11. Prezentarea proiectului in limba engleza: (Max. 10 pagini)

11.1. THE IMPORTANCE AND THE RELEVANCE OF THE SCIENTIFIC CONTENT

Context and motivation. The *Web services* have emerged by a natural need to extend the information technology. The *Web services* provide a standard way to ensure the interoperability among different software applications running on a variety of platforms. Organizations use the Web service technology in Entreprise application integration (EAI) and business-to-bussines (B2B) intergration on the Internet. In each of these two categories, the Web services can vary in complexity from simple functions of query-answer type, to sophisticated tranzactions among several parts, on multiple plans and at a long term. Regardless of the application, the *Web services* are used for flexibile integration of loosely coupled systems that can be decomposed and recomposed to reflect the dynamic nature of the business. The Web services promise to turn the Web from a static collection of documents into a vast library of programs. This is the reason why the notion of service is of a considerable interest from both industry and academic research. The Web Service technology has opened the door towards a new era of Computer Science, dominated by applications with a high degree of intelligence, capable of making decisions and searching for information on the Internet. *The software applications available on the Web can be accessed, executed, and composed due to the idea of Web Services*. The current standard technologies for Web services (WSDL, UDDI) provide descriptions only at the syntactic level of their functionality, without any formal description of their semantics. The lack of any machine intrepretable semantics requires human intrevention for the discovery and composition of services, which avoids the use of Web services in complex business contexts, where the automation of these processes is necesary. Semantic Web Services relax this restriction by annotating services with semantic descriptions provided by *ontologies*. The semantic descriptions are necessary in order to allow automatic *Web service* composition. The need to automate the process of *Web service* composition can be best motivated by a simple example from the domain of meat product traceability (we consider that the whole chain of the business process is modeled as a composition of services): a Romanian retailer wants to buy a certain quantity of meat products (salami, sausages) according to the following constraints: the price should not exceed 5 Euro/kg for salami, and 4 Euro/kg for sausages respectively; the delivery should be done within an interval of 5 days; finally, the trasportation price should be of maximum 200 Euro. The following actors are involved in such a business process: the retailer, the salami and sausages producers, and the transporters. In the case of manual Web service composition, the customer would need to do the following tasks: a) search for producers who are offering the needed products, at the specified price, and with delivery in five days; b) search for transport companies that assure the trasportation to the desired destination and whose price is not over 200 Euro; c) call the services in the correct order so that the desired result is obtained. The question becomes even more complicated when several services that have the same functionality but different QoS parameters are involved in composition. In such conditions, the user will need to choose from each category of services the ones that, when composed together, best satisfy his/her needs. This simple scenario is suggestive enough to underline the need to automate the process of Web Service composition. Ideally, the user should specify the objective as well as the QoS constraints to a Web Service Composition tool which will localize the necessary services and the sequence of their invocation. In an automatic composition, the users's role is limited to specifying the functional requirements. The system is the one to define the data and control flow by assembling individual services based on the inputs provided and outputs expected by the user. Some of the advantages provided by the automatic composition are illustated below: A) improved efficiency: a reduction in the complexity and time necessary to generate and execute a composition, and also an improvement of efficiency by selecting the best possible available services; B) in case when the composition is accomplished in a dynamic fashion, the involved services can be replaced in time by other newly appeared services that accomplish the requirements more rapidly, cheaper, or at higher standards; C) the automatic composition assumes the eventuality that the criteria for the accomplishment of composition may change; it adjusts the composition to find services that best suit to the new requirements; D) the automatic composition tackles the situation where a service involved in composition is unavailable; in this case the system can accomplish an alternative composition, in which the unavailable service is not involved. The complete automation of the process of *Web service* composition requires the automation of the following steps: the discovery of Web services, the composition of Web services, and the execution of the Web service resulted from the composition.

Relevance of the scientific context. Complexity of the problem. Despite all the efforts, the automatic composition of Web services is an extremely complex and difficult task. We present below the dimensions of the problem complexity and the significant types of approaches encountered in the literature:

1. Diversity of semantic data models. The actors involved in composition (the service provider and the service requestor) can use different semantic data models to annotate/query the service descriptions. In this case reconciliation between the two data models is required. The **WSMO** working group [14] has developed a complex conceptual model which describes all the dimensions of a service composition using ontologies. The requests and the Web services are defined in the same way, but separately. Mediators are used as intermediates between requests, Web services and different ontologies. It is important to mention for this approach that no aspects related to orchestration, choreography, or data types are specified. OWL-S [17] is another well known model for the semantic description of Web services and of service composition. As opposed to WSMO, in OWL-S, both requests and Web services are described by a single element (Service Profile), without any definition for the mediator. Because of the absence of mediators, only pattern based compositions and static compositions can be described in OWL-S.

2. Dynamics of the domain. The available Web services undergo a continous change. Some services disappear while others appear, and yet other ones can be temporarily unavailable. Even if there are well established contracts with the service providers, by which they guarantee the availability of the services offered, better services than the extant ones could appear from other providers. It is absolutely crucial in such conditions that the development of the automatic service composition to be an iterative process.

3. Coordination of composition. When composing Web services and building complex software systems, the interactions involed require coordination of the sequences of operations, to ensure corectness and consistency. Consequently, new coordination protocols are needed. Different standardization efforts have been taken in order to provide modelling abstractions and simplify Web service developlment (WS-Coordination [6] by IBM and WS-CF [3] by Sun).

4. Transaction. Business processes are usually long running processes that can last hours or even weeks. In such conditions, the management of *transactions* and the *compensation* of services are important aspects that should be taken into account in Web service composition. Very important to name are the WS-Transaction standard [7], proposed by IBM, and WS-TXM [5] proposed by Sun.

5. Context. In terms of Web services the context refers to the information utilized by the Web service to adjust its execution and output in order to provide the client with a personalized behavior. The context can be extended with new types information at any time, without any changes to the underlying infrastructure. The context may contain information such as a customer's name, address and current location, the type of client device (hardware and software), or all the kinds of preferences regarding the communication. The WS-Context standard [4] proposed by Sun specifies the context and the context management.

6. Conversation modeling. It facilitates service discovery and dynamic binding, service composition model validation, conversation model generation etc. Conversation modeling ensures the involvement of components (Web services) in conversation, making decisions, and the adjustment of the behavior of services to their context.

7. Execution monitoring. There are two approaches for the execution of the composite Web services: centralized and distributed execution. The centralized execution is similar to the client-server paradigm. In this case, the server is the central scheduler that controls the execution of the components of the composite Web service. The **e-flow** platform [8] works with a centralized scheduler. In contrast, the distributed paradigm expects the participating Web services to share their execution context. Each of the hosts running a web service has its own coordinator, which has to collaborate with the coordinators of the other hosts, to guarantee a correct ordered execution of the services. **SELF-SERV** [15] uses such a distributed execution system.

8. Modeling the quality of services (QoS). The QoS aspects are of great importance in satisfying the users' requirements and preferences. They can be organized in: runtime related QoS aspects (scalability, performance etc.), transaction support related QoS aspects (stability, cost, completeness etc.), and security related QoS aspects (authentication, authorisation, confidentiality etc.).

It follows from the above descriptions that the research field of automatic composition of semantic Web services is a top research area, of great actuality in information technology worldwide and nationwide. The subject of the project proposed here covers several research areas, fields, which will need not only the integration of the research results on these directions, but also mostly the

collaboration of the research team members specialized in the different directions. For the majority of the team members, their own research directions in this project are closely related to their doctorate/master thesis subject on which they work today. The research directions covered by our team are: *Artificial Intelligence* (all the present day systems for automatic service composition use techniques from the AI domain); *Semantic Web Service technology* (the automatic composition of *Web services* cannot be accomplished without semantically annotated services); *development of ontologies for semantic annotation of Web services* (domain ontologies are required in order to populate the semantic descriptions of Web services); *Mathematics* (the majority of the algorithms for the selection *Web services* are from the domain of statistics (ex.: *Multi-dimension 0-1 Knapsack Problem*)); *service oriented distributed computing*. The relevance of the research subject proposed here is also illustrated by the large number of papers that present research results in the area at different international conferences and by the large number of research groups from universities and companies wordlwide whose research is focused on this area. To argue this statement, we will present a statistics with the doctoral theses elaborated in this area in the years 2004-2007: 256 doctoral theses in the area of *Web services*; 51 doctoral theses in the area of *Web service composition*; 7 doctoral theses in the area of *automatic Web service composition*. This statistics has been derived on the basis of the information provided by the ProQuest data base which indexes 1.6 million doctoral theses. The area of the project proposed here is of great actuality and novelty. The automatic Web service composition is crucial for the success of the Entreprise type Application integration (EAI) and the integration of type business-to-bussines (B2B) on the Internet. All the research directions involved in this project represent the new fields of information technology, focused on distributed processing, including the Internet. ***The greatest challenge of this research area is that nowadays there is no established and available methodology for automatic Web service discovery and composition, which would be an essential requirement for the development of the Semantic Web domain. All of these constitute part of the aspects which lead to the conclusion that the automatic composition of Web services still requires much research effort. We plan to contribute to this effort by the project proposal presented here.***

Similar research work and results. In what follows, we shall do a critical evaluation of the existent approaches worldwide which deal with the automatic composition of Web services.

WebDG [1] proposes an approach in which the automatic Web service composition is accomplished in four phases: specification, matchmaking, selection and generation. In the specification phase, an XML format description of the desired composition is generated. In the matchmaking phase, this description is translated into a couple of composition plans on the basis of some composability rules. In the selection phase, the user selects the desired plan on the basis of the QoS parameters defined in its profile, and, in the generation phase, a detailed description of the composed service is generated. The main drawback of this approach is that the user has to provide a high level description in XML format. Another aspect is that the execution will fail in case when one of the services is not available.

McIlarith and Son [12] propose an approach of constructing an agent based technology starting from the notion of generic procedures and constraints provided by the user. They argue that an enriched version of the Golog programming language provides a natural formalism for programming the *Web services*. These contributions are accomplished by developing a ConGolog interpreter which communicates with the *Web services* via an Open Agent Architecture (OAA). The main disadvantage is that the services and procedures are written in first order logic.

Rao et al. [13] discusses the use of the GraphPlan algorithm to generate a process. The system is based on an interaction with the user, and consequently it provides a limited support for automation. This approach doesn't take into account the input/output messaje schema and only considers sequential workflow patterns, even though, there could also be other types of patterns (ex.: parallel, loop) in a service composition.

Cardoso et al. [8] focus on Web service discovery and on solving the structural and semantic heterogeneity of a manually created workflow whose activities are abstract descriptions of Web services.

The **WSMO** group [14] refers to the problem of the mediation of processes as orchestration. A graphical tool is presented in [18] to guide the user in the composition process, but no mechanism for the automation of the composition process is present.

A correlation between **HTN** planning and the representation of Web services in OWL-S is discussed in [16]. The HTN planning use the approach to refine the plans by applying actions or decomposing the tasks. Their strategy is to decompose high level tasks into smaller subtasks, until arriving at primitive,

atomic tasks, which can be executed directly. This way, the complexity of planning the tasks that require several actions is reduced. The proposed mechanism of decomposing the high level tasks is problematic, since, if the intervention of the human factor is required, then the whole notion of automation fails.
In the framework of the **Meteor-S** project [11], a tool has been developed (Web Service Composition Tool) for dynamic composition of Web services, which allows to design processes based on business constraints. The idea behind this tool is to describe the composed service as an abstract process in BPEL, and then to discover the services whose *Profile* matches with the defined abstract process. Once the requested service is discovered, the candidate services are selected based on the business and process constraints. The disadvantage of this approach is that the proposed technique is not totally automated.
In **our country**, the automatic Web service composition is not a visible approach. This is the reason why we didn't make an evaluation of approaches proposed by research group from our country.

11.2. Project Objectives

The objective of the proposed project is the study and elaboration of a theory and of a unitary framework for ontology driven automatic web service composition. For this objective, we will study, elaborate, and validate experimentally models, methods, algorithms, and techniques of automatic Web service composition, aiming at: dynamic service discovery, the development of algorithms for service selection based on quality of service (QoS) criteria, research and elaboration of strategies for automatic composition and dynamic invocation of services. In order to test, assess, and validate the proposed composition methods, we will implement an experimental platform for automatic Web service composition which will also allow a comparison with other projects of the same kind. We wish to develop a flexible solution, which is to involve a minimum of human effort whenever the composition scenario changes. The main objective of the project is decomposed in the following sub-objectives:

- Development of the conceptual architecture for Web service composition, corresponding to the unitary theory of automatic composition we wish develop in the framework of this project
- Study and development of the domain ontology model
- Define techniques for semantic annotation of Web service descriptions
- Development of the QoS model
- Study and development of the conceptual model for capturing the requirements and their integration with the domain ontology and QoS model
- Study, analysis and development of techniques and strategies for automatic Web service composition
- Development of algorithms for the selection of the Web services participant in the composition process
- Development of two case studies which are to validate the research ideas
- Implementation of an experimental prototype of the platform for automatic Web service composition
- Analysis of results, proving the efficiency of the adopted solution, and corrector actions

11.3. Research Methodology

1. Development of a conceptual architecture for Web service composition. The conceptual architecture for Web service composition (Figure 1a and 1b) correspunds to the unitary theory of automatic composition we wish to develop in the framework of this project. The ***Desing Time*** module contains the following components (Figure 1a): Ontology Management, Ontology Repository, WSDL Repository, SAWSDL Repository and UDDI Repository. In the design phase, the WSDL files of the Web services will be annotaded with concepts from the domain ontology, and then they will be published in UDDI. The ***Run Time*** module contains the following components (Figure 1b): Ontology driven user interface, Broker, Abstract workflow repository, Semantic UDDI Registry, Discovered Engine, Discovery Web Service Set and QoS based Selection Module. The client specifies the functional requirements and the QoS constraints via an ontology guided interface. This interface restricts the vocabulary used by the client when formulating requests, to concepts existing in the ontology. Based on these specifications, a template in XML format will be generated, which will be sent to the *Broker*. The *Broker* represents the core of this architecture. It interacts with the *Abstract Workflow Repository* module, by sending to it the functionality requested by the user. The *Broker* also interacts with the *QoS based Selection* module, by sending to it the QoS constraints. The *Broker* is also responsible for updates related to the QoS parameters, for generating concrete workflows, and also for the invocation of services. *Discovery Engine* is the module that makes the selection of *classes of services* (services that have the same functionality, but differ in the QoS parameters) participant in composition. *QoS based Selection Module* will make the selection (based on the QoS model) out of each class of services. It will select those services that, when composed, would best satisfy the QoS constraints

imposed by the client.

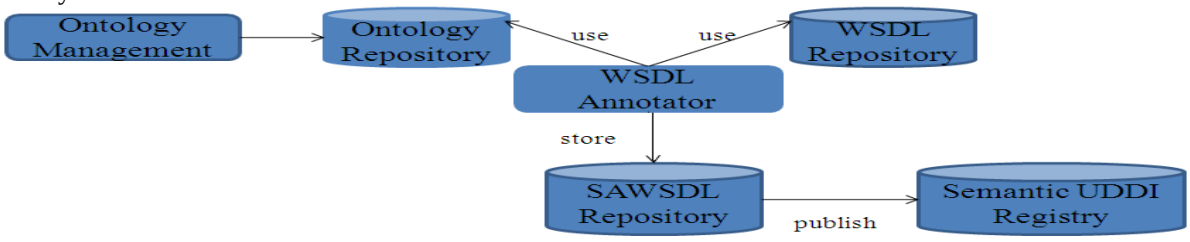

Figura 1a) Desing Time module

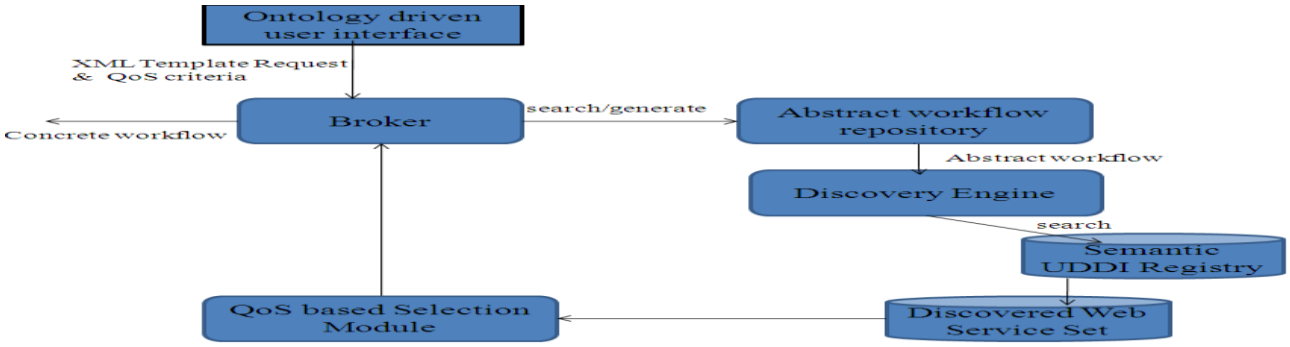

Figura 1b) Run Time module

2. Study and development of the domain ontology model. We will seek the development of a domain ontology model, starting from the following criteria: a) to provide a relevant view of the domain; b) to have a structure that can be easily adapted/extended to other similar domains; c) to define well structured taxonomies and relations in order to avoid the redundancy of data and to facilitate inferences; d) to provide the semantic information necessary for the discovery, selection and automatic composition of Web services. Taking into account these aspects, we will develop a core ontology that will contain the generic concepts necessary for the semantic annotation of Web services. This ontology will be easily adaptable to similar business domains by adding domain specific sub-trees under the appropriate nodes of the core ontology. A detailed description of the steps pursued in the design of the domain ontology is presented in what follows:

Purpose and domain. It is very important from the beginning to clarify for what purpose we want to construct the ontology and who are its potential users. To this aim, we will have to answer the following questions: a) Which is the domain the ontology will cover? b) For what purpose we will use the ontology? c) What are the types of queries to which the ontology will provide an answer? d) Who will use the ontology?

Building the ontology. Based on the already identified purpose and domain, the actual building of the ontology will consist of three steps: a) capturing (identifying the key concepts and relations in the domain of interest), b) coding (the explicit represenatation of the captured conceptualization, in a formal language) and c) integration of existent ontologies.

Evaluation. Gomez-Perez gives a definition for *evaluation*: "In order to make a technical judgement of the ontologies, the associated software environment and documentation relative to a reference framework should be analyzed. The reference framework could be: request specifications, competence requests and/or the real universe".

3. Define techniques for semantic annotation of Web service descriptions. Adding semantics to the service descriptions is an essential step in automatic Web service composition. We wish to make a comparative study between the 3 approaches (*OWL-S, WSMO, SAWSDL*) recommended by W3C to add semantics to service descriptions, to identify which are the advantages of each approach in the context of the automatic composition, as well as some possible aspects not dealt with in the three approaches. The domain ontology will be the starting point for the 3 approaches. The domain ontologies are required in OWL-S and WSMO in order to populate the generic descriptions of the Web services in OWL-S/WSMO format. The domain ontologis are also required in SAWSDL in order add semantic annotations to the diifferent parts of a WSDL document. The results of this comparative study will guide us in choosing/extending the most suitable semantic annotation model in the context of our approach with regard to the automatic composition of Web services.

4. Development of the QoS model. The QoS of the resulting composed service has a determinant role in satisfying the users' requests and preferences. In the presence of multiple services with the same functionality, the choice will be made based on their QoS. The following aspects will be taken into account in developing the QoS model:

Extensibility. We will consider as unpractical to have a standard QoS model to be used for all the services from all the domains. For the QoS model, a set of generic criteria, common to all the Web services will be defined, as well as a set of criteria specific to the domain to which a service belongs. In our approach, the QoS model will be extensible, featuring the possibility to add new domain specific criteria, which will then be used to evaluate the QoS of the Web services without changing the computational model.

Adaptability. It is known that different users can have different preferences or requirements related to QoS. It is important to be able to represent the QoS from the perspective of the preferences of service requestors, in other words, to design an adaptable QoS model.

Monitoring and updating. Once a set of criteria has been defined for a particular domain, we have to ensure that the QoS information is collected in a correct manner. In our approach, we will consider that the QoS information can be collected directly from the descriptions published by the providers, by monitoring the execution, or based on the feedback from the requestors. We will consider that the providers have the possibility to browse through the QoS information and that they can improve the QoS of the provided services.

5. Study and development of the conceptual model for capturing the requirements and their integration with the domain ontology and QoS model. In the development of a model for capturing the requirements of the service requestor (functional requirements/QoS constraints) we will try to answer the following questions: a) Do the service provider and requestor use concepts from the same ontology or from different ontologies? b) Is it necessary to develop a QoS ontology? c) What structure would this ontology have? In case when we let the service provider/requestor the freedom to use concepts from different ontologies then the "ontology reconciliation" problem occurs, which has to be dealt with. An alternative to this approach would be the construction of an ontology guided interface that assists the requestor in formulating requests, by actually confining him/her to use concepts from the ontology developed by the provider.

6. Study, analysis and development of techniques and strategies for automatic Web service composition. Based on the above mentioned comparative study, we have noticed that the planning from the field of artificial intelligence seems to be the most promising approach for the automatic Web service composition. Determining the most suitable artificial intelligence planner which could be used in *Web service* composition has a crucial role for the success of the composition. When using a planner to compose Web services, an effective means of representing the state of the problem/world has to be established. In the classical artificial intelligence planning, the state is represented by a set of ground literals represented in first order logic. However, the state of a problem of composing some Web services whose semantic description is expressed in OWL is an OWL knowledge base. An efficient solution has to represent the state in a way that keeps the OWL semantics, and that is meanwhile compatible with artificial intelligence planning. Besides the study and analysis of the behavior of planners in the context of automatic composition, we also wish to study the possibility of accomplishing automatic composition by using genetic algorithms or an agent platform.

7. Development of algorithms for the selection of the Web services participant in the composition process. The development of algorithms for the selection of the services participant in composition having as result the maximization of the QoS of the service resulting after the composition has a determinant role in satisfying the users' requests and preferences. When developing selection algorithms, we have to take into account several aspects: a) first the set of quality criteria that are taken into account in the composition process has to be established (we can take into account a single quality criterion or several ones); b) the establishment of the model on which the composition is based (we can have a composition process in which the services are chained sequentially, in parallel, or conditionally); c) whether the selection is accomplished locally for each *class of services*, or an approach in which the selection is accomplished globally is adopted.

8. Development of two case studies which are to validate the research ideas. The development of case studies has an important role in Web service composition. They establish a scenario after which the composition is accomplished: which are the services involved in composition, the order of their invocation (sequential, parallel etc.), the domain the services participant in composition belong to. The case studies serve as test base for the experimental prototype, giving to us the possibility to validate the proposed solutions and to prove their efficiency in a concrete domain. Our case studies are inspired from the real world and they are modeling complex problems, of great actuality. As a first case study, we will analyze the problem of external traceability of the food products (we consider that the whole chain of the business process is modeled as a service composition). This case study is described in the introductory part. The second case study is the classical example of planning a trip. It represents a well known example from the literature and it provides to us the possibility to compare ourselves with other extant approaches from both the qualitative and quantitative point of view.

9. Implementation of an experimental prototype of the platform for automatic Web service composition. In a first stage, we plan to develop a study prototype for automatic composition of Web services, based on the proposed architecture. The components of the system will be approached, by starting from an initial, minimal version,

which will be augmented on the fly with new functionalities. In every moment, the problem of ensuring the interoperability among these components will also be posed, which is an important aspect in the automatic Web service composition. Thus, we will work with a system implementation, which initially will be minimal, though which will evolve in time and will allow evaluating the current stage of research. The implementation will always be further developed whenever new specifications will be added according to the established objectives of the project. The experimental prototype obtained this way will be used in validating the theoretical research. This way, publication of practical results will also be possible as a proof of the proposed theoretical ideas. The functional implementation of the prototype will also allow, besides the experimental evaluation, the comparison with other projects of the same kind. For the implementation, the paradigm of object oriented languages will be used, which allow a rapid prototyping and an easy extension of the functionality in the direction aimed by the objectives of the research. The implementation of the experimental prototype will be accomplished by using Java technologies, due to the advantages they come with: platform independence, object oriented approach, the existence of a large number of IDE platforms and open source tools that can be used in building the experimental prototype. The following resources have been identified as necessary for the implementation of the experimental prototype: NetBeans IDE – to develop Web services; Sun Java System Application Server 9.0; Protege ontology editor [19] – to develop domain ontologies; Radiant [10] – to semantically annotate WSDL files; Jena Ontology API [9] – to extract concepts from an ontology; JUDDI Registry – to publish/search for Web services; Java Agent Development Framework (JADE) [2].

10. Analysis of results, proving the efficiency of the adopted solution, and corrector actions. The method will be compared with other, previously developed methods. The advantages of our approach as compared with extant ones will be highlighted, together with possible disadvantages/aspects that remained not dealt with in the composition. The experimental prototype will be tested on two different case studies, in order to highlight the degree of adaptability of the system. Comparisons will be made between different composition strategies and also metrics will be established for quantitative/qualitative evaluation of the results obtained. Comparisons will be made between the experimental results obtained after using different selection algorithms in order to see which of the algorithms are more efficient. The efficiency of the algorithms will be studied for the case when the number of services participant in composition is increased incrementally.

Referinte

[1] A. Bouguettay, B. Medjahed et al., *WebDG, A Platform for E-Government Web Services, ER (Workshops) 2004, 553-56*5.

[2] R. H. Bordini, M.Dastani, et. Al, *Jade - A Java Agent Development Framework*, Multi-Agent Programming Book, Publisher Springer US,pp.: 125-147,ISBN 978-0-387-24568-3;

[3] Bunting, D., Hurley, M.C.O., Little, et al. (2003a) *Web Services Coordination Framework (WS-CF) Ver1.0*, http://developers.sun.com/techtopics/webservices/wscaf/wscf.pdf, July 28.

[4] Bunting, D., Hurley, M.C.O., Little, M., et. al. (2003d) *Web Services Context (WS-Context) Ver1.0*, http://developers.sun.com/techtopics/webservices/wscaf/wsctx.pdf, July 28

[5] Bunting, D., Hurley, M.C.O., et. al. (2003c) *Web Services Transaction Management (WS-TXM) Ver1.0*, http://developers.sun.com/techtopics/webservices/wscaf/wstxm.pdf, July 28.

[6] Cabrera, F. *et al*. (2002)*(WS-coordination)*, ftp://www6.software.ibm.com/software/developer/library/ws-coordination.pdf

[7] Cabrera, F., Copeland, G., Cox, B., Freund, T., Klein, J., Storey, T. and Thatte, S. (2001) *Specification: Web Services Transaction (WS-Transaction)*, http://www-106.ibm.com/ developerworks/webservices/library/ws-transpec/.

[8] J. Cardoso, and A. Sheth, *Semantic e-Workflow Composition*, Journal of Intelligent Inform. Syst., Nov. 2003. 21(3): p. 191-225.

[9] J. J. Carroll, I. Dickinson, C. Dollin, et. al, *Jena: Implementing the semantic web recommendations*. Technical Report HPL-2003. http://citeseer.ist.psu.edu/carroll04jena.html

[10] K. Gomadam, K. Verma, D. Brewer, A. P.Sheth, J. A. Miller, *A tool for semantic annotation of Web Services*, 4th International Semantic Web Conference (ISWC 2005) Galway, Ireland.

[11] K. Verma, K. Gomadam, Amit P. Sheth, John A. Miller, Zixin Wu"The METEOR-S Approach for Configuring and Executing Dynamic Web Processes", Technical Report

[12] S. McIlraith and T. Son, *Adapting Golog for Composition of Semantic Web Services*, *Proceedings of the Eighth International Conference on Knowledge Representation and Reasoning (KR2002), 2002*.

[13]. Rao, J., et al., *A Mixed Initiative Approach to Semantic Web Service Discovery and Composition: SAP's Guided Procedures Framework*, in *The IEEE Intl Conf on Web Services (ICWS'06)*. 2006

[14] Roman, D., et al., *Web Service Modeling Ontology.* Applied Ontology, 1(1): 2005

[15] Q. Z. Sheng, B. Benatallah, M. Dumas, and E. Mak. SELF-SERV: A Platform for Rapid Composition of Web Services in a Peer-to-Peer Environment. In Proc. of the 28th VLDB Conference, Hong Kong, China, August 2002

[16] E. Sirin et al., *Template-based Composition of Semantic Web Services, AAAI Fall Symposium Series, 2005*.
[17] Coalition, O.S. *OWL-S: Semantic markup for web services*. 2003, http://www.w3.org/Submission/OWL-S/.
[18] Farshad, H., et al., *Semantic Web Service Composition in IRS-III: The Structured Approach*, in *Proc. of the 7 IEEE Intl Conf on Ecommerce Technology (CEC'05)*, 2005.
[19] M. Horridge, H. Knublauch, et al., *A Practical Guide To Building OWL Ontologies Using The Protege-OWL*

11.4. Necessary Resources:

11.4.1. Human Resource

11.4.1.1. Project Coordinator

11.4.1.1.1 Scientific Competence of the Project Coordinator

1.Competence domains and significative theoretical or practical results

Service Oriented Distributed Systems. The objective of this research area is to study and elaborate middleware level systems that integrate a set of collaborative resources for Web Services development. Specific researches were targeted to: (**i**) Composing, orchestrating and choreography of Web services aiming static, dynamic, decentralized and automatic and autonomic composition with simulating and verifying facilities; (**ii**) Ensuring of transactional support and defining of failure tolerance coordination mechanisms for security and quality of services; (**iii**) Business rule and interaction patterns capturing, agent based workflow execution aiming deliberative, reactive and pro-active cooperation; **Results**:

- V. Chifu, **I.Salomie**, *An architecture for QoS driven Automatic Web Service Composition, Proc. of 2nd IEEE Int. Conference on Intelligent Computer Comm. and Proc.*, Cluj-Napoca, Sept. 2006, pag. 121-127, ISBN (10) 973-662-233-9
- C.Cosara, **I.Salomie**, M.Dinsoreanu – "A Quality Model for Service Selection", in *Proc. of 2nd IEEE Int Conf on Intelligent Computer Comm. and Processing*, Cluj-Napoca, September 2006, pag. 129-133, ISBN (10) 973-662-233-9
- **I. Salomie**, M. Disoreanu, A. Moga and I. Soos - "Adding self-healing behaviour to dynamic Web Service Composition" reviewed and accepted to the *WSEAS Multi-Conference*, Bucharest, October 2006

Mobile and Pervasive Distributed Systems. The objective of this research area is the study and development of mobile and pervasive systems, reactive and pro-active in a close relationship with the context where they reside and operate. We have studied capturing and representation of context knowledge as well as composing and creating context-aware services. **Results:**

- A.Rarau, K.Pusztai, **I. Salomie,** *Software Framework for Building Context Aware Applications using multiFacet Items* in In Proceedings of 2nd International Workshop on Software Aspects of Context (IWSAC5), Santorini, Greece, July 2005
- A. Rarau, K. Pusztai. **I.Salomie**, *MultiFacet Item based Context-Aware Applications* in International Journal of Computing and Information Sciences 3(2): 10-18, August 2005
- T. Marian, B. Dumitriu, M. Dinsoreanu, **I. Salomie**, *A framework of reusable structures for mobile agent development*, in Proceedings of IEEE INES 2004 Conference, Cluj-Napoca, Romania, Sept. 19-21, pag. 279-284, ISBN 973-662-120-0
- Rarau, A., Salomie, I., Pusztai, K. - *On Synchronization in a Mobile Environment*, in Eric Horlait (ed) Mobile Agents for Telecommunication Applications., Lecture Notes in Computer Science 1931, Springer 2000

Web-based Educational Systems. The objective of this research area is to study and develop cooperative mobile agents for student knowledge evaluation in eLearning systems. The mobile agents of JADE and Aglet platforms have been used for coding and transporting assessment questions from the virtual university to the students. The intelligence embedded in the mobile agents was also used for driving the evaluation process and result processing. **Results:**

- M. Dragomiroiu, R.Gyorody and **I. Salomie**, *Application Framework Development for Virtual Learning Environments*, ITI25, International Conference on Information Technology Interface (IEEE), June 16-19, Dubrovnik, Croatia.
- **I. Salomie**, S. Nedevschi, *Mobile Agents for e-Assessment in Virtual Universities*, in F.Restivo and L.Ribeiro (editors) Web Based Learning Environments, FEUP Publ. House, Porto, 2000, p. 161 - 163

Autonomic Systems. This research area is targeting ways of approaching the management of complex distributed systems. Within the frame of this research we approach the increasing system complexity in an autonomic way by using the CHOP computing paradigms. These paradigms allow for the design of self-Configuring, self-Healing, self-Optimizing and self-Protecting systems. **Results:**

- **I. Salomie**, Al. Moga, M. Dinsoreanu, J. Soos, *Enhancing Web Service Composition with Self-healing Facilities*, *WSEAS Trans. on Information Science and Applications*, Issue 1, Vol. 4, Jan. 2007, ISSN 1709-0832, pp. 42-50.
- Al. Moga, J. Soos, **I. Salomie**, M. Dinsoreanu, Adding Self-healing Behaviour to Dynamic Web Service Composition, *Proc. of the 5th WSEAS Int. Conf. on Data Networks, Communications & Computers*, Bucharest, Oct. 16-17, 2006, pp. 206-211.

Mobile Agents based Middleware. The objective of this research area is to study and use mobile agents of Aglet and JADE platforms for capturing, transport and use of distributed systems know how. Other achievements include defining and implementing middleware provisions for the management, communication, coordination and interoperability of mobile agents. **Results:**

- M. Dinsoreanu, C. Godja, C. Anghel, **I. Salomie**, T. Coffey, *Mobile Agent based Solutions for Knowledge Assessment in eLearning Environments*, in Proceedings of EUROMEDIA'2003 Conference, Plymouth University, Plymouth, UK, 2003
- M. Dinsoreanu, I. Salomie, K. Pusztai, *On the design of agent-based systems using UML and extensions*, in Proceedings of the 24th IEEE International Conf. on Information Technology Interfaces, pag. 205 - 210, Cavat, Croatia, June 24-27, 2002
- M. Dinsoreanu, **I. Salomie**, K. Pusztai, *On Modeling a Mobile Agent-based Assessment Service*, Periodica Politechnica, Trans. on Automatic Control and Computer Science, Vol.47 (61), 2002, ISSN 1224-600X, CONTI2002, Timisoara, Romania
- Chifu E. St., Dinsoreanu M., Salomie I**.**, Teglas C., Hamza-Lup G. - *Mobile Evaluation Engines based on Latent Semantic Analysis*, Proceedings of First RoEduNet International Conference, April 2002, Cluj-Napoca,Romania

Adaptive and fault tolerant middleware. The objective of this research area is the study and development mechanisms of achieving services with prescribed qualities imposed by certain QoSs and SLA agreements, considering the error conditions and the possibility of failures at components and systems level. **Results:**

- M. Dragomiroiu, R. Gyorody, and **I. Salomie**, *Designing Reusable Web-Applications by employing Enterprise Frameworks*, 18th Inter. Symposium on Computers and Information Sciences (IEEE), Antalya, Turkey, Nov. 2003, published in Springer Verlag, Lecture Notes in Computer Science Series, Vol. 2869, pag. 1051-1059.
- M. Ventuneac, T. Coffey, M. Dragomiroiu and **I. Salomie**, *A Policy-based Security Framework for Virtual Learning Environments* in Proc. of 14 Int. Conf. on Control Systems and Computer Science, Bucharest, Romania, July 2-5, 2003.
- M. Dragomiroiu, R. Gyorodi, M. Ventuneac, **I. Salomie** and T. Coffey, *Web-Applications, An Enterprise Frameworks Based Approach*, Proc. of Eng. of Modern Electrical Systems, Computer Science Session, Oradea, Romania, May 29-June 1, 2003

Security of Distributed Systems. The objective of this research area is to study ways of identifying flaws in security protocol design and study security frameworks for web-enabled applications. Specific researches also include contextual authentication and development of security services and security management components.**Results:**

- T. Coffey, M. Ventuneac, T. Newe, **I. Salomie**, *On Investigating the Security and Fairness of a Fair Exchange Protocol using logic-based verification*, in Proc. of IEEE INES 2004 Conf., Cluj-Napoca, Romania, Sept. 19-21, pag. 325-330, ISBN 973-662-120-0
- M. Ventuneac, T. Coffey, and **I. Salomie**, *A policy-based Security Framework for Web-enabled Applications*, Proc. of International Symposium on Information and Communication Technologies, Dublin, Trinity College, July 2003
- M. Ventuneac, M. Dragomiroiu, **I. Salomie** and T. Coffey. *Security Policies for Customizable Access Control in Virtual Learning Environments*, Proc. of Eng. of Modern Electrical Systems, Oradea, Romania, May 29 – June 1, 2003

2. Scientific papers published (in the last 2 years)

- **I. Salomie**, T. Cioara, I. Anghel, M. Dinsoreanu, T. Salomie, *Workflow Models Enhanced with Process Algebra Verification for Industrial Business Processes*, The 11th WSEAS International Conf. on Computers, Crete Island, Greece, July 2007 (accepted)

- V. Chifu, **I**. **Salomie**, E**.**Chifu, *Taxonomy learning for semantic annotation of Web services*, The 11th WSEAS International Conference on Computers, Crete Island, Greece, July 2007 (accepted)

- V. Chifu**, I. Salomie,** E. Chifu, *Ontology Model for traceability services in food industry*, ICETE 2007, The International IEEE-ACM SIGMIS Joint Conference on e-Business and Telecommunications, Barcelona, Spain,July 2007 (accepted)

- **I. Salomie**, T. Cioara, I. Anghel, M. Dinsoreanu, T. Salomie, *Machine and Business Modeling and Simulation for Workflow Integration*, Proc. of the 9th WSEAS In. Conf. on Automatic Control, Modeling and Simulation, pag. 165 - 170, Istanbul, Turkey, May 2007, ISSN1790-5117, ISBN 978-960-8457-72-0

- **I. Salomie,** Al. Moga , M. Dinsoreanu, J. Soos, *Enhancing Web Service Composition with Self-healing Facilities*, in *WSEAS Transactions on Information science and applications*, Issue 1, Vol. 4, Jan. 2007, ISSN 1709-0832, p. 42-50.

- Al.Moga, J. Soos, **I. Salomie**, M. Dinsoreanu, *Adding Self-healing Behaviour to Dynamic Web Service Composition*, *Proc. of the 5th WSEAS Int. Conf. on Data Networks, Commnunications&Computers*, Bucharest, Romania, Oct. 16-17, 2006, page 206-211.

- A. Rarau, **I. Salomie,** *Adding Context Awareness to C#*, EuroSSC 2006, Book Chapter in *Lecture Notes in Computer Science*, Volume 4272/2006, ISSN 0302-9743, ISBN 978-3-540-47842-3, pp. 98-112

3.Scientific books in the domain (monographyes, treates, other books) ISI indexed, available in international databases, and/or published at prestigious national or international publishing houses

- **I. Salomie**, K. Pusztai, S. Nedevschi (editors), *Web based Educational Technology*, Casa Cartii de Stiinta Publ. House, Cluj-Napoca, Casa Cartii de Stiinta, Cluj-Napoca, Romania, 2000

-M. Dinsoreanu, **I. Salomie** , *Object Oriented Methods* (in Romanian), Casa Cartii de Stiinta Publ. House, Cluj-Napoca, 1999

- **I. Salomie ,***Object Oriented Techniques*(in Romanian), Microinformatica Publ. House, Cluj-Napoca, 1995;

- I.Ignat, **I. Salomie,** R. Dollinger, A. Netin, *Fundamentals of Systems and Computer Science* (in Romanian), TUCN Publ. Dept., 1995

- **Salomie I.**, Letia, I.A., Sidorov, S. - "Data Structures and Programming Techniques in C" (in Romanian), EXE Publ. House, Cluj-Napoca, 1991

4.Organized Conferences

- Program Committee Member, IEEE ICCP'07, 3nd IEEE International Conference on Intelligent Computer Communication and Processing, Cluj-Napoca, September 2007
- Section Co-Chair, 9th WSEAS In. Conf. on Automatic Control, Modeling and Simulation, Istanbul, May 2007
- Program Committee Member, IEEE ICCP'06, 2nd IEEE International Conference on Intelligent Computer Communication and Processing, Cluj-Napoca, September 2006
- Section Chairman, IEEE ICCP'06, 2nd IEEE International Conference on Intelligent Computer Communication and Processing, Cluj-Napoca, September 2006
- Technical Program Committee Member, INES 2004 (8th International Conf. on Intelligent Engn. Systems, Cluj-Napoca)
- Section Chairman, INES 2004 (8th Internat. Conference on Intelligent Engineering Systems, Cluj-Napoca, 2004)
- Program Committee Member, ICETA 2001, Kosice, Slovak Republic

5. Invited Professor / Research Fellow

- Invited Professor, 2001-2004, Electronic and Computer Engineering Department, University of Limerick, Ireland
- Invited Professor, 1996, Loyola College in Maryland, USA
- Research Fellow, University of Nottingham, UK, 1993

6. Evaluator in foreign countries for PhD diplomas: University of Limerick, Ireland, Dr. Thomas Newe, 2003; University of Limerick, Ireland, Dr. Kevin Johnson, 2005

11.4.1.1.2. Managerial competence of the project coordinator

National and/or international research projects or contracts won by competition as project coordinator

1.**CEEX FOOD-TRACE** - Integrated IT system for assuring traceability and quality control in food industry, 2006 – scientific coordinator for the Technical University of Cluj-Napoca, Romania, AGRAL Program, Contract nr. 33/2006, Finances: 1.500.000 RON (2006-2008), Participants: Technical University of Cluj-Napoca (Coordinator), University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, SISTEC Cluj-Napoca, CIA Cluj-Napoca

2.**CEEX SCANURGENT** - Screening, profilaxy and correction of children's genital-urinal congenital malformations using minimal invasive techniques (laparoscopy, endoscopy), 2006 – scientific coordinator for the Technical University of Cluj-Napoca, Romania ,VIASAN Program, Finances: 150.000 RON, Participants: Medicine University of Cluj-Napoca (coordinator), Technical University of Cluj-Napoca, Oncological Institute Cluj-Napoca

3.**CEEX INTELPRO** – Intelligent system for assisting the therapeutically decision at patients with prostate cancer, INFOSOC Program, Contract 18, CEEX-I03/2005, Finances: 1.500.000 RON (2005-2008), Participants: Medicine University of Cluj-Napoca (coordinator), Universitatea Technical University of Cluj-Napoca, Oncological Institute Cluj-Napoca, SAIA, S.C. IPA S.A.

4. **Curricula development reasearch with Microsoft technologies** (2003-2004), For: Microsoft Research,

Cambridge, Finance: USD 27.500, Project coordinator for "Distributed Systems" and "Programing Techniques"
5. **Automated Verification of Security Protocols** (2002-2006), For: Irish Research Council for Science, Finance: Euro 190.000, Responsible for Technical University of Cluj-Napoca
6. **Network for Web based Education in European Studies** (CONED), Tempus IB_JEP-13467-98, 1998-2001. International Project Coordinator, Finances: Euro 250.000, For: EU Phare Project, Participants: Technical University of Cluj-Napoca (Coordinator), University of Limerick, Politechnico di Torino, University of Utrecht
7.**Mobile calculus oriented on services in distributed systems**, code CNCSIS 653, MEdC, 1998-2000, Project Coordinator
The coordination of laboratories, centers and/or research institutes**:** Founder of "Distributed Systems Research Laboratory", Technical University of Cluj-Napoca, http://dsrl.coned.utcluj.ro

11.4.1.2. Research Team

The list of research team members: (without the project coordinator)

Nr. crt.	Name	Year of birth	Title	phd * *	Signature
1	Dinsoreanu Mihaela	1970	Conferentiar	yes	
2	Chifu Viorica	1973	Assistent	Attending	
3	Cioara Tudor	1982	Researcher	No	
4	Anghel Ionut	1983	Researcher	No	

11.4.1.2.1. Experienced Researchers

Mihaela Dinsoreanu is **Conf.dr**. at the Computer Science Department of the Technical University of Cluj-Napoca.
Experience: A. Inteligent systems based on ontologies reasearches in the CEEX projects INTELPRO - system for assisting the therapeutical decision at patients with prostate cancer and FOOD-TRACE - Integrated IT system for assuring traceability and quality control in food industry. These are open projects. **B.** Researches in the domain of modeling distributed systems using technologies based on agents for the PhD thesis. The thesis has an interdisciplinary character combining elements from research domains like: software engineering based on agents, distributed systems, formal modeling. The essential theoretical and applicative aspects of modeling systems using agents at different abstraction levels are treated in the thesis. The proposed solutions have been validated with many practical implementations like: a generic platform independent framework which implements defined structures, a specific application for evaluating students' knowledge developed using the framework mentioned and an application for formal verification of agents behaviour.
Competence Domains: Agent based systems, inteligent systems based on ontologies, software engineering.
Book: Developing agent based systems, UTPress, Cluj-Napoca, 2006, ISBN 973-662-219-3
Papers:
I. Salomie, A. Moga, M. Dinsoreanu, J. Soos, *Enhancing Web Service Composition with Self-Healing facilities*, WSEAS TRANSACTIONS on INFORMATION SCIENCE & APPLICATIONS, Issue 1, Volume 4, 2006, ISSN 1709-0832
II. C.Cosara, I. Salomie, M.Dinsoreanu, *A Quality Model for Service Selection*, 2nd IEEE Internat. Conf. on Intelligent Computer Communication and Processing, Cluj-Napoca, 2006, ISBN 973-662-233-9
III. Moga Al., Soos J. Salomie I., Dinsoreanu M., Adding Self-healing Behaviour to Dynamic Web Service Composition, 5th WSEAS Int. Conf. on DATA NETWORKS, COMMUNICATIONS & COMPUTERS, Bucuresti, 2006
IV.M.Dinsoreanu, I.Salomie, C. Godja, C. Anghel, T.Coffey, *Mobile Agent Based Solutions for Knowledge Assessment in eLearning Environments*, In Proc. of EUROMEDIA'2003 Conference, Plymouth University, Plymouth, UK, April 14-16, 2003
V.M.Dinsoreanu, I.Salomie, C. Godja, C. Anghel, T.Coffey, *Mobile Agent Solutions for Student Assessment in Virtual Learning Environments*, accepted at IAWTIC 2003 Conference, 12-14 Feb. 2003 Viena, Austria.
Member in the Projects

I. FOOD-TRACE - Integrated IT system for assuring traceability and quality control in food industry,

Contract
CEEX/2006

II. SCANURGENT - Screening, profilaxy and correction of children's genital-urinal congenital malformations
using minimal invasive techniques (laparoscopy, endoscopy), Contract CEEX/2006

III. INTELPRO - Intelligent system for assisting the therapeutically decision at patients with prostate cancer,
Contract CEEX/2005

IV. Intelligent System For The Noninvasive Detection and Evaluation of Liver Fibrosis, Restructuration and Dysplastic Nodules, Using 2d/3D Ultrasound and Molecular Markers – SIDEF, Contract CEEX/2006

11.4.1.2.2. Junior Researchers

Viorica Chifu is PhD student at the Computer Science Department of the Technical University of Cluj-Napoca having as PhD thesis *Automated composition of Web services based on QoS*. **Competence Domains:** *Ontology Learning, Semantic Web Services, Automated Web Service Composition.* Based on her experience, Viorica Chifu will be involved in the following activities from the project plan: developing domain ontology models, developing automated composition techniques and strategies, obtaining an experimental prototype. **Papers: 1.**V.R. Chifu, I. Salomie. **An architecture for QoS driven automatic web service composition**, IEEE 2nd International Conference on Intelligent Computer Communication and Processing, September 2006.**2**.V.R. Chifu, I. Salomie, E.S.Chifu. **Ontology model for traceability services in Food Industry**, ICETE(accepted), Barcelona, Spain, July 2007.

Tudor Cioara is MSc student at the Computer Science Department of the Technical University of Cluj-Napoca having as dissertation thesis *Distributed Models with SOA and Web Services.* **Competence Domains**: *Distributed Systems, Web Services, service oriented architectures, business modeling.* Based on his experience, Tudor Cioara will be involved in the next activities from the project plan: domain study, developing annotation techniques and models, developing selection algorithms, obtaining an experimental prototype. **Papers**: **1.** I. Salomie, T. Cioara, I. Anghel, et al. **Machine and Business Modeling and Simulation for Workflow Integration**, WSEAS Istanbul Turkey 2007.**2.** I. Salomie, T. Cioara, I. Anghel et. al. **Workflow Models Enhanced with Process Algebra Verification for Industrial Business Processes**, WSEAS Crete, 2007.

Ionut Anghel is MSc student at the Computer Science Department of the Technical University of Cluj-Napoca having as dissertation thesis *Service Oriented Distributed Systems*. **Competence Domains**: *Distributed Systems, Web Services, service oriented architectures, business modeling.* Based on his experience, Ionut Anghel will be involved in the next activities from the project plan: developing QoS models, developing annotation techniques and models, obtaining an experimental prototype, testing, corrective actions. **Papers**: **1.** I. Salomie, T. Cioara, I. Anghel et al. **Machine and Business Modeling and Simulation for Workflow Integration**, WSEAS Istanbul Turkey 2007.**2.** I. Salomie, T. Cioara, I. Anghel et al. **Workflow Models Enhanced with Process Algebra Verification for Industrial Business Processes**,WSEAS Crete 2007

11.4.2 Other Resources

11.4.2.1. Financial Resources

The costs are structured in years and phase expendure. The staff cost was calculated with respect to HG 475/2007 regulations. In Table 1 explicitely specifies the costs for every research team member and also his/her activity weight in comparison with the full norm.

		2007		2008		2009		2010		Total
Nr.crt.	Phase Name	Value	% from full norm	Value	% from full norm	Value	% from full norm	Value	% from full norm	Value
1	Staff costs	60000		200000		200000		120000		580000
	Prof. I.Salomie	13000	30.51	50300	30.00	50300	30.00	25100	19.7	138700
	Conf. M.Dinsoreanu	13000	30.51	50300	30.00	50300	30.00	25100	19.7	138700
	As. V. Chifu	14694	51.18	43000	38.00	43000	38.00	30200	35	130894
	MSc. T. Cioara	9653	51.18	28200	38.00	28200	38.00	19800	35	85853
	MSc. I. Anghel	9653	51.18	28200	38.00	28200	38.00	19800	35	85853
2	Indirect costs	15000		52500		52500		30000		150000

3	Motilities	5000		10000		10000		10000		35000
4	Logistic	20000		87500		87500		40000		235000
	Total on years	100000		350000		350000		200000		1000000

Table 1. The project cost structure

11.4.2.2. Available Infrastructure

The research project will proceed in the Distributed Systems Research Laboratory. The DSRL lab has the following resources:7 IntelCore 2.4GHz, 2Gb RAM Computers; 1 Intel Core 3.4 GHz, 4GbRAM Computer; 3 Intel Pentium 2.66GHz, 512Mb RAM Computer

Other Resources: HP LaserJet Printer, Xerox 5815, HP ScanJet ADF Scanner, 2 UPS APC, wireless Access Point

The Microsoft Licenses are available through the Microsoft Academic Agreement Program.