Understanding Autonomic Network Management: A Look into the Past, a Solution for the Future

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Understanding Autonomic Network Management: A Look into the Past, a Solution for the Future

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Abstract

The evolution of mobile network technologies and their vertical integration, heterogeneity of applications, and the advent of sophisticated end-user devices have continuously been expanding the complexity of network management tasks. In addition, there is a significant urge for the dynamic reconfiguration of networks to meet operators' costs and to achieve their performance objectives. These facts substantiate the idea of pushing the classical human dependent network management approaches out of the equation to a great extent. The vast scope of network management makes it difficult to have a common understanding and definition, which is often noticeable in different research articles. The situation is further worsened by the network evolution timeline that traverses several technological shifts, such as the time when computer networks and mobile networks were far apart, to the time of fully IP-based and converged networks. Hence, one of the main aims of this paper is to provide a study of the network management evolution in general and in particular the concepts of autonomic network management, so that researchers may be equipped to understand the involved concepts. To achieve the aforementioned objective, the authors carried out an elaborate analysis of the different network management approaches, mapped them to a timeline, and discussed their features. This analysis sets the stage for an extensive discussion of the enabling concepts of autonomic network management, followed by a survey of research projects targeting the advancement of the autonomic networking vision. Having identified incomplete realizations of autonomic network management due to simplifying assumptions, this paper focused on the relevant aspects of architectural construction with the presentation of the core challenges to be addressed so as to realize a fully autonomic network management framework. These challenges led us to reconstruct the design goals that the contributions of this work were built upon. The first proposal of this paper is to deploy intelligent software agents on different hierarchical layers of the proposed mobile network architecture. The agents implement different stages of cognitive control loops and contribute to learning algorithms for various management tasks. CoDIPAS-RL learning framework is used for layer specific learning decisions. To advance the autonomic network management, the authors also propose a novel idea of self-learning that enables the meta-learning vision. This paper concludes with a discussion on the implementation of our autonomic network management framework and with a use case that shows the performance of the proposed approach.

Keywords: Autonomic Network Management, Self-X Network Management, Meta Learning

1. Introduction

In the last few decades, the world has been witnessing the fast-paced evolution of telecommunication networks, driven by the positioning of networks as the main delivery channel for most modern services. Today, the traces of this development can be followed by looking at the increased share of delay sensitive and bandwidth-hungry applications, e.g., from voice-only communication to HD video streaming, and other envisioned concepts such as smart cities. The robust air interface, the integration of IP networks and the availability of low-cost multimedia terminals have provided a suitable infrastructure for this evolving pattern. Furthermore, the technological developments have freed the operators from being locked into end-to-end knitted solutions of incumbent vendors. Unfortunately, it seems clear that Network Management (NM) systems failed to keep the pace with the fast-evolving mobile network technologies. The evolution of NM approaches thus far has brought partial autonomics in the NM that support the network operations officer in attaining his goals. However, the deployment of a full-fledged distributed Autonomic Network Management (ANM) system is yet to be achieved.

The present paper follows a two-pronged approach to advance the research in this area by i) equipping the readers with the required background knowledge to understand the problems in realizing the desired ANM system, and ii) contributing a suitable architectural design. The paper starts by providing an overview and our understanding of the ANM paradigm. To equip the reader with a rich understanding of NM, we then provide the required background by presenting a timeline and discussion of relevant evolution milestones in Section 2, and in particular

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