Models and Architecture for Autonomic Network Management

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ABSTRACT

This paper presents a model-based framework to support the automated and adaptive deployment of communication services for QoS. The application domain targets cooperative group activities applied to military emergency operation management systems. Various models are introduced to represent the different levels of cooperation (applicative / middleware / transport). The adaptation decision process relies on structural model transformations while its enforcement is based on the dynamic composition of micro-protocols and software components. Automated deployment is performed both at the transport (i.e. UDP-TCP level) and middleware level. The architecture to support automated network management based on these models is introduced and its performance is evaluated through the use of a Java prototype. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: Computer Supported Cooperative Work; Decision Models; Distributed Design; Hierarchical Model; Networking; Software Architecture; Traffic Management

INTRODUCTION

Cooperative group activities using wireless mobile communicating systems constitute an increasingly evolving application domain. It is likely to be one of the most important directions that may enable reliable and efficient human and machine-to-machine cooperation under the current networking systems and software, and may deeply shape their future deployment.
Such activity-support systems have to deal with dynamically evolving activity-level requirements under constantly changing network-level unpredictable constraints. Maintaining reliable connectivity and QoS in such a communication context is difficult. Adaptive service provisioning should help the different provisioning actors to achieve this goal and constitutes a challenge for different research communities.

Ad hoc solutions are not likely to be applicable to solve such a complex problem. Providing a basic framework for automated services and QoS deployment may constitute an important contribution towards solving such a problem.

Aiming to answering this problem, we propose a model-based framework for adaptability management. Our framework has been elaborated in the context of network management systems with service provisioning at the transport and network layers of the TCP/IP stack as the final objectives.

Our approach provides, refines and exploits different models, each one representing a different point of view on the context. The models that represent other aspects of communication are automatically generated from higher level models representing the cooperation requirements and the communication constraints. Our research efforts have been developed to cover communication at the transport layer as well as the network layer.

Our paper is organized as follows. Section 2 describes related work. Section 3 describes the different models of the framework. Section 4 presents an architecture to support the use of these models for automated network adaptation as well as an example of their use in response to a change of collaboration. This architecture is currently under study and development within the European NETQoS Project. Section 5 provides an evaluation of the system’s performances under different loads. Finally, section 6 presents conclusions and future works.

RELATED WORK

Classification of Context Adaptation Solutions

This section studies and classifies the main facets of adaptation: its objectives, techniques and properties.

Adaptation Objectives

Adaptation targets several objectives depending on the context in which it takes place. QoS aspects such as access bandwidth issues in roaming scenarios are considered by Kaloxylos (2006). End to end QoS optimization for the Best Effort Internet makes heavy use of adaptation techniques such as considered by Akan (2004). Security in wireless networks, such as firewalls activation and deactivation, can also benefit from adaptability as studied in Perez (2004). Resources optimization related to device power, computation or storage capability are presented by Marshall (2001).

Adaptation Techniques

Application layer – Wu (2001) addresses adaptation of video streaming applications for the Best-Effort Internet. The proposed techniques are based on two mechanisms: an applicative congestion control (rate control, rate-adaptive video encoding) and time aware error control with FEC.

Middleware layer – Reflexive architectures such as OpenORB or Xmiddle as presented by Capra (2003) are good supports for adaptation as they allow run-time modification of the architecture.

Transport layer - TCP’s congestion control is a well-known adaptation example. Akan (2004) presents various types of mobile applications in wireless Internet are studied. Adaptation consists in parameterization of congestion control mechanisms using context information. Exposito (2003) and Hutchinson (1991) define the architectural adaptation of transport pro-
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