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Software-Intensive Systems and New Computing Paradigms

Challenges and Visions

Springer

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Preface

Software-intensive systems have become increasingly important for a multitude of products and services from all sectors of the economy, our national and international infrastructure, and our daily lives. The ongoing decrease in size and cost of microprocessors and storage devices is leading to the development of ever more distributed and decentralized systems. Systems are assembled as dynamic federations of autonomous and evolving components instead of monolithic applications, they perform tasks of staggering complexity with continuously changing requirements and in a permanently evolving environment. In the near future novel technologies will allow the construction of systems with millions of nodes, and systems will be likely to contain subsystems based on new computing paradigms such as molecular computing.

To identify these emergent trends, their impact on the information society in the next 10–15 years, and the challenges they present to computing, software engineering, cognition and intelligence, the European Commission has established two Coordinated Actions: initially the project "Beyond the Horizon"[1] and then, starting in 2006, the project "InterLink"[2]. Both projects are coordinated by the European Research Consortium for Informatics and Mathematics (ERCIM EEIG) and funded by the Future and Emerging Technologies (FET) Unit of the European Commission. The ongoing project InterLink is composed of three thematic working groups: software-intensive systems and new computing paradigms; ambient computing and communication environments; intelligent and cognitive systems.

This volume presents the results of the working group on software-intensive systems and novel computing paradigms. The objective was to imagine the landscape in which the next generations of software-intensive systems will operate. To this end three workshops were organized on this topic. Participation in the workshops was by invitation only. Over 30 leading researchers from Europe, Asia, Australia, USA, and Canada presented and discussed future R&D directions, challenges, and visions in the emerging areas of software-intensive systems and new computing paradigms. Each workshop was structured by a three-step process: At first the participants presented those topics and developments they considered to be the most interesting and challenging in the field. Then the participants split into working groups according to the central themes that had been identified in the initial presentations. In a concluding plenary session the results of the working groups were integrated.

From the beginning of the workshops it was evident that future software-intensive systems will feature massive numbers of nodes per system, operate

[1] http://beyond-the-horizon.ics.forth.gr/
[2] http://interlink.ics.forth.gr/

in open, non-deterministic environments, deal with large amounts of data, interact with humans or other software-intensive systems, and adapt to new requirements, technologies or environments without redeployment. To characterize software-intensive systems with these properties, the workshop participants agreed on the term "ensembles." Key research topics comprise the design of emergent systems, management of uncertainty, dependability and trustworthiness of ensembles.

Another important aspect is the development of self-organizing systems with autonomic behavior. Present programming paradigms are less and less adequate the more autonomous software-intensive systems become. New paradigms have to be invented, implemented and evaluated in order to develop high-quality and efficient "ensemble computing systems." Unconventional computing paradigms inspired by biology, chemistry, life or nature are active areas of research areas. The field is now mature enough that true applications in realistic environments can be built and also deployed on traditional Von-Neumann architectures.

This volume starts with an overview of the current state of the art and the research challenges in engineering software-intensive systems. The remainder of the book consists of invited papers of the working group participants and is structured in three major parts: ensemble engineering, theory and formal methods, and novel computing paradigms. These papers cover a broad spectrum of relevant topics ranging from methods, languages and tools for ensemble engineering, socio-technical and cyber-physical systems, ensembles in urban environments, formal methods and mathematical foundations for ensembles, orchestration languages to disruptive paradigms such as molecular and chemical computing.

Many persons contributed to the success of our workshop series. We offer sincere thanks to all of them. We are particularly grateful to Jessica Michel, Patricia Ho-Hune, and Florence Pesce of ERCIM for their invaluable work and effort in preparing and organizing the workshops. Their friendly manner and managerial skills contributed a great deal to the success of the workshops. We thank our workshop hosts in Urbana-Champaign, Grigore Rosu and José Meseguer, for a productive and friendly work environment. The InterLink project would not have been possible without the scientific coordination of Constanine Stephanidis, Dimitris Plexouxakis, and Antonis Argyros. We thank the EC project officers Wide Hogenhout, Thomas Skordas, and Walter van der Velde for their continuing encouragement and support. We are also grateful to Springer for their helpful collaboration and assistance in producing this volume. Our sincere thanks go to all authors for the high quality of their scientific contributions and for accommodating our tight schedule. Finally, we thank all workshop participants for the lively discussions and their deep insights into the subject matter.

September 2008

Martin Wirsing
Jean-Pierre Banâtre
Matthias Hölzl
Axel Rauschmayer

Coordination Action InterLink

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3. Intelligent and cognitive systems
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- Jeff W. Sanders
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- Lui Sha
- Doug Smith
- Graeme Smith
- Darko Stefanovic
- Carolyn Talcott
- Christof Teuscher
- Martin Wirsing

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