Autonomic Communication

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Editors

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Springer

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Foreword

As information technology becomes increasingly more sophisticated and capable, repeated studies have demonstrated that this has been matched by an increasing cost and complexity in configuring, managing and servicing such systems.

Despite the obvious benefits in performance & scalability that has been provided by the ongoing evolution of faster CPUs, increased network bandwidth and storage capacity, the cost of dynamically managing the hardware, software and infrastructure has continued to rise at an alarming rate.

Autonomic Computing emerged at the dawn of the 21st century out of cross-industry and academic research and development in simplifying administration, configuration, deployment and management of IT systems.

Driven by a need to address what many had seen as a growing crisis in the IT industry for increased visibility, control and automation of complex IT systems, autonomic computing focuses upon providing embedded and integrated management systems that enable self-healing, self-configuration, self-optimization and self-protection.

As we move into the era of energy-aware IT systems and cloud-computing, the needs for autonomic systems have continue to evolve. Recently there has been an increased awareness of the need for efficient utilization of data centers associated with the changing economics of energy supply and the politics of climate change. Optimal use of communications infrastructure and the associated middleware has becoming increasingly critical. Embedded autonomic capabilities to provide self-management has become critical in delivering new dynamic infrastructure in IT.

Increased use of the Internet has led to global-scale broad-band networking. When coupled with adoption of wireless communications and mobile computing by consumers and enterprises, the need for self-managing network services and autonomic communications becomes more pressing. The same network infrastructure is being shared across more and more services. Enterprises, consumers and governments expect to have communication systems that can autonomically recover from failures or reconfigure themselves to cope with increased demand.

Those same network services are also being used to provide interfaces onto traditional physical infrastructure: Smart utility grids for efficient production and distri-

bution of gas, water and electricity, wireless home-metering, remote wireless tracking of parcels, shipping containers and wireless monitoring of the environment and climate change. These are all expected to become the norm as we progress towards the 'Smart Planet'.

This volume is a timely overview of the evolution of autonomic computing to communications, networking and sensor systems, and provides detailed insights into the multi-disciplinary research topics that comprise the field of Autonomic Computing and Communications.

April 2009

Dr. Matt Ellis
Vice President
Autonomic Computing, IBM

Preface

The emerging world is pervasive and strives towards integrating people, technology, environment and knowledge. This emerging vision supports approaches that set the user at the center of attention, while technology becomes invisible, hidden in the natural surroundings, but still functional, autonomous, self-adaptive, available when needed, and interactive.

Achieving this vision requires innovative communication architectures and services. Communication/networking solutions should become task- and knowledge-driven, enabling a service oriented, requirement and trust based development of communication infrastructure. The growing complexity of control requires increasingly distributed and self-organizing structures, relying on simple and dependable elements that are able to collaborate to develop sophisticated behaviors, and that can adapt to an evolving situation where new resources can become available, administrative domains can change and economic models can vary.

The networking and seamless integration of concepts, technologies and devices in a dynamically changing environment poses many challenges to the research community. There remain such crucial issues as interoperability, programmability, management, openness, reliability, performance, context awareness, intelligence, autonomy, security, privacy, safety, semantics, etc. However, the overall scale, complexity, heterogeneity and dynamics of these networked environments, together, result in essential management challenges which clearly go beyond current paradigms and practices, and need a fundamentally new approach.

Autonomic Communication is such an approach. It is inspired by biological systems and envisions communication systems that are large self-managing which can organize, configure, optimize, protect and heal themselves with minimal involvement of human administrators.

This edited volume explores conceptual models and associated technologies that will help realize the vision of autonomic communication, where devices and applications seamlessly interconnect, intelligently cooperate and autonomously manage themselves, and as a result, enable the borders of virtual and real world to vanish or become significantly blurred. The chapters contributing to the edited volume are the genuine testimony to the challenges and prospects of this rapidly growing area.

The volume is composed of 14 chapters covering a wide range of issue related to autonomic communication and are organized into 3 parts as listed below.

- Autonomic Communication Infrastructure
- Autonomic Communication Services and Middleware
- Applications to Ad-Hoc (Sensor) Networks and Pervasive Systems

Part I – Autonomic Communication Infrastructure: Part I focuses on various aspects of autonomic communication infrastructure and contains 4 chapters. Chapter 1 titled "*Bio-inspired Autonomic Structures: a middleware for Telecommunications Ecosystems*" investigates a bio-inspired autonomic middleware capable of leveraging the assets of the underlying network infrastructure whilst, at the same time, supporting the development of future Telecommunications and Internet Ecosystems. Chapter 2 titled "*Social-based autonomic routing in opportunistic networks*" investigates contex-aware routing in opportunistic autonomic infrastructures under the prism of peoples' social behavior. Chapter 3 titled "*A Collaborative Knowledge Plane for Autonomic Networks*" looks at a knowledge plane architecture aiming at self-adaptation and self-organization. Chapter 4 titled "*A Rate Feedback Predictive Control Scheme Based on Neural Network and Control Theory for Autonomic Communication*" tackles the difficulty in designing an efficient congestion control scheme by using back propagation neural networks.

Part II – Autonomic Communication Services and Middleware: Part II focuses on specific autonomic communication services and middleware frameworks, and contains 5 chapters. Chapter 5 titled "*Hovering Information – Self-Organising Information that Finds its Own Storage*" investigates a hovering information model and reports on simulations performed using replication and caching algorithms. Chapter 6 titled "*The CASCADAS Framework for Autonomic Communications*" presents a prototype distributed component-ware framework for autonomic and situation-aware communication and demonstrates it via a Pervasive Behavioural Advertisement scenario. Chapter 7 titled "*Autonomic Middleware for Automotive Embedded Systems*" describes an advanced autonomic platform-independent middleware framework focused on automotive embedded systems where high flexibility and automatic run-time reconfiguration is needed. Chapter 8 titled "*Social Opportunistic Computing: Design for Autonomic User-Centric Systems*" focuses on the diffusion of data in autonomic computing environments and the way the social attitudes of mobile users impact their design. Chapter 9 titled "*Programming and Validation Techniques for Reliable Goal-driven Autonomic Software*" investigates time and concurrency which are the most critical notions of complex software interactions in autonomous flight systems.

Part III – Applications to Ad-Hoc (Sensor) Networks and Pervasive Systems: Part III focuses on the applications of autonomic communication to ad-hoc (sensor) networks and pervasive systems, and contains 5 chapters. Chapter 10 titled "*Autonomic Communication in Pervasive Multimodal Multimedia Computing System*" focuses on autonomic communication protocols involved in the detection of interaction context and the multimodal computing system's corresponding adaptation. Chapter 11 titled "*Self-healing for Autonomic Pervasive Computing*" focuses on

the self-healing aspects of autonomic pervasive computing and demonstrates it as a service in the Middleware Adaptability for Resource discovery, Knowledge usability, and Self-healing platform. Chapter 12 titled "*Map-based Design for Autonomic Wireless Sensor Networks*" presents an approach that exploits the spatial correlation of sensor readings and builds a model that abstracts from low-level communication issues and supports general applications by allowing for efficient event detection, prediction and queries. Chapter 13 titled "*An Efficient, Scalable and Robust P2P Overlay for Autonomic Communication*" focuses on the applicability of P2P systems in autonomic communication domain. Chapter 14 titled "*Autonomic and Co-evolutionary Sensor Networking with BiSNET/e*" proposes a biologically inspired architecture that allows wireless sensor network applications to simultaneously satisfy conflicting operational objectives by adapting to dynamic network conditions (e.g., network traffic and node/link failures) through evolution.

Our sincere thanks go to the authors who have contributed to this edited volume by sharing their most recent research findings and expertise. The anonymous reviewers deserve our thanks for their constructive criticism, helpful comments and in-depth insights. Finally, we would like to express our gratitude to Springer for agreeing to publish this volume and especially to Valerie Schofield and her editorial team that we interacted with on a continuous basis. We do hope the community of researchers and practitioners will find the content of this volume inspiring, insightful and enjoyable.

April 2009

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