

Chapter 9

Enabling Frameworks for Autonomic Adaptation of Protocols in Future Internet Systems

Vangelis Gazis

University of Athens, Greece

Eleni Patouni

University of Athens, Greece

Nancy Alonistioti

University of Athens, Greece

ABSTRACT

The emergence of several networking standards has been continuous over the last decade. Engineering creativity spawned a wide gamut of innovative technologies for wireless and wireline communications. This increase in technological portfolios, in combination with the requirement to migrate legacy systems and to maximize the use of large investments in network installations, resulted in the design of multiple network evolution paths. Combined with the increasing sophistication of networking technologies, this variety of choice in design has run counter to the simplification – and the efficiency – of management procedures. The task of managing network infrastructures is confronted with an increasingly disharmonious Babel of standards involving interfaces, protocols, topologies, and versions. As a result, there has been a turn of research interest towards an autonomous mode of management where the elements of the managed system display individualistic proactive behavior that strives to maintain their modus operandi within specific bounds. The umbrella term autonomic computing and communications refers to a capability set that includes a system's ability to monitor selected aspects of its own operation, collect, and record any data resulting from these observations, evaluate its performance under the light of its own operational history, possibly also identifying trends and recurring patterns in the process, and, in the case of subpar performance, undertaking corrective actions targeted to achieve a satisfactory level of performance. To this end, dynamically adaptable protocol stack offer a systemic capacity for change during runtime according to current operational requirements, thus providing an essential framework feature of autonomic systems.

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INTRODUCTION

The continuous development of telecommunication standards over the last decade has produced a wide gamut of networking technologies. This includes wireless access systems, such as cellular systems (e.g., GSM, GPRS, GERAN, EDGE, UMTS, cdma2000, 3GPP HSPA, etc), broadband WLAN type systems (e.g., IEEE 802.11a/b/g), fixed wireless access systems (e.g., IEEE 802.16d/e), broadcast systems (e.g., DAB, DVB-T/S/C/H, DMB) and short-range wireless systems (e.g., Bluetooth, IEEE 802.15.3a, IEEE 802.15.4) while new ones are being developed rapidly (e.g., 3GPP LTE). Similar developments characterize landline and carrier networking, where several innovative technologies (e.g., Gigabit Ethernet, ADSL/VDSL, IP over SONET, Ethernet over SDH, MPLS/GMPLS, etc) have emerged and/or are being intensively developed.

The intensification of standardization activity has spawned several new protocols and brought on a wave of revisions to existing ones. The fierce rate of standardization promotes a ‘mix-and-match’ approach to the definition of protocol stack standards that challenges the traditional – so-called ‘silo’ – approach to the design of a protocol stack. The latter suffers from extreme vertical integration and lack of flexibility in horizontal tasks (i.e., that involve different protocol stacks) related primarily to resource management and cross-standard coordination. The increase brought on by standardization in the number of protocols, aggravated further by the definition of multiple releases and versions, has further perplexed network management tasks. Large-scale network systems like the 3GPP one provide a rich set of options with regard to the interfaces and protocols supported in network deployment. This increase in technological portfolios, in combination with the requirement to migrate legacy systems and to maximize the use of large investments in network installations, resulted in the design of multiple network evolution paths. Combined with the increas-

ing sophistication of networking technologies, this variety of choice in design has run counter to the simplification – and the efficiency – of management procedures. As a result, the task of managing the network infrastructure is confronted with a disharmonious Babel of standards, interfaces, protocols, topologies, and versions.

In addition, the increasing adoption of wireless technologies to access Internet content runs against fundamental design assumptions imprinted in the IETF protocol stacks. These performance limitations are attributed to the black-box principle in protocol stack architecture. To address this issue, the introduction of cross-layer information exchange and the dynamic adaptation of protocol stacks during runtime have been proposed and investigated. Several approaches are now being currently considered to support the autonomic management paradigm where individual network systems can take proactive and/or reactive management actions upon themselves.

Albeit relatively young, the vision of autonomic communications is being pursued intensely by several research activities in both industry and academia. These activities involve the definition, design and deployment of ‘self-x’ features in emerging communication systems and devices. Following the model proposed by IBM (Kephart & Chess, 2003), an autonomic system should at least incorporate four attributes: self-configuring, self-healing, self-optimizing and self-protecting, commonly referred to as self-CHOP features. Additional novel features for autonomic networking that are exploited in recent research efforts include self-organization, the latter being defined as the system’s ability to manifest coherent behavior at the macroscopic scale as the aggregate result of peer-to-peer interactions among system constituents at the microscopic scale.

This vision lays the ground for the deployment of advanced concepts in the Future Internet architecture, including those involving a device agnostic and protocol independent approach to the definition of systems with self-configuring and

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