchange of biometric information in a common way (National Institute of Standards and Technology, 2004). Among other features, CBEFF promotes interoperability of biometric-based applications and simplifies software and hardware integration process.

NIST recognized the potential of web services and their application in biometrics research field. Thus, project WS-BD (Web Services for Biometric Devices) (Micheals & Kevin, 2012) was created as a mean of providing interoperability of biometric systems. Limitation of WS-BD is that it only applies to the acquisition process of biometric samples.

OASIS BIAS represents efforts of the International Committee for IT Standards (INCITS) to provide a documented, open framework for developing functionalities needed for biometrics based identity management, which can be easily and conveniently accessed through web services. This standard defines and describes methods and relationships through which the BIAS framework can be used within Web services based on XML technology, as well as on service-oriented architectures (OASIS Committee Specification, 2011).

4. BIOMETRICS COMMUNICATION PROTOCOLS

As part of the project "Multimodal biometry in identity management", Laboratory for multimedia communications at the Faculty of Organizational sciences, develops framework for multimodal biometric system development (MMBIO) (Milovanović, Minović, & Starčević, 2012) . One of the problems that needed to be addressed within MMBIO framework is the interoperability problem. It is necessary to design communication protocols and implement software classes required for the functioning of framework in network environment. This chapter describes the solution that is used in MMBIO framework in order to solve the already mentioned issue (Šošević, 2013).

Biometric communication protocols within the framework are divided as follows:

- acquisition
- unimodal
- database
- multimodal

Commands that belong to above mentioned protocols are categorized according to their purpose. Database commands and unimodal commands are further divided into subcategories.

Unimodal commands

The unimodal category consists of those commands that are used to manipulate biometric samples, as well as those commands which are used for authentication. Manipulation of biometric samples includes commands CheckQuality, TransformData and ClassifyBiometricSamples. CheckQuality command is the quality check of the sample after the sample has been captured by the sensor. Using the TransformData command, biometric sample is being processed and transformed to another form. More specifically, some of pre-processing algorithms are applied to the biometric sample. There is a also the possibility to classify biometric sample using a classification algorithm or class. Classification can be done by issuing the ClassifyBiometricSample command.
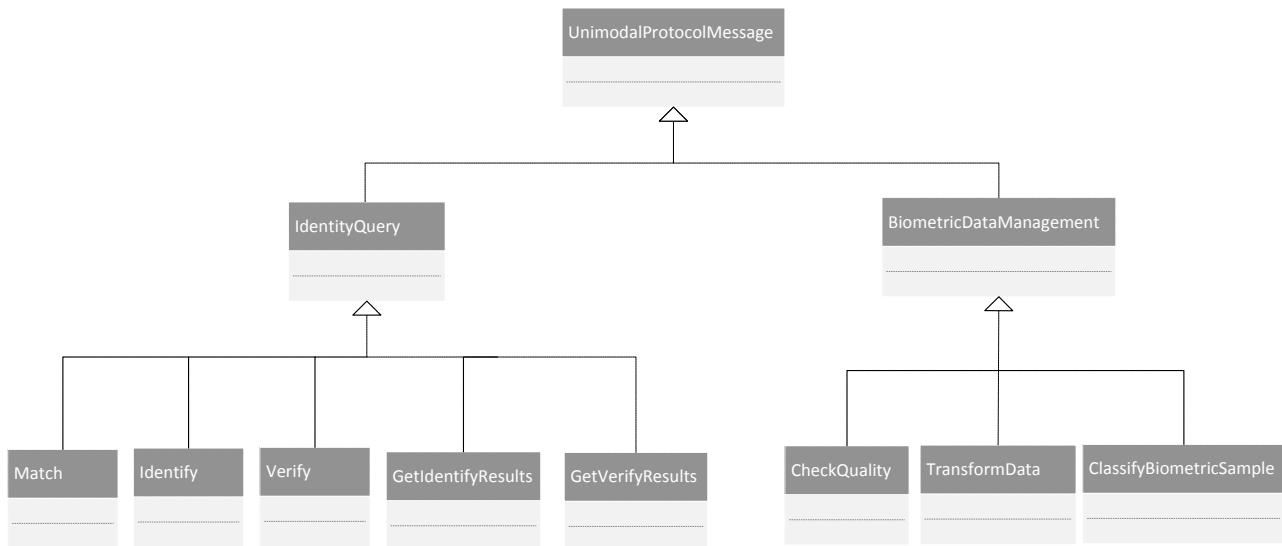

Figure 1: Unimodal commands class diagram

Authentication commands include the process of comparing biometric samples. Precisely, they include two main working modes of a biometric system - identification and verification. Match command initiates comparison of two biometric samples, resulting in a matching score. Besides this command, there are more complex commands - Identify, which executes identification process and Verify, which executes verification process. Two more commands are present in this category - GetIdentifyResults and GetVerifyResults, which are reserved for usage in case of asynchronous communication. Those commands are not yet defined in the current version of protocol specification, which is one of the issues that need to be solved.

Acquisition commands

Acquisition category consists of commands used for direct configuration and managing a biometric sensor. It includes commands SetConfiguration, GetConfiguration, TryLock, ReleaseLock and Capture. Settings to be used by the sensor during samples capture can be set by issuing the SetConfiguration command. There is also an option to view the current sensor configuration via the command GetConfiguration. TryLock and ReleaseLock commands are a part of the mechanism that enables concurrent access to each sensor. Before changing any settings, biometric system has to "take" the sensor by placing a lock (using the command TryLock). By issuing Capture command, the sensor is requested to perform a capture of biometric sample.
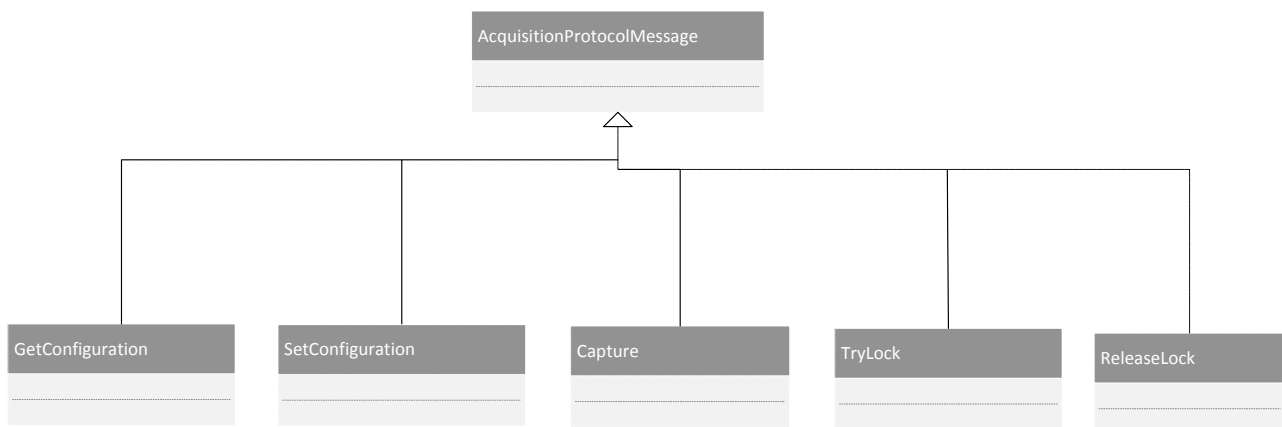

Figure 2: Acquisition commands class diagram

Database commands

Database commands are divided into two groups:
- metadata management commands
- biometric data management commands

Metadata management commands include CreateUser, AddUserToSubset, RemoveUserFromSubset, as well as commands for biographic data management - SetBiographicData, GetBiographicData, DeleteBiographicData and ListBiographicData. It is important to note that metadata also consists of users' biographical information. It is clear that in addition to storing multimodal biometric data in the database, it is also required to save information about users. New user in the database can be created using the CreateUser command. There is also an option to define user subsets in the database (i.e. users from Europe, America, Asia...). Users' belonging to a subset can be defined by issuing AddUserToSubset command. On the other hand, it is also possible to remove the user from the specified subset by using the RemoveUserFromSubset command.

Setting biographical information for the user can be done by calling the SetBiographicData command. Deleting biographical data from the database is done with DeleteBiographicData command. Proposed protocol also provides mechanism for viewing biographical data. Certain biographical data can be extracted from the database by issuing the GetBiographicData command. Also, ListBiographicData enables system user to list all biographical data for a targeted user.
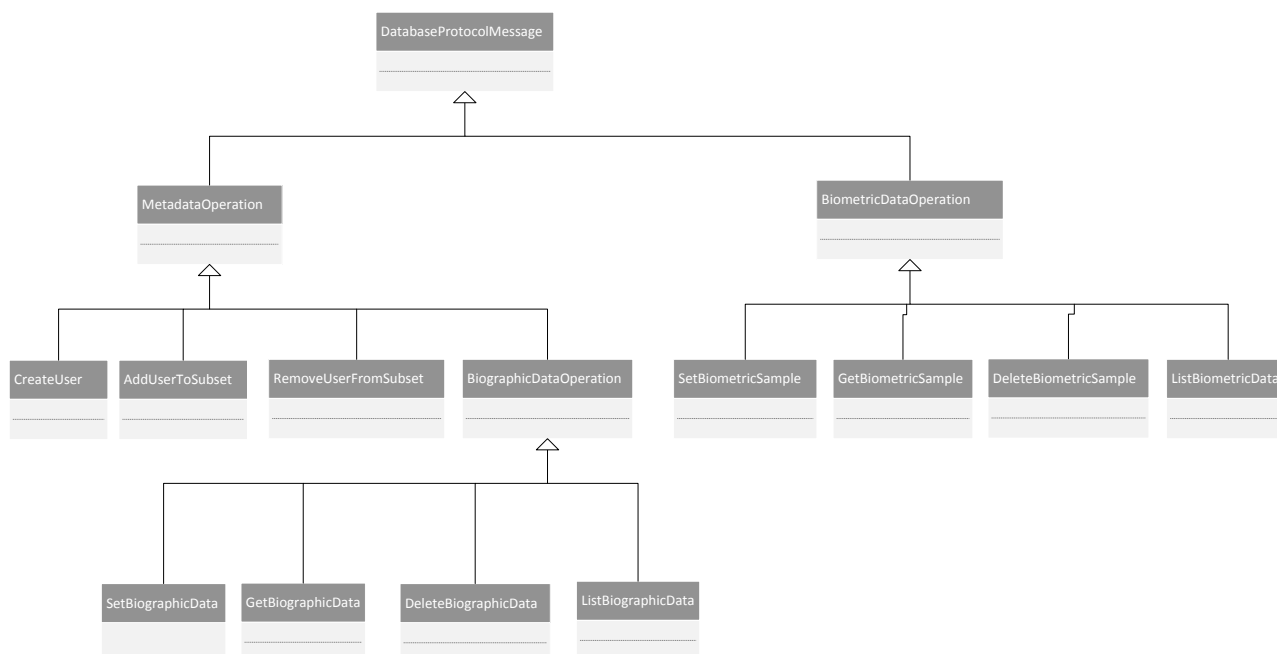

Figure 3: Database commands class diagram

Biometric data management includes similar commands as in biographical data management group. Those commands are SetBiometricSample, GetBiometricSample, DeleteBiometricSample and ListBiometricData. Using SetBiometricSample a biometric sample for a certain user is recorded in the database. If you need to retrieve biometric sample from the database, it can be done by issuing the GetBiometricSample command. To delete saved biometric sample of an user, DeleteBiometricSample command can be used. Also, it is possible to extract all biometric samples of desired user by using the ListBiometricData command.

Multimodal commands

Multimodal commands are those that are used to utilize the functionalities provided by a multimodal biometric system. FuseScores and FuseScoresList commands are members of this category. Using the FuseScores command, matching scores obtained by executing the verification process are fused. By issuing the FuseScoresList command, fusion of matching scores obtained by executing identification process is done. When using both of these commands it is required to define fusion algorithm that is desired to be applied in fusion process. The difference between verification scores fusion and identification scores fusion is that verification process returns only one matching score per modality, while identification process returns a list of matching scores. Thus, the result of FuseScores command is the score calculated by using selected

fusion algorithm. On the other hand, issuing FuseScoresList command results with a list of scores calculated by applying selected fusion algorithm on identification matching scores list.
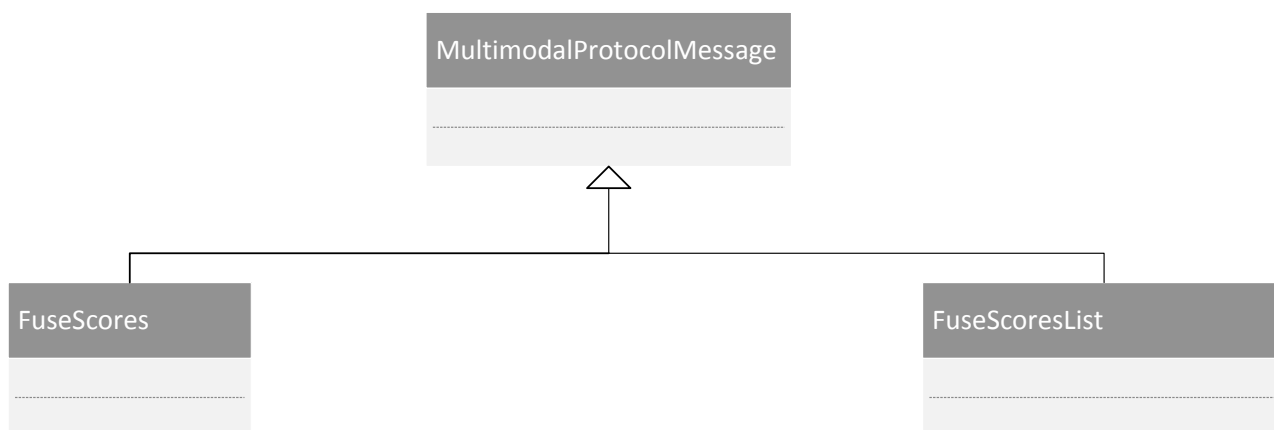

Figure 4: Multimodal commands class diagram

4. CONCLUSION

This paper describes the interoperability problem in multimodal biometric systems. First chapter provided an introduction to the application of biometric systems in institutions and organizations. Afterwards, the term interoperability has been defined and its meaning in the field of multimodal biometrics has been explained. Also, the biometric systems interoperability problem has been stated and current state of the problem has been presented by reviewing the existing relevant literature. In the final chapter, possible solution for the interoperability problem has been proposed in the form of biometric communication protocols and related commands.

Presented communication protocols are being used in MMBIO framework for multimodal biometric systems development. By implementing the defined protocols the interoperability problem in biometric systems is trying to be solved. Communication protocols must be sufficiently generic, but also they need to support all functionalities which are provided by integral parts of a multimodal biometric system. Throughout the paper, several communication protocols used in different segments of biometric system functioning have been presented. Those segments are acquisition, unimodal segment, database segment and segment related to the multimodal approach.

Of course, protocols presented in this paper have several shortcomings. Primarily, all protocol messages are designed in such way that they include synchronous communication. Asynchronous communication is not supported currently. Therefore, adaptation of protocols to asynchronous mode of communication is one of directions of further research. Also, it is necessary to define header fields and information transmitted via protocol messages. It should be considered adjusting developed protocols with existing standards such as CBEFF and/or BIAS.

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THE IMPACT OF APPLYING INTERNATIONAL SPECIFICATIONS AND STANDARDS TO BIOMETRIC SYSTEMS

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Abstract: *The rapid development of biometric systems and their wide application in practice have led to the emergence of the large number of hardware and software manufacturers on the international market. This phenomenon caused the problem of interoperability of biometric systems. This problem significantly affects the functioning and performance of biometric systems, with special emphasis on the security of biometric data to be exchanged. In this paper, the application of international specifications and standards is suggested as an important part of the solution to this problem. These specifications and standards, such as BioAPI and CBEFF specifications, registered and published as multistandards by ISO (International Organization for Standardization), propose the establishment of single plaform (BioAPI) and unique format for data exchange (CBEFF), to facilitate the functioning of the biometric systems regardless of hardware or software manufacturers.*

Keywords*: Biometrics, Standards, Specifications, BioAPI, CBEFF*

1. INTRODUCTION

First of all, the term of interoperability should be defined. Li and Jane (2009, p. 27) state that "interoperability in the field of ICT includes the use of the same format or protocol without disrupting the performances of the system". This is related to the functioning and communication between parts of the same system, as well as cooperation and communication between various systems.

Since Biometrics is increasingly presented on the market (for example, access control, e-commerce, internet banking and other areas that require a high level of data security in authentication) and, as Li and Jane (2009, p. 18) point out, "Biometrics uses physical or behavioral characteristics of an individual to uniquely identify the user during authentication", the security of information as well as communication between the parts of a biometric system must be at the highest level. Deravi (2008, p. 34) discusses that "due to the fact that the development of biometric technologies and devices, as well as software applications, gained the momentum, there was the problem of large number of manufacturers and the problem of communication between the softwares and devices from different manufacturers (so-called "vendor lock-in")".

Considering those facts, leck of unique platform as well as unique format for information exchange between components of one biometric system or between different biometric systems has become the big problem. So, as it stands in The BioAPI Consortium report ("BioAPI Specification Version 1.1", 2001), in 1998 BioAPI Consortium has been formed with the main aim to create BioAPI specification and define a unique platform for communication between applications and biometric technologies regardless of the manufacturer. Subsequently, BioAPI with the status of an international standard should accelerate the acceptance of biometric technologies and a large number of commercial applications at the international level.

On the other hand, as Deravi (2008) points out, since there was no single format that would facilitate the exchange of biometric information, cooperation between NIST Institute and BioAPI Consortium has formed CBEFF (Common Biometric Exchange Formats Framework) as an idea to establish a unique format for the exchange of biometric information between different systems with the emphasis on data security. Primarily, the format for the exchange of fingerprints was established, followed by NISTIR 6529 specification, which applies to all biometric modalities, today now known as CBEFF. The current version NISTIR 6529-A is an extended version of CBEFF which, unlike previous versions, may contain information of various biometric modalities at the same time or more information of a single modality.

In the following text, these specifications are described through examples in detail, emphasizing their role in improvement of the interoperability of biometric systems.

2. BIOAPI SPECIFICATION

In The BioAPI Consortium report ("BioAPI Specification Version 1.1", 2001, p. 7) stands that "BioAPI is a standard that defines a simple biometric application interfaces, standardized modular approach to biometric

functions, algorithms and devices, standardized methods for distinguishing biometric data and device types, and support for biometric identification in distributed computer environments".

In the same report ("BioAPI Specification Version 1.1", 2001) stands that BioAPI provides the basic functions of biometric systems, such as Enrollment, Verification and Identification, and includes a database interface that allows to BSP, a software which communicates with the device for enrollment and verification, to manage the Identification of the population. Also, BioAPI defines an API (Application Program Interface) for the application developers and SPI (Service Provider Interface) for developers in the field of biometric technology. Those interfaces present the two basic levels of BioAPI platform.

3. STRUCTURE OF BIOAPI PLATFORM

The basic version, BioAPI v1.1, consists of two essential parts presented in Figure 1 ("BioAPI Specification Version 1.1, 2001", p.17): API, Biometric Application Programming Interface, or application level, and the SPI or Biometric Service Provider Interface. API is the highest level where the basic biometric functions, that each software application must contain in order to communicate with BioAPI platform, are implemented.
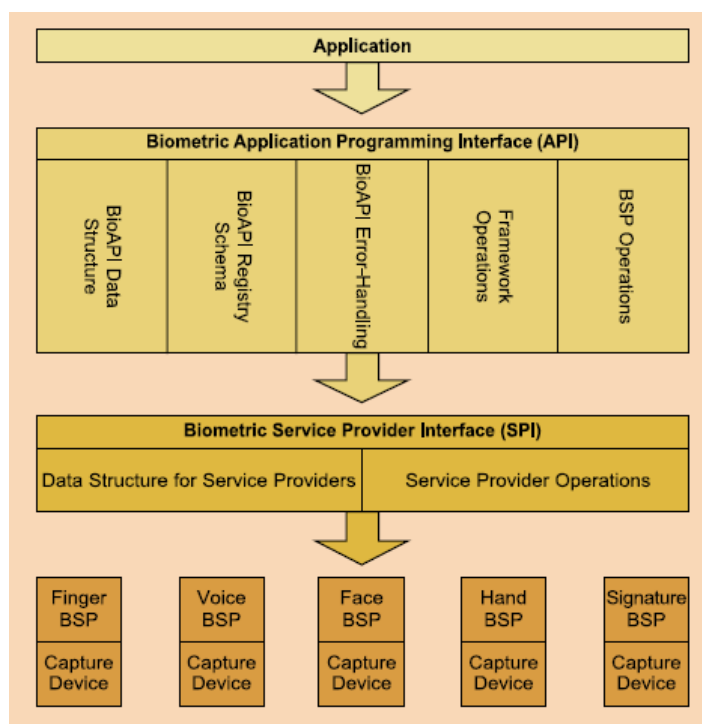

Figure 1: *Structure of BioAPI platform* ("BioAPI Specification Version 1.1, 2001", p.17)

In The BioAPI Consortium report ("BioAPI Specification Version 1.1", 2001) stands that API level is organized into five categories as shown in Figure 1. The first category is the Biometric Data Structure and defines all the data structures that are used in the application. BioAPI Registy Schema is used to store information for each component within BioAPI. BioAPI Error Handling defines operations for error management within BioAPI. Framework Operations defines general operations for running and disabling applications. BSP Operations provides operations for data exchange and communication between the application and the BSP. All biometric operations Capture, Process, Enroll, Verify, Identify and so on, are defined by the BSP Operations. Among other things, BSP Operations provides operations that allow applications to access and manage biometric databases.

In the same report ("BioAPI Specification Version 1.1", 2001) stands that SPI consists of two categories: Data Structure for Service Providers and Service Provider Operations (BSP). SPI communicates 1-on-1 with the BSP. API calls are routed to the SPI. Every BSP is connected to the BioAPI via SPI. BSP (Biometric Service Provider), regardless of the manufacturer, is a software that communicates with the biometric device and must be compatible with SPI interface specification, because it is the only way to be engaged into the BioAPI working environment and to be used by all biometric applications compatible with BioAPI. BSP contains the unique aspects of individual biometric technologies, namely the products and devices of certain manufacturers (for example, there are BSP for face, hands, iris etc.). BSP can be local or distributed. Local BSP completely operates within a single platform, while distributed BSP can be instantiated and loaded as a separate client-server components with a client-server communication. For biometric applications, client-server architecture is usually applied because it is safer environment for the executive biometric algorithms,

and when it comes to the identification of a large population this architecture has enough power to run the biometric algorithm unlike local BSP. In addition, the database can be placed on a server, which makes client work easier.

4. BIOAPI COMPLIANT BIOMETRIC SYSTEM EXAMPLE

In the following text there is small example of a biometric system for face verification of the persons, which works within LAN (Local Area Network), and it is also compliant with BioAPI specification and based on a client-server architecture.

4.1 BSP FOR FACE VERIFICATION COMPLIANT WITH BIOAPI (SPI LEVEL)

In their paper, Yuan, Hui, Leung and Gao (2004) discuss the significance of compliance of biometric system with BioAPI explaining the small example of biometric system for face verification. Apart from the mandatory operations defined in the SPI, Yuan et al. (2004) explain that the four primitive biometric functions Capture, Process, CreateTemplate and VerifyMatch are implemented. LEM algorithm is used to compare face images due to recognizing a person. On a sample of 30 users LEM showed nearly a 100% accuracy in recognizing.

Capture is a function for taking a picture of an individual faces, when enrolling or verifying person. It provides a GUI or graphical user interface for taking a picture with the camera. Taking picture provides picture frame, face image and user information (such as Customer Identification Number).

Process function allows preprocessing and normalization of the face samples for verification. It takes the raw data after Capture function and output is processed biometric data.

CreateTemplate function processes the raw array of pictures (gallery) after the Capture function done working to create a template for enrolling. It involves three steps: pre-processing, normalization and LEM formatting. Array of nine images is generated from the raw data (in the form of a single data), which are standardized for LEM. After that, the image information is encoded and returned to the launched application and stored in the Application Database.

The last function VerifyMatch compares the processed biometric data after Process function and face templates from Application Database.

4.2 BIOAPI COMPATIBLE APPLICATION FOR FACE VERIFICATION (API LEVEL)

Yuan et al. (2004) in their paper explain the importance and performance of BioAPI compatible application, called FaceControl, for access control to the protected area. The application is implemented in a client-server architecture. The client makes a face image, while the server processes and verifies the raw image with the stored templates from the database. The client and the server communicate via LAN. Figure 2 (Yuan et al. 2004, p. 295) and Figure 3 (Yuan et al.,2004, p. 296) illustrate the client-server processing in FaceControl application by calling the primitive functions included within BSP.

Figure 2 (Yuan et al., 2004, p. 295) presents the process of enrollment. The client uses the Capture function to enroll. The output is an intermediate data in the form of image-array. It is sent to the server. Server calls CreateTemplate function from the BSP. After processing, template-array is created and recorded in the database.
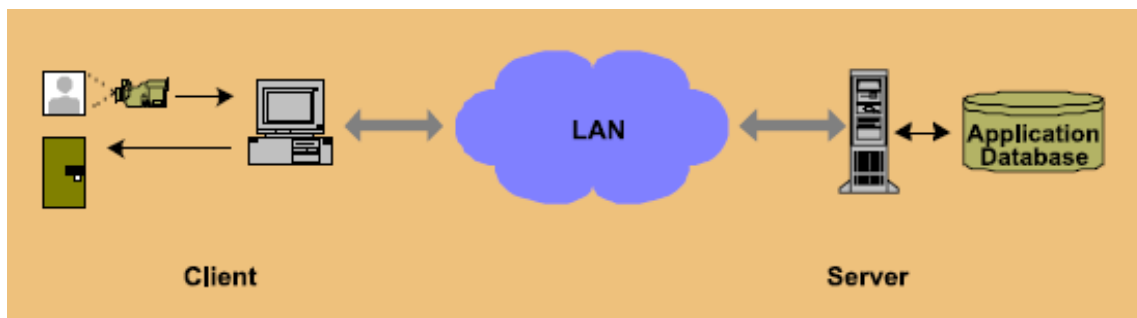
Figure 2: *Process of enrollment* (Yuan et al., 2004, p. 295)

Figure 3 (Yuan et al., 2004, p. 296) explains the verification process. On the client side, FaceControl calls Capture function for face verification. After taking picture output is intermediate biometric data that is sent to the server for verification. On the server side after Process function output is processed data and it will be compared using VerifyMatch function with template array called from the Application Database. The result is

returned to the application FaceControl on the the client side. The result of the verification implies whether person may approach to the protected area or not.

Figure 3: *Process of verification* (Yuan et al., 2004, p. 296)

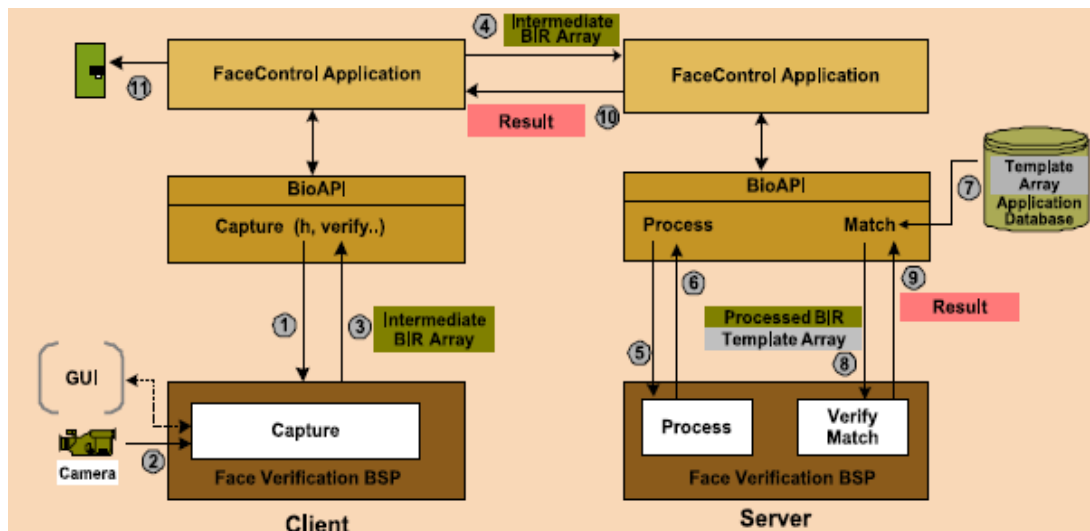## 5. CBEFF (COMMON BIOMETRIC EXCHANGE FORMATS FRAMEWORK)

Clarke (2011, p.57) defines CBEFF as "set of general guidelines for the establishment of standards or specifications compliant with standard, created by some of the so-called patron organizations like BioAPI Consortium, ISO, ANSI, NIST, etc.". Clarke (2011) state that CBEFF record comprises a set of elements of the biometric data used for biometric information exchange between the various components within one biometric system or between more biometric systems. CBEFF record is compliant with (patron) format defined by some of the standards. An essential part of CBEFF record is BDB defined by one of the client organizations that is registered with the IBIA association (International Biometric Industry Association).

Clarke (2011) points out that compatibility of biometric data with the standard or specification in the exchange of information enables smooth exchange of data regardless of the manufacturer or biometric technology. If two systems during data exchange use different standards or specifications that are consistent with CBEFF framework, there are standardized applications that transform CBEFF basic structure from one patron format to another patron format for easier communication, which improves system interoperability.

6. CBEFF DATA STRUCTURE

According to NIST report ("CBEFF", 2004) there are two CBEFF data structures: basic and nested. The basic CBEFF structure refers to one biometric modality such as face, iris, fingerprint, etc. The nested structure can be very complex and generally contains the data elements of two or more biometric modalities.

6.1 CBEFF BASIC DATA STRUCTURE

In the basic structure, CBEFF data elements are placed in the fields within CBEFF record (file). Fields are grouped into the three main sections: SBH, BDB and SB. Each section includes fields that are required or optional.

6.1.1 SBH (STANDARD BIOMETRIC HEADER)

In the NIST report ("CBEFF", 2004) stands that SBH is composed of the basic fields that may be required or optional, and carries a particular set of data necessary for the exchange within the system or between the different systems, as it is described in Table 1 (NIST report, "CBEFF", 2004, p.6). Each field is described and presented within Table 1.

Table 1: *SBH fields* (NIST report, "CBEFF", 2004, p.6)

Field Name	Required or Optional	Description
SBH Security Options	R	Defines data security
Integrity Options	R	This field defines which the integrity attribute goes with data. Signature or MAC.
CBEFF Header Version	O	-
Patron Header Version	O	Patron Format Specification or Standard version.
Biometric Type	O	Biometric type (e.g., fingerprint, voice, etc.).
Biometric Subtype	O	Additional specification within a biometric type.
Biometric Data Type	O	Level of processing applied to this data (e.g., raw, processed, etc.).
Biometric Purpose	O	Intended use of the data (e.g., enrolment, verification, etc.).
Biometric Data Quality	O	Quality of the biometric data.
Biometric Creation Date	O	Creation date and time of the biometric data.
Validity Period	O	Valid-From and Valid-Until Dates for this record.
Creator	O	Text identifier of the application's owner.
Index	O	Unique identifier for the biometric reference data within the record's application space.
Subheader/Basic Structure Count	O	Number of CBEFF Structures in the level below this header's level in a CBEFF nested structure.
BDB Format Owner	R	ID of the Group or Vendor which defined the BDB.
BDB Format Type	R	BDB Format Type as specified by the Format Owner.
Product Identifier (PID)	O	Unique (registered) identifier of the entity that created the biometric data.
Patron Format Identifier	O	Unique (registered) identifier of the patron format of the next lower nested level.
Biometric Data Block (BDB)	**R**	**Defined by the Format Owner. May be encrypted.**
Signature	**R**	**Signature or MAC. Only present if the SBH Security Options value is "Integrity-Only" or "Privacy-and-Integrity".**

It can be concluded that each biometric record with this kind of structure is standardized and ready to be exchanged with the component or system that uses the same CBEFF format, and used as well for different purpose such as enrollment, verification, etc.

6.1.2 BDB (BIOMETRIC DATA BLOCK)

This section according to NIST report ("CBEFF", 2004) contains the biometric data of a certain modality (iris, face, hand print, fingerprint, etc.). It represents a memory block specified by the owner of the data type (modality). It can be standardized and non-standardized, depending on whether it is adopted by an official body, working group or consortium. Manufacturer, the official body for standardization, working group or consortium may determine that this field contains only the biometric template. Also they can determine the structure of the data with additional parameters and information. Patron format specifications may require that BDB must be encrypted (specially defined encryption) or uncoded, which is an optional security measure.

6.1.3 SB (SIGNATURE BLOCK)

This field contains a unique digital signature (content was determined by the patron format specification) and it is a security measure.

6.2 CBEFF NESTED DATA STRUCTURE

In the NIST report ("CBEFF", 2004) stands that nested structure exists when it comes to exchange of more then one biometric modality (fingerprint, face, voice, iris, etc.) simultaneously and/or more biometric data of one modality. It contains root header and sub-headers. Each sub-header corresponds to a certain modality. In the Figure 4 (NIST report, "CBEFF", 2004, p.14) example of nested CBEFF structure is presented. This CBEFF record carries the data of two modalities: voice and fingerprints. BDB sections are standardized or non-standardized. The record is protected by the signature.
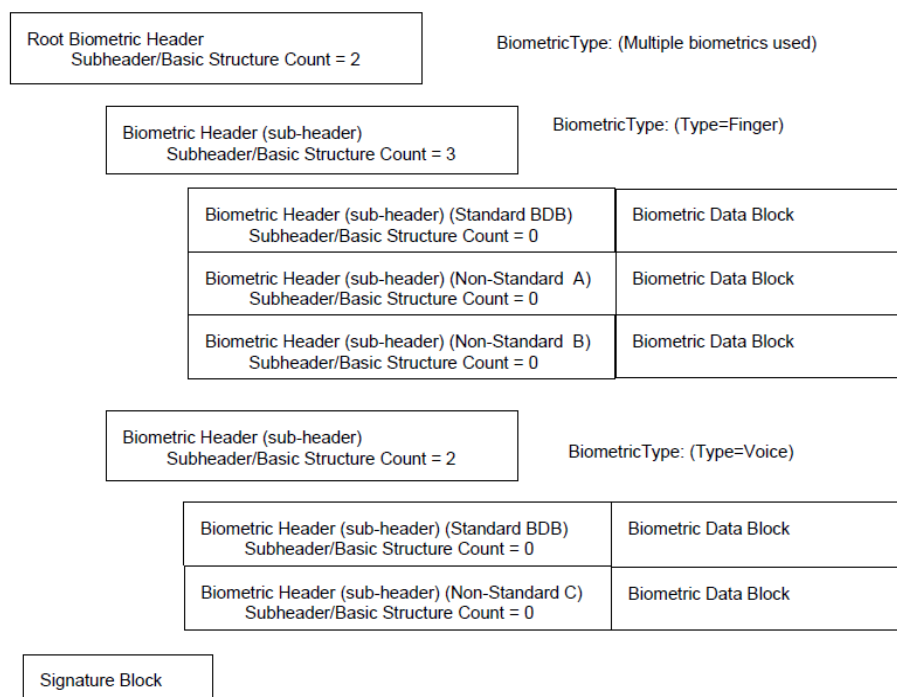
Root Biometric Header
Subheader/Basic Structure Count = 2   BiometricType: (Multiple biometrics used)

Biometric Header (sub-header)
Subheader/Basic Structure Count = 3   BiometricType: (Type=Finger)

Biometric Header (sub-header) (Standard BDB) Subheader/Basic Structure Count = 0	Biometric Data Block
Biometric Header (sub-header) (Non-Standard A) Subheader/Basic Structure Count = 0	Biometric Data Block
Biometric Header (sub-header) (Non-Standard B) Subheader/Basic Structure Count = 0	Biometric Data Block

Biometric Header (sub-header)
Subheader/Basic Structure Count = 2   BiometricType: (Type=Voice)

Biometric Header (sub-header) (Standard BDB) Subheader/Basic Structure Count = 0	Biometric Data Block
Biometric Header (sub-header) (Non-Standard C) Subheader/Basic Structure Count = 0	Biometric Data Block

Signature Block

Figure 4: *CBEFF nested structure* (NIST report, "CBEFF", 2004, p.14)

7. CONCLUSION

Standardization of biometric systems is a key to their successful implementation and operation. The establishment of the unique working environment, unique working protocols, technical interfaces and everything else that makes a platform functionally independent such as BioAPI, implies that biometric systems gain two very important characteristics - interoperability and interchangeability (replacing system components without disturbing the operation of the system) that make them unique and allow system operating regardless of the origin of components. Components become changeable, systems become more functional and harmonized, communication within the system easier, and more important is that the costs of development and exploitation of components and systems are becoming lower.

On the other hand, several multiple standards published in U.S. (by ANSI, NIST) as well as worldwide (by ISO), based on CBEFF, proves the importance and the advantages of CBEFF framework in terms of improving system interoperability and security in exchanging data.

Simultaneous application of an independent platform and a unique format for the exchange of biometric information, solves the problem of interoperability of biometric systems as well as security of biometric data exchange, and elevates to a higher level the exploitation of existing biometric systems as well as development of modern and sophisticated biometric systems.

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NOVEL APPROACH FOR TEXT PLAGIARISM DETECTION

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Abstract: *With the widespread use of the Internet for educational and personal purposes, access to the online books and research papers have become much easier for everybody. But that has also resulted in making text plagiarism become much easier to perform and plague the research publishing industry. In this paper, we tackled the problem of computer-assisted text plagiarism detection. We have developed an algorithm for plagiarism detection based on the combination of string matching and bag of words techniques. The algorithm is language and topic agnostic and can be applied to different cases of text plagiarism problems. The evaluation has shown that algorithm gives good results in detecting text plagiarism in documents with different topics. Also, it gives almost the same results as a commercial tool it has been compared with. Future work would include more extensive evaluation and development of a full-fledged web application for plagiarism detection based on this algorithm.*

Keywords: plagiarism detection, plagiarism detection systems, bag of words, string matching, algorithm

1. INTRODUCTION

Problem of plagiarism of essays and thesis work in education is a growing nuisance. Omnipresence of the Web makes the process of finding similar works significantly easier and thus the opportunity for a student to copy/paste a paragraph, page or even a complete work of somebody else becomes trivial. Pew Research Centre has performed a study and reports that 89 percent of study participants credited the rise of plagiarism to the widespread use of computers and the Internet. In the same report, authors state that 55 percent of college presidents have seen increase of plagiarism in students' papers in the past 10 years, while only 2 percent declared plagiarism is on the decline (Parker et al, 2011). Proper procedure when re-using somebody else's work would be to properly reference the original paper and thus give the appropriate credits to the author. However, the problem arises in cases when other author's content is re-used without proper referencing, which arrogates his/her work and contribution.

The topic of this paper is to design a technique for plagiarism detection in texts. This technique should be language agnostic in order to avoid lexicological and morphological specificities of a language a text is written in. This would also enable wider use of the new technique. The technique for plagiarism detection is based on the algorithm for calculating text similarity of two text documents. The algorithm is described in this paper. It is assumed that if two documents have a high text similarity score, than one document is a plagiarism of the other. This paper also describes a reference implementation of the text plagiarism detection technique and it is written in the Java programming language. The reference implementation was used to test the technique and compare its results with other approaches and tools. Also, the reference application can be downloaded and used within other applications or as a separate program.

The following section (Sec. 2) will describe common methods of text plagiarism and approaches for their detection. Section 3 presents the new approach for calculating text similarity that we are introducing in this paper. After that, in Section 4, the algorithm for calculating text similarity score is described and is followed by an example of calculating text similarity score (Sec. 5). Section 6 presents the reference implementation software of the new algorithm that was used to perform the evaluation of the algorithm (Sec. 7). Finally, we conclude the paper and give outline of directions for the further research (Sec. 8).

2. STATE OF THE ART

By observing various examples of text plagiarism, commonly found methods for illegitimate text usage can be summarized as follows (Gipp et al, 2011):
- *Copy & Paste plagiarism* - the direct copying of an entire text or part without a quotation;
- *Disguised plagiarism* - includes addition or modification of some parts of a text in order to disguise the act of copying someone else's work;
- *Undue paraphrasing* - the intentional rewriting of other peoples' ideas;
- *Translated plagiarism* - the machine or human translation of paragraphs from other sources from one language to another without adding references;

- *Idea plagiarism* - the appropriation of research methods, experimental setups, argumentative structures, and background sources.

Clough (Clough, 2003) identifies similar forms of plagiarism methods and distinguishes between: Word-for-word plagiarism, Paraphrasing plagiarism, Plagiarism of secondary sources, Plagiarism of the form of a source, and Plagiarism of ideas.

Existing plagiarism detection systems (PDS) can be categorized into *extrinsic* and *intrinsic* plagiarism detection. Extrinsic PDS method is a comparison of a document with a corpus of reference documents. Intrinsic PDS method does not use a reference corpus for comparison, but uses methods that resembles human ability to spot potential cases of plagiarism just by reading the content and detect variations in writing style (Eiselt et al, 2009; Alzahrani et al, 2012; Seaward & Matwin, 2009).

There are many different approaches of plagiarism detection, as well as their variations. The most commonly used approaches are (Gipp et al, 2011; Gipp & Meuschke, 2011):
- *Fingerprinting* method is currently the most widely applied approach for plagiarism detection. Documents are represented as a digest composed of a set of substrings of original text. These sets are called fingerprints, and their elements are called minutiae. After the formation of fingerprints of two documents, matching of fingerprints and their minutiaes are performed;
- *String matching* involves searching for verbatim text overlaps between texts. If the matching string is longer than given threshold, then the text is considered as a plagiarism;
- *Bag of words* analysis assumes representing documents as one or multiple vectors, e.g. parts of the document, which are used to calculate text similarity.
- *Citation-based Plagiarism Detection* is intended for academic works that have a lot of references. This approach uses citations and references for determining similarities between documents in order to identify plagiarism;
- *Stylometry* is one of the most used methods for intrinsic plagiarism detection where linguistic features of a suspicious text are examined in order to detect variations in writing style.

3. DESCRIPTION OF A NOVEL ALGORITHM FOR CALCULATING TEXT SIMILARITY

The algorithm for calculating text similarity that is proposed in this paper receives as input two text documents whose contents are being compared. The result is a similarity score of these text documents that ranges between 0 and 1. The algorithm consists of the following steps:
1. Generating the list of the most frequent words in both documents separately. The number of the most frequent words the algorithm should find is configurable. All words that do not add to the context of the text content are ignored (prepositions, conjunctions, etc.). The most frequent words are sorted in descending order by the number of occurrences in the text.
2. Finding intersection of the most frequent words from both text documents.
3. In this step, occurrences of the most frequent words (from the intersection list generated in step 2) are looked up in both text documents. For each occurrence of the most frequent word, a context window is created. Context window is composed of the most frequent word and words that precedes and follows it. Context window enables detecting the same parts of sentences in two text documents as they preserve the context a frequent word has occurred in. That means if someone has copied someone else's text, context windows are going to be the same in both text documents.
4. Context windows for both text documents are compared and text similarity score is calculated according to the formula that is described in the following section.

Example of half context window

Listing 1 presents two examples of half context windows. Half context window consists of only one word that proceeds or one word follows the most frequent word. These two examples show context windows for the words *start* and *globalization*.

start: [	***globalization***: [
is ***start***,	begin ***globalization***,
start process,	***globalization*** reflected,
its ***start***,	called ***globalization***,
start corresponds,	***globalization*** should,
one ***start***,	is ***globalization***,
start is,	***globalization*** occurs,
period ***start***,	for ***globalization***,
start eight,	***globalization*** preceded,
doesn't ***start***,	is ***globalization***,
]	]

Listing 1: Example of half context window

Example of context window of length 1

Listing 2 presents examples of context windows of length 1 for words *start* and *globalization*. Context window of length 1 has one word preceding and one word following the most frequent word.

start: [	***globalization***: [
is ***start*** process,	begin ***globalization*** reflected,
its ***start*** corresponds,	called ***globalization*** should,
one ***start*** is,	is ***globalization*** occurs,
period ***start*** eight,	for ***globalization*** preceded,
doesn't ***start*** training,	is ***globalization*** made,
]	]

Listing 2: Example of context window length 1

4. CALCULATING TEXT SIMILARITY SCORE

First, for each of the most frequent words we calculate its context window matching score by using the formula (1).

$$cwm_l = \frac{ct}{st} \qquad (1)$$

where:

cwm (context window match score)	Score of the context window matching for the particular most frequent word
ct	Number of context windows that appear in both text documents for the particular most frequent word
st	Total number of unique context windows in both text documents for the particular most frequent word
l	Context window length

Word weight is obtained by the formula (2).

$$ww_i = \frac{cw_i}{\sum_{j=0}^{m} cw_j} \qquad (2)$$

where:

ww (word weight)	Word weight in relation to the whole set of the most frequent words
cw (context window)	Number of context windows for the i most frequent word
m	Number of the most frequent words in a document

The formula for calculating the text similarity score:

$$ss = \left(\sum_{i=0}^{k} ww_i \cdot cwm_i\right) \cdot \frac{k}{n} \qquad (3)$$

where:

ss (similarity score)	The similarity score of two text documents
ww (word weight)	Word weight of i in relation to whole set of the most frequent words
cwm_i (context window match)	The degree of matching of context windows for i the most frequent word
n	Number of the most frequent words
k	Number of words obtained by intersection of the most frequent words in two documents

5. EXAMPLE OF TEXT SIMILARITY CALCULATION

Figure 1 presents an example of calculating the text similarity score of two text documents. First, ten most frequent words are found in both texts (n = 10). In these two lists of the most frequent words, 7 words are the same (k=7). For example, the most frequent word "PHP" appears 20 times in the first text document, while it appears 30 times in the second text document. For each word from this intersection set, context windows are created and compared. For instance, for the word "PHP" the same context windows appear 15 times in both text documents (ct = 15), while there are 35 unique context windows in both text documents (st = 35). Context window match (cwm) score for this word is 15/35 = 0.43.

Word weight (ww) is the weight of a word in a document (from the set of the most frequent words). For example, the most frequent word "PHP" appears 20 times in the first document, while the total number of occurrences of all most frequent words is 142. When 20 is divided with 142, a calculated word weight for the word "PHP" is 0.14 (ww = 0.14).
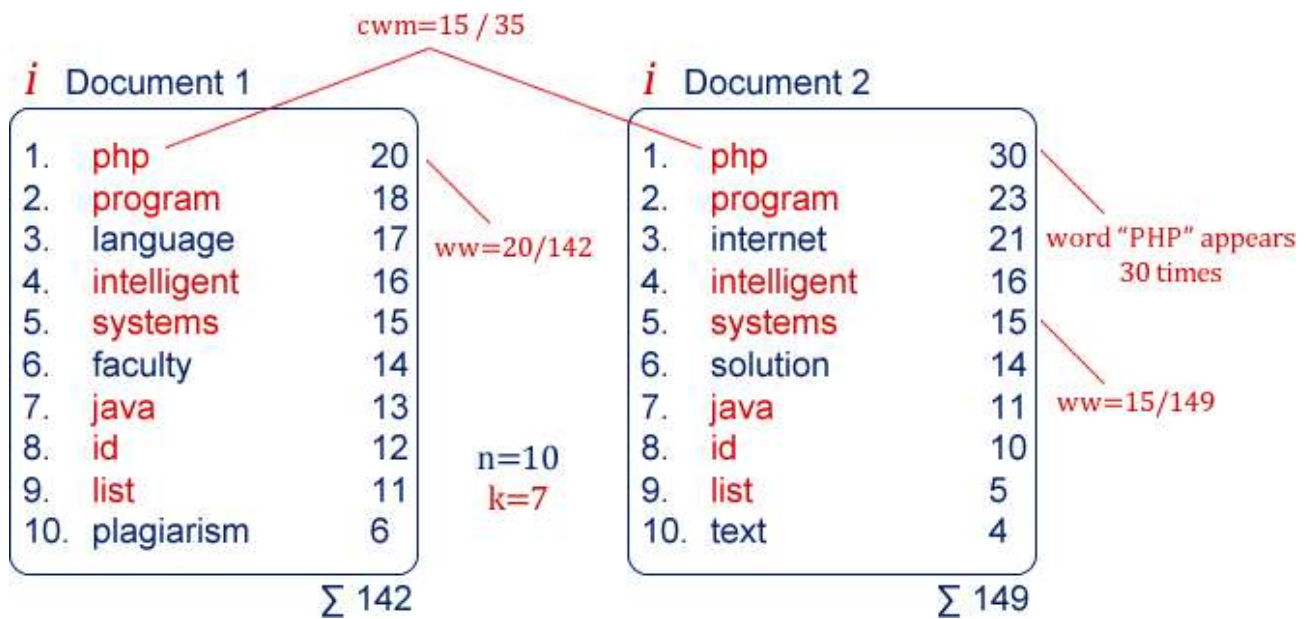
Figure 1: Example of computing the similarity score

For each of the most frequent words this process is repeated, and then these values are used for calculating the text similarity score. Values of context window match and word weight are multiplied and this value is summed for all of the most frequent words. In the end, the total sum of all final values is multiplied with a degree of matching of the most common words in both documents (k/n).

6. SOFTWARE DESCRIPTION

In order to evaluate this algorithm, we have created a prototype application in the Java programming language that implements the algorithm for calculating text similarity score (Fig. 2). The application allows loading original text document and several test documents that will be compared with the original. Also, the application supports loading content from .doc, .pdf and .txt files.

User can choose a number of the most frequent words to be looked for and the length of the context window, which can affect precision of calculating the text similarity score. When application finishes comparison of text documents, it displays the result of matching documents in the range of 0 to 100.

Also, after completion of documents comparison, application displays a report (Fig. 3) that contains all relevant information about the process of calculating text similarity score.
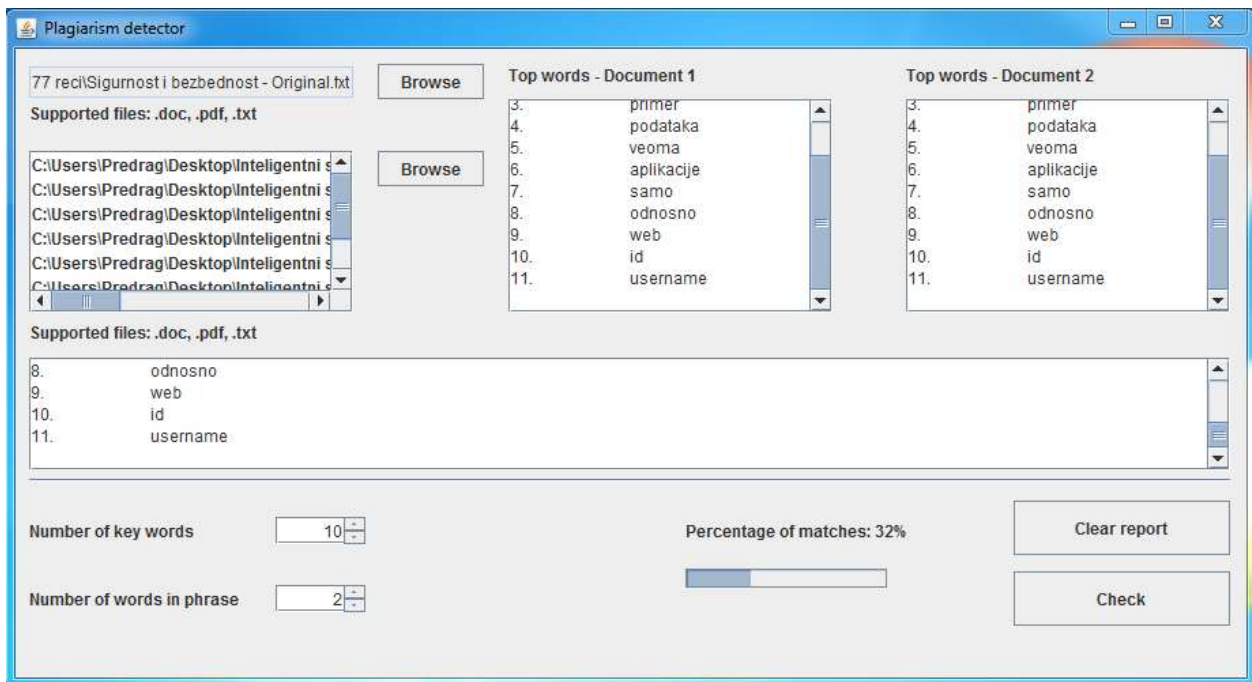
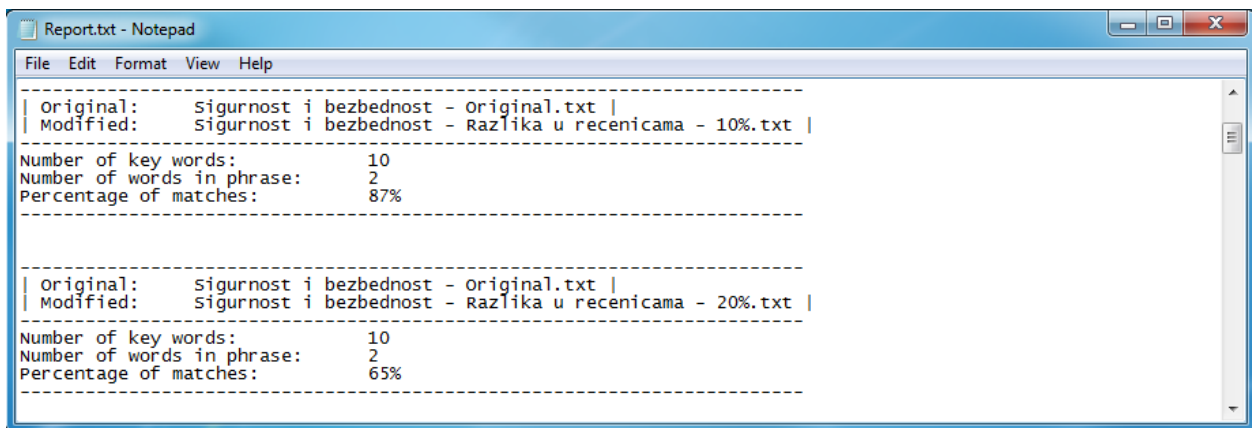**Figure 2:** GUI of the plagiarism detection prototype application

Figure 3: Report example

7. EVALUATION

Previously developed prototype application was used for the evaluation process. Six different text documents in Serbian language with different topics and number of words were selected. And for each of them we have created a comparison set consisting of the texts with the same content, but modified in a specific way. Modification was performed in two ways in order to get approximately realistic situation of re-using someone else's work. The first method, called *Random changed words*, consisted of randomly selecting words in a document and modifying it by adding several characters to the end of the word. The assumption behind this approach is that the potential plagiarist will modify only certain words in a document. In the second approach, called *Randomised sentence words*, a document was modified by randomly changing the order of words in a sentence. The assumption behind this approach is that a potential plagiarist will replace a sentence from the original document with another sentence that uses the same or similar words. In total, we have generated 84 different test documents to evaluate the algorithm with.

Table 1: Examples of modifications in test documents

Original text Globalization is the process of international integration arising from the interchange of world views, products, ideas, and other aspects of culture.
Random changed words Globalization is the \<modified word\> of international integration \<modified word\> from the interchange of world views, products, ideas, and \<modified word\> aspects of culture.
Randomized sentence words aspects integration is the world process products of international arising from the of views, ideas, interchange and other globalization of culture.

Using these two modification methods we have generated seven test versions of each original document, but with the content modified in 10, 20, 30, 40, 50, 60, and 70 percent.

Evaluation of the algorithm was performed by comparing content of each of the original text documents with respective versions of modified documents. We evaluated each test document with different configurations of the number of the most frequent words and different context widow lengths. The number of the most frequent words (n) was set to 10 and 30 words. And we have also tested the algorithm to compare different lengths of context windows (cwl), i.e. half context windows, context window of the length one and the length two. The algorithm was tested with these six combinations of configurations over the test documents generated by the two modification techniques. Configuration combinations are:

- C1 – n = 10, cwl = ½
- C2 – n = 30, cwl = ½
- C3 – n = 10, cwl = 1
- C4 – n = 30, cwl = 1
- C5 – n = 10, cwl = 2
- C6 – n = 30, cwl = 2

Also, with the same test dataset, we have tested the performance of the commercial plagiarism tool Plagiarism Checker X[1] in order to compare its results with the algorithm described in this paper.

Comparing document versions generated by the two modification methods, we can observe that the algorithm scored higher the documents modified with the *Randomised sentence words* approach. Out of 84 different versions of test documents, in 63 cases the algorithm gave the best results when configuration C2 was used. In 14 cases the best results were achieved with configuration C1 and in only 7 cases C4 gave the best results.

When observing the performance of the comercial tool Plagiarism Checker X, it gave slightly better results with documents generated with the *Randomised sentence words* modification method. But with documents generated with the *Random changed words* modification method, the comercial tool gave far worse results..

Tabelar presentation of the evaluation results can be found on the following page: http://is.fon.rs/node/29. Also, generated test documents used for the evaluation can be retrieved from the same page.

8. CONCLUSION AND FUTURE WORK

From the evaluation results, we can make a conclusion that the algorithm for plagiarism detection introduced in this paper has the best results when number of the most frequent words is set to 30 and half context window is used (configuration C2). This configuration gives the best results with test corpuses generated with both modification methods (*Random changed words* and *Randomised sentence words*). When compared with results of the commercial tool Plagiarism Checker X, the commercial tool gives slightly better results. But here, we should have in mind that this tool is commercial and closed source.

For the future work, we plan to further develop the algorithm. One of the improvements would be to combine this approach with the Citation-based Plagiarism Detection method. Also, we plan to perform evaluation of the algorithm with texts in other languages, first of all English. The prototype application developed for performing the evaluation will be documented in detail and published on the Web as an open-source library.

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[1] Plagiarism Checker X is a commercial program for plagiarism detect with various functionalities, such as comparing two documents, compare multiple documents and online document search. link: http://plagiarismcheckerx.com/

The goal is to develop a full-fledged web application based on the new algorithm that can be used in educational institutions for plagiarism detection.

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NEW PROCUREMENT MODEL

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Abstract: *The new procurement model would serve for improvements of procurement process in many companies which use an old purchasing model which covered only procure to pay process. The procure-to-pay cycle, including all activities from the procurement of fixed assets, goods and services to receiving invoices and paying vendors, is the basic business process. The companies, especially in public sector, do not have optimal control of risks in procurement process and face with late fees, wasted time, break in business process and with non-compliance issues such as fraud or overlooked incidents. In order to mitigate these risks and increase market competitiveness, the company must to develop and implement the modern procurement model. Having after developing of new purchasing model which including the whole cycle from sourcing to paying of obligation in procurement, it would be crucial for company to implement an adequate software solution in order to automatize all purchasing processes as much as possible. SAP and Oracle EBS as ERP systems earned more than 38% of total ERP software revenues in 2012 on world-wide basis (Pang, Dharmasthira, Eschinger, Motoyoshi and Brant, 2012), offer up-to-date solutions for procurement processes. The choice of the right solution for companies is the last, but the most important stage in order to close procurement model (Manojlov, Lutovac, 2012 SymOrg). This paper is taken into consideration all the facts and standing conclusions from previous procurement models as the source for developing new solution. In order to create new business model for procurement, we used comparative method for analysis of software solutions by using of external sources, survey to assess level of centralization of procurement in several companies where data are collected through interviews with CEO and Managers of these companies. Additionally, description method is used in order to establish link between relations and rules in old procurement model. In most companies, the change of business model for procurement is seen as a necessary step and focus is placed on that a change of business model is needed. In this paper, we elaborate the characteristics of old procurement models and define steps & guidelines as approach in implementation of new procurement model. The benefits of creating the right procurement model for the company are substantial, not only in terms of cost reduction, but also in the ability to better focus resources, enhance value from supplier collaboration and innovation, and more fully captured contractual promises.*

Keywords: *New procurement model, procure to pay, optimization in purchasing, ERP*

1. INTRODUCTION

The role of the procurement can be formulated on many ways depending of the specifics in the company. The connection between the company`s operation and procurement is very closed. The significance of procurement processes has strong relation with definition of final product of the company. If company is repetitive manufacturer with classic finished products included various raw materials plus external services in their BOM`s, the procurement department plays the critical role. In discrete manufacturing and service companies, the procurement model has the less influence on the whole business process. However, the procurement is basic process for trading companies. Many trading (distribution & retail) companies structure their business model on discount model with vendor who deliver strategic goods to them. The typical examples of these companies are Agroglobe d.o.o. (structure their Profitability Analysis model based on earning per vendor) and Phoenix (has the methodology of discounts related to rebates and early payments).

The cost of raw materials occupies the first position of all the other costs, so any deviations emerged during the links of purchasing have an effect on the realization of the company"s anticipated goal, and further will have an influence on the enterprise profit target. While abundant of potential risks and uncertainty exist in the whole process of purchasing in such a changeable environment of market economy.

The role of procurement in Serbia is still defined very differently than the rest of the developed world. The public companies in Serbia have the limitation of law who prescribed strict rules in Public procurement act (Ministry of finance Serbia, 2014). On the other hand, there is no clear approach related to procurement strategy in private sector. The main decision about procurements in private sectors for strategic materials, services or fixed assets are mainly based on friendly relationships between vendor and customer.

Till the middle of the 90`s due to the generally accepted view, the procurement department belonged to the production in production company and belonged to the sales in distribution company. According to this traditional approach, the objective of the procurement model has to follow settings in production process: Right Quality, the Right Quantity, at the Right Price, at the Right Place, at the Right Time (P. N. Mukherjee, 2006). It is not so far till the true from today`s practice in procurement. Instead of this, purchasing must become supply management. New approach of procurement must to be much wider, primarily the procurement serves to the sales and adversely the sales must to dictate procurement. Anyhow, new procurement model must to operate with many variables in order to obtain competitive advantage.

2. OLD PROCUREMENT MODELS

What procurement exactly means? According to Oxford English Dictionary, "procure" means to obtain some item, while "purchase" means also to obtain some item in exchange for payment. So, although sometimes these two words are used interchangeably, they have varied interpretations. Tony Colwell (Colwell 2011) referred to "procurement" in the public sector as "care and effort" in upstream activities – strategy, sourcing and negotiating – up to execution of a contract. The exact responsibility of the procurement division may vary across organizations, but often post-execution activities, like contract management, placement of orders for deliveries, the management of day-to-day supplies, and processing payments, are also included in its scope.

Considering level of centralization, there are 3 basic models for procurement, any others are hybrid models, a combination of these three (Colwell, 2011):
▪ Local, where all activity, decision making and control is managed locally and is autonomous.
▪ Central, where decision making and procurement activity is coordinated centrally. (There may be local activity and controls outside the scope of procurement, for example, calling off supply under a centrally negotiated contract.)
▪ Networked, where decision making is not independent, but is controlled in some way across local units, like node, or nodes, on the network.

The combinations of vertical and horizontal centralization in purchasing process divided procurement model on federal procurement and centrally led procurement model.
▪ At federal procurement, managed by the central governance, some items are controlled at local level, while others are controlled centrally. Usually the centre defines the autonomy degree of local level by mutual agreement or by mandate.
▪ At centrally-led network procurement, activity is managed across local unit, the control is performed by the nodes on the network where the centre acts as the primary node.

Generally, centralized procurement in mid and big companies often fails to live up to its promises. Apart from historically falling short on delivering to the bottom line, we are facing new issues such as sustainability. The size of the company is the most important variable for level of centralization of procurement in the companies.

For purpose of this work, we performed research with CEO and/or Procurement Managers in several companies during first quarter of 2014. The main point of this research was impact of level of centralization and planning on the size of the company. Some of the companies who participated in research are TENT d.o.o., Sintelon, Relja Junior, Computer Shop etc.). The results are in table below:

Table 1: Level on centralization on size of the company

	Annual level of sales	Planning	Centralization
Small company	Under 20k EUR	Annual	High
Mid company	From 20k-100k EUR	Monthly	Mid
Big company	Under 100k EUR	Daily based on MRP	Low

This research shows that level of centralization in procurement decreases in large companies and the planning is most complicated organized in large companies. Anyhow, this paper will count of all facts in old procurement model and generate the new one which focused on supply management.

Generally, the base for old procurement models lies in their centralization. Our research shows that centralization is valid in small and low organized companies. The crucial point of modern procurement model is considering many variables.

The top priority in putting together a powerful operating model is not the issue of overall centralization or decentralization; it is determining how best to structure procurement"s various roles in corporate, business unit, and functional-level purchasing. Should the procurement function own, control, and manage the entire process for every corporate stakeholder? Should it participate actively in the purchasing decisions and processes of the individual business units, functions, and geographic regions in which the company operates? Or should it merely carry out those purchasing decisions?

Additionally, some authors (G. Zakeri, D. Craigiey, A. Philpottz and M. Todd, 2013) used linear programming of demands in order to have optimal procurement. They proved that an efficient linear programming formulation for the demand response of a price taker, industrial or commercial user of electricity has some ability to self-generate. According to them, new procurement initiated new procurement. They established a monotonicity result that indicates fuel supply of S may be spent in successive steps adding to S in total.

There are many reasons that the operating models constructed to procure and pay for goods and services prove inadequate. They may not include the processes, tools, or resources needed to fully execute the sourcing strategy.

They may not be properly connected to organizational decision making or sufficiently integrated into key corporate planning processes. Decision making authority and accountability may not be clearly defined. Or the IT systems that enable them may be fragmented, impeding efficiency and clouding the visibility necessary to ensure compliance with overall purchasing policies and objectives.

3. SPEND ANALYSIS

One of the most powerful tools in procurement process is spend analysis. Any procurement analyst must to operate with some kind of spend analyze. It is the basic report in procurement cycle. Generally, spend analysis is the process of collecting, cleansing, classifying and analyzing expenditure data from all sources within the organization (i.e. purchasing card, eProcurement systems, etc.). The process analyzes the current, past and forecasted expenditures to allow visibility of data by vendor, by commodity or service, and by department within the organization. Spend analysis can be used to make future management decisions by providing answers to such questions as: what was bought; when was it bought; where was it purchased; how many vendors were used and how much was spent with each; how much was paid for the item.

Procurement should work to identify all spend data, internal and external, for the organization. Once spend data sources are identified, the data should be collected and automated. The second steps in spend analyze is cleansing. This process is necessary to insure accurate organization and correlation of spend data and to enable actionable analyses. The cleansing must to include the following activities:
- Grouping and categorizing spend data should be done by adopting an internal taxonomy or by adopting an industry-standard classification scheme.
- Higher-level classification of spend at the category or vendor level is the first step in grouping and categorizing spend data. Examples include: categorizing goods and services that are being acquired; determining how many vendors are being used for specific categories; and how much the organization is spending on specific categories, in total and with each vendor.
- Item-level detail of spend data enables a precise view of spending with each vendor and for each commodity on an organizational, departmental, project, and buyer basis.
- Additional enhancements should also be applied to the collected spend data. These include but are not limited to: contract terms, minority or women owned business status, alternative parts data, industry pricing indexes, average selling prices, vendor financial risk scores, performance information, lead times and inflation.

The third phase is automation of data extraction, classification, enhancement, and analysis and services that can streamline existing procedures and make spending analysis a repeatable process.

Last phase is analyzing of spend data. In this phase, the procurement analyst make must to assess whether the current procurement structure, processes, and roles are adequate to support a more strategic approach to acquiring goods and services (e.g. whether cross-functional commodity teams would provide more effective, coordinated management of high-dollar, high-volume categories of goods, services, and vendors on an on-going basis).

Ernst & Young, leading auditing & consulting company in USA, presented several benefits from spend analyze in procurement process on US markets in research from 2012.

Table 2: List of benefits for companies from spend analyse (EY publication, 2012)

Eliminate duplicate vendors (Reduction depends on previous efforts.)
Reduce material and service costs through informed strategic sourcing strategies based on the data
Improve contract compliance
Use contract pricing to create savings
Meet regulatory reporting rules
Improve inventory management by cutting excess stocks
Lower inventory costs
Reduce expediting costs
Improve product management by cutting unnecessary part introductions
Increase part reuse
Align design and supply strategies
Facilitate early vendor integration
Reduce spend analysis project cycles
Refocus procurement professionals on strategic tasks

Normally, the significance of certain benefit depends of various factors in the company. These results arisen from procurement models on US companies must be projected on other world-wide market.

As an example, we examined two companies with different size (one is more and other is large) and their management view of these benefits in Serbia. For small company such as Relja Junior d.o.o., the most important thing in the business is to have lower inventory costs and reduce expediting costs. On the other hand, expectations from spend analysis for energy Serbian giant EPS are much different. They expect elimination of duplicate vendors and reducing of material and service costs through informed strategic sourcing strategies based on the data.

Spend analysis begins with identifying internal and external sources for collecting spend related data for the organization. Once data is collected, it should be cleansed, grouped, categorized and analyzed.

Finally, the data should be updated regularly and the spend analysis process should be performed on a continual basis to support decisions on strategic sourcing and procurement management for the organization.

4. PROCUREMENT MODELS IN EPR SYSTEMS – SAP EPR AND ORACLE EBS

As previously mentioned, they are two main players on ERP market related to procurement, SAP and Oracle. Additionally, four major technology segments are recognized in analyze from Deloitte Central Europe from 2012 including: 1) Spend Visibility, 2) eSourcing/Decision Support, 3) eProcurement/EIPP, and 4) Information, Performance, and Risk Management. The marketplace is characterized by a dominance of „top tier" vendors such as Ariba, SAP, and Oracle with an array of niche vendors providing technology and services. According to the last news published by SAP in 2013, Ariba became the contained part of SAP, so Oracle and SAP are the main players.
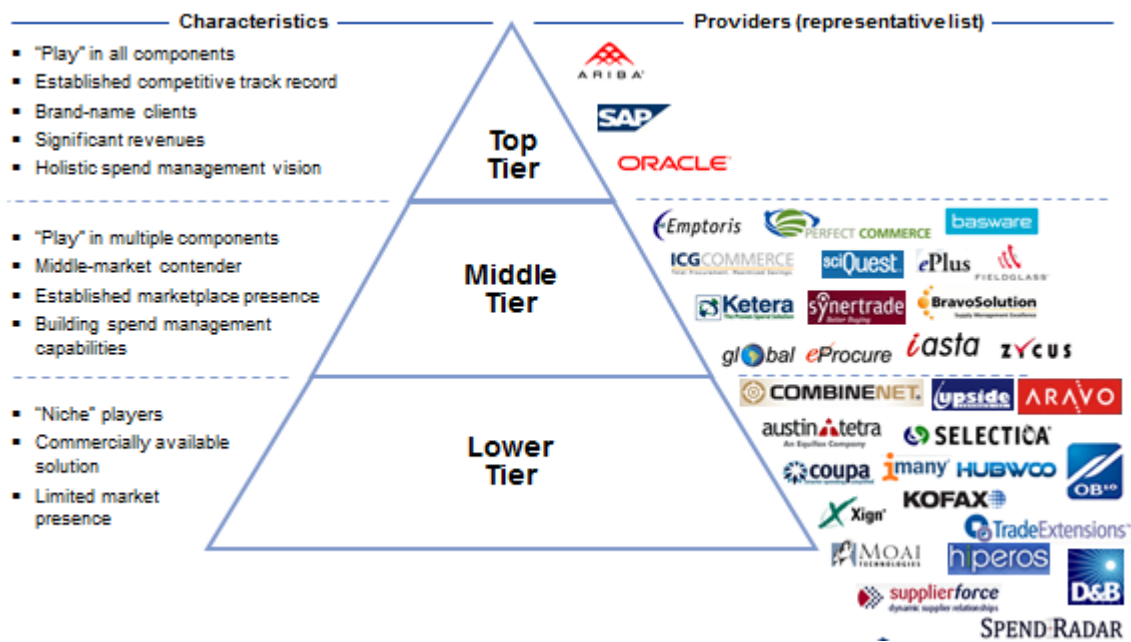
Figure 1: Sourcing & Procurement Technology Landscape

Anyhow, the both ERP systems offer the functionalities for procurement. In SAP, the procurement, also called Material Management module has two sub-modules: Purchasing and Inventory Management. Purchasing relies on master data such as Material Master, Vendor Master, and Info Records. An Inventory Management component handles all movements in inventory management process. Purchasing integrates tightly with other SAP modules such as Financial Accounting, Sales and Distribution, and Controlling. Purchasing causes commitments to be posted to Controlling; and when goods are received, posting can be made against cost centers. Also, when goods are received, SAP posts an Accounting document to Financial Accounting (FI) against a specified General Ledger account. Sales and Distribution passes requirements to Purchasing in the form of Procurement Proposals generated during MRP.

Oracle EBS has stand-alone application called Purchasing. Additionally, Oracle launched "Oracle Advanced Procurement Application". "Oracle Advanced Procurement" is the integrated suite of applications that dramatically cut all supply management costs. Oracle Advanced Procurement reduces spending on goods and services, streamlines procure-to-pay processes, and drives policy compliance.

Analyzing of SAP ERP 7.0 and Oracle EBS 12, the both solutions have the following advantages comparing to other software technology for automatization of procurement processes:
- Automated posting in General Ledger application
- Various field and consequently controls in purchasing master data
- MRP workflow process (some technical prerequisite must to be established for Oracle EBS)
- Integrated planning with production and sales
- Complete procure-to-pay automation
- Budget-based procurement (SAP solved this problem with Ariba and Oracle EBS with extension on Oracle Advanced Procurement)

The client that implements the ERP system has no usually internal expertise that is necessary for the implementation of complex software. Thus, the client engages an external consulting company to actively lead and participate in the implementation of the ERP project (Manojlov & Lutovac, 2012). The company must to pay attention of functionalities related to procurement processes, because it is the main point for integration on other separated modules.

5. NEW MODEL BASED ON COMBINING „SOURSE TO CONTRACT (S2C)" AND „PROCURE TO PAY (P2P)"

The new procurement model should be divided into two models. First is S2C and the second one is P2P. S2C covers all activities from sourcing to contracting and P2P covers all activities from purchasing to paying of vendors. Implementation of these two components is not "must", but desired. The company will have an optimal procurement optimization, only if implement the both components.

Generally, an old fashion companies had to have P2P concept without S2C component. Especially, S2C add value for the company in combination with well-structured P2P concept. Source to contract and procure to pay must to feed each other. In modern company, P2P co-exist with S2C and adversely. During an investigation an old procurement models, we defined several phase for P2P and S2C cycle. P2P are consisting from the following phases:

a) *Identify Need* as identification of requirement to purchase products and/or services, either planned or unplanned
b) *Create Requisition* as creation of a formal request for goods and/or services
c) *Approvals* which allows necessary company`s approver to review and sign-off on purchase requisition
d) *Create purchase order* as creation and issuance of an order to vendors, including acknowledgement, confirmation and any changes
e) *Receive* as formal receipt of goods and services, including quality inspection checks and appropriate escalation in case of errors
f) *Payment* in the form of efficient and accurate payment to vendor after verification of goods receipt and purchase order matching (2-way or 3-way matching) to ensure compliance
g) *Collect Performance Data* as measurement and collection of metrics (lead time variability, defect rate, etc.) used for continuous improvement of internal and vendor performance

The last phase called "Collect Performance Data" of P2P model should be starting point for analyze spend in S2C model. Therefore S2M model are consisting from:

a) *Analyze Spend* as systematic categorization, archival, retrieval and analysis of spend-related information
b) *Conduct Demand Management* as proactive management of demand
c) *Analyze the Supply Market* as active tracking of industry trends and relevant changes in the supplier base
d) *Define Sourcing Strategies* as application of the most relevant sourcing strategy and tactics for each spend category
e) *Tender Bid Process / Negotiate* in the way of standardized process to conduct bid process and vendor negotiations
f) *Finalize KPIs (Key Performance Indicators) & Contract* - key performance indices that track and measure the supplier performance and internal compliance to preferred vendor lists and contracts

Last phase "Defining of KPI & Contract" (f) initiate identification of needs as lighter for starting point in P2P model (a). Also, the company must to define the relevant persons in order to manage in each step of these two models. The most important thing is defining of leaders i.e. there should be two persons: Leader of P2P and Leader of S2C models.

Additionally, P2P and S2C should be treated as horizontal approach of procurement. S2C is upstream application and P2P is downstream application. However, the most important thing is to define a set of core principles guide "The Source-To-Contract" and "Procure-To-Pay" processes. These set of core principles must to be developed as a basic for implementation of procurement model in the company. Normally, adaption of this model has to follow and consider the company`s specifics. In table 3, the boundaries of new procurement model is set for each components.

Therefore, the source-to-contract capability is built on a dynamic, closed-loop process that has the ability to address and focus on both indirect and direct spend. On the other hand "procure-to-pay" capability is built on the above principles in a way that reduces transactional work to enable increased focus on value-added strategic activities.

The benefits of adopting the right procurement model for the company are substantial, not only in terms of cost reduction but also in the ability to better focus resources, enhance value from supplier collaboration and innovation, and more fully capture contractual promises.

Table 3: S2C (Upstream) and P2P (Downstream) instructions for implementation of model

SOURCE TO CONTRACT (UPSTREAM)	PROCURE TO PAY (DOWNSTREAM)
Spend Intelligence	**Automation & Intelligence**
Create automated "company-wide" spend analysis that generates periodic "canned" and ad-hoc reporting aligned with strategic sourcing goals and category requirements	Create a "lights out" automated transaction factory where cost effective to do so and capture data in a clean way that allows analysis that creates procurement intelligence
Organizational Planning	**Governance & Compliance**
Create a 2 to 3 year "calendar" prioritizing sourcing opportunities / events company-wide, which is updated annually and for market/contract events to manage ad-hoc needs	Create a common standard of company-wide policies, procedures, and approvals that are integrated into the P2P workflow and tie to other functional systems to drive compliance and individual adherence
Formalized Strategies & Management	**Strategic Management**
Create uniform category playbooks defining the driving forces behind price, market complexity, and business impact. The primary category value levers & tactics are defined with total cost of ownership (TCO) in mind and tied to operating guidelines	Create procurement and category strategies that minimize the need for ad-hoc /exception management and incorporates supplier scorecards, supplier management tools, and preferred supplier compliance reporting/monitoring
Governance & Compliance	**Self-Service & Connectivity**
Create defined policies, procedures, and roles & responsibilities that manage strategic sourcing and category management (e.g. mission, guiding principles, category span of control, category segmentation, etc.)	Create the system connectivity necessary to support user and supplier self-service; online catalogs, product/service master, supplier portal, electronic document exchange, etc.

Theoretical validation of the new procurement model will initiate the following facts:
- Globalization trend is the lighter for the company to drive of best pricing model / reduce of costs and have the process called "spend under management" during the S2C phase of the model.
- Improving of management of supplies, qualities, and cost risks in the step of spend analyze.
- Enabling of operational excellence and aligning to the needs of the business. Supply chain risks in term of increased regulatory, supply security, quality, and recall risks are forcing some companies to evaluate their risk mitigation strategies during the S2C phase of the model.
- Operate "As One". S2C and P2P phase must to be operated as one in order establish an optimal procurement organization and mitigation the risk of failures in whole business process.
- Proactively manage strategic supplier relationship in the step of analyzing of supply market in order to increase focus sustainability. Key trend for proactive procurement management is the fact that customers and governments become demanding companies which have plans to make their operations more sustainable.

6. CONCLUSION

The main strength of new procurement model is strong cooperation between P2P and S2C phases in procurement. An old procurement models take into consideration only P2P part of procurement. New procurement model, presented in last chapter of this paper, has holistic approach and P2P and S2C are strongly cooperated. It covers the processes from initiation of need to realization of procurement in P2P component which serving as input data in analysing of spend to finalization of key performance indicators in S2P component.

Additionally, the new procurement model must to provide the basic assumption for providing of robust supply-side information, metrics, and alerts that integrate with implementation of technology applications such as Oracle BI Applications or SAP Ariba. It delivers specific insight across the organization in order to increase the company"s performances in managing its customers, suppliers, and financial decisions.

Many authors tried to develop procurement model such as Tony Colwell (2011), G. Zakeri, D. Craigiey, A. Philpottz, M. Todd (2013), but nobody from them is not taking into considering all relevant facts in procurement process.

This model will be the starting point for many companies to define their procurement strategy and consequently redefine their position on the market. The next step will be practical validation of new procurement model through implementation of the model in real company.

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WEARABLE COMPUTING IN EDUCATION

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Abstract: *This paper represents an overview of wearable computing technologies that have been applied in education. The focus of this paper is on the existing models of the application trough the method of analyzing different authors and their ideas. Purpose of this analysis is sublimation of knowledge and current practice trough analytical and deductive methods, as well as the proposal of wearable computing model in education. Utility of this model is primarily sublimation of previous knowledge and emphasis to its use in education. Most important finding is that wearable computing is still poorly used in education, therefore further study of its potential academic use is recommended. Consequently, this paper contains a proposal model for introducing wearable computing technologies and Google Glass in academic educational institutions.*

Keywords: wearable computing, education, ubiquitous computing, blending learning, Smart Watches, Google Glass, NFC tags

1. INTRODUCTION

New technologies are changing the way of the daily life. Education is just one of the aspects of the modern world that can not be imagined without use of technology. In the current academic education using desktop computing is quite common. Desktop environment (PC, Laptop, Mobile phones) involves the use of graphical interfaces and is based on work with icons, windows, folders, wallpapers, tool-bars and desktop widgets (Desktop environment). The use of technology in all aspects of life including education led to the creation of the following concepts: ubiquitous computing (ubiquitous computing), a hybrid learning (blending learning) and wearable computing (wearable computing). These concepts are interrelated. To understand the idea of wearable computing in education it is necessary to understand all three terms which will also be discussed in this paper.

The first part of the paper begins with brief description of the concept of wearable computing and its historical review. The second part is a review of literature and existing models as well as the review of commercializes wearable computing technologies that are used in medicine, sports or entertainment, and may represent a "milestone" for application in education. The third part of the paper contains a proposal of introducing these technologies in academic educational institutions as a learning tool. Through this paper will be shown that wearable computing technologies can be used in two ways: for learning technical science in specialized curses for students and as a tool for each individual which should facilitate communication among students and professors, provide better flow of information and knowledge and enable easier and more reproductive learning at any time. While the analytical part of this paper covers both scenarios, proposed model highlights the second approach. Thus, research direction focus on increasing communication between students and professors, increasing the efficiency of information distribution and increasing the quality of group assignments by using Google glasses in correlation with other wearable computer elements.

2. WEARABLE COMPUTING CONCEPT AND HISTORY

Wearable computing that use sensors, wireless communication and mobile phones is just one part of the ubiquitous computing concept. Contemporary concept of ubiquitous computing was set by Weiser (1988) and it is based on the interaction between man and computer, where the computer is integrated into everyday objects used by everyone. He predicted widespread use of computers and "omnipresence" in all aspects of life. Further, ubiquitous computing in education was initiated by the creation of ubiquitous learning paradigm which is a transition from traditional learning to e-learning. Mentioned paradigm implies to environment that enables learning anywhere and anytime, with the help of computers and computer-based technologies (Yahya et al., 2010). This type of learning completely disregards traditional teachings, which in practice has not yet occurred. Despite the application of technology for learning the traditional view is not completely replaced, which leads to the creation of blended learning concept. The so-called "hybrid learning" or blended learning is a learning system based on synergy of traditional and e-learning. Charles R Graham in

his work synthesizes different definitions for this term, and sets blended learning as: "a combination of online learning and face-to-face learning" (Bonk & Graham, 2006).

Blended learning uses web - based courses, collaboration software in real-time systems, knowledge management, combined with self-learning and face-to-face (Singh, 2003) and it can be use for tutoring through blended learning platform, which has proven more effective in "sharing information, for clarification of learning areas and planning activities" then traditional approach to tutoring (De Smet et al., 2008).

The next step in the development of learning models in higher education is the application of wearable computing technology. Wearable computing technology provides a higher level of synchronization with the user and their needs, and it does not requires from user to interrupts his task during process of collection and providing data. During last ten years it is being gradually introduced in education, which is the subject of this paper.

Historically, a wearable computing concept as an idea of a portable device that will provide useful information to a user is much older than it looks. The first mechanical inventions that can be carried by user are considered to be the beginning of the wearable computing idea. The precursor of the concept is a pocket watch founded in 1510. by Peter Henlein in Nuremberg ("The history of wearable Computing"). One of the next interesting steps towards today concept of wearable computing is Vannevar Bush "Memex" desribed in article "As We May Think " in 1945. Although it is not constitute as wearable technology, it is used to increase user's memory. Modern concept of wearable computing is also based on this idea. "Memex" is a private file or library that should contain the records, books, correspondence, and based on its flexibility provides easy content accessibility, and serves as a user memory supplement (Bush, 1945). In the modern sense, wearable computing has been used for the first time, for the prediction of the outcome of roulette, by Ed Thorp and Claude Shannon's in the year 1966. The wearable computing device made for this purpose was worn in a shoe (Miller, 2012 ; "Wearable Computing").

In the 21st century, the concept of wearable computing is far more complex. Since first pocket watch and "Memex", the wearable computing concept is being developed as a technology that should be able to swimmingly help user in fulfilling various tasks. It is not enough that the device is portable, easy to use and provides information on the complex demands placed by the user at any time. It is necessary that it simultaneously and continuously provides information to the user through the process of feedback without disturbing user during his task fulfillment. The emphasis is on a greater synchronization that in the future should be complete. In 1981. The Steve Mann designed a backpack based on wearable multimedia computing system. Part of this technology is the display, which is worn on the head and covers one eye. The display supports text, graphics and audio. The concept allows the user to work with variety of computer applications while on the move performing other activities. Later, 1999th Mann has created EyeTap digital eyeglasses that collect video data from the surrounding, then sends data to a computer which processes it and delivers back to the glasses in such a way that real picture is replaced with processed one. It is the beginning of creating so-called AR (augmentative reality) known as enlarged reality. Mann has continued to refine the prototype of the glasses with the help of sophisticated new technologies that have since become available ("Wearable computing"). In 2014. this idea is modified and commercialized under the name Google Glass.

Defining the wearable computing concept:

"Wearable computing is the study or practice of inventing, designing, building, or using miniature body-borne computational and sensory devices. Wearable computers may be worn under, over, or in clothing, or may also be themselves clothes" (Mann, 1996).

Mann later expands his definition of wearable computing, and binds it with concept humanistic intelligence. Humanistic Intelligence is an inseparable intertwining of computers and humans. Wearable computing is the embodiment of humanistic intelligence and comprises three components: stability, increase and mediation (Herzog & Witt, 2007). Further, one of the founders of the first International Conference of wearable computing called the International Symposium of Wearable Computing is Thad Starner also believes that wearable computing is a term to describe a system that is able to be at all times available to user with use of feedback loop. Specifically, he believes that wearable computing should be able to "observe and model the user's environment and the user's physical and mental condition (Herzog & Witt, 2007)". Definition of wearable computing is subjected to changes in accordance with the development of technology. To better understand the concept it is necessary to determine the elements that underlie this technology as follows (Herzog & Witt, 2007):

- **The operating system is constant**- system has a role of secondary support that is always available for providing useful functions to the user.
- **Seamless integration with environment**- system in not an obstacle and does not interfere with the user as he performs other physical tasks.
- **Context awareness**- system is sensitive to changes in the environment and the changes related to user.

- **Flexibility**- during application operation system can automatically adopt interaction style in order to reduce mental effort of the user.

3. REVIEW OF WEARABLE COMPUTING IN EDUCATION

Wearable computing technology is entering an era of commercialization, but still has not become an inseparable part of higher education. Wearable computing in education is mostly used in small temporary research groups. This technology is still away from the usual learning applications, such as desktop computing. According with specified, this part of the paper will provide a brief overview of the current wearable computing use in education. Use can be for learning about new technologies, manipulating campus environment or as a learning tool instead of classic learning materials like books and desktop computers. There are cases that can even be used as a aid for students with disabilities.

3.1 Wearable computing for learning technical sciences

Most famous example for learning new technologies is use of Lily Pad Arduino in education. Lily Pad Arduino is a wearable computing tool introduced into the market in the period of 2007-2009 year. It is based on microcontroller panel (ATmega168V ATmega328V I) which can be sewn to different textile materials. This tool was designed by Leach Beucheley and Spark Fun Electric. Range of products are wide: heat sensors, light sensors, MP3 , battery, LED White, accelerometer and more, and they can measure different variables. while connected with Arduino Software to a computer. This way, user gets all the information on collected data trough Lily Pad system (official Arduino Website). Leach Bulechley and colleagues conducted an experimental workshop based on Lily Pad tool. The idea was to implement a process of gaining knowledge of the electronic, programming and computer-based e-textile technology as part of wearable computing technology in workshop conducted at the high school population. Although, the authors believe that Lily Pad can be used in university education programs too. The paper disclosed the observation that the female population has lesser tendency to choose computer science programs. This kind of creative teaching in secondary schools can increase the number of women who will choose to study computer science at faculty (Buechley et al., 2008).

Similar example is Grace Nagai's work in 2010. Nagai and associates conducted a study where the wearable computing technologies are used for teaching robotics. Also, the practical work is carried out on the secondary school students, but the authors at the very beginning as well in the conclusion argues that this program is suitable for the use in higher education. Platform is named TeeBoard. As in the case of Lily Pad technology it represents a synergy of textiles and electronic components. The difference from the Lily Pad concept is in programming language, which is in this case adapted for users with no previous programming experience and knowledge of the C language. For that purpose Brick Layer graphical text-based program was created in Java Script that can be run by Web browser. The student do not types commands in C language, but use descriptive predefined structure called "blocks" or "bricks" that uses graphic text logical unit. User arranges "blocks" on a computer in that manner that they represents command path for wearable computer sensors on T-shirt (Nagai et al., 2010). Educational benefits from this program are the same as in the previous example.

3.2 Wearable computing for automatization of classrooms and campus environment

Another case of wearable computing application is done by Ho Park (2008) and associates from the Korean Institute for Advanced Science and Technology is development of advanced ubiquitous environment under the campus environment. This concept named U-TOPIA use different technologies: hardware/software, user interface, communication technology, and UFC wearable computer. The use is manipulation of environment like turn on/off devices and record scene. Interface called i-Trow was developed, which is based on the wireless device for recognizing gestures. In a separate control room devices that can be manipulated through this concept were set up. The idea is that individual can use wearable technology and wireless communication to assign commands to different intelligent devices. To make this idea come to life it has been developed an UFC wearable computer whose main characteristics are "modularity and sensitivity". UFC wearable computer designed to look like addition to clothes - buttons, necklaces, Zig Bee earrings (earrings with Zig Bee transceiver) was connected to the devices trough standard USB protocol. Another essential part of this platform is a wireless ring-shaped device for gesture and movement recognition.
This way students can use the wearable computing sensors to turn on and off music, amplified and mute music, turn off and on printer, watch pictures, send and delete files (Ho Park et al., 2008).

Cooter Willis and Sumi Helal are creators of model intended for blind users within the campus environment. This model does not cover learning process. It is merely a tool for the blind users in educational institutions.

The concept was created on the idea of the need to facilitate the movement of persons with visual impairments. The technology is based on RFID (Radio Frequency Identification) Information Grid in the framework of wearable computing model.

System used to notify the user about the location and distance of objects is RIFD tag placed on all larger objects in the environment as well as the doors and hallway so the better information could be transmitted to the user. NAVCOM belt containing Devantech SRF08 Range Finder was used as wearable computing element. This Range Finder can read the object distance from 3 cm to 6 m, with the ability to detect the distance of up to 16 objects. The above mentioned technologies can communicate with mobile phones over Bluetooth SPP connection. This concept should facilitate the mobility of blind students across campus (Willis & Helal).

3.3 Wearable computing as a learning tool

For the benefit of this paper, Wei Hsun Lee's and Chieh Kuo's work will be introduced as well. They propose the use NFC tags (Near Field Communication tags) as a ubiquitous platform for interactive learning. The platform supports NFC reading model, P2P (Peer-to-Peer) model and wireless communications. They are also supported by the NFC phones that can identify each NFC tag individually by its ID code. This model is proposed for use in education. Idea is providing simultaneous answers to questions from the professor at the end of the lecture, in order to determine how much students understand the lecture. The concept is programming NFC tags in responding manner A / B / C / D so students can gave answer to the professor questions using tags. Answers are given with click on tags, then sent via NFC phones and delivered with the help of Bluetooth to Notebook of professor. Thus, the results of the collected answers are given in real time by all students and they are shown up automatically on the professor Notebook screen. This way the teacher is very quickly able to assess how much students understand his lecture (Lee & Kuo, 2014).

Wearable computing can be used as well, for learning to play piano. PianoTouch system is Wearable Haptic Piano Instruction System that is used for passive learning. Wearable computing gloves with vibration motor on fingers can simulate movement needed for playing compositions. Laptop. MP3 player or mobile phone can communicate via Bluetooth with PianoTuch and control it by producing music output. Vibration on fingers that are coming from PianoTuch gloves indicate which finger is needed for playing note (Huang et al.,2008). The model proved to be very effective.

In order to a certain technology become an integral part of daily life it is necessary to become available for the masses, and easily applicable. As such wearable computing technology is not designed to be exclusively used at the university learning technology courses, but also to "serve the people and facilitate tasks (Duval et al., 2010)" in a much wider use. One of the conditions for its wide range of applications is to be accepted by users (Bergmann & McGregor, 2011). This is because it is expected from wearable computing technology to become an integral part of higher education in the future, as desktop computing is today. By far the greatest degree of commercialization this technology experienced is in medical and Fitness use.

The concept of wearable computing for the general population was successfully introduced by the company Nike. Product Nike Shoes Bluetooth, appeared on the market in 2012. Nike Shoes Bluetooth link Bluetooth technology with iPhone and iPhod Tuch trough applications to provide an overview of variables: such as strength, speed, number of exercises . ("Nike makes Bluetooth Smart sensors cool and fun"; "Nike Smart Shoes Communicate via Bluetooth"). Nike has introduced wearable computing technology to the general population and thus opens the possibility of using the same in the different segments of everyday life.

During last two years Smart Watches have been emerged on market. Smart Watches can use daily application such as weather forecast and news, remote applications like camera and thermostat, fitness applications, games and tools applications for measurements and calculations. Most of the watches allow viewing of messages, e-mail, and can be sync with Facebook and Twitter. The user can receive calls or dial the number for the remote connection and wireless technology associated with a mobile phone.

One more useful example of commercialization of wearable computing is application of wireless sensor networks ad wearable computing technology in medicine. Monitoring vital signs of patients using this technology becomes significant practice in medicine science. These examples point to the gradual commercialization of the latest technological achievements in different spheres of life. Education is only one of the segments in which these technologies with modification and adjustment may be applied.

4. APPLICATION MODEL FOR SMART GLASSES AND WATCHES IN E-LEARNING

Google Glass is currently the most interesting wearable computing technology available in the market and is designed for commercial purposes. It is the type of smart glasses which allows the user to input voice commands so glasses can capture what the user sees. Therefore they support commands without hands, and in real time share what the user sees. It has option to show the direction of movement if the user is lost, to answer questions and translate voice of user to foreign language (Google Glass website). The initial idea

is that the Google Glass can be use in educational institutions. In 2013. Forbes published an article in which Dr. Grossmann is proposing the application of Google Glass for medical student education.

The idea is based on consultations in real time where the student may request and receive instructions via glasses thanks to the transmission of visual and audio data. This can lead to serious consultation during surgery. To support his idea Dr. Grossmann made video footage showing the consultations with the student via Google Glass during the student surgical exercise on manikin (Nosta, 2013). Models that are proposed in this paper emphasize the usefulness of wearable computing smart glasses technology as a learning tool that should provide better and faster communication, exchange of data and knowledge in educational environment.

First model that is proposed in this paper is based on some features of Google Glass and possibilities for further modification. Some of the faculties such as Faculty of Biology, Faculty of Veterinary and Medicine, Department of Physical Teaching, Faculty of Pharmacy, Faculty of Medicine within their courses required field learning. At the Faculty of Biology and Faculty of Pharmacy, students do field collecting of plant samples. For them this model considers the possibility that smart glasses can provide in field learning process.. Google Glass allows connection with applications for mobile phones which are supported with GPS technologies. GPS and applications based on it can be used for its precision timing capability and position information. GPS option in conjunction with the transfer of data in real time with Google Glass should provide information about student's position on the field, so professor can easily form task groups for field learning. In accordance, it is possible for professor to simultaneously run multiple groups. GPS allows tracking of student's location and movement. Google Glass feature that supports text and audio setup further allow quick tasks and instructions providing. Mixing it with already mentioned idea of eye movement tracker it can easily provide readable information for student while he is moving. This model enables different groups setting at different locations at the same time. This would be feasible only if all the students and professor have Google Glass to work with. Each student would be capable to get instructions on his smart glasses and to ask additional questions if it is needed. This way real time communication allows the teacher to give useful advices while the student performs the collection of study materials from nature that are required for different works/tasks. With already mentioned option of asking questions and getting responses via glasses, thanks to the Internet and Wi-Fi, use of this model can further reduce the need for the professor presence on the field. Each time a student collect some materials from nature with the simple question asking can get basic information about the same material from the Internet on Google Glass. This way, instead sitting in a classroom and learning from books smart glasses allow students to learn in fare more interesting manner trough synergy of field learning, tutoring and text based information, all at the same time using modern technology. Another useful way of using Google Glass would be a simultaneous recording of certain material that the student sees and explanations given by the teacher regarding the same material. In this way the student is able to review the recorded lectures later, in order to better prepare for the exam.
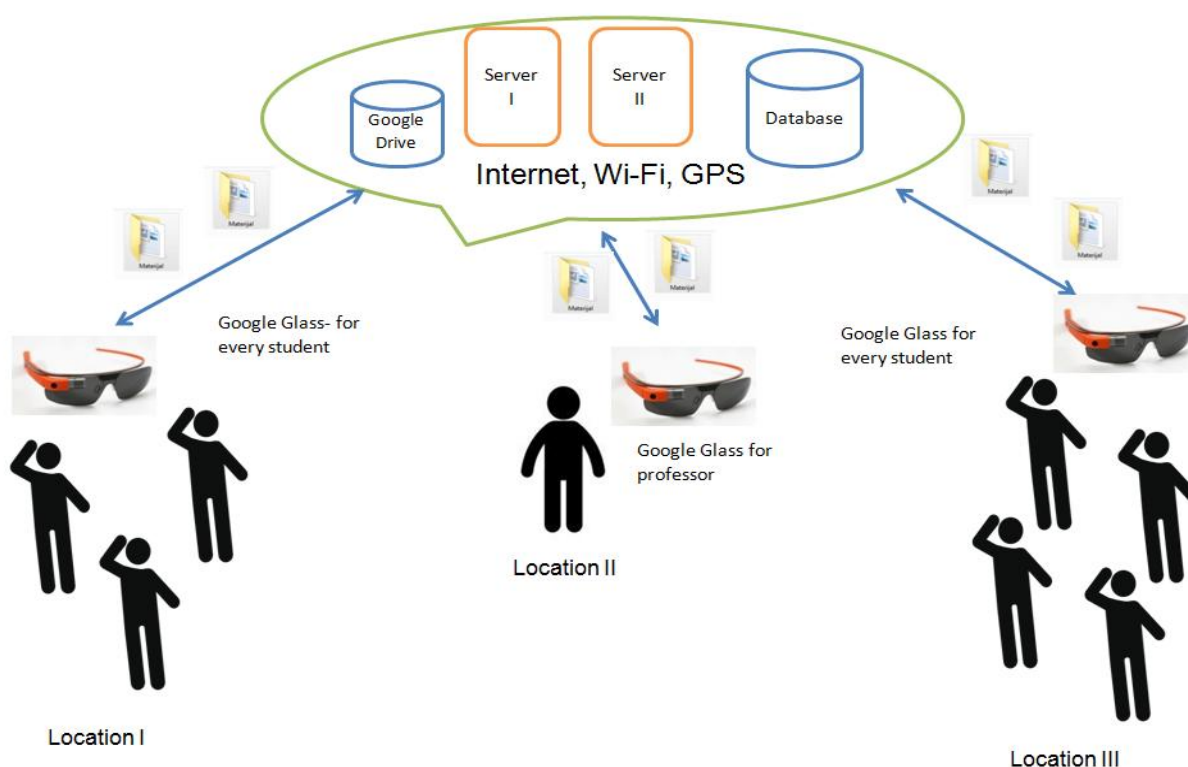

Figure 1: Communication between professor and students on various locations

Learning can be improved by fare trough motivating students to make their own scripts, from which they will later learn. Camera on Goggle Glass allows students to take pictures or record a particular material in real time. Information collected this way can be stored in a database that was created specifically for this purpose. Continue through questioning Google Glass (which has already been mentioned) a student can take information that considers most relevant, pare it with a particular image and store it in the script that is resembles to data storage. Student can manipulate collected information in the way that is most suited for him and for later learning. In the future it is expected that technology will recognize every material trough shapes and colors recognition programs. Today, recognition technology is primarily used to identify human faces (Hsu et al., 2002; Wang & Tan, 2002). These systems are expensive and complex. 2D Gabor, RBG color model SPD and other models that support this technology can be modified and applied in identification of plants and animals with smart glasses so that students would be able to see, take visual record and simultaneously recognize specific plants in real time, tanks to recognition program and Internet. Basically, students would get an answer about the plant/animal or some material trough recognition program and Internet on their smart glasses. If this application comes to life it would be indeed the application of augmented reality. As we can see Google Glass can be modified and used in a far more complex manner then they are used at the moment, and that applies even if we do not add any new features and performances.

Second model is based on the combination of Google Glass with Smart Watches and NFC tags used in classrooms. Faculty can allocate the necessary funding for certain courses and endure students with Smart Watches for personal use. These watches should facilitate communication with teachers so that students will be provided with working material and teaching schedule on the Smart Watches. Updating information on them will be enabled through NFC tag that is placed on all tables within the classroom or amphitheater where lectures and exercises are held. By leaning Smart Watch to a NFC tag automatically via Wi-Fi technology materials are updated as well as class schedules. NFC tag is associated with database of a certain course which holds and preserves data in the Cloud environment of the Faculty. Model diagram provides an example of Cloud environment of the Faculty that is base for communication with students. It provides all the necessary information and data for the teaching models of e-learning.

Communication with students can be improved with NFC tag and Smart Watch. All information would be provided to students using NFC tags and Wi - Fi technology for updating data on student's Smart Watches. The teaching team is the one who is responsible to create the necessary data and input it to the Cloud environment. It is understood that the Faculty has its own web site for sharing information as well. First, professors need to prepare the data for Interface from which website is going to be updated with fresh data. After passing the data into the appropriate form it is ready for downloading over the NFC tag. Idea is to allow all students with Smart Watches to easily and simply, in the shortest possible time interval come in possession with working material immediately after the lecture. NFC tag can be programmed to recognize the ID of each Smart Watch and thus can be used for the keeping evidence of student's presence at lectures and exercises. Data on keeping presence evidence can be storage also in Cloud space database of Faculty. Model also assumes that the students have a Google Glass that can be connected to their Smart Phones.

With modification of Google Glass and installing sensors to recognize the device ID similar as in NFC tag, it would be possible to achieve communication between the Smart Phone and Google Glass. Smart Watches have touchpad. After connecting the devices via Wi-Fi networks, using a touchpad screen student can issue a command to transfer the material from Smart Phone to Google Glasses. Also, in order not to interfere with another student task one can use touchpad on Smart Watch for commanding Google Glass what text student wants to follow up and read at any given moment on a screen of Google Glass. The final process of communication is between Google Glass and Google Drive in Cloud environment. Google Drive allows storage of documents in Cloud environment which reduces the memory usage of the Google Glass and the student is able to access recorded documents anytime and anywhere if there is a Wi-Fi network. This model must be supported by 3G and Wi-Fi communication.
Next graphic represent communication flow between students and professor using Google Glass.
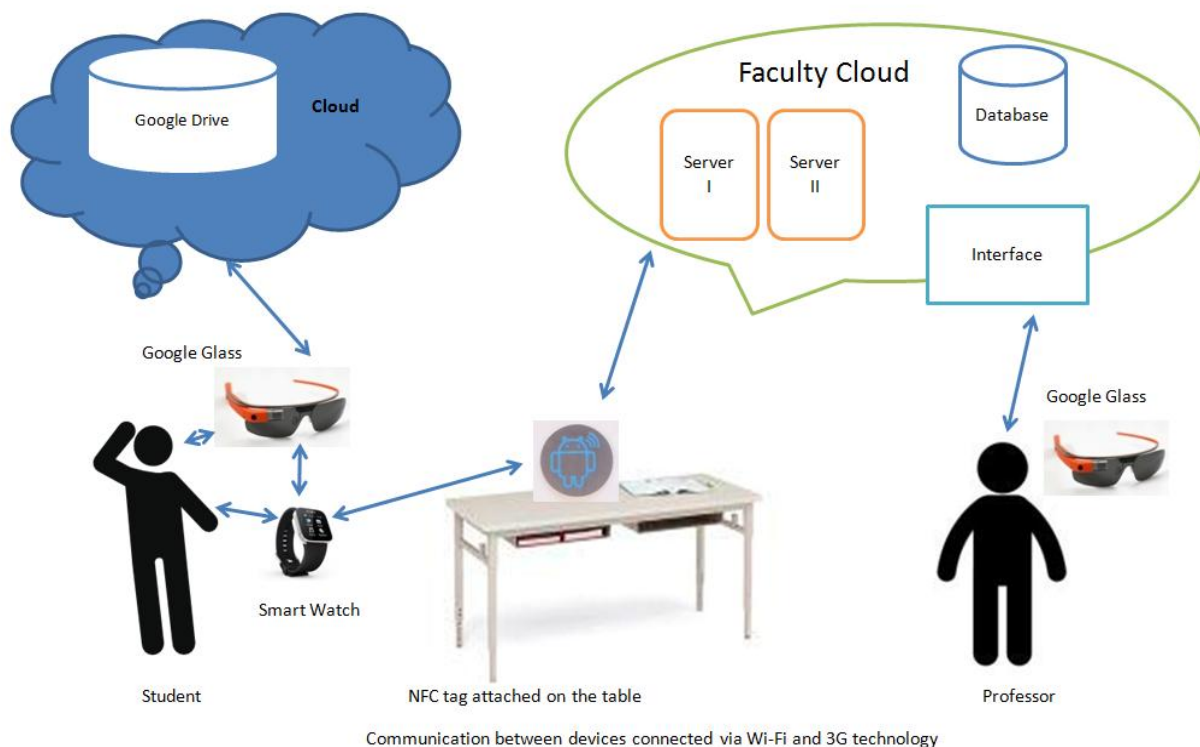
Figure 2: Information flow via Google Glass in classroom

6. CONCLUSION

Wearable computing technology is a concept that is not fully reached its potential in any segment and especially in education use. At this point some of the essential characteristics like context awareness, flexibility and Augmentative Reality are not fully met. As far as its use in education there in not enough papers with implementation models so in that field there is a lot of free space for research and for proposing something new. Models presented in this paper are not perfect but can be god "milestone" for future research. There are some good sides and bad sides of these models. First of all models we gave are intended to lower barrier between old educational systems and new technologies. Further, using wearable computing in education can really help to create even better communication among students and professors and it can be the key to create new successful generations. We live in the time of fast information so we need to provide adequate access to it in educational environment as well. The first model emphasize to applicability of the wearable computing at different locations at the same time. Second model more highlights the need for faster information flow. The good side of second model is uniformity of the process of obtaining information which can help students and professors because there is no much space for incomplete information awareness and communication loops. Represented models are based on idea of using wearable computing for all students not only for the one with technical knowledge and programs. Wearable computing should allow easier and faster communication both between teachers and students and among students as well.

Bad side of these models is time that is needed to make them work. Further, students and professors are needed to be trained to use wearable computing technology. From professors is expected to update their materials on time without delay. Face to face communication is minimized and it can be negative in psychological manner. In larger student groups there can be cheating with the registration of present students. Professors should after registration is done by students count number of students in classroom and number on registered Smart Phones and then compare obtained information. The good side of this model is idea of pushing wearable computing technologies in educational purpose so the information flaw is better and the productivity is higher in all faculty activities. Regarding to all, proposed models need to be further developed in accordance with the available technology and knowledge.

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IMPROVING OF THE QUALITY AND RELIABILITY IN THE DEVELOPMENT OF THE SOFTWARE SOLUTIONS

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Abstract: *The software engineering is aimed to finding renewable, anticipated processes or methodologies of the software solutions. The methodological proceedings improve the quality and the reliability level of software, whereat all quality factors are grouped in the unitary paradigm, which determine software solutions of the modern software development, and they are oriented to reusable assets.*

Keywords: *the quality and reliability of the software, object oriented programming, component programming, reusability assets.*

1. INTRODUCTION

Modern software engineering deals with the process of software development, with theoretical knowledge, practical procedures and proper conducting of development activities. Software engineering passes through a large number of researching and practical phases. The quality of a software product is evaluated and estimated many times, whereat the three most important aspects are: the quality of the software according to user's perception, the quality of the software process production and the quality in the frame of business environment where the software will be used, whereat the software products will be estimated, the maintenance and developing methods. Generally, the software quality is estimated only by mathematical models, which include defects measuring in the programmed code, the number of dismissals (termination of performance or program failures) the time required for software development, with reference to finding and fixing errors in the software code.

2. COMPONENT AS A BASIS OBJECT-ORIENTED (OO) PROGRAMMING

The object oriented approach to the development deals with objects as independent and autonomous units, in which the whole partially participate in making software. Formally the objects make components, which contain single solutions, in building up complex and demanding Software. The basic approach of this development is to select, configure, to specialize and to figure a new software program which is being built. The components are very dependant on their size, complexity, functional and technical possibilities. OO programming has raised the quality of software solutions on a higher level and it contributes to formalize the develop software for multiple purposes. OO software development is about methodological, modern and flexible technology that provides solutions to create a better quality of software solutions and software development too. Only the OO programming provides tools and techniques of multi-functional software solutions (Reusability assets-R) i e components that depend of precisely defined methodological activities: production methods, R management, infrastructure, placement and using of R values.

The quality criteria are numerous, but generally they are divided into: internal and external criteria. External criteria (speed of software performance, simplicity of appliance, interface and functionality of software solutions) are usually in the interest of the final users. The interest of professional programmers is based on internal quality criteria, such as procedures in the implementation and distribution (reusability, scalability and robustness of software components, which are independent software units). The quality of external criteria is based on the quality of internal criteria. ''The ability of an program unit (program, class, subprogram, method) to work out according to its specification, whereat the specification means the precise description of what the program unit needs to do, it's called ''the correctness''[A], which is the most important quality criterion of OO engineering.

3. IMPROVING OF SOFTWARE QUALITY

Improving of software quality (Software Quality Assurance SQA) is a multidimensional concept. It requires measurement of many parameters in determining of potential targets and limits of the software quality. It is particularly complex to specify which parameters have to be measured and to provide testing of software system according to the specified outputs of software quality all of processes during development or project documentationfor supporting. It is necessary to specify all the measurement parametersand provide testing of a software system according to the specified outputs of software quality.

The research quality range can be extended to different aspects of business skills, where the software is integral part. Accordingly, we assume that the technical improvement of business and working environment reflects automatically the business value.

In this respect, setting the software features standards, to follow it, analyze and specify the target to achieve the specified outputs, are part of the practice software standardization. Some of the standards in the frame of international defined(International Organization for Standardization-ISO) as ISO 9000[B](Information Technology) or JUS/ISO 12207[C](Software life cycle processes) then (International Electro Technical Commission-IEC[D]). ISO/IEC 9126 international standard of the software quality is divided into four parts (ISO-9126[E]) which analyzes and defines:
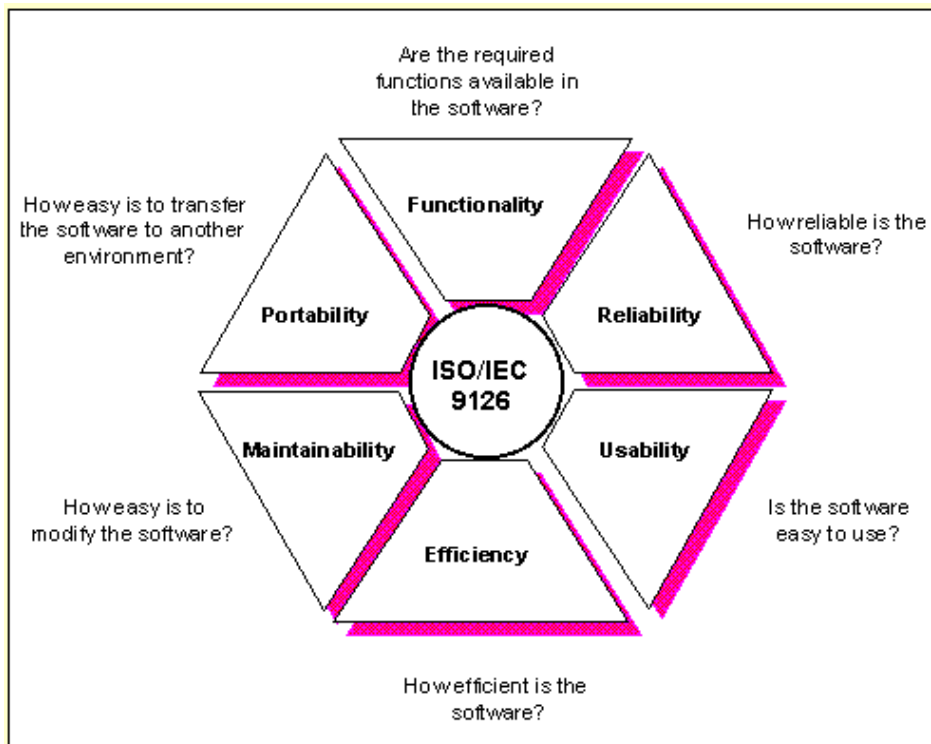

Figure 1:ISO9126software qualitymodel[F]

- ISO/IEC 9123 1 quality model
- ISO/IEC 9126 2 external software metrics
- ISO/IEC 9126 3 internal software metrics
- ISO/IEC 91264 quality in use metrics

According to the quality model ISO/IEC 9126[G] each subfeature affects on one basic feature on a higher level.

The evaluation of software quality should be specified on the standardized features, which ISO/IEC 9126-1 defines in the six most important attributes of a **good software system**:

1. Functionality
2. Reliability
3. Usability
4. Efficiency
5. Maintenance
6. Portability

Each attribute has a set of elements that can be measured using internal or external software metrics. To evaluate software products, primarily means to assess its reliability, which is reflected in the two most important factors: complexity and size of the program. The typical variables in which the values can be readout are:

- Total number of errors
- Length of program- thousands of code lines (KLOC)[H]
- Thousands of non comment source statements (KNCSS)
- Number of errors in the date inputs
- Number of different operators (keywords)
- Number of different operands (data inputs)

The complexity of programming task slows down its development and maintenance also. The natural complexity of the task may be very different from the evident complexity of developed program for this task. Software is a ''discrete'' system and it is essentially the cause of its complexity. The software product is measured in metrics from different aspects, and it precisespecific actions and realistic information in:

- Preparing of the specification of contract obligations
- Checking of software specifications
- Maintenance and costs checking
- Improving of productivity
- Improving the quality
- Reliability increase
- Basis defining for further predictions
- Requirements for new software tools and additional training.

The complexity and the ''discretion'' of the software system sometimes creates a confusing situation by using the terms software measurement and software measurement and software metrics. We would like to say that the software metrics involves quantitative measures derived from attributes in the software cycle, in mechanical or algorithmic way, so it doesn't depend on device which is measured on the quality of software, whereby it can be: a human, hardware, software or any similar combination. Measuring of software products provides:

- Objectivity, reliability, security, accuracy, suitability, uniformity, formulary process and process of logical thinking
- And not at all measuring by intuition.

The most prominent objective-formal attitude of software development is represented in ''Program-based components''. (Component-oriented programming-COP)[I]Components programming enables unified implementation, software development methodologies, but it is not always completely. The development of the internal part of components is similar to the development of other types of software (OO, structural etc). On the other side, the development of the external part of components is still relatively unexplored, and there are no excellent solutions for some component features:

- Define the connection between the components
- Distribution (clustering) components of the physical parts of the system and
- Time independence of running components (how to continue the performance of distributed applications if a component isn't available).

4. THE METHODOLOGICAL FRAMES WHICH JUSTIFY THE PROGRAM UTILITY BASED ON COMPONENTS

Building of methodological frames and models that prove the improvement of software solutions can be described as a difficult task, because it isn't included all of factors which can be measurable. Which tasks in development or maintenance will be planned, and how it will be implemented, it is estimated in costs and benefits analysis.(cost/benefitJ). This model takes into consideration the positive and negative factors that get into the analysis of total costs and benefits, and that indicates if the planned action is recommended. The costs/benefits analysis is carried out with financial support. If we want to include the intangible items in the analysis, then we have to give a valuation for the same, you will inevitably include the subjective factors in the measuring process. Yet, in accordance with all aspects of measurements and assessment, cost/benefit analysis is the best technique in the process of deciding if the R is deserved investment.

R metrics, define measurable categories, valuation software products, with its indicators are reflected in continues monitoring of cost/benefit connections, during the development and maintenance of software systems. The metrics assess the segments in which the R software shows a positive result, as evidenced by a group of 6 metrics:

- The quality, productivity and metrics of time-to-market
- R metrics economy
- R metric library
- R metric products
- Re-use of the metric values

The primary results such as quality, productivity and time coming out on market are used as input parameters for the economic model of software reuses. All other metrics contribute to the primary.

5. METRICS OF REUSED CURRENT VALUE

The reused software is proved by metrics of reused current value and R metrics. The formula realizations of R metrics define measuring of the following parameters:

A. Metric size: measuring the size of R values
   Measurement: KNCSS values R
   Benefits: provides useful measure of capacity in planning R
B. Number of R for each value:
   Metrics: Number R in relation to, the time until
   Benefits: Measuring the frequency of R values. The low frequency may indicate that the required re-engineering values and the efforts should be directed at the reusable R values, and the functions that they perform.
C. R Metrics:
   Metrics :Measurement of re-utilization of value based on fundamental R characteristics. Such marks can be subjective appraisals by user (excellent, good, average, meager, poor), while there is a way to get R metrics to be evaluated by automated tools.
   Benefits: The characteristics are identified which creator of R values in particular way emphasizes to fulfill the needs of users.

The measurements of the R size can be numerous. It is listed six models that define R metrics are sufficient to demonstrate the advantages of software built on R values. The methodology defines accurately and thoroughly all steps of a complex research of this type known by the name ''the goal questions-metrics''. This method is basically every metric and the research always begins and gradually leads to pre-approved methodology steps of this method.

(The number of errors and thefailureofthe program)
Quality R = --
(KNCSS thenew software) or (KNCSS inR-values)

R metrics defined measures the concentration of defects in the application program:

1. It is compared the concentration of errors in R values in the new software, whereat the better quality on a higher level of participation in the new software program.
2. It is determined the level of concentration errors before and after their integration of R values in the project of development, taking into account the errors appear additionally due to the integration of R values in the new product.

(The number of errors and thefailureofthe program)
Quality R= --
(KNCSS in softwarewithoutR) or the(in the software ofKNCSSR)

Figure 2: Formula of the new program quality with or without the R value[K]

Preponderance of errors significantly reduces the quality and reliability of software. The sharing of R values and its integration into new software products, from technical point of view, requires an analysis or other additional parameters through the following information:
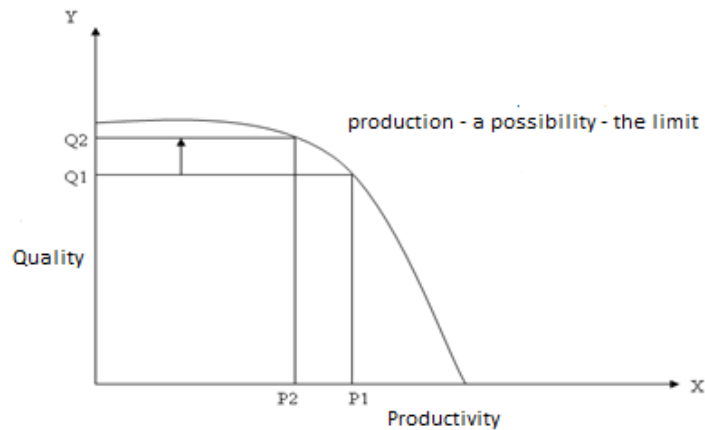
Figure 3: Mutual exclusionbetweenquality and productivity[L]

- Functionality- the area in which the program fulfills the user's requirements. R components can quickly create a prototype that will allow changes to the functionality of future decisions on the fly, during the current development.
- Accuracy- the level in which the software is released from extra efforts of designing and coding errors because it is constantly tested and reused.
- Reliability- the degree or reliability and accurate performance of certain functions with minimum glitches.
- Performance- the successful implementation of R program as an adequate response on time. The maintenance ability performance is under various conditions for a specified time.
- Usability- the application software is friendly to users, easy to use and learn, the user procedures are fast executed and it is easy to prepare and to interpret the input and output parameters.
- Localization- R values have the foreseen functionality for certain volume of business, but in the specific locations of application software emerging the requirements may be modified, where the necessity appears for regional users.
- Support- of maintainability R software. The engineers creators of R value takes over and the process of their maintenance. Under these conditions, the cost decreases per unit of product.
- Flexibility- R software provides the ability to modify the system requirements. Only changing parameters of the R component, is sufficient to modify the output values of R.
- Integrity- reflects controlled an authorized access to software or data.
- Testing- testing to fulfill the requirements of the program proves the achievement of the planned functionality.
- Portability- meet requirements of transfer programs from one hardware configuration or operating system to another or the ability to transfer between different working environments.
- Strong operational R software raises the level of interoperability of software, because the components of the re-handling routines are used by other systems. Therefore, the time and effort which are invested in the development and debugging of the original components of individual modules, which are used many times, und it is ultimately worth. The cost is amortized on a large number of component usages, which indicates the viability of the usage.

Comparison between quality and productivity provides a choice of outputs and inputs. The output is limited by comparison of these two parameters. The production graph is limited with labor, time, and capital, where input produces alternative exits. ''Curve- production-possibility-boundary'' as it is shown in the chart tells about the production, which gives a choice of thresholds of productivity or quality, which is mutually exclusive to a certain point. If we illustrate by the following picture, we can say that the effort involved in achieving the quality product Q1, entails a certain level of productivity P1. However if you would like to make some mistakes and weaknesses, and raise the level of quality in Q2, it requires the additional labor costs and time, which would otherwise bring down the level of productivity in P2. The company management according to offered parameters should decide which threshold wants to implement, higher productivity, lower productivity or vice versa R components dampen the benefits of raising productivity and quality of new software products but sometimes priorities need to be defined.

6. RELIAIBLITY IN SOFTWARE DEVELOPMENT

The methodology which estimates the **quality** of its **software** processes tries to raise the quality which also affects the raising of **reliability** of **software**.By analyzing the factors, it helps to improve the quality of the end-products usability. The equation measures these factors.

The semantic meanings of the terms are:

C_d -   price debugging
t -   estimated lifetime of the software product
f -   relative frequency with which the components are executed
E - tf -   number of repeating the code that will be executed
p -   assumption that the component contains an error code
r – fp - reliability or assumption of errors causing product
c_f -   price for code of broken code components
K-   1000 fold passage through software
     (Note: all formulas are the references[M])

It should be determine breaking points that represents the value of going through the lines of program code for debugging, is equal to the expected cost due to defects or errors or when the component code uses only one product:

$$C_d = Epc_f$$

If the component code is potentially multiple times in the N product, then the total number of performance components was:

$$E_{total}= \sum_{i=1}^{N} E_i$$

Thus, the breakpoint when the component code used in the N product is:

$$C_d N= E_{total}\ pc_f$$

Because the Etotal > E to be exactly Cd N ≥ Cd. More pieces of code are executed, the higher cost of lurking bugs in the code that can be justified, until they are amortized in a number of use. R cannot afford more debugging to reduce P ie assumption is that the component contains an error, which improves r ie reliability of a software product.

1. If we assume that we have a software component that is reusable, we can perform analysis of quality and reliability, according to the proposed methodology.

c_f = 80€.
E= 10.000 performance
P= 0,001 presumption that contains an error

Then C_d = Epc_f
             = 10.000 x 0,001 x 80€
             = **800€**
     price debugging components

(Reliability) R =fp=10,000*0.001= 10is the number ofthe assumptionsthatthe component codecontains an errorafter10,000repetitions:

    80 € /10possible numberof detectederrors=8 €,   which   is   the   pricefordebugginga   single passthroughthe codecomponents.

If the cost of the development program lines of code is ie components that may contains an error, € 80, with 10.000 replications discover 10 possible errors, then the reliability is extremely high after the passage of 10.000 lines of code in the program. Price for each debugging is 8 €. The more debugging or going through lines of code, the less opportunity for error and greater reliability software solutions(R), which is seen in the following formula:

R = fp = 1.000 * 0.001 times passes assumption errors = 1
R = fp = 10,000 times passes * 0.0001 assumption errors= 1

2. On the basis of these analyzes, we make a conclusion, that the cost fo 8 € to pass through a single component should not be justified. On the other hand, if the software component of the real potential for R (re-use) of three products where a component is executed 10H, 20H and 30H times, recognizing that cf=80 € and P= 0.001 then:

$E_r = E_{pi} = 10H + 20H + 30H = 60H$
$C_d (3) = 60H \times 0{,}001 \times 80€ = €4.8H$
$E_{pc_f} = 60.000 \times 0{,}001 \times 80€ = \textbf{4.800€}$

Reliability R = fp = 60,000 * 0.001 = 60 is the number of assumptions, it is possible to detect an error in the code components after 60,000 repetitions, 80 € / 60 = 1,33 €, which is the price for debugging a single pass through the code.

The mathematical expression confirms that the 6-fold increase of debugging is a reasonable cost price, which is given 6 times repeatedly, passing through the component code, and it don't increase the reliability of software. If the € 80 cost component code is, and we assume that there are mistakes, and we have calculated that the assumptions of possible 10 errors in the code after 10.000 repetitions 8€ is a price for each pass through the code during debugging. However, if the same code is used in three organizations, and each has 10.000, 20.000, 30.000 passing through the same code, so debugging is 6 times increased, in which case the value of 1.33 €is an extremely low cost per debugging passing through the code.

5. CONCLUSION

The scope of the research quality of the software system business is the legal capacity, whereat the quality depends on the products and services which are provided by complex business systems, where software is an integral part. Therefore, improving the technical quality of software operating environment, reflects the business value of complex business systems.

With this methodology it is estimated the quality of software by their actions and it tries to raise not only the quality but also the level of reliability of the software. Analyzing the factors of improving the quality in the most rational and efficient war, it is amortized the R component, which participates in the development of software applications, which increases the quality and reliability of the final product of their used time and the effort in developing and debugging the original reusable components is shortened and it is multiplied in its use, since the manifold usage justifies the time spent for building, debugging and testing of components because the components are already prepared as a partial software solutions. The rational use of your time gives a space to perform quality, reliable and comprehensive analysis, which usually requires more resources and time and expert, which affect the proper development of the project tasks. The quality and reliability in the development of software solutions assimilated paradigm Reusable Assets-Component Software Development.

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SOFTWARE SOLUTION FOR THE PRODUCTION QUALITY MONITORING

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Abstract: *This paper presents the main elements of the development of a software solution for monitoring the quality of production during the execution of the production cycle. Controlling elements are based on the tracking malfunctions which can be seen at the assembly of the final product. The specificity of the present software solution represents the monitoring of workers and supervisors in the analysis of production quality. Monitoring the quality of production during the execution of the production cycle has a wide range of implications for the organizational elements of the company and production planning. Analysis of malfunctions during the assembly of the final product significantly improves the quality of production, shortening of the production cycle, as well as a more efficient choice of suppliers and elements for installation. The software solution presented in this paper is designed in such a way that it can be universally applicable to all forms of industrial production at the assembly of the final product.*

Keywords: *Software Development, Information Technology, Quality Control, Production Cycle, Production Analysis*

1. INTRODUCTION

Analysis of production quality is one of the most important elements of industrial production. Quality creates one of crucial factors in the placement of the final product. However, analysis of the actual quality and identified defects during production significantly affect other business segments. A large number of identified deficiencies in terms of poor installation inevitably implies a number of organizational and technical measures in terms of the improvement of the production process. Reduction of certain defects during production affects the shortening production cycles due to eliminating the need for subsequent finalization of the finished product. Also, the improvement in the production process results in adequate production planning, management of human and material resources, as well as achieving financial effects.

Considering the importance of achieving quality production, to this issue is given great importance. Mitra (2012) this issue of improves by a statistical approach to the analysis of quality. Modern methods of quality control include numerous methodologies (Wadsworth et al., 2002, Besterfield, 2004, Christensen et al., 2007).

The analysis of production quality a number of authors highlights with the different approaches, introducing new improvements in this area:
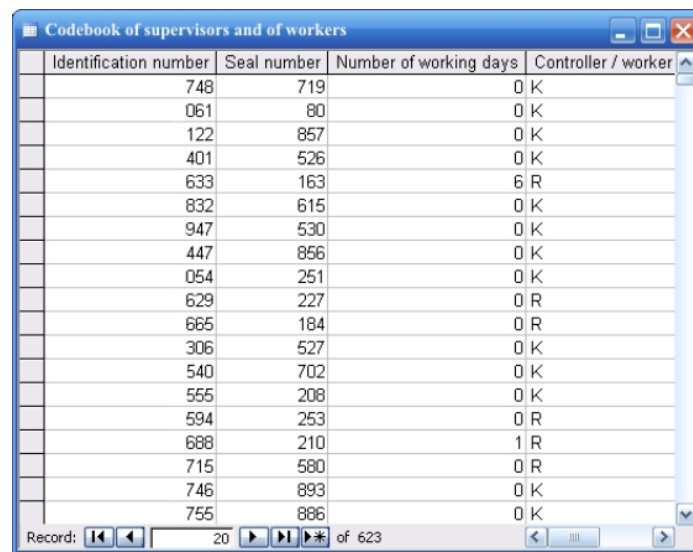- Various quality techniques for manufacturing (Reece, 2007)
- Implementation of quality control stations (Shetwan et al., 2011)
- A modeling approach for quality control (Weiss, 2013)
- Quality control model based on danger theory (Zhang et al., 2009)
- Implementation of n-line quality control (Pan et al. 2009)
- Implementation of intelligent quality control system (Zhao et al. 2009)

An essential element of improving production quality control is the implementation of information technology. In this sense Demant et al. (2012) highlight opportunities of visual quality control in manufacturing. Chen et al. (2010) accent of consideration set to the application of data mining technology in the analysis of quality control. Certainly one of the most important elements of the application of information technology refers to the automation of certain segments of quality control in manufacturing (Maki & Teranishi, 2001).

Software solution which is presented in this paper is a computer support for monitoring and analysis of quality of products at their final assembly, as well as individual components of the installation. The specificity of this approach is based on recording of product quality and registration of certain defects during the manufacturing process. In addition to timely response, in terms of subsequent finalization of finished products and elimination of identified deficiencies, this approach also aims to analyze the production process and improve organizational and technological elements of production.

2. REVIEW OF THE SOFTWARE SOLUTION

The basic elements of a database of the considered software solution are based on records of individual malfunctions, control elements, as well as information about workers and supervisors who participate in the monitoring of the quality of production. Figure 1 shows the Codebook of workers and supervisors with their basic data, which is one of the original table for the analysis of the results of the monitoring of quality control application. The structure of the code list table is based only on basic data on workers and controls, directly relevant to the activity of monitoring the quality of installation. Through the relational model, these basic data can be linked to other tables in the database of integral information system and thus obtain other information about the workers and supervisors who participate in this activity. Registration number of workers is the unique identification number of workers or supervisors in the entire enterprise information system and the primary key of the table in the function of connecting with other database tables. Seal number of workers or supervisors means the identification number of workers at the check list in monitoring of quality. The table includes the number of working days for monitoring quality control as well as required field which defines the worker or supervisor.

Figure 1: Codebook of supervisors and of workers

Table with control elements is a database table for quality analysis of installation. In addition to the primary key which uniquely marks individual pre-defined control elements. The specificity of records makes points of workers and supervisors for indicating the importance of individual malfunctions. The table contains predefined values for expressing the importance of identified eventual malfunctions over individual elements of the control. Figure 2 summarizes the structure of this table.

Figure 2: The table of control elements

The table Irregularities is the most important table in the database intended for monitoring the quality control of installation, Figure 3. In the table records are kept on concrete individual control elements which represent sub-assemblies in which the specific defect was observed. Basic data which constitute record of individual malfunctions are, in addition to the elements of control and identified malfunctions, the identification number of each product, the date of inspection and the number of seals of workers or supervisors. Data is automatically joined values of some important malfunctions in the Table of control elements.

Number of product	Date of Inspection	Element of Control	Malfunction	Number of worker seals	Number of controller seals	Workers points	Controller points
7555835	5/9/1998	Corrector	Leakage	59	134	0	0
7555835	5/9/1998	Corrector	Leakage	15	134	0	0
7555735	5/9/1998	Sunshade	Bad installation	229	884	1	1
7555735	5/9/1998	Basis of clutches	Adjusting	105	672	3	3
7555735	5/9/1998	Basis of clutches	Adjusting	19	672	3	3
7551751	5/11/1998	Corrector	Harsh work	59	134	0	0
7551751	5/11/1998	Conductor	Poor performance	105	672	0	0
7551751	5/11/1998	Conductor	Poor performance	19	672	0	0
7551751	5/11/1998	Filling with oil	Inadequate level	153		3	3
7551597	5/11/1998	Dashboard	Deformation	28	184	0	0
7551597	5/11/1998	Floor mat	Bad installation	115	884	1	0
7551597	5/11/1998	Floor mat	Bad installation	28	884	1	1
7555837	5/9/1998	Glass lifters	Harsh work	25	884	3	3
7555837	5/9/1998	Corrector	Leakage	15	134	0	0
7555837	5/9/1998	Conductor	Poor performance	105	672	0	0
7555837	5/9/1998	Conductor	Poor performance	19	672	0	0
7555837	5/9/1998	Basis of clutches	Adjusting	105	672	3	3
7555837	5/9/1998	Basis of clutches	Adjusting	19	672	3	3
7555837	5/9/1998	Floor mat	Bad installation	255	884	1	0

Record: 20 of 294

Figure 3: The table of data on individually identified defects

Based on previously entered data, the software solutions enable creation of a number of reports, by which in different aspects can analyze required information on quality control. Figure 4 shows a report of improprieties with other related data, grouped for specific final products. This allows the analysis of all malfunctions identified over certain products. Additionally, of great importance are the reports by which the observed malfunctions are grouped according to individual elements of control. This analysis is carried out on certain sub-assemblies with the associated disadvantages. This analysis affects the selection of individual components and determination to a particular supplier in terms of quality. A large number of malfunctions, which indicate poor installation, implies different measures for improving individual operations of installing, to the structural and technological improvements.

Figure 4: A report on irregularities grouped for specific final products

When considering the quality control of the presented software solution, accent is placed on the statements relating to the monitoring of work of the supervisors and workers in the process of monitoring and failure analysis. Figure 5 shows the data report only about the controls in this activity. Based on the number of seals, controllers obtained automatically, through the rest of the most important information, information about the controls, by establishing relational links with the table codebooks of controllers. Reports are formed grouped for individual controllers, where the information relates to a summary presentation of the acquired points of controllers, regarding the importance of identified malfunctions. In purpose of analysis the controller operation, an important information is a summary presented number of working days for control on this activity and achieved points in relation to the number of working days. In this way can be evaluated the work of controllers and their contribution to the detection of deficiencies in the quality control of production. Based on the displayed personal identification number of the controller, by establishing relational links to other tables of the integrated information system, it is possible to obtain all other necessary information about them. In the same way enables creating reports about the workers, by which can be evaluated their work in the quality control activities., Figure 6.

Figure 5: Report about the controls

Automatization of the report creation about the controls is performed by placing a query over tables of the relational database. The following listing is an appropriate program for the creation of this report, created with SQL (Structured Query Language) language, the universal language for accessing relational databases:

INSERT INTO [REPORT controllers] (NoSealController, SumOfPointsController) SELECT DISTINCTROW REPORT.NoSealController, Sum(REPORT.PointsController) AS SumOfPointsController FROM REPORT GROUP BY REPORT.NoSealController ORDER BY Sum(REPORT.PointsController) DESC;
UPDATE DISTINCTROW [REPORT controllers] INNER JOIN [CODEBOOKS CONTROLLER I WORKERS] ON [REPORT controllers].NoSealController = [CODEBOOKS CONTROLLER I WORKERS].NoSeal SET [REPORT controllers].IdentificationNo = [CODEBOOKS CONTROLLER I WORKERS]![IdentificationNo], [REPORT controllers].NoWorkingDays = [CODEBOOKS CONTROLLER I WORKERS]![NoWorkingDays]
WHERE ((([CODEBOOKS CONTROLLER I WORKERS].KontrolorWorker)="K"));

In addition to previous report which has a general character, one of the most important analysis refers to the work of supervisors or workers on a monthly basis or within a specified period, Figure 7. By this is perceived detailed and summary results of the work, in order to establish stimulating measures and rewards according to the effect of operation. In addition to data on observed irregularities in certain elements of control, in this sense are of importance and generated summary points that describe the overall significance of results. The programming code for creating this report is presented in the following listing:

Figure 6: Report on workers

INSERT INTO REPORT (NoProduct, DateInspections, ElementControl, Malfunction, NoSealWORKERS, NoSealController, PointsWORKERS, PointsController)
SELECT DISTINCTROW MALFUNCTIONI.NoProduct, MALFUNCTIONI.DateInspections, MALFUNCTIONI.ElementControl, MALFUNCTIONI.Malfunction, MALFUNCTIONI.NoSealaWORKERS, MALFUNCTIONI.NoSealaController, MALFUNCTIONI.PointsWORKERS, MALFUNCTIONI.PointsController FROM MALFUNCTIONI WHERE (((MALFUNCTIONI.DateInspections)>=[SIGN INITIAL DATE] And (MALFUNCTIONI.DateInspections)<=[SIGN FINAL DATE]));

Figure 7: Report on the work of the supervisors on a monthly basis

3. CONCLUSION

In this paper are presented basic elements in the development of a software solution, which enables computer support for recording and analysis of malfunctions of finished products. The most important elements of the considered solution are presented . Discussed computer support is created using MS Access software tool, which is one of the most suitable tool for this purpose. The reasons for this can be seen in the speed of development of software support in all areas: creating a database, automation of calculation and analysis of data by setting the query, formation of different satisfactory reports for business purposes.

In addition to monitoring the quality of the product and identified malfunctions, the prezented software solution enables the analysis and evaluation of supervisors and workers in the quality control process. Evaluation of the work is provided in general terms and in a period of time, such as monthly. In this sense there is a possibility of evaluating and rewarding work by performance and by the importance of the identified irregularities in the quality control.

By predefined codebooks of supervisors and workers, as well as with a table of elements of control, it is enabled automatical creation of reports, with all necessary information, based on the entered elements of control and malfunctions, identified during the production process. Database tables, formed for the purpose of this software solutionis, is possible to link with other databases of the integral enterprise information system by a relational model, in order to obtain a large number of other reports. In this sense, the presented solution is not an isolated segment, but part of the overall information system.

An important feature of the displayed solution is a logical overall structure, in terms of its universal applicability in all industrial company, with the characteristic of the assembly of the final product. The greatest significance for the application of the considered software solution can have in case of execution of complex products with a large number of parts. In this sense, the solution may represent a conceptual basis for the development of own computer support in the individual industrial production.

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DEVELOPING JOOMLA COMPONENT FOR THE VOTING SYSTEM BASED ON COMPARATIVE ANALYSIS

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Abstract: *Ideas on the theory of voting have been adopted in number of recent online applications. Web search engines and recommendation systems use various voting methods for ranking results. The paper addresses a problem of implementing different types of voting systems, along with their definition and history. It points out the necessity of comparing them in order to complement different types and to suggest their improvement. Special attention is dedicated to the comparative analysis of voting systems, and applying Single-winner system of voting to Joomla component. Joomla component "Music recommendation" is developed.*

Keywords*: Voting system, Single-winner, Joomla component, Music recommendation, Model-View Controller.*

1. INTRODUCTION

Ideas on the theory of voting have been adopted in number of recent online applications. Recommendation systems have proven to be valuable tool for online users to cope with the information overload and to provide useful suggestions related to various decision-making processes (Ricci et.al, 2011). Various voting methods for ranking results have been proposed and many of them have been successfully deployed in the business and academic applications.

However, there are a lot of concerns in regard to adaption and design of learning mechanisms and algorithms for review ranking. Therefore, this research will be addressing this issue. Paper goal is to provide an insight into different types of voting systems, along with their definition and history. Special attention is dedicated to the comparative analysis of voting systems, and applying Single-winner system of voting to Joomla component. The growing attention on modeling in software development has subsequently brought the design of components in forefront. The specification and design of the component is strongly related to its availability and usability. Model-View-Controller (MVC) software architecture is recognized as the most used and accepted approach for designing a component (Bose, 2010).

First, literature overview presents the scope of the work done in defining different types of voting systems and Component-based software development approach. UML class diagram and process workflow of "Music recommendation" voting is given in section 4. Section 5 examines existing voting systems in order to define appropriate voting mechanism for "Music recommendation" component. In conclusion, we discuss research outcomes and ideas for future work.

2. VOTING SYSTEMS

Voting system or electoral system represents the way by which voters choose between given options in elections or on political referendums. The system sets the rules for achieving valid voting credential, as well as rules for aggregating votes in final results.

Common voting systems are: majority rule, proportional representation or plurality voting with many variations, such as first past the post or preferential voting (Rivest and Shen, 2010). Social choice theory or theory of voting represents a mathematical theory for formal analysis of combining individual opinions, preferences and interests to reach collective decision. From a standpoint of majority rule voting system, those who aren"t familiar with voting theory are usually surprised that another voting system exists and that there are differences in meaning to be supported by majority. Therefore, majority rule voting can sometimes get the results that majority does not support. If there were only two options on each election, a winner would be chosen only by majority rules voting. However, if there were three or more options, it might happen that none of them get the majority votes of most or least liked. A simple choice does not allow voters to express

their order of preference and their feelings towards certain options. Different voting systems may give very different results, particularly in situations where the majority does not clearly specify their preferences.

Voting system determines a form of voting ballot, a set of legal votes, counting method and an algorithm for determining the results. Based on an algorithm, voting systems are divided into two general types: Single-winner and Multiple-winner voting systems (Nurmi, 2010). Moreover, the voting system may also specify how voting power is distributed among voters and distribution of voters in the subgroup whose votes are counted independently.

Conduct of elections in practice is not considered as a part of the voting system. It does not specify whether the ballot is in the form of plain paper, cards ticking or on a computer screen. A voting system also does not determine whether and how votes are kept confidential, the way to check whether the votes were counted correctly or who is allowed to vote.

3. COMPARATIVE ANALYSIS OF VOTING SYSTEMS

According to the algorithms for determining the results, voting systems are divided into: Single-winner and Multiple-winner voting systems. Scope of our work is in Single-winner voting system and it is applied in developed Joomla component.

Based on the voting method, Single-winner voting systems are divided into:

1. One vote or Sequential voting systems

In these systems voters vote for only one candidate and it is distinguished from the voting system applied in Joomla component "Music recommendations". In the game each participant must vote for all recommended songs, not just for one. The best known Sequential voting systems are: Majority, Approval, Runoff and Random ballot voting system (Johnson, 2005).

Under the Majority system, a candidate must receive an absolute majority of votes to be a winner. This system encourages tactical voting and voters are pressured to vote for one of the two candidates with the highest chance of winning, because a vote for any other candidate is most likely wasted vote with no impact on the final result. Its implementation would be very simple, but it is not appropriate for the application where wasted votes should not appear. Approving voting system is similar to a Majority system. Voters can vote for as many candidates as they wish and the candidate with the most votes wins. It is simple and more flexible for voters. However, it is not used for the application because voter must give points to each song. In a Runoff voting, a candidate wins in the first round if obtains an absolute majority of the votes. Otherwise, a second round is held between the two candidates with most first-round votes and the winner is the candidate with best score from the second round. The last type of Sequential voting system is a Random ballot. In this system, a winner is chosen by random selection of a ballot. The use of a random ballot voting wouldn"t make any sense, because it wouldn"t depend on voters" preferences.

2. Ranked voting systems

Ranked voting system allows voters to rank candidates in order of preference. Ranking voting systems are divided into: Borda count, Bucklin, Instant-runoff, Condorcet, Coombs, Supplementary and Position voting system. These systems are the most similar to the voting system of the component "Music recommendations".

Under the Instant-runoff system, voters rank candidate by giving mark „1" to the most preferred candidate, mark „2" to the second-most preferred and so forth in ascending order, while the order in "Music recommendations" voting system depends on the total number of candidates. The ordering process in Instant-runoff system is simpler for voters and also for implementation. The winner is a candidate who receives over 50 percent of the first preference votes. Otherwise, the candidate with the fewest first preference votes is eliminated and the points of eliminated candidate are assigned to the remaining candidates, who are ranked next in order of preference. The process flow is repeated until one candidate wins by gaining more than half the votes (Gehring, 2007). The processes of eliminating the candidates and assigning their points to the remaining candidates are not suitable for "Music recommendations" voting system. In "Music recommendations" system, it is necessary to assign the total number of points by all participants to each song.

Borda count is the most similar voting system to the "Music recommendations" voting. Voters rank candidates in order of preference, by giving a certain number of points which depends on the number of candidates. The candidate with most points is the winner. The only difference between Borda count and "Music recommendations" voting is used series of points.

Condorcet methods use pairwise counting and compare candidates one-on-one. The winner is the candidate whom voters prefer to each other candidate (Johnson, 2005). This method is implemented in "Music recommendations" voting in case where two or more songs have the same total number of points. The final rank is determined by Condorcet method in the aggregate ranking. The pairwise counts can be displayed in matrix. Under the Supplementary voting system, voters express only a first and second choice of candidate. If no one receives an absolute majority of first choice votes, all candidates are eliminated except the two leading candidates. The system is not suitable for "Music recommendations" voting, because in the second round the votes of eliminated candidates are transferred to the candidate of voters" next preference. On the other hand, Bucklin voting allows ranking the candidates in order of preference. If one candidate has a majority of first preference votes, the candidate wins. Otherwise, the second choices are added and this cumulative method is not suitable for "Music recommendations" system, since the winner is the candidate with the most points added.

3.   Rated voting systems

Under those systems, voters give grades to each candidate from specific series of points. They are divided into: Range voting systems and Majority judgment (LeDuc, 2002). In Range voting system, the ranking ballot is used and voters rank each candidate with a number from defined series. The candidate with the highest sum wins. This method increases the level of tactical voting. Majority judgment system allows voters to judge each candidate and method of six grading levels is suggest, from "excellent" to "rejected". The median grade for each candidate is calculated and the candidate with the highest median grade wins. The difference between Range and Majority judgment voting is in calculation of highest score.

4. DEVELOPING A COMPONENT FOR JOOMLA CMS

Bose (2010) describes Component-based software development (CBD) as approach based on the idea to develop software systems by selecting appropriate off-the-shelf components and then to assemble them with a well-defined software architecture (p.2). Complex software systems are built efficiently using component based approach in a short period of time. It brings the design of the component to the forefront. Model-View-Controller (MVC) software architecture is recognized as the most used and accepted approach for designing a component. This approach divides the component into three functional parts: data access, data presentation and business logic. The changes made in one part do not affect others.

The Model is responsible for data management, i.e. extracting data from database or from other data sources. In developing a component there can be multiple models and each of them can be defined for different data sources. It includes methods of presenting, creating, updating data and others methods related to handling data. The Model is all business logic with no knowledge of the View.

The View is responsible for presenting the data pulled out from the database. In Joomla CMS, it renders a HTML page from data using the general scheme. The View never changes the state of a database and only shows its condition retrieved from the model. Requests for data change are issued by the Controller and the Model executes them. Modules are automatically associated with a view by the Controller. The Controller selects the appropriate model or multiple models based on user requests and forwards requests to the model. It creates the view and ties it to one or more models. The duty of the Controller is to create a view, not to present data.

In Joomla CMS, each part of MVC is represented by an abstract class: JModel, JView and JController (Whitepaper 2011). These classes are in library joomla.application.component. Figure 1 shows the relationship of these classes.
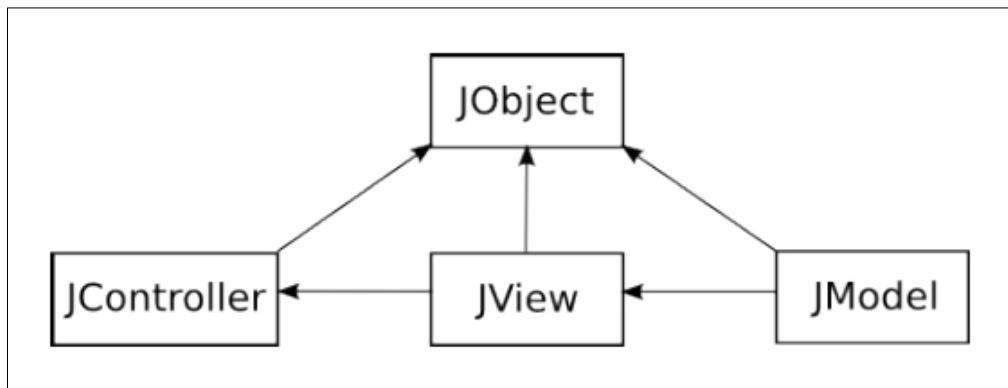
Figure 1: MVC – the relationship of abstract classes

5. DEVELOPING A JOOMLA COMPONENT "MUSIC RECOMMENDATIONS"

5.1 A problem statement

The progress and development trend of Internet communication and the popularization of music websites have encouraged the music fans to seek for more information about music tracks and artists. Music recommendations based on previous searches of every registered user are provided by specific sites, such as YouTube. However, the personal recommendations have significant influence on user online music tracks and artists choices. They affect users' perceptions of trustworthiness. Therefore, "Music recommendations" component was created in autumn 2008 and it reached over 1000 new songs.

In the absence of adequate methods, "Music recommendations" occurred in the form of separate sub form on the main forum. The game take place on a weekly basis and the week is divided into three phases: setting the songs, listening and voting. Two days, Sunday and Monday, are reserved for setting the songs. Each member has an opportunity to recommend a song within these two days on forums" topic created by the administrator. Songs are mostly described by attributes: name of the artist, title of the song, YouTube link and additional information, which is optional and represents members" comment on the song. Listening activity lasts for the rest of the week, accurately until Saturday, the day which is reserved for voting. Each member is required to send their ballots to last week"s winner on Saturday until midnight. Members are voting for each song except their own by specific scoring system, which depends on the number of participants and administrator publish it on the eve of voting. If member forgets to vote or for any other reason doesn"t send his votes, will be disqualified from the current week voting. When all participants vote, last week"s winner adds the points and publishes them on the same topic as song recommendations. In addition to this topic, there are topics on which is possible to comment on the results and the songs. There are also archives of all recommendations, winners and scored.

Increasing demand cause a need for reducing "the human factor" to the smallest possible level, i.e. to create an application for adding the points, creating and closing a voting week, etc. Moreover, number of participants expressed the wish for setting anonymous recommendations which is not allowed on forum. It reduces subjectivity to zero during the voting process.

Therefore, the Joomla component called "Music recommendations" is created as a part of the website with idea to make the game more interesting and user-friendly. Figure 2 illustrates the voting website page of "Music recommendations" component.
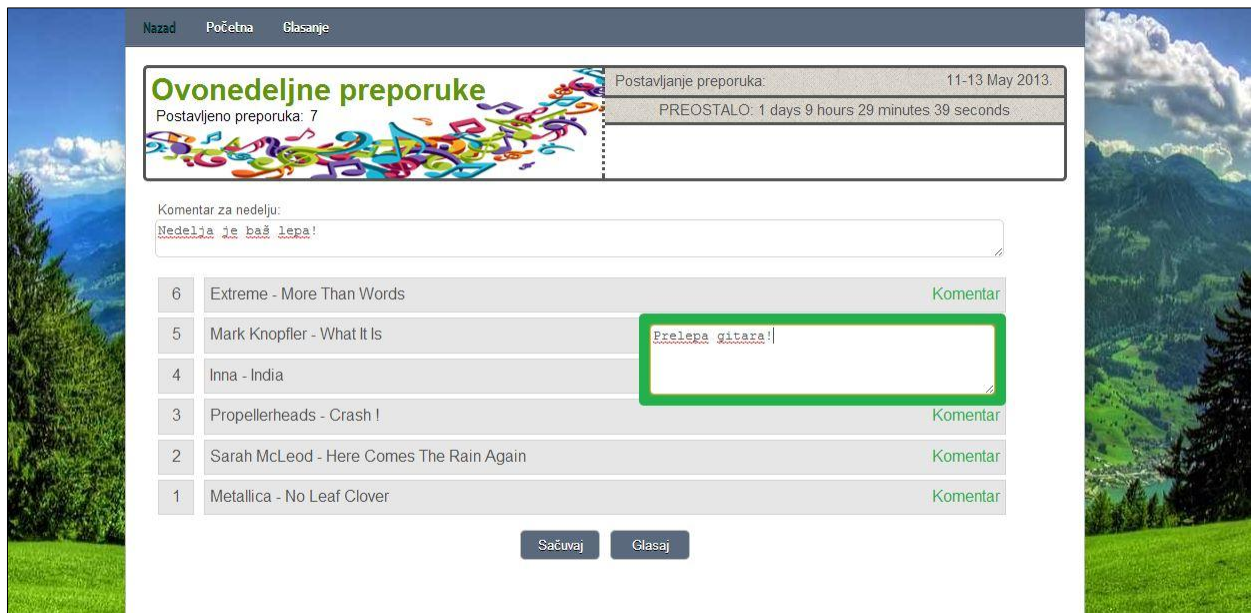
Figure 2: Page for voting

5.2 The component model structure

The organization structure of the model consists of four blocks: current settings, process, history and exit. The model is given in Table 1.

Table 1: The organization structure of the model for "Music recommendations"

Current settings (home) – recommendations set out in the current week
Process (settings, voting, results)
History – results from last week
Exit (back) – exit from "Music recommendations"

"Music recommendations" game takes place on a weekly basis, from Saturday (00:00) up to next Saturday (00:00) and each week represents a process. Two days, Sunday and Monday, are reserved for settings the songs and other days are for voting. Each process is divided into two parts: setting and voting. Thus the week can have two statuses: "setting" and "voting". In first part, participants set songs and review the songs set by other participants. The second part of voting allows the participants to vote for posted songs. If all participants voted before the time for voting expired, weeks" status would become "locked". In this period participants can"t set songs. They can only watch the election results from the current week. Results from last weeks are always available in the "History". The process diagram is given in Figure 3.

$$t1 = t3 - \text{Monday (00:00)}, \quad t2 - \text{Saturday (00:00)} \qquad (1)$$

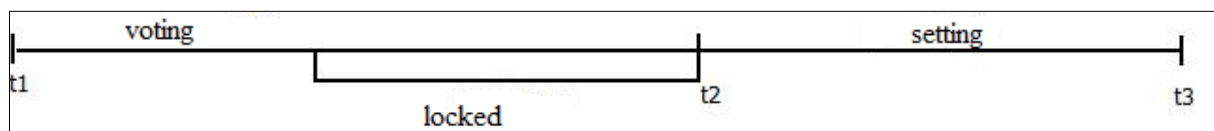**Figure 3:** Time intervals of a process

The specification and design of the component is strongly related to its availability and usability. Object-oriented design of the component is illustrated through UML class diagram (Figure 4), as the most important structural model. The objects and information structures used by application, both internally and in communication with users, are described.
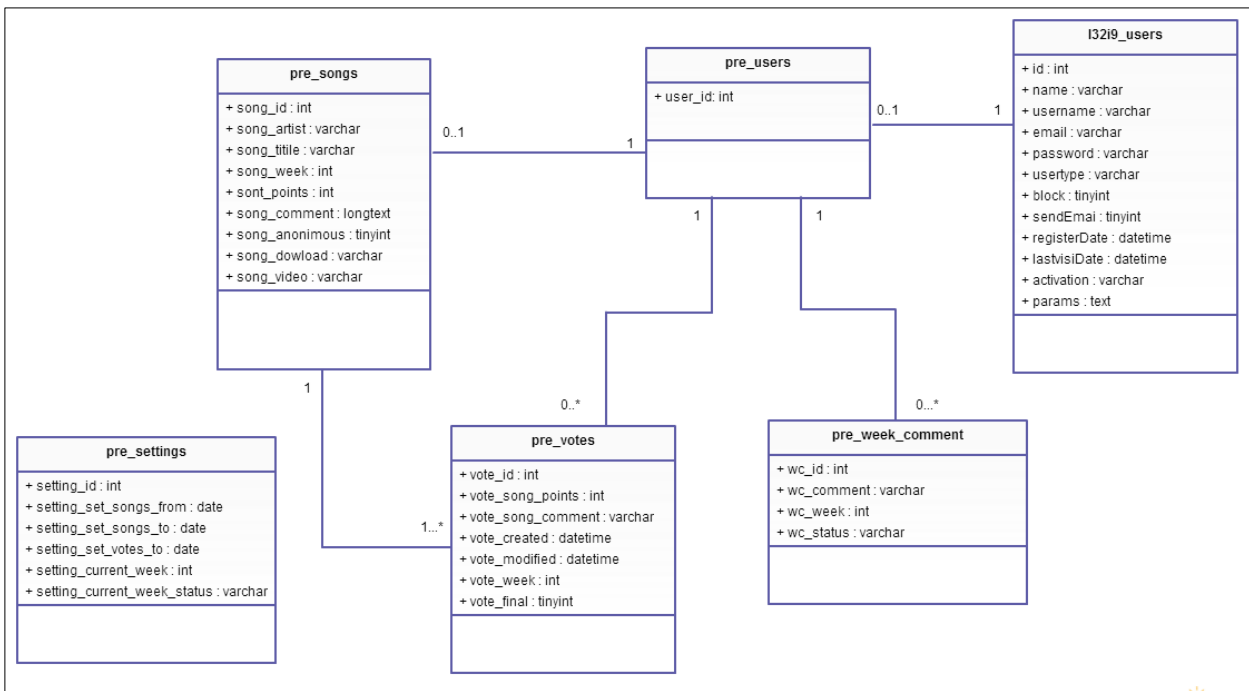
Figure 4: UML class diagram

5.3 Joomla component "Music recommendations" voting system

Creating ballot is the first step in implementing voting system of Joomla component "Music recommendations". The ballot includes all the candidates who are qualified to compete. If member recommends a song to others, member will be eligible to participate as a candidate in voting process. The voters are also the candidates on the ballot.

Moreover, each member who recommends a song can announce whether the previous set songs are known to member. If 30 percent of all participants know the song set by one of the participants, the song has to be replaced by a new one. Otherwise, the member will be disqualified not just as a candidate but also as a voter. The number of voter and candidates is equal, because a member who doesn''t recommend a song has no rights to be a voter. After defining the number of candidates and voters, the voting process can be performed. Each voter ranks songs from other participants except their own. Ranking refers to giving points to each song that the other participants set in a particular order, so the most points are given to a song the voter has liked the most and so on. Voter must give points to each song in a way that one value from defined series of points can be applied to only one song. Ratings depend on the number of candidates, i.e. the number of songs that are posted. Rule by which the points are given is represented in Table 2.

Table 2: The ratio of the number of participants and points

Number of participants	Series of points
< 9	1, 2, 3, 4, 5, …
10	10, 8 ,7, 6, 5, 4, 3, 2, 1
11	12, 10, 8 ,7, 6, 5, 4, 3, 2, 1
12	14, 12, 10, 8 ,7, 6, 5, 4, 3, 2, 1
13	14, 12, 10, 9, 8 ,7, 6, 5, 4, 3, 2, 1
14	16, 14, 12, 10, 9, 8 ,7, 6, 5, 4, 3, 2, 1
15	16, 14, 12, 11, 10, 9, 8 ,7, 6, 5, 4, 3, 2, 1
16	18, 16, 14, 12, 11, 10, 9, 8 ,7, 6, 5, 4, 3, 2, 1
17	18, 16, 14, 13, 12, 11, 10, 9, 8 ,7, 6, 5, 4, 3, 2, 1

After the voting, the points that are given to each candidate are calculating. The points are added up and the candidate with highest total number of points wins. Other candidates get their ranking positions in the aggregate ranking list.

If two candidates have the same total number of points, they will be compered in terms of the position they hold in rankings by other voters. The candidate who holds better position in ranking list of one voter gets 1 point. The process continues until positions of candidates are compared in ranking list of all voters, not considering the ranking list of candidates who are compared. The candidate with highest number of points, i.e. who holds the better position in ranking list of other voters, is a winner.

If a voter doesn't vote, voters" recommended song is automatically disqualified and the position of that song on the aggregate ranking list is taken by a song that was placed underneath.

6. CONCLUSION

There are numerous types of voting systems in use around the world. Different voting systems may give very different results based on rules which enforce how votes are collected, counted and added to get a final result. Moreover, the number of voters can have influence on counting method and an algorithm for determining the results. There is no single voting method that fits all cases. Many of existing voting systems are complementary, with strengths in different areas. It is necessary to understand in-depth the algorithms of different voting systems and choose the right one. Therefore, the special attention is dedicated to the comparative analysis of voting systems. The algorithms of assigning the grades are observed and process flow for determining the winner is briefly described for each best known voting system. Based on in-depth analysis and a problem statement, the appropriate voting system is select for "Music recommendations" website component. The advantages of Ranked voting systems are applied in developing Joomla component "Music recommendations". Under defined voting system, participants rank the candidates in order of preference, by giving different grades from series of points to each candidate. The total score of each candidate is presented in the aggregate ranking list. In "Music recommendations" system a voter is also a candidate. Voters must rank songs if they want to stay in the game. In this way, system motivates voters to participate in the game.

It is important to emphasize that Single-winner voting system isn't completely applied in developing Joomla component, only some elements. The main contribution of this work is reflecting through the creation of Joomla component based on Model-View-Controller software architecture with own voting method. UML class diagram of the component is presented. The resulting method and component can be widely accepted and future research intends to explore new improvements of the method and its further implementation.

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PROJECT MANAGEMENT IMPACT DURING ERP SYSTEM IMPLEMENTATION

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Abstract: *This research model was developed through a multidisciplinary combinatory approach, theory of decision-making and project management. In the research, the study of influence of project management during the implementation of ERP solutions in Serbian companies is presented. The development of IS in companies is being researched, the metric of responsibilities on the project is presented, the role of project manager is identified, representing the percentage of companies with established ERP solutions by sector and size and the reasons for implementing SAP ERP solutions in Serbian companies is reviewed. The study systematically presented: a comparative analysis of IS before and after use of ERP solutions, a comparative overview of the new and old system in surveyed Serbian companies, the display module implemented in those companies, the percentage impact of SAP ERP solution implementation in Serbia, the total cost of ERP ownership as a percentage and the cost percentage in surveyed companies.*

Keywords: *ERP system, implementation, information system, enterprise.*

1 INTRODUCTION

In this research paper, based on the systematic study of the relevant literature and research performed in surveyed companies in Serbia, with different type of activities, production processes and the ownership structure, on a representative sample, using the questionnaire, the methodological aspects of the implementation process of ERP system have been researched and evaluated. Eminent authors, (Monk, EF& W Agner, BJ 2006) define ERP as the most important software in the company, which coordinates data / information in all areas of business. ERP solutions help manage business processes through the use of a database and shared management reporting tools. ERP solutions support the efficient functioning of business processes through business operations including sales, marketing, manufacturing, logistics, finance and human resources. Harwood, S. (2004) pointed out that ERP cannot be, in any way, classified as a database with pre-built software.

2 ERP FACTS

ERP solutions enable us to provide automated support for business processes and improved access to information and assistance in the implementation, including process modeling and documentation and tools that support the training and development of ERP solutions, (Denic et al., 2013).
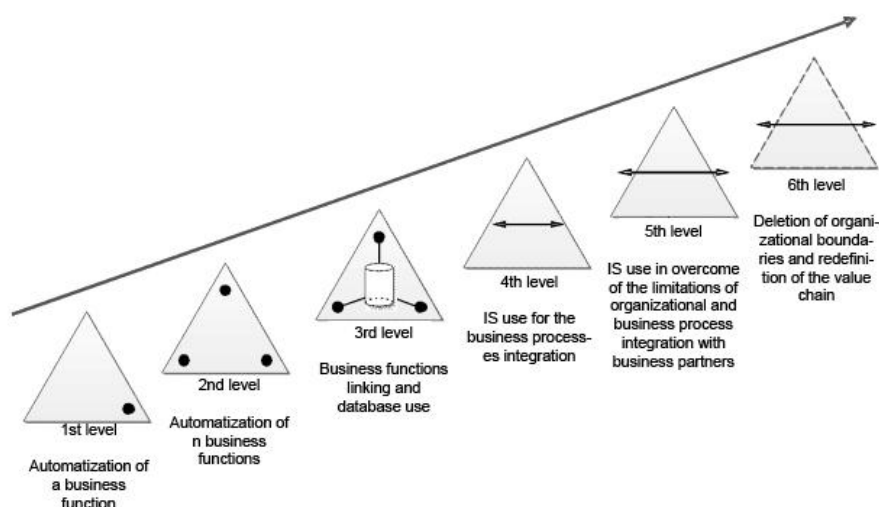

Figure 1: The development of IS in the organization

Source: Boddy D., Boonstra A. & Kennedy G. (2008). Managing information systems– strategy and organization. England etc.: Prentice Hall.

ERP solutions also allow the integration of business processes within and outside the organization, so that the boundaries between organizations disappear by changing their business value. Such systems are called Integrated IS or ERP solutions and their development is presented in the figure 1.

If there is a need to describe the ERP solution from the standpoint of the user, the following can be done: (Hamilton S. 2002).
- the way of making every product and service shall be defined
- the requirements of specific products or specific customer requirements shall be set
- the realistic business plans and proper time delivery of products and services shall be defined
- in order to coordinate activities in the supply chain the schedule shall be used
- the accurate calculation of product costs providing useful information for managers is allowed.

2 PROJECT MANAGEMENT AND ACCOUNTABILITY DURING PROJECT IMPLEMENTATION

The following Table 1 presents Serbian companies, with various types of activities, the production processes and the ownership structure (representative sample), where ERP system was implemented and which participated in the survey and also, the results of research.

Table 1 Companies that participated in the survey

Company Name	Activities of the company	Years In Business	Number of Employees	Web site
Srpska fabrika stakla A.D.	Glass industry	105	870	www.srpskafabrikastakla.com
Swisslion Takovo	Confectionery	17	2762	www.swisslion-takovo.com
Holcim Srbija	Manufacture of cement, aggregates and ready-mixed concrete	135	334	www.holcim.rs
JP PTT Srbija	Postal services, e-commerce, Internet	174	15336	www.posta.rs
Dijamant Zrenjenin	Food industry	76	585	www.dijamant.rs

Source: Research conducted in enterprises in Serbia, 2014.

The following Table 2 presents the results of research related to the review of the reasons for implementing SAP ERP solutions in the above mentioned Serbian companies, which show that every company has its priority reason for the introduction of modern ERP solution, which can be summarized in improving operations and creating positive effects of operations, increase of company value by creating competitive advantage, as well as the survival of the companies in the increasingly open global market in terms of the current global economic crisis. (Denic et al., 2014).

Table 2 Reasons for implementing SAP ERP solutions to enterprises in Serbia

Company name	Reasons for implementing SAP ERP solutions to enterprises
Srpska fabrika stakla A.D.	Improving the business, increasing the company's value.
Swisslion Takovo	Greater efficiency and productivity of operations.
Holcim Srbija	Within its own corporate SAP ERP.
JP PTT Srbija	The current system has unorganized data system. SAP ERP offers the lowest business risk.
Dijamant Zrenjenin	Effective business management and replacement of existing information systems.

Source: Research conducted in enterprises in Serbia, 2014.

In the analyzed companies it is predicted that they shall, together and individually, determine the respective roles and responsibilities in the project implementation of ERP solutions. The appropriate personnel working on a project is of the utmost importance therefore, the personnel have to be carefully selected. The teams working on the project plan development and implementation of appropriate ERP solution are typically diverse teams made from staff belonging to the solution makers and solution purchasers. (Denic N., Zivic N.,

Siljkovic B., 2013). It is important that in the team are, from both sides, adequate interlocutors, who recognize the problems which can occur.

During implementation, the staff was changing mostly in the team of solution makers. The project leader failed to suggest new staff members, and the people from other projects have been spontaneously hired, which had significant influence on the team motivation. In that respect, the project manager performed most of the work alone, and this fact suggested that the Purchaser had no professional leadership. From the Purchaser side, the team included two computer experts who were, more or less, coordinating the project in terms of connecting applications to support production of a new ERP solution. The project included eleven people in total from which six were engaged directly from the purchasing company and five from solution makers company. Also, project manager was chosen from the purchasing company and the other five representatives were from various areas of ERP solution knowledge. The role of information transfer and the inclusion of end-users in a new information system were assigned to them.

Prerequisite for participation in the project was that they were well introduced to the procedures for operating in the old information system. The solution makers offered one person to be appointed as the leader of the project, while the other four had the advisory role, each in specifically defined area. That is how they performed necessary programming work, because they had the role of the creator, more or less. They were even more motivated to work on the project, since it was shown that successful project is in the interest of all participants in the project, although there was very little time to perform. In that respect, the overtime was not an obstacle. From our point of view, regarding the success of the above projects, the prevailing opinion is that some companies can be observed as unsuccessful in ERP solution implementation, and that some companies, from the project management point, can be presented as an example of a successful project implementation and reconstruction of the existing information system. Due to the short period of implementation, the success of such project is more the exception than the rule.

Key users were additionally motivated to work on the project. Top level management, project team leaders and department leaders, had working meetings at which they discussed the progress of the project, as well as the problems and solutions. Despite the very short time for the project realization (three months) and the complexity of the project, it was realized in due time. At the end, the users accepted the implemented ERP solution.

The following Table 3 shows the metrics of responsibility on the project implementation of ERP solutions for companies.

Table 3: Metrics responsibilities on the project

	PM	PMC	PS	FSP
Definition of the target	P		C	
The requirements of a new information system	CO	PA	C	CO
Preparation of the draft document	P	P	C	C
Establishing the project organization	PA	P	C	
Determination of resources, team leader, motivation of participants in the project	PA	P	CO	
Management and supervision costs	CO		C	CO
Taking measures in case of deviation	PA	P	C	CO
Time monitoring of the project	CO	P	C	
Supervision of quality	CO	P		
Communication	PA	P		
Report on the progress of the project	P	P		
The conclusion of the project - report	P		C	C

Source: Denic N., Dasic B., Maslovara J. 2013.). Profitability of the investment project of introducing modern business information systems, Technics Technologies Education Management, Vol. 8, No. 1, 367–372.

Legend:
PM - project manager,
PMC - project manager of contractor,
PS - project supervisor,
FSP- financial supervisor of the project,
P-performing,
C-confirmation,
CO-cooperate,
PA- provides the answers

The management that manages changes in a company shall consist of well educated and high quality individuals, who have authority in the company, and enjoy the respect of subordinate staff, who must be able to understand the technical support of people in the company, which are implementing the ERP system and to have the trust at all levels of the business of the company,(Denic N., Zivic N., Siljkovic B., 2013). In this way, the company spreads good atmosphere and mood and desire for change, which is one of the most powerful advocates of change in a viewpoint. Most project managers are preparing very detailed reports on the cost parameters and they spent time in the implementation of ERP systems, and often, at the same time, they inform about the benefits and savings of ERP systems implementation. It is necessary to obtain data regarding the time which IT staff, in the company, is spending each month in order to prepare different orders or in fixing the errors associated with the Management orders and also, how much time is consumed in planning and control of the business system. However, this can be easily overcome with different tools, which allows the management to solely, and very simple, create their own orders. The ERP solution works more efficient if employees and IT staff work as a homogenous group.

Previous evaluations showed the importance of the project manager during implementation of ERP solutions in the company. Detailed presentation on the review of relevant scientific literature is presented in the table 4 while Figure 2 shows the percentage of companies with established ERP solutions across sectors and size, for year 2007.

Table 4 Some champion definitions found in the literature

Authors	Definition
Beath (1991, p. 355)	"Information technology champions are managers who actively and vigorously promote their personal vision for using information technology, pushing the project over or around approval and implementation hurdles."
Chakrabarti and Hauschildt (1989, p. 166)	"The Champion (process promoter) acts as a linkage. He has the knowledge of the organization and knows who should be concerned with the innovation, thus connecting the sponsor with the expert. His strength is the ability to translate the technical language of the innovation into one which is commonly used in the organization. By becoming a salesman of the new idea, the champion is able to develop a plan of action. His diplomatic talents provide access to different people within the organization".
Day (1994, p.149)	"The agent who helps the venture navigates the socio-political environment inside the corporation".
Ettlie et al. (1984, p.687)	"A person advocating" for the project.
Fischer et al. (1986, p. 13)	"The key characteristic of the product champion is the tension between the individual and what the organization wants".
Howell and Higgins (1990, p. 40)	Champions "make a decisive contribution to the innovation process by actively and enthusiastically promoting the innovation, building support, overcoming resistance and ensuring that the innovation is implemented".
Rothwell et al. (1974, p. 291)	"Any individual who made a decisive contribution to the innovation by actively and enthusiastically promoting its progress through critical stages".
Maidique (1980, p. 64)	"A member of an organization who creates, defines or adopts an idea for a new technological innovation and who is willing to risk his or her position and prestige to make possible the innovation's successful implementation".
Markham et al. (1991, p. 219)	"A role where individuals are strong advocates for a project and generate positive behavioral support for an innovation during its development or work on behalf of the project in the face of organizational neutrality or opposition".
Smith et al. (1984, p. 25)	"Sells idea to obtain resources. The major salesman to management for accelerating progress toward commercialization".
Shane (1994, p. 29)	"An advocate whose goal is to promote the innovation".
Roberts and Fusfeld (1981, p. 186)	"Recognizing, proposing, pushing and demonstrating a new (his or her own or someone else's) technical idea, approach or procedure for formal management approval".
Schon (1963, p. 84)	"Essentially the champion must be a man willing to put himself on the line for an idea of doubtful success. He is willing to fail. But he is capable of using any and every means of informal sales and pressure in order to succeed".

Source: Roure L. (1999). "Cultural Differences in Product Champions Characteristics: A comparison of France and Germany". Centre de Recherche DMSP, cahier n°. 268.
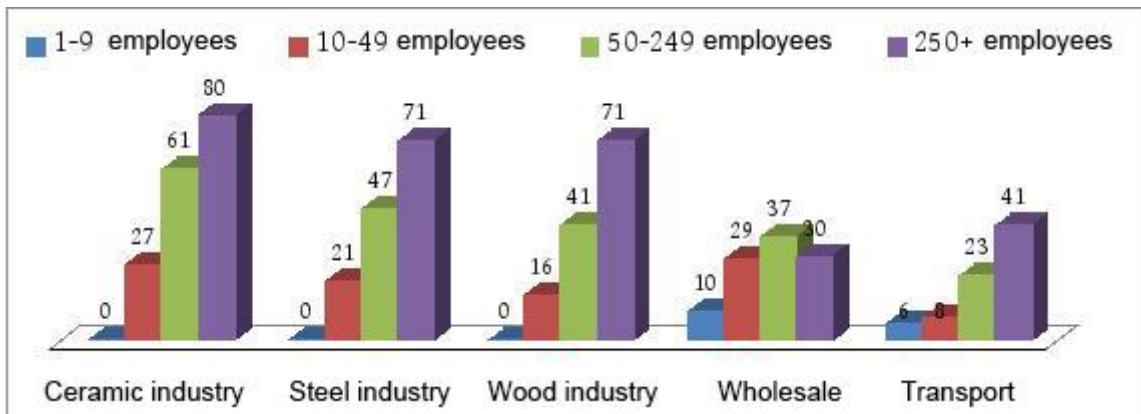
Figure 2: Percentage of companies with established ERP solutions by sector and size in 2007

Legend: The core of these industries is (100%) represented by the companies from seven EU Member States (Germany, France, Italy, Spain, Poland, Sweden, United Kingdom) and 811 companies from the chemical industry, 349 companies from the steel industry, 661 companies from the furniture industry, 1026 companies in the retail and transport activities 997 companies have been included.

3 REVIEW AFTER IMPLEMENTATION

Table 5: Comparison of IS before and after ERP solutions

	Before using ERP solutions	**With the help of ERP solutions**
Information Systems	Unconnected systems.	Integration system.
Coordination	Lack of coordination between business functions (e.g. production and sales)	Supports coordination between business functions.
Databases	Unconnected data. The data have different meanings. Inconsistent data definitions.	Linking data. The data has the same meaning in all business functions
Maintenance	Maintenance of individual IS. Inconsistent results. Expensive to maintain separate IS.	Uniform maintenance. Changes affecting several systems.
Interfaces	Impossible exchange interfaces between systems.	Unified interface between systems.
Information	Repetition, inconsistency.	Information is available in real time (e.g. customers, suppliers)
Architecture system	Is not uniform.	Based on a client / server.
Processes	Incompatible processes.	The integrated business processes based on business models
Applications	Various applications (e.g. several different systems for acquisition).	Uniform application - modules (e.g. common data acquisition)

As shown in the above Table 5 Sumner, M. (2004) amongst other, claims that the greatest success of the ERP solutions is to ensure the availability, visibility and consistency of data across the enterprise.The respondents' opinion, after the implementation of the new SAP ERP solution, in comparison to the old software solutions, was positive, and 80% were satisfied with the new solution and new user interface.

Figure 3 shows a comparative overview of the new and old software solutions.
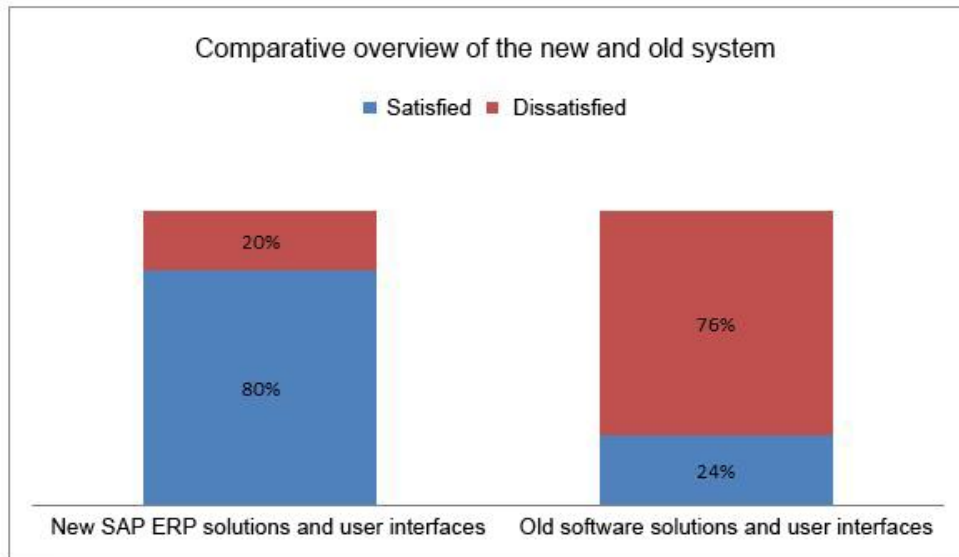
Figure 3 Comparative overview of the new and old system in chosen companies in Serbia
Source: Research conducted in enterprises in Serbia, 2014.

Table 6 presents an outline of the implemented modules in these companies.

Table 6 Display module implemented in companies

Company name	Implemented modules in chosen companies
Srpska fabrika stakla A.D.	FI, CO, MM, SD, PP
Swisslion Takovo	FI, CO, MM, SD, PP, BC
Holcim Srbija	FI, CO, MM, SD, PP, PM
JP PTT Srbija	FI, FI-AA, CO, MM, IM, HR, BC
Dijamant Zrenjenin	FI, CO, MM, SD, HR, PS, BC

Source: Research conducted in enterprises in Serbia, 2014.

Figure 4 shows the percentage of the implementation impact of SAP ERP solutions in Serbia. Implementation of SAP ERP solutions resulted in lower operating costs (80%) and it facilitated the management of the company with the maximum percentage. From a sample of implemented SAP ERP solution, implementation is completed in 60% of the sample, according to the planned time, while 40% is completed within the planned budget. The participant`s expectations from SAP ERP solution implementation were 60% while the quality of knowledge, adopted by the participants, is increased to the maximum.
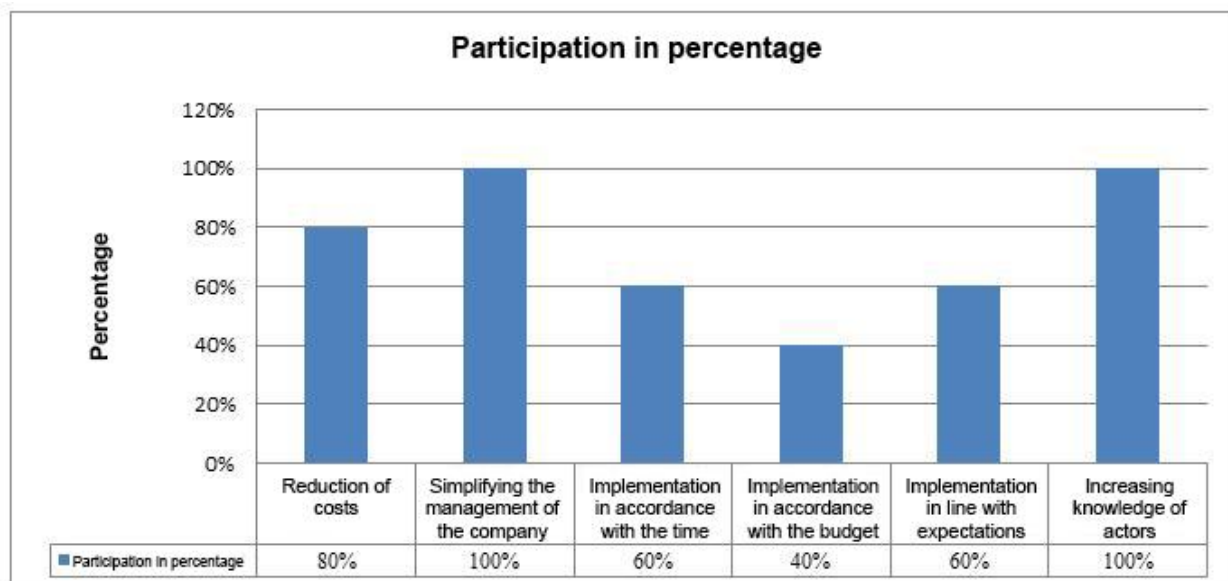

Figure 4 The percentage impact of implementing SAP ERP solutions in Serbia
Source: Research conducted in enterprises in Serbia, 2014.

A very important category in the process of introducing and implementing ERP solutions are costs. Most of the cost can be measured, i.e. they can be easily identified and evaluated in terms of the amount, while the advantages (benefits) of ERP solution implementation are difficult to estimate in that manner. They can be divided into two categories: (Cotterell M. & Hughes B. (1995).

▪ Direct benefits of ERP solutions are those that can be evaluated in terms of the amount, such as (Bodde et al., 2008) direct cost savings (reduction in costs due to automation of processes, such as reducing paper invoices), quality improvement (e.g. reduction of errors), avoiding the increase of costs (e.g. lower maintenance costs due to less damage), increased revenue (e.g. sales increase through new services), the survival of the business (e.g. if an organization wants to stay in business, it must provide certain services).

▪ Intangible benefits are usually long-term benefits of the project and they are immeasurable in terms of the amount, and very difficult to estimate. Olson (2004) states that they include the expected increase in the market share, improve customer`s service and image of the company. In addition, these benefits include satisfaction (dissatisfaction) of employees, supply chain integration and the ability to support e-commerce. Intangible benefits often lead to real competitive advantage, although the economic impact is often difficult or impossible to be accurately estimated.

Table 7: Total Cost of Ownership of ERP as a percentage

Costs	Disposable	Recurring
Direct costs:		
Hardware	5 -1 0%	
Software	2 5-30%	
Maintaining ERP Provider		2 0-30%
Programming	5%	
Training	1 0%	
Consulting	1 5-20%	
Indirect costs:		
Employees	10%	5%

Source: Harwood S. (2004). ERP: the implementation cycle. Oxford [etc.]: Butter worth Heinemann.

In the previous table 7 the total cost of ownership of ERP is presented, as a percentage, while in the following figure 5 the percentage of the cost of SAP ERP implementations in companies in Serbia is presented. The largest percentage of costs requires the involvement of consultants. The procurement and purchase of new equipment represents 13% of the total project cost.
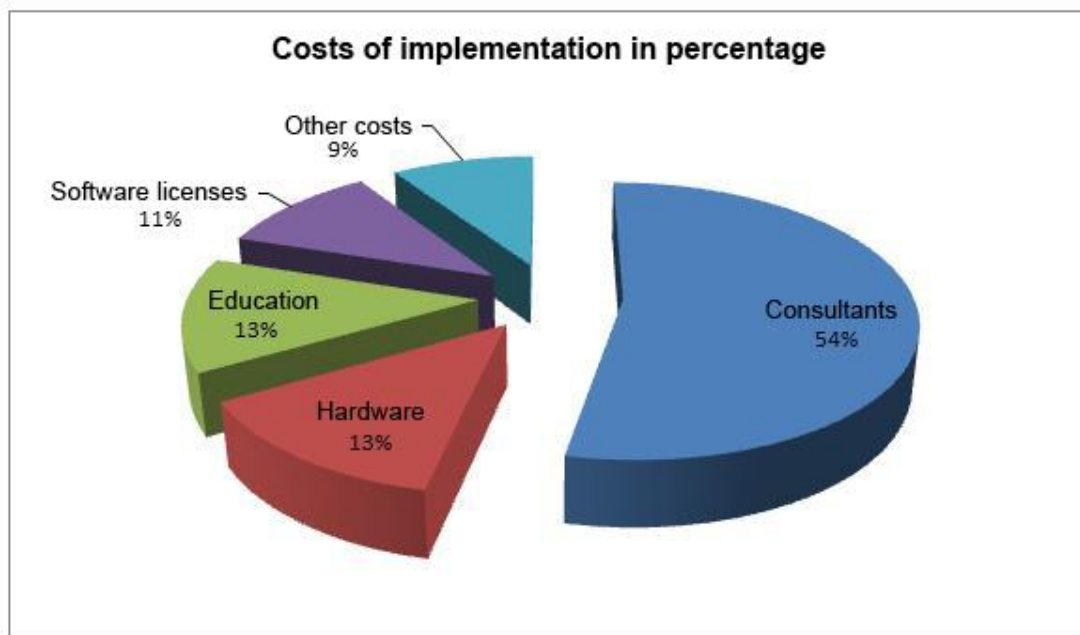

Figure 5 The percentage of the cost of the sample surveyed companies in Serbia
Source: Research conducted in enterprises in Serbia, 2014.

Given that ERP is a new information technology, and as such is constant, it is shown that the structure and goals of employees in the organization are changing, organizational structure, working values, information and knowledge are also changing, company goals are causing the change and that naturally create resistance,(Denic N.,2010). Usually, there are three types of planned changes in the organization of the company due to the implementation of ERP systems: structural changes, technological changes and changes focused on people (employees). Success is multidimensional and it refers to time and goals. Today`s success, does not have to be considered as such in two years (or 6 months). EPR systems which today provide a competitive advantage will provide such advantage if (or when) the competition reaches that competitive advantage (the advantage can become only a business expense). Success is sometimes evaluated depending on the company's unique goals in connection with the system.

The advantages of the implementation are:(Denic N., Zivic N., Dasic B., 2013)
- Real time Information across all functional areas,
- Standardization and accuracy of data, integrated information,
- Inclusion of "best practice" in the application,
- Standardization and acceleration of the business processes.

4 CONCLUSION

Given that ERP systems are new theme on this market and that relevant literature regarding the implementation of the ERP system exists only in developed countries, and that countries in the developing and third-world countries do not have the necessary knowledge and experience in the field of ERP systems implementation, this research paper provides a modest contribution to an improvement of research of above mentioned issues. Enterprise Resource Planning (ERP) systems are currently highly demanded in companies in Serbia and the region, especially for companies in the manufacturing and services based on industrial production, because they provide an effective management system that leads to significant improvement of productivity. What is presented in this paper is a comprehensive study to identify critical success factors and key benefits of ERP systems implementation using the responses from the concrete, chosen companies. The importance of these factors is examined in Serbian companies through the poll questionnaire. The results of the study provided practical guidance for business owners, management and ERP consultants in order to be more effective in managing the implementation of ERP solutions with its increasingly limited resources. In this paper, we were engaged in the research framework of the adoption and use of ERP systems, and we payed attention to the following questions: What are the factors and how much they influence on the adoption and use of ERP solutions by the company users. All previous studies have emphasized a small number of factors, so that none of them gives clear answers to the questions asked. In the introduction, the ERP system was presented, actually in order to be more precise, we have presented various definitions of ERP solutions and implemented an overview of the development of ERP solutions. In addition, we explained the advantages and limitations of ERP solutions, as well as trends in ERP solutions. Afterwards, the life cycle of ERP solutions is presented, and it was divided into four phases: identification of needs, selection of suppliers, the introduction and use,(Anderegg T.2000). If all of these phases are not being implemented during the life cycle of implementation, then their impact is significant in respect to the next phase of the life cycle and, directly or indirectly, to the adoption of ERP solutions by the users. The main contribution of this meticulously research is a comprehensive review of ERP solutions and its lifecycle.

Results of systematic research of the relevant literature and research conducted in different companies by type of activity and ownership structure clearly showed the following problems in project management of ERP solutions implementation in Serbian companies:
- Vague scope of the project,
- Under-definition of requirements,
- Bad assessment of deadlines
- There's no application of project management methods
- Frequent changes in management or project team members,
- Inadequate or insufficient training of end-users,
- Project does not provide solutions to interact with other systems.
- Lack of documentation of the system and the project as a whole.

Research has shown and confirmed that the benefits for the company which implemented the ERP system can be seen in perspective. It is also shown that, the most companies, do not assess the benefits and

impacts of the implemented ERP system to the organization and its operations. It is also indicative that the largest number of companies would not accept the research which will be conducted outside the company in respect to the effectiveness of the implemented ERP systems and their impact on the company.

As further directions of development and trends in ERP system implementation, the appropriate analytical methodology Hierarchy Process (AHP) can be used, and it can be used to determine the weight of the key success factors of ERP system implementation instead of, as up to now, the citations number of the key success factors, which were being used by some authors. Hestermann with co-authors (2009), in their research points, also emphasizes that in recent years the following trends were affecting ERP systems (especially for medium-sized enterprises):

- Verticalization system
- Modernization through the use of service-oriented architecture (SOA),
- Globalization, which is not only a characteristic of large companies,
- Consolidation of the market with a large number of mergers and acquisitions of ERP manufacturers.

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MANAGING THE RISKS IN INFORMATION TECHNOLOGY (IT) AND ROLE OF INTERNAL AUDITING

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Abstract: *Information technologies provide new business opportunities and increase the economic effectiveness of the organization. With the increased application of information technology there occur new potential risks that must be identified and controlled. The paper emphasizes the importance of internal audit in risk management of information technology. Audit of Information Technology is considered an activity of crucial importance in achieving the expected efficiency of information technology. This paper describes the methods of risk assessment, control activities, objectives and contribution of internal auditing in the process of risk management of information technologies.*

Keywords: organization, information technologies, management, risk management, control and internal auditing.

1. INTRODUCTION

Rapid technological progress affects all areas of human activity, including the objectives, strategies, methodologies, techniques, practices and criteria for evaluating the efficiency of control functioning in the risk management process. Innovations and changes in information technologies are relatively frequent, providing new opportunities, but they also carry numerous risks to be managed, which is a new challenge for the management. New computerized systems that are being introduced to meet the goals must be under control, and any events that may prevent the fulfillment of the objectives must be identified and risks assessed. Information technologies (IT) are of capital i.e. of strategic importance to business, and therefore, require a proper organization, management and control. Information is controlled by the information system, which in that way, become the basis of modern business. The success of the entire business depends largely on the operation of its information system, for which reason it is necessary to pay due attention to issues relating to the introduction of effective control of information technology. Otherwise, the survival of the entire organization business can be questionable.

Organization management has the task to establish a convenient system for risk management in information technology, primarily to assess the fulfillment of the planned development objectives, identifying, eliminating or reducing the risk to a minimum. It is therefore necessary that the process of risk management implements the internal auditing, as a professional, independent and advisory function, which is a new challenge for the internal auditing. When defining the risk management strategy in IT, the function of internal audit is also included. It justifies a range of control activities in order to identify and assess the risks, it is focused on the areas of higher risk and on the probability that the risky situation will occur, as well as on the potential negative effects on the business, which that risky situation might cause.

2. INTERNAL AUDIT AS A COMPONENT OF RISK MANAGEMENT PROCESS in IT

The audit of information systems (information systems auditing) is most frequently referred to as auditing of information technology, Weber (1999) pointing out that the auditing the information technologies "is the process of gathering and assessing evidence based on which it can be determined whether the information system operates in the function of property preservation and integrity of data, whether it allows the efficient realization of business objectives, and whether the business resources are used in an efficient manner."
Internal audit provides independent and objective test functions, objectives and activities of an information system as to gather evidence that can be independently analyzed or be a good basis for the revision of other business areas of the organization. Internal audit collects sufficient and competent evidence on:
- the efficiency, effectiveness and cost-effectiveness of the information system (the three "E"),
- the preservation of the integrity of information systems and data, and
- whether the information system meets the requirements of legislation, policies and rules on generally accepted business practices of the organization.

Information technology innovations are always important. They provide new business opportunities and increase economic efficiency In addition, by its operation, the internal audit helps in establishing the control

environment, that must be established by an organization, as a part of the policy of compliance with certain standards. Activities of auditing system in information technology must be focused towards the creation of an effective control environment that ensures the identification, evaluation and prevention of risks and provides transparency of the internal control processes, (Sobel, 2007). Therefore, the internal audit function within the organization plays an important role in the risk management of information technology.

3. RISK ASSESSMENT AND OBJECTIVES OF GENERAL CONTROL ACTIVITIES IN AUDIT OF IT

It is almost impossible to imagine the flow of business processes of the organization and provision of timely and reliable information needed to make different business decisions without the use of information technology. Therefore, it is not necessary to emphasize the impact of information technology on the overall business process of the organization. Reliable information system allows a prompt transmission of accurate information to management and employees, coming from internal and external sources, which are of importance to them to carry out tasks under their responsibility. The erroneous risk assessments in information systems are not rare done by the management, which business organizations can present as huge losses. According to McNamee (2008) the most common examples of such estimates include:

1) The minimum investments in IT because there are leaders who believe that IT investments will not yield the expected results, as being unprofitable and
2) Lack of or inadequate supervision upon the information system.

Internal auditing carries out the evaluating procedures of the selected internal controls of information system to determine its compliance with the objectives of the organization or with the appropriate adopted internal control procedures. According to James (1999) the task of internal audit is that continuously checks how the system of internal control of electronic data processing. These methods usually comprise individual programs and procedures, as well as the environment in which processing of such data takes place.

3.1. THE PROCEDURE OF RISK ASSESSMENT IN IT

The success of risk management is to assess when and how to minimize risk, eliminate or accept a certain extent. The basic assumption of the risk assessment is preliminary familiarization with the organization's goals and risk exposure to achieve the set goals. Risk assessment is an important activity of internal audit in risk management of information technology. It involves performing procedures to identify and analyze risks. Identification and analysis of risk instruments of modern risk management IT. Risk assessment up includes the identification and ranking of all relevant internal and external factors that could prevent the realization of the goals of the organization. At the stage of IT risk assessment, the internal audit function assesses the adequacy of internal control system. To achieve implement the following activities:

1) Determine the scope of the business processes of the organization that are subject to risks and the most important elements of organizational and business processes and the system of internal controls;
2) Assess the control framework and established controls in relation to the objectives, risks, and past experience;
3) Checks whether the system of internal control is of the appropriate nature and whether it operates successfully, primarily for protection against risks.

After learning about the organizational structure, business organization and system of internal controls, the internal audit determines the methods and techniques for risk identification, and then for its analysis and assessment. The risk assessment includes identification of the dangers followed by the gaps of information systems. According to Sawyer (2005), IT risk can be classified into two groups: (1) random and (2) intentional. One of the biggest dangers of random data processing is the threat of equipment destruction, the destruction of a folder, deleting data, assigning the wrong commands, force major (fire, floods and earthquakes), explosions , or acts of terrorism, loss of management personnel, improper installation of equipment etc. Intentional dangers (threats) are generally pre-designed frauds, such as data stealing, the use of prohibited programs, the abuse of certain data, hackers, various acts of sabotage, viruses etc.

When internal audit identifies potential risks, the next step to take is to identify the property that is most exposed to hazards listed, and then follows the risk assessment process. It often deals with forecasts of potential losses. It is therefore a very important task of auditing to, after the completion of the task, deliver the report to the management which will present and document any deficiencies in the control system, if noticed. The report will present their opinion on the possible consequences of deficiencies in control procedures, as well as suggestions for taking the possible preventive and corrective actions and measures to improve such controls, and implement process control of corrective actions and measures. Thus, the internal audit established in the risk management process is organized as a permanent activity.

3.2. CRITICAL AREAS AND OBJECTIVES OF GENERAL CONTROL ACTIVITIES IN IT

Control audit activities related to risk management of information technology, nowadays, are almost unavoidable. Internal Audit of Information technologies has a supervisory role and is the holder of various control activities, in cases where it is estimated that the main risks are those associated with information technology. Management is responsible for: (1) the establishment of an adequate system of internal controls and information technology to ensure that all critical areas and key business processes are covered by the control; (2) to design appropriate procedures to inform the employees of the policies and procedures of the organization, as well as of all changes. Employees are required to apply establish the control policies and procedures. According to Sawyer (2005), the general control of the internal audit is a set of policies and procedures that are meaningful in the risk management process, in order to achieve the following objectives:

1) *Provision of information.* Internal audit helps the management to provide accurate, timely and complete information, including accounting information for planning and monitoring the performance and reports on business operations;
2) *Ensuring the compliances.* Internal audit helps to ensure compliance policies and procedures of the organization with the legal requirements applicable to the business of the organization;
3) *To promote efficiency and efficiency of business operations.* Internal audit provides an environment in which the managers and employees can increase their efficiency and effectiveness;
4) *Realization of planned goals.* Internal auditing provides a mechanism for monitoring the achievement of pre-set objectives and tasks of the organization.

According to Moeller (2007), internal audit can adequately protect the information system, only if it is informed of all the threats that can attack and endanger it. This includes identifying of areas where the threat is greatest-the threat of the existence of errors or loss. To be effective, internal audit pays the greatest attention to potentially risky areas. Audit of Information Technology is considered an activity of crucial importance in achieving the expected efficiency of information technology, for several reasons, according to Weber (1999) the most common are:

1) To preserve the integrity of data
2) Preservation of tangible and intangible assets and
3) Protection of privacy.

Preserving the integrity of data. Data are a sensitive resource of organization, as they enable the analysis of business in the past, current and future periods. Data integrity implies to completeness, clarity and truthfulness. Data are complete when all business events are covered. Clarity means that the data can be interpreted in only one way and the user of the data must be in a dilemma regarding its meaning. Data are true when they faithfully reflect the events to which they refer. In view of the above facts, data integrity is a very important activity of the audit. It aims to verify whether the internal controls of information system are established, and if so, whether they work adequately.

By the proper processing the data are converted into information that is the basis of so-called information economy. Bringing the quality decisions, long and short term ones, mainly depends on the quality of data or information on which decisions are made. If an image is created of an organization on the basis of exact information data, the organization will have greater opportunities to adapt its operations to constant changes. But if the image is created on the basis of incorrect information, the organization will inevitably suffer significant losses, which are difficult to be compensated. This may be due to the lack of appropriate IT controls carried out by the internal audit.

Preservation of the assets of the information system of an organization. It is undisputed that data are a very important resource of an organization, but it is equally true for other IT assets (hardware, software, staff). As a consequence of the influence of supply and demand, the prices of IT equipment are decreased, the total value of the equipment with software grows, and increasing is the price of labor experts in the field of IT. There are few experts in the field of computer science as compared to the needs of the organization, especially when it comes to e-business mode, which, from the global point of view, plays a dominant role. Even the most developed countries in the world have problems to adjust the rate of technological progress to the number of necessary experts. They resolve this issue by hiring experts who come from less developed countries, like our country, and these, on the other hand, have a problem because of the emigration of such experts. Any loss of IT resource, either data or property being in question, results in large financial problems in the organization. If, for example, there comes to a loss of a program (software), the confidential information could come into the hands of competitors, leading to large losses.

Activities carried out by internal audits for the purpose of protecting these assets are difficult because of the nature of property, and therefore, they are to be carried out with special due diligence of auditors. The

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reasons why the traditional methods of managing IT assets must be replaced with new modern methods are: (1) a large value of intangible IT assets (2) big volume of this the assets (a large number of software codes), (3) infrastructure network of information system is located in different geographical areas, and (4) Internet work, presented at present, means the work in cyberspace. Possibility of any loss of these assets should be prevented by appropriate actions and measures, the significant role of which is the internal audit.

Protection of privacy In the information system, among other things, the data of the staff are collected and preserved, which can even be of personal nature. These are, for example, the data on the health status of employees, their culture, economic status, qualifications, family situation, education, political and religious orientation, etc. If the data of the privacy of the staff are not protected adequately, it may happen that they come into the hands of malicious persons. As privacy is one of the basic human rights, the organization needs to work on passing legislation and measures to protect and preserve the privacy of persons employed (business software solutions in Serbia, Belgrade (2011). Each organization, with its internal acts determines it's the issues of individual privacy and the necessary measures of protection, thus building up its information system. By control and auditing of information system will be established whether these rules are respected and conducted in the organization, to what extent and what results are achieved.

4. CONCLUSION

Information system is the basic infrastructure of business in an economy and the holder of the information resources of business, so any improvement of their efficiency, effectiveness, and cost-efficiency, as well as improving the preservation of assets and the integrity of data, will greatly affect the business strategy and business results of the organization. Any technology, including information technology itself, is neutral and can be of use to individuals or organizations and to the human community in general, but it can also be misused. The problem lies in its implementation. Appropriate risk management system in IT means the establishment of a number of procedures and criteria for the identification of rapid technological change, in order to fulfill the tasks and set the criteria for risk tolerance for the purpose of taking the necessary actions and measures for proper management of IT risks. Key events of rapid technological changes shall be subject to the identification and assessment of risks throughout the entire business process at all levels of management.

The main objective of the organization in managing the risks in information technology is to determine the procedures and scope of practice of the top-level management and executive management bodies, when making strategic decisions about the cost-effectiveness of IT investments, as well as when bringing the decisions, by which the business risks of extensive use of information system are managed.

Integrated internal audit in risk management system of information technology helps the organization establish an adequate system of internal control of IT, leading to the achievement of defined strategic objectives of the organization. It contributes to assuring quality, relevant and reliable information base for decision-making and management, which gives a positive reflection of the organization and increases its value, which is the basic concept of successful management.

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THE INTRODUCTION OF THE EFFECTIVE METHOD OF GIS TECHNOLOGY IN WATER SUPPLY SYSTEMS

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Abstract: *This document presents the created effective method of introducing Geographic Information System into Water Supply Systems. The main aim of this paper is to analyse the project on the introduction of GIS Technology in Water Supply Systems in Serbia. The result of the thorough analysis and research is the introduction of the effective method of GIS Technology. This method is developed and successfully implemented in Water Utility Service 'Vodovod Valjevo'. The main purpose of this method is the effective introduction of Geographic Information System with the maximization of the major effects. The created method can be used for the educational purposes but also as a starting point for the implementation of the project on the introduction of GIS Technology in other organizations which deal with water supply systems, only with the written consent of Water Utility Service 'Vodovod Valjevo'. The method consists of thirteen introductory phases. Five of these phases are the basic structural phases whereas eight other phases represent the phases of assessment, measurements and control. When the decision about introducing GIS Technology has been made, the main motivating factor for the introduction and implementation of the project is the enhancement of the whole organization's efficiency. The major expected effects of the implementation and introduction of GIS Technology in Water Supply Systems are: the increase in the economy, the development of the information system, the enhancement of employees' professional competences, and much better organization of the water supply system as well as the introduction of the strategy for ecologically sustainable development. This paper also presents the basic GIS software packages which are used in Water Supply Systems in Serbia and their functional analysis.*

Keywords: *geographic information system, efficiency, method, organization, water supply system*

1. INTRODUCTION

Following the development of information and communication technology management of PUC "Water Valjevo" in association withthe service of development is defined as a priority increasing of organizational effectiveness by information systems development.

 „An information system can be defined as a set of interrelated components that collect, manipulate, store and disseminate data and information and provide a feedback mechanism to meet an objective" (Vavpotič., 2012). The introducing of geographic information system and its full integration with business information systems imposed as a priority in modern organizations including the PUC "Water Valjevo. Developed geographic information system will be used as a basis for reducing losses in water supply network,increasing efficiency, reducing negative impacts on the environment, the development of information system, increasing professional competence of employees and raising the level of organization.

2. COMPOSITION

Observing the effectiveness of water supply systems in Serbia can be easy to spot weaknesses in terms of ratio of the quantity of produced water for drinking and the amount of water which is invoiced to the direct customers. For the calculation of organizational effectiveness, we used the formula E(X), which place in relation precisely this type of loss and the goal of research is to reduce this kind of loss and increasing organizational effectiveness in this way.

$$E(X) = \frac{X}{Y^!} * 100 \ \%$$

E(X) – coefficient of organizational effectiveness of water supply system
X- the quantity of water billed to the direct customers
$Y^{!\text{-}}$ the quantity of water produced

To make GIS system to be effective it is necessary to introduce GIS by the created model and to observe the phases of introduction. In this way, the GIS will achieve maximum results. Text that follows shows the phases of GIS technology introduction, created by effective method.

The introduction of GIS technology by an effective method consists of the following phases:
- The decision on implementation of GIS technology;
- Measuring justifiability of decisions;
- Forming the team;
- Review of the decision of all team positions;
- Hardware-technical structure;
- Review of the hardware-technical structure justification;
- Software solution;
- Rating of software solutions;
- Organizational procedures;
- Rating of defined organizational procedures;
- Evaluation of the first phase of the introduction of GIS technology;
- Rating the second phase of the introduction of GIS technology;
- Quarterly evaluation and control (include a review and re-consideration of the first 10 points.

The decision on implementation of GIS technology
The decision on the implementation of GIS technology represents the initial stage in the process of raising organizational effectiveness of water supply systems. This decision has to be made by top management that has a clear vision of the main objective of implementing GIS technology, the effects of the introduction of GIS, the cost of the project and the time schedule of the implementation.
The decision must be presented in clear, concise, formal, written document which must be verified by all relevant institutions in the organization. In case of PUC "Water Valjevo" it is supervisory board, the general manager, director of production and technical department and director of economic, legal and general affairs. Such written decision shall be submitted, in addition to the signatories themselves, and all managers of work units, department managers, heads of services, to all employees information system tasks that are expected full involvement in the implementation of future projects.

Measuring justifiability of decisions
As all other decisions, if we want to be relevant, timely, effective and supported by as many employees it is necessary to be periodically reviewed and examine justification. In the PUC "Vodovod Valjevo" justifiability of decisions is measured in such a way that to each of employee sent a questionnaire with the question "Do you think that is in the PUC" Water Valjevo "required the introduction of GIS technology?" If the answer is affirmative to all employee shall be given the opportunity to present on the same form their opinions, proposals, suggestions regarding the implementation of the project. Thus the completed questionnaire each employee sign and submitted to a central database.

Forming the team
Since the decision has been made by the top management in the next phase should form a team. Engineer of organizational sciences defines organizational roles, tasks and responsibilities of team members. The company's management elected among the staff members of the project team and the immediate supervisor of the team. As with any team, goal is full implementation of project by defined term plans and budgets. Members of the GIS team must achieve a synergistic effect. In addition, to staff from the organization team, can join and external consultants with relevant competent knowledge in this field.

Review of the decision of all team positions
For the successful execution of all activities of the project each team member must possess adequate knowledge or ability to learn and acquire new knowledge. Phase of the review is carried out on the way that team members in a closed questionnaire listed the name of a member who they feel most competent as a team leader. Thus obtained results is compared with already done choices and manager should make the decision reviewed. Also, team manager once again considers all positions in team and makes a proposal to the director of production and technical department makes the final decision on the selection of team members.

Hardware infrastructure
The basic elements of hardware infrastructure are: server, personal computers, tablet computers, portable computers, computer networks, storage devices, plotters, printers, GPS devices, total station, permanent

stations, orthophoto base, cadastral maps, transportation equipment, and in some cases, unmanned aircraft for orthophoto record.

Review of the hardware infrastructure justification

Selection of the basic elements of hardware infrastructure is choice of the management of each organization and the final decision is made by the manager of the project team within the available budget.

Software solution

To software selection must be given maximum attention because the market faced a number of software solutions that are more or less compatible with the needs of the organization. The most important software that GIS team should have can be classified into two major groups. The first group consists of software to run on the field and they are: software for independent GPS devices, software for GPS receivers, software for portable field computers and software for total station. The second group consists of software to work in an office and are software that are used to transfer and convert the data from the GPS device to the database server, the basic GIS software for data entry and processing on desktop computers, designed primarily for use in the office, reporting software and the database itself. For decision making of the choice of software may be used different.

"The decision-making model developed and implemented by Utility Service Department Vodovod in Valjevo consists of three phases. In the first stage, the employee, who is responsible for the Information System, decided upon the alternatives which will be the case of the furher analysis and decision-making process based on the Additional questionnaire" (Stajčić., 2012).

The main requirements that GIS software in water supply systems must meet are:
- The possibility that the same descriptive class feature keeps the lines, points and polygons;
- The ability to display the results of input on an unlimited number workstations without additional licensing and with its own software solution;
- The possibility that the visual appearance of each element on the layer folder changes independent of the pre-defined layout for the same;
- Integrated module for calibration, refinement and georeferencing of scanned maps;
- Support for raster files size up to A0;
- Nativna / Built-in support for connection without any additional application layer / attachment to all common RDBMS systems that can run on Linux and Microsoft operating systems;
- Built-in "CAD like" drawingoptions with the GUI and the principles of work similar to AutoCAD;
- During digitization, software must be able that element that is digitalised use already delineated geometry and takes her vertex coordinates;
- Defining a virtual column over the attribute tables that are dependent on the attributes that exist in the attribute table;
- Conversion in the multilayer PDF document with coordinates;
- Built-in support for Bing Maps without additional licensing;
- Built-in functionality to connect to the Google Earth service;
- Built-in ability to export data for Google Earth model;
- The possibility of developing additional modules and applications using its own development environment with its own editor, programming languages and compilers optimized for desktop GIS platform;
- Minimum of five developed own tools used in water supply systems;
- The supplier shall present a document certifying that he is authorized by the manufacturer, to sell the software in the Republic of Serbia.

All software for data entry and data processing can be divided into two major group. The first group consists of commercial solutions, and other non-commercial open source solutions:

1. Commercial solutions:
   - *ESRI ArcGis;*
   - *AutoCAD® Raster Design, AutoCAD Map 3D;*
   - *MapInfo;*
   - *MapSoft.*

   - "The software solution of ESRI company, ArcGIS is a synonym for reliable software for data entry and processing." (Esri., 2014). ESRI solutions are reliable and suitable for large water supply systems as a comprehensive solution. It includes 3D terrain modeling, ArcGIS Server, ArcGIS Web. All these modules are required water supply systems in later stages of the GIS. ArcGIS price, if supplied with all functionalities, is beyond the capabilities of small water supply systems the size of

the PUC "Vodovod Valjevo" so that the solution to price criterion is not acceptable. Large water systems, such as the water system Novi Sad, successfully implement this software solution. Analysis of software solutions for the model PUC "Water Valjevo" - Symorg 2012, this software solution is denoted as unacceptable because of the high cost of implementation and after the first round vote.

- AutoCAD ® Raster Design, AutoCAD Map 3D, are solutions that the PUC "Vodovod Valjevo" successfully implement and use since 2014. This solution comes in a package AutoDesk Suite. This solution comes in a package with other CAD functionalities but does not include all the basic requirements placed in GIS software. Since the PUC "Vodovod Valjevo" already owns the GIS solution and in view that does not meet all the software requirements, this solution is not considered as a solution that will be used as the basic GIS tools. The main representative of this software for our market is Autodesk.

- MapInfo is a basic GIS software solution of U.S. company Pitney Bowes Software, which has all the basic requirements of the GIS solution should have. "Its have the possibility of further development using its own compiler and programming language" (Lama., 2014). Modules such as WebGIS, 3D modeling are modules that this software includes with additional licensing. These functionalities are not required in the initial phase of the introduction of GIS technology, so this solution is acceptable because the cost is totally suited for smaller water supply systems. Water supply system of Uzice and Nis use this software solution. The main representative of this software for our market is firm Lama.

- MapSoft solution of Chinese company is the main GIS solution that recently appeared on the our market. This solution has not yet been implemented in any water supply system in Serbia. Therefore, this software solution is not acceptable for the water supply systems which as a condition placed delivery of the reference list. "This software solution has the possibility of additional software development" (Docus., 2014). Additional tools for water supply systems are still in the development stage, therefore, does not yet have the opportunity to present all the functionalities of the developed modules, thus the reliability of the further development of this tool is hard to measure. The main representative of this software for our market is firm Docus Cacak.

2. Non-commercial open source solutions are:
   - *Grass*
   - *Chameleon*
   - *Geonetwork opensource*
   - *Geotools*
   - *Gvsig*
   - *Ilwis*
   - *Jump gis*
   - *Openlayers*
   - *Postgis*
   - *Quantum gis*
   - *Terraview.*

These software solutions are suitable for minimum water supply systems and water supply systems which are not able to devote the funds and want to start with the implementation of GIS. In larger water supply systems, these software tools can be used as an additional solution. According to their functional characteristics these solutions do not meet all the basic requirements. The PUC "Vodovod Valjevo" successfully used Quantum GIS. This software is used to upload georeferenced cadastral plans and orthophoto basis. Given that the GIS department needed sophisticated software tools, this non-commercial solutions are seen as complementary and can be used in work places where entry is required and reading spatial data and where it is not planned expenditure and financial investment.

Rating of software solutions
According to the turbulent and dynamic software development, organizations that want to effectively use new technologies must review the decision of a chosen software. Once selected software solution will not be a permanent solution, it is justified at one time and one time interval. This period can not be defined in advance, but must be continuously performed evaluation of available software to help organizations always have the kind of software which is most appropriate at a given moment. Check and reviews of software in water supply systems should be carried out once half-yearly.

Organizational procedures
Organizational proceduras are a necessary prerequisite for effective GIS. Applying and defining redesigned and brand new procedures enable achieving a higher level of management. Organizational procedures must cover all aspects of the GIS team work, and the work of all departments which own data entries in a single

database. In PUC "Vodovod Valjevo" case were redesigned management procedures for defining the consumer, measuring points and measuring devices. Completely new organizational procedures created for entry of digitized projects, with all the objects and associated attributes, they are set as a prerequisite in creating.

Rating of defined organizational procedures
It is necessary to observe organizational procedures and re-review them, also and pre-defined stages. This procedure is necessary to carry out semi-annually. If determine the need for change then should redesign organizational procedures and defines an entirely new organizational procedures.

Evaluation of the first phase of the introduction of GIS technology
Represents a phase of measurement and control of the results achieved in increasing organizational effectiveness . GIS technology as a basis for raising organizational effectiveness has a purpose only if the coefficient of efficiency of the water supply system is stagnant or has grow. In the event of an unexpected fall of the coefficient, estimate of the first phase of introducing GIS is not positive, and expected results are not satisfactory. If this ratio declined it is necessary to determine the cause and to define strategies for proactive action. In the PUC "Vodovod Valjevo" the expected increase of this ratio for the first phase is only 1-2%. The low level of increase of organizational effectiveness is due to the fact that this is the introduction of new technologies whose implementation takes time to train all staff and work on the application of the use of GIS database can not go completely synchronized, but about using can speak only after 0,5-1% of the base is formed. Evaluation of the first phase should be carried out after the formation of 2,5% of the total base.

Rating the second phase of the introduction of GIS technology represents the second phase of the measurement and control of the results achieved in increasing organizational effectiveness. In the PUC "Vodovod Valjevo" the expected increase of this ratio for the second stage is only 2.5-5%. At this stage it is expected a significant increase of organizational effectiveness. It is assumed that the staff have sufficient training, the technology is fully integrated and therefore the coefficient can not be dramatically lower than expected. The second phase of the evaluation should be carried out after the forming up to 5% of the total base.

Quarterly evaluation and control (include a review and re-consideration of the first 10 points). Period of introducing GIS project in the water supply system should be divide into smaller cycles of time. These cycles should not be less than 4 months. After the end of each cycle should determine the coefficient of organizational effectiveness. This ratio can vary according to the number of available personnel involved in the operation, their training level, the type of used technology and method of application. This phase is presented by activity number 16 on the Gantt chart 1 (Figure 1).
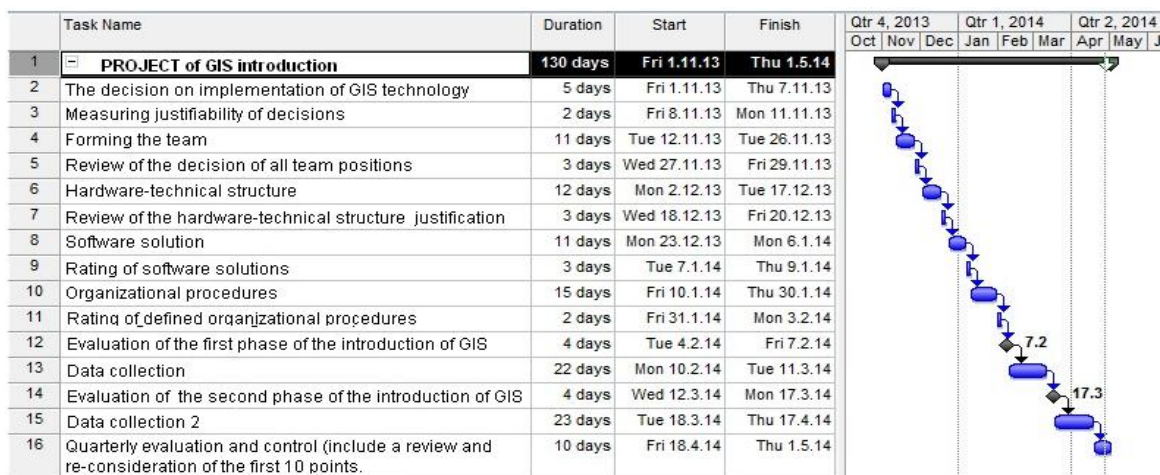
	Task Name	Duration	Start	Finish	Qtr 4, 2013 Oct Nov Dec	Qtr 1, 2014 Jan Feb Mar	Qtr 2, 2014 Apr May J
1	PROJECT of GIS introduction	130 days	Fri 1.11.13	Thu 1.5.14			
2	The decision on implementation of GIS technology	5 days	Fri 1.11.13	Thu 7.11.13			
3	Measuring justifiability of decisions	2 days	Fri 8.11.13	Mon 11.11.13			
4	Forming the team	11 days	Tue 12.11.13	Tue 26.11.13			
5	Review of the decision of all team positions	3 days	Wed 27.11.13	Fri 29.11.13			
6	Hardware-technical structure	12 days	Mon 2.12.13	Tue 17.12.13			
7	Review of the hardware-technical structure justification	3 days	Wed 18.12.13	Fri 20.12.13			
8	Software solution	11 days	Mon 23.12.13	Mon 6.1.14			
9	Rating of software solutions	3 days	Tue 7.1.14	Thu 9.1.14			
10	Organizational procedures	15 days	Fri 10.1.14	Thu 30.1.14			
11	Rating of defined organizational procedures	2 days	Fri 31.1.14	Mon 3.2.14			
12	Evaluation of the first phase of the introduction of GIS	4 days	Tue 4.2.14	Fri 7.2.14		7.2	
13	Data collection	22 days	Mon 10.2.14	Tue 11.3.14			
14	Evaluation of the second phase of the introduction of GIS	4 days	Wed 12.3.14	Mon 17.3.14		17.3	
15	Data collection 2	23 days	Tue 18.3.14	Thu 17.4.14			
16	Quarterly evaluation and control (include a review and re-consideration of the first 10 points.	10 days	Fri 18.4.14	Thu 1.5.14			

Figure 1: Gantt chart activities of GIS technology introduction

3. THE MAIN EFFECT OF INTRODUCING GIS TECHNOLOGY AT AFOREMENTIONED METHOD

The most significant direct effects of implementation are:
- the impact on the effectiveness;
- ecologically sustainable development;
- impact on the development of information systems;
- raising the professional competence of employees and

- a higher level of organization.

The impact on economy increasing
Large losses in water supply systems is the losses of water that is not invoiced to final consumers, but it is distributed in the system. The loss of water that is not billed to the final consumers, measured by the percentage is moving at about 50%. In water systems that are more economical, this percentage is much lower leads to a level below 10%. The aim of the PUC "Vodovod Valjevo" is phase shift implementation of GIS as a basis for measuring losses in the network. In this way in phases will be revealed and losses in the network. By detecting network losses and their elimination we will increase economy of the water supply system. In case of PUC "Vodovod Valjevo" long term goal is phased shift reduction of losses and bringing to the desired level of about 10%. The expected level of economy increasing is about 5% by looking at each phase of the implementation of GIS respectively.

The introduction of GIS technology in water supply systems form the basis of respecting principles of environmental management and the basic application of ecological strategies in their business. In fact, since water supply systems encompass a large amount of water they greatly affect the environment. Along with the increased environmental awareness and the need to introduce sustainable development there is and the growing need to introduce all forms of technology that will contribute to environmental protection. GIS technology has been used in water supply systems as a basis for the analysis of water losses in the network is a necessary condition for the respect of the principles of environmental management. The basic principle of environmental management that will be accepted is the principle of change in consumption patterns. The water in the system will be distributed with respect to this principle as the water system to be operated in this manner classified as environmentally responsible system.

The impact on the development of information systems,
Geographic information system viewed as part of the information system of organization aims to increase the effectiveness of water suplly systems. In fact, in a common base of information system enter data collected by GIS technology. These data is available to all users of the information system. In this way, the impact of GIS on the overall information system is very large. The most significant benefit of this way of linking is the availability of spatial data. PUC "Vodovod Valjevo" is in the process of integration of geographic information system.

A higher level of organization.
Geographic information system is not goal in itself, but should be seen as a means to achieve the strategy of raising the effectiveness of the organization. In water supply systems, GIS should be implemented in a way to raise the level of organization of the system. Introducing of GIS must follow, redesigning the organizational structure, defining organizational roles and tasks. The introduction of GIS has to follow the definition of completely new procedures that have not existed. In this way, occurs complexity of the organizational structure but only In this way GIS contribute to the development of the entire organizational structure and then we can talk about a higher level of organization. Procedures must cover all aspects of work with GIS in order to avoid situations that GIS remains an isolated part of the system.

Raising the professional competence of employees
All employees can be divided into two groups. The first group consists of persons who will use the information from the database, these employees expand their knowledge in the use of spatial data. The number of this employees will be equal to the number of personal computer users within the information system, which means that practically all users of the information system have access to information collected by GIS technology.The second group of employees are members of the GIS team. These members will be able to use themselves all the software and all the GIS hardware. Also, they will expand knowledge and gain new experience in organization, environmental management and information system. Their knowledge and experience will expand by the seminars, forums and direct benchmarking with organizations that have adopted GIS.

4. CONCLUSION

Geographic information systems in water supply systems is the basis for increasing organizational effectiveness . Geographic information system should be considered as part of the overall information system within the organization and as such it needs to be fully integrated with business information system. Only in this way, from information system can be expected maximization of results . All water supply systems are required to define as one of the goals of their business implementation of geographic information system. This objective is necessary to set, but and begin its implementation . The realization of this project does not always and in every case must be limited in terms of the water supply system is not able

to allocate some funds. Water supply systems can start this business with minimal financial investment,by engaging human potential. Water supply systems that do not have these resources can hire external consultants.

With the introduction of geographical information systems in water supply systems will achieve the expected raise of organizational effectiveness. The introduction of GIS technology we expect realization of direct effects: increase of economy, environmentally sustainable development, impact on the development of an information system, raising the professional competence of employees and higher level of organization . All direct effects are already achieved in the PUC "Vodovod Valjevo ."

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IMPROVING SERBIAN HEALTHCARE SYSTEM WITH "FIND A MEDICINE"

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Abstract: *The main objective of this paper is to present a software system developed to provide access to data of public interest related to Serbian healthcare system. The focus will be on pharmaceutical institutions and information regarding medicines and their availability in pharmacies. The software integrates and centralize all relevant information from all healthcare institutions in Serbia. As a result, the system provides benefits to all stakeholders: citizens, healthcare institutions and National Health Insurance Fund (NHIF). Citizens can find the nearest pharmacies that has medicines they need at the time. Healthcare institutions integrates data from all organization units - pharmacies, enabling efficient medicines stock management. For the first time NHIF have access to accurate stock level for all medicines in all pharmacies in Serbia. NHIF uses the system to analyze the data in order to make decisions concerning procurements, rationalization, control raising performances and cutting costs of healthcare system. Software system is consisted of four integrated modules. Medicines search is provided in the form of web application at NHIF official website, and on Healthcare institutions websites, and also in the form of Android application for smart phones. Besides the system contains data integration module and analysis and reporting module.*

Keywords*: data of public interest, Serbian National Health Insurance Fund, Find a medicine, Medicines stock level, Software*

1. INTRODUCTION

The economic situation in the Republic of Serbia and inefficient management of the healthcare system has led to major problems in the functioning of almost all of its parts. This situation affected the healthcare institutions at almost all levels of healthcare system. Frequent shortages of medicines and medical supplies, increasing waiting lists, insufficient capacity to provide healthcare services are just some of the key issues facing the healthcare system.

NHIF has recognized these problems and set up a high priority level to resolve them. NHIF has performed a detailed analysis of the state of the healthcare system in order to determine the precise steps that will help to solve each of these problems. During the analysis it was determined that many health care institutions, and consequently the NHIF does not have information that are the indicators of the success of performing their activities. On the other hand, there are institutions that have well-maintained information systems and the necessary information, but this information in different institutions vary in content and structure. This situation did not meet the requirements of the users of the healthcare system. They did not have access to the necessary information related to healthcare. Also, due to incomplete and different data structures any attempt to aggregate data analysis by NHIF at the republic level was very difficult. That is the reason why increasing access to data of public interest have been identified as one of the preconditions in solving pressing problems. Yasnoff et al (2000) point out that "development of effective public health information systems requires understanding public health informatics (PHI), the systematic application of information and computer science and technology to public health practice, research, and learning".

The focus of this paper will be on pharmaceutical institutions and information regarding medicines and their availability in pharmacies. Frequent shortages and unbalanced distribution of medicines in healthcare institutions resulted with serious threats to the health condition of the insured persons. Also, it happens that old people and people with serious medical conditions visit several pharmacies in order to find a required medicines. Many pharmacies did not implemented any kind of searching of medicines stock level, while searching the medicines stock level at the republic level was out of the question.

The subject of this paper is the importance of transparency and functional integration of pharmacies data of public interest on a daily basis in order to improve the functioning of the healthcare system as a whole. Leape et al. (2009) proposed to increase the level of transparency as one of the measures to increase the level of organization of the healthcare system. In this way it can be ensured:

- uploading the medicines stock level on a daily basis in order to perform procurement of necessary medicines,
- perform their uniform distribution by pharmacies as it would not happen that in the a city or part of the city there is no required medicine, and in other has more than necessary. This leads to accumulation of inventories and hence unnecessary costs,
- provide a stable supply of medicines which would prevent possible shortages and
- simplifies the way users of healthcare services find required medicines

2. DATA OF PUBLIC INTEREST

The most important step toward better healthcare system was to identify the data of public importance which health care institutions have to make accessible on a daily basis. Primarily, it was necessary to define the unique structure of the data in order to enable adequate integration and analysis.

NHIF management board made a decision on data which will be mandatory as a content of a website of every health care institution and forced them to operate in accordance to this act. This act was published in Official Gazette no. 52 and was applicable from 14th of June, 2013.

NHIF made detailed specification of the data which every type of health care institution have to make public. This specification divided data to set of categories for every type of health care institution. So we have:
- Primary health care level
- Secondary and tertiary health care level
- **Pharmaceutical institutions**
- **Pharmaceutical institutions founded by means of private property that have signed contract with NHIF**
- Rehabilitation facilities
- Department of Public Health and the Institute

This paper is focused to pharmacy institutions, and relevant information identified are:
- Medicines - part regarding data of medicines that are financed from obligatory health insurance. This provides insured persons, health care institutions, medicine manufacturers and public in general to have insight to the information of the medicine
- Medicines stock level - related to the stock level of medicines, implant materials and medicine devices based on information provided by health care institutions.

This way NHIF standardized and simplified gathering of information from all pharmaceutical institutions and enabled centralized data analysis, better stock optimization and easier medicine search. Leape et al (2009) argues that all this leads to cost reduction and increasing satisfaction and trust of insured persons in the health care system.

It is very important to point out that along with the public pharmaceutical institutions which consists NHIF pharmacy network, this system includes pharmaceutical institutions founded by means of private property that have signed contract with NHIF to issue the prescription medication. This doubled the number of pharmacies and made medicine search easier and much more useful. On the other hand pharmaceutical institutions founded by means of private property that have signed contract with NHIF have opportunity to promote themselves and increase the sale.

3. FIND A MEDICINE

The software system that is the result of this project provides accessibility of data regarding the level of stock of medicines and medical devices as the information of public interest for each pharmaceutical institution and all associated pharmacies, as well as the centralization of these data for the purpose of business analysis.

This project was implemented as a Content Management System (CMS) which, in addition to functionalities related to input and display of data enables the functionalities related to the processing and analyzing the collected data.

The project has been realized through the implementation of three web applications and one android application which together constitute content management system. One web application is designed for employees of health care facilities and provides data entry concerning stocks of medicines in a pharmaceutical institution. Data entry is enabled by using web forms that are an integral part of the Content Management System. Users can upload the XML file which reduces the work load of employees. Another web application is meant to employees in NHIF and enables data analysis in order to improve control and

business operations. The third web application and Android application allows all citizens to access information of public interest and enables them to search of medicines they need.

Figure 1 shows the designed software applications. All business logic is located on the application server at NHIF, and communicates with a database server. The following applications has been developed, targeted to different user categories:

- The citizens - have the opportunity to view and search information of healthcare institutions. The ability to search the data is provided in two different ways:
  - Using a web application, which requires a web browser. It is available at http://rfzo.rs/index.php/component/content/article/16-infolekovi/2012-10-29-12-35-11/501-pronadji-lek,
  - Using the mobile application, which requires Android mobile phone. Application is free and available for download at https://play.google.com/store/apps/details?id=rs.rfzo.apoteke&hl=en. Pan et al. (2007) point out that mobile devices are getting smaller, smarter, and more connected, any time and any access to any information while on the move. According to Noordam et al. (2011) mobile devices are widely used within the health system.
- The pharmaceutical institution - responsible for entering and updating the data. This information is available to citizens and the NHIF.
- The National Health Insurance Fund - have the possibility of analyzing the data and creating business reports
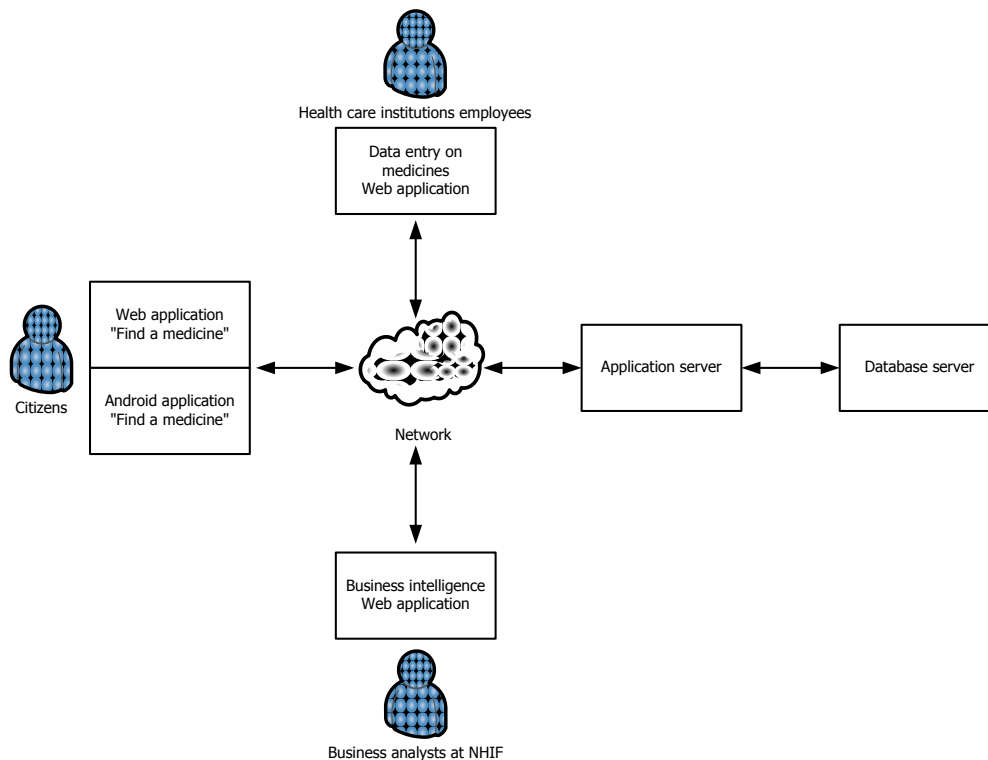

Figure 1: Designed software applications

The system enables all citizens to search the stock levels for all medicines and to find the pharmacy that is closest to the users location, and have the searched medicines on the stock at the moment of search. In addition, citizens are able to report all observed problems in system operation, especially in case the pharmacy refuses to issue a medicine while the stock level the pharmacy reported for requested medicine shows positive value. In this way, NHIF got another controlling mechanism and the ability to quickly react so to prevent these situations in future.

Table 1 represents the number of pharmacies in each branch office of NHIF. Numbers includes the public pharmacies and also the pharmacies founded by means of private property that have signed contract with NHIF.

Table 1: Number of pharmacies included in the system

Branch	Number of pharmacies
Belgrade branch	668
Bor branch	36
Valjevo branch	54
Vranje branch	50
Zaječar branch	21
Zrenjanin branch	64
Jagodina branch	59
Kikinda branch	63
Kragujevac branch	67
Kraljevo branch	44
Kruševac branch	23
Leskovac branch	73
Niš branch	127
Novi Pazar branch	24
Novi Sad branch	212
Pančevo branch	122
Pirot branch	29
Požarevac branch	49
Prokuplje branch	18
Smederevo branch	120
Sombor branch	65
Sremska Mitrovica branch	67
Subotica branch	87
Užice branch	39
Čačak branch	40
Šabac branch	107
TOTAL:	**2328**
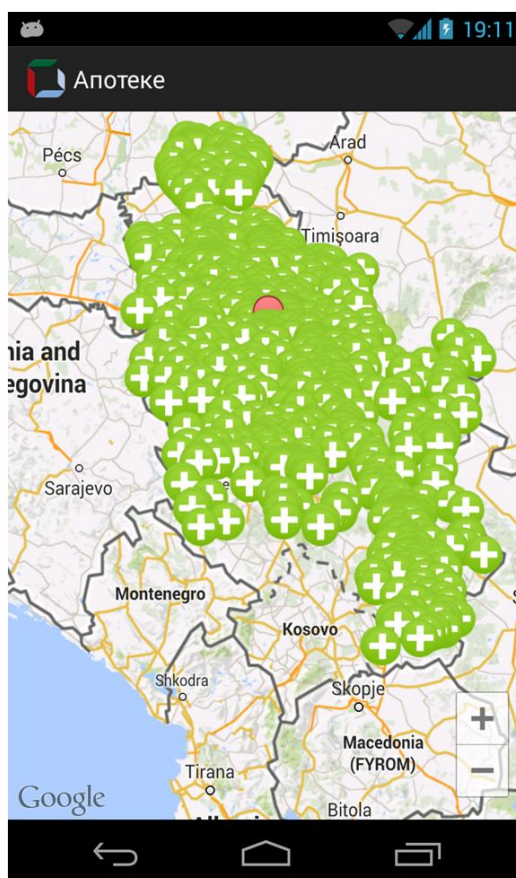
Figure 2: Each "+" sign represents a pharmacy that uploaded accurate medicines stock level

Information about the current medicines stock level at pharmaceutical institution can be submitted in the form of XML (Extendable Markup Language) document. It should be noted that the institution may submit an XML document that applies to all pharmacies in its network, but also any pharmacy can separately submit their medicines stock level. This way the flexibility is achieved because pharmaceutical institution at its sole discretion choose how to submit the data.

XML has become the standard for data exchange between systems. Based on the current medicines stock level in pharmaceutical institution the information system generates the XML document. The generated XML document must be well-formed and valid. For validation of XML documents it is necessary to use pre-defined XML schema. According to Varlamis & Vazirgiannis (2001), the schema can be used to validate the structure of the XML document automatically. An example of the generated XML document is shown in Figure 3.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<PharmacyMedicineQunatitiyView>
      <PharmacyMedicineQunatity>
            <Pharmacy>32212133</Pharmacy>
            <OrganizationUnits>
                  <OrganizationUnit>1</OrganizationUnit>
                  <Dates>
                        <Date date="2013-06-18">
                              <JKL>0010200</JKL>
                              <Quantity>4.404</Quantity>
                              <JKL>0011551</JKL>
                              <Quantity>8.681</Quantity>
                              <JKL>0011553</JKL>
                              <Quantity>80.790</Quantity>
                              <JKL>0011841</JKL>
                              <Quantity>89.300</Quantity>
                              <JKL>0011856</JKL>
                              <Quantity>26.762</Quantity>
...
                        </Date>
                  </Dates>
            </OrganizationUnits>
      </PharmacyMedicineQunatity>
</PharmacyMedicineQunatitiyView>
```

Figure 3: "Medicines stock level" XML document

As presented, the "Medicines stock level" XML document contains following elements:
- **Pharmacy** - represents the identification number of pharmaceutical institution. The identification number must be in accordance with unified health institution registry at NHIF.
- **OrganizationUnits** - a complex element consisted of the list of all organizational units - pharmacies, and medicines stock level for a date for all organizational units.
- **OrganizationUnit** - represents the identification number of the concrete organizational unit - pharmacy. The identification number must be in accordance with unified health institution organizational units registry at NHIF.
- **Dates** - represents a complex element consisted of medicines stock levels for specified dates for a concrete organizational unit - pharmacy.
- **Date** - represents an element that contains attribute Date of medicines stock level.
- **JKL** - represents the identification code of medicine. This code must be in accordance with unified medicines registry at NHIF.
- **Quantity** - represents the available quantity of the concrete medicine at specified date at the specified organizational unit, at the specified pharmaceutical institution.
- In **Date** element, elements **JKL** and **Quantity** is repeated, and **Quantity** is given for each **JKL**.

The information system of pharmaceutical institution or pharmacy must provide the validation mechanism because only valid documents can be uploaded and integrated in the system. Figure 4 shows the algorithm for creation and uploading the Medicine stock level XML document at the system.
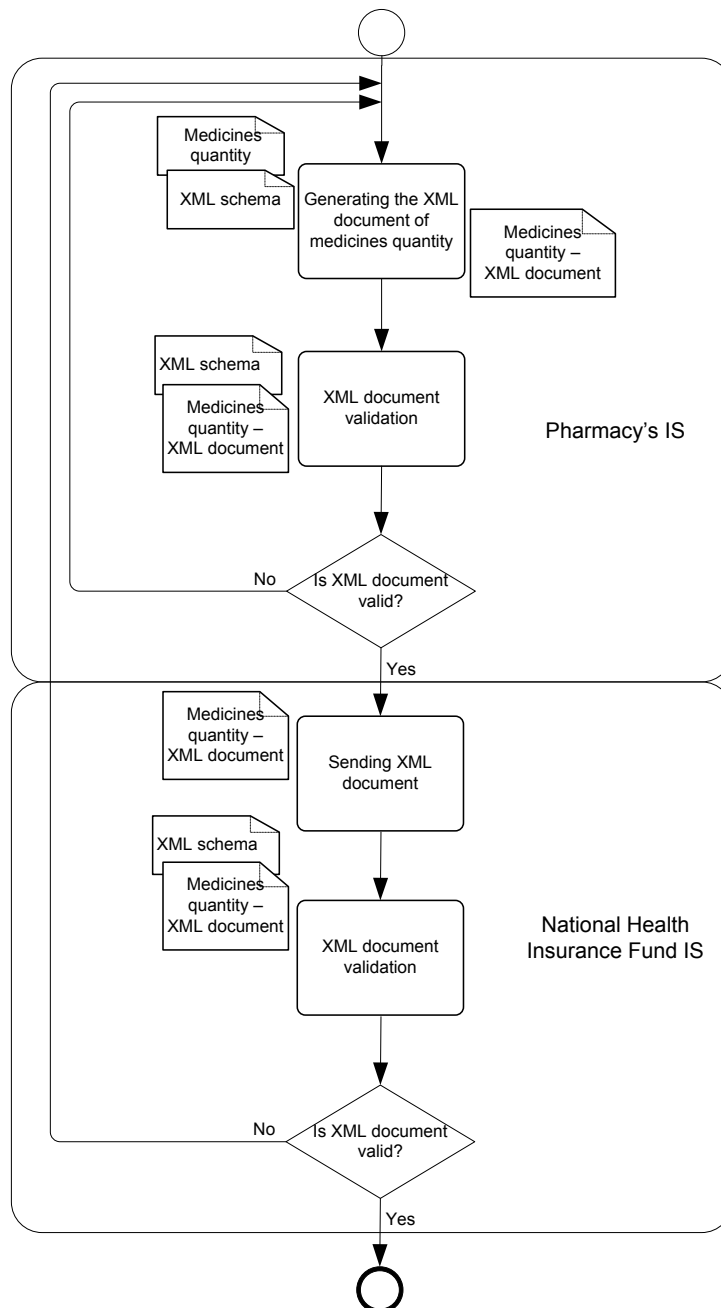
Figure 4: The algorithm for creation and uploading the Medicine stock level XML document

As a development platform of this system the JavaEE (Java Enterprise Edition) has been used:

- Java Server Faces - JSF as user interface of the web application. According to Mann (2005), JSF includes a set of web-based HTML controls and mechanisms for event processing. For each pharmacy is being displayed the position on a map, working hours, phone number and available quantities of required medicines in order to provide all necessary information so the user can get his medicine quickly. Web application user interface is shown in Figure 5.
- Enterprise Java Beans - EJB as business logic of the system, running on the GlassFish application server.
- Android SDK - used as the user interface of the application running on the Android operating system. Whipple et al (2009) point out that Android allows the development of innovative applications that can fully take advantage of the device's hardware (e.g. access to location services based on GPS system). Using location service applications become aware of the environment (position of user) of the execution. For each pharmacy is being displayed the position on a map, working hours, phone number and available quantities of required medicines. Android user interface is shown in Figure 6.
- Microsoft SQL Server 2012 database server as relational database. Madsen (2010) argues that relational data modelling presents power and most-popular database design method.
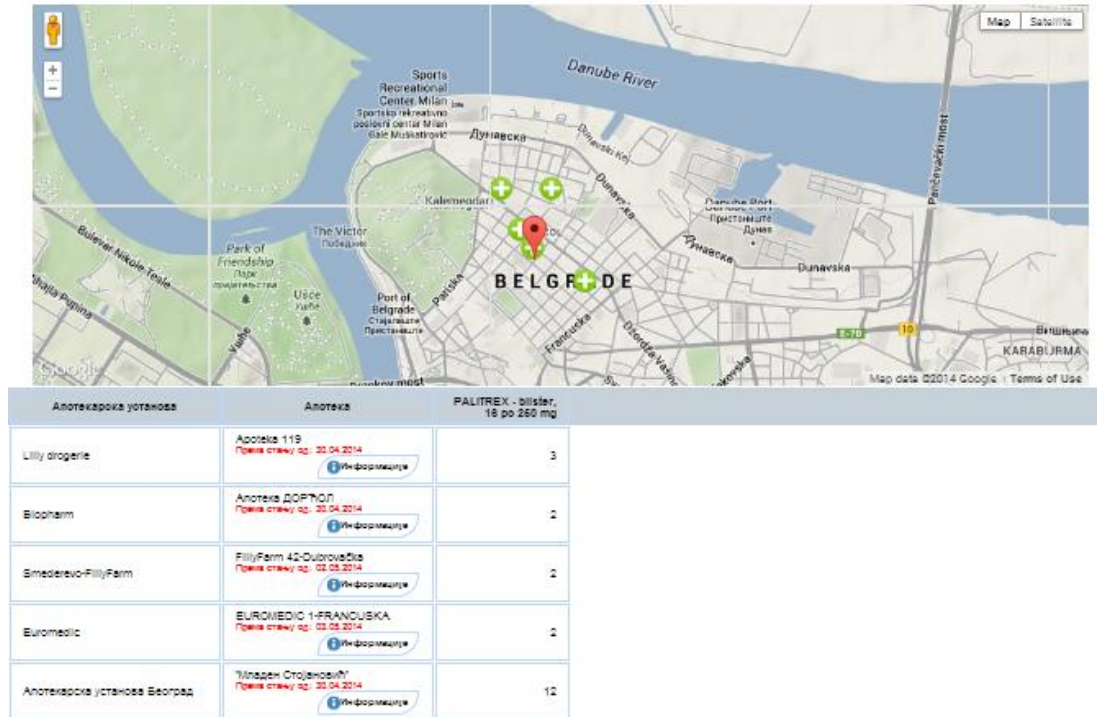
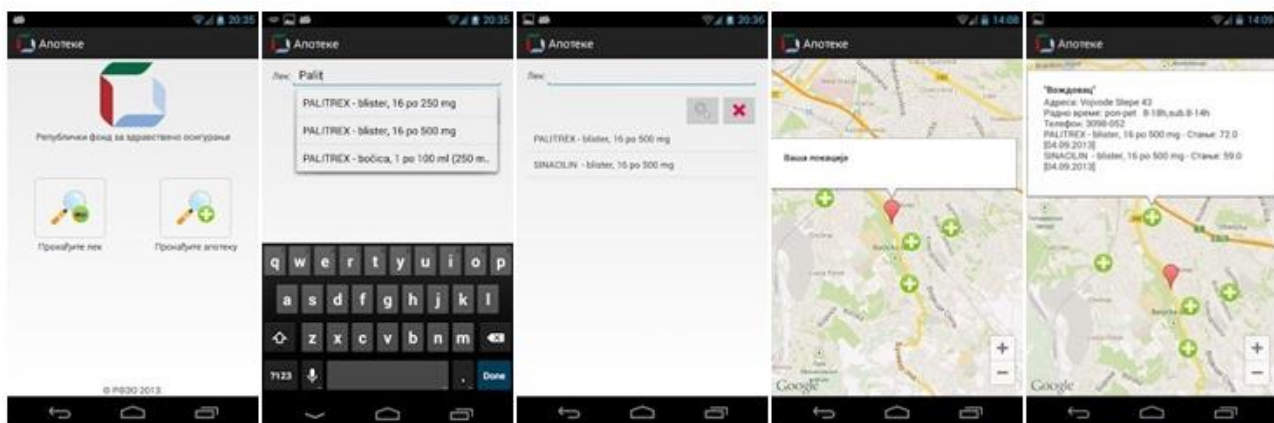**Figure 5:** User interface of the "Find a medicine" web application

Figure 6: User interface of the "Find a medicine" Android application

These technologies are stable and supported by the largest software companies. In this way, applications which have been created are scalable and easy to maintain. These technologies are widely accepted and have strong support in the open-source community.

4. CONCLUSION

This paper presented software system which supports availability of pharmaceutical institution's public data, their integration and centralized collection. This data were identified as very important for both: users of health care insurance and NHIF.

One of the goals of this system was to provide centralized data analysis and better medicine stock control. In order to do that NHIF standardized the data of pharmaceutical institutions relevant for medicine stock management. Health care institutions have to send medicine stock level information in requested XML format on daily basis. This data are checked and saved in NHIF central data storage. As stated before, this enables centralized analysis, stock level optimization and provides possibility to find nearest pharmacies that have requested medicines. System also offers a possibility to make an irregularity report (inconsistency of medicine stock data provided on the website with real stock level in the pharmacy) which can be used as an additional measure of control.

As a result, the system provides benefits to all stakeholders: citizens, healthcare institutions and NHIF. Citizens can find the nearest pharmacies that has medicines they need at the time. Healthcare institutions integrates data from all organization units - pharmacies, enabling efficient medicines stock management. For the first time NHIF have access to accurate stock level for all medicines in all pharmacies in Serbia. NHIF uses the system to analyze the data in order to make decisions concerning procurements, rationalization, control raising performances and cutting costs of healthcare system.

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AHP DECISION SUPPORT IN SLA NEGOTIATION[1]

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Abstract: *This paper analyses business-related Service Level Agreement (SLA) lifecycle phases. Focus is on SLA negotiation phase from user's perspective, where user may be end user or another service provider. Analytical Hierarchy Process (AHP) is chosen as a method for multi criteria decision making analysis. Goal is set to be SLA election among all offered SLA templates. Relevant criteria are defined by user's preference. Alternatives are SLA templates offered by service providers.*

Keywords: *service provider, user, SLA, lifecycle, negotiating, AHP*

1. INTRODUCTION

Service Level Agreement (SLA) is a contract between the service provider and the user which defines all technical, financial and legal aspects related to a particular service (Hasselmeyer, Merschr, Koller, Quyen, Schubert, Wieder, 2007). The term "user" can be regarded to an end-user, or another provider. The negotiation between service provider and user is based on a SLA template, which defines parameter ranges of service characteristics supported by the service provider. SLAs contain Quality of Service (QoS) properties that must be maintained by a provider during service provisioning. These properties, defined as a set of Service Level Objectives (SLOs), should be measured and monitored during the time period of provisioning the particular service that has been agreed in the SLA. The SLA must also contain a set of penalty clauses which could be applied in cases when service providers do not meet the agreed conditions of SLA. Specification, monitoring and identification of how SLOs may be impacted by the choice of specific penalty clauses are not straightforward. The participation of a trusted mediator may be necessary in order to solve conflicts between involved parties. Automating this conflict resolution process may provide substantial benefits. There are several possible outcomes. These include monetary penalties, impact on potential future agreements between the involved parties and the enforced rerunning of the agreed service. There are a number of concerns when issuing penalties for SLA noncompliance (determining whether the service provider is the only party that should be penalized, or determining the type of penalties that are applied to each party). Usage of monetary penalties requires certain payment system. Knowing the provider"s reputation, user can make decisions regarding the best service provider for a specific task. Reputation, based on the previous behaviour of the provider, can be represented as a numerical value quantifying compliance to one or more SLAs. This value can be used by other users to determine whether or not to negotiate with specific provider. In this paper, we focus on user perspective of SLA negotiation phase where user must evaluate all offered SLA templates and finally choose service provider to sign an agreement with.

The paper is organized as follows. After introductory remarks, second part of this paper analyses all stages of SLA lifecycle: planning and development, negotiation and sales, implementation, operation and maintenance, periodic assessment of the Quality of Service (QoS). Third part represents analysis of negotiation phase from user"s perspective. Several criteria and parameter ranges are defined according to user preferences. AHP is chosen as the most appropriate multi criteria decision making method. Concluding remarks are given at the end of the paper.

2. SLA LIFECYCLE

SLA lifecycle consists of at least five phases, as shown in Figure 1, (Stojanovic, Bostjancic-Rakas, 2009):

- Planning and development – considers a number of QoS and SLA aspects. It defines generic parameters and technology-specific parameters; design and development of SLA template that ensures that offered QoS guarantees are realistic;

- Negotiation and sales – a service provider must negotiate and agree with the user about technical details of a service, where QoS parameters may be customized or the same as those offered in the standard template;
- Implementation – configuration and activation of the service, beginning of operation;
- Operation and maintenance –monitoring and operation, real-time QoS reporting and service quality validation and real-time SLA violation handling;
- Periodic assessment of the QoS and whether it meets the SLA –scheduled during a single user SLA agreement period where the assessment is related to the delivered QoS against the SLA parameter values and limits, and the levels of user satisfaction with the service product.
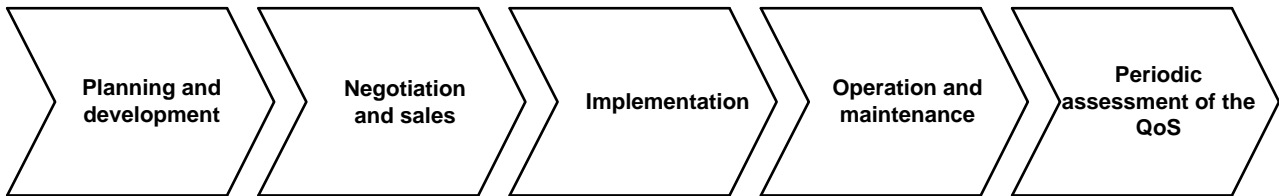-

Figure 1. SLA lifecycle

SLA contains, among others, a service description and a list of guarantee terms that describe the duties of the involved parties, i.e. guarantees given by the provider and obligations to be observed by the user. The provider guarantees the fulfilment of specific service level objectives on well-defined metrics, and the payment of penalties - compensation in case of violating a service level objective (Schulz, 2011).The SLOs may include service availability, user response time, service response time, service outage resolution time etc.(Raju, Dhivya, Saranya, Abbinaya, 2013).

The negotiation between service provider and user is usually based on a SLA template. A template defines parameter ranges of certain service characteristics which are supported by the service provider. In the simplest case, there are no parameter options for the user. User can either accept the given offer or reject it. More complex negotiations are also possible (Andrieux, Czajkowski, Dan, Keahey, Ludwig, Nakata, Pruyne, Rofrano, Tuecke, Xu, 2006).

2.1 Template specification

Business practice in specification of SLA templates is not often economically efficient and present obstacle to successful business operation (Taylor & Tofts, 2006). A particular challenge for the specification of SLA templates is to obtain an understanding of the dependency between technical and business aspects. Definition of an evaluation function that maps each possible SLA template to a scalar scoring value that can be interpreted economically may address before mentioned challenges. The function is based on technical characteristics of the service provider, and gives a business-relevant evaluation of the SLA template. Thus, the evaluation function combines technical and business parameters from each SLA template into a single scoring value. Usually, many SLA templates result in the same score and a landscape of scoring values is formed. This landscape and its visualization provide a useful decision support for the selection of SLA templates that are actually offered to potential users. The final decision of the service provider is based on additional information like market situation and analysis of competitors (Schulz, 2011).

The approach for designing SLA templates by defining a scoring function on the space of all possible SLA templates is proposed in (Schulz, 2011). This methodology is depicted in Figure 2.
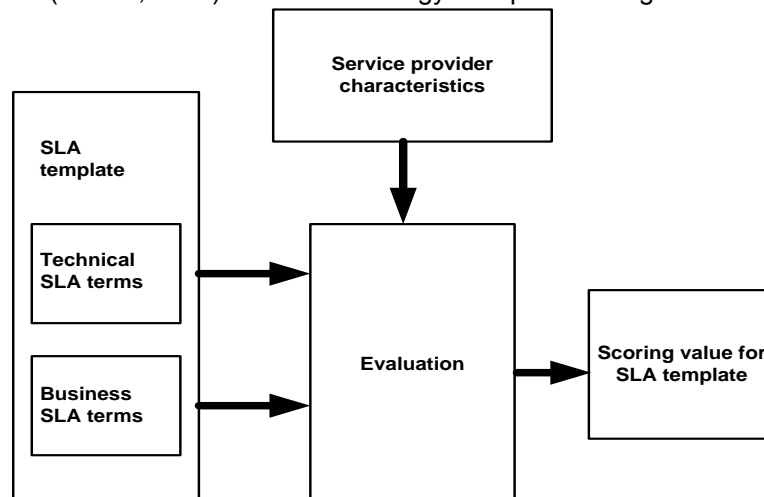

Figure 2. Designing SLA templates (Schulz, 2011)

The guarantee terms in a SLA specify allowed ranges for quality metrics and business value parameters like price and penalties. The technical terms express service level objectives by defining thresholds on the quality metrics. The fulfilment of objectives is evaluated over a defined time period. If the objectives are not met, an agreed penalty has to be paid by the provider. This can be a monetary payment or a period of free service usage, or some other form of compensation. The amount and calculation rule for the determination of penalty is defined in the business terms of the SLA.

Another input for the evaluation function is the service provider characteristic. This is a probability model for the quality metrics, based on empirical data of the service provider during past service operation (Dingle, Knottenbelt, Wang, L, 2008).

Metrics that can be observed are availability, response times, resource utilisations, throughputs and system productivity. Availability of the service is the ratio of time during which service is provided to users depending on the Mean – time – to Failure (MTTF) and Mean – time – to – Repair (MTTR). It can be represented as:

$$A = MMTF / (MTTF + MTTR) \tag{1}$$

Response time is the time from a user sending a request to receiving a response. SLAs are often concerned with means, variances, and percentiles of response times. Resource utilisation is the ratio of time for which a given resource is used by a given service. For example, it may be required that a service does not utilise more than 10% of available network bandwidth. Throughput is the average rate at which a given set of activities occurs. Productivity is a weighted sum of the throughput of a number of activities, where the weights are user specified rewards associated with completion of each activity. If the unit of the reward is financial, this measures a system‟s profitability.

If the metrics depend on external parameters like varying user workload, the effect of external factors can be reduced by defining user obligations in the SLA and hence narrowing the range of external parameters. Combining the probability model for SLO metrics and the penalty model, an expected penalty can be derived. For each pair (target value, violation penalty) defined in the SLA template, the amount of expected penalty is calculated and represents the desired scoring value.

2.2 SLA negotiation

Many of the negotiation techniques can be applied for SLA such as game theory, time based decision making functions, machine learning, genetic algorithm, intelligent agents etc. Service negotiation is primarily based on decision making. In order to achieve rapid, effortless, and useful negotiation service, Analytic Hierarchy Process (AHP) might be used. AHP deals with many large, dynamic and complex problems. The advantages of AHP over other multi criteria methods are flexibility and ability to check the inconsistencies.

2.3 Monitoring

Monitoring of SLA begins once an SLA has been defined. A copy of the SLA must be maintained by all involved parties. It is necessary to distinguish between an „agreement date‟ (agreeing of an SLA) and an „effective date‟ (subsequently providing a service based on the SLOs that have been agreed) since a request to provide a service based on the SLOs may be undertaken at a time much later than when the SLOs were agreed. The monitoring infrastructure is used to identify the difference between the agreed upon SLO and the value that was actually delivered during service. It is necessary to define what constitutes a violation. Monitoring plays an important role in determining whether an SLA has been violated, and thereby determine which penalty clause should be applied as a consequence.

Providers‟ reputation and users‟ trust are largely based on the provided monitoring infrastructure. In the context of SLAs three monitoring modules can be distinguished: a trusted third party (TTP), a trusted module at the service provider, and a module on the user side. The trusted third party provides an independent module that can monitor all communication between users and service providers. After successfully completing the SLA all involved parties receive a signed ticket from the TTP that can be used for reputation building of the service provider. Trusted modules can also monitor communication between user and service provider and can similarly provide tickets after successful completion of an SLA. The main difference between TTP and trusted module is that the trusted module is integrated into the service provider. Thus, the internal state of the service provider can also be observed. However, their implementation is difficult. Usage of a module on the user side requires a user to determine if metrics diverge from the predicted behaviour of the service provider. In situations that require a high level of assurance, these monitoring modules can be combined. It is essential to monitor all relevant metrics and to provide all involved parties to retrieve such data in appropriate format.

Usually, a TTP module satisfies all required functionality for a monitoring service. Once a user and a service provider (SP) have created an SLA, the service provision is monitored by a TTP. This TTP can be a trusted module executing on the service provider‟s system, or a server that is physically separated from the service provider. In all cases, the service provider must not have any access to the TTP, outside of the interactions that are properly defined. Built-in module and separate server are conceptually identical. However, the attacks on a built-in module can potentially be more difficult to detect. At the same time, user should have access to the TTP monitoring mediator for audit purposes, but without possibility to modify the data recorded

by the TTP. Messages are exchanged between the User (U), Service Provider (SP) and Trusted Third Party (TTP), as depicted on Figure 3. The TTP maintains a database of reputations (RDB), updating it whenever a provisioning takes place. The RDB is useful to import the reputation score at the beginning of a service provision and export it back at the end of the service provision so it can be used by other possible users. A user may also hold a local reputation value associated with a provider – based on monitoring the SLAs that it holds with a provider.
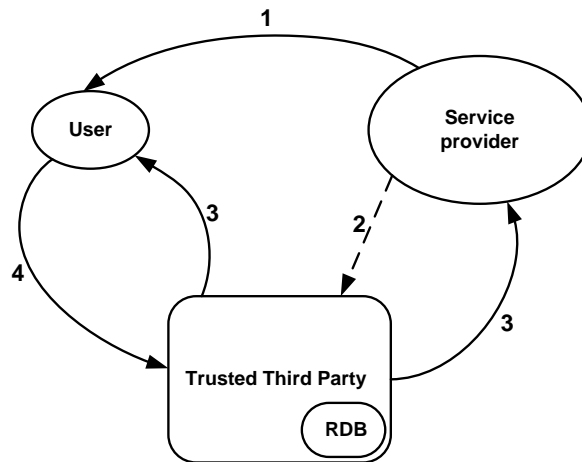

Figure 3. Messages exchange between the user, service provider and trusted third party

Whenever a service provider provides a service to a user (1), it is monitored by the TTP (2). This causes the TTP to update the reputation of the involved SP. The TTP sends a message to both the SP and the user notifying them about the update (3). User then sends a message containing its response (R) to the transaction. This response is used by the TTP to update the reputation of the service provider. Once the user sends its response, the TTP generates the new reputation of the service provider.

2.4 Types of violation

One of the main issues that the provider and the user have to agree during the SLA negotiation is the penalty scheme. Both the service provider and the user are free to decide what penalty to associate to the various types of SLA violations, in accordance with the weight of the parameter that was not fulfilled. Non-fulfilment comprises defective performance (parameter monitored at lower level), late performance (service provided at the appropriate level but with unjustified delays), and no performance (service not provided at all).

Based on these descriptions the following categories could be defined:
- All–or–nothing provisioning: provisioning of a service meets all the SLOs –i.e., all of the SLO constraints must be satisfied for a successful delivery of a service;
- Partial provisioning: provisioning of a service meets some of the SLOs – i.e., some of the SLO constraints must be satisfied for a successful delivery of a service;
- Weighted partial provisioning: provision of a service meets SLOs that have a weighting greater than a threshold.

Monitoring can be used for detection whether an SLA has been violated. Typically such violations result in a complete failure – making SLA violations an all-or-nothing provisioning process. In that situation a completely new SLA needs to be negotiated, possibly with another service provider, which requires additional effort on both the user and the service provider. Based on this all-or-nothing approach, it is preferable for the provider to satisfy all of the SLOs. An SLA typically contains several SLOs, where some SLOs may have higher priority than others. The importance of the different SLOs may be established during the SLA negotiation phase. Both user and service provider can then react differently according to the importance of the violated SLO. Weighted metrics can also be used to ensure a flexible and fair penalty mechanism in case an SLA violation occurs. Thus instead of terminating the SLA altogether it might be possible to renegotiate the violated part of the SLA. The more important the violated SLO is, the more difficult it will be to renegotiate the SLA.

2.5 Penalty clauses

Using penalty clauses in SLAs can lead to two questions that need to be answered: what types of penalty clauses can be used and how they can be included in SLAs. The focus is on penalty clauses for service providers. Behind the imposition of any contractual sanctions lies the idea that faulty behaviour of a provider should be deterred.

A penalty clause in an SLA may consist of the following:

- A decrease in the agreed payment for using the service – a direct financial sanction;
- A reduction in price along with additional compensation for subsequent interaction;
- A reduction in usage of service from the provider;
- A decrease of the reputation of the provider.

All parties involved in SLA negotiation can agree on a direct financial sanction for SLA violation. Usually, the amount to be paid depends on the value of the loss suffered by the user through the violation. Due to the difficulties in proving and recording the financial value of the loss, during the negotiation phase the parties may choose an agreed payment for non-performance that is a fixed monetary value that will have to be paid upon non-performance, regardless of the fact that no financial loss was suffered by the user. The service provider can deposit the negotiated penalty at a TTP that acts as a mediator, before the service provision commences. On successful completion of the service provision, based on the SLA, the TTP returns the deposit to the service provider; otherwise the user receives the deposit as compensation for the SLA violation. In this case, a trusted monitoring mediator is required since a user can never prove by itself that an SLA was violated. Another possibility is that a user reduces its usage of services from a provider that violated an SLA. A third kind of penalty clause can lead to a change in the reputation of a provider. In such a system the reputation of service providers that violate SLAs will decrease. Correct determination of the service provider"s reputation is necessary. In the SLA negotiation phase service provider and user can agree on which reputation mechanism to use.

2.6 Quantifying Reputation

Formally, an SLA consists of a collection of metrics $m=\{m_1, m_2,…, m_n\}$ and time interval δt representing the period over which the SLA is valid. For each metric in an SLA its success or violation can be determined. Thus, success (m) takes value of 1 if metric m is fulfilled and value of 0 if metric m is failed.

The success rate φ of an SLA can be defined as the number of successful metrics relative to the total number of metrics n:

$$\varphi = \sum_{i=1}^{n} \frac{success(m_i)}{n} \tag{2}$$

Each metric can be weighted according to its relative importance for the user. Each weight, ω, can have a value between 0 and 1, where 1 means very important and 0 represents no importance to the user.

This gives the weighted success rate, τ:

$$\tau = \sum_{i=1}^{n} \frac{success(m_i)}{n} \times \omega_i \tag{3}$$

The weighted success rate, τ, of an SLA objectively quantifies how satisfied a user is with it. The weighted satisfaction rate, ψ, of a collection of SLAs can similarly be calculated:

$$\psi = \sum_{j=1}^{k} \frac{\tau_j}{k} \times \rho_j \tag{4}$$

where ρ represents a weighting factor that corresponds to the importance of each individual SLA, and k is a number of SLA contained in a given collection. Finally, the reputation, R, of a service provider can then be quantified by:

$$R = \sum_{l=1}^{p} \frac{\psi_l}{p} \tag{5}$$

where p represents number of all SLA collections. Initially, a service provider will obtain some default value for its reputation and as the number of agreements served increases its reputation will more accurately be reflected by R (Omer, Warnier, Quillinan, Brazier, Cojocarasu, 2008).

2.7 Termination

An SLA may be terminated in the following situations:
- when the service being defined in the SLA has completed;
- when the time period over which the SLA has been agreed upon has expired;
- when the provider is no-longer available after an SLA has been agreed (for instance, the provider is under liquidation).

In all three cases, it is necessary for the SLA to be removed from both the user and the provider. Where an SLA was used to provision a service, it is necessary to determine whether any violations had occurred during provisioning. As indicated above, penalty clauses are also part of the SLA, and need to be agreed between the user and the provider.

3. USER PERSPECTIVE OF SLA NEGOTIATION BASED ON ANALYTICAL HIERARCHY PROCESS

In this part of our paper, we analyse which SLA agreement user will choose among all possible SLA templates offered by the service providers. The decision is made using AHP. As mentioned above, AHP is very valuable decision making support. We suppose that user can either sign or reject offered SLA template, i.e. there are no parameter options for the user. Also, service provider offers one SLA template to one user. Various criteria along with alternatives for a particular problem can be implemented for SLA election. One example of possible criteria and alternatives are shown in Figure 4.
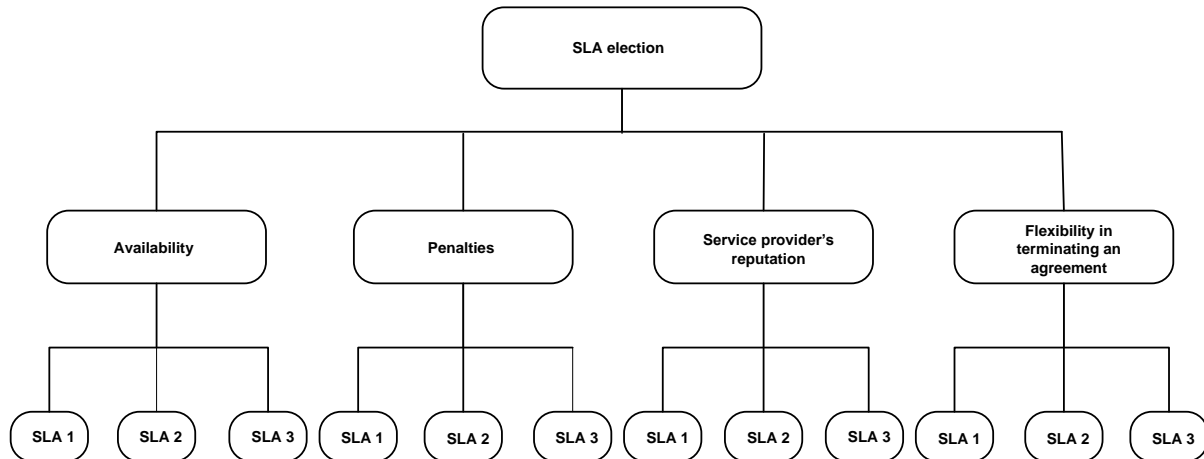

Figure 4. Structure of AHP decision making model

The user is choosing a service provider among three possible to sign an agreement with. Chosen criteria are availability, reputation of the service providers, penalty and flexibility in terminating an agreement. Availability is calculated using Eq. (1). We suppose that user prefers high availability, above 0.95. Reputation of service providers is monitored during previous service provisioning, and calculated using Eq. (5). We suppose that recorded data are available by TTP. Penalty clauses are defined in SLA negotiating phase. User has some flexibility in terminating an agreement on request under certain circumstances defined during negotiation. Relevant parameters in each SLA template are given in Table 1.

Table 1. Offered SLA templates

Relevant parameters	Service provider 1	Service provider 2	Service provider 3
Availability	0.967	0.941	0.982
Reputation	0.526	0.761	0.837
Penalty	20% price decrease	a month free of charge	30% price decrease
Flexibility in termination	compensation of all remaining financial obligations by user	compensation of 75% of all remaining financial obligations by user	compensation of all remaining financial obligations by user

We observe the two possible cases, regarding user preferences: (1) user is more sensitive in terms of availability and penalty clauses, and (2) user is more sensitive in terms of service provider"s reputation and penalty clauses. Obtained results are presented in Figure 5 and Figure 6, respectively.
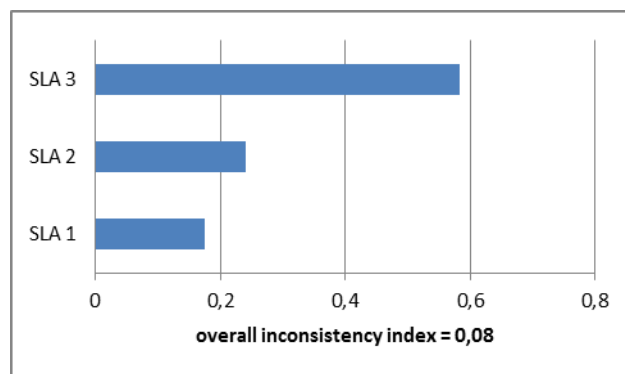

Figure 5. AHP results, case (1)

In the first case, both service provider 1 and service provider 3 offer high availability, above 0.95. Thus, an availability criterion is satisfied. From user‴s perspective, penalties are also essential. Suppose that user prefers a certain time period of free service provisioning. Hence, service provider 2 is in advantage compared to service providers 1 and 3. Reputation of service providers is not essential in this case, but it is preferable to take higher values. Flexibility in terminating an agreement is also not essential, but user always prefers lower amount to be paid in the case of terminating an agreement before agreed SLA has expired. According to AHP, service provider 3 offers the best conditions and user will sign this agreement.
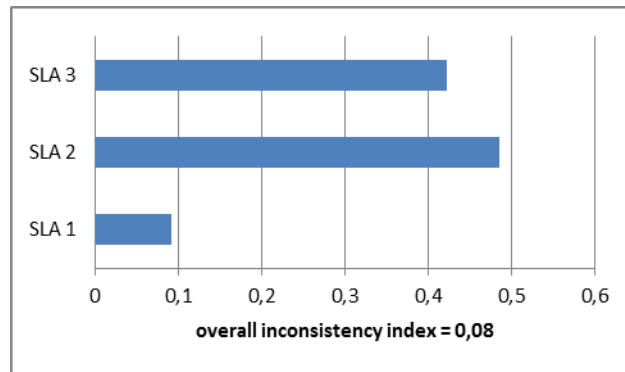

Figure 6.AHP results, case (2)

Case (2) presents the situation where user is more sensitive in terms of provider‴s reputation based on previous service provisioning and penalty for SLA violation. As mentioned before, reputation is provided by TTP and it is preferable to be as high as possible. Penalties are also of great importance. Again, service provider 2 has advantage in comparison with other service providers, since user prefers a period of free service usage. Service availability and flexibility in terminating an agreement are not crucial. However, availability should be above 0.95 and it is preferable that user has possibility to terminate an SLA with the lowest financial compensation. Considering all criteria, service provider 2 best matches user‴s requests. Thus, AHP suggests user to sign an SLA with service provider 2.

4. CONCLUSION

This paper presents business-related aspect of SLA through all lifecycle phases, from template design, through negotiation, implementation, operation, maintenance and monitoring to termination of an agreement. The focus is on SLA negotiation phase based on SLA templates. Essential challenge for the specification of SLA templates is to achieve understanding of the dependency between technical and business aspects. The proposed methodology for establishing a quantitative relationship between technical and economical parameters, which maps each SLA template to economical scoring value, is described. Monitored data in previous service provisioning are provided by mediator between service provider and user, Trusted Third Party. Service provider‴s reputation is than calculated according to available recorded monitoring data. AHP is chosen as the most appropriate multi criteria method for decision support. Relevant criteria are set by user. Two cases are observed. The first one, when user is more sensitive in terms of availability and penalty clauses defined in SLA template, and the second one, when user is more sensitive in terms of service provider‴s reputation and penalty clauses. In both cases, user obtains precise results with very low inconsistency index thus increasing a possibility of making satisfactory decision.

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