Meta Architecture for Intelligent Information Systems

- Possition paper -

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ABSTRACT
In this paper, we identify meta architecture of the Intelligent Information Systems as an open research problem addressing some of the big challenges that the Information Technology industry is now facing in the environment of current trends on the turbulent global market. As the foundation of future research, the proposed metamodel is to be evaluated against different application areas as well as related information technologies, starting with the area of social computing.

Author Keywords
Meta architecture, social computing.

ACM Classification Keywords
H.5.3 Group and Organization Interfaces

INTRODUCTION
Advancements in the Information Technology (IT) are rapidly becoming leading force in human society development. As a consequence, the mutual impact is more and more evident where IT not only changes the way humans live and work (including businesses, social life, government, entertainment, etc.) but it also suffers tremendous pressure to deliver human-oriented value that is actually needed. We have witnessed last years how big the expectations for IT could be: ".com" bubble spectacularly raised immediately after emergence of first signs of the great value that Internet, as the global IT infrastructure, brings along.

Intelligent Information Systems (IIS) represent the next generation of information systems embodying knowledge that allows them to exhibit intelligent behavior, cooperate with users and other systems in problem solving, discovery, access, retrieval and manipulation of a wide variety of multimedia data and knowledge, and reason under uncertainty 6. The IIS is no more only passive (collecting information, processing and presenting it in a structured way as a classical information system does) but also open, global, interactive and reflective (it is an integral part of a global environment, it reasons about behavior, communicates and collaborates, has the purpose and mission, etc.). This new setting presents fundamentally new challenges to the IT research community that is no more closed and "elitistic" but expected to provide pervasive open platforms for heterogeneous and multi-disciplinary work. Having a historical perspective, we can see IT advancing in a predictable sequence of five "mega waves", where we currently are at the end of the third and at the beginning of the emerging fourth mega wave 5.

In this paper we present the vision of what the value-add frontier of IT development will be on the forth "mega wave". We identify IIS as the central point in the world of content, systems, organizations, communities, and businesses converging into a global virtual infospace. We also argue that the meta architecture of the IIS is the most promising approach to provide necessary "virtualness", separation of concerns, and value-add in the global infospace environment. Hence, we propose metamodel of *the Intelligent Information Systems Virtual Machine (IISVM)* - a universal platform for transparent from-value-to-machine design.

ASPECT ORIENTED IIS DESIGN
For design of the IIS systems we adopt best practices form the Aspect Oriented Programming (AOP) 4 discipline, with a goal to generalize separation of concerns principle up to the strategy level. The principle empower us to cope with high problem complexity by adopting approaches already proven in the software systems design, (such as component-based approach 9, meta-programming 1, etc.) and applying them transparently across whole chain of concerns up to the highest abstraction levels (such as value creation 12, resource planning 11 and coordination 14, and e-Business models 13). As a result of the approach, we envision *the Intelligent Information Systems Virtual Machine (IISVM)*: A universal, transparent, and pervasive IT platform for development of reflective value-driven applications.

Technology aspect of the IIS is increasingly correlated to the areas such as 6: discovery of knowledge from large data collections; providing cooperative support to users in complex query formulation and refinement; access,

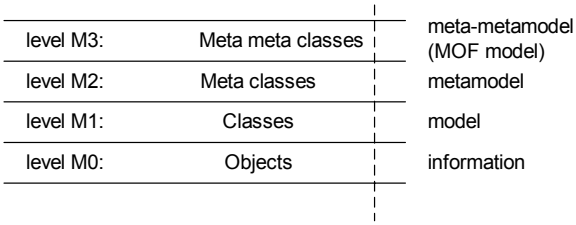

Figure 1: MOF four layer metadata architecture

retrieval, storage and management of large collections of (multimedia) data and knowledge; information integration from multiple heterogeneous data and knowledge sources; behavior and information unity in virtual systems, and reasoning about information under uncertain conditions. Having in mind ultimate impact of the global network, the emerging need for new tools and techniques for management of these dynamic and evolving information spaces existing on a global scale over the Internet is evident.

Value (business and social) aspect of the IIS has evolved, due to the global acceptance of the Internet, from very limited impact (when computing centers were used for IT support of big enterprises needs only) to increasingly high (e-government, e-communities, e-business, e-learning, etc.). Consequently, IIS is required not only to automate information processing, storage and distribution but also to reason about issues such as knowledge sharing 9,13, value creation 12, and social impact 15.

Design aspect of the IIS includes interoperability, platform independence, reusability, concurrency and abstraction. This aspect has been in the focus of research in IT community for a long time 8, resulting in emerging technologies such as Model Driven Architecture 16 and Service Oriented Architecture 20. Our belief is that the design aspect will benefit the most from the proposed approach by adopting mechanisms from other aspects as design components (for example, applying auctions and value-based formal business models to the collaboration of software components and platforms, e.g. see 18) while ”borrowing” well-known proven design practices to other aspects as well.

META ARCHITECTURE

We base meta architecture of the IISVM on the Meta Object Facility (MOF) four layer metadata architecture (Figure 1:) 3. We adopt the level M3 from the MOF model and the reflection on the same level 1,3, while building the proposed meta architecture on the M2 level.

The proposed metamodel is shown in Figure 2: . We may distinguish “object” and “relation” meta meta objects (instances of meta meta classes): mClass, mComponent, mActor, and mRole may be interpreted as “object” meta classes, while Generalization, Agregation, Communication and Association as relation meta classes.

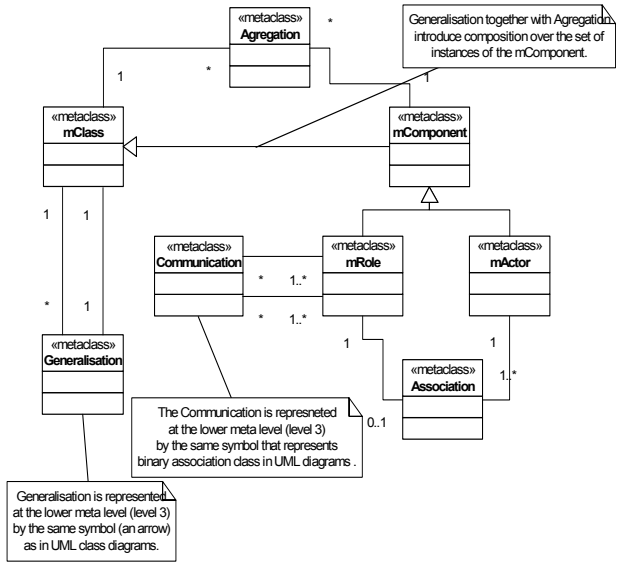

Figure 2: The IIS metamodel

The metamodel facilitates unified approach to different aspects of the IIS design (as previously described): mClass, Aggregation and Generalization support the technology aspect following object-oriented programming approach; mComponent, Communication, and Association support design aspect, while mActor, and mRole support business and social aspect. The fact that all that meta classes belong to the same metamodel enable us to reason about the system in a transparent and unified way across all aspects of the IIS.

Let us given the set of components and the set of classes of objects from the set of components. Following well-established theory of the object-oriented programming, represented with the UML standardization initiative and the MOF architecture 3, there is an inheritance relation (the generalization meta class in Figure 2:) introduced in the set of classes. For example, in a system where User, Mediator, ServiceProvider are possible components, all of IndividualUser, EnterpriseUser, and Administrator classes may share the common base class User.

It should be noted that the mComponent is specialized into two sub-classes: mRole and mActor. The idea is to separate architectural concerns of behavior from the interaction concerns: The only component that may have associated actions and/or behavior is the mActor class, while mRole component is the only one that may be involved in an interaction by means of the associated Communication. In this way, an actor that have specified behavior and performs some actions may interact with the rest of the system only if it is encountered in an interaction by accepting some role in the system. An actor may have multiple roles and multiple actors may “play” the same role.

In the proposed architecture, the Communication is not a component (it doesn't inherit mComponent class). In this way, we provide the crucially important flexibility for dealing with reflectiveness and interaction. For example, let us consider a simple client-server setting. Traditionally, we have two roles (client and server) assigned to two components (e.g. web browser and web server, respectively) with implicitly assumed communication capabilities. However, the proposed architecture enables us to identify the third role: the client-server interaction role. The client and server roles do not communicate directly, but by means of the interaction role. In this way, we are able to implement the interaction role by different components that may act as a network communication protocol 20, an auction based negotiation 18,2, or a very complex social interaction 15,23.

SOCIAL COMPUTING: AN APPLICATION CASE STUDY

Social computing is an emerging inter-disciplinary research area addressing synergy potential of social aspects in the information society. It builds on the mass adoption of information technologies: Current estimates of Internet users hover around 200 million, with one billion users anticipated by 2005, together with the 'Net's technology-mediated communication services that provide unique opportunities for extending many human pursuits 21. Following the trend towards fully pervasive computing where end-points of information streams may be humans as well as machines, it is evident that the social dimension becomes crucially important 22,24. Also, we are in a transition from traditional understanding of computers as "things that think" (what computers can do?) to much more powerful "things that make us smart" (what people and computers can do together?) 23.

We believe that the proposed IISVM architecture may answer the challenge of achieving full power of the social aspect of the computing in general. Particularly, it is possible to develop solutions for efficient addressing of social reflection of the computing in diverse application fields, such as e.g. education 24, enterprise applications, etc. Our current research is focused on development of the concept of "recommendation" in the social computing environment, as an application testbed for the proposed architecture.

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