Model and service driven knowledge-based architecture for process execution

Darko Galinec,
Information and Communications Technology Department
Ministry of Defence of The Republic of Croatia
Bauerova 31/2, Zagreb
darko.galinec@morh.hr

Slavko Vidović
Faculty of Organization and Informatics
Universtiy of Zagreb
Pavlinska 2, Varaždin
slavko.vidovic@foi.hr

Abstract. *World development of business process management today tends to process execution directly from models, as a set of activated services. In the world there are two trends for automatic execution of processes. First one is technology direction based upon software technology and the use of process server and Business Process Execution Language (BPEL) [5]. Second direction is based upon artificial intelligence and Model-Based Reasoning (MBR) mechanism [8]. In this paper we were focused on the second approach defined above. Essential factors influencing efficient and effective management of service providing to the users are worked out. Model and service driven knowledge-based architecture, including innovation management and knowledge management integrated with business process management is shaped. Through the experiment conducted at SRMA™ software platform using model-based reasoning and concrete methodology, enforceability of the software development process for service providing has been proven.*

Keywords. model-based reasoning, process execution, process knowledge, process model.

1 Introduction

Model-based reasoning (MBR) is based upon knowledge about structure and behavior of system or device for understanding of which expert system is designed. Use of model-based expert systems can overcome some obstacles that appear wthin expert systems with rule-based reasoning (RBR). For such systems control program or inference engine i.e. rule interpreters are used. Best known control programs are programs which use data-driven processing with forward chaining as well as goal-driven processing with backward chaining [9].

Expert systems with model-based reasoning include development of a model-based upon thorough, deep knowledge of device (system) which is necessary to diagnose and troubleshoot errors that occur in its work. Since conclusions of such models are performed directly from knowledge of structure and behavior of system, within model-based expert expert systems conclusions are based upon logic and reasoning from the "first principles" i.e . common sense. In many cases, conclusion based upon models is combined with other methods of knowledge representation and reasoning [9, pp. 520]. An important feature of model-based reasoning is portability. Rule based system's characteristic is that it contains knowledge of experts on solving problems described by rules [3]. They are valid for a single and specific case, and such knowledge can not be applied to solve similar problems. Model-based reasoning contains full working knowledge on work of system described by model and, theoretically, can be applied to solve problems in connection with any similar systems [9, pp. 521]. In this sense model-based reasoning is a generic category and approach to solving problems within system.
Hypothesis: Processes of defense information system can be operated as services targeted towards users of system. Such services are based upon knowledge and are driven by methodologies being implemented throughout role-based organization, standardization of processes and learning mechanisms.

2 Services

For service management an important concept is "production of services". Like in material production, within such a concept standardization of production of services is performed i.e. shaped models of business processes represents standards for their execution. Also, database, document and knowledge bases are created as a means by which, in addition to existing ones, system may introduce some future service.

Service is configured - to bring its components and descriptions listed in database with help of special-purpose application system. In this way it becomes a standard solution available for use in enterprise. Service can refer to delivery of specific output values based upon queries, and some input values. Output values of service may be some temporary organizational forms, e.g. organizational units directed towards customer - external environment (front office), organizational unit to support business

systems - internal environment (back office) and units for giving assistance to users (help-desk).

System that supports above mentioned must include knowledge that is created using special learning mechanisms, enabling transfer of knowledge from process of innovation into future standard solution. Standard solution is being studied and reviewed, there is innovation, and based upon it a new standardization, where business processes are improved.

Such system and concepts that it contains enable project management as process of service management [4]. Corresponding systemic architecture shows that project management is a form of service providing within large business service category which includes counseling, material, finance, insurance, education, healthcare and many others.

3 Model and service driven knowledge-based architecture

A business process is a set of activities that is initiated by an event, transforms information or materials and produces an output. Value chains produce outputs that are valued by customers. Other processes produce outputs that are valued by other processes [1].

3.1 Process execution and knowledge

Business process apply information system's services in the individual process steps. A key requirement is to provide guidance and control of business processes from beginning to end (*End-to-End - E2E*). Services are carried out by resources: technology (software and servers) or organizational (people and teams). World Development of business process management seeks execution of business processes directly from model, as a set of activated services. In the world there are two trends for automatic process execution:

1. Technology direction based upon software, technology and the use of process servers, based upon BPEL in [5].
2. Direction based upon artificial intelligence, which is b based upon mechanism of reasoning MBR [8].

We focus on the second approach defined above:

1. Models of business processes must be able to automatically execute, and thus eliminates need for programmers' engagement. Highest level of use of knowledge in an enterprise is one within which knowledge required for process execution is contained within information system. Instead of human knowledge needed to encode, process execution takes place on the basis of knowledge, which is in process model.
2. Process knowledge is knowledge about system behavior and is multilevel organized:
   Level I: knowledge about behavior shown by methodologies and meta-methodologies.
   Level II: knowledge of standardized processes in process models that are determined by the use of norms.
   Level III: knowledge in practice presented as good/best practices and experiences in learning from mistakes (*Lessons Learned - LL*).

Processes complementary to abovementioned knowledge are processes of learning and processes of innovation management (innovation of products/services and innovation of processes). A key requirement is that modified model or new process model defined in system can immediately be executed without using programming work.

Automated reasoning based upon models allows for enforceability of process model. MBR technique uses formal models such as automata, process algebra and Petri-nets to carry out tasks of process modeling, verification, monitoring and diagnosis [8]. Petri-nets as a general model, given in [2] allows for modeling of processes and systems for execution.

3.2 Model behavior

a) Behavior of system, showing value chains, was modeled using methodology and process model.
b) Standardized business process consists of process steps that occur within roles and responsibilities throughout role-based organization. Learning mechanisms allow for external learning (import of knowledge) and internal learning (process innovation, good practice, learning from mistakes), and creation of new knowledge for execution of process steps.
c) Process steps invoke one or more services defined by service models that use knowledge disciplines needed to provide services (usually delivery of serviced is carried out through working assignments, whose actors have certain knowledge disciplines. Actors of provision of services may be applications or people.
d) Use of resources for functioning of information system, as part of actual process steps, employs generic application components.
e) Control of process steps for executing business process from beginning to end contains following procedures: completing certain process steps (execution and delivery of one or more services) activates start of execution of following process step in a row and process continuation. Process control layer contains control of process steps and process connections (process logic), and enables control of its flow.

Example:
Using control of process connection 1 execution of connection between process steps 3 and 4 is proven.
Then execution of process step 4 begins using control of process step 2, which starts execution of service 1 (application) and generic application component 1 within applications layer (Figure 1).

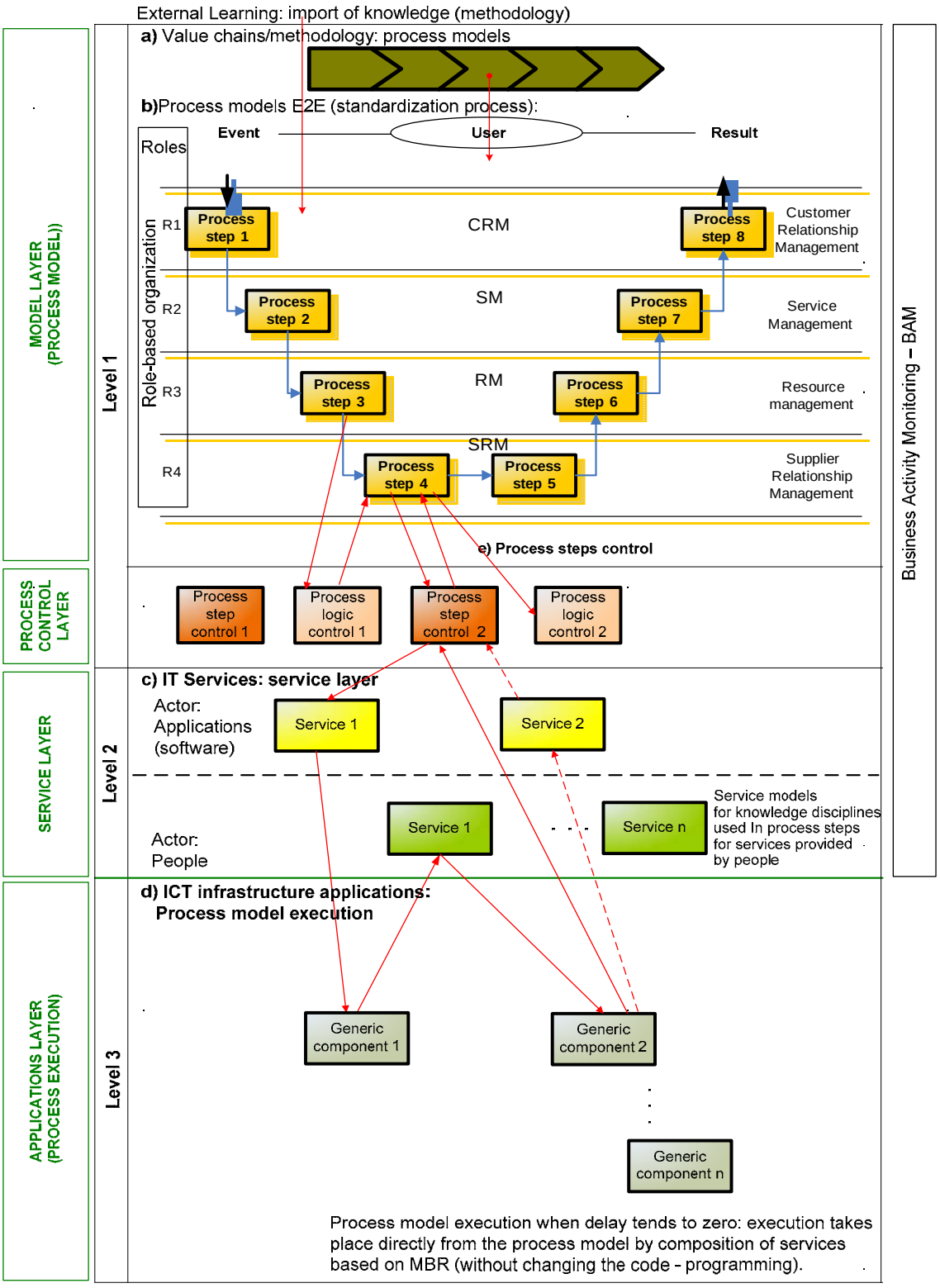

Figure 1: Model and service driven architecture for process execution based upon knowledge

This component is interacting with service 2 (human), which uses a generic component 2. In presented case, result of processing of generic component 2 can be used in two ways. The first way is that a generic component 2 is to deliver result of processing to control of process step 2 (directly). In other way service 2 starts (application), after which execution result of control is handing to process step 2 (indirectly). After successful execution of specified control process step 4 completes, and begins a new control of process connection between process steps 4 and 5, using control of process connection 2, etc.
Business activity monitoring (BAM) system is achieved in architecture parts of a), b), c) and e).

3.3. Knowledge-based services

Innovation management and knowledge management are integrated with process management:

f) Knowledge–based services are modeled through integration of complementary processes of innovation management and knowledge management (good practices, lessons learned) with process management.
g) Use of existing knowledge for execution of processes or for purpose of learning, supports complementary processes. Use of knowledge encompasses cycle as follows:
   - In performing services knowledge needed in this process step is claimed for from system,
   - System involves good practices and lessons learned, templates and other standards,
   - Actor accepts execution of knowledge as part of learning process (principle of Just in Time Learning - JIT).
h) Complementary process of innovation runs through practice of provision of services/processes/projects to the following cycle:
   - Based upon practical experience (a certain process steps, services, projects) innovation is proposed,
   - Assessment of value of innovations is carried out through evaluation, selection and activation (for future use)
   - Application of innovation (as a new standard that will change future behavior of system) provides connection of knowledge and process steps (which may represent a stage of completion or completion of process or project).

4. Proof of the hypothesis

Service management system is based upon software side, database and model-based reasoning. System is goal-driven (employs backward chaining) and uses relational database for storage of data. Software layer which uses data, is designed on the basis of object-oriented approach, analysis and programming using principles of encapsulation and inheritance.

For modeling of software components' interdependence, competitiveness and synchronization of usage of system's resources as well as reasoning enforcement object Petri nets are used.

Classes (as sets of one or more objects) are related to context of the problem (e.g. methodology), and contain corresponding instances (objects) of specified class (e.g. a particular methodology).

Employing execution of processes directly from business process models, whole process of software development is simplified. This process normally includes:

1. Business processes analysis, defining business requirements and business process modeling
2. Forming parts of an information system (design)
3. Development
4. Testing
5. Deployment
6. Implementation
7. Maintenance and support.

An example of implementation of this approach is Service and Resources Management Architecture - SRMA™ InfoDom Group LLC, Zagreb, upon which platform the research was carried out [7]. Conducting the experiments on SRMA™ platform process enforceability of software development process using Rational Unified Process (RUP) methodology of IBM has been tested, through the following steps:

1. Import of IBM RUP methodology to the system.
2. Process standardization is employed applying methodological elements.
3. Starting and generating a new project as an instance of the process model.
4. View of the project after generating the project plan.
5. Review phase of the project analysis using Petri-net.

The results of experiment proved feasibility of automatic enforceability of the process model. In presented case, response time (delay in execution) for automatic process execution from the process model tends toward zero (14 seconds, measured in this case).

Execution of the process was achieved directly from the process model by composition of services based upon model based reasoning, without programming.

Innovation management and knowledge management integrated with process management are shown in Figure 2.

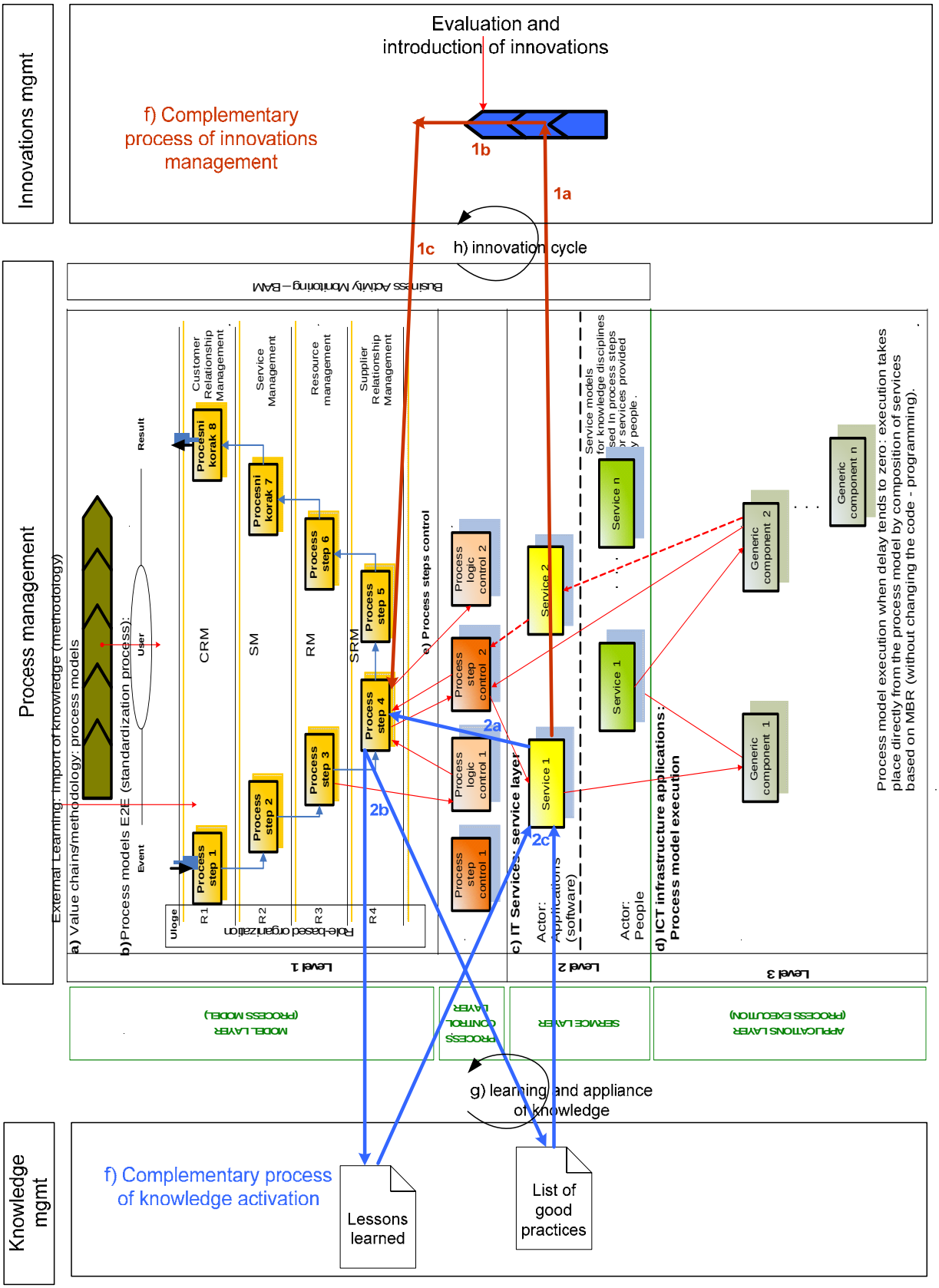

Figure 2: Innovation management along with knowledge management integrated with process management

Description of the implementation:
Software development process is performed using SRMA™ application system as an implementation for company for telecommunications in The Republic of Croatia. When the methodology is imported in the shape of text format, it is being transferred into the relational database. Based on such data Petri-nets are used for process modeling (graphic), verification, monitoring, diagnosis, software components' synchronization and reasoning enforcement. As a result, the project plan is generated. It consists of the project phases and steps described in Figure 5. Project phases are: initiation, planning, analysis, design, construction, transition and closing. Generated plan which includes project (process) phases and process steps represents business process model upon which the process was running. Within each project phase process steps are modeled and executed by the means of MBR and Petri-nets. Within each process step appropriate generic components of the applications were polled, according to process sequence executed.
Example: within initiation project phase the following process steps are modeled and executed:

1. Project delivery,
2. Risk analysis,
3. Address book of project participants creation,
4. Kick-off presentation,
5. Framework plan for delivery phase,
6. Project plan,
7. Project charter.

Appendix: Figure 3 shows start of automatic generation of the project plan based upon methodology IBM RUP (starting time is visible). Figure 4 depicts completion of the aforementioned process within 14 seconds (completion time is visible). Figure 5 shows project phases and deliverables (process steps) automatically generated within 14 seconds, based upon imported methodology.

6. Conclusion

To address complexity in managing services (which are used by business processes in subsequent steps), possibilities of executing business processes directly from models of business processes are explored. The solution is sought using reasoning mechanism based upon models, which represents a different direction than execution of business processes based upon Business Process Execution Language.
Possibilities of practical use of the presented solution are as follows.

1. Knowledge management and innovation management.
2. Business process standardization through process transformation.
3. Management of the complex programs and projects.

Benefits of such an implementation are:

1. When carrying out process from model rationalization is achieved, because in this way four phases of software life cycle are eliminated:
   a) Design,
   b) Development,
   c) Testing,
   d) Installation.
2. Effect of such a procedure provides significantly reduction of complexity of information system.
3. It directly affects implementation of project requirements - performance in a given time and within a given budget i.e. reduction of time and costs.

Service Management driven by knowledge based upon process models as a set of activated services is employed, it solves the question of complexity through execution of business processes directly from the model, without changing software application. The model is based upon the mechanism of reasoning MBR [8]. Research is conducted on SRMA™ platform where feasibility of the process of service software development which employs specific methodology has been tested.
Processes of defense information system can be operated as services targeted towards users of system. Such services are based upon knowledge and are driven by methodologies being implemented throughout role-based organization, standardization of processes and learning mechanisms.

Proof of the hypothesis by modus ponens (inductive reasoning) [9, pp. 512]:

According to hypothesis given in Chapter 1 (premise) automatic enforceability of the process model as a service has been proven by the experiment conducted. Aforementioned is done using - IBM RUP as typical widespread methodology and industry-tested practice for software and systems delivery and implementation and for effective project management of today [6] (conclusion).

Further investigations are directed towards calculation of frequency distribution of response related to various methodologies employed. Such a distribution should be characterized by, for example, an arithmetic mean, indicating the average delay in execution, along with associated standard measures of deviation from the average.

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Appendix

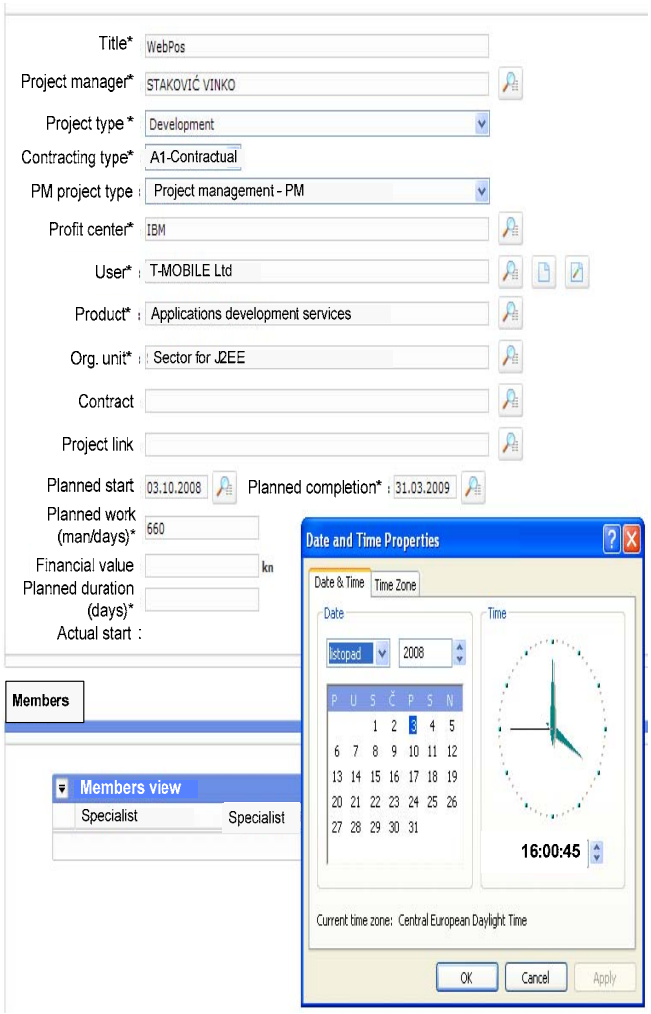

Figure 3: Beginning of automatic generation of project plan based upon methodology IBM RUP

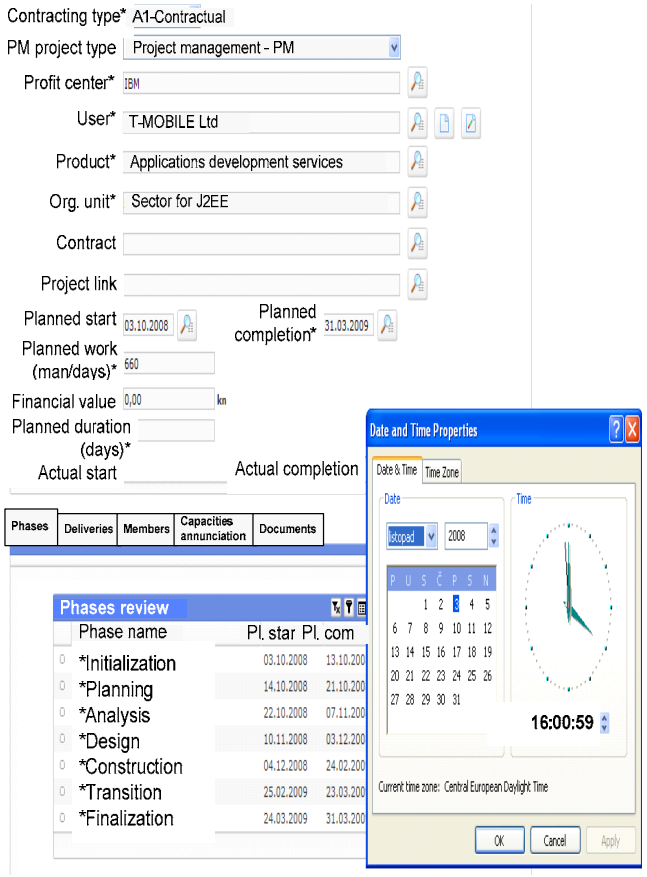

Figure 4: Completion of automatic generation of project plan within 14 seconds

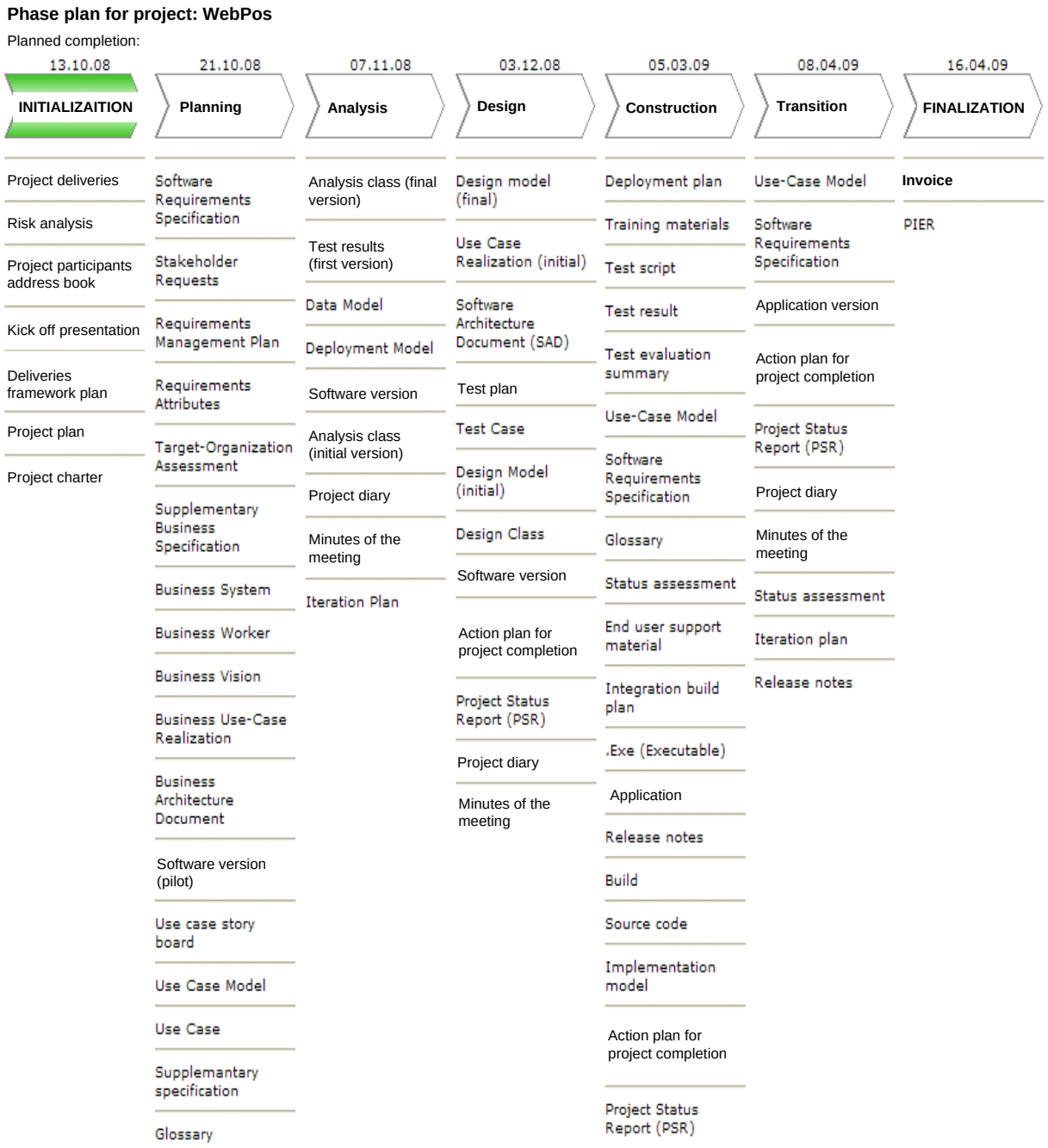

Figure 5: Project phases and deliverables after project plan generation