Chapter 2

Ontology-Based Network Management for Autonomic Communications

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ABSTRACT

This chapter is focused on state-of-the art issues in the area of ontology-based autonomic communications and it considers how ontologies can be useful for network management as a way to achieve semantic interoperability among different network management models. In addition, it presents the autonomic communications paradigm as a possible solution to the ever-growing complexity of commercial networks due to the increasing complexity of individual network elements, the need for intelligent network and communication services and the heterogeneity of connected equipment. Finally, the chapter analyses how ontologies can be used to combine data correlation and inference technologies in autonomic networks. Such technologies are used as core components to build autonomic networks.

INTRODUCTION

Nowadays multimedia information is transmitted under the control of different protocols through various physical devices manufactured and operated by different vendors. Many integrated network management models use different technologies for resource management. Such network management frameworks include SNMP (Simple Network Management Protocol), OSI-SM (Open Systems Interconnection-Systems Management), CMIP (Common Management Information Protocol), DMI (Desktop Management Interface) and WBEM (Web-based Enterprise Management). As different management technologies are used for the same-networked system, semantic interoperability is required among all different network management models in order to provide a unified view of the whole managed system (López de Vergara et al., 2003). Such a semantic interoperability is achieved using ontologies, which could allow machine-supported network management data interpretation and integration.

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From another perspective, there is an increasing network complexity due to the increasing complexity of individual network elements, the need for intelligent network and communication services and the heterogeneity of connected equipment. The ever-growing size and complexity of commercial networks impose new intelligent techniques to manage their operation and communications. The central problem in system and network management is the critical human intervention that is time-consuming, expensive, and error-prone. Many systems management tasks such as system configuration, performance analysis, performance tuning, error handling, and availability management are often performed manually. This work can be time-consuming and error-prone, and it requires a growing number of highly skilled personnel, making IT systems costly. It has been estimated that companies have to spend 33–50% of their total cost of ownership recovering from or preparing against failures (Patterson et al., 2002). Autonomic computing will decline this complexity crisis of commercial networks and automate all the above system management tasks. A high level of autonomy characterizes autonomic systems, while human intervention is only foreseen in the definition of business goals. Autonomic communications improve the ability of network and services to cope with unpredicted change, including changes in topology, load, task, the physical and logical characteristics of the networks that can be accessed, and so forth (Dobson et. al, 2006). Autonomic communications seek to simplify the management of complex communications structures and reduce the need for manual intervention and management. Autonomic communication is more oriented towards distributed systems and services and to the management of network resources at both the infrastructure and the user levels. On the contrary, autonomic computing is more directly oriented towards application software and management of computing resources (Quitadamo and Zambonelli, 2007).

It is worth noting that autonomic communication treats the Internet as an ecosystem (the Internet Ecosystem) and adopts a methodology of using context-awareness and distributed policy-based control to achieve efficiency, resilience, immunity and evolvability in large-scale heterogeneous communication infrastructures. Autonomic communication enables an evolving network platform for sensing, communicating, decision-making, and reacting, with high degree of autonomy to easy human efforts. It draws on a number of existing disciplines including protocol design, network management, artificial intelligence, pervasive computing, control theory, game theory, semantics, biology, context-aware systems, sensor networks, trust, and security. Research in autonomic network management focuses on the development of highly distributed algorithms that seek to optimize one or more aspects of network operation and/or performance, in essence aiming to provide various self-management capabilities. In this context, many researchers are investigating the potential use of biologically-inspired algorithms and processes (Bicocchi & Zambonelli, 2007).

This chapter explores ontology-based autonomic communication issues and how ontologies can be useful for network management as a way to achieve semantic interoperability among different network management models. In addition, it presents how ontologies can be used to combine data correlation and inference technologies in autonomic networks.

BACKGROUND

An ontology is a set of knowledge terms including the vocabulary, the semantic interconnections, and some simple rules of inference and logic for some particular topic (Brewster et al., 2004). An ontology is made up of three parts:

- *Classes and instances* used to model elements.
- *Properties* which establish relationships between the concepts of an ontology.