A Report on the First European Conference on Software Architecture (ECSA'2007)

Carlos E. Cuesta
Kybele, Dept. Comp. Lang. and Syst. II
Rey Juan Carlos University
Móstoles 28933 Madrid, Spain
carlos.cuesta@urjc.es

Esperanza Marcos
Kybele, Dept. Comp. Lang. and Syst. II
Rey Juan Carlos University
Móstoles 28933 Madrid, Spain
esperanza.marcos@urjc.es

1. INTRODUCTION

Software Architecture, defined as the formal study of the structures and patterns of complex software systems, is already in its second decade as a regular discipline within Software Engineering. Not so long ago, architectures were simply left implicit. Today this would not be possible anymore; software applications cannot be conceived as isolated monoliths. Almost any software piece is now part of another system, and these systems have become themselves distributed, more complex, and larger.

Information systems are perhaps the best example, as they have become software-intensive systems. Though their original appeal was the management of data, nowadays they use these capabilities also to manage mostly everything else, including the interaction between actors or the enforcing of workflow policies. Their design has become a matter of integrating different frameworks and component models, independent subsystems or even full applications. The need to explicitly describe and manage these relationships has made architectural reasoning critical. Today architectures face important challenges, from the issues derived of their dynamic and evolutionary nature, to the complexity of integrating large-scale systems of systems, perhaps using novel paradigms such as service-orientation.

This report focuses on the First European Conference on Software Architecture (ECSA'2007), which was held in Aranjuez near Madrid, in Spain, during 24-26 September, 2007. This conference is already considered as the premier European meeting for researchers in the field. In this edition, the meeting was promoted to a full-fledged conference, built on the success of the previous series of European workshops, held in the UK in 2004, Italy in 2005 and France in 2006. This edition has been organized and hosted by the Kybele Research group from Rey Juan Carlos University in Madrid, led by Dr. Carlos E. Cuesta and Dr. Esperanza Marcos, who acted as Conference Co-chairs. In turn, the Program Committee was chaired by Prof. Flavio Oquendo from the University of South Brittany in France.

The Conference received 62 paper submissions, from which the Program Committee selected finally 18. Papers were categorized into three kinds according to their length –long, short and position paper– and four kinds according to their contents –full paper, emerging research, experience report and research challenge–. Only five of them were accepted as full papers, giving an acceptance ratio of 10%, which raises up to 30% when every presented paper is considered. Moreover, the Conference also included a poster session, in which an additional 25% of the authors were invited to re-submit their papers in the form of posters. The Conference Proceedings [1] were published by Springer as the volume 4758 of the Lecture Notes in Computer Science series.

The research in these papers was presented by Conference attendants during five thematic sessions, namely: (i) Architecture Description and Evolution, (ii) Architecture Analysis, (iii) Architecture-Based Approaches and Applications, (iv) Challenges in Software Architecture and (v) Service-Oriented Architectures. The conference included also a very lively poster session, conceived as an integral part of the main program, where the 16 accepted posters were exposed and presented to an evaluation jury.

Finally, there were three keynote talks during the conference, given by some of the world-wide topmost researchers in the area. Professor David Garlan exposed the need to use high-level architectural descriptions to achieve task-oriented computing. Professor Ron Morrison detailed how the evolutionary nature of software requires to consider the dynamic structure of architectures, to be able to deal with emergent behaviour. And Professor Mike Papazoglou exposed the core concepts and ideas behind service-oriented architecture.

In the remainder of this article we will briefly summarize some of the ideas and issues which were discussed during these talks, and the different sessions.

2. KEYNOTE TALKS

Three outstanding and well-known researchers in the field of Software Architecture were invited to give keynote talks about the state-of-the-art in the field, and outline research challenges for the immediate future.

The first talk, also the conference opening, was given by David Garlan, from Carnegie Mellon University. He advo-

cated the human-level notion of *task*, the full set of activities that the system must perform to fulfill an user's need. A task-oriented approach requires the participation of many components and hence defines very complex architectures. This also implies the *adaptive integration* of the system.

The second talk was given by Ron Morrison, from the University of St. Andrews. It dealt with active, self-describing architectures and their *dynamic co-evolution*, where a system is in a constant state of flux. The notions of locus and incarnation were defined to identify evolution boundaries, and a control-inspired solution, in the form of Producer/Evolver pairs, was proposed.

The third talk, also the conference closing, was given by Michael Papazoglou, from Tilburg University. He presented complete outline of the state-of-the-art in SOA and the notion of service, where he stressed the need for an adequate engineering methodology. The study concluded by describing the Enterprise Service Bus, a high-level infrastructural architecture for business services.

In summary, the three talks exposed three critical and also related issues for the future of software architectures.

3. ARCHITECTURE DESCRIPTION

The first session tackled a traditional topic of Software Architecture research, the accurate description of architectures. However, none of the papers followed a traditional approach; most of them focused on the difficult issue of system evolution and dynamic architecture, while the other discussed the need for more elaborate semantics.

This last paper discussed the lack of actual semantic capabilities in architecture description languages (ADLs). The use of an *ontological* framework at the meta-level, based on description logics, was proposed, and defined to be integrated into any existing ADL or even UML.

As noted, the remaining three papers focused on *dynamic architectures*. The first one used a formal approach for the description of *publish/subscribe* architectural styles. These are built by combining patterns described as graphs, detailed using the Z notation, so that the consistency can be proved. Dynamic evolution is covered in the form of guarded graph-rewriting rules, also written in Z. Another proposal intended to provide a standard way to deal with *static* architecture evolution, by defining a pattern-based approach inspired by Jackson's notion of *problem frames*. Requirements are captured in the form of such frames, and every frame is mapped to some standard pattern; then requirements evolution imply architectural change. Finally, the last one presented a complete framework for the *incremental evolution* of software architectures. It is based in the notion of architecture integration pattern, which structure the knowledge required to integrate new functionality. Inspired by aspect-orientation, it provides a set of actions which define a domain analysis of dynamic architecture.

Morrison's keynote dealt also with architectural evolution, also a popular topic in the poster session. There is a clear trend to stress the relevance of this issue, and this will surely influence many future developments in this research area.

4. ARCHITECTURE ANALYSIS

A classic topic in software architecture research, it seems to focus currently on the methodological side. Beyond the traditional use of formal methods, analysis has now a goal-oriented flavor, and it is supported by empirical techniques.

Several papers proposed a goal-oriented method to evaluate architectures. The first one exposed the size limitations imposed by scenario-based approaches such as ATAM, and proposed a GQM approach, based on organizational patterns and goal-guided metrics, which seems to adapt to large-scale architectures. The second one used another goal-oriented method, the i^* framework, which models functional and non-functional requirements in terms of actor dependendencies. Architectures are then generated from requirements using certain guidelines; the choice between alternatives is made using metrics. The third paper discussed the inadequacy of existing architectural metrics, which don't consider system-wide concerns, and proposed a concern-driven measurement framework, designed to assess architecture modularity and, again, to choose among different alternative architectures.

The remaining paper was the only one which used a formal approach. The proposal uses a semi-formal diagrammatic language, which is translated to Maude specifications, and model-checked against LTL. State explosion is reduced by using hierarchic encapsulation.

In summary, there is a clear trend to consider goal-oriented approaches. This implies also that the role of architectural metrics is becoming central; research in this area is consequently expanding.

5. ARCHITECTURE-BASED METHODS

This session was devoted to describe developments in which the role of architecture was considered critical. In every case, a generic perspective was used, so that their particular conclusions could be extended to a wider scope.

The first paper exposed the interest of combining architectural and model-driven approaches, using a case study about Wireless Sensor Networks (WSN). Domain-specific models are combined to architectural PIMs, and then transformed into platform-specific applications, using standard MDE tools. The second one tackled the problem of developing adaptive user interfaces in context-aware applications. To solve it, an aspect-oriented, event-based framework architecture, is defined, where *adaptability aspects* are able to modify the interface to react to certain situations. The third paper exposed the experience of developing an architecture for multimodal systems, which is shown to comply with the W3C Multimodal Interaction Framework. Separation of concerns is achieved by defining a *staged architecture*, in which a new concern is added at every stage. The last paper introduced a method for architecture migration at the code level, where software evolves by imposing a new architecture to existing code. This approach uses *graph transformation* techniques, and is driven by annotations of code categories, which define the nodes.

In summary, every lecture described an hybrid approach. Two of them were inspired by aspect-oriented concepts, while the other two were directly supported by model-driven tech-

niques. Obviously, research in both areas is having a relevant impact in Software Architecture.

6. CHALLENGES IN ARCHITECTURE

This session was devoted to describe some of the challenges faced by current research in Software Architecture. While some works described concrete developments about them, the rest discussed additional issues and outlined a research agenda for the immediate future.

Several papers discussed the issue of capturing architectural design decisions. The first paper proposed to use the background on knowledge management to define adequate means for sharing it, and identified the desired properties of an architectural knowledge sharing tool. The second one reflected on the impact of these architectural decisions, and proposed to estimate their consequences by using patterns, which should be extended to include additional information about quality attributes. The third paper discussed the issues in applying the principles of Empirical Software Engineering to Software Architecture. There are very few empirical studies within the field, and it is argued that concrete criteria must still be defined to decide when an architecture is good enough. Some additional issues were also identified.

Finally, the remaining paper presented a complete review of the state-of-the-art in Software Architecture, considering the case of large-scale complex systems. It first reviews academic research, its challenges and limitations, and then industrial research, exposing its contributions. To conclude, a research agenda for both, and their synergies, is proposed.

7. SERVICE-ORIENTED ARCHITECTURE

Though service-orientation was one of the main topics in the conference, only a few papers about services made their way into the final program.

The first paper described a simple approach to model service-oriented architectures using a conventional ADL. This is made by providing a new "web service" connector for an ArchJava extension, so that glue code is automatically generated. The second paper presented a concrete architecture, where services are used to interface to several distributed high-performance computing (HPC) systems, to combine them and to expose the result.

Finally, the keynote talk by Michael Papazoglou, can also be related to the topic of the session, though his approach was more conceptual, rather than simply technological.

8. POSTER SESSION

The poster session was intended from the start an integral part of the Conference's main program, instead of considering it as a side activity. In fact, most of the conference attendants participated in this session, which gathered a lot of interest. To some extent, the poster session could be considered as a general session on emerging research. Most of the topics were also considered by some papers in the main program, so there is a continuity between them. Sixteen different posters were presented, gathering authors from the UK, Mexico, Australia, Germany, Portugal, France, Italy, Brazil and Spain. The variety of their approaches, their interdisciplinary nature and the intertwinning of their topics made the session particularly dynamic and active. An international jury examined every poster and listened to the individual presentation of every author. After this evaluation, they granted the Best Poster Award to a work describing a goal-oriented methodology for the automatic synthesis and generation of *proto-architectures* from the initial requirements specification.

The most popular topic was the relationship and mutual influence of *software architecture and Model-Driven Engineering* (MDE) approaches; both the role of architectures within MDE, and the use of model-driven techniques in architecture. The second most popular topic was *aspect-oriented architecture*, that is, explicit separation of concerns in architecture, leading to non-modular structures and crosscutting models. This theme is already a classic of European research, and it is still very popular. The next topic was the study *architectural styles*, dealing both their impact on design, and the definition of new proposals. This was also generalized to a full model, and to concrete kinds of architecture. The fourth topic was *architecture evolution and dynamic reconfiguration*, also an important topic in the main program. Different techniques to support dynamism were proposed, namely reflective self-description, aspect-oriented dynamic reconfiguration, and event-based middleware. And finally, a single poster was devoted to the documentation and management of *architectural design decisions*, a topic also already considered within the main program.

In summary, six posters were devoted to the first topic, five (two of them indirectly) to the second one, four to the third, three to the fourth and one for the fifth theme. There was also a certain degree of overlapping between them, which helped to make the discussion even more interesting.

9. SUMMARY AND FUTURE WORK

The conference was an intense and active meeting and was perceived for the partipants as a great success. The European research community on Software Architecture has been definitely established and can be considered as a solid one, with its own character and specific features, which often differ from those from the international community.

The ECSA series of conferences will continue for years to come. The next edition will be held in Cyprus, and there are prospects until 2010. In 2009 it will be a joint event gathering ECSA and WICSA, the first and topmost conference on Software Architecture. This builds on the ongoing cooperation between the two communities, and confirms ECSA as the second international event in the field.

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10. REFERENCES

[1] F. Oquendo, editor. *Software Architecture, First European Conference (ECSA 2007) Proceedings*, volume 4758 of *Lecture Notes in Computer Science*, Aranjuez, Spain, Sept. 2007. Springer.