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Contents

Information Systems Framework Synthesis
on the Base of a Logical Approach

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Abstract—We consider an approach to the information system framework synthesis. This approach implements OMG's Model Driven Architecture transformation on the base of combination of logical and imperative programming languages. Information system is modeled using UML Class Diagram. The transformation procedures are represented as rules and source code templates. The generated framework is a set of source code modules, which form libraries for further development. An example of approach application and further improvement of the transformation implementation are considered.

I. INTRODUCTION

Information systems (IS) at present are constructed on the base of a common scheme, where IS consists at least of the following three subsystems:

Most of the information systems also have analytical and report generation subsystems.

1) *Data Warehouse (Storage)* provides persistent data layer for program objects, storage formats, and productive access to the stored data.
2) *Application Control Layer*, which usually is referred to as business-logics layer; it is a domain object interaction model implemented as a program. The layer mainly realizes changing the warehouse data, providing the soundness with respect to domain.
3) *User Interface represents* stored and processed data for users and propagates events initiated by users to application control layer.

At present there are popular approaches used in construction of complex IS, rising development performance, namely

1) Component architectures and environments, which allow high code reuse,
2) Visual modeling of various aspects of the project under development followed by a code generation.

Complex environments such as SAP R/3, JavaBeans, EJB, CORBA, COM/DCOM/ActiveX, .Net are examples of the first approach. Their libraries include professional grade relatively abstract implementations of key subsystems. Developers combine and specify predefined behavior of the library modules to the problem domain. We consider that Rapid Application Development (RAD) systems belong to the component environments. Famous examples of RAD-systems are Borland Delphi/C++ and their contemporary derivatives, as well as Microsoft Visual Studio.

Visual modeling techniques, e.g. Computer Aided Software Engineering (CASE), allow one to deal with complex systems and projects, representing them as an abstract formalized model. CASE-systems use UML to model IS implemented in object-oriented programming and

storage environments. CASE instrumental software has code generation routines to convert visual models into source code modules. Usually, the generation routines are mutually independent and represent a viewpoint of CASE-system manufacturer to the process of the visual model representation. There is no standard approach to user interface generation in popular CASE-systems.

Visual modeling is intended for takeover the complexity problem during software design and manufacturing, as well as it is a way of formalized communication between developers and customers. Model Driven Architecture (MDA) [1] is a further development of CASE-system aimed to provide solution for the following problems of IS development:

1) Rapid development of software construction technologies and programming techniques, results in frequent change of software development platforms and accumulation of legacy source and binary code.
2) Necessity to support a number of parallel versions of the software on various hardware platforms and operating systems; for example, most of popular Internet services have applications for mobile platforms (iOS, Android).
3) Reuse of models and corresponding implementation source code in new projects, and accumulation of formalized knowledge on designing and implementation of IS subsystems.

Key concepts of MDA are CIM, PIM, PSM, and PDM. Computation Independent Model (CIM) reflects software's external requirements – its interfaces. CIM hides internal structural elements, and therefore can be used to define specifications and checking requirements. Platform Independent Model (PIM) is a model of the software reflecting most of the structural and some semantic aspects of the software, but this model contains no information about implementation of the structures on the target program architecture. UML Class Diagram, which is extended with some tag values and additional stereotypes, is a relatively common example of PIM. The extension (marking) allows one to denote implementation nuances for structures. Platform Specific Model (PSM) is a model, which can be implemented as a source code of the subsystems, e.g., it could be a physical structure of a relational database, which is directly (algorithmic or by means of code templates) translated into DDL SQL-requests.

MDA formalizes part of Software Life Cycle concept [2], which reflects a path from domain to results of implementation stage (see Fig.1). Initially an idea of a program is proposed. On the first step basic terms and functionality requirements are iteratively collected, which correspond to MDA's CIM. The next step is a requirements analysis, which results in forming a general project outline corresponding to PIM. The developer's design activity results in detailed system design, i.e., PSM, followed by the implementation stage of the software components.

MDA is a methodology for developing software by means of partial automatic source code generation of IS from visual models, so it can be considered as an approach to generative programming [3,4]. The main distinction from generic CASE-systems is that the code generation routines are not fixed and can be extended and adapted to the project requirements and developers' way of structures and functions implementation. It can, e.g., be adapted to describe even IS based on component architectures.

The transformation of the PIM into PSMs is carried out under control of a Platform Description Model (PDM). PDM contains information and algorithms of PIM's structure analysis and generation of corresponding data structures in PSMs. Sometimes PSM is understood as specific variant of PIM. The tag values and stereotypes are used to direct the

transformation of PIM's structures into certain frames.

The aim of our research is to create a complex integrative MDA technology to support designers and programmers with flexible transformation technique, which is by nature adaptive to their peculiar way of software development. Especial interest for us is adaptation of the MDA to extreme and agile programming. This paper devoted to consider our experience of an approach to transformation implementation based on substantial use of a local language and rule-based inference systems.
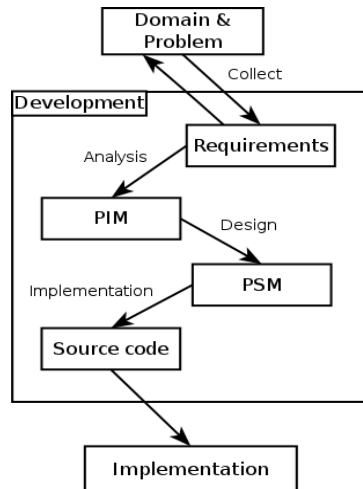
Fig. 1. MDA reflects the Software Life Cycle

II. TRANSFORMATION IMPLEMENTATION

There are a number of approaches to the transformation implementation. Algorithmic approach, where all the transformation procedures are implemented with an imperative programming language; XSLT transformations allow to represent transformation as production rules; graph theory and graph transformation; usage of domain specific language [5]. We use logical approach to define transformation as a set of productions and a pattern-directed inference engine [6] and a transformation scenario.

Patterns are represented as a mix of Prolog and Python programs. Pattern query is a Prolog rule located in so called __doc__-strings of Python instance methods. The bodies of instance methods are execution parts of the patterns. Parameters passed to the methods are results of corresponding pattern queries inference. Instances itself are modules, i.e. a set of patterns and algorithms that transform part of PIM into a part of PSM. Consider the following example of patterns which are supposed to recognize and generate SQL query to create relational database table for storing object instances of IS under development.

```
class RulesMixing: # Set of patterns
    def rule_primitive_class(self, cls, oid, oidType):
        # figure out the basics of relation coding
        # in relational tables
        """ % this starts __doc__ string
        primitive_class(Cls, OIDAttr, OidType):-
            element(Cls, 'Class'),
```

```
        \+stereotype(Cls, 'abstract'),
        stereotype(Cls, 'OODB'),
        \+internal_only(Cls),
        stereotype(Cls, 'primitive'),
        attribute(Cls, OIDAttr),
        type(OIDAttr, OidType),
        stereotype(OIDAttr, 'OIDkey'),!.
    """ # this ends __doc__ string
    self.BASE_CLASS = cls
    # we found the root of the class hierarchy
    self.BASE_CLASS_NAME = self.getName(cls)
    self.OID_NAME= self.getName(oid)
    # attribute for object reference
    self.OID_TYPE = self.coerceAttrType(oid, oidType)
    # choose a type for the object reference
    return self.BASE_CLASS_NAME, cls, oid,
            self.OID_NAME
    # the values are passed to a for statement.
  def rule_persistent_class(self, cls):
    # a class is persistent if its instances
    # are to be stored and it is not a type.
    """
    persistent_class(Cls):-
        element(Cls, 'Class'),
        \+stereotype(Cls, 'abstract'),
        stereotype(Cls, 'OODB'),\+internal_only(Cls).
    """
    # this pattern has no body
. . . . . . . . . . . . . . . . . . .
class SQLTranslator(Translator, RulesMixing): # a module
  # it generates SQL-script of database structure
  def genClass(self, cls):
    # Generate SQL-script for a class cls
    answer = [] # list of source lines
    if cls in self.generated:  # is it already
        return answer          # generated?
    for _, parent in self.query('class_parent',
        (cls, '#')): # generate all ancestors
      . . . . . . . . . . . . . . . . . . . . . . . .
    name=self.getName(cls)      # name of the class
    doc=cls.getDocumentation() # documentation
    if doc:                     # is it not empty?
        answer.append('/*\n%s\n*/' % doc)
    attribs = self.genSchema(cls)
    # generate table attributes
    if not self.isEmpty(attribs):
        answer.append("CREATE TABLE %s (" % name)
        answer.append(attribs) # table attributes
        answer.append(")%s;" %
            self.getTableType(cls))
    else:
```

```
    print "The class has no attributes."
self.addFact("oodb_table('%s', '%s')" %
    (cls.getId(), name)) # assert conclusion
# on a relation of class to table
self.generated.append(cls)
return answer # return generated code
```

Method *genClass* is executed from outside for each answer *Cls* of *persistent_class(Cls)* query. Structure of the base class, recognized by rule *rule_primitive_class*, greatly affects a way of object references representation of the rest of the relational database tables.

This approach has cumulative advantage over above mentioned techniques: expressive production-like transformation representation, powerful imperative and retrospection abilities of Python, existing template engines used in Python web frameworks, and it is a tool, which is not tied to specific set of development environments.

We develop a software designing technique for MDA based on multistage transformation of PIM into a PSM consisting of specific submodels (Fig. 1). To transform the UML models its XMI (XML Metadata Interchange) file is loaded. This format is a kind of XML, so DOM2 API is used to access PIM's structure. XMI is a standard data format supported by various proprietary and free software technologies and libraries. The DOM2 tree is translated into Prolog facts by means of requests from patterns. Object Constraint Language (OCL) expressions are extracted from PIM and represented as syntax trees.

At first a general reasoning about object structure is carried out, basic properties are recognized. Other modules use the reasoning results to refine implementation variants of synthesized program objects. Each module specifies PIM's structures with additional facts about existing structures and creates new objects and relations. For example, SQL database transformation module merges inherited abstract part of attributes to the class and generates table description on the base of the merge. The process is controlled by scenario represented as a list of leaf nodes to be executed.
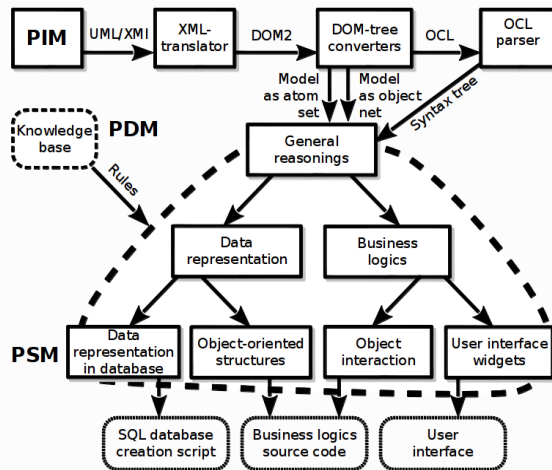

Fig. 2 Architecture of transformation engine

If all nodes of the scenario are executed and all their solutions (queries) are satisfied and processed, then the set of all the facts in working memory defines PSM. The source code is generated on the base of obtained PSM. A generator module executes a query and fills in a source code template with query results.

Results of transformations and code generation are combined in object libraries. Objects from libraries are used in construction of business-logics of developed IS. Programmers supplement generated code by inheriting it in new classes. This approach partially solves the problem of generated source code modification by programmers.

The XMI file can contain not only the structure information, but also some semantic values for its elements. This information used to increase the control over the transformation procedure, in particular, for filtering information by using some criteria. UML have the following semantic definition language structures:

1) Stereotypes to create new elements of UML;
2) Tagged values to create properties for the elements;
3) Constraints to formally define logical constraints, invariant, pre- and postconditions for a method invocation.

Let us consider a simple example. Assume that there exists a class in an UML Class Diagram that has at least a string field *name*. If we mark the class with, e.g., «Reference Book» stereotype, then all many-to-one relations to the class can be interpreted in relational database context as many-to-one relation and corresponding tables, and reference fields *ID* are generated. Having recognized the stereotype and the relation, user interface generator can construct a widget and its controller (in sense of Model-View-Controller paradigm) to select appropriate record from the reference book and store the reference book *ID* in corresponding table and object. Now, the generated code in various subsystems is logically and mutually depended.

In order to adopt the transformation engine and its knowledge base to developer's instrumental software and technologies, one imports Python module, inherits and modifies its set of patterns and generation modules, specifies new module in scenario. In the application example in the following section we used inheritance to refine a generic SQL relational table transformation to specific properties of MySQL server.

III. APPLICATION OF THE TECHNIQUE TO CONSTRUCT A FRAMEWORK OF AN INFORMATION SYSTEM IN MEDICINE

In 2005 we applied our transformation engine in the life cycle of medical IS named "Population cancer registry" development for recording cases of cancer incidence in Irkutsk Regional Oncology Center (hereafter hospital). The IS was to accumulate data on the cases happened in Irkutsk Region (Irkutsk Oblast). The territory is about $768\,000$ km^2, and its population is about $2\,500\,000$ people (2011); every year around 8000-9000 cases are recorded. The necessity of the development is dictated by Ministry of Health and Social Development of the Russian Federation by a corresponding directive in 1999.

Previous version of the IS was based on Microsoft Access'95 and designed as stand-alone applications with common server database developed since 1999. As in 2005 there were no high bandwidth channels to the hospitals subordinate clinics and oncology medical offices, as well as most of the offices were not connected to Internet at all, the input data came to the clinic as filled in printed forms by regular mail or with courier every month. Then all the forms

were recorded into database by stuff of organizational-methodical department of hospital. The IS and operating system peculiarities did not allow the usage of the system for medical doctors directly in their offices: response time of IS was very low and there were no obvious ways of overcoming that problem; the system had also closed proprietary design.

In that time Russian government began to support a number of programs of development, including digital medicine and communication channels quality and productivity improvement. In the same time Internet technologies and software as a service started to dominate on market; a number of open-source technologies become mature. Hospital and regional administration decided to realize new version of IS, which are to be the international platform of network infrastructure accumulating all oncology data streams from various medical information systems in the region. There was also financial support in amount of 10 400 euro for the initial state of the project.

Initial condition to the IS development was somewhat indefinite: there were a diversity of hardware and software (out-of-date personal computers and operating systems); structures of input documents though were approved by the above mentioned decree, but they were informal; there was a lack input data to required report forms; also there was no standard strategy of IS implementation as an application for user. In this situation we decided to organize development mostly on an abstract level, which would allow generating frameworks for randomly appeared new requirements.

As the UML editing tool we used Gentleware Poseidon for UML Community Edition v. 3. The IS's PIM was presented as the marked UML Class Diagram and contained more than 100 classes, interfaces and other auxiliary structures. PIM represented whole class/instance, records and enumeration structures. Most of the classes were marked by «OODB» stereotype to be stored in relational database MySQL-4.1 as objects. Some of the classes were marked as «Reference book». Records represented joined lists of attributes, which were included in class as a complex structural attribute (e.g. passport data), but stored in the same table as their class.
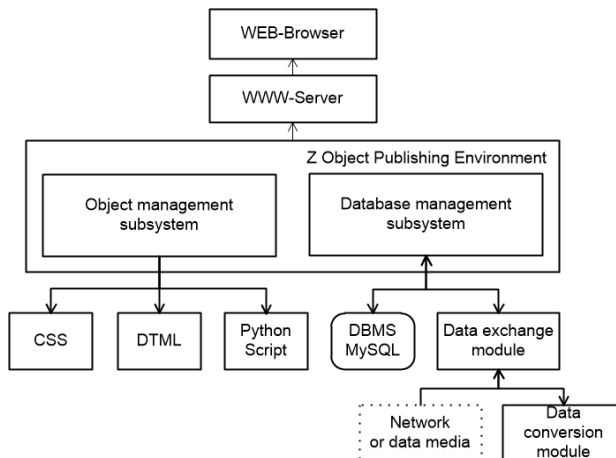

Fig. 3. Architecture of Population cancer register medical IS

Enumerations are structures, whose attributes used as constants in database, business logics code and user interface.

Attributes of classes were marked with various tag values. For example, tag value "name" denote a notation of the attribute in user interface forms, "index" (true or false) suggested to the transformation engine to add an index in database definition for the attribute; "index_kind" (btree, hash, etc.) refined the variant of index engine; set of "widget:…" tag values controlled variants of attribute user interface representation. By means of the tag values we denoted the storing engines for persistent classes, grouping attributes on user interface forms, the layout was implemented manually.

As target platform the following software were chosen: Gentoo Linux OS; MySQL-4.1/5.1 with InnoDB and MySAM engines as relational database server; object-oriented Internet application framework Zope-2.7.3 and Python programming language as business-logic implementation environment; XML as data presentation format. Transformation engine has about ten modules; each module has about ten original (noninherited) rules. In Fig. 3 architecture of the IS is presented.

The constructed transformation system has generated a complete DDL script for database, representing all the classes as objects referring each other through object identifier OID and some of retrospection instance data (inheritance between classes); complete set of business-logics Zope objects represented as Zope folders with full support of contexts; complete flexible templates for object-relational layer between MySQL tables and Zope objects, the layer engine based on Zope SQL Methods; set of markup Zope Page Templates for the presentation format for export/import objects; template of Pascal language program for data export from previous version of IS; C-language efficient data importer from XML-representation; templates of input fields for user interface. For Zope objects we have also generated methods reflecting class-to-class relations, e.g., methods to get all tumor cases for a patient. The transformation engine has also generated the metadata, which used by Zope methods for special utility purposes. Our instrumental software has generated 91 tables for database and more than 8000 lines of source code. The kernel of the transformation engine and most of the rules was implemented in the context of the project for 3 human-months. The transformation cycles took about 1 minute.

The generated source code, methods and modules were integrated into IS with calling the code or inheriting it, so we could regenerate the framework without loss of later made changes of source code. Database data integrity supported manually and was periodically reimported from the database of the previous version. User interface was constructed manually from widgets, supplied by object's methods.

Using the MDA in this project we faced a number of problems. To the end of the design stage PIM occupied 4 m^2 and could be displayed only partially on the screen, some time was spent for periodical layout adjustment (location and color) of the model classes by their properties. Memory integrated YAP (Prolog) and Python transformation engine started to crash on big-size input PIM, we switched to less productive process- and stream-integrated version of the engine. Practictitioner programmers did not share our optimism about MDA usage: they preferred verbal form of modeling; they were forced to implement report generation subsystem. Some years later Gentleware decided to charge for new and all old versions of Poseidon for UML CE, but none of investigated free UML editors can load our model now.

At the end of the design stage we had almost functional IS supporting most of required function but it have somewhat ugly interface: medical stuff was too busy to help us with testing and refining. Presently the PIM is used on-site programmers as source information for recreation of production grade version on Django/PostgreSQL platform. Now the IS is used in

the oncology hospital.

IV. CURRENT DEVELOPMENT OF THE TECHNIQUE

Further development of the technique is aimed at raising performance and expressive abilities of the transformation system, as well as its reliability. Main problem is that it is hard to provide efficient and in the same time sound integration of Prolog and Python: both systems have its memory management units but different memory management strategies. We decided to shift the system to use powerful expressive abilities of LogTalk Prolog [7] macro package supplying it with an imperative subsystem and a template engine. LogTalk is an object-oriented logic programming language that can use most Prolog implementations as a back-end compiler and inference engine. As a multi-paradigm object-oriented language, it includes support for prototype and class inheritance, protocols/interfaces descriptions, component-based programming through category-based composition, event-driven programming, and high-level multi-threading programming.

In the new implementation [8] of the transformation we take advantage of the same object-oriented hierarchical modular architecture as before, but set up another goal - to support transformation in both directions: from abstract PIM to source code and from the source code to abstract models. This should partially allow developers to

1) modify generated source code and conserve changes, i.e., account them in PSM and PIM;
2) develop software on the various levels of abstraction;
3) accumulate libraries of complexes of models and their implementations as well as transformation modules.

The results of the investigation will be realized in a software development environment, integrating UML design software and source code IDEs. The integration engine is to be based on change propagation [9]: the modifications made are recognized by the environment and pushed to other utilities.

A. *LogTalk transformation module example*

Let's consider a code example written in the LogTalk programming language. We have the following interface class for access to the loaded XMI DOM2 tree. This class is used in Model class, that is a primarily recognize the model in XMI file.

```
:- object(class, instantiates(class)).
        :- private(attributes_list/1,
                operations_list/1,
                . . . . . . . . .
                parse_operations/2).
        :- public(new/5,
                new/2,
                name/1,
                operations/1,
                attributes/1).
. . . . . . . . . . . . . . . . . . .
:- end_object
```

Next code is an example of a transformation procedure

```
:- object(TransformToSQL(Class, Type) )
. . . . . . . . . . . . . . . . . . .
%Parametric object allows to customize some parameters
        database(Database) :-
                parameter(1, Database).
        class(Class) :-
                parameter(2, Class).
        databasetype(DatabaseType) :-
                parameter(3, DatabaseType).

        gen_sql(Name, Attributes, Output) :-
                append("CREATE TABLE", class::Name,
                        Output),
                append(Output, ::gen_attributes(
                        class::attributes,
                        Attributes), Output),
        append(Output, ::databasetype, Output).
. . . . . . . . . . . . . . . . . . .
:-end_object
```

Call to the *gen_sql* method looks like *TransformToSQL(Student, "Inno DB")*.

B. Change propagation

Definition of change propagation in [9] from the MDA pint of view can be interpreted as a way of transformation. Transformation engine compares two versions of PIMs, recognizes the difference and corrects PSM and source code in the corresponding points of change. The transformation approach uses specially stored links between objects from PIM and corresponding generated object in PSM. When an object changes or deleted its image in PSM traced by its link.

We suggest extending this idea to allow the propagation in both directions, including from PSM to PIM. This should results in the following additional advantages:

1) Record the stages of the development as complexes of abstract models and corresponding source code fragments;
2) Allow designers to transfer the model complexes between projects.

To deal with stated extension and planned features we proposed to apply the theory of systems of complexes (configurations), successfully used in geography research [10], to software life cycle, implying that the software development is a natural process. The theory shows how to represent model elements, relations between elements, transformations and links as complexes, as an element of a category. In [10] we shown that as the model complex and a change are elements of the same set of complexes, hence the change is expressed with the same language structures as the model complex. Similar arguments are true for transformation modules; they can transform both the model and its change.

Some practical examples have been found, like *diffutils* package of any Unix distribution, which demonstrate the investigation results. The package allows programmer figuring out the differences between two versions of a source code text file (*patch file*) and apply the *patch file* to the sources. The package contains two main utilities *diff* and *patch*. The first utility compares two ASCII or Unicode texts and produces a new text file with a representation of the difference between input files.

```
--- t1.cpp 2012-02-12 11:50:42.668030039 +0900
+++ t2.cpp 2012-02-12 11:52:44.944957992 +0900
@@ -2,6 +2,7 @@
     char * name;
 };

-class Pupil:Person {
-    Class * cls;
+class Student:Person {
+    char * stud_no;
+    Group * group;
 }
```

In this example shows that the difference is shown with the same ASCII or Unicode characters: the text is shifted by one character right so the first column became control column, where characters define a modification. The space character denotes a context of the text part under change. The minus character denotes part that to be removed, and plus character denotes the new text composition to be added into the context. As in one patch file the whole project change set can be stored, special format substrings "---" and "+++" are used to denote the particular files, and "@@" is used to denote general relative position of the first line of the context in the files.

Links from PIM to PSM express context of changes more precisely than patch file format, and allow back transformation engine to recognize the differences. We suggest using an intermediate text format between PSM and generated source code. This format reflects the links and also account that the generated source code in a general case is not a flat text anymore. The format can be constructed on the base of a D.Knuth's Literate programming [11] implementation. Literate program itself is a tagged tree representation of computer program, and those tags can be generated from PIM and PSM and reflect the links and abstract objects of the model. In opposite direction the changes of the source code now can be more precisely recognized having the tags at hand. There are well developed tangling and untangling algorithms (reverse direction), e.g. in [12].

C. UML plus BPMN

BPMN is a Business Process Model and Notation [13]. This notation is quite popular in the enterprise development, but it has no capabilities to deal with the structural presentation and modeling computer systems, so, it cannot override UML in this task. An example of a BPMN notation application is as follows (Fig. 4) [14]:
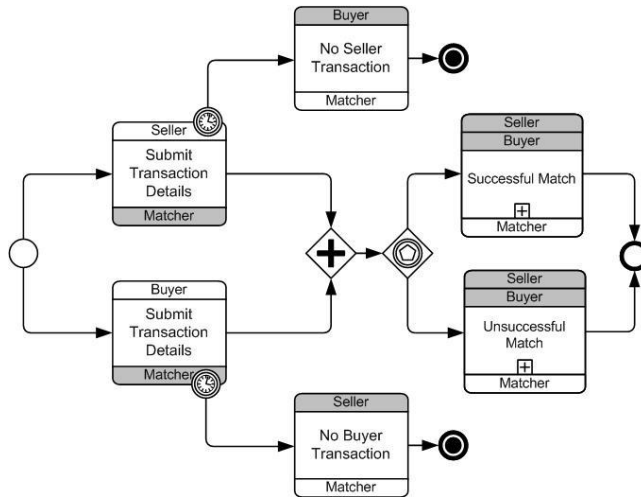
Fig. 4. BPMN diagram example.

The BPMN is well suited for creating a description of business processes. In our opinion, it is better than UML action diagrams, which is very complicated and not very useful. One can use the BPMN in business process describing, and it can be integrated with UML. In the future version of our tool, we will present the capabilities for processing the BPMN and to produce code from their model complex. Many open-source tools are capable to produce code, so we can adopt their approach into our engine of the code generation. Therefore, the main feature of the future version of our model transformation instrumental software under development is to produce code from both, UML and BPMN models of information system.

V. CONCLUSION

We have considered an existing implementation of transformation engine for Model Driven Architecture approach to software development in the case of information systems. The approach is based on mixing high level object-oriented programming language Python and logic language Prolog. The transformation is represented as network of modules. Each module carries on a subtransformation and implemented in a pattern-directed fashion. An example of application in medicine and further development of the system is considered.

One of the aims of the research is to construct a software development tools based on analogy. For example, having stores in a revision control systems all the states, models and stages of MDA software development as change complexes, it probably be possible to construct new sequence of differences for new original model.

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A metrics framework for measuring changeability
of UML class diagrams

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Abstract— The growing attention on modeling in software development calls for establishment of quality frameworks and metrics at all levels. The paper addresses the issue of quality model metrics in an early stage, focusing on changeability goal as ability of model to evolve rapidly and continuously. We propose a comprehensive flexible metrics framework, consisting of several model characteristics, capable to adjust to a number of modeling purposes. The framework defines complexity as a key quality characteristic which affects model changeability, viewed as one of modeling purposes. Our approach is illustrated through case studies of UML class diagrams from the practice, measuring corresponding complexity metrics. The first results indicate that degree of model changeability closely depends upon different kind of relationships among classes. The paper points out the necessity of assessing the quality of models built at the very beginning of software design in order to get high quality software artifacts.

Keywords— changeability goal**,** metrics framework, quality model, UML class diagrams

I. INTRODUCTION

In today's changing and competitive business environment, organizations are in a constant struggle to obtain dominance in the market. Aware of the fact that information systems and technologies are one of the most dominate technology in the world, they invest substantial financial resources for delivering quality software as their competitive advantage.

The growing attention on modeling in software development has subsequently brought the quality of models in forefront. As a new paradigm, Model-Driven Software Engineering (MDSE) emphasizes the usage of models as primary artifacts when specifying, developing, analyzing, verifying and managing software systems. Models are expected to get more complex with time and their dynamic adaptation to everyday changing environment would be one of the most difficult challenges developers have to face. Therefore, there are a lot of concerns in regard to the quality of models.

Delivering high quality software in an economic way requires control measurements over the products in all stages of its life cycle. It is well known that, in order to develop high quality software system, the focus should be on measuring the quality of the models built at the very beginning of software design and analysis. As B. Boehm pointed out, unwanted complexity and problems in the artifacts produced in the initial stages have significant impacts on cost to detect and solve them in later stages of development [1]. This observation encourages the assessment of software products in an earlier stage and the paper will be addressing this issue.

In this study we focused on UML class diagrams, the tool for conceptual modeling, as a key artifact of business understanding and clarity. The basic question to be answered is what metric for UML class diagrams can help to assess the quality of early designs. We want to investigate existing metrics, in order to measure quality characteristics which have significant impact on the changeability as today's key model quality goal.

First, literature overview presents the scope of the work done in defining quality

frameworks and modeling goals in software engineering. Section 3 presents the interpretation of model quality characteristics through multiple perspectives in IT balanced scorecard framework with focus on future growth perspective. It provides a clear overview of model quality goals as a good basis for defining relevant metric in evaluating changeability. Section 4 examines existing metrics and contains an overview of UML class diagrams metrics regarding model complexity and size. A basic formula for measuring model complexity is given in section 5. In the conclusion, we discuss research outcomes and ideas for future work.

II. LITERATURE REVIEW

The problem of determining software metrics for UML class diagrams is receiving a growing attention. Until now, the greatest number of papers has been focused on defining quality frameworks and comparison of several metrics for class diagrams on complexity, while only a small number of them performed empirical and conceptual studies on the mentioned topic.

The quality of a model can be considered from many different perspectives. Models on different levels of abstraction and different viewpoints have specific quality goals. Claxton and McDougal have come to conclusion that assessing the quality of anything means measuring the right things in the right way, based on its future role and purpose. They highlighted the fact that quality model evaluation has to be based on the stakeholders' needs [2]. In this context quality model is defined as "the set of characteristics and relationships between them, which provides the basis for specifying quality requirements and evaluating quality" by ISO/IEC 14598 international standard. In the literature there are many proposed quality models oriented to set of characteristics and sub-characteristic of software quality and ISO 9126 is the one commonly used [3]. Therefore, measurements defined for quality of model should be related to specific quality goals.

Parastoo Mohagheghi, Vegard Dehlen and Tor Neple identified six basic quality goals of models widely used in literature for building high quality models. The most important goals for measuring the quality of models have been identified as correctness, completeness, consistency, comprehensibility, confinement and changeability. These quality goals focus on the quality of models describing the system [4].

The further subject of this research will be a review of existing metrics, model quality characteristics and their assignment to four different perspectives using IT balanced scorecard tool.

III. MODEL QUALITY SPECIFICATION

The multi-view and multi-abstraction level development approach means that each of the diagrams and abstraction levels might require specific quality goals and metrics. "Research on quality in MDE should take into account the various modeling purposes, relations of purposes to quality goals and the dependencies or conflicts between them" is the point that Mohagheghi and Dehlen highlight in their work [3].

Following ISO 9126, the quality model presented by Lange and Chaudron, consists of a set of quality attributes where similar are grouped into a same quality characteristic. They examined the relationship between purposes of modeling and model characteristics, showing influences of lower level concepts on the higher level. This quality model takes two uses into account: maintainability and development. For each phase some modeling purposes are defined

and quality characteristics are related to each purpose. In Fig. 1 we can see how these two variables are connected. These characteristics are further related to metrics [5].

The field of research of this paper is the quality of conceptual models, which should be understandable for external stakeholders but not necessarily detailed. Therefore we propose a comprehensive framework for performance evaluation, the IT Balanced Scorecard (IT BSC), through which the vision and strategy of an organization are transformed into a set of strategic objectives and performance measures [6]. Looking through multiple perspectives on the problem we get clear overview of the goals and characteristics as a good basis for defining useful metrics. The originally defined concept of IT BSC, intended for profit organizations, does not fully suit the needs of software models and it is necessary to adapt balanced scorecard to corresponding stakeholders and business perspectives. The original IT BSC model is shown in Fig. 2.
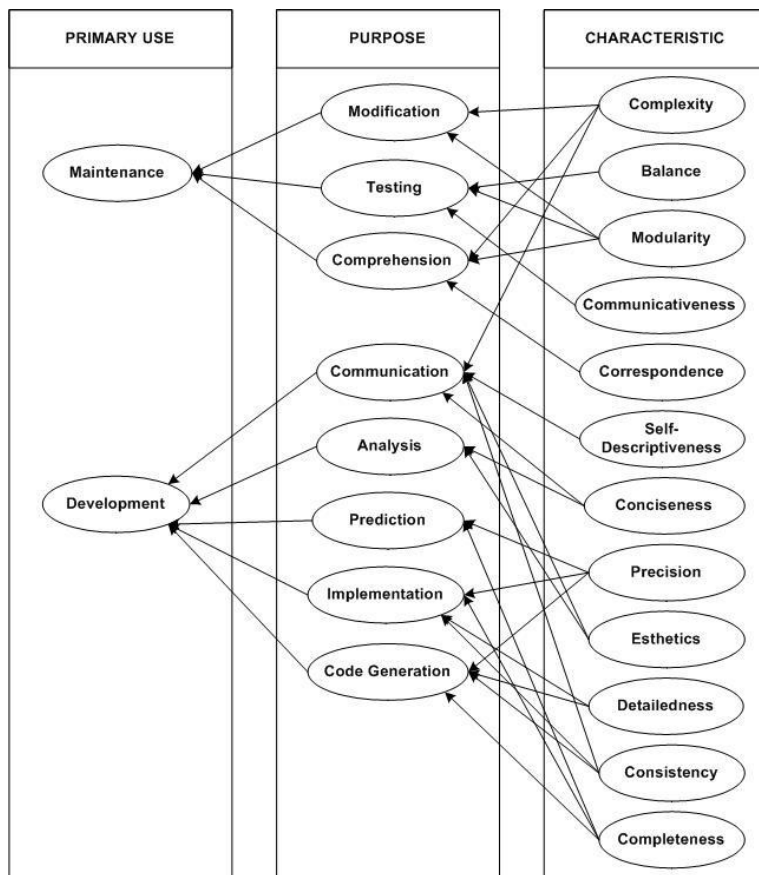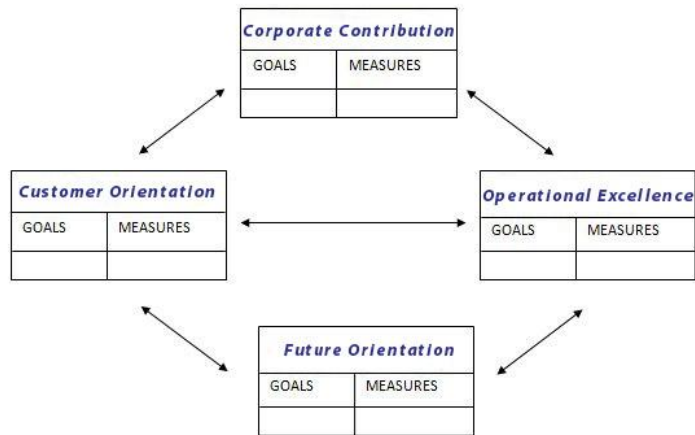

Fig. 1 Model Quality

Fig. 2 IT Balanced Scorecard

Regarding model quality we introduce the following four perspectives: software designer perspective, client perspective, resource perspective and future growth perspective. The adapted IT BSC model with assigned model characteristics is shown in Fig. 3. Comprehensive analysis of characteristics shows that number of them has influence on more than one perspective goal since they are highly interconnected.

In environments, where business needs and requirements are frequently changed, the priority is to create a model with capability to evolve rapidly and continuously. Significant impact of complexity characteristics on modification purpose is shown on the presented quality model in Fig. 1. Further on we will focus on the changeability goal, covered by future growth perspective in IT BSC, addressing the question how to measure the level of model flexibility to changes.

IV. EXISTING MODEL METRICS

Today, a growing number of companies is using UML as a common language for their project artifacts and has adopted UML as their organization's standard. Need for measuring their characteristics has arisen, particularly for concrete UML class diagrams as the most important structural models. UML class diagrams play important role in the conceptual modeling phase and their quality can have a significant impact on the overall quality of the system.

Bearing in mind that what we measure and why we measure differs between models and source code, we thoroughly analyzed the existent measures that could be applied to class diagrams at the high level design stage. Although there is a number of metrics and rules in literature, a lack of studies that analyze the quality characteristics of UML class diagrams model on high conceptual level can be noted. Classification of model metrics detected in literature so far can be found in state of the art analysis regarding model metrics [7]. Beside model size and design metrics, a few model-specific metrics related to comprehensibility of

models have also been discovered. A case study conducted by Genero *et al.* is one of the rare studies on this topic, where emphasis is given to the size and structural complexity of metrics of class diagrams in order to observe if any connection exits between the complexity and size of UML class diagrams and their maintainability. It confirms substantial correlation between complexity as independent variable and external characteristics of maintainability: understandability and modifiability. The obtained results show that the metrics related to associations, aggregations, generalizations and dependencies, are the most relevant [8].

Concerning these results we can conclude that the changeability quality goal also depends on complexity and size characteristics of a model. Thus we will use presenting metrics in Fig. 4 for overall calculation, where we exclude Number of Methods (NM) and Number of Dependencies (NDep) metrics since they are not suitable for class diagrams on conceptual level. On the other hand, we need to take into account association class element of UML class diagrams, so Number of Association Classes (NAssocC) metric is introduced.

SOFTWARE DESIGNER PERSPECTIVE	CLIENT PERSPECTIVE
Complexity Modularity Consistency Precisions Detailednees Balance	Correspondence Completeness Self-Descriptiveness Communicativeness Esthetics
RESOURCE PERSPECTIVE	**FUTURE GROWTH PERSPECTIVE**
Complexity Completeness Detailedness Precisions	**Complexity** Modularity Correspondence

Fig. 3 IT Balanced Scorecard for model characteristics

V. RESEARCH RESULTS

Very few empirical studies available on the Internet have been done to measure complexity of models from the practice, in order to assess their ability of adjustments to everyday changes in requirements. For the purpose of examining this quality characteristic, the following relevant case studies were set. In corporation with our industrial partners we conduct research on three existing conceptual models. The models are from different companies with the same domain. They cover supplying and warehousing functions and differ little in model size, which depends on business processes and documents types of each company.

	METRIC DESCRIPTION
Number of Classes (NC)	The total number of classes.
Number of Attributes (NA)	The total number of attributes.
Number of Associations (NAssoc)	The total number of association relationships.
Number of Generalizations (NGen)	The total number of generalization relationships, each "parent-child" pair.
Number of Aggregations (NAgg)	The total number of aggregation relationships, each "whole-part" pair.
Number of Association Classes (NAssocC)	The total number of association classes.
Number of Generalization hierarchies (NGenH)	The total number of generalization hierarchies.
Number of Aggregation hierarchies (NAggH)	The total number of aggregation hierarchies (whole-part structure).
Maximum DIT (MaxDIT)	Maximum DIT (*Depth of Inheritance Tree)* value obtained for each class. The DIT value for the class within a generalization hierarchy is the longest path from the class to the root of the hierarchy.
Maximum HAgg (MaxHAgg)	Maximum HAgg value obtained for each class. The HAgg value for class within an aggregation hierarchy is the longest path from the class to the leaves.

Fig. 4 UML class diagram size and structural complexity metrics

As the basis for measuring complexity of class diagrams on conceptual level, we use appropriate metrics proposed by others which are selected and improved in this paper. Not all of existing metrics are suitable for this level of abstraction and we want to emphasize this fact. As already mentioned, number of methods in class and total number of dependency relationships are beyond the scope of our research. The key elements of class diagram are classes and relations. Essentially, there are three types of relationships: association, generalization and aggregation. They differ in dependency between the classes and therefore it is important to distinguish complexities of different kind of relationships.

Moreover we must not neglect aggregation and generalization hierarchy, which greatly affects the quality of model. On the other hand, aggregation class element plays an important role in model complexity and is necessary to be a part of our metrics framework. Obtained results for each model are shown in Table I.

From discussion above it is obviously that selected metrics have different influence on the overall model complexity degree. Different degree of their influence has to be concerned. Comparing complexity between metrics leads to characterize them by different weights specified by software decision makers. The reliance on experts' decision is considered very efficient in case of various decision making situations. Expert or group of experts assigns weights to indicators before aggregating them into a composite indicator. Weights should reflect importance of each indicator on composite one. Based on our experience and knowledge we evaluated metrics importance and weights that are presented in Table II.

TABLE I

OBTAINED METRICS VALUE PER CASE STUDY

	Case study 1	Case study 2	Case study 3
Number of Classes	26	31	20
Number of Attributes	119	83	85
Number of Associations	28	17	28
Number of Aggregations	13	7	7
Number of Generalizations	0	10	0
Number of Association Classes	0	3	4
Number of Generalization Hierarchies	0	3	0
Number of Aggregation Hierarchies	10	6	5
Maximum DIT	0	1	0
Maximum Aggregation Hierarchy	2	2	2

TABLE II

EVALUATING METRICS WEIGHTS

Metrics	NC	NA	NAssoc	NAgg	NGen
Weights	0.6	0.2	1	1.4	1.6

Metrics	NAssocC	NAggH	MaxDIT	MaxHAgg	NGenH
Weights	1.4	1.2	1.1	1.1	1.2

The idea is to introduce a flexible measuring framework which will be able to adjust to a number of modeling purposes and case studies by software design experts. No matter which method is used, weights are essentially value judgments and have the property of underlying different effects in the construction of a composite [9], [10].

Finally the outcome illustrates higher complexity of first model in comparison to other two. Lack of generalization relationships and association classes in first model does not seem to be important here. On the other hand, it makes the difference between second and third model although third model contains greater number of association relations. Therefore, a significant role in overall complexity is also played by number of associations. Despite our belief that they cause the lowest dependency between the classes, in large numbers their impact can be crucial for changeability feature. It should be noted that first model has almost twice more aggregation relationships than others. As we expected slightly variances in model size do not seem to be essential for determining complexity characteristic.

Brief analyses of obtained metrics value verify the importance of dependency level between the classes as the key factor to define complexity, having significant impact on model future growth perspective. Degree of changeability closely depends upon relationships among classes.

We use the following formula to obtain complexity characteristic value:

$$C_j = \sum M_i W_i. \tag{1}$$

Where: C_j= complexity characteristic value of individual conceptual model, M_i= metric value, W_i= weight assign to the concrete metric.

Here we show the final results of our research.

TABLE III
MODEL COMPLEXITY CALCULATION

	Case study 1	Case study 2	Case study 3
C_j	99.8	96.3	80.6

VI. CONCLUSION AND FUTURE WORK

In this paper, we analyzed quality frameworks and UML class diagram metrics based on existing literature, providing some initial observations on quality goals through IT balanced scorecard tool. The model covers all of the aspects that influence the quality of conceptual model, underlying changeability goal as essential in software engineering today.

The main contribution of this work is reflecting through the findings obtained from industrial models. The existing metrics regarding complexity of UML class diagrams were examined from different viewpoints, adjusted to conceptual level and different weights in participating in overall calculation of model complexity assigned to metrics. Considering previous results of structural complexity and size metrics as good predictors of understandability and modifiability model characteristics [8] and based on our findings, we can make final conclusion that degree of model changeability closely depends upon its complexity, particularly upon relationships among classes.

Despite a few number of industrial models applied here, the paper could be a good starting point for further research and case studies. Further steps in this research would be the improvement of overall complexity calculation, the inclusion of other quality characteristics and metrics which are important for assessing changeability quality goal, as well as the determination of each individual characteristics influence degree on final composition with observation of their mutual dependency.

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Design, Implementation, and Evaluation of a Web-Based System for Alumni Data Collection

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Abstract— Most standards for quality assurance in higher education area demand establishing and maintaining connections between higher education institutions and their stakeholders. For assessing quality of academic programmes and introducing changes and innovations into curricula connections to alumni are of special interest. Alumni employment rates and job position listings are useful indicators of quality of the institution and could be used for different purposes, like attracting prospective students and business partners. This paper presents the design and implementation of a web-based system that is used as an efficient tool for communication between higher education institution and its graduated students, and for collecting and analysis of alumni related data that could be used for different purposes, including improvement of academic programmes. The system was designed and implemented at the Faculty of Electrical Engineering East Sarajevo. Evaluation of the system performance showed good results in terms of data collected and attitudes of alumni with regard to introduction and use of the system.

Keywords—alumni, data collection, educational quality, web portal.

I. INTRODUCTION

Maintaining connections to all relevant stakeholders is a requirement usually introduced by standards for quality assurance (QA) in higher education. European standards for internal QA in higher education demand significant role of students, graduated students, employers, labour market and other relevant stakeholders in the QA process [1]. Establishing and maintaining connections to these stakeholders enables getting valuable feedback that could be used for many purposes. One of the main uses of alumni and employer feedback is for analysis of quality of academic programmes and adapting curricula to new demands of labour market [2], [3]. This is especially significant in engineering education, where things are continually changing and new technologies are frequently introduced [4]. Graduate employment ratio and feedback from employers that are hiring new graduates could be useful indicators of an academic programme quality [5], [6]. Beside the quality assurance dimension, establishing and maintaining connections to alumni provides many other benefits to higher education institutions (HEIs), to their students, as well as to alumni. Alumni stakeholder group is considered as one of the most significant resources that HEIs have nationally and internationally because of the potential value they can add to HEIs [7]. The added value is not just a financial nature, but also includes enhanced social interaction, networking and knowledge sharing, promotion of an institution and participation in its strategic development.

A significant body of research deals with various aspects of using alumni feedback in higher education [2]-[10]. However, a limited amount of research is concerned with information technology supported means for alumni data collection [2], [7], [8]. In [11], graduate tracking systems (GTSs) were analyzed in 10 countries around the world in terms of their owners, objectives, and used methodology. Most GTSs at national level are used to provide information to policy makers, while almost all of them are also used for providing

information to universities for use in analysis and improvement of academic programmes. Most GTSs use paper-based or electronic surveys for surveying all students who have graduated in specific year. The methods of collecting alumni related data are mostly based on alumni surveys that are conducted within several years after graduation. Contact information from alumni databases or university career services are usually used for sending surveys to potential participants. In case when the information are out-of-date, or where alumni databases and career services do not exist, various methods are used for collecting alumni contact information, ranging from manual search for names on search engines [9], to harvesting LinkedIn alumni profiles [10]. Most of the related works were concerned on how the data collected from alumni could be used for improvement of academic programmes and institutions. Some of them were concerned with how the data could be collected. Many problems exist in alumni data collection process, mostly related to availability and accuracy of contact information of potential survey participants, as well as to efficiency and effectiveness of the process. This paper presents a web-based system that could be used to address some of the mentioned problems.

The Internet and Web facilitated communication giving the institutions possibility to easily reach their audience, disseminate relevant information and to retrieve feedback. Having this in mind, a web-based graduate tracking system was developed at the Faculty of Electrical Engineering East Sarajevo (FEE) in order to try solving the problem of missing connections between the institution and its stakeholders [3]. Main goals of the system were to create a human and professional network and to encourage all the stakeholders, at first the alumni group, to register their contact and employment information. The system was also intended to provide efficient means of communication between the alumni, and between the alumni and the institution. After the initial design of the system, that was presented earlier in [3], the system was improved with additional features providing advanced communication and alumni tracking features, as well as interoperability with other systems. This paper presents the design, implementation, and performance evaluation of the system. Although the proposed system has many features common to similar alumni tracking systems (e.g. alumni directory, alumni search), it offers some distinctive features such as significantly different approach in collection of alumni contact and employment data, integration with today's popular social networking sites, extraction of various reports that could be used for direct support to QA at HEIs, and interoperability with proprietary university information systems.

II. SYSTEM DESIGN AND IMPLEMENTATION

Main functions of the system are collection of alumni contact data, collection and analysis of employment data (e.g. employment ratio, average time of waiting for the first employment), collection and analysis of feedback from alumni using built-in survey module, and providing efficient means of communication between alumni and HEIs. Users of the system are alumni, university quality assurance and management staff, as well as other unregistered users in role of web site visitors. Most of the data is entered into the system by registered alumni users within their profiles. Personal data contained in alumni records is confidential and secured by appropriate security mechanisms. Unregistered users have limited access to data. Registered users are able to access more information, depending on their role and privacy settings in the alumni profiles. Architecture of the system is presented in Fig. 1.
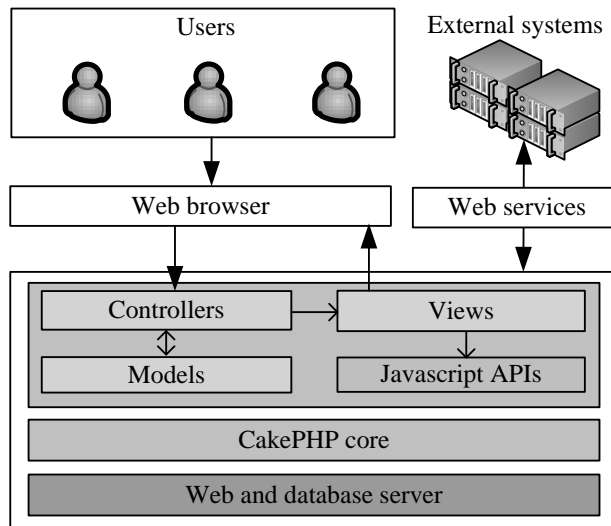
Fig. 1 System architecture

A. *Main functionalities of the system*

Main functionalities of the system are separated into several groups: collecting alumni contact and employment data, reporting based on the collected data, collecting additional feedback from alumni using built-in survey module, and collaboration with other systems.

Alumni contact and employment data are stored within alumni profile. Alumni profile contains personal information, contact information, educational and employment information of each graduate. Alumni profiles could be generated in two ways. One way is to use existing data from the university information system and to automatically populate alumni profiles with personal and educational information. The other way is to create alumni profile manually during the alumni registration process. After initial creation of alumni profile, alumni are regularly reminded to update their contact and employment information.

Based on the collected personal and employment data, the system provides a number of listings and reports. Some of them are available to public, like alumni and job directories in textual and graphical form (Google Maps), while others are available only to registered users (e.g. employment statistics). An illustration of employment statistics screen is shown in Fig. 2.

A. *Survey module*

In order to automate collection of additional feedback from alumni, a special survey module was designed. This module enables users to easily create custom survey, distribute invitation to participants, collect, present and optionally export results of the survey for later use or analysis in other software (e.g. Excel or SPSS). A number of options is available for creating surveys, such as defining questions of different types, defining custom answering scales, setting date and time limits, security options, etc. A screenshot of the online survey form created by the survey module is shown in Fig. 3. Survey results are available in textual and simple graphical form (Fig. 4).
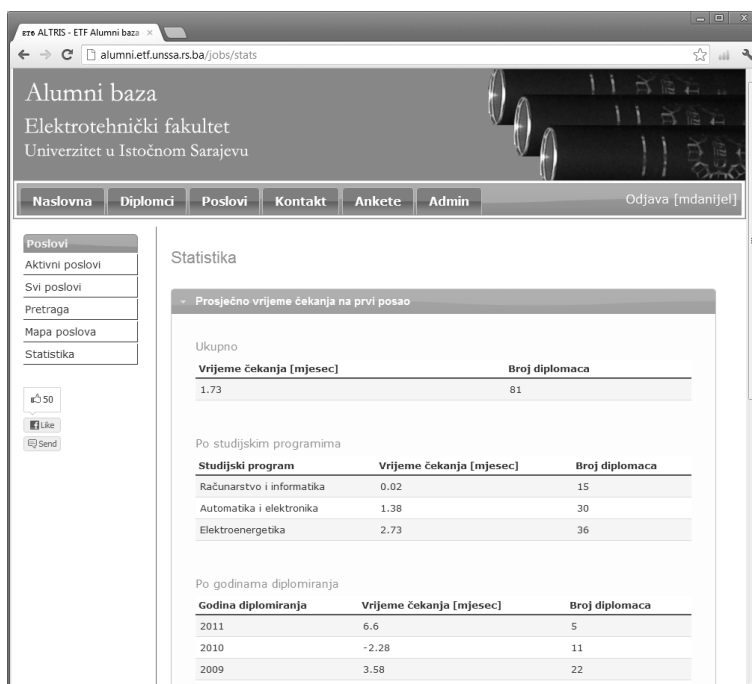
Fig. 2 Employment statistics showing average time of waiting for the first employment after graduation

B. Collaboration with other systems

Collaboration with other systems is mostly performed by REST (Representational State Transfer) web services. The system is capable to import data from other systems, as well to export data for use in other systems. For importing alumni data from existing university information systems, the system acts as a web service consumer. The web service is expected to return JSON formatted result. For export of data, the system exposes a set of web services. The web services were easily created using CakePHP rapid application development framework features that enable returning various representations of resources (e.g. JSON, XML).

A widespread of social networking tools is evident in last decade, no matter if they were used at workplace, at home or at university [12], [13]. HEIs widely use social networks to interact with students, teaching staff and community [13]. For this reason, the proposed system is also integrated with some popular social networking sites and email providers. For registered users it is possible to use an existing Facebook, Google or Windows Live account to log into the system. Integration with the mentioned systems was done using appropriate APIs available for these systems and following the OAuth 2.0 authentication and authorization protocol. Beside remote authentication, the system provides automated distribution of selected information (posts, news, events) to Facebook users who have 'liked' the system web page.

Fig. 3 Online survey form

Fig. 4 Survey results in textual and graphical form

C. Implementation

The system was implemented on a common open-source LAMP (Linux, Apache, MySQL,

PHP) platform using CakePHP rapid application development framework. The CakePHP framework is used for development of web applications based on MVC (Model-View-Controller) pattern. Client-side scripts are used at a view level for validation of input on the client-side and for improving look-and-feel of the user interface to the system. A publically available jQuery Javascript library is used for handling events and improving functionality of user interface elements, like calendars and auto complete drop-down lists. Another important component that is used at the view level is Google Maps Javascript API. Views that display pages with maps are using Google Maps Javascript API for displaying Google Map inside the page, placing markers at desired locations and for handling user generated events on the maps. Maps are used for displaying alumni residence and job locations, and for selecting exact locations of residence and job in alumni profile.

III. PERFORMANCE EVALUATION

Evaluation of the system performance was done by analyzing collected data and by conducting alumni survey. The system is in operation at the FEE since June 2011. The alumni database currently contains 3824 alumni records for the FEE graduates who have graduated in almost last 50 years, beginning from 1965 and up to 2012. Alumni profiles were imported from the FEE student information system with accurate information about the graduates at time of their graduation. Since the majority of the FEE graduates who graduated more than 20 years ago left Bosnia and Herzegovina, it was hard to get their contacts and to invite them to register at alumni web portal. In spite of this fact, 21 of these graduates registered after finding information about them on the FEE alumni web portal by using the Internet search engines. Situation with more recent graduates that graduated in last 10 years was much better since the FEE had official records with contact information that were used to send email invitations. At the time of writing, the total number of registered alumni is 226. Number of graduates per graduation year, and number registered and employed graduates for the last 12 years is shown in Fig. 5. Employment ratio of all registered alumni is 78.86%. Total number of registered jobs is 180, with 110 of currently active jobs.

Fig. 5 A total number of graduates and number of registered and employed graduates per graduation year

Based on the alumni employment records, the system generates detailed employment

statistics. Some of interesting employment indicators are: an average time of waiting for the first employment; number of jo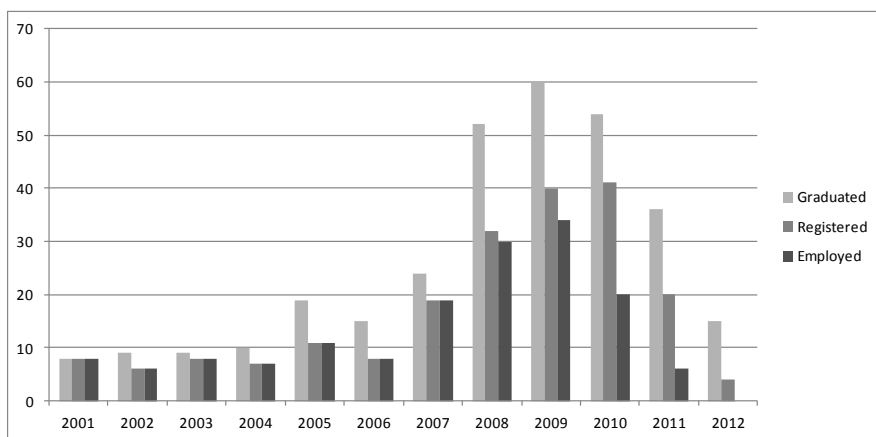bs by sector/industry; number of jobs in public/private sector and number of jobs in the field of study. In total, average time of waiting for the first employment is 1.73 months for 81 graduates. To calculate this indicator, it is required to register data about the first employment in the alumni profile. Almost half of registered and employed alumni did not enter this data into their profiles. The top three sectors by number of active jobs are: power sector (30.91%), public administration (23.64%) and education sector (20%). A total of 77 (70%) of active jobs are registered as jobs in the field of study. Number of active jobs in the private sector is only 18 (16.36%).

The alumni survey was conducted using built-in survey module. All registered alumni were invited to participate in the survey by sending them and email invitation with direct link for accessing the survey. The survey contained statements for getting the alumni feedback regarding their interest for maintaining contacts and cooperation with the FEE, participation in the alumni social events, ease of use of the system, and possible benefits that it could bring to alumni community and the FEE. A total number of respondents to the survey was 90 (42% of 214 registered alumni at the time of conducting the survey). The results of the survey showed positive attitude of alumni towards introduction of the system. There were several useful comments and suggestions from the survey participants regarding introduction of the system and intensifying social activities among graduates and between the FEE and alumni.

IV. CONCLUSION

This paper presented a web-based system designed for efficient collection of alumni contact and employment data. Significance of the system for higher education institutions was discussed, the design and main features of the system were presented, as well as some results of the system performance evaluation. By using this kind of system, connections and relationships could be efficiently re-established and maintained for benefits of higher education institutions and other stakeholders. A confirmation of this is the 63% of registered FEE alumni and interest of almost 95% of the surveyed FEE alumni to maintain contacts and continue cooperation with their alma mater, which is a good starting point for the current situation in Bosnia and Herzegovina and the region. Employment information and feedback provided by alumni could be used for analysis of quality of academic programmes and introducing appropriate measures for their improvement. Employment rates depend also on many other factors in a country, but they could also be interpreted as useful indicators of an academic programme quality and labour market needs.

The system currently has features for connecting HEIs and alumni. Additional modules and functionalities are planned in future work to enhance existing features, and to add new features for involving additional stakeholders such as employers, labour market, relevant ministries of education, undergraduate students, prospective students and their parents. All of these stakeholders have specific roles in the institution activities, and specific needs for accessing information. For example, relevant ministries of education are interested in employment rates and demands of the labour market as input data for defining admission policies and quotes. On the other hand, prospective students and their parents are interested in the same data, but from the other perspective, when deciding which academic programme to choose. The role of the proposed system is to provide efficient means of communication between the institution and its stakeholders, and to provide tools for efficient collection and analysis of data that could be used for institutional advancement and for benefits of all relevant stakeholders.

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E-Business and Business Process Change in companies in the Republic of Macedonia

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Abstract—In order to survive and become more competitive in today's complex, dynamic and global environment, companies and their managers are forced to search for new ways of managing e-business initiatives. Companies are pressured to become more flexible, fast responding and customer oriented. To achieve these goals they should become process oriented. Business process orientation and process thinking help management to leverage the use of the information and communication technologies and the Internet, and hence to implement e-business with a greater success. Hence, the goal of this paper is to reveal the meaning and importance of business process orientation and business process change when transitioning to e-business. The main research question was to understand the potential benefits of business process redesign (BPR) projects when implementing integrated e-business solutions and their impact on competitiveness of companies. To achieve the goal of the paper, an interview with managers of Macedonian companies was conducted based on the previously prepared questionnaire for business process orientation, business process change i.e. business process redesign, in order to confirm (or reject) the assumption that BPR is a success factor for higher level of e-business implementation. Based on the analysis of the results from the empirical study some general conclusion and future recommendations are given at the end of the paper.

Keywords— E-business, business process change, business process orientation, business process redesign.

I. INTRODUCTION

Striving to survive and become more competitive in today's e-environment, companies and their managers should redefine their strategies, organizational structures and business processes and to build technological infrastructure necessary for successful implementation of e-business solutions.

In order to achieve better market position and satisfy customers' needs better than competition does, companies and their managers should simultaneously conduct two projects:
1) business process change/redesign and
2) implementation of e-business solutions.

In today's global environment, companies are pressured to become more flexible, fast responding and customer oriented. To achieve these goals they should become process oriented. Business process orientation and process thinking help management to leverage the use of the information and communication technologies and the Internet, and hence migrate to e-business with a greater success.

In that sense, business process orientation has become one of the most important management paradigms in the new millennium [1].

II. BUSINESS PROCESS ORIENTATION

The competitive global environment of the 21st century has reraised attention to business

processes because companies primarily consist of business processes and not of products and services. Likewise, organization's performance nowadays is envisioned in the efficiency of its business processes that on the other hand requires a process orientation. Managing a business, means managing its processes [2]. Though, very important and key for the business survival and competitiveness, business processes has been neglected in the management literature for a long time, mainly because of the predominance of the functional organization of work.

Today, many companies worldwide have understood the meaning of their business process and are treating them as strategic assets. Very famous example is the dot-com company - Amazon.com which has patented its business processes: one-click ordering and internet-customer-based referral system – known as „affiliates".

Companies competing in the new, digital economy should reassess the strategic importance of their business processes, and understand their organizations not only as constructions of functions and departments, but as highly integrated systems of business processes. In a word, they should become business process oriented. [2].

Although, business process orientation (further in the text BPO) is not yet recognized as an independent approach, it pulls significant attention from practitioners and researchers worldwide. BPO represents a generic concept of numerous management philosophies that use process perspective to improve business performance [3]. Many authors through time like Deming, Porter, Davenport, Short, Hammer, Byrne, Imai, Drucker, Rummler, Brache and Melan have viewed this concept as the new model of the organization. This new way of thinking and viewing the organization in the literature has been generally described as business process orientation.

In the extensive literature on business process management, there are numerous definitions of BPO that vary, but one that is more generic and comprises all the elements of the concept is McCormack's and Johnson's [2] definition of process orientation: An organization that, in all its thinking, emphasizes process as opposed to hierarchies with a special emphasis on outcomes and customer satisfaction. The concept of BPO is based on the assumption that the value to customers is delivered by streamlining and accelerating work patterns [2], [4]. Placing the focus directly towards customer and managing end-to-end processes provides a strategic approach in achieving a competitive advantage in the current customer-centric business environment.

It is worth mentioning that the concept of business process orientation should not be equalized with a process-based organizational structure, since one company can reach a certain level of BPO maturity without formally being organized horizontally [5]. Due to that it can be concluded that process approach can be applied to any organization.

Moving towards process orientation for companies means numerous benefits like more efficient execution of work resulting in cost savings, improved customer focus, better integration across the organization and increased flexibility of the company accompanied with improved customer satisfaction. Another benefit from process focus is improved flow of hand-offs between functions that leads to cycle time reduction [6]. Process orientation reflected in processes that are broadly defined eliminates redundant activities, verifying inputs one time for all functions within organization [7].

Although empirical evidence is lacking, several models have emerged during the last few years proving that process–oriented organizations have better organizational performance rather than the ones that are not process oriented. They indicate positive impact of BPO on

organizational performance [8], [9]. Further, it is indicated that investments in business processes creates competitive advantage for companies and provides significant improvement to the overall system [8], [9].

III. BUSINESS PROCESS CHANGE

Today, e-business initiatives have made the need to streamline, integrate and automate business processes even more pressing. As mentioned, business processes are crucial for organization's success. In order to maximize its competitiveness companies need to have business processes which are both well designed and work effectively.

In the literature, there are two basic ways of business process change. One is improvement and the other is innovation. But most of the companies when changing their business processes are placing themselves somewhere in the middle of these two concepts. This methodology is generally recognized as business process redesign [10]. Although these methodologies have different names in the literature, they are mainly recognized as business process improvement and business process re-engineering.

Business process improvement (BPI) is a systematic approach that helps organizations makes significant changes in the way they do business. Business process reengineering (BPR) is the radical redesign of organizations processes i.e. radical change rather than a series of incremental changes. BPI is the process of developing and implementing incremental improvements for a process and it is used when business is manageable and processes are relatively consistent. There is low risk associated with BPI and it starts with the existing process. Opposite, BPR is a fundamental corporate reorganization based upon the processes that deliver value to customers. It typically involves re-orienting a business from a product or location viewpoint to a customer focus which means achieving some degree of business process orientation.

The major difference between these two methodologies is that BPI is based on problem solving, and BPR is based on radical change of the overall process. BPI is a tactical and BPR is strategic undertake for the company. Business Process Re-engineering is generally used at the strategic level, when major threats or opportunities in the business's external environment prompt a fundamental re-think of the large-scale core processes critical to the operation of the value chain. Business Process Redesign is an intermediate scale of change operation, appropriate for medium-sized processes that require extensive improvement or change. Redesign efforts often result in changed job descriptions and the introduction of some automation. Business Process Improvement represents a tactical level, incremental technique that is appropriate for developing smaller, stable, existing processes.

Depending on the complexity of business processes, Harmon [10] proposes the following matrix of business process change:
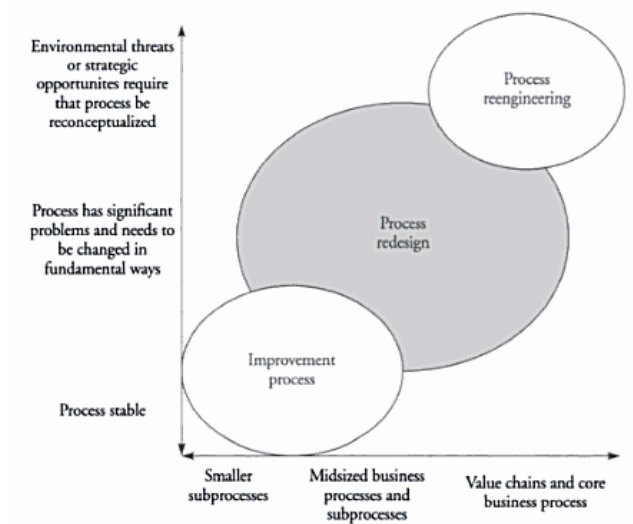
Source: P. Harmon, Business process change: A manager's guide to improving, redesigning, and automating processes, Morgan Kaufmann Publishers, Boston, 2003, p.39

Fig 1 Business process re- engineering, business porcess redesign and busines process imporvement

In order to achieve effective and efficient process change, it is very important that the level of process change fits the process itself. But, the level of required process change is also likely to reflect the process capability maturity of the business. If the business has mature process capabilities, process improvement efforts will be more or less continuous, undertaken by managers and their process teams. If a business has a low degree of process maturity then a process redesign effort might be required to establish the initial process capabilities.

Since business process re-engineering efforts of the 1990's didn't met the expectations, business process redesign and integration of business processes have become a vehicle for achieving sustainable value for companies.

Implementing integrated e-business solutions in companies requires business process orientation and organizational transformation. Business process redesign is a pervasive but challenging tool for transforming organizations. BPR is a change management approach aimed at achieving quantum improvements in overall organizational performance [11].

IV. E-BUSINESS AND BUSINESS PROCESS CHANGE IN COMPANIES IN THE REPUBLIC OF MACEDONIA – SURVEY RESULTS

A. E-business in companies in the Republic of Macedonia

The process of creation and implementation of an integrated e-business solution nowadays is imperative for organizations. Information and communication technologies are implemented in great extent in each organization regardless its size, industry type and its market position. For organizations of leading market economies, the implementation of ICT and e-business in all aspects of the society and business is not new. Hence, in the time when technology is not a choice but an imperative for doing business, only the way of using it will be a considerable competitive advantage, and not the technology itself.

The correlation between the level of usage of ICT and competitiveness is familiar in the

literature (Sharpe, 2006), as well as there are specific empirical evidence for the correlation between knowledge management tools, inter-organizational relationships and innovation with firm performance [12]. It is worth mentioning that the implementation of ICT is generally analyzed from innovation of business process management perspective. The competitive advantage of a company can be reflected in aligned business processed.

The level of implementation of ICT in organizations can vary. The fully –flagged e-business solutions are the best choice, since they provide synchronization of all business processes and activities and integration of all data form business operation of the companies. The integration of ERP systems with CRM modules in companies is becoming a common practice, but the trend of the extended enterprise where an overall integration with suppliers as well is provided, is not yet a case for companies in the Republic of Macedonia.

According to the data of the State Statistical Office of the Republic of Macedonia, in January 2011, electronic transmission of data suitable for automatic processing, i.e. sending and/or receiving of data via any computer network (Internet or other), in an agreed or standard format which allows their automatic processing (e.g. EDI, EDIFACT, XML), to or from systems out of the enterprise, was performed by 37.4% of the enterprises. E-invoices suitable for automatic processing were more frequently received (by 9.3% of the enterprises) than sent (by 6.0%). Sharing information electronically and automatically between different functions of the enterprise was performed by 47.0% of the enterprises. Their own website/home page had 58.9% of the enterprises, and 10.4% had online ordering enabled via their website. During 2010, 6.9% of the enterprises with at least 10 employees had web-sales i.e. have received orders for goods or services via website, while 7.1% sent orders for buying goods/services via website. [13].

TABLE I

ICT USE IN COMPANIES IN THE REPUBLIC OF MAcEDONIA IN 2011, (% OF TOTAL)

Enterprises (number of employees)	Open source ERP or CRM applications for business process automation	Electronic transmission of data suitable for automatic processing (EDI, XML, etc.)	Automatic share of information within the enterprise
10 - 49	12.8	31.9	40.4
50 - 249	13.3	39.8	49.6
250 +	19.5	51.0	65.1

Source. www.stat.gov.mk

It is evident that large companies (with more than 250 employees) have higher levels of implementation of ERP and CRM applications for business process automation, as well as higher level of electronic transmission of data (EDI, XML, etc.) and automatic share of information within the enterprise than the medium and small companies.

In the Republic of Macedonia, although the necessity of using ICT and integrated e-business solutions is recognized from many managers of companies of all sizes, Macedonian companies are still legging behind the world. This situation is not surprising, having in mind the level of countries' overall economic development. The extensive use of ICT and integrated e-business solutions represent an imperative for the survival of Macedonian companies, not only on global market, but on the regional and domestic market as well.

B. Business process change/redesign in companies in the Republic of Macedonia

The goal of this paper is to consider the potential benefits of BPR projects when implementing integrated e-business solutions and their impact on competitiveness of companies in the Republic of Macedonia, as well as an initial estimation of process orientation of Macedonian companies. In this part of the paper, the results of the empirical study will be presented. The main research question was to understand whether the business process change/redesign is a necessary project when implementing integrated e-business solutions in companies i.e. whether business process change is a critical factor of successful e-business implementation in companies in the Republic of Macedonia.

In order to understand the relationship between BPR and the level of e-business, an interview with managers in Macedonian companies was conducted based on the previously prepared questionnaire for business process orientation, business process change i.e. business process redesign, in order to confirm the assumption that BPR is a success factor for higher level of e-business implementation.

Since the research question was whether the higher level of e-business implementation is resulting from the BPR effort, the sample was chosen based on the previous selection to estimate the level of e-business implementation in companies in the Republic of Macedonia. The chosen sample was 30 companies with higher (highest) level of e-business adoption in the country, but the interview was conducted with 19 companies i.e. with their managers. The selection of companies for interview was made according the following criteria. First, the factor location of the companies doesn't play significant role since most of the companies with higher level of implementation of ICT and e-business solutions were located in the capital. Second, regarding the size of the companies (small, medium, large), small companies were excluded from the research since the level of e-business implementation is low in these companies in the country. Medium and large companies were selected for deeper analysis of the impact of BPR on e-business implementation. Third, regarding the industry type, several companies were selected from different industries previously indicated as leaders in e-business adoption in the country, like finance i.e. banking sector, telecommunications, ICT sector, manufacturing, and construction.

Regarding the profile of respondents, since the e-business implementation and BPR are concepts of strategic importance for companies and require support from the top management, respondents were mainly CEOs, IT managers, HR managers and marketing and sales managers in interviewed companies.

The questionnaire encompasses 4 parts. Part A was referring to business process orientation of companies. Part B was referring to the needs and reasons for business process change in companies. Part C was containing questions regarding BPR projects. Part D contains general questions about the company and the profile of respondent. At the end of the questionnaire, a part for comments of the respondents was also left, which helped us to better understand the problems that managers are facing when implementing e-business solutions and undertaking BPR projects.

Based on the analysis conducted on the results obtained by the interview, it can be concluded in general that managers of Macedonian companies understand the meaning and importance of business processes and they view their organization as a network, system of business processes. Though, they understand the benefits and advantages of horizontal organization of work, still more than 3/4 of respondents confirm that the management and

work in their organizations are still based on functions and not business processes. But, company can be process oriented without being formally horizontally organized. The interview shows that no company, yet, has process manager and process owner appointed although more than 20% of the respondents understand the necessity for appointing management staff based both on functions and processes.

The second part of the interview showed that 21% have made fundamental changes on their processes and business functions, 2/3 have automated their processes and functions, and 11% didn't conduct any changes in their business. Among the various reasons for conducting business process change specifically process automation; more than a half said that the change is needed for obtaining faster process and functioning. Only 2 respondents said that automation is needed for the reduction of the number of employees. The results also have shown that managers still don't think that the implementation of ICT and the Internet in the business is reason enough for business process change. Very surprising was the fact that 2 of the respondents are following the technological trends not because of the benefits that technology can provide for the organizational performance, but in order to "keep pace with the technology" which is not justified effort at all. Managers are investing in expensive software packages, but they are not using them in their full extent and for the right purpose. In order to avoid the negative effects of this not justified investment in technology, managers and employees should be trained for the benefits that technology can provide for improving overall organizational performance. Being aware of the right capacity and possibilities of e-business solutions companies can become more competitive, not only on domestic and regional, but on the world market as well. Managers in Macedonian companies still don't understand the strategic importance of ICT. Very often, they leave the decision for investing in ICT on lower level management, usually IT management.

The third part of the questionnaire referring to the BPR project showed that 4 companies are redesigning their business processes, 7 are planning to conduct BPR in the next 12 months, 5 in the next 2 years, and 3 don't plan to redesign their processes in order to implement e-business solutions.

Major motive for realization of BPR for managers is increased overall efficiency, increased customer satisfaction, competitiveness, as well as improving the information flow within the organizational units.

The implementation of ICT and e-business isn't recognized as important reason for conducting BPR. Regarding the financial returns of business process redesign effort, more than one half of respondents expect increased profit and 1/5 doesn't expect any financial result which indicates that managers don't understand the effects of realization of such a project when implementing ICT in the business.

The realization of BPR project mainly is initiated by the top management. Having in mind the fact that the most of interviewed companies are with dominance of foreign capital and the dominance of foreign partners in the managerial boards, it can be concluded that the initiative for change derives from foreign partners.

For realization of BPR project, more than a half of the respondents will use consultants help, and they think that the management needs extensive training in the field, which indicates that there is a lack of expertise in Macedonian companies on this topic.

Based on the initial data obtained by interviewing managers of Macedonian companies, it can be concluded that:

1) Managers of Macedonian companies understand the meaning and importance of the use of ICT and integrated e-business solutions in achieving competitiveness and increasing productivity;

2) They understand the meaning and importance of business processes although their companies and work are still organized based on functions;

3) They still don't recognize BPR as important factor when implementation ICT and e-business in companies;

4) They require intensive training and knowledge dissemination in the business process management domain.

Business process change/redesign and e-business are strategic decisions and require top management support, financial investment, time and commitment of all human resources in the company. The trip towards process focused organization is not a revolutionary but rather an evolutionary effort. This means that companies should join all of its resources and forces in order to gain the promised benefits from these projects. This counts for Macedonian companies as well.

V. CONCLUSION

Planning, designing and creation of e-business solutions for companies are one of the main projects of the contemporary management in the new millennium. These solutions, representing very important projects for company's survival in the global market place, require solid methodological approach in order to be completed successfully. E-business solutions can be considered as valuable source of competitive advantage for companies, and as such they should be implemented in companies with highest attention.

Regarding the level of e-business implementation in companies in the Republic of Macedonia, it can be concluded that although the necessity of using ICT and integrated e-business solutions is recognized from many managers in the country, there is still a considerable gap with the world.

Though the integration of ERP systems with CRM modules in companies is becoming a common practice worldwide, as well as the trend of the "extended enterprise", that is not yet a case for companies in the Republic of Macedonia.

Regarding the business process orientation, managers in Macedonian companies are aware of the importance of business processes, but their companies i.e. the work is still organized namely based on functions. But, as confirmed in the literature, companies should not be completely horizontally organized in order to be process oriented.

In order to take the advantage of the process orientation when implementing integrated e-business solutions, companies, i.e. their managers have to understand that it is very important to start thinking and acting in a process way, since customers are five times less satisfied from the business process than the unsatisfactory product or service.

Regarding the estimation of the business process maturity level in companies in the Republic of Macedonia, a more solid empirical base should be formed in order to systematically analyze the level of BPO. Knowing where we are in comparison to others (regional and global competition), can help Macedonian companies to become more competitive and aware that the highest levels of process maturity can increase the overall performance of companies.

Macedonian business sector need guidance on the business process management trip by the

educational institutions in the country.

Since the importance of this new management paradigm is recognized, the Faculty of Economics – Skopje, makes his pioneer steps in incorporating business process management topics in the faculties' curricula.

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Importance of the Social Media and their Integration in the Internet Marketing Strategies of the Companies

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Abstract— The Internet is becoming an indispensable tool for the individuals and business community. Modern life and contemporary work are heavily based on Internet. Consumer behavior and their expectations are changing. Knowledge of the consumer behavior represents an important element in building a successful marketing strategy. For a modern company today it is necessary to make analysis of their customer's behavior that will assist in developing strategies for their retention and attraction. Social networks play an increasingly important role in this. Nearly four out of five active Internet users today are active users of social networks. According to the Internet World Statistics data the number of social media's population continues to grow. Today, understanding of the influence of social media is becoming crucial for the business success. The purpose of this paper is to present the needs of companies for incorporating social media into their online marketing strategies.

Keywords— Consumers, Internet, Marketing strategy, Social media

I. CONSUMERS OF INTERNET SOCIAL MEDIA

The social media represent an integral part of everyday modern life of almost every person today. The social media are becoming significant source of information used by consumers, especially during the search phase when they are trying to make a purchase decision. On the other hand, the increased usage of social networks enables the companies to take care of brands and to influence the purchase process.

The social media is a tool for communication, presentation and cooperation of the companies with their existing and potential consumers, where the information flow is bidirectional.

There are many kinds and ways of classification of social media.

The generic types of social networks are the following [1:715-716]:
1) General social networks – place on the Internet for gathering and meeting friends, sharing content, schedules and interests (Facebook and MySpace e.g.).
2) Exchanging experiences networks – networks for professionals and practitioners, handicraft producers, software developers or musicians (LinkedIn for business and JustPlainFolks for music e.g.).
3) Networks created according to interests – networks built according to interest for sport, music, finance, politics, life-styles, etc. (E-democracy - for political discussions e.g.).
4) Sponsored networks – networks created from commercial, governmental and nongovernmental organizations for different purposes.

In this paper we will make a review of the general social networks and experience

exchanging-networks (professional networking).

The social media not only connect individuals, but provide personalized way of communication of companies with their consumers, so that they become significant marketing tool for the companies. Researches show that consumers use social media as a source of information for products and services. The presence of the companies on these social networks enables them to increase the number of consumers and the opportunities for purchasing and informing.

Each company which wants to satisfy the consumers' needs should actively approach to the implementation of the social media into their business strategy. Ignoring this media means ignoring million existing and potential consumers who are presence on the social media every day.

Facebook, Twitter and LinkedIn are on the top of the list of social networks and they become the most popular between the consumers and companies. The number of consumers of these networks increases every day and therefore the company's plans and the performance of these networks change.

Facebook is the biggest and most popular social network where the friends, colleagues, relatives, companies, organizations etc. can connect each other and can communicate and share information, links, contents, photos etc. Facebook offers great opportunities for business and it is a social network that changes the view of the world and people's life and attracts several thousands of new users every day. On this network, there is an opportunity to create profile, group or page. While the individuals mostly create Facebook profiles sharing their photo and other basic information for business, brands, products and services is more convenient to create a page or "Facebook page". With selecting the "Facebook for Business" option, the companies have the opportunity to see all the functions and features that Facebook offers for the business users.

According to data for year 2011, Europe is at the first place with 223.4 million Facebook users (out of 900 million Facebook users registered today); second is Asia with 183.9 million and third is North America with 174,600,000 users [2].
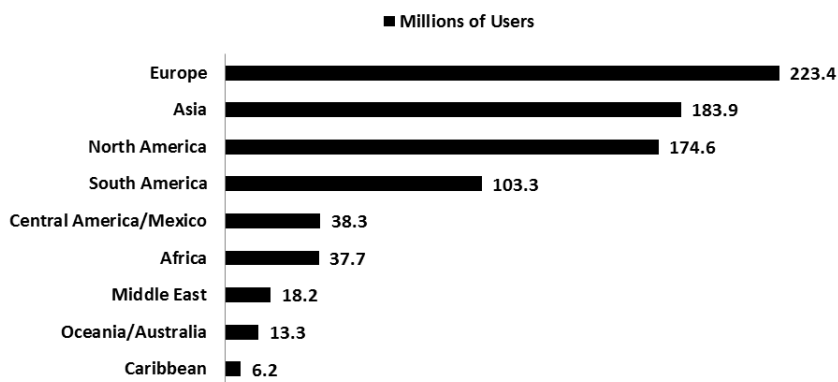

Fig. 1. Facebook users in the world by geographical regions - 2011

According to the rate of Facebook penetration, Europe is on the third place, or 27.4 percent of total population in Europe uses Facebook. The first place has North America with 50.3%. In

Republic of Macedonia out of 1,069.32 Internet users (by the end of 31 December 2011), 879,540 use Facebook or 42.3 percent from the total population of the country is present on the Facebook social network [3].

LinkedIn is a social media designed to connect professionals and businesses, enabling them to share information, get replies and promote themselves and their businesses. LinkedIn is network which provides networking and making business contacts. At this network the users can create profile with photo and short review of information for professionals and/or business careers and achievements. The profile is a base for connecting with other LinkedIn members. The text contained in the profile is searchable through the network (and popular search engines, Google e.g.) and enables connecting with appropriate companies or professionals.

Twitter is a network which enables the registered users to send or receive short messages known as "tweets". This network has about 300 million users, students, professionals, organizations. The companies use Twitter as a communication tool for realization of their marketing goals. Also, companies can share information about products and services, follow the competition; inform for everyday events and answer questions to the consumers. This network offers great opportunities for the companies, but also requires active participation, so that asked questions and negative comments can be answered on time.

There is no doubt that social networks are integral part of each individual and gradually change people's life and behavior. Not joining these networks reduces the opportunity for easier communication, access to huge volume of data, fast information, learning etc. At the same time social media networks change the companies' environment and the way of creating business strategies and operations.

II. INTERNET MARKETING STRATEGIES FOR ESTABLISHING CONTACT WITH THE CONSUMERS

Internet technology provides better opportunities for companies to establish recognized strategic positioning in relation to previous generations of information technology. It makes strategy more necessary than ever before. Internet companies can be top winners - if they understand the compromise between Internet and traditional approaches and if they are able to create really distinctive strategies. Internet architecture, together with the other improvements in the software architecture and development tools, has turned internet technology in more powerful strategic tool [4].

The development of the Internet and web technologies provides appearance of new marketing and internet marketing strategies. Attracting consumers is the first step in creating successful business, but after that another significant step follows – maintaining and managing consumers. Significant Internet marketing strategies for establishing connection with consumers are: affiliate marketing, viral marketing, permission marketing, search engine marketing, advertising networks etc.

Affiliate marketing is a type of agreement between groups of associates, from one side are publishers (also known as 'the affiliates'), that display advertising on the Internet, and on the other side are the marketers whose aim is to attract consumers and to increase their online sale. The most common tool for affiliate marketing is the "banner"[1] from the online marketer that is

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[1] Banner is a common form of advertising on the Internet. The banner is an advertisement of 460x68 pixels, usually placed at the top of the page and is intended to attract traffic to a website by linking to the website of the advertiser.

placed on the publisher's website (owner of the website) for specified compensation (based on visitor's click, sales or leads). By clicking on the banner, the consumers are redirect to the marketer's website. The affiliate marketing relies purely on the financial motivation to drive sales, and that is the main difference with the referral marketing where the main motivation relies on trust and personal relationship. Amazon.com for example has strong affiliate program and its logo can be seen by around 1 million affiliate sites. Smaller online companies and individuals with significant traffic on their websites use affiliate marketing through joining to third-party services provided by intermediaries to track traffic or sales that are referred from affiliates.

Viral marketing refers to an internet marketing strategy that encourages consumers to communicate the marketing message to others (friends, colleagues, relatives etc.) with the opportunity to spread the message and its influence exponentially. This strategy enables the message to be spread quickly to large number of users, such as the case like viruses. Viral marketing can be used by email, group messages, forums, Chat rooms, social networks etc.

To make the viral campaign effective, Justin Kirby, a viral marketing specialist (www.dmc.co.uk) suggest three unnecessary points [5:401]:

1) Creative material – "viral agent". This includes creative offer or message and how can it be spread (text, photo, video)
2) Plating. Identifying to which websites, blogs or people the email should be sent to, so they can begin spreading the virus.
3) Following. To follow the effect, to evaluate cost recovery from development of viral agent and plating.

Permission marketing or known as "opt-in e-mail" presents internet marketing strategy used by companies, so that they ask the consumers for accordance to send them commercials and other marketing materials. Most often companies on their website give an option for registration with email in order to get news, catalogues and other information from the company owner of the website. With every received message on email, the consumer has an option to logout from the page if he doesn't want to get commercial materials from the company any more. An opposite of this technique is spam usage that means sending unwanted message via email to the consumers. The usage of mailing list for sending information about company and its products and services is popular way of advertising, also known as *email marketing*. Email messages can be combined with specified photos, videos which promote the product or URL (Universal resource locators) addresses. This strategy enables to reach the preferred consumers cheap and fast. Forming email lists is powerful tool for targeting consumers.

Search engine marketing is internet strategy that enables promotion on company's website at the web search. A lot of engines enable the companies free submitting of their Internet addresses, called URL so that their URL can be searched electronically.

Ad networks provide advertising opportunities for companies who want to promote their products and services to internet consumers. These sites are usually called web publishers. Ad networks share the revenue with the publisher. This networks developed software that follows consumer's movements among the network members (Amazon, Google, Yahoo, eBay e.g.). At each visit the software for network advertising decides which banner ads, videos and other advertisements will show the consumer the different sites in the network. One of the most popular networks for advertising is Doubleclick.com [1:388-389].

Commonly known consumer retention strategies are: personalization, customization or user adjustment etc.

The internet marketing strategy facilitates the communication of the companies and their consumers using blogs, online games, internet radio, internet TV other and social media tools.

III. SOCIAL MEDIA INTEGRAL ELEMENT OF INTERNET MARKETING STRATEGIES

With the revolution of social media consumers worldwide become very most powerful. They forced companies to think about how to become more transparent and responsible. Social media enabled companies in times of economic crisis to learn how to do more with less money - to receive messages from consumers, to spend less money on classic media. People want to share and feel connected to others, brands, organizations and even governmental institutions that they love and trust. Facebook Like button, introduced in April 2010, has already been added to more than two million different web pages. This button enables more than 900 million users with one click to express approval of the company, organization, product or idea. Social media look like the world's largest cocktail party where everyone can hear what others say and join the conversation with someone else on any topic of their choice. But there is a difference between the real and online entertainment. What is significant in the first, there is a conversation with many people in one night, but online and via social networks there are numerous conversations with thousands or millions of people at once. And in the both parties will be found pleasant and unpleasant people [6:4-6].

Some reports [7] confirmed that consumers who log on to Facebook once a month and buy least quarterly, 62 percent of those buyers read comments from their friends related to the products. These comments help consumers to learn about products, and to 48 percent of them social sharing helps find information about products.

For the companies, research shows that their presence on social platforms and strategic involvement in discussions of social networks is aimed at supporting business goals, fostering favor of consumers to the brand and creating additional value. At the 64 percent of the companies, structure and roles within the marketing department, human resources and public relations have changed significantly as a consequence of social work, while most companies today (80 percent) regularly carry out some form of measuring the success of their activities at the social media, but also face challenges in measuring the scope of the external public. In seeking ways to measure the return on investment in social media, 84 percent of companies are focused on information from the target public engagements on social networks, 69 percent follow the number of messages, 53 percent analyze the attention that they have achieved, and 51 percent assess the tonality of the message and the feedback from the target audience [8].

Marketing on the social networks is moving with quick steps. Companies seriously incorporate it into marketing strategies and very carefully follow and communicate with many customers present at these media. Even for 42 percent of the companies today, Facebook is critical or important to their business [9]. Strategy performance of companies on the social media should include several important elements: they will promote (which products and services and on which target group), their registration on social media (social media selection and registration), finding appropriate manager of social media such as Ping.fm and Hoot Suite, prepared plan for updating, with whose realization will provide valuable information about the company's work, a way of finding friends and followers, active involvement of friends and followers and plan for continuous active performance [10].

A lot of companies adhere to many rules when it comes to social media marketing. Companies preparing plans for publication, monitor comments, use tool for managing announcements, doing promotions and recruiting fans and have separate teams responsible for social networks. One such example is a "Bozinovski - Watches and Jewelry" company that integrates social media into their marketing strategy. This company uses the tools of hootsite.com monitor the comments and posts on social media. Tools of wildfireapp.com are also used to create interactive promotions on social media [11]. The fact that this company has over ten thousand Facebook fans shows the effective approach to social media.

eMarketer [12] predicts that for advertising on social networks 7.72 billion dollars will be spend in 2012, including paid advertising on social networks, social games and applications. Growth in 2012 will be faster than in 2011, although in 2013 and 2014, eMarketer expects growth rates to fall, but still remain with double-digit figure. By 2014, eMarketer expects nearly 12 billion dollars going to advertise on social networks worldwide. Nearly half of that money has come from the U.S. and little changes in the predicted period are expected. In 2012, the U.S. for advertising on social networks will spend 3.63 billion dollars compared to 2.54 billion dollars in 2011, and continue to climb to 5.59 billion dollars by 2014.
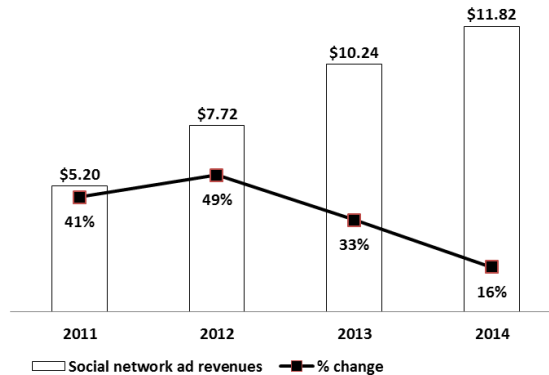

Fig. 2. Social Network Ad Revenues Worldwide, 2011-2014 (billions and % change)

There is no doubt that social media become a major business media, which should be integrated into the online business strategy to be enable to reply to the new consumer environment and increase their number.

IV. CONCLUSION

In the new Internet environment the companies have to be consumer-oriented to be competitive on the market. Consumers represent the most important part for the company. The company can provide long-term competitive power only through solid long-term relationships with consumers. Internet sites for social networking and blogs on the internet have bigger impact on consumer behavior. The company's presence on social media gives them the opportunity to reach a wide range of people, to present their products and/or services, to communicate with existing or potential customers, answer their questions, to adapt and to analyze the needs of consumers. The consumer, however, who will visit the social profile of the company, will receive more information about products and services of the company. Hence, the companies that will integrate elements of social media marketing strategy have a

greater ability to influence the consumer's decision to purchase.

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Managing critical infrastructure for sustainable development in the telecommunications sector in the Republic of Serbia

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Abstract - In last decades countries worldwide persisted in their efforts to foster competition in telecommunication/ICT markets. All regulatory focuses were directed to ensure competition and to regulation of the ICT market. More recently, electronic content, cyber security, data protection, privacy and environmental issues have entered into the scope of regulatory activities. In parallel on the global and national level discussion on Critical Telecom Network Infrastructure - CTI resulted in Strategies for CTI. This paper deals with basics of critical infrastructure, addressing definitions and standards with a highlight on the telecom sector. In the paper some situations in the region and Serbia and potential future steps are presented in order to initiate discussion on the need for regulation of Critical Telecom Network Infrastructure - CTI in Serbia.

Keywords—critical infrastructure, serbian CTI, teelcommunication infrastructure,

I. INTRODUCTION

In last decades countries worldwide persisted in their efforts to foster competition in telecommunication/ICT markets. All regulatory focuses were directed to ensure competition and to regulation of the ICT market. More recently, electronic content, cyber security, data protection, privacy and environmental issues have entered into the scope of regulatory activities.

Analyzing ICT sector, the data from 2011 have shown that the ICT sector continued to grow rapidly, with the exception of fixed telephony, where penetration rates have been on the decline since 2005. Many predictions are available giving the answers on what is the next in sector development. Venture Partners in their prediction made 2009-2010, shown in Fig. 1, presented their view on four dimensions of ICT development till 2025, e.g. Networks, Wireless, Content/Applications and Devices.

As Fig. 1 illustrates the increased use of online applications and services to communicate and do business (such as social media, cloud services, e-payment and other m-banking services) bring a host of new regulatory issues to the fore, for all ICT stakeholders. Many papers deal with security and privacy of data [1] and many problems in this respect are solved out by service providers. Therefore, these issues, in spite that are closely related to Critical Telecommunication Network Infrastructure - CTI are not in the scope of this paper and the paper discusses infrastructural problems.
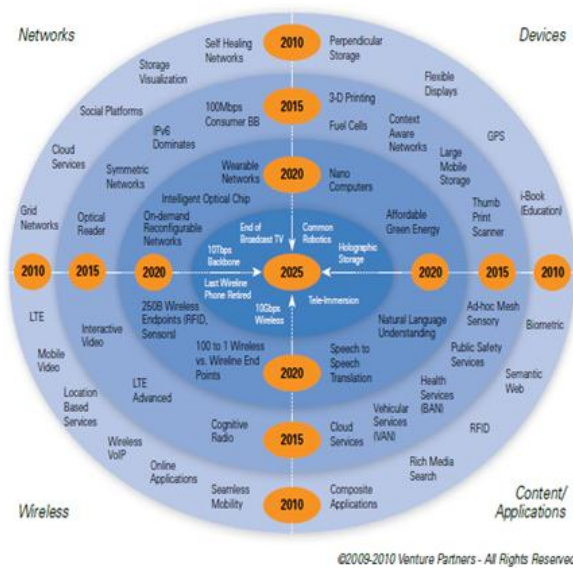
Fig. 1 The 21st century Ecosystem

Worldwide, telecommunication networks are considered as an inseparable part of social interaction and protecting these networks from malicious attacks and natural disasters that could lead to the unavailability or loss of integrity and confidentiality of network services is thus an important aspect that cannot be ignored. It should be highlighted that e-infrastructures, composed of e-communication networks, distributed computing, middleware, software and applications, play an essential role in the advancement of knowledge and technology. Due to their ability to assemble a "critical mass" of people and investment, they contribute to all levels of society' and economy's development. They are therefore important assets which should be protected at any side and should be considered as a part of national critical infrastructure. In this paper we try to open questions on is it necessary to regulate CTI and if yes in what extend it should be regulated. For this reason, we started from definition of critical infrastructure and relationship between different critical infrastructures. In brief we list the general standards for critical infrastructure and specific standards for critical telecom infrastructure.

II. WHAT IS CRITICAL INFRASTRUCTURE?

There are many definitions of the Critical Infrastructure - CI, but all of them in principle refer to assets which are essential to the economy and society. Some of these definitions for different region and countries (USA, Australia) are listed below.

USA: "Critical infrastructure and key resources (CIKR) refer to a broad array of assets which are essential to the everyday functionality of social, economic, political and cultural systems in the United States. The interruption of CIKR poses significant threats to the continuity of these systems and can result in property damage, human casualties and significant economic losses. In recent years, efforts to both identify and mitigate systemic vulnerabilities through federal, state, local and private infrastructure protection plans have improved the readiness of the United States for disruptive events and terrorist threats. However, strategies that focus on worst-case vulnerability reduction, while potentially effective, do not necessarily

ensure the best allocation of protective resources. This vulnerability conundrum presents a significant challenge to advanced disaster planning efforts. The purpose of this paper is to highlight the conundrum in the context of CIKR" [2]".

Australia: "Critical Infrastructure are those physical facilities, supply chains, information technology and communication networks, which, if destroyed or rendered unavailable for an extended period, would significantly impact on the social or economic well-being of the nation, or affect Australia's ability to conduct national defense and ensure national security"[3].

The CI is a subject within EU regulation. In the EU Council directive 2008/114/EC following terminology is used:

(a)"Critical infrastructure means an asset, system or part thereof located in the Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have significant impact in a Member State as a result of the failure to maintain those functions".

(b) 'European critical infrastructure' or 'ECI' means critical infrastructure located in the Member States the disruption or destruction of which would have a significant impact on at least two Member States. The significance of the impact shall be assessed in terms of cross-cutting criteria. This includes effects resulting from cross-sector dependencies on other types of infrastructure. [11]; List of European CI is given in Annex I of [11] and shown in Table I.

TABLE I

EU CRITICAL INFRASTRUCTURE SECTORS

Sector	Subsector	
I Energy	1. Electricity	Infrastructures and facilities for generation and transmission of electricity
	2. Oil	Oil production, refining, treatment
	3. Gas	Gas production, refining, treatment
II Transport	4. Road transport 5. Rail transport 6. Air transport 7. Inland waterways transport 8. Ocean and short-sea shipping and ports	

This Directive constitutes a first step in a step-by-step approach to identify and designate ECIs and assess the need to improve their protection. As such, this Directive concentrates on the energy and transport sectors and should be reviewed with a view to assessing its impact and the need to include other sectors within its scope, inter alia, the information and communication technology ('ICT') sector.

Member States identification of critical infrastructures which may be designated as ECIs is undertaken pursuant to Article 3. Therefore the list of ECI sectors in itself does not generate a generic obligation to designate an ECI in each sector. According to the Article 3 of DIRECTIVE 2008/114/EC, under the point 3, priority to be included in the ECI is given to the ICT sector: A review of this Directive started on 12 January 2012.

Based on literature review, the main elements of national CI could be identified as:

- Information & Communications (telecom, networks, Internet)

- Electric Power (conventional, nuclear)
- Transportation
- Oil & Gas (supply, transport, refining, distribution)
- Banking and Finance
- Water & Emergency Services
- Government (+military).

The critical infrastructures within the county are a complex "system of systems." Interdependencies are generally not well understood and disruptions in one infrastructure can propagate into other infrastructures. Between those CIs interdependencies is very strong. Critical infrastructures interact at different levels, and failure in one infrastructure may impact the functionality of other infrastructures. The significant importance of these infrastructures over the society and their interferences means that sufficient safety and security measures should be identified to reduce the risks of failure [4]. The Fig. 2 illustrates the interdependency between some CI.
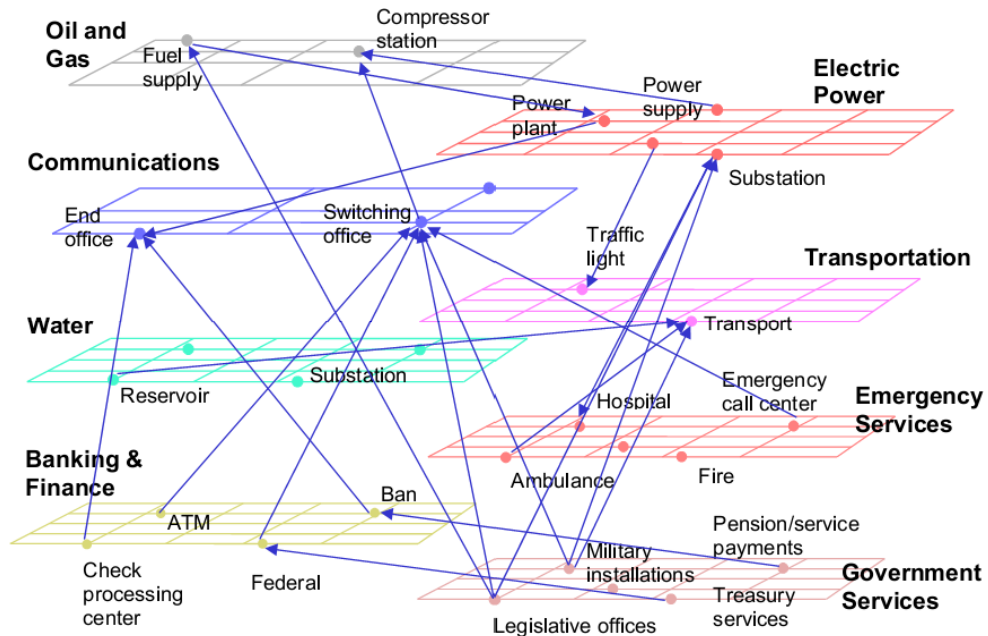

Fig. 2 Interdependency between different sectors [5]

It is clear from the Fig. 2 that there is a great deal of interdependency between the Telecommunication Sector and a number of the functionaries within the utility community. Almost all of the utilities have critical requirements for communications of any form. Alternatively, the communications community has a number of instances where they are dependent on the utilities, what leads to the conclusion that communications is a key infrastructure, central to all others, so that understanding and modeling the risk due to communications disruptions is a high priority in order to enhance public safety and

infrastructure resiliency [6].

Within the ITU's family, Critical national telecommunication infrastructure has not been explicitly defined. However, many references to the protection of critical national infrastructure exist especially in the context of security of telecommunications/ICT networks and services (PP-10 Res. 130, PP-10 Res. 174, ITU CS/Art.38, ITU CS/Art.34, ITU CS/Art.35) and several workshops on this issue were held.

Using above mentioned definitions we can say, in general, that CTI is very often dependent on the context in which it is used and on the overall country approach to the CI. A CTI can be identified as a public or private network that carries information relevant to national security and safety or information of high financial value. CTI can also be defined physically as the whole network or a part of the network that exchanges information of high significance. The clear strategy for management of CTI would help operators and society and economy identifying critical infrastructures and critical resources and the impact of the failure to other sectors and their CI.

Many of the country's broadband policies and plans focus on building nationwide broadband infrastructure, stimulating demand through the adoption of online services and applications, and extending connectivity to provide universal access and this infrastructure could be considered as CTNI. From the other hand, some authors refer that if the objective of the network itself is to exchange confidential information among nations, the whole network itself can be defined as a CTI [7].

III. IMPACT OF THE FAILURE OF COMMUNICATIONS SECTOR SYSTEMS

The impact of the failure of the Communication sector is subject of many studies, in which assessment of the overall risk is evaluated.
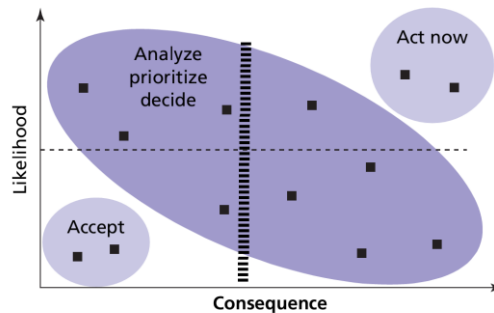

Fig. 3 Risk profile for potential disruption in communication sector [8]

For risk management different methodologies could be used. One of the ways for risk assessment is illustrated in Fig. 3, which plots the risk profiles for potential disruptions in the telecom sector.

When the risk is low (lower left corner), the event is unlikely to happen, and if it does, the consequence of the event is relatively low. Therefore, the most appropriate course may be to simply accept the risk, and live with the consequences. However, when risk is high (upper right corner), we should act immediately to reduce that risk as much as we are able to. When risk is in the broad middle area, then it is especially important to analyze and prioritize before

decisions can be made. All of these analyses should be used to identify critical resources and critical telecom network infrastructure. Furthermore, risk-informed decisions are needed, not only for network protection, but to help identify investment strategies and other options that best reduce overall risk.

As an example of dependencies among telecom and other infrastructures, we can observe communications, power, and emergency services and the potential cascading effects among them as shown in Fig. 4.
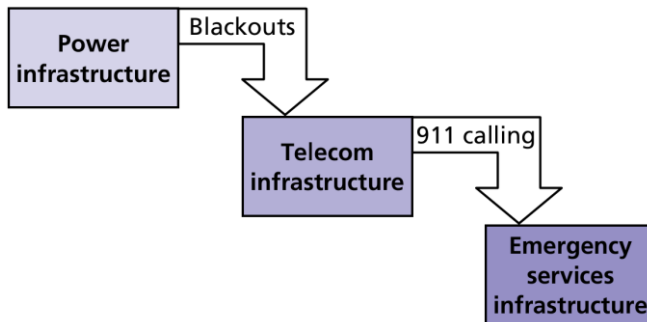

Fig. 4 Example cascading of impacts across industries: power, telecom, and emergency services [8]

In general, cascading across infrastructures can occur in almost any order, but telecommunications have been always a central component surrounding the disruption and is especially important in mitigating the disruptive effects.

IV. STANDARDIZATION FRAMEWROK ON CRITICAL INFRASTRUCTURE

Critical infrastructure management is directly dependent on risk management processes. Which infrastructural element will be considered an element of national critical infrastructure depends on decisions of the risk management team. Accordingly, discoursing of critical infrastructure models is an inseparable process from setting up risk management steps related to infrastructure.

Global standardization framework

Global standardization framework on risk management is defined in the ISO 3100 Standard[9].

Elements of risk management process are defined using family of standards relating to risk management codified by the International Organization for Standardization, ISO 31000. They are divided into several groups: Establish the context, Identify risk, Analyze risk, Evaluate the risk, Treat risk, and two groups of processes that are conducting simultaneously with the prior: Monitor & Review and Communicate & Consult. Starting from international standard ISO 31000, methodologies for risk management could be derived.

Within USA Homeland Security document which represents an annex to the National Infrastructure Protection Plan, framework for risk management in the telecom sector is developed (Schaffer, et al., 2010). Elements of this plan are extracted so they completely correspond to protection of telecommunication infrastructure problem. They are actually adjusted elements, derived from International Standard ISO 31000.

CTI related standards

As we have said previously, specific standard for CTI has not been explicitly defined, However, there are numerous security standards and specifications designed for telecom operators by international standard organizations (ISO/IEC, 3GPP, 3GPP2, ITU-T), see Table II, which could be used in defining strategies for CTI.

TABLE II

SECURITY STANDARDS FOR TELECOM OPERATORS [4]

Org.	Standard/Specifications	Description
ISO/IEC	27001:2005 27002:2005 27011:2008	Specifies requirements for an Information Security Management System, a code of practice for information security management and a standard applicable to telecommunications organizations
3GPP, 3GPP2	33-Series, S.S0086 and others	Provides specifications for security standards for GSM, W-CDMA and LTE
3GPP2	S.S0086 and others	Provides specifications for security standards for GSM (including GPRS and EDGE), W-CDMA and LTE (including advanced L TE) mobile systems
ITU- T	E.408-409 X.805, X.1051	Security requirements, threat identification frameworks and guidelines for risk mitigation, Incident organization, Security architecture for systems providing end-to-end communications

V. SITUATION IN THE REGION AND SERBIA

Many countries worldwide has identified their CTI and related bodies responsible for CTI (USA, Canada, Germany, Sweden, Norway). Several countries have started projects on CTI (Brazil). Considering the situation in our region, we can say that CTI issues are not very often discussed [10].

Recessionary conditions in the region contribute to this situation. If CTI is mentioned then it is within general regulation on CI.

In *Slovenia*, regulation of CTI is within the Directive on European critical infrastructure [11].

As far as, in *Republic of Croatia* for critical infrastructure no legal framework is in place, but ministries in charges has established the special interdepartmental working group. The basis for their work is the Council Directive 2008/114/EC. Within Hrvatska elektroprivreda (Croatian Power Utility Company) the project on CI is prepared.

In *Bosnia & Herzegovina* Computer Emergency Response/Readiness Team-CERT is established in order to prevent, support and react on computer's attacks on information and automated systems, which are critical infrastructure. In this sense critical infrastructure comprises all systems affecting functioning and quality of society such as railroad signalization systems, power distribution, government systems and telecommunications and information systems.

In *Montenegro*, also, National Computer incident response team-CIRT is established to be the focal point for coordination and data exchange, protection against cyber attacks and recovery after cyber attacks. All governmental bodies and national critical infrastructure are its users.

In *Serbia*, National Strategy for an Information Society in Serbia 2020, deals with the

protection of critical infrastructure in chapter 6.2 in relation to information security, attacks using ICT and ways of protection [12]. In this document the need for defining criteria for identification of critical infrastructure is required. National strategy for protection and rescue in emergency situations and Law on Emergency Situations [13] has not referred to CTI. Within the Project" Managing critical infrastructure for sustainable development in the postal, railway and communications sector in the Republic of Serbia" (Project No. 036 022) CI for three mentioned sectors is discussed. The main Project's objective is to identify critical infrastructure systems, whose efficiency and effectiveness is essential for the smooth growth and development of economy and society. The part of the Project is dealing with CTI and is carried out by the project team from Transport and Traffic Engineering Faculty team and Telecom Serbia. Having in mind all factors that can attack telecom infrastructure (natural disasters, targeted attacks, some unintentional disturbance) and different ownership on telecom infrastructures (public and private), the issues about CTI become regulatory issues [14]. The National backbone network is under discussion and CTI, its regulation and operator's obligations should not be neglected in those discussions.

EU Council Directive 2008/114/EC is a basis for the next steps in defining criteria for CI. In its Annex III procedure which shall be implemented by each Member State goes through the following series of consecutive steps [11]:

Step 1 - Each Member State shall apply the sectoral criteria in order to make a first selection of critical infrastructures within a sector;

Step 2 - Each Member State shall apply the definition of critical infrastructure pursuant to Article 2(a) to the potential ECI identified under step 1. For infrastructure providing an essential service, the availability of alternatives, and the duration of disruption/recovery will be taken into account;

Step 3 - Each Member State shall apply the transboundary element of the definition of ECI pursuant to Article 2(b) to the potential ECI that has passed the first two steps of this procedure. A potential ECI which does satisfy the definition will follow the next step of the procedure. For infrastructure providing an essential service, the availability of alternatives, and the duration of disruption/recovery will be taken into account; Step 4 - Each Member State shall apply the cross-cutting criteria to the remaining potential ECIs. The cross-cutting criteria shall take into account: the severity of impact; and, for infrastructure providing an essential service, the availability of alternatives; and the duration of disruption/recovery.

For detailed definition of CTI and critical resources within telecom infrastructure, and for application of fundamental network security features it is necessary to: identify the critical points of telecom infrastructure ; to propose recommendations intended to prevent security incidents and to guarantee service and business continuity if they happen; to elaborate strategies and policies to protect telecom infrastructure; and to analyze interdependence among different infrastructures; to propose recommendations intended to prevent security incidents and to guarantee service and business continuity if they happen; to elaborate strategies and policies to protect telecom infrastructure.

VI. CONCLUSION

One of the fundamental condition in regard to CTI is development of a systematic legal approach which ensure that country's CTIs is a part of international CTI. It requires harmonization with the provision of the international institutional organization's framework.

Also, awareness-raising regarding the necessity of CTI security is an important part of CTI policy. It should define the obligations of CI organizations in the country to disseminate public information in order to raise awareness of its importance. For Europe, the legal frame for critical infrastructure has been made in EU Council Directive 2008/114/EC. Regarding critical telecommunications infrastructure one initiative of this kind is undertaken by the European Union, which intends to carry out "best practice" promotional campaigns and to encourage members to exchange data with one another. This approach could be applied in the SEE region too.

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Development of Multiplatform CMS System with Zend Framework

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Abstract – This paper presents the use of the Zend framework in the realization of a CMS system that can generate multiplatform web content in a responsive web design approach.Use of a framework can help developers tocreate better web applications, which are easier to maintain, faster to build, multifunctional and multiplatform based. The Zend framework provides an implementation of the MVC pattern.

Keywords— responsive design, zend framework, mvc, multiplatform.

I. INTRODUCTION

The emergence of the Internet has led to changes in many aspects of human activity. The biggest impact the Internet has, is the development of the global business environment. The second impact is happing right now, and that is the emergence of smart phones. Today, increasing numbers of people access the Internet via their mobile device instead of a PC. The number of mobile devices in use has already surpassed the number of personal computers. It is estimated that the difference between these two numbers will only increase in the years to come [1]. When programmers are building web applications they have to think not only about user experience on desktop computers but also have to think about user experience on tablet and mobile devices. Because of the great penetration of smart handheld devices it is necessary to build multiplatform and multifunctional web applications.

II. FRAMEWORK

Using frameworks in the world of software development has long been known. However, in the world of web development it is new. A software framework is a set of libraries, and an execution environment that allows programmers to develop web applications faster and more organized. The main idea of the framework is observed after the use of frequently used functions and basic structures upon which programmers can develop their applications. Most experienced developers have their own libraries, which are used on a project basis for faster growth. However, the development of web applications based on open-source frameworks has its apparent advantages. In addition, an open-source framework is more reliable, because it is tested and used by many programmers. The biggest advantage of using frameworks is that all developers in a team working on a project should follow the same rules and conventions when developing web applications. This allows easy integration of new developers to work on the project if they are familiar with the rules and conventions of the used framework.

A. Zend Framework

Zend Framework is an open source framework for the development of web applications and it is based on the PHP programming language. It contains a group of tools for design and

implementation. Each tool contains built-in functions for input and validation of data, caching, security and so forth. Unlike other frameworks, Zend uses a so-called "Looselycoupled" architecture. This means that although the framework includes a number of components, these components are the most independent of each other and have a minimum interconnection.

Zend Framework also provides a complete implementation of the Model-View-Controller (MVC) pattern. Zend framework also supports modules which helps us increase our dynamism in developing web application. Using modules with MVC is referred as HMVC (Hierarchical Model View Controller) pattern. MVC is a widely recognized design pattern that separates our database and business logic from the presentation layer (in this case, the (X)HTML). Separation of presentation and logic aids in maintainability, by producing clean and understandable code. Furthermore, it means that the developer can update the layout and design of a site without having to worry about wading through PHP script tags. The Zend controller is an implementation of the MVC design pattern (Fig. 1). When the browser sends a request, the dispatcher searches the according controller to handle the request.

Software design patterns are a standard solution to common problems. This means that although implementations and solutions are different, the concept of problem solving is the same.
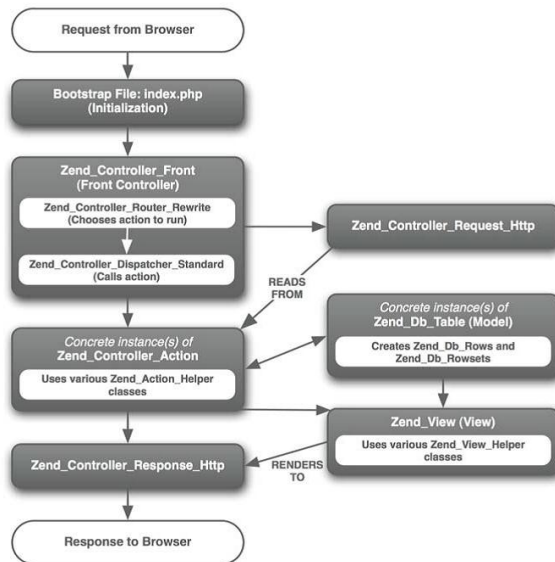

Fig. 1 Design of theMVC pattern in Zend, which shows the three main parts of a web application

B. Models

Almost every application has its own database, regardless of whether it is something as simple as a username and password or as complex as an online shop. In MVC, the data are layered and presented with one or more models. The models provide tools to download, read, delete, and in general manipulate data. This layer is completely ignorant of how data are displayed to the user. It provides an independent logical interface for the manipulation of application data.

C. View

The view is the logical display of an application. For web applications it is mainly HTML code that makes a web application, but other types of code can be included, for example XML, which is used for RSS feeds. Also, if the site allows data export to CSV format, the generation of such a file would be the job of the browser. Viewers are also known as the templates because they allow displaying the data generated in the model. It is also common that the more complex templates transfer in the so-called *ViewHelper*. They help for better exploitation of code.

D. Controller

The controller is the code that makes the rest of the application. For web applications, the controller is the one who decides what will be executed based on the user's current request. For Zend applications, the controller is based on a design pattern known as Front Controller that uses a handler called Zend_Controller_Frontas a command for action (Zend_Controller_Action) working in tandem. The front controller accepts all server requests and runs the appropriate action. This process is known as the routing and dispatching.

E. Modules

One of the greatest think about Zend framework is unlike others frameworks it supports modules. Using modules gives us great dynamism when working in a team, because we can look at modules as they are small separate applications inside our big application. In our example, we have module for blog section, module for gallery and so on. Blog section and gallery have nothing in common, this way we can have one developer concentrating on developing a blog section while other developer can concentrate on developing gallery and so on.
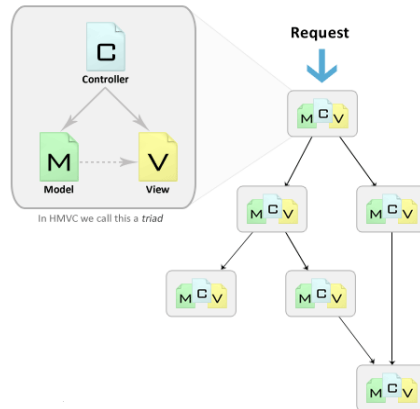

Fig. 2 Hierarchical Model View Controller Pattern

III. RESPONSIVE DESIGN

Most often we have seen that there is no optimization and adaptation of existing sites or new sites for mobile users. The web content might be too wide to fit the screen of mobile device – user equipment. Often, web pages that have been initially designed for desktop computers are too encumbered with content so they are practically unsuitable for users accessing them via mobile devices [1].

A solution for this problem is to use some kind of detection and adaptation. In the development of this CMS system a responsive design approach is used. Responsive web design is the approach that suggests that design and development should respond to the user's behavior and environment based on screen size, platform and orientation. The practice consists of a mix of flexible grids and layouts, images and an intelligent use of CSS media queries. As a user switches from his laptop to his iPad, the website should automatically switch to accommodate for resolution, image size and scripting abilities. In other words, the website should have the technology to automatically *respond* to the user's preferences [2]. This approach could be used if developers are confident that the access devices fully support the filtering of media and when a mobile website is dedicated to a specific group of users who have devices with the possibility of filtering media [1].

A. *Responsive design in action*

The idea is to first code the *Default layout* (width of 992px), and then use CSS3 media queries to code several child layouts: 768px, 480px and 320px width. The *Default layout* will be served to any browsers that do not support media queries, whereas the child layouts will be served, as appropriate, to browsers that do. They will also inherit all styles given to the *Default layout*, so coding them is very fast. To break it down, recent versions of Firefox, Chrome, Safari, Opera, Nokia Webkit, WebOS, Blackberry OS, as well as Internet Explorer 9, Android Webkit, and Mobile Safari (all iPhones, iPads, and iPod Touches) will use the layout most appropriate to them. Internet Explorer 6–8 and most old mobile devices will only use the *Default layout*.

The goal is to make building websites with multiple layouts efficient, and to make the layouts feel consistent. Since every layout is based on the same grid, elements used in one layout can often be reused in the others without changing them. For example, simply adjusting the width or font-size of an element in one layout is often enough to make it work in another. And even if more changes are re-quired, the common baseline grid and type presets will make the element fit in. Fig. 2 shows the main page of the CMS implementation, which uses this approach.
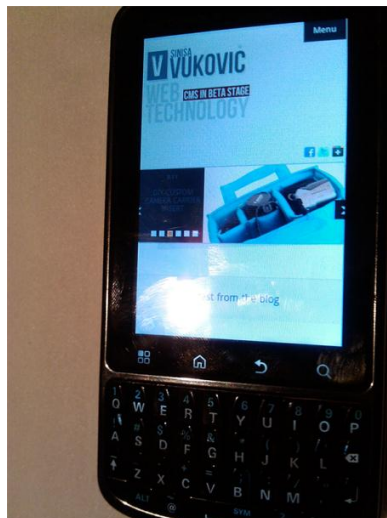

Fig. 3 Main page shown on mobile device

IV. IMPLEMENTATION OF CMS SYSTEM

The reason why PHP is growing so rapidly as a server-side scripting language is that it is easy to learn. Many functions are included without needing any sort of namespace importing, and programmers don't even have to write object oriented code if they don't want to. Variables are weakly typed and the syntax is fairly familiar. But PHP's ease of use is also its downfall. Because there are fewer restrictions on the structure of the written code, it's much easier to write bad code.

PHP frameworks like CakePHP, CodeIgniter and the Zend Framework provide a solid structure for code whilst also offering some extra functionality that would be much harder to replicate on its own. It's important to note that the frameworks mentioned follow the MVC pattern. Making multiplatform based sites in this way is easier.

In the realization of thisCMS system the following technologies are used: HTML5, CSS3, JavaScript, AJAX, jQuery, PHP and MySQL database.

This CMS system is divided into front-end development (public) and back-end development (administration). The public part is more focused on interactivity, design and optimization for mobile devices. The public part consists of a*main page*, a*blog section*, a*gallery*, and *pages*. The main page or index page is the place where we want to segregate important information or parts of our site. The blog section consists of articles, which can be filtered by categories or tags. A single selected article contains headline, date created, category that belongs to, body text, social widgets, tags, related posts and facebook comment. The gallery consists of albums. While pages are used for creating independent pages like 'about us', 'contact' etc.
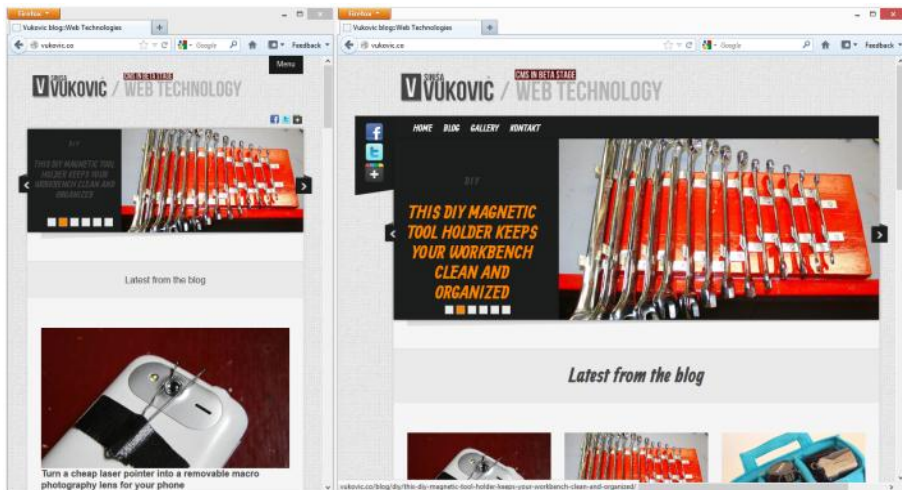

Fig. 4 Index page in public section

The administration part is protected and only two types of users can access it – administrators and writers. Depending on the role some parts of the administrative area are not accessible. This panel consists of *dashboard*, *users*, *categories*, *posts*, *pages*, *menu section*, *gallery*, and *settings panel*.

For creating a post we first have to create a category. Ordering categories is eased by *drag'n'drop* support.

Fig. 5 Drag and drop support for ordering categories

A blog post consists of a headline, a slug (friendly URL), a category list, a headline image, the body text, and tags. Pages are similar to blog post, except they don't need a headline image and tags.
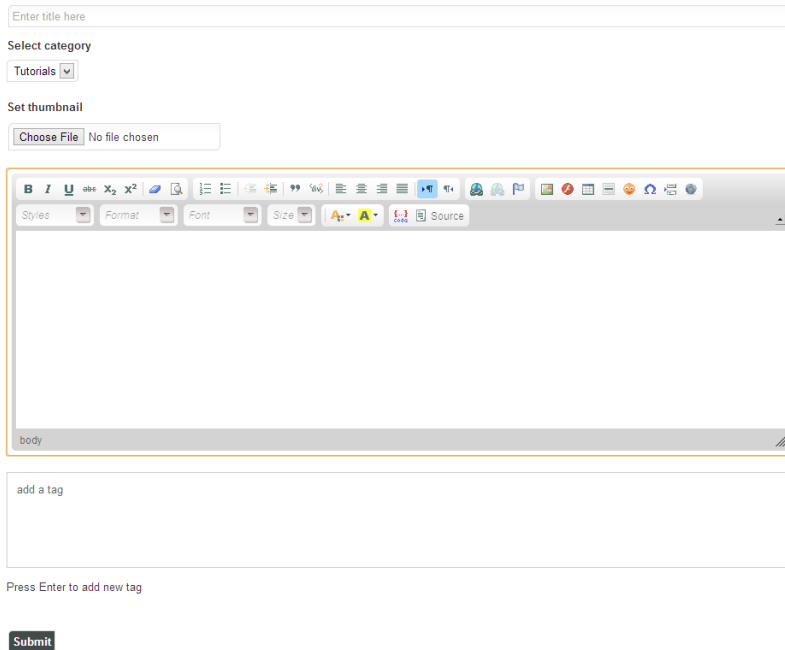

Fig. 6 Section for adding posts

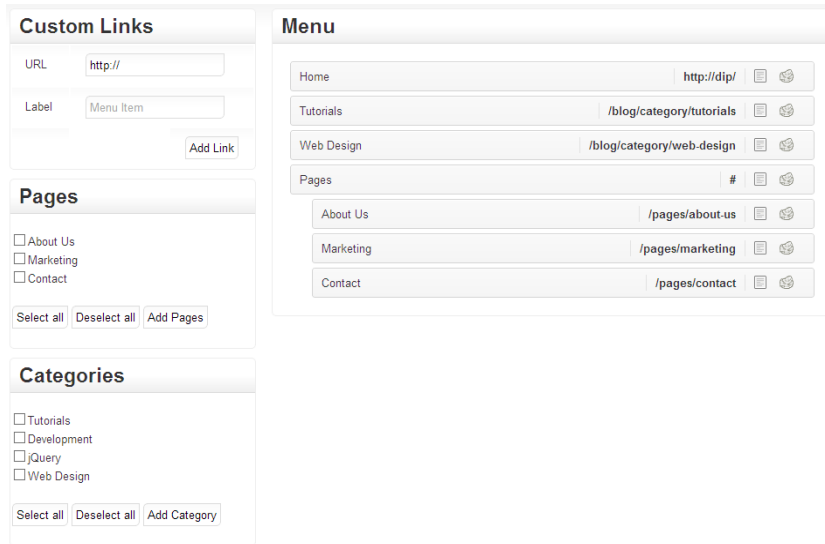Menu management gives dynamism to our system. With this, we can easily maintain our main menu.

Fig. 7 Menu management section

The gallery section consists of albums and images. Uploading multiple images is done with the *Uploadify* script, which uses a combination of flash and javascript to upload images, once an image is uploaded it is passed to PHP to do the rest.
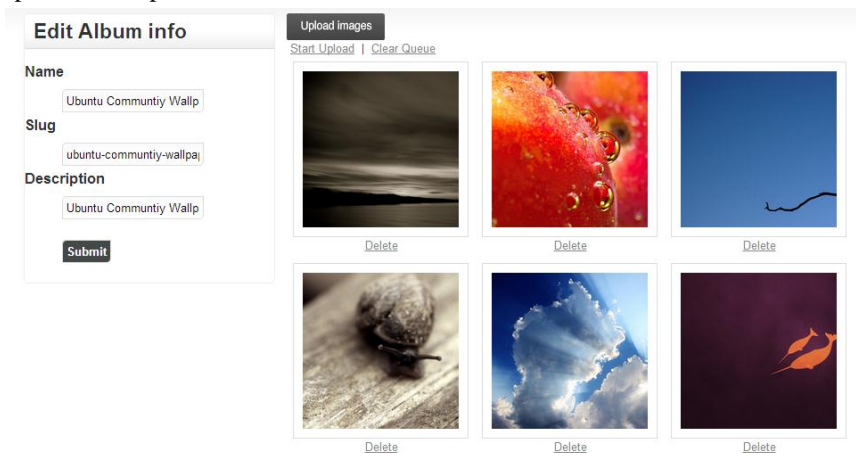

Fig. 8 Uploaded images in selected album

V. CONCLUSION

Developing web applications with frameworks reduces development time and increases maintainability. Using responsive design increases the support for multiplatform with a minimum effort and with only a single design. The main disadvantage of optimization based on CSS media queries is that only a small number of old devices support it.

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Extraction of a Thesaurus and a Project Structure from Open-source Software GIT Repository

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Abstract – The paper deals with the problem of automatic extraction of a project structure and its ontology from revision control system's commit network. The problem is solved on the base of logical analysis of project branching structure and grouping the branches according to the ontology. The aim of the research is to investigate a possibility to describe the project structure in ontology terms of the project domain.

I. INTRODUCTION

The evolution of instrumental software is aimed at shifting the programmer's creative activity to the higher level of abstraction. The programming technologies like UML, CASE, MDA (Model Driven Architecture) allow programmer to consider (to model) the software systems under development on the higher level of abstraction as compared to the source code of subsystems; all of them usually generate parts of the source code from their abstract models. Ontological models are abstract models which basically denote the terminological basis and special entity sets of project domain and the developed software. The ontological models reflect a set of terms used by programmers to describe software artifacts, various technical documentation and other texts related to the software. We consider a problem of ontology models construction and use them in development automation within the software life cycle.

The ontology model (hereafter "ontology") can be extracted from the texts as thesaurus [1] and be further developed in the life cycle of the software. From other hand side the ontology modification sometimes implies also the software modifications, thus, the ontology affects in some degree the software development process. To support the statement we try to construct a thesaurus used in various text messages related to open-source software project, accounting branching structure of the project. The branching structure is extracted from GIT commit network (repository) of the project source code. Hierarchical structure of ontology could in some extend correlate with project structure. Under *project structure* we consider tree-like representation of the project branching structure; the tree reflects hierarchical division of the project to inferior subprojects.
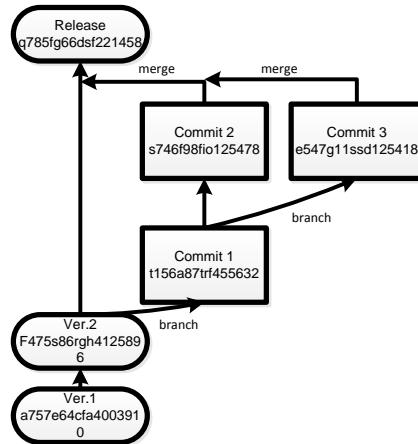
Fig. 1 An example diagram of a GIT-network

The source information for the investigation is a network graph structure representing all development, branching, and merging modes of the project sources stored in its GIT repository (see Fig. 1). The network reflects a time line of the project development process. Each new branching node can be interpreted as starting or continuation point of a subproject, but many of the branches are devoted to fixing errors. Merge points can be interpreted as finishing or committing points of a subproject. So the analysis of the commit network is, in general, a pattern recognition problem under control of heuristics. In our case the heuristics are defined as mutual relevance of branches.

II. PROCEDURE FOR PAPER SUBMISSION

In order to compare the thesaurus and the project structure, a tree of project structure should be extracted from GIT-network of open-source project source code. GIT is a distributed version control system developed by Linus Torvalds pecially to manage the development of the Linux kernel as very complex project [2]. GIT supports rapid split and merge versions of the source code, includes tools for visualization and navigation. GIT also supports each developer a local copy of the entire history of the development. The changes that made locally can be propagated from one repository to another by various ways. In addition, this system allows representing the history of the changes (the network) graphically.

Nodes of GIT network are versions of the source code and are identified by the SHA1-hashed strings and accompanied with commit messages. Every commit is a fixation of changes made in a working copy of the main repository of the project, as well as a description of the changes. In the graph representation the nodes are connected to each other, each combination of the connections form either linear intervals of the development either splitting (branching) subprojects or merging of the subprojects or their results in a superior subproject.

The branching and merging in GIT can appear as results of two different kind of programmer's activity. The first activity is cloning a repository, e.g., creating local copy of the main project repository and incorporating the changes made in the main repository. The second case, which is of our interest, is the project development itself. In this case according to developer recommendation of GIT programmer should create a lightweight branch of the repository, develop the feature or correct an error, and then merge results to a superior branch,

in particular in the main branch. The simplified graphical representation of the software development served by GIT is given in Fig. 1. In the essence the merged results cloning and modifications are the usual case of branch formation.

Besides branching and merging nodes the development timeline contains linear intervals. Linear intervals reflect most probably a logical sequence of the development events related to the same subproject. The same is true for a sequence of merging events coming from an auxiliary subproject branch. Branching most frequently denote creation of a subproject.

To recognize branches in GIT-network an analytical program is being developed in the programming environment XSB [3]. XSB is chosen due to its powerful ability to index dynamic facts on their arguments. The idea is to develop a set of Prolog rules which will recognize template subgraphs and construct markup structure denoting for each node its role and inclusion. The source data for the analysis is a set of Prolog facts about GIT-network obtained by means of translation of the network structure.

A. Recognition of basic structures

The translation subsystem is developed using the programming language Python, as well as its libraries GitPython. GitPython is a Python library used to interact with GIT repositories at various levels of abstraction. GitPython provides object model access to a GIT repository. It allows traverse the repository to find parent commits, trees, source code objects, binary blobs, etc. It provides abstractions of GIT objects for easy access of repository data.

The translation subsystem transforms the structure of the project represented in a GIT repository into a text format, which can be loaded by XSB predicates `consult/1` or `load_dyn/2`, i.e., into a collection of facts (Fig. 2). The facts in this case are the SHA1-hashed commits identifiers. The facts establish parent-child relationship between nodes. The versions in a GIT repository can be marked with tags, which are labels assigned to a specific commit of the source code. The tag label as a compound string value can express a symbolic name for a group of committed files, and a common version of each file in the group in some general versioning principle. This property of tags gives us a possibility to consider the inheritance of the individual parts of the project, and different versions of the project as well.
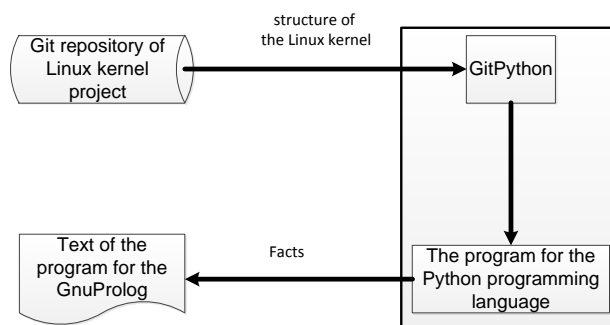

Fig. 2 Extraction node information from GIT repository

The following prolog sentences are examples of a GIT-network translation:
```
node('df145gt6984tgh1254fr').
node('4684dsf457fesae4452').
```

```
node('qw78er96ty54ui12opo').
node('as558df74g110hyu058').
parent('df145gt6984tgh1254fr',
    '4684dsf457fesae4452').
parent('df145gt6984tgh1254fr',
    'qw78er96ty54ui12opo').
parent('4684dsf457fesae4452',
    'as558df74g110hyu058').
parent('qw78er96ty54ui12opo',
    'as558df74g110hyu058').
```

These phreses are basic structure recognition rules.
```
branch(Z,X,Y):-
   parent(Z, X), parent(Z, Y), X\=Z.
merge(X,Y,Z):-
   parent(X, Z), parent(Y, Z), X\=Z.
tag('v3.3-rc2', '4564dfgert84tgdre4gs').
recent('v3.3-rc2', 'v3.3-rc1').
tagged(T,R):-tag(T,R),!.
tagged(T,R):-parent(P,R), tagged(T,P).
```

The facts of the structure `node/1` denote existence of the nodes in the GIT network. Facts `parent/2` denote inheritance relation between existing nodes. Facts `tag/2` associates a tag value with a node, and `recent/2` defines a versioning order between tags. Rules `branch/3` and `merge/3` are base rules for recognition of branching and merging; rule `tagged/2` reveals whether a node belongs to a tagged set of commits. In order to extract the project structure it is necessary to run all recognition rules and write down all combinations of variable values obtained as a result of Prolog's logical inference.

The following prolog rules recognize linear development intervals of nodes.
```
merged(X,Y):-
      merge(X,_,Y),!.
nbr(X):-
      branch(_,_,X), !, fail.
nbr(X):-
      merge(_,_,X), !, fail.
nbr(_).
strict(X,X, K, K, 1):-
      nbr(X).
strict(X,Y, K, [Z|T], N):-
      nbr(X),
      parent(Z,X),
      strict(Z,Y, K, T, M),
      N is M+1.
/*      Recognition of chains.*/
/*      -//- between branch & merge.*/
chain(X,Y, [X,Z|T], N):-
      branch(Z,_,X),
```

```
        \+ foundchain(Z, _,_, _),
        strict(Z,R,[Y],T, N),
        merge(R,_,Y),
        cache(foundchain(Z,X,Y,N)).
chain(X,Y, [X,Y], 0):-
        branch(Y,_,X),
        \+ foundchain(Y, _,_, _),
        merge(X,_,Y),
        cache(foundchain(Y,X,Y,0)).
/*        -//- between merge & branch.*/
chain(X,Y, [X,Z|T], N):-
        merge(Z,_,X),
        \+ foundchain(Z, _,_, _),
        strict(Z,R,[Y],T, N),
        branch(R,_,Y),
        cache(foundchain(Z,X,Y,N)).
chain(X,Y, [X,Y], 0):-
        merge(Y,_,X),
        \+ foundchain(Y, _,_, _),
        branch(X,_,Y),
        cache(foundchain(Y,X,Y,0)).
```

Predicate `chain/4` defines relation between a starting node, an ending node, a path and the length of the path. A path is, e.g., a linear piece of GIT network, which starts from branching, ends at merging, has no branching and merging inside. Predicate `nbr/1` denotes the argument is neither branching, nor merging node; `strict/5` recognizes linear subpath inside branch under recognition. Predicate (dynamic fact) `foundchain/4` stores the result of the recognition. Its arguments are start node, end node, path identifier, and path length. The path identifier is a node inside path, which distinct the path between various paths having common branching and merging nodes and the same length. Length is used to debug algorithms: we filter program output with command line `grep` utility and calculate statistics by number of processed branches according to their lengths. Auxiliary predicate `cache/1` stores dynamic fact `foundchain/4` in working memory and shows the progress of recognition.

III. THESAURUS EXTRACTION

After branching structure has been deduced from GIT network, the nodes of the structure should be labeled by terms. The labeling denotes names of subprojects and their purposes, as well as project-subproject relationships (fig 3.). The labeling terms are obtained from texts associated with commit messages of GIT network nodes. In this section we consider an approach, which used to construct a thesaurus and labeling from commit messages. The thesaurus extraction approach is based on technique described in [4].
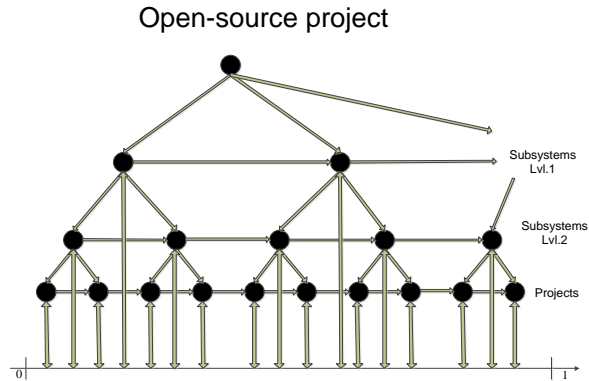
Open-source project

Fig. 3 Extraction node information from GIT repository

Thesaurus is a way of formalizing object domains of software under development, it is kind of ontology. Ontology is an object domain model consisting of a set of concepts and a set of assertions about these concepts, based on which classes, relations, functions and individuals can be described. Ontologies are intuitively used by programmers to refer objects and their relationships to be implemented. Hypothetically, using of ontologies allows automating the development some parts of information models.

A.   *A general scheme of thesaurus construction*

On the first step a set of independent texts are prepared. The texts are stored in fast access database. After that full text index of the stemmed words (hereafter terms) of the texts is produced. The index should contain forth and back references between terms and texts.

On the second step the terminological basis construction algorithm looks through the texts and tries to join adjacent terms found in texts in a compound term. The full text index frequency for the compound term is figured out. The join succeeds if the frequency of the term decreases not more than in 0.7 times (the coefficient is arbitrary and subject of experiments). If an original single term is used at lest once as first word of a compound term, then it is removed from the terminological basis.

On the next step full text index is transformed into terminological index, where the terms are mapped into their frequencies of appearances in the texts. Now the texts are represented as points in property space, where each of the property is a term of the terminological basis. If term appearances frequencies are similar for two texts then the texts are similar and located near to each other in the property space. The set of texts are processed by some hierarchical clustering algorithm, which induced the hierarchy of classes of semantically similar texts. We use agglomerative clustering methods as it has lower computation complexity with comparison to divisive methods.

On the last step in each join node of cluster the terminological index is recalculated for the texts belonging to the node. The most frequent term is selected among the terms appeared in the texts. This term denotes the semantic of the node. Also among most frequent terms a set of terms can be chosen, the set will also describe the semantic of the texts. The resulting hierarchy clustering also denotes class-subclass (term-subterm) relationship between terms as required by thesaurus.

B.   Implementation of the scheme

The set of independent texts are constructed from joined together commit messages from one recognized branch. It is supposed that all programmer's work in a branch devoted to one problem.

The joined commits stored in a MySQL MySAM table. The stemmed word index is generated by means of slightly modified Sphinx search engine (http://www.sphinxsearch.com). Sphinx is an open source full text search tool, designed from the ground up with performance, relevance (i.e., search quality), and integration simplicity in mind. It lets programmer index and search data stored in an SQL database or in other storages. Sphinx also supports database server interface and a MySQL embedded mode. Our modifications allow relating engine's CRC32-coding of the stemmed words with the original worlds; originally the engine does not store this relation. Also we made some API modifications to unload the index in a Python language dictionary-like structure.

A terminological basis is induced by a Python script according to the above described scheme using a library `hcluster` for the hierarchical cluster construction. The main role of the Python program is to calculate indexes for the subsets and convert data structures before and after processing with the external library modules.

IV. CONCLUSION

In this paper we considered software for a project structure analysis of a software project revision control system commit network. An open-source project and its GIT-network are used as testing ground. The GIT-network is essentially represented as 2-D structure, where the first dimension is a structural location of a subproject, the second dimension is a time moments of the commits of each of subproject. Logic recognition procedures have been developed and implemented as Prolog program to recognize the space coordinate of each commit. Procedures for ontology extraction and labeling the project tree from the commit messages have been implemented.

In the essence we are interested in investigation of the possibility to describe the software development process in terms of ontological model and source code representation, i.e., some kind of functional relations between structures. From other hand side the source code change commit messages describe the ontology change (Fig. 4): some messages can be interpreted in constructive fashion by means of description of the source code changes.
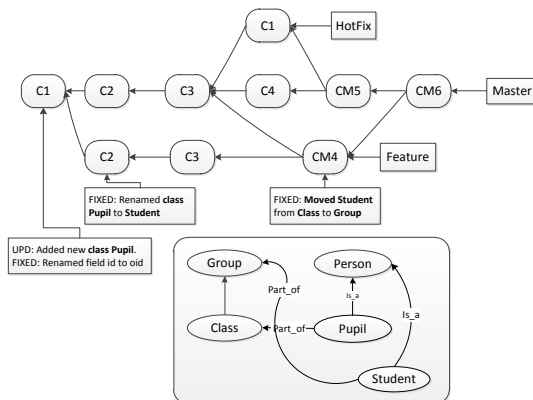

Fig. 4 Ontology terms are the semantic basis of commit messages

Test investigations of the developed software were conducted on three independent open-source projects taken from github.com. The structures of these projects have been converted to the lists of facts in Prolog, and, using the recognition rules, we separated the linear section of the development process of each project. Unfortunately, we were unable to label branches with terms extracted from developers' commit messages. The obtained terms were irrelevant to programming terms at all. Experiments with filtering terms by frequencies have also failed. At first glance it seems that the problem occurs because the messages contain mostly references (links) to external messages on development boards (forums, bug lists, tickets, etc.), and the rest of texts was only action made by programmers (e.g. "Fixed bug #2343"). To solve this problem we need to analyze messages that are referenced by the commits. In addition, it would be of purpose to extract programmers' slang vocabulary firstly from the terminological basis.

In the same time by means of the hierarchy clustering we managed to recognize adjacent branches dealing with a common problem, most of them are located near by the time line. This inspires us to proceed with the experiments further. The structure recognition and thesaurus construction can be improved if some tagging information of the messages, such as fields 'FIX:', 'TODO:' is used and analyzed.

The results of the investigations supposed to be used as an advisory or a project planning subsystem in a new generation of designers' instrumental software. For example, having modified a formalized ontology, the instrumental software could suggest a modification of an UML Class Diagram or advice designers to implement new software function on the base of the new feature textual description analysis [5].

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A Case Study from Iskratel: Improving the User Experience in a Telecommunications Company

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Abstract—This paper presents a case study from the international telecommunications company Iskratel. As a result of increased competition on world markets the company started to look for ways to be more successful than its competitors. Since it was impossible to lower prices, the company decided to improve the user experience of its products, which could be the factor that gives a competitive advantage over the other products on the market. The activities at Iskratel over the past three years introduced to improve the overall user experience of company's products and services are presented.

Keywords—User experience, User-centered design, Iskratel, User Evaluation.

I. INTRODUCTION

The business success of a company is, apart from the complexity of its technology, also measured by how well the products and services of the company serve their customers. The world is highly competitive, with a wide choice of technically reliable products, services and solutions with numerous functionalities. In such a world, products and services with a better user experience have a competitive advantage over the other products on the market.

In this paper we present a case study from the international telecommunications company Iskratel, a Slovenian company with more than 50 years of experience in the world of telecommunications. The company develops telecommunications solutions for rural and suburban areas and designs comprehensive solutions for the communication needs of the information society [1]. In the past, when competition was not a problem, the company was mainly concerned with improving its technology. However, as competition on the market increased, the company started to look for ways to be more successful than its competitors. It was soon realized that price was not the only factor that gives a company a competitive advantage. For this reason Iskratel decided to make user experience a factor that makes its products more attractive to its customers than competing products on the market.

Until fairly recently, the user experience of products and services in the company was only evaluated in the development phases, i.e., in the phases of designing and implementing the products. The users were not involved in any assessment of product quality from the standpoint of usability and user experience and in building these findings into the requirements for new versions of an existing or new product [2]. That is why the users' opinions, needs, wants, expectations and practices were not satisfactorily integrated into the product requirements.

At Iskratel the improvement of processes is a continuous task. Based on analyses of the product's weaknesses, improvements were needed to increase the users' satisfaction. The company recognized that close cooperation with users may contribute to a better user satisfaction and user experience. That is why Iskratel began a close cooperation with its users

from the specification of the product requirements to the testing of the new technology at the users' premises and the assurance of high-quality support [3]. The activities at Iskratel over the past three years designed to improve the overall user experience of the company's products and services are presented in this paper.

II. USER EXPERIENCE

A. Definition

Before we continue with the presentation of the activities, we would like to clarify what the term user experience means. According to ISO 9241-210 user experience is defined as "a person's perceptions and responses that result from the use or anticipated use of a product, system or service" [4]. User experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after use.

A product with optimal user experience is primarily usable; however, it provides much more than pure usability. If usability is understood as a form of rationality (e.g., effective in achieving a particular goal), the user experience is happening at the level of emotions. Parts of the user experience are, for example, professional design, which is confidence-inspiring, and a clear and concise text that provokes an irrepressible desire to use. A product with optimal user experience invites and engages the user, leaving a positive memory. As a result, the user returns to the product and is happy to use the product again and again.

B. User-Experience Guidelines

Preparing user-experience guidelines is usually the first (unfortunately, in many cases also the only) step towards the process of improving the overall user experience in a company. So, when Iskratel decided to improve the user experience of its products, the first task assigned to the user-experience team was to prepare a user-experience guidelines document. A set of best-case experiences, user-experience guidelines and information were collected in a document, which is constantly being updated. An example of a best-case and worst-case scenario from the document is shown in Fig. 1. The aim of the document is to ensure that user-experience design is even more closely integrated into the development process for future products [5].

Figure 5: Bad practice example - Due to poor user interface design, most users did not know how to use styles in Word
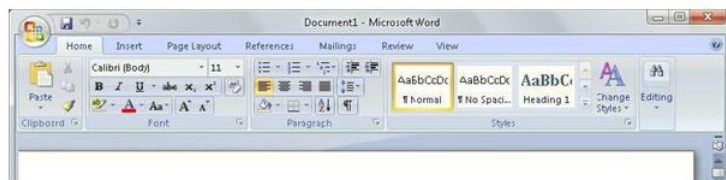
Figure 6: Good practice example – Due to the good user interface design, users intuitively know how to use styles in the new MS Word

Fig. 1 Examples of a best-case and worst-case scenario in the user-experience guidelines document

However, a user-guidelines document is not enough to achieve a great user experience. Users have to be involved continuously throughout the development process – from the product conceptualization phases till the very end, i.e., testing the new products and technology with the users. The approach where extensive attention is given to the users is known as user-centered design (UCD) [6].

III. USER-CENTERED DESIGN

A. Definitions

The term user-centered design/development (UCD) has its origins in the mid-1980s [6]. UCD represents a design philosophy and a process in which the needs, wants, and limitations of the end-user of a product or application are given extensive attention at each stage of the design and development process. UCD is the key to designing for good user experiences. Users' needs and values must be understood first, before designing and evaluating the products and solutions [7]. Understanding who the users are and what they need is the single most critical activity to developing a quality product and/or solution. Understanding the users usually begins by developing a user profile [8].

B. User Profiles

User profiles are detailed descriptions of the users' attributes, such as age, gender, level of education, occupation, experience, key tasks, etc. These characteristics usually reflect a range that the target users fall within, for example, ages 25-50. User profiles help the project team understand who they are developing the product for, and help the user researchers when recruiting users for further study activities.

There are several user characteristics that should be considered when developing a thorough user profile. In their book, Courage and Baxter provided an ideal list of user characteristics that should be taken into account when creating a user profile [8]. However, researchers usually do not have access to all of the information necessary to create an ideal list of user characteristics. Additionally, some of the user characteristics are more important than others, depending on the product, the context of use and the situation. That is why the user characteristics should be prioritized and only key characteristics should be considered. For example, for Iskratel users, the key user characteristics considered are:

- Demographic characteristics – age and gender.
- Education - degree, courses taken.
- Occupation experience – current job position, and responsibilities, previous jobs and responsibilities, years of experience.
- Computer experience - computer skills, years of experience.
- Specific product experience – experience with competitors' products or other domain-specific products, usage trends.
- Domain knowledge - the users' understanding of the product area.
- Task – primary, secondary tasks.
- Technology available - computer hardware, software, other tools that are often used.
- Attitudes and values – product preferences, fear of technology.
- Criticality of errors - in general, the possible consequences of a user's error.

The key user characteristics were used for creating a user profile for the typical Iskratel user, as shown in **TABLE I**.

TABLE I

USER CHARACTERISTICS FOR TYPICAL ISKRATEL USERS

KEY USER CHARACTERISTICS		
Demographic characteristics	Age	25-55
	Gender	80% male 20% female
Education	Degree	High school to bachelor's degree (usually college)
	Courses taken	Computer science, telecommunications, electronics, electrical engineering
Occupation	Job position	Telecom operators
	Responsibilities	Monitor and/or operate equipment related to telecommunications sector
Computer experience	Skills	Basic computer skills
	Experience	Expert users
Tasks	Primary tasks	Responding or transferring calls as per the requirement. Answering service–related questions of common types. Sending messages to people or notification lists regarding extraordinary events and alarms. If any complaint is received regarding the functioning of the systems, maintenance technicians are informed by the telecommunications operator. Taking note of the identification numbers of callers for future reference.
	Secondary tasks	Setting up conference calls along with monitoring where the information system is located. Managing all the related documents in such a way that accurate records and data are always available as per the requirement. Managing all the related documents in such a way that accurate records and data are always available as per the requirement.
Technology	Hardware	Desktop computer, operator terminal, stationary or mobile phone.
	Software	Applications specifically developed for telecom systems.
Attitudes and values	Product preferences	Easy to handle and operate.
Criticality of errors	Consequences	From mild to severe consequences.

C. Personas

User profiles provide data for developing *personas*. A persona is a fictional individual created to describe a real end-user. Personas are designed to give real users life and help team members feel connected to them. One of the most important advantages of personas is that they help all team members to think about the same persona, instead of each team member working towards his or her own vision of who the end-user is.

At Iskratel, three personas were developed for each user profile. Altogether, there were eighteen personas developed for the company's target users. Developing multiple personas for a single user profile helps to cover the range of characteristics for the selected user profile. One of the personas we developed for the user profile presented above is shown in Fig. 2.

Fig. 2 Persona for a typical Iskratel user.

D. Use-Case Scenarios

Use-case scenarios provide examples of usage and specify how users carry out their tasks in a specified context. Such scenarios can be used as an input to design and provide a basis for subsequent usability testing.

Use-case scenarios are most useful when they are created early in the product-development cycle as specific, realistic and detailed examples of what a target user would do, but without making any reference what user-interface features would be used.

An example for a use-case scenario is shown in Fig. 3.

Fig. 3 Use-case scenario for Iskratel

IV. USER EVALUATIONS

User evaluations are really important for improving the overall user experience in a company. User evaluations are used to assess five product aspects: efficiency, affection, helpfulness, control and learnability. User evaluations take place in different phases of the product development. For example, in the early stages of the product development user evaluations are applied to predict the usability and usefulness of future products, to verify whether the developers understand the user requirements and for a quick and informal testing of ideas. User evaluations at a later stage of the product development focus on the identification of difficulties users have when using the product and on product improvements. Even though user evaluations take place throughout the product-development life cycle, it is important to have as much of them in the early stages, because correcting errors in the early stages costs less than correcting errors in the later stages.

When conducting a user evaluation it is necessary to select the proper user-evaluation methods for evaluating the product in a given environment, to determine the appropriate number of expert evaluators and end-user participants, and to determine the types of activities that users will accomplish using the product.

There are many different methods for testing the usability and the user experience of a product. Which method should be used depends on several criteria, such as [9]:

- The aim and objectives of the evaluation

- The availability of human resources (expert evaluators, end-users, developers)

- The profile of the evaluation participants (end-users and/or expert evaluators)

- The number of participants in the evaluation

- The location where the evaluation takes place (user's environment or a laboratory)

- The technical equipment required

- The level of development of the evaluated product

- The expected level of product reliability

- The expected level of detail of the evaluation results.

For a successful user evaluation of a product, it is not necessary to use only one method. Different methods perform differently in different situations in assessing and finding different difficulties. Therefore, it is reasonable to use multiple methods to improve the overall usability and user experience of a certain product.

To evaluate the overall usability and user experience of the company's products, services and solutions, Iskratel normally uses the following methods:

- Heuristic evaluation, which is an informal and relatively inexpensive evaluation method. In this method, expert evaluators decide whether the elements of the user interface are in accordance with certain principles of user-interface design [10].

- System Usability Scale (SUS), which is a simple, flexible, and affordable questionnaire. SUS can be used to assess a wide range of products and services. SUS is a simple, ten-item attitude Likert scale giving a global view of subjective assessments of usability [11].

- Task analysis, which analyses what a user is required to do in terms of actions and/or cognitive processes to achieve a task. A detailed task analysis is conducted to

understand the current system and the information flows within it [12].

- AttrakDiff, which evaluates and compares the hedonic and pragmatic quality of interactive products. The evaluation data enables us to gauge how the attractiveness of the product is experienced, in terms of usability and appearance and whether optimization is necessary [13].

V. CONCLUSION

This paper presents several activities at Iskratel from the past three years carried out in order to improve the overall user experience of the company's products and services. Iskratel is an international telecommunications company which decided that user experience could be the factor that gives Iskratel's products a competitive advantage over other products on the market.

Preparing a user-experience guidelines document was the first step towards the process of improving the overall user experience in Iskratel. However, since using only a user-guidelines document was not enough for achieving a great user experience, Iskratel introduced the UCD approach in its product-development processes. In order to understand its users, the company developed user profiles for its typical users. User profiles provided data for developing *personas*, which are fictional individuals created to describe real end-users. To understand the context of use of its products and services, Iskratel created several use-case scenarios, which provide examples of usage and specify how users carry out their tasks in a specified context. Finally, the company suggested several user-evaluation methods to assess and improve the usability and user experience of its products and services.

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Simulating e-Commerce Client-Server Interaction for Capacity Planning

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Abstract—Contemporary ways of doing business are heavily dependent on the e-Commerce/ e-Business paradigm. The highest priority of an e-Commerce Web site's management is to assure pertinent Quality-of-Service (QoS) levels of their Web services continually, in order to keep the potential e-Customers satisfied. Otherwise, it faces an immense possibility of losing both e-Customers and revenues, along with a big possibility of gaining bad reputation due to either poor performance or unavailability of the e-Commerce Web site. In order to avoid numerous unpleasant consequences, by designing and implementing e-Commerce Web sites that will always meet e-Customer's high expectations, a relevant performance models have to be utilized to obtain appropriate performance metrics. A continuous assessment of current performances and especially predicting future needs are the subjects of capacity planning methodologies. Within this paper, such a predictive model has been described and evaluated by using discrete-event simulation of both the client-side and server-side processes involved. In addition, the paper discusses the performance metrics obtained as a function of the intensity and quality of the workload parameters.

Keywords—capacity planning, client-server interaction, discrete-event simulation, e-Commerce.

I. INTRODUCTION

Keeping e-Customers of a particular e-Commerce Web site satisfied has always been a task of a highest priority for its management. E-Customers' dissatisfaction can lead to company's bad reputation, loses of both current and potential e-Customers, and substantial financial loses. Besides other leading factors for e-Customers' dissatisfaction, poor Web site performance is ranked second, just behind high product prices and shipping costs [1]. Since most Internet users have broadband connections today, poor Web site performance, including even Web site crashes, have been considered the main generators of e-Customers' dissatisfaction. According to Hoxmeier & DiCesare, user satisfaction is inversely related to response time, which 'could be the single most important variable when it comes to user satisfaction' [2]. In the virtual world of Internet, where time is money, speed is the only one-dimensional criterion that matters, whilst the expression 'faster is better' is the simplest equation in the entire field of Internet strategy [3]. Regarding the response time, the famous '8-seconds rule' has already changed. Four seconds is now considered the maximum length of time the average online shopper will wait for a Web page to load in a browser, before potentially abandoning the retail site, with a tendency to be halved again in the forthcoming years [1]. In order to assure pertinent QoS levels of the vital performance metrics, including the response time, a capacity planning methodology, based on the usage of relevant predictive models, has to be applied continually, as a crucial part of the e-Commerce Web site deployment. The solely aim of the process of capacity planning is to provide an unambiguous answer to the following question: 'Is the existing hardware infrastructure of a particular e-Commerce Web site capable to assure and maintain relevant Quality of Service (QoS) levels continually, having on mind the

unpredictable and stochastic nature of e-Customer's online behavior?' In that context, Menascé & Almeida [4] define capacity planning as being '… the process of predicting when the future load levels will saturate the system and determining the most cost-effective way of delaying system saturation as much as possible', taking into account the natural evolution of the existing workload, the deployment of new applications and services, as well as the unpredictable and stochastic changes in e-Customer's behavior. Capacity planning requires appliance of predictive models, in order to make a prediction of the system's performance parameters, including: response times, throughput, network utilization, or resource queue lengths. All of these measures have to be estimated for a given set of known input parameters, including system parameters, resource parameters, and workload parameters. Contrary to trivial approach of applying non-regular, intuitive, *ad hoc* procedures that rely on arbitrary rules of thumb and personal experience, which usually lack proactive and continuous, scientifically based capacity planning methodology, a very systematic and thorough approach to addressing capacity planning issues, both on a system and component level, was developed by Menascé & Almeida [4] [5]. Their approach relies on utilization of the probability theory, the construction of a state transition graph, known as Customer Behavior Model Graph (CBMG) for a particular e-Commerce Web site, and the appliance of the theory of queues and queuing networks. The resulting predictive performance models, which consist of closed-form expressions for evaluating various performance metrics, offer analytical/numerical solution, and have been developed both on a system and component level. Yet another novel approach to capacity planning, based on modeling e-Customer's online behavior during e-Commerce shopping session, using the class of Deterministic and Stochastic Petri Nets (DSPNs), has been proposed by Mitrevski *et al.* [6]. It is suitable for obtaining various client-side related performance metrics, since it is also based on a CBMG of a particular e-Commerce Web site, and includes a stochastic temporal specification of the thinking times during e-Customer's stay in three main states: 'Browse', 'Search', and 'Checkout' (Fig. 1).
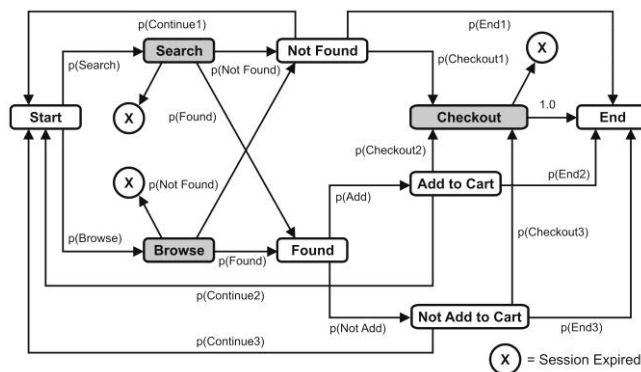

Fig. 1 CBMG corresponding to the DSPN model of e-Customer's online shopping behavior
(based on Mitrevski et al. [6])

The idea for utilizing the class of DSPN for modeling purposes is based on the fact that the underlying stochastic processes of both the e-Customer's online session and that one of the DSPN are, in fact, of the same type, i.e. Markov regenerative processes. This approach offers a possibility for obtaining both analytical and numerical solution, and the model can be also

efficiently solved by specialized software. For the purposes of this paper, the DSPN model proposed by Mitrevski *et al.* [6], and represented via its CBMG (Fig. 1) will be utilized only as a template for implementing the logic of an e-Customer's online behavior within the discrete-event simulation model.

II. DISCRETE-EVENT SIMULATION APPROACH TO CAPACITY PLANNING

Discrete-event simulation (DES) is one of the most widely used techniques for evaluating stochastic models. DES utilizes a mathematical/logical model of a physical system that portrays state changes at precise points in simulation time. Both the nature of the state changes and the time at which the changes occur, require precise description. Within DES, time advances not at equal size time steps, but rather until the next event can occur, so that the duration of activities determines how much the clock advances. Rather than employing any DES software simulator, we have used the open-source SimPy/Python programming environment for capacity planning purposes. SimPy (an acronym from 'Simulation in Python') is an extensible, object-oriented, process-based, general-purpose discrete-event simulation programming language, based on standard Python [7] [8] [9]. Compared to software simulators, and especially to all types of analytical/numerical solution methods, the usage of simulation programming language offers the greatest flexibility in terms of modeling power, and the maximum ability to depict an arbitrary level of details. For instance, all of the following aspects of the e-Commerce paradigm have been successfully modeled in SimPy: the client-side (the e-Customer's online behavior); the server-side (the hardware configuration of a typical e-Commerce Web site, on a system level); various classes of e-Customers (the qualitative component of the workload specification); the workload intensity (the quantitative component of the workload specification); the HTTP requests generation, for the three main functions invoked by the e-Customer: 'Browse', 'Search', and 'Checkout';   the propagation delays of the HTTP requests being forwarded from clients' browser towards e-Commerce servers and the delays of the corresponding responses, via Internet; and evaluation of plethora of performance metrics for both client- and server-side. Our SimPy implementation internally consists of three processes (named *Source*, *Customer*, and *Request*), along with their corresponding Process Execution Methods (PEMs) (Fig. 2).
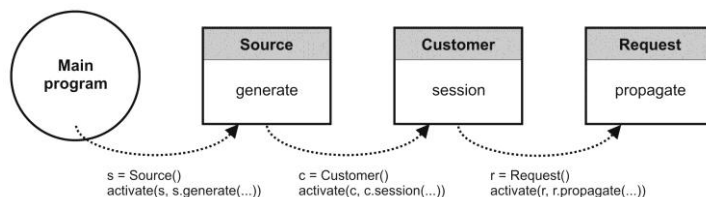

Fig. 2 A schematic representation of the internal structure of the SimPy simulation model

The *Source* process implements the generation of e-Customers according to the given arrival rate, and according to the probability distribution of their type. It also defines the parameters of the simulation runs. The *Customer* process implements the client-side, i.e. the e-Customer's online behavior during the online session, in accordance with the CBMG, depicted on Fig. 1. As stated previously, an e-Customer spends an arbitrary time, exponentially distributed, while being in three particular states, including 'Browse', 'Search', and 'Checkout'. The actual thinking times for those operations are being drawn from the same

exponential distributions based on the average thinking times, i.e. 1.0, 1.0, and 3.0 minutes, respectively, for all classes of e-Customers, since we assume that e-Customers are all moderately experienced and need approximately the same amount of time whenever they perform those operations. If the e-Customers' segmentation into classes was based, for instance, on their experience (e.g. non-experienced, moderately experienced, and highly experienced), instead on their shopping behavior, the average thinking times for the 'Browse', 'Search' and 'Checkout' operations would be class-dependent, i.e. the non-experienced e-Customers would be assigned considerably bigger thinking times than the highly experienced ones. Whenever an e-Customer visits those states, a corresponding HTTP request has been generated and directed towards the e-Commerce Web site. Finally, the *Request* process implements the server-side, i.e. the propagation of each particular HTTP request through the e-Commerce Web site's hardware infrastructure, being already specified. Each Web site's server has been modeled on a system level, rather than on a component level. Since HTTP requests are processed by a particular server in a FIFO (FCFS) manner, each of them has been modeled as a resource with an infinite queue length, for simplicity reasons.

III. WORKLOAD CHARACTERIZATION

The performance of any distributed system, like an e-Commerce Web site, which incorporates many clients, servers, and networks, depends heavily on the characteristics of its workload. According to Menascé & Almeida, the workload of a system can be defined as a set of all inputs that the system receives from its environment during any given period of time [4]. We focus on the workload characterization of the client-side. One has to be aware of two fundamental facts: first, e-Customers are not mutually equal, having on mind their online behavior; second, e-Customers access the Web site and invoke specific e-Commerce functions in an unpredictable and stochastic manner. The first fact is related to the qualitative aspects of the workload characterization. Many studies, including [10], have shown that it is possible to distinguish among various classes of e-Customers, having minded their online behavior during shopping sessions. Due to simplicity reasons, we model three basic classes of e-Customers regarding the intensity of buying online, i.e. *Rare Shoppers*, *Ordinary Shoppers*, and *Frequent Shoppers*. The specifics of their online shopping behavior can be defined through specification of the probabilities within the CBMG (Fig. 1), as shown in Table I. A mixture of various classes of e-Customers can be specified by defining a discrete random variable along with its probability mass function (pmf). If there are k disjoint classes of e-Customers identified, e.g. $(t_1, t_2, …, t_k)$, then each of them can be assigned a corresponding probability from the pmf vector $(p_1, p_2, …, p_k)$, such that $\sum_{i=1}^{k} p_i = 1$, as a measure of its particular participation within the workload mixture. For our proposed classification: ($t_1 = $ *Rare Shopper*, $t_2 = $ *Ordinary Shopper*, $t_3 = $ *Frequent Shopper*), we are going to investigate the performance as a result of the service demand caused by three possible operating scenarios: $S_1(p_1 = 10\%; p_2 = 30\%; p_3 = 60\%)$, $S_2(p_1 = 33\%; p_2 = 34\%, p_3 = 33\%)$, and $S_3(p_1 = 50\%; p_2 = 30\%; p_3 = 20\%)$. It is also worthy to point out the flexibility of the model, i.e. the fact that by varying the values of the probabilities within the Table I, it is possible to model a wide range of different classes of e-Customers. For instance, for younger or novel e-Customers, the probability p(Browse) would be higher than the probability p(Search), due to their lack of experience. Similarly, the probability p(End2) of ending the online session without paying, after putting an item in the shopping basket, will be considerably higher with reluctant e-Customers.

TABLE I

DEFINING VARIOUS CLASSES OF E-CUSTOMERS USING DSPN MODEL (CBMG) PROBABILITIES

CBMG (DSPN model) probabilities	Rare Shoppers	Ordinary Shoppers	Frequent Shoppers
p(Browse)	0.50	0.50	0.50
p(Search)	$1 - p$(Browse)	$1 - p$(Browse)	$1 - p$(Browse)
p(Found)	0.10	0.50	0.90
p(Not Found)	$1 - p$(Found)	$1 - p$(Found)	$1 - p$(Found)
p(Add)	0.10	0.50	0.90
p(Not Add)	$1 - p$(Add)	$1 - p$(Add)	$1 - p$(Add)
p(Continue1)	0.10	0.33	0.50
p(Checkout1)	0.10	0.34	0.45
p(End1)	0.80	0.33	0.05
p(Continue2)	0.10	0.33	0.50
p(Checkout2)	0.10	0.34	0.45
p(End2)	0.80	0.33	0.05
p(Continue3)	0.10	0.33	0.50
p(Checkout3)	0.10	0.34	0.45
p(End3)	0.80	0.33	0.05

The second fact is related to the quantitative aspects of the workload characterization. The arrival process of e-Customers is a Poisson process [11], since: there is a zero probability of two arrivals at exactly the same instant of time; the number of arrivals in the future is independent of what have happened in the past; the number of arrivals in the future is independent and identically distributed (i.i.d.) random variable over time, i.e. the process is stationary.

The inter-arrival times of a Poisson process comprise an i.i.d. random variable with an exponential distribution. Therefore, since the memoryless property of the exponential distribution holds at any instant of time, the expected time until the next arrival is a constant and is given by $1/\lambda$, where λ is the arrival rate [e-Customers/s] [12]. If λ is the overall arrival rate for a given operating scenario (S_1, S_2, or S_3), each of them comprising of a mixture of e-Customer's types (t_1, t_2, …, t_k), along with a corresponding probability mass function (p_1, p_2, …, p_k), then the arrival rate of each e-Customer's type is given by the product $\lambda \cdot p_i$ ($i = 1, 2, …, k$) [12].

IV. MODELING THE SERVER-SIDE

E-Commerce sites, especially those of the leading Internet retailers, have multi-tier hardware architecture, consisting of multiple servers, distributed throughout two or more LAN segments. In such a way, the site's architecture becomes more scalable, more flexible, more reliable and highly available [13]. We have modelled the e-Commerce server-side on a system level, not on a component level, as a set of resources, each having a queue with an infinite capacity. We keep in mind the simplest possible 2-tier hardware architecture of a medium-to-large scale e-Commerce system, consisting of a Front-End Server (FES), a Web Server (WS), a Database Server (DbS), an Application Server (ApS) and an Authentication Server (AuS), distributed into two high-speed LAN segments (Fig. 3). Each HTTP request may need several operations, i.e. types of processing by some of the back-end servers, before completing. Moreover, a request may have to be processed more than once in a particular back-end server. Fig. 4 depicts the typical Client-Server Interaction Diagram (CSID) for the 'Search' HTTP request [14]. Table II shows which sequence of servers is being activated for each request type [15].
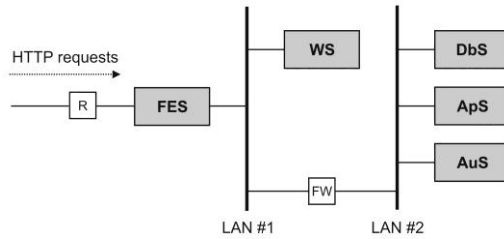
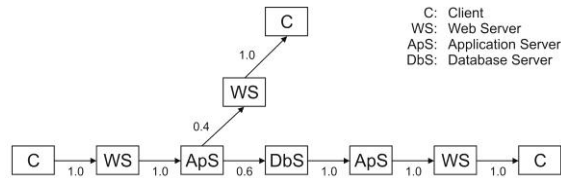Fig. 3 Schematic representation of e-Commerce server-side hardware architecture

Fig. 4 CSID for the 'Search' e-Commerce function (Source: Menascé & Almeida [14])

TABLE II

A SEQUENCE OF BACK-END SERVERS ADDRESSED, FOR EACH SPECIFIC HTTP REQUEST'S TYPE

| Type of request	Back-end servers addressed
Search	WS, ApS, DbS, ApS, WS
Browse	WS, DbS, WS
Checkout	WS, AuS, DbS, AuS, WS

Table III summarizes the different back-end servers [15], along with the mean processing time [ms] and supposed standard deviation (σ). We assume that the processing time has a Normal distribution and can vary up to $\pm 10\%$ ($\pm 3\sigma$) of its mean. In addition, the propagation time (transmission delay) via Internet WANs has been modeled as a random variable with a Normal distribution and parameters $N(\mu = 0.5$ [s]; $\sigma = 0.133333$ [s]), which yields 99.73% of the values within the interval [0.1, …, 0.9] [s]. At the server-side, the transmission delays between the servers have been neglected, due to the usage of high-speed LAN segments, as well as the propagation times in routers and firewalls.

TABLE III

SERVERS' STOCHASTIC PROCESSING TIME PARAMETERS

Server	Mean processing time [ms]	Standard deviation [ms]	Range of values [ms]
Front-End Server (FES)	1.0	3.33333E-05	[0.9, …, 1.1]
Web Server (WS)	10.0	3.33333E-04	[9.0, …, 11.0]
Database Server (DbS)	5.0	1.66666E-04	[4.5, …, 5.5]
Application Server (ApS)	10.0	3.33333E-04	[9.0, …, 11.0]
Authentication Server (AuS)	10.0	3.33333E-04	[9.0, …, 11.0]

V. SIMULATION RESULTS

For each of the specified scenarios, a series of simulation runs have been carried out in order to estimate the values of various performance metrics, as a function of the arrival rates of e-Customers, ranging within the interval [0.0, …, 30.0] $[s^{-1}]$ with a step of 0.5. Each run took into account a time window of 7200 seconds, or 2 hours of simulated time, long enough to get steady-state values of the estimated parameters. The response time is one of the most known and frequently used server-side performance metrics, which is of a vital interest to e-Customers. The average response time as a function of the e-Customer's arrival rate is given on Fig. 5a, for the three operating scenarios. As expected, Fig. 5a shows that the operating scenario S_1 generates a workload intensity that puts the biggest service demand on the Web site's infrastructure, since *Frequent Shoppers* are presented with 60%. Consequently, this means more repeated invocation of 'Add-to-Cart' and 'Checkout' functions, which pose greater number of HTTP requests to servers, especially to the Web server, queuing them to wait (Fig. 5b), thus resulting in bigger overall processing delays, decreased throughput (Fig. 5c) and decreased utilization (Fig. 5d). The estimated critical values of e-Customer's arrival rates for which the average response time reaches the 'psychological' threshold of 4.0 seconds for all three scenarios, have been obtained by using linear interpolation method, and they are, respectively, $\lambda_{S1} = 14.78$; $\lambda_{S2} = 19.81$; and $\lambda_{S3} = 24.28$. The Web site's management strive is to retain at least those values, or, in the best case, to try to push them towards bigger ones, i.e. towards the right end of the axis, although during burst periods, e.g. holiday seasons, one can expect even higher percentage of *Frequent Shoppers* and consequently, a decrease of the critical values of arrival rates. To achieve this goal, relevant horizontal/vertical/diagonal scaling techniques of e-Commerce Web hardware infrastructure have to be applied on systems' component(s) that represent a bottleneck in the whole system, especially the Web server (WS). Regarding the experienced response time (RT), e-Customers have been categorized into three disjoint groups, including those experiencing a RT less than 2.0 seconds, e-Customers experiencing a RT between 2.0 and 4.0 seconds, and e-Customers experiencing a RT more than 4.0 seconds. The percentage of 'unhappy' e-Customers, i.e. those experiencing a RT lasting for more than 4.0 seconds, is increasing with the e-Customers' arrival rate, for all three operating scenarios. For instance, for a fixed $\lambda = 20$ [e-Customers/s], the percentage of unhappy e-Customers is 98.69% (Scenario S_1), 67.66% (Scenario S_2) and 0.00% (Scenario S_3).
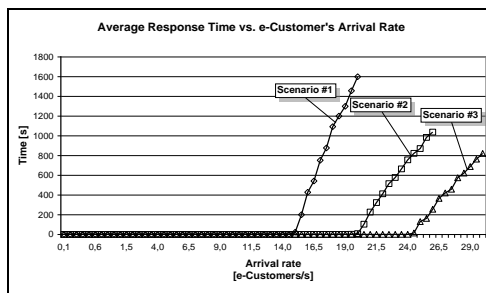
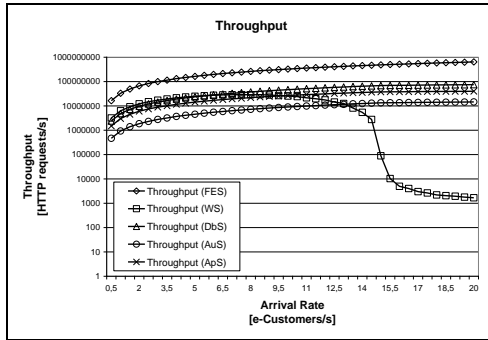

(a) Average response time vs. e-Customer's arrival rate
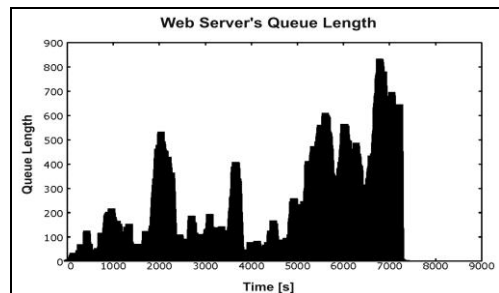
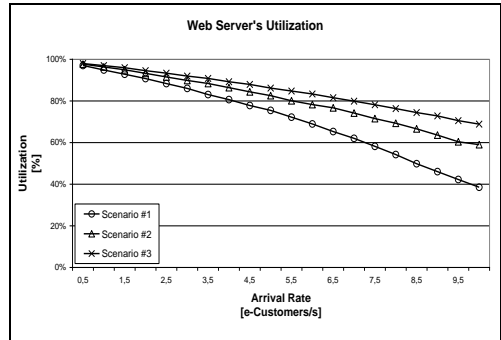
(b) The dynamics of Web server's queue length over time (Scenario S_1; $\lambda_{S1} = 14.78$)

(c) Throughput of various server-side systems vs. e-Customers' arrival rate (Scenario S_1)

(d) Utilization [%] of the Web server (WS) for the three operating scenarios

Fig. 5 Simulation results

At client-side, besides numerous performance metrics that have been obtained, we first give those that can be also computed using the corresponding CBMG [4] [5] (Table IV):

- PM1: the average number of visits to each state, per session;
- PM2: steady-state probabilities of being in each state (except the 'Add-to-Cart' state);
- PM3: the percentage of customers that have left the site after having added at least one item into their shopping cart;
- PM4: the average session length [s];
- PM5: the 'Buy-to-Visit' ratio, showing how many sessions out of the total number have terminated with buying something.

We have also obtained the performance indicators, sublimed in Table V, including:

- PM6: the average sojourn time [s] spent in each state, per session;
- PM7: the percentage of sessions that have ended with an empty shopping cart;
- PM8: the average number of HTTP requests generated, per session;
- PM9: the percentage of e-Customers' sessions completed regularly;
- PM10/PM11: the average number of items being put in the shopping cart per session, both being paid for (PM10) and not being paid for (PM11). These performance measures can be used for estimating specific, business-oriented performance metrics, like *revenue throughput* [€/s] and *potential loss throughput* [€/s] [5].

TABLE IV

CLIENT-SIDE PERFORMANCE METRICS THAT CAN BE ALSO DERIVED DIRECTLY FROM THE CBMG

	Performance metrics	Scenario #1	Scenario #2	Scenario #3
PM1	'Browse'	0,84909	0,74141	0,68267
	'Search'	0,84773	0,74106	0,68317
	'Add-to-Cart'	1,03331	0,62983	0,41752
	'Checkout'	0,50874	0,30612	0,20076
PM2	'Browse'	0.26869	0.31117	0.35036
	'Search'	0.26897	0.31242	0.35155
	'Checkout'	0.46234	0.37641	0.29809
PM3	---	≅ 10.75%	≅ 8.93%	≅ 7.27%
PM4	---	189.4 [s]	142.6 [s]	116.3 [s]
PM5	---	≅ 0.5	≅ 0.3	≅ 0.2

TABLE V

ADDITIONAL CLIENT-SIDE PERFORMANCE METRICS

Performance metrics		Scenario #1	Scenario #2	Scenario #3
PM6	'Browse'	50.94720	44.54833	40.88380
	'Search'	50.89374	44.37167	40.74863
	'Checkout'	87.58523	53.67539	34.66748
PM7	---	19.62%	40.62%	53.82%
PM8	---	3.20799	2.41300	1.976329
PM9	---	98.59%	98.85%	99.02%
PM10	---	0.863179	0.507155	0.321171
PM11	---	0.157805	0.120595	0.093406

VI. CONCLUSION

Discrete-event simulation by means of SimPy/Python code programming has proven to be an extremely powerful and flexible approach in modeling stochastic systems and/or processes like those already present with the contemporary e-Commerce paradigm. It allows one not only to assess a huge number of performance parameters that can be utilized for capacity planning, but also to experiment with various scenarios and hardware infrastructure's modalities, both on a system and component level. Still, the main obstacle with this approach is that it is both complex to implement and time-consuming. Regarding the substance in focus, the results obtained comply with those already given by Menascé & Almeida [4], whilst the DSPN model proposed by Mitrevski *et al.* [6] has proven to be a solid platform for capturing various e-Shoppers' behaviors. At server-side, future work includes performing a series of simulations in order to investigate the effects of a horizontal/vertical/diagonal scaling of the Web server, consideration of the availability and reliability (dependability) issues, and cost issues, as well. At client-side, future work includes verification of the performance metrics already obtained, both analytically/numerically, and by usage of dedicated software tools (TimeNET or DSPNExpress), and enrichment of the existing simulation model by including other general e-Commerce specific functions, in order to obtain more credible results. The simulation model can be also enhanced by introducing new classes of e-Customers, new performability metrics, as well as several other characteristic operating scenarios.

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Remote Visualization of Finite Element Calculation Results in Vascular Interventions Decision Making

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Abstract — Paper presents an overview of software platform used by cardiologist in remote visualization of finite element calculation results in order to study of blood flow in human carotid arteries. Finite element solver PAK-F is used for the calculation of viscous fluid flow. Thus, governing equations of fluid flow are presented. The geometry of carotid artery bifurcation is obtained through the reconstruction based on images from Multi Slice Computed Tomography (MSCT). Simulation of blood flow through the carotid artery bifurcation is conducted on a realistic three-dimensional patient-specific geometry. Developed software platform is tool which can give useful on site inputs to cardiologists. They determines if some cardiac intervention is required and in which moment of plaque development.

Keywords — Remote visualization, FEM, artery bifurcation, decision making.

I. INTRODUCTION

Atherosclerosis is one of the most widespread diseases that affecting blood vessels in the human body. Artery bifurcations are among the most frequent site affected by atherosclerosis, being involved in up to 20% of percutaneous interventions. Several studies on the distribution of atherosclerotic plaques in human arterial systems have shown that atherosclerosis occurs predominantly at certain location of the vascular tree where the arteries have relatively complex geometry that result in disturbed blood flow behavior. In these regions, complex hemodynamic conditions dictate the localization and progression of atheroma.

The studies [1-4] show those very responsible flow-related hemodynamic factors affecting the distribution of atherosclerosis are low or reversed wall shear stress. Computational fluid dynamics (CFD) is an area of fluid dynamics that can be applied to study the hemodynamic factors in human body.

Over the years, mathematical modeling, has established as a complementary to experimental approach in investigating clinical problems as well as predicting the biomechanical behavior. The results of the finite element models may be trusted if they take into account all impacts, including the actual geometry of the domain. In other words, anthropometric variability of size and shape should not be neglected.

II. METHODS

A. Basic equations of incompressible viscous fluid flow

Differential equations that govern the blood flow [5-7] are the Navier-Stokes equation. Essentially, Navier-Stokes equation represents the second Newton's law applied to the mass of fluid in control volume. This set of equations is expanded with continuity equation of fluid flow.

Using Galerkin method, with appropriate interpolation functions and integration by volume of finite element, a matrix form of previous equations is obtained:

$$\mathbf{M}\dot{\mathbf{V}} + \mathbf{K}_{vv}\mathbf{V} + \mathbf{K}_{vp}\mathbf{P} = \mathbf{F}_v \tag{1}$$

$$\mathbf{K}_{vp}^{T}\mathbf{V} = 0 \tag{2}$$

Components of this matrix and vectors are:

$$\bar{\mathbf{M}}_{IJ} = \rho \int_{V} h_{I} h_{J} \, dV \tag{3}$$

$$\left(\bar{\mathbf{K}}_{vv}\right)_{IJ} = \int_{V} h_{I} v_{j} h_{J,j} \, dV + \int_{V} \mu h_{I,j} h_{J,j} \, dV \tag{4}$$

$$\left(\mathbf{K}_{vpi}\right)_{IJ} = -\int_{V} h_{I,i} \hat{h}_{J} \, dV \tag{5}$$

$$\left(\mathbf{F}_{vi}\right)_{I} = \int_{V} h_{I} f_{i}^{V} \, dV + \int_{S} h_{I} \left(-p\delta_{ij} + \mu v_{i,j}\right) n_{j} \, dS \tag{6}$$

By grouping equations (1) and (2), system of differential equations is presented as:

$$\begin{bmatrix} \mathbf{M} & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \dot{\mathbf{V}} \\ \dot{\mathbf{P}} \end{bmatrix} + \begin{bmatrix} \mathbf{K}_{vv} & \mathbf{K}_{vp} \\ \mathbf{K}_{vp}^{T} & 0 \end{bmatrix} \begin{bmatrix} \mathbf{V} \\ \mathbf{P} \end{bmatrix} = \begin{bmatrix} \mathbf{F}_v \\ 0 \end{bmatrix} \tag{7}$$

The system of equations (7) is a symmetrical system of nonlinear differential equations of first order by unknown values in nodes $\mathbf{V}$ and $\mathbf{P}$. The matrix $\mathbf{K}_{vv}$ (4) is nonlinear, since it depends on velocity.

Wall shear stress is a hemodynamic factor which has great importance to study the problem of blood flow. Wall shear stress is calculated using equation:

$$\boldsymbol{\tau}_{W} = -\mu \frac{\partial \mathbf{u}_{t}}{\partial \mathbf{n}}\bigg|_{wall} \tag{8}$$

where $\boldsymbol{\tau}_{W}$ is wall shear stress, $\mathbf{u}_{t}$ is tangential velocity and $\mathbf{n}$ is the direction of a unit vector normal to the wall at the moment.

B. In-house software PAK-F

The in-house software package PAK-F [8] is developed by Laboratory for Engineering Software (University of Kragujevac, Faculty of Engineering, Kragujevac). It consists of modules for steady and transient incompressible fluid flow with heat transfer and is based on finite element method and the fundamental equations of viscous fluid flow.

The main program loops per time steps. Within this loop there is loop per iterations. Solving nonlinear equations of fluid flow (7) is performed iteratively. The size of unbalanced loads is determined in current iteration and corresponds to the increments of speed and pressure. This procedure continues until convergence criteria are not satisfied or until corresponding increments of displacements and pressures are not become enough small.

Results obtained by PAK-F are written in *. vtk file for post-process in software Paraview

[9], as described in [10].

C. Mesh generation

To apply the methodology of calculating the fluid flow hemodynamic parameters (blood) to the human's bifurcations, it is necessary to make a realistic patient-specific model. A schematic model of the carotid bifurcation is shown in Fig. 1. In order to create an analysis file for software PAK-F, it is necessary to create finite element model. Reconstruction of the geometry of blood vessels is conducted in the software Mimics, based on MSCT images of patient provided by Clinical Centre of Serbia (Belgrade). Multiblock approach is used in mesh generation [11]. Blocks are created by in-house software STL2BLOCK. Based on blocks, quadratic eight-node isoparametric elements are generated in IA-FEMesh [12] (Fig. 2).
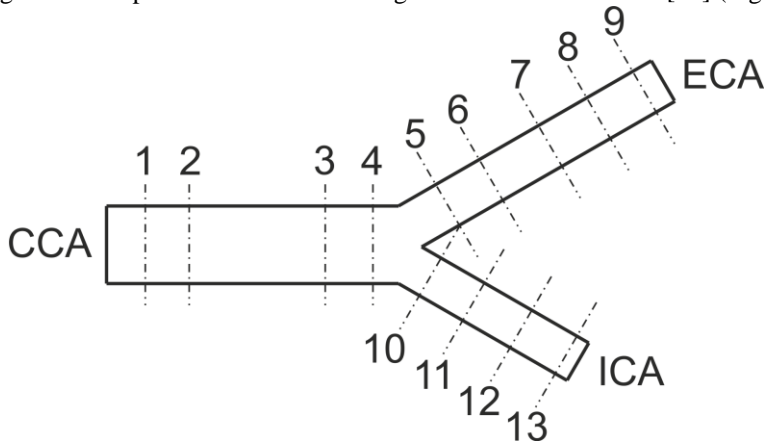

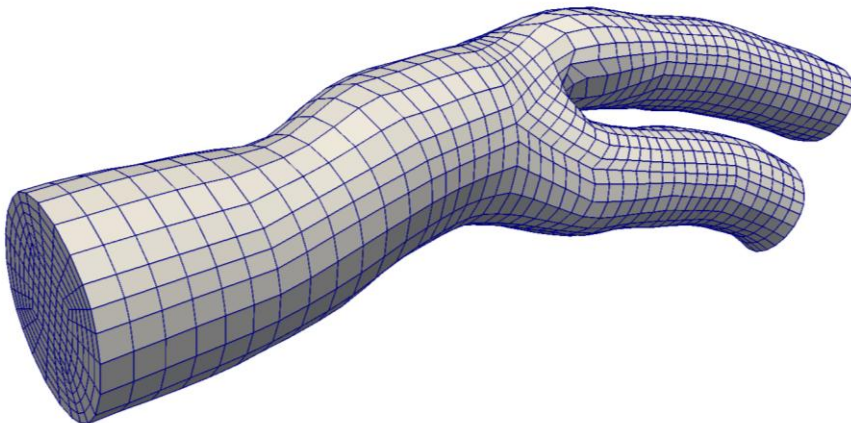Fig. 1 Schematic model of carotid artery bifurcation

Fig. 2 FEM model of carotid artery bifurcation

The calculation was performed in 30 steps (10 by 0.02s and 20 by 0.03s which gives in total 0.8s). The average flow velocity in the inlet is measured for each observed patient. Density of

blood and coefficient of dynamic viscosity are adopted according to [13-16].

D. Remote Visualization with ParaView

ParaView is an open-source, multi-platform client-server data analysis and visualization application. ParaView is developed to analyze extremely large datasets using distributed memory computing resources. The ParaView client runs on office computer (Clinical Centre of Serbia, Belgrade) while the server runs at the remote computing site (Laboratory for Engineering Software, Kragujevac), Fig. 3. Running ParaView remotely in a client-server configuration may involves establishing an ssh tunnel to the login node, launching the ParaView server, connecting the server to the client over. The following text describes the steps to install ParaView on desktop and configure it to launch remote jobs within the ParaView GUI [9].
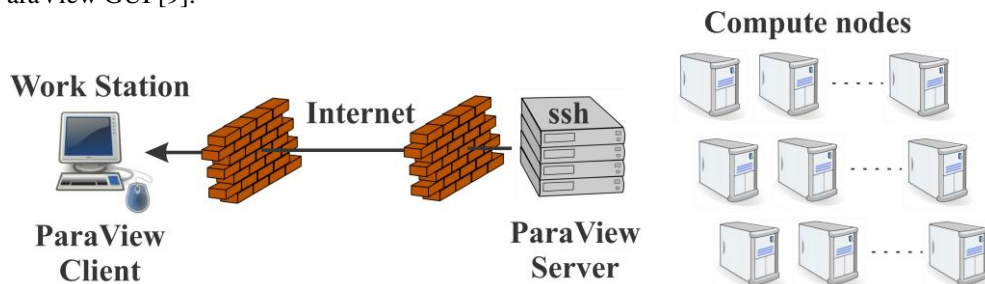

Fig. 3 Calculation data remote visualization in Paraview via Internet

The first step is to install ParaView. Version 3.14.1 is currently the recommended version [9]. The ParaView client is a serial application and is always run with the *paraview* command. The ParaView server is enabled with the *pvserver* command. For new server configuration ParaView will run an external command to start the server. The external command will be run using exec() (Posix systems) or CreateProcess() (Win32), so shell-specific functionality such as redirection or "&" cannot be used. A set of predefined and user-defined environment variables are used to communicate connection parameters.

To simplify the user experience, predefined ParaView server configurations for users from Clinical Center of Serbia is provided. This is performed with an external XML file. This page defines an XML schema for storing server configurations that is based on the existing functionality. Meaning of tags in xml file is given in the following text [9].

The <Servers> tag is the root element of the document, which contains zero-to-many <Server> tags. Each <Server> tag represents a configured server:

a) The "name" attribute uniquely identifies the server configuration, and is displayed in the user interface.

b) The "resource" attribute specifies the type of server connection, server host(s) and optional port(s) for making a connection. Value is **cs://ccs_server** for client-pvserver configurations with forward connection i.e. client connects to the server.

The <CommandStartup> tag is used to run an external command to start a server. An optional <Options> tag can be used to prompt the user for options required at startup. Each <Option> tag represents an option that the user will be prompted to modify before startup.

a) The "name" attribute defines the name of the option, which will become its variable name when used as a run-time environment variable, and for purposes of string-substitution in <Argument> tags.

a) The "label" attribute defines a human-readable label for the option, which will be used in the user interface.

b) The optional "readonly" attribute can be used to designate options which are user-visible, but cannot be modified.

c) The optional "save" attribute can be used to indicate that the value choosen by the user for this option will be saved in the registry so that it's preserved across ParaView sessions.

d) A <Range> tag designates a numeric option that is only valid over a range of values. The "type" attribute controls the type of number controlled. Valid values are "int" for integers and "double" for floating-point numbers, respectively. The "min" and "max" attributes specify the minimum and maximum allowable values for the option (inclusive). The "step" attribute specifies the preferred amount to increment / decrement values in the user interface. The "default" attribute specifies the initial value of the option. As a special-case for integer ranges, a default value of "random" will generate a random number as the default each time the user is prompted for a value.

e) A <String> tag designates an option that accepts freeform text as its value. The "default" attribute specifies the initial value of the option.

f) A <File> tag designates an option that accepts freeform text along with a file browse button to assist in choosing a filepath. The "default" attribute specifies the initial value of the option.

g) A <Boolean> tag designates an option that is either on/off or true/false. The "true" attribute specifies what the option value will be if enabled by the user. The "false" attribute specifies what the option value will be if disabled by the user. The "default" attribute specifies the initial value of the option, either "true" or "false".

h) An <Enumeration> tag designates an option that can be one of a finite set of values. The "default" attribute specifies the initial value of the option, which must be one of its enumerated values. Each <Entry> tag describes one allowed value. The "name" tag specifies the value for that choice. The "label" tag provides human-readable text that will be displayed in the user interface for that choice.

A <Command> tag is used to specify the external command and its startup arguments.

a) The "exec" attribute specifies the filename of the command to be run. The system PATH will be used to search for the command, unless an absolute path is specified. If the value for this attribute is specified as $STRING$, then it will be replaced with the value of a predefined or user-defined (through <Option/>) variable.

b) The "timeout" attribute specifies the maximum amount of time (in seconds) that the client will wait for the server to start.

c) The "delay" attribute specifies a delay (in seconds) between the time the startup command completes and the time that the client attempts a connection to the server.

d) <Argument> tags are command-line arguments that will be passed to the startup command. String substitution is performed on each argument, replacing each $STRING$ with the value of a predefined or user-defined variable. Arguments whose value is an empty string are not passed to the startup command.

The <ManualStartup> tag indicates that the user will manually start the given server prior to connecting. An optional <Options> tag can be used to prompt the user for options required at startup. PV_SERVER_PORT, PV_DATA_SERVER_PORT, PV_RENDER_SREVER_PORT, and PV_CONNECT_ID are the variables that make sense in this context.

Configuration file is saved on location depending on operating system. Configuration interface for connecting with server is shown in Fig. 4.
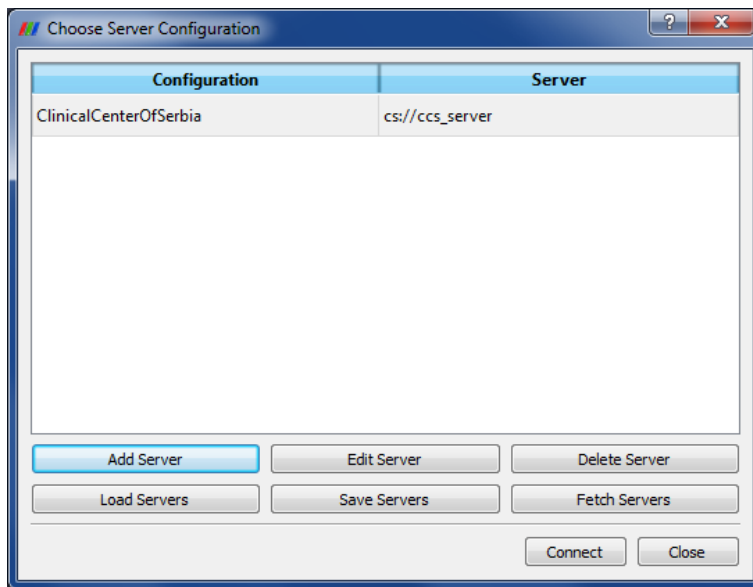

Fig. 4 Configuration interface for connecting with server

III. RESULTS

Graphical user interface of Paraview in remote visualization of calculation data example is shown in Fig. 5. With ParaView cardiologists can quickly build visualizations to analyze analyzing data using qualitative and quantitative techniques. The data exploration can be done interactively in 3D or programmatically using ParaView's batch processing capabilities. In this way, doctors can have the full advantage of using a shared remote high-performance rendering without leaving their offices.

Velocity field along a streamlines in steps 1, 3 and 5 are shown in Figures 6, 7 and 8, respectively [17-18]. Fluid velocity is changed depending on the region that is being observed on carotid artery bifurcation. On the internal carotid artery (ICA) there is a narrowing of blood vessels which leads to increased blood flow velocity.

Wall shear stress in the 5th step of cardiac cycle is shown in Fig. 9. There is maximum value

of wall shear stress at peak systolic flow. On the external carotid artery (ECA), where cross section is bigger and flow velocity is smaller, there are low values of wall shear stress. In areas where wall shear stress has small values, there is possibility for the occurrence of atherosclerosis.
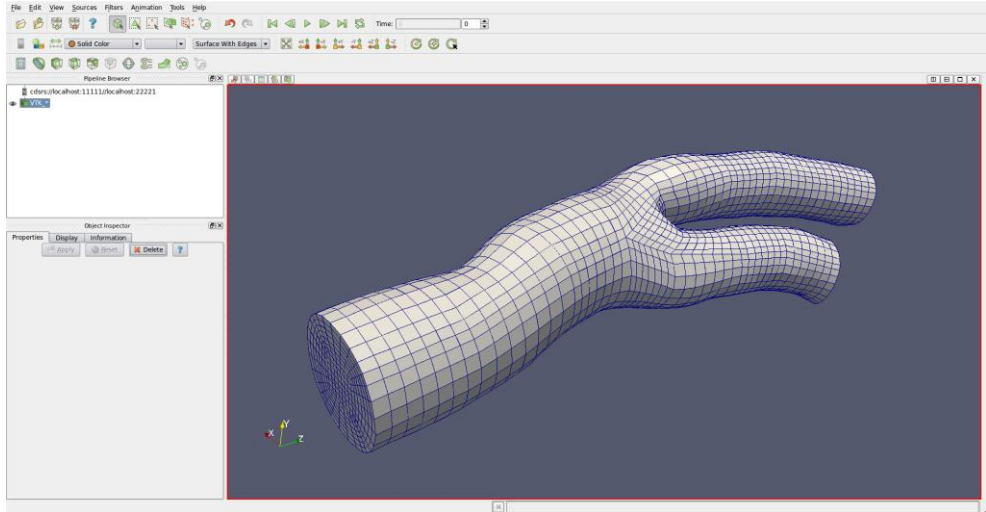

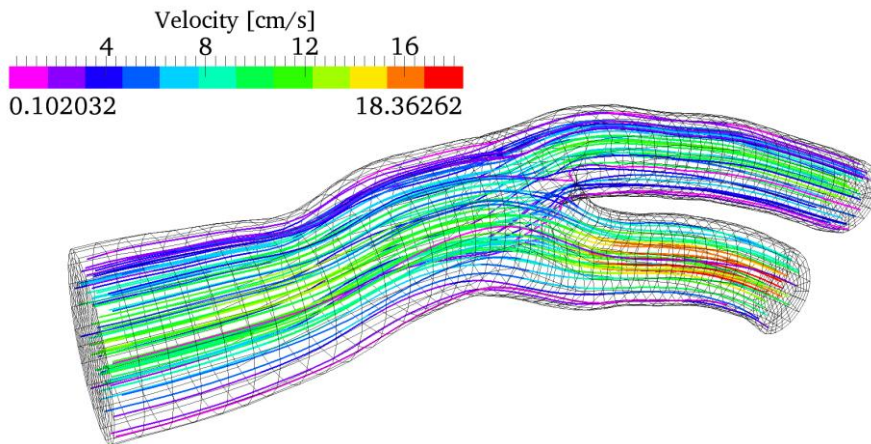Fig. 5 Paraview GIU in remote visualization of calculation data example
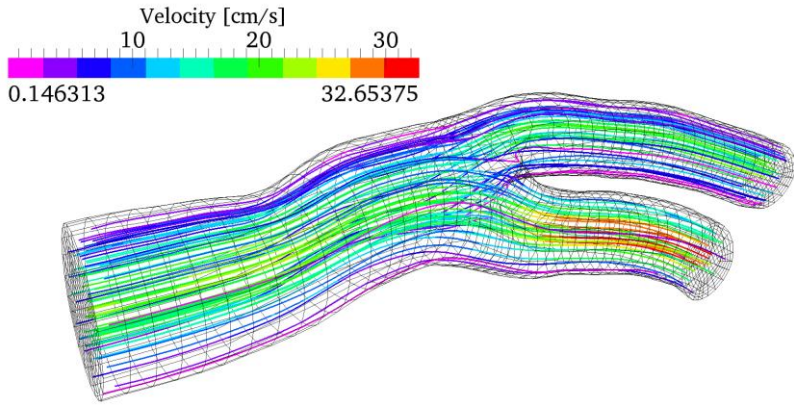

Fig. 6 Velocity field in 1st step
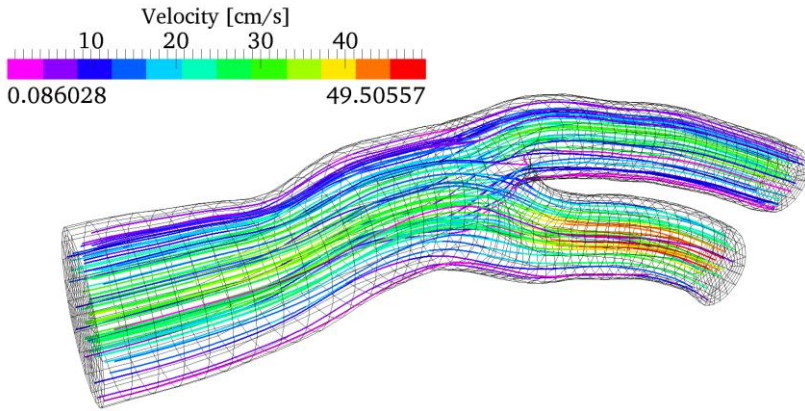
Fig. 7 Velocity field in 3rd step
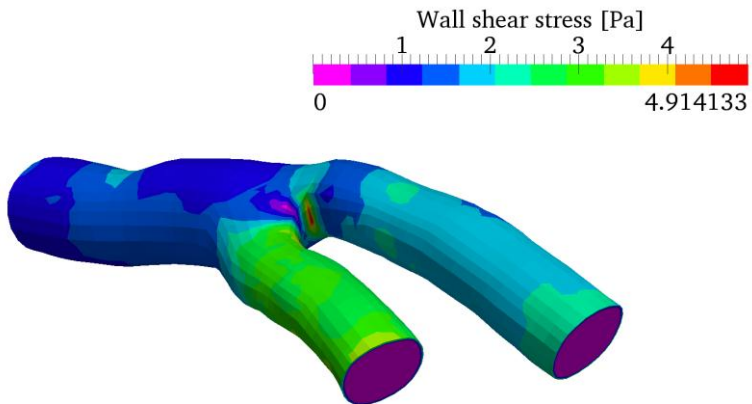

Fig. 8 Velocity field in 5th step

Fig. 9 Wall shear stress in 5th step

IV. CONCLUSION

Provided case study illustrates the application of PAK-F in the study of hemodynamic characteristics of patient-specific carotid artery bifurcation. Calculation results are displayed client side (medics) by client-server application.

The combination of PAK-F with certain programs for pre-processing and post-processing gets a powerful tool in decision making. The previous considerations indicate that developed platform is software tool which can give useful inputs to cardiologists. They have clear view about insight of the blood flow through carotid artery bifurcation, so they can suggest surgical intervention or not.

Constriction problems of blood vessel can be successfully solved by installing the stents in positions with a possibility of total congestion of blood vessels. After placing the stent, blood vessel lumen and cross section is increased. Due to the rapid creating the model, calculation, and the presentation to cardiologists, approximate analysis of the coarse models may be conducted at each physical of individual patient. In this way it is possible to monitor the patient and determine the optimal moment in time of plaque development for stenting.

The ongoing research is oriented to the upgrade of software that will give a platform for coronary arteries and heart malfunctioning simulation.

The large variety of hardware, operating systems, and MPI implementations makes installing precompiled binaries of parallel ParaView impossible. Thus, to use ParaView on a parallel server, user has to compile ParaView from source. The server is a parallel MPI program that must be launched as a parallel job. The most common way is to use the *mpirun* command.

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Use of information technology in hydrological analysis

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Abstract - Present paper demonstrates the use of information technology in hydrological analyses. A model of the catchment area of River Banjska was made using graph theory and digital terrain model. SQL query was used for searching data in tables, in order to perform hydrologic analysis of digital terrain models of River Banjska basin. The aim of this paper is to demonstrate the practical value of the developed model in future hydrological analyses.

Keywords— Hydroinformatic, digital terrain model, directed graph

I. INTRODUCTION

Hydroinformatics is a scientific discipline that, in a narrow sense, covers and connects digital terrain models, computational geometry, relational databases, database browsing and graph theory. In a broader sense, hydroinformatics also covers hydrological models that use the physical representation of hydrologic processes.

Graph theory defines computer presentation of graphs, as well as the graph browsing algorithms. The directed graph presented in this paper has been constructed in order to represent River Banjska hydrographic network. This graph will further be used for the analysis of water management in this basin.

For this purpose has been used the digital terrain model of the basin of River Banjska, tributary to River Juzna Morava. Digital Elevation Model (DEM) has a regular structure of a 25 x 25 m square grid. It served as the basis for hydrological processing by ArcHydro software, developed by the Center for Research in Water Resources of the University of Texas. DEM analysis is a preprocessing procedure that involves elimination of all irregularities arising from imperfections of the digital elevation model creation. Processing procedure defines flow direction (Flow Direction method) on all DEM segments and water accumulation (Flow Accumulation method) based on flow direction on each of the grid squares (using Flow Direction method). Results have been used to obtain flow definition (Stream Definition method) and basin delineation at all points of connection of river network, as well as at the basin exit.

Hydraulic junctions (Hydro Junctions object) and river sections (Hydro Edges objects) have been defined in the later stages and they have been recorded in .mdb database tables, attributes of which include geometry data (shape: Point, shape: Line and shape: Polygon). This concept is called the Object Relational Database. Tables of this database are connected through key fields and external fields. Database browsing has been implemented by means of the standard query language – SQL.

II. GRAPH THEORY

A graph G=(V,E) is made of the collection of nodes V and the collection of edges E. Edges represent relations between the nodes and they correspond to pairs of nodes. Graph can be

directed, if the branches are organized pairs, or undirected, if the branches are not organized pairs [1]. Graph can be cyclic, or acyclic, representing nodes and links in hydrotechnics.

A simple graph is a graph with no parallel and cyclic junctions, where parallel junctions are the junctions with double connection to two same nodes, while cyclic junctions connect one node within a graph with itself. The edges in a simple graph are unique links, where $E=(i,j)=(j,i)$ applies to all edges.

A complete graph is a simple graph with the maximum number of junctions [1]. The highest possible number of junctions is NC^2, where NC is the number of sets of nodes. If cyclic junctions (NC) are excluded and the remainder is divided by two (as NC^2 is obtained by taking each junction twice), the total number of links of a complete graph is $NC \cdot (NC-1)/2$.

If graph nodes represent specific objects in space, then they belong to the Euclidean graph. Planar graph is the Euclidian graph whereby the edges represented in a plane have no intersections [5]. If a graph does not include rings (cyclic junctions) and provided that the number of edges in a graph equals the number of nodes minus one, if there is only one edge connecting two nodes and if any of the junctions of the graph is omitted, then the graph is called the Tree (branch network).

One of more significant problems in graph theory is the subject of the Minimum Spanning Tree. The minimum spanning tree is a subgraph that includes all graph nodes with the minimum sum length of edges [6]. Thus, the minimum spanning tree is a Tree, i.e. a graph with a branch network. If there is an undirected weight graph, the minimum spanning tree is the tree, the edges of which have the smallest sum of weights. Sum weight of edges is often called the cost of the tree, due to the application of this concept in industry. It is important to note that such trees need not to be unique to a certain graph, that is, there can be several minimum trees with the same "cost" of tree for the same graph.

The hydrographic network is graph directed in an acyclic way, where the edges are presented as the organized pairs of nodes and where the rule $(i,j) \neq (j,i)$ applies. When each of the edges memorizes an attribute associated with the specific object (for example, the length of the river section), then this graph becomes a weight graph.

Acyclic directed graphs have a linear branched structure. If the direction of edges is known, the nodes can be used in order to arrive from one end of the graph to another. Unlike the acyclic ones, cyclic graphs define circular (cycled) arrangement of nodes and edges.

Topologic sorting of the directed acyclic graph $G=(V, E)$ is a linear organization of all nodes, whereby if the graph G has branch (u, v), then the node u is located before node v in the resulting series of nodes [6]. If the graph is not acyclic, topologic sorting is not possible. Directed acyclic graph is frequently used to present the connections between events. Branch (u, v) means that the event *u* must end before the execution of the event *v* starts.

Topologic sorting may be used for identification of the shortest (or the only possible) routes from all nodes to the exit node. This is very important in hydroinformatics, as topologic sorting of hydronodes defines the direction of the graph, i.e. the direction of water movement along the hydrographic network.

A directed graph has been formed between the nodes and edges in River Banjska basin. The set of river network nodes has been defined by the entity *HydroJunction*, while the set of edges has been presented by the entity *HydroEdge*. The entity *HydroEdge* is the link between the river network nodes, and, thus, each edge possesses data on its start and end nodes. By this method were formed two organized sets of nodes and edges. The *entity HydroJunction* is made

of nodes representing sources and confluences and the exit node located at the most downstream end of the hydrographic network ("Vranjska Banja" HS). A directed graph has been formed only from the nodes which have the basin that mouths to them – *confluence nodes and exit node*. Fig. 1 shows the directed graph of River Banjska up to the "Vranjska Banja" HS.
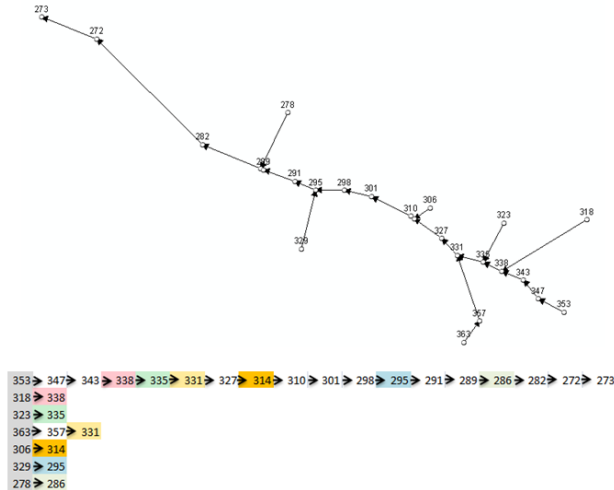

Fig. 1 Directed graph of River Banjska up to the "Vranjska Banja" HS with the connectivity list

III. DIGITAL TERRAIN MODEL

Digital Elevation Model (DTM) is used for the representation of terrain's surface. Historically, the DTM model was developed at the Massachusetts Institute of Technology in 1950 [2]. One of the DTM definitions reads: DTM is a numerical and mathematical terrain representation created by application of respective height and position measurements, density- and distribution-wise compatible with the terrain. Hence, the height of all points on the analyzed terrain can be automatically generated by interpolation, with the corresponding accuracy.

There are several methods of representation of terrain's surface. They are as follows [4]: DHT (Digital Height Model), DGM (Digital Ground Model) and DTED (Digital Terrain Elevation Data).

DTM structure can be regular or irregular. Regular structure represents a grid of rectangles, while the irregular one represents an arbitrary grid of triangles created on the basis of known point coordinates (x, y, z). Two types of digital models are the most frequent: the Grid structure and the TIN structure.

The size of the grid structure is affected by many morphological parameters, such as slope, river network density and curviness of the watercourse. In addition, the quality of the DEM is affected by geodetic maps that limit grid resolution. To select the optimal resolution DEM for hydrologic analysis, a sensitivity study of river networks for two small basins in the western part of United States [8] was performed. On this occasion, the authors have used field size grid structures in the range from 2 m to 90 m and formed the river. It was concluded that the optimum size of the grid structure in the basin was 10 m.
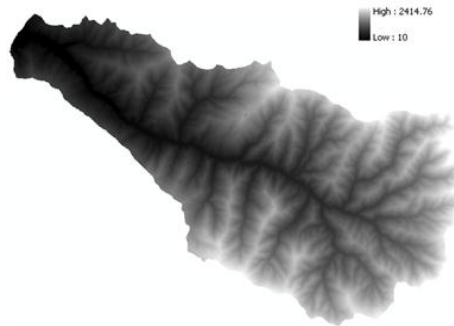
Fig. 2 Digital elevation model characterized by a 25 x 25 m square

Digital elevation model (DEM) of River Banjska was made using scanned analog topographic map with the 1:25000 scale (Fig. 2). For digitizing of contour lines in order to form a vector model were used geodetic maps. Conversion to raster format, which consists of regular grid structures, was performed. Equidistance contour was equal to e = 10 m and, because of this, the accuracy of DEM was e/3 = 3.33 m [2]. A digital elevation model with a regular 25 x 25 m grid structure was created. The choice of the size of the fields was affected by the lack of satellite images, which resulted in the use of topographic maps that are less accurate.

Digital elevation model of the River Banjska basin terrain was used for the hydrologic processing of the terrain (Fig. 2). Terrain processing has been performed by the ArcHydro software operating in the ArcGIS environment. Preprocessing has been performed using the DEM tools developed by the University of Texas (Austin).

An important step in the DEM processing was the embedding of the previously defined river network. This procedure helps to avoid the problem of water transition to other basins, as a consequence of inevitable errors made in the creation of the digital terrain model.

DEM processing involves computation of flow direction, water accumulation, definition of river network, segmentation of river course and delineation of the basin area. Segmented river course and known flow directions provide for the identification of the basin area.

A. Preprocessing

An important step in DEM preprocessing was a formation of the previously defined river network, which is embedded into DEM [3]. This procedure involves entering of the river network (.dwg) in the vector form, redrawn from the topographic map, and its conversion into the raster form. This raster is embedded into DEM in such a manner that the lowest points are corrected. After the embedding has been completed, the lowest DEM points should correspond to the entered river network.

This procedure helps to avoid the problem of water transition to another basin, than can occur as a consequence of inevitable errors made in the process of terrain digitalization.

B. Processing

DEM processing includes determination of flow direction for each square of the DEM grid, accumulation of grid of squares, what is conducted by means of predefined flow directions,

river network formation, river course segmentation and, as the final task, basin surface delineation.

Water flow direction has a twofold definition. In hydrology, it is a direction with the biggest terrain slope. In hydroinformatics, the terrain is divided by the grid of squares so that each square is surrounded by another eight squares [7]. Height differences between the central square and the other eight squares can then be calculated. Diagonal directions have longer water routes than those that are perpendicular, and, thus, the calculation of the central distances of diagonal squares requires multiplication by √2. Central distances used to calculate head and water flow will correspond to the direction of the biggest head of the heads calculated for the eight directions. Fig. 3 shows grid distribution of unit width, while the numbers in the grid are an indication of elevation.
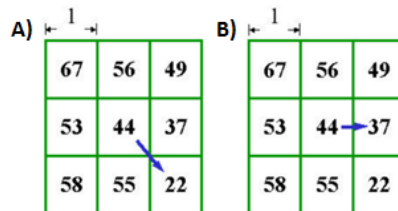

Fig. 3 Illustration of flow direction, diagonal (A) and central (B)

Flow direction determination involved the use of the model with eight potential head directions from one square of the grid, four along perpendicular directions and four along inter-directions [1]. Such a model of head determination is called D8. There is also a simplified model D4 that involves only main directions (north, west, south and east). Direction determination under the digital model starts from the most upstream to the most downstream grid square. The goal of head direction determination from the square grid in one DEM is the formation of a raster containing data on the total water accumulation in the basin (Fig. 4). Each square grid will be assigned a number representing how many upstream squares mouth into the subject square. Data on water accumulation in each of the grid segments are crucial for stream definition and catchment grid delineation.
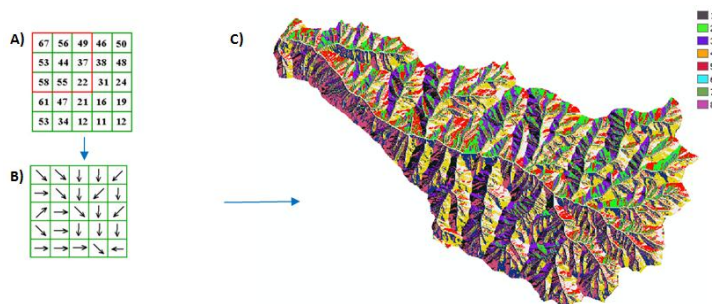

Fig. 4 Square height (A), water flow direction (Flow Direction) in a single segment (B) and the entire basin area (C)

C. Flow Accumulation

Square heights and flow directions as defined by the maximum head in the D8 model (Fig. 5A, B) are presented for a wider area. This method has been used to compute the flow directions for the 25 x 25 m square grid (Flow Direction) of the River Banjska basin up to the "Vranjska Banja" hydrologic station (Fig. 5C) [7]. Flow directions have been identified by different colors.
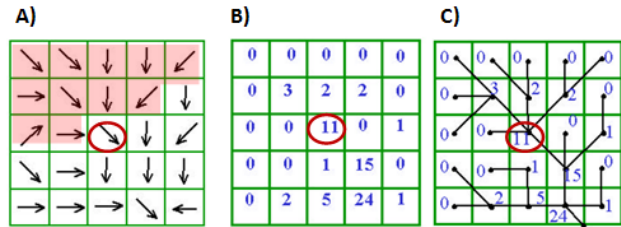

Fig. 5 Square By flow direction (A) and flow accumulation (B and C)

Based on predefined water flow directions one can determine Flow Accumulation for each square in the grid of squares [1]. The value of flow accumulation is equal to zero in the fields without inflow, i.e. in the edge fields. This value is different from zero in all other fields. The number of accumulated squares is determined separately for each grid square. For example, the central field of one DEM part in Fig. 5A has 11 accumulated squares and this is a sum of all upstream squares converging to the central one.

The water accumulation problem is resolved by application of acyclic graph theory. The result of this operation is a sum of upstream squares gravitating to the subject square. The query of the graph, i.e. the layer of water flow direction (Flow Direction), according to the mentioned criterion, is shown in Fig. 5B. The results arising from data on water accumulation are of fundamental importance for the further analyses.

Fig. 6 shows flow accumulation for the entire River Banjska basin. White color corresponds to the points of agglomeration of accumulated squares, while the white groups provide the image of the future hydrographic network.

Fig. 6 Flow accumulation in the River Banjska basin up to the "Vranjska Banja" HS

This figure provides a conclusion that the lighter colors corresponds to the valleys on the terrain. These points are the points of abrupt water accumulation along the slopes and, thus, the

number of squares that the water drains from is the highest at the exit from the basin, i.e. at the profile of the "Vranjska Banja" HS (174 942 squares).

D. Formation of river network - Stream Definition

In order to form river network (Stream Definition), it is necessary to determine the number of accumulated squares in the entire basin area.

This requirement is applicable to the entire basin area and it is applied from the most upstream parts of the basin area towards the downstream parts [1]. Actually, stream definition formation may be defined as a query (SQL query) along the raster layer of the accumulated grid squares, the value of which is either higher or equal to the assigned initial requirement of the stream definition formation.

Fig. 7A shows the accumulated squares in one segment of the DEM, as a result of the analysis from the previous chapter (3.2.2). If the preset criterion is to form the flow by the accumulation of 5 grid squares, then this criterion for a 25 square grid is met with 4 grid squares highlighted in red (Fig. 7A). Connection of the squares results in the river course shown in red in Fig. 7B.
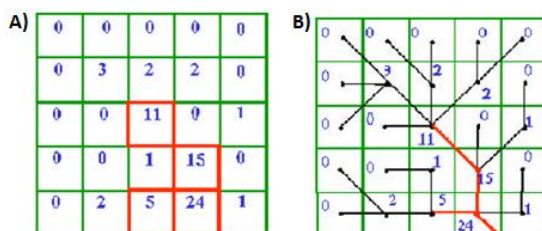

Fig. 7 Accumulation of grid squares and stream definition in the subject basin segment

The conclusion is that the resulting grid is obtained in the raster form and that the reduction of the criterion on the number of accumulated squares leads to an increase in the number of the squares in the raster and vice versa.

The criterion for the formation of river network in the River Banjska basin was that the river flow should be formed upon the basis of 1000 accumulated squares on a DEM grid. The formation procedure is iterative and, according to the preset criterion, the grid is drawn on the 1:25 000 scale topographic map. If the raster layer fits well to the hydrographic network on the topographic map, then the criterion for stream definition is considered met. Fig. 8 shows the raster representing the river network of River Banjska starting from the "Vranjska Banja" HS.
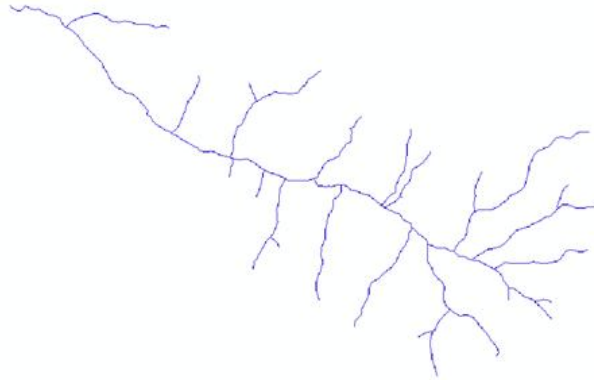
Fig. 8 Formation of the river flow (Stream Definition) on River Banjska starting from the "Vranjska Banja" HS

E. Stream Segmentation and Catchment Grid Delineation

In order to start with the catchment grid delineation, all segments of stream definition should be defined separately, i.e. it is necessary to perform the segmentation of the stream definition raster layer (Stream Segmentation). Segments are formed between the edge parts of the grid and the parts whereon the river network branches. This segmentation is shown in Fig. 9.
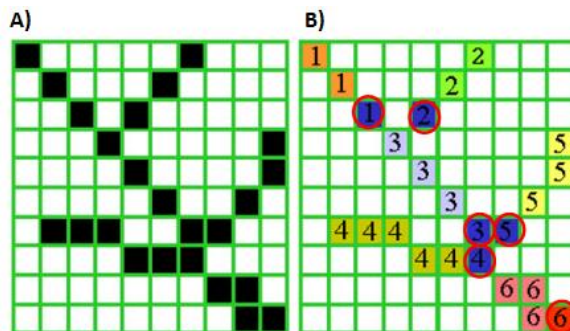

Fig. 9 Segmentation of the river network in a single basin segment

Fig. 9 shows six segments of river network. Definition edges, where basin delineation is performed, have been highlighted. The layer with accumulated grid squares, with predefined delineation points, was also used. Delineation is performed from the starting points of the river segments along the basin watersheds. Watersheds run along the points where the value of accumulated squares is equal to zero, while the squares of water flow directions correspond to different basins.

Fig. 10A shows all river flow segments in different colors - there are total of 49 of them up to the "Vranjska Banja" HS. Flow accumulation and stream segmentation layers have been used for the catchment grid delineation in the raster form. Catchment grids (49 of them in total) have been formed at the points of river flow junctions (Fig. 10B).
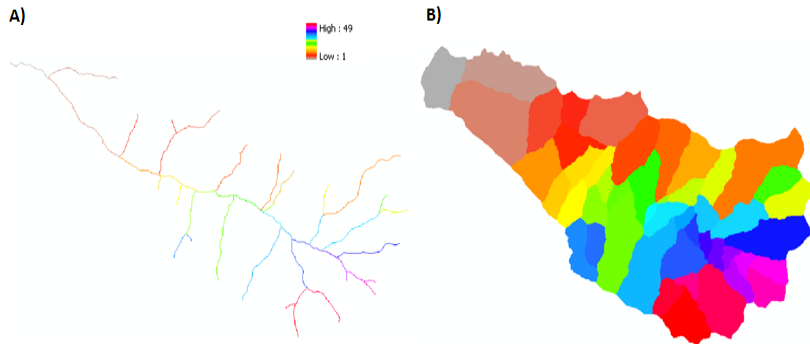
Fig. 10 Formation of river sections (Stream links) (A) and Catchment Grid Delineation (B)

Hydrologic analyses create a need for basin area merging because catchment grid delineation is usually performed at the points of hydrologic stations and water management objects. The raster that has defined the stream segmentation will have to be modified. Fig. 11 shows grouping of the river network into a single segment, while Fig. 9 shows one part of the river course with six segments.
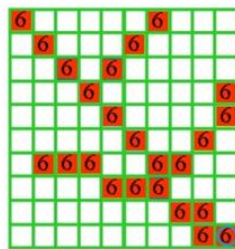

Fig. 11 Stream segments merging into one part of the basin

Results of segment merging allow for catchment grid delineation to be performed only in the most downstream part of the segment.

F. Drainage Points and Lines

Delineation means the drawing of the catchments areas at the points of stream junctions and the points of water measurement stations and water management objects. Raster layer shown in Fig. 10B is used for the formation of catchment vector form, i.e. for raster vectorization. Catchments in the raster layer are the same as in the vector layer. The vector layer of the catchment contains data on the size and scope of the catchment, as well as the minimum and maximum elevation taken from the DEM.

Flow accumulation and stream links raster layers are used to generate the vector form of drainage line. This is the method used to form vector layer for each river network segment, attributes of which contain the data on the downstream drainage point.

Flow accumulation and catchment grid delineation layers are used to generate catchment drainage points. This is the method used to form one drainage point for each catchment exit, attributes of which contain data on the associated catchment. Fig. 12 shows the vector forms of catchment, drainage points and drainage lines of the catchment.
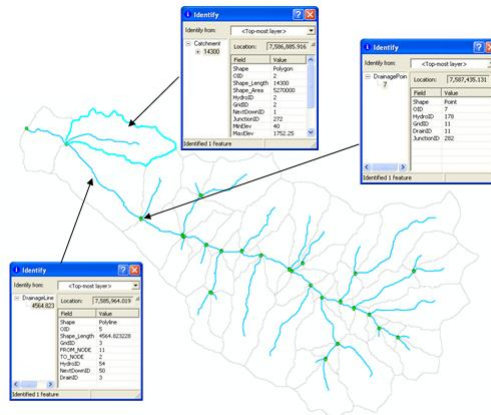
Fig. 12 Vector form of the catchment, drainage lines and drainage points of the catchment

Catchments, drainage points and drainage lines of the catchment are the spatial databases of complex structure – grids. Drainage points are the connection between the drainage lines and the catchment. Geometric data are recorded in the .mdb database supported by the MS Access software package. Basic geometric data are given in the attributes of the entities such as points, lines and polygons.

Each entity has attributes providing for its unambiguous identification. Such set of attributes is called the primary key. In order to form a link between the entities it is necessary to define external keys. The primary key of an entity is used to define the link to the external key of another entity. Entities may be assigned several primary and external keys. Each entity has attributes providing for its unambiguous identification. Such set of attributes is called the primary key. In order to form a link between the entities it is necessary to define external keys. The primary key of an entity is used to define the link to the external key of another entity. Entities may be assigned several primary and external keys.

Drainage points have the following attributes:
1) GridID - primary key used to create a link between Catchment and Drainage Point entities and
2) DrainID - external key used to make a link to a Drainage Line entity.

Drainage Line has the following attributes:
1) DrainID – primary key and
2) Shape_Length – drainage line length (m).

Catchments have the following attributes:
1) HydroID - primary key,
2) GridID – external key used to make a link to a Drainage Point entity,
3) Min_Elev – the minimum elevation in the catchment (m a.s.l.),
4) Max_Elev – the maximum elevation in the catchment (m a.s.l.),
5) Shape_Length – catchment perimeter (m) and
6) Shape_Area – catchment area (m^2).

G. Hydronodes and Stream Segments

Hydronodes and stream segments are formed on the basis of Drainage Line, Drainage Point and Catchment entities. The processing of the aforementioned entities results in two new entities - Hydro Edge and Hydro Junction. By means of the external key, tables are connected to the layers they have been formed from.

As opposed to Drainage Point entity, Hydro Junction layer is located at the point of flow origination, at the confluences and catchment exits. In this case, catchment exit is the "Vranjska Banja" hydrologic station. Drainage Point entities occur at the confluences as individual drainage points of each of the catchments, while Hydro Junction represents a unique exit from both catchments located immediately after their confluence.

Hydro Edge represents a polyline connecting two nodes (Hydro Junction) in the stream. This layer is in geometric terms identical to the Drainage Line layer and their difference is reflected in the points they connect and, as such, their attributes differ.

The set of Hydro Edge connections (attributes FROM_JUNC and TO_JUNC) and Hydro Junction points (attributes HydroID) is actually a definition of the directed acyclic graph, G=(E, V). Hydro Junction is a set of nodes organized through HydroID attributes, while Hydro Edge is the set of edges that are actually connected by the Hydro Junction set of nodes. Attributes of the connection with nodes are FROM_JUNC and TO_JUNC. Fig. 13 shows the connections of DrainPoint, DrainLine, Catchment, HydroEdge and HydroJunction entities.
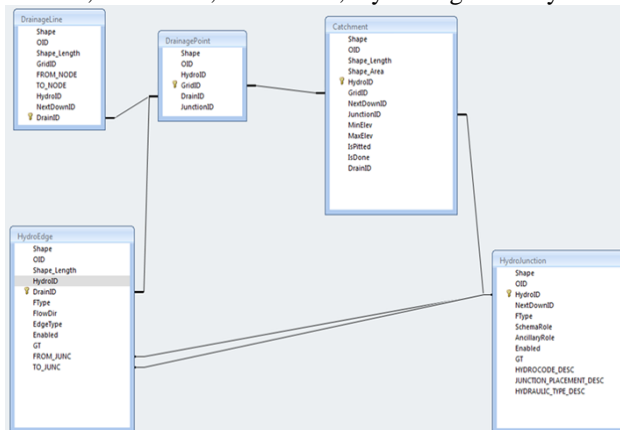
Fig. 13 Connections of DrainPoint, DrainLine, Catchment, HydroEdge and HydroJunction entities

IV. CONCLUSION

Present paper explains the basic forms of digital terrain models, as well as the advantages and disadvantages of each of the forms. Two types of regular structures have been defined, the Grid structure and QuadTree structure. Irregular triangulated grid of the terrain model has been also explained, as well as the methods and rules of its formation. The presented example has used the 25 m x 25 m regular quadratic structure of grid distribution of the River Banjska basin.

Hydrologic processing has been performed by means of the ArcHydro software operating in the ArcGIS environment. Preprocessing of DEM has been also performed and all irregularities created in digital terrain model formation have been eliminated. This has been the

method to perform hydrographic network embedding in the DEM. In subsequent stages, flow directions and flow accumulations have been defined in DEM and the river network has been defined and stream segmentation has been performed. Based on stream segmentation, catchment delineation at the end of segments has been executed.

River network nodes and sections have been created and the key fields have been used to connect them to associated catchment. Catchment drainage points and drainage lines have been also formed. All are located in a relational .mdb database that provides for SQL queries.

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Energy-Efficiency Study of Power-Aware Software Applications

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Abstract – Smartphone and tablet devices will blow past PC sales in a few years. Therefore in the near future most of today complex PC software solutions will switch to mobile implementations. However, the energy requirements of these software solutions surpass by far the energy storage capacities available with today battery technologies. Furthermore, modern power management mechanisms implemented by low power devices and mobile operating systems cannot support energy requirements of highly computational or communication intensive applications. Therefore, energy saving mechanisms implemented at the higher layers of the system are considered the next important step in the implementation of highly energy-efficient mobile solutions. The study presented by this paper discusses the options available to involve mobile applications in a so called holistic energy management solution.

Keywords—energy management, mobile applications, software, power-aware

I. INTRODUCTION

In 2011 something profound has been observed on the ITC market, the smartphone sales overtook PC sales [1]. Following the current trends, the smartphone sales will soon dwarf PC sales (Fig. 1). On the other hand, tablets are still in the early penetration phase. But following the same trends presented by Business Insider (Fig. 1), they will soon reach the number of PC sold. In this context, the future of ITC is certainly going mobile, changing thus the way we interact each other, we are doing business or we entertain ourselves.
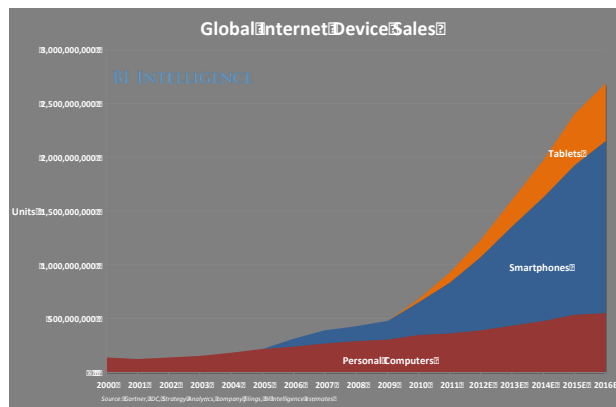

Fig. 1 Global units sold of PCs, smartphones and tablets [1]

Multiple factors contributed to the fast development of mobile devices and applications switch toward mobility:

- The increasing performance of the low power processing units and increasing their number and type within a single mobile device (multicore CPU, GPU).
- The increasing communication bandwidths and higher transfer rates of the wireless infrastructure together with a diversity of communication interfaces (WiFi, UMTS).
- The increasing capacity and speed of memory and storage.
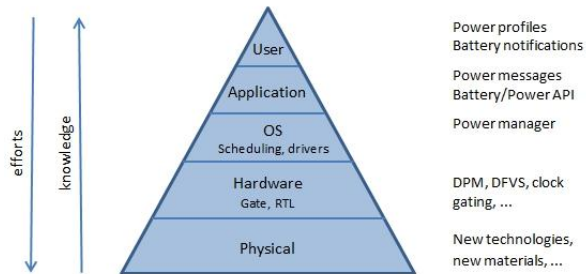- The increasing number of sensors and interfaces (GPS, NFC, accelerometer).

Fig. 2 Today power management efforts

These previous factors contributed also to development of various types of new mobile applications like: mobile games, mobile augmented reality, location and context aware services, etc. The new features built in mobile devices and their applications come with an increase of resources usage and energy consumption. The cost that devices have to pay for running such applications is the reduction of the battery lifetime and consequently the devices' autonomy. Therefore, prolonging the battery lifetime of mobile devices was one of the main research topics in mobile computing during the last decade.

Modern power management mechanisms implemented by mobile devices and operating systems cannot support energy requirements of today highly computational or communication intensive applications. Therefore, energy saving mechanisms involving the higher layers of mobile systems is considered the next important step in the implementation of highly energy-efficient mobile solutions. The study presented by this paper discusses the limitations of today power management strategies and the options available to involve mobile applications in a so called holistic energy management solution.

II. LIMITS OF LOW-LEVEL POWER MANAGEMENT STRATEGIES

Various power management strategies have been proposed and implemented during the last years in order to reduce the power consumption of the battery powered devices. Power management strategies refer to the set of hardware mechanisms and software algorithms implemented by a computing system to control their power use. These strategies can be implemented at different abstraction layers of a computing system: physical and hardware level, operating system level, application level and user level (Fig. 2). Most of the nowadays efforts are directed to lower layers power saving strategies and higher layers are left behind (Fig. 2).

Power management is a multidisciplinary field that involves many aspects (i.e., energy, temperature, reliability, software), each of which is complex enough to merit a survey of its own. Unfortunately, despite considerable effort to prolong the battery lifetimes of mobile devices, there is no standard efficient solution established for all mobile applications and their hosting devices. This is mainly because the lower layer power management implementations faced their limitation on high-end smart mobile and tablet devices.

These limits are further described for the lower layers power management strategies (Fig. 2):

- Physical layer – at this level we consider the efforts directed toward low power circuits design and new transistor technologies investigated to support low power circuits. In this category we include the transistor level power consumption reduction research effort.

- Hardware layer – at this layer we consider the efforts directed to gate level, register transfer logic and system architecture level power consumption reduction. In this category we include power management mechanism like: DPM (Dynamic Power Management), DVFS (Dynamic Voltage and Frequency Scaling), Clock gating, Power gating, etc.

- Operating system layer – at this layer we consider the efforts directed to operating system and device drivers power management. In this category we include the power management algorithms implemented by OS and device drivers.

The scaling process has been the main factor that drove the development of both high-performance and low-power integrated circuits. By reducing the transistor sizes either increasing performance at the same power consumption or the same performance at the lower power consumption can be achieved. But the limits for the processing frequency are already reached, demonstrated by the current development of multi- and many-cores CPUs. However, continuous technology scaling raises design challenges and concerns due to excessive power consumption [2]. Although switching energy per gate decreases with scaling, the power consumption of the whole device continue to increase due to the leakage current increase and larger number of switching elements [2]. Furthermore, power consumption of mobile devices must be kept under 3W due to the thermal dissipation problems, thus making power management efficiency even more compelling.

Dynamic power management (DPM) techniques have been proposed and implemented in order to mitigate power consumption increase of the computing systems. The DPM algorithms minimize power consumption by selectively placing the system's unused components in their specific low-power consuming states. The most used DPM algorithms are those based on a time-out strategy. Their disadvantage consists in unnecessary power consumption states during the wait time before entering a low-power consumption state. A second class of DPM algorithms is based on a prediction of system or component behavior for a future time period. In this case, a component will be placed in a low-power consumption state if it is not currently used and the module predicts another longer inactivity period. A false prediction will lead to an increased consumption and also will cause a performance drop. A third class of algorithms is that of random algorithms, which is based on distributions that reflect the component request activation time. These distributions are based on simulations or event monitoring in a system during a given period of time. The main challenge for DPM algorithms is to select the timing and power states for each component of the system. Higher-level applications can provide

important knowledge to these algorithms in order to improve their overall efficiency. The knowledge on how available energy has to be used by the system and allocated by DPM algorithms increases from lower layers to upper layers of the system (Fig. 2). For example, a user application is the most able to say how long its tasks or threads will last and thus it can provide valuable information to DPM algorithms implemented by OS. Another example presented in [3] proposes to achieve wireless communication power saving through selectively choosing short periods of time to suspend communication, directly by user applications.

Dynamic Voltage-Frequency Scaling (DVFS), implemented by most available processors, is the most used method for energy consumption reduction while executing tasks with various performance requirements. DVFS saves energy by shifting between several levels of processor voltages and frequencies to execute tasks with the required or expected performance [4]. But, the existing power management mechanisms based on DVFS have several major limitations. The first one is that most of them still focus on the scheduler and rarely explore other opportunities for slack reclamation [4]. The second limitation is that they only use one frequency, from a discrete set of frequencies, to perform each task [4]. The third limitation is the variety of implementations on multi-core platforms: scaling every core, group of cores of the whole processor. And the last one is the hardware interconnection problems between blocks or cores running at different voltages and frequencies levels. The interconnection implies voltage shifters that introduce latencies and signal degradation. The knowledge available at the higher layers of the system is valuable to increase the efficiency of slack reclamation techniques of processors through efficient use of the generated tasks' slack times by an independent scheduler.
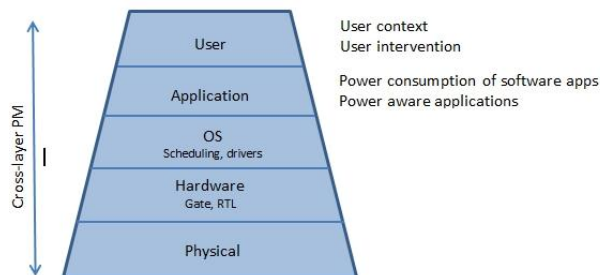

Fig. 3 Future trends of power management efforts

III. State of the Art of High-Level Power Management Strategies

Considering the limitations of lower-level power management strategies, application-level energy efficiency mechanisms are considered the next important step in the evolution of highly power-efficient mobile systems. The final user is also an important element to be introduced within the energy efficiency and management cycle (Fig. 3). However the normal user lacks the basic understanding of the low-level power management mechanisms, even though he is the most able to choose how to consume the remaining energy within the battery. Therefore power management techniques should propagate to higher levels of the system, more specifically to the user applications level (Fig. 3).

Power management mechanisms implemented by today mobile devices provide poor API and services to higher layers of the system (Fig.2). OS usually provide APIs for battery status

access and power management. The first API provides user applications with the access to the energy level available in the battery. The second API provides a very limited set of functions and events for user applications to slightly control the power management features of the OS (e.g. prevent display standby activation). Future research directions on application-level power management include measurement and estimation models for energy consumption of software applications and development of energy-aware software applications. Energy consumption models estimate how much energy each application consumes apart from the total energy consumption of the device. The roles of the power-aware application models are first to make the applications aware of their own power consumption and to adapt themselves to reduce consumed power and second to promote and translate system's power management states and actions to the user in a user friendly way. This feature allows higher-level applications to make the users aware of application specific energy consumption aspects and allow users to actively interact with power management mechanisms in a much more effective and informed way.

Furthermore, the accelerated development of the smart devices failed to integrate the user in the decision process concerning the device's power management according to his/hers needs. We believe that it is important for future power management techniques to integrate the user preferences as part of the process. But the user has no capacity to understand and to comprise all aspects and elements of power management as implemented in today operating systems. Therefore power management techniques should propagate to higher levels of the system, more specifically to the user applications level in a user friendly manner.

During the last years several application-level power management solutions were proposed [5-9]. In [5] an energy-aware framework for dynamic software management of mobile systems was proposed. The authors have designed a user space module, separated of the operating system, which permits the QoS (Quality of Services) based adaptation implemented at the application level. The energy consumption of the mobile applications is computed using predefined software macro-models which are hard to be implemented in practice for different types of applications. Unlike the solution adopted in [5] we estimate online the power consumption of the applications by measuring the battery and system's components parameters. The framework proposed in [5] was validated using three applications: video player, speech recognizer, and voice-over-IP.

In [6] an energy optimization framework for software tasks is proposed. The work is focused on the optimization algorithm based on Markov decision process. The authors propose efficient techniques to solve the optimization problem based on dynamic programming and illustrate how it can be used in the context of realistic applications such as WiFi radio power optimization and email synchronization. Unlike the framework presented in [6] we consider monitoring and providing power consumption feedback to mobile applications.

In [7] a cross-layer framework for power management of mobile devices is presented. The proposed framework involves different layers of a mobile system, from device drivers to user applications. The main goal of the framework is to aggregate the QoS levels of applications and select the optimum component specific power management policies according with the power requirements of the running applications.

In [8] a user-centered energy-aware mobile operating system is presented. The proposed OS manages the hardware resources proactively allowing opportunistic access to external resources nearby. The work presented in [8] follow another approach, using an opportunistic access to computing resources available in nearby devices using local wireless interfaces and information about users' social networks.
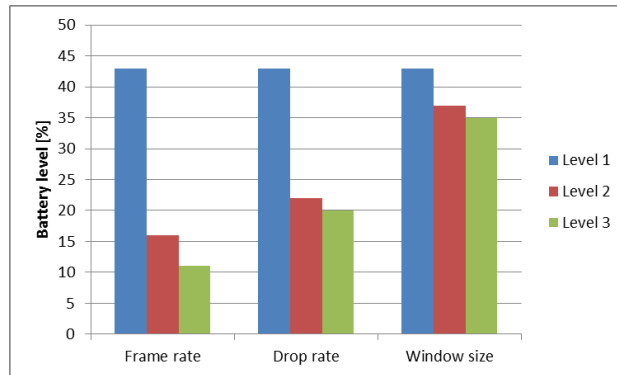
Fig. 4 Power reduction of video player adaption

The authors of [9] proposed and implemented a design framework called GreenRT, for developing power-aware soft real-time applications. They considered that the task in soft real-time applications must run quickly enough to meet the deadlines, but there is no extra benefit from running them faster than that so that the task finishes earlier. The energy could be saved if tasks are executed with a lower frequency clock in order to meet exactly their deadline, but not earlier than then their deadline. The framework [9] allows an application to monitor its progress and adjusts the processor frequency dynamically to finish its jobs in time. The framework is using the concept of DVFS. However the framework proposed by Chen et al. is not generic, it is highly dependent on the managed application.

IV. ENERGY-AWARE VIDEO PLAYER

The energy-aware test application we implemented based on model proposed in [10] is a video rendering system for a mobile device, which was tested on Pocket PC LOOX T380 Fujitsu Siemens. The proposed application adapts itself dynamically to the energy consumption of the mobile device modifying some parameters, which change some characteristics of the video rendering, to ensure a power usage reduction.

The application was created in three stages: in the first stage the video rendering system was created, in the second stage the influence of some parameters of the system on the device's battery power level was studied and finally in the last stage the obtained results in the energy-aware video player application were applied. The energy adaptation algorithm obtained during the evaluation and calibration tests is further presented. The parameters of the system that were taken into account were: the frame rate, the dimensions of the rendering window and the rendering frequency. For each parameter we selected three adaption levels (Level 1 to Level 3). Each level has specific meaning for the three adaption parameters.

```
WHILE not exit condition
        READ battery status from framework
        IF (battery status <= 60%) AND (battery status > 50%)
                SET windows size to 0.66 of its original size
        ELSE IF (battery status <= 50%) AND (battery status > 40%)
                SET frame drop rate to 1/3
        ELSE IF (battery status <= 40%)
                SET frame display rate to 3
        END IF
END WHILE
```

When the device's battery level reaches the level of 60% from the total energy available when the battery is fully charged the parameter rendering window will be applied and the rendering window will be reduced by 1.5 from its initial dimensions. When the device's battery level reaches 50% the rendering window will be changed back to the initial dimensions and the frame rate will be multiplied by 3. After the device's battery level reaches 40% the parameter that ensures the best energy reduction will be applied, that is the rendering frequency. The frame rate will be established at the initial frame rate of the movie and the rendering frequency will be 3, indicating that only the frames from 3 to 3 seconds will be rendered. The parameter that ensures the best energy reduction is used last because when the battery's energy reaches a low level a better energy reduction is needed to ensure that the device will function a longer time. Power saving results only for software adaption are presented in Fig. 4.

V. CONCLUSION

Modern power management mechanisms implemented by mobile devices and operating systems cannot support energy requirements of today highly computational or communication intensive applications. Therefore, energy saving mechanisms involving the higher layers of mobile systems is considered the next important step in the implementation of highly energy-efficient mobile solutions. The study presented by this paper discusses the limitations of today power management strategies and the options available to involve mobile applications in a so called holistic energy management solution.

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