Integration of service, network and system management: current and forthcoming trends

José Luís Oliveira
DET/IEETA, Universidade de Aveiro
3810 Aveiro, Portugal
{jlo@det.ua.pt}

Rui L. Aguiar
DET, Universidade de Aveiro
3810 Aveiro, Portugal

and

Rui Pedro Lopes
ESTiG, Instituto Politécnico de Bragança,
5300 Bragança, Portugal

ABSTRACT

A major problem that industry is being faced with is related to the miscellaneous of management requirements and to the explosion of management information. Network and systems management often make use of different tools and technologies. The introduction of Quality of Service in the Internet will bring increased needs for efficient service management approaches in the network. The integration of these different kinds of management approaches into a common framework is critical for the future development of the Internet and intranets. This paper exploits the usage of software agents acting as mediators between different management protocols and data and assuring transparent integration of those dissimilar solutions.

Keywords: Service Management, Network Management, Agents, Distributed Management, QoS.

I. INTRODUTION

Existing management architectures are typically based on dissimilar approaches concerning the managed environment – networks, systems, services (…). This divorce may become increasingly large since current expectations for the Internet includes massive quantities of very diverse elements, ranging from resource-limited devices (i.e., palmtops, mobile phones, etc.) to large-scale distributed applications (i.e., Web-based DBMS, WAP, etc.). The introduction of QoS on IP-based transactions will deliver a new set of management issues: for end-user services to be properly controlled, all the devices involved in the path will have to be properly controlled. The shift in capabilities and in the number of elements to be managed may require management paradigms different from existing ones. Thus the integration of different kinds of management approaches into a common framework is critical for the future development of the Internet and intranets - it would provide the ability to manage these increasingly spread and dissimilar elements, in order to support the management of the services that they collectively provide. For instance, a goal would be to be able to manage a PDA, a desktop PC, a firewall router, and an enterprise's electronic mail service within the same framework and preferably with the same tool(s).

The Internet is providing (trying to at least) a new set of technological solutions that helps to manage network bandwidth in order to provide different levels of QoS (Figure 1). Unfortunately, the remaining issues surrounding these problems are still being tackled in disjoint working groups. The following paragraphs illustrate currently approaches being taken inside some standardization fora (IETF and DMTF), which can influence and be influenced by the introduction of QoS on Internet.

The Integrated Services approach exploited the potentialities of RSVP to introduce QoS assurances in the network. But RSVP is non-scalable, which impairs the overall deployment of QoS over the Internet. To handle this problem, a scalable mechanism for the introduction of QoS in the network has been developed by the IETF Differentiated Services (DS) group [1].

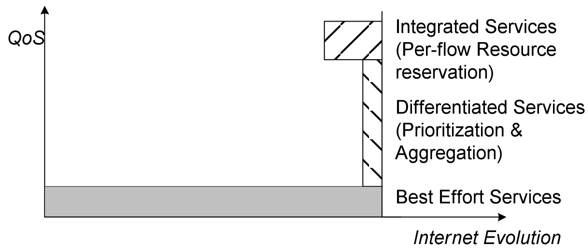

Figure 1 - The evolution of QoS approaches on the Internet.

Differentiated Services define two main types of services being provided over the DS domain (the part of the network supporting the DS framework, under the control of a single entity): quantitative and qualitative services. For quantitative services, DS requires both the ingress and egress points in the network to be known in advance, in order for proper network provisioning to be done. Qualitative services are defined in function of relative network behaviour, and do not suffer this constraint. Services by themselves are not defined in the DS work, and a clear separation is made between the services and the network building blocks supporting these services. A customer is issued a Service Level Agreement (SLA); the service provider will convert it in a Traffic Conditioning Specification (TCS), implementable in the network equipment. This TCS will have two major components: a router behaviour description; and network boundary functions (comprising classification, marking, dropping and shaping traffic). Thus, DS is seen as the generic technology bricks to use for the construction of the transport services discussed in the previous section. This is an issue of paramount importance for our discussion on network evolution. On the lower transport level, some providers may resort to RSVP or ATM for providing similar transport services – and certainly some mix of a multitude of technologies will occur in the Internet. Naturally higher-level management frameworks will also differ, increasing global network management problems. Several management strategies may be in place at the same time across a set of DS domains, supporting a single end-to-end service – typically the notion of Bandwidth Broker (BB) appears, as the (logically centralized) entity able to manage and control each DS domain.

This is quite far from basic Internet management, until recently guided by the simplicity and minimalism that originated the very successful SNMP framework. Despite its on-going evolutions (SNMPv3), it still lacks scalability due to the inherent broad range of management information and polling based operations. The introduction of differentiated services into the network will highlight these limitations even further. Considering *system integration* as a requirement for future customers for advanced Internet services, it is to be expected that a common platform will allow the management of network, services, systems and users. This goal may seem to imply, for instance, that such entities as the Bandwidth Broker [2] or Police Enforcement Points [3] should be controlled by SNMP – if it aims to remain as the reference management framework. However, it increasingly seems that SNMP is being limited to the underlying technology and new emergent frameworks will address upper level management (CIM, LDAP, DEN, XML).

Other issues concerned with complex management framework notions are: policies authentication, and user access control. Traditional IP-IP communications demand some well-known simple support services (such as DNS), and usual management strategies have coped well in this environment. However, increasing service complexity will imply new requirements for service and network control.

Policies are key for this kind of need, and SNMP has not been designed for this task. As a complex issue, its several aspects are being covered by different proposals.

For instance, [4] is proposing a framework to share policies and policy information in a vendor-independent manner; specific schemata will be used specifically for QoS traffic management (as the one between diverse Bandwidth Brokers). One objective that is not covered here is the extension of the framework in order to include exchange and management of policy data between heterogeneous policy domains. As it is predictable an even larger number of interacting enterprises exploring the Internet, with different kinds of customers (customers of one provider can be provider can be providers for its one customers), this topic will be very important to achieve end-to-end QoS negotiation and enforcement.

An architectural framework for understanding the authorization of Internet resources and services and derives requirements for authorization protocols is discussed in [5]. The list of target applications for this framework includes at least IP Telephony, SS7, Bandwidth Broker, and Network Access Server. This work can have great impact on the way Bandwidth Brokers interacts and about how polices will be defined – in short, how services can be implemented across the Internet.

II. SOFTWARE AGENTS

Internet technologies and concepts are dramatically changing the way enterprises provide, maintain and use traditional IT services. This successive increase on complexity will continuously increase the barrier between technology and end-users. Between these two actors there is a group of technicians, acting in areas so diverse as network operation and management or end-user services, which are also behind the voracity of this change. New paradigms have to be available to handle the pressures of these new demands. Recent exploited paradigms, namely the Software Agent one, seem to provide solutions for some of those problems [6][7][8].

The software agent concept is fully detailed in the literature [9][10][11]. Besides the basic terminology, it is clear today a division between two main type of agent: Intelligent (IA) and Mobile (MA). The first, which inherits some of the fundamental concepts of the Artificial Intelligence domain, is characterised by some levels of learning, autonomy and proactivity to act on behalf of users or other agents.

Another characteristic that can augment agent functionality is mobility – a mobile agent. The MA technology will enable, for instance, telecommunications services to be provided instantly and customised directly at the locations where the intelligence is needed, namely it will enable "Intelligence on Demand".

Terminology, Heterogeneity, Semantics Languages, are some the range of Agents' related issues that are being covered by two main standard frameworks: the Foundation for Intelligent Physical Agents (FIPA), closely-coupled with Intelligent Agents, and MASIF, more connected with mobile agents and their interoperability problems.

FIPA has released several specifications related to agent technology, for example, Agent Management, Agent Communication Language, Agent Security Management, Human-Agent Interaction and others [12]. In short, the specifications provide "basic agent technologies that can be integrated by agent systems developers to make complex systems with a high degree of interoperability".

QoS negotiation results in an end-to-end establishment of a required service with minimum working parameters. This negotiation involves three entities: the user, the service provider and the network provider [12]. We can think of a related paradigm as a personal travel assistant. When a client wants to go to somewhere he usually needs transport means, a hotel and usually some kind of entertaining services, such as visiting the opera. The negotiation of services involves several parts: transport service providers, hotel, travel agencies and so on. The understanding between all parts is fundamental for the client to get the required service level. This understanding is based on the existence of a way to communicate, or a language common to all parts. In addition it is also necessary some means to identify the providers of a service so that negotiation may take place.

This is where FIPA acts, by defining standards for agents to communicate [13] and interact with each other and with other entities to achieve individual or common goals. In particular, communication networks across the world rely on different technology and on different providers. Agents are a promising technology as they facilitate automatic negotiation of appropriate deals and configuration of services at different levels as well as distributed resource allocation [14].

On the other hand, the OMG (Object Management Group) is promoting the MASIF specification [15] to ensure interoperability between mobile agent platforms. Behind this specification there are four primary concepts (Figure 2): the Agent that is the central yet the atomic entity in MASIF standard; the Place concept defines the contexts, such as access control, for a set of agents; the agent system (AS) is a physical platform to create, interprets, execute, transfer and terminate agents; and the Region that is a set of AS that shares the same authority.

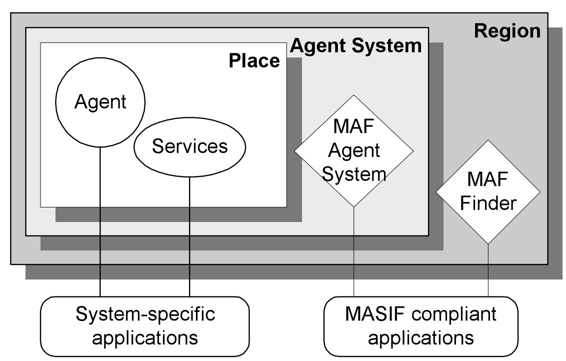

Figure 2 - MASIF architecture.

MASIF defines two IDL-based interfaces: the *MAFFinder* and the *MAFAgentSystem*. The *MAFFinder* interface is part of the Region and it includes functions such as register, unregister and lookup. The *MAFAgentSystem* interface, which is part of the AS, defines methods and objects that support agent management tasks agent lifecycle services and general information services.

Although MASIF interfaces allow locating, creating, suspending or resuming agents and agent systems, there are some missing aspects of the agent lifecycle.

For example, it is not possible to force an agent to move, or to create a place inside some specified agent system. These operations must be performed by system-specific services.

III. AGENTS FOR SERVICE MANAGEMENT

Currently, service management in the Internet can be looked at as a simple issue, as most of the contracts in place provide mostly best-effort assurances. Management is frequently done with simple parameters, such as bandwidth, time, type of protocol or traffic (seldom). Inter-providers agreements are mostly peering agreements, defining what protocols to transport from one service provider to the other. With QoS in the network, this environment becomes more complex, as end-to-end connections may (and frequently will need) require several SP to support contracted parameters of QoS.

While the envisaged communications scenarios are countless and enough complex for current technology, new approaches have to be planned in order to cope with this situation. Active networks are currently an issue that, besides its constraints on performance and security, can play an important rule on this evolution. The main idea is to separate network devices hardware from protocol-oriented applications. Agents are used here as the way to provide such kind of functionality.

Our proposal on the usage of agents covers different aspects on the interchange of information between bandwidth brokers, to be deployed in different time frames, as more knowledge and standardization on mechanisms for service management of QoS in the Internet develops. We will use agents as the management delegates inside BB, with specific capabilities being delegated on these agents.

If QoS capabilities become common in the Internet, then the management of each domain will become much more complex, with technologies as Differentiated Services capabilities and MPLS facilities, or even IntServ services, being deployed [16]. The range of services to be provided is probably even more diverse [17], and severe management problems will appear for cross-domain service requests.

No fixed management configuration will be able to provide services on-demand in this type of environment. Most of the traffic patterns across the Internet are short-lived, and long setup establishment times will not be useful in this situation. This means that each BB will need to provide response to service requests in short time, often from a administrative domain (AD) quite far (in geographic terms) from its own. This could lead to changes in the typically peering agreements between neighborhood ADs. This brings an added economic complexity to this process.

This late addition is not a necessity, however. It is much more reasonable (and that's the usual in the current telecommunications world) for each AD to still establish contracts with its neighbors, and to assume that every request from its neighbor is to be charged under that contract – leaving the responsibility of passing this cost to other party to its neighbor.

In this context, the contract between ISPs will provide for some bandwidth usage – but not only in terms of interconnection, but also in terms of transport to other points – with some QoS parameters associated. For instance, an AD (B) may have a contract stating "the neighbor ISP (A) will have a 2 Mbps connection to me, and I will assure that 1 Mbps of its traffic will reach ISP (C) with top priority". For this type of situation, in reality one domain is actually sub-allocating some of its resources to one of its neighbors. This is our reference management framework: ISPs will establish contracts where they will "rent" some of their resources to the traffic originating from their peers. As an added-bonus, this situation simplifies the setup time of each connection request, as the contracts between ISPs will naturally imply large blocks of traffic to benefit from multiplexing effects. Thus, a specific flow will not need to wait for the setup of the whole connection across the multiple domains: in principle this connection will be (at least administratively) established.

This architecture is depicted in Figure 3. The BB supports all network configuration and measurement commands, as well as a policy and accounting motors. Furthermore, it supports a mobile delegates area, which interacts with the BB thought policy and authorization motors. Although able to address and configure the network equipment of the AD, these mobile agents can only interact though an accounting agent (which verifies the costs in which the agent is incurring), a policy agent (which verifies if the agent is issuing a valid command for him) and a network configuration interface (which will interface the configuration commands available at the BB interface into specific equipment commands, using the management protocol appropriate).

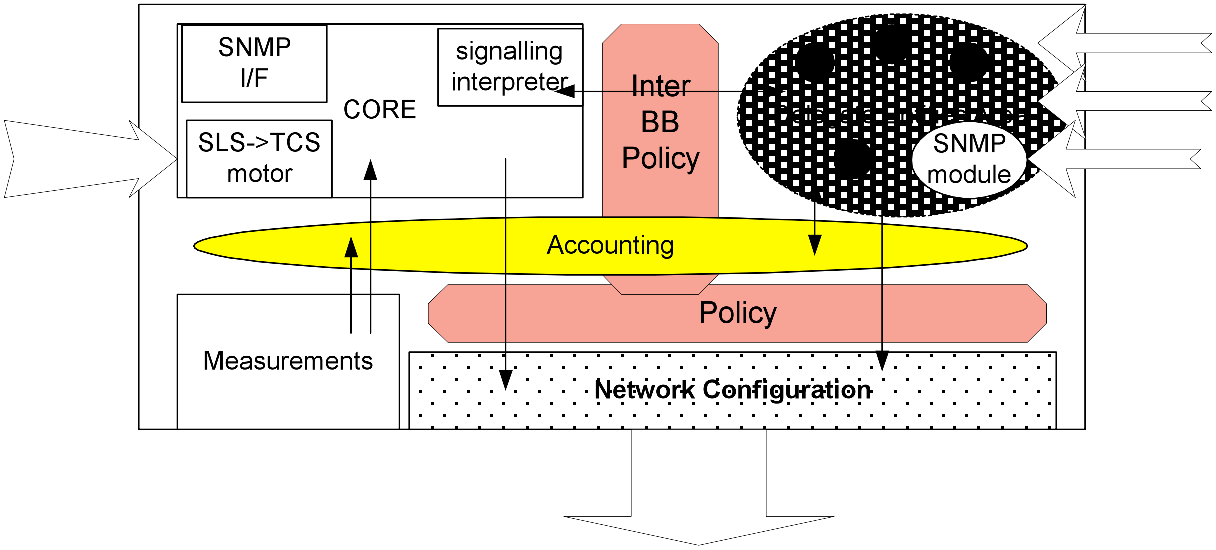

Figure 3 – BBs architecture supporting mobile agents (shown as black dots) as management delegates.

This architecture provides a layered approach to BB evolution and allows AD management to evolve separate strategies for its different aspects. For once, the issues of network management are handled on a separate block; thus network management protocols may be changed, without fundamentally changing the BB operation. Furthermore, the issues of policies and policy control are the responsibility of a different layer, and this can implement as complex a procedure as required, and evolve as necessary. And finally, agents are allowed to interoperate directly with the BB. In practice this will lead to increasingly complex interactions as technology evolves.

The local BB is the environment for the Agent System, and has to ensure the stability if its platform. The agents by themselves, their complexity and degree of autonomy are the responsibility of the issuing domain. Agent will naturally have a living period paralleled by the peering agreement between the domains, and their operation limits will be constrained by the terms of this agreement (enforced by the policy task). Its capabilities will depend on the specific policies of the issuing domain.

IV. CONCLUSIONS

With the new services requirements that are emerging in the Internet the envisaged communications scenarios are countless and enough complex to be managed with current technology. New integration approaches have to be planned in order to cope with this situation. Besides its constraints on performance and security, Active Agents is a recent paradigm that can help to handle this growing complexity.

We discussed the problems arising from the multitude of models for networks, for systems and for services management, and how the imposition of QoS will inflate such diversity.

Taking the active network concept, which is being carried out along experiences where software dynamics is a must, we extend this concept to create an open environment that facilitates the negotiation of QoS and the fulfilment of operators' policies.

V. REFERENCES

[1] S. Blake, et al. "An Architecture for Differentiated Services", Internet RFC 2475, December 1998.

[2] R. Neilsen et al, "A Discussion of Bandwidth Broker Requirements for Internet2 Qbone Deployment, Version 0.7", Internet 2 Q-Bone Requirements, http://www.merit.edu/working.groups/i2-qbone-bb/requirements.html, 1999.

[3] R. Yavatkar, et al., "A Framework for Policy-based Admission Control", Internet Draft <draft-ietf-rap-framework-03.txt, April 1999.

[4] M. Stevens, et al., "Policy Framework", Internet Draft <http://ietf.org/internet-drafts/draft-ietf-policy-framework-00.txt>, September 1999.

[5] J. Vollbrecht, et al., "AAA Authorization Framework", Internet Draft <http://ietf.org/internet-drafts/draft-ietf-aaa-authz-arch-00.txt> October 1999.

[6] Lopes, R., Oliveira, J.L., 1999, 'Software Agents in Network Management', ICEIS'99, 1st International Conference on Enterprise Information Systems, Setúbal, Portugal, February 1999.

[7] J. L. Oliveira, R. P. Lopes, "Distributed Management based on Mobile Agents", MATA'99, Eds. A. Karmouch and R. Impey, Word Scientific, pgs. 243-258, 1999.

[8] R. P. Lopes, J. L. Oliveira, "On the use of Mobility in Distributed Network Management", in HICSS-33 – Hawaii International Conference on System Sciences, Hawaii, January 2000.

[9] J. Bradshaw (ed.), Software Agents, AAAI Press/MIT Press, 1997

[10] A. Karmouch (ed.), "Mobile Software Agents for Telecommunications", IEEE Communications, Vol. 36, No. 7 1998.

[11] T. Magedanz, R. Glitho (eds), "Mobile Agent-Based Network and Service Management", Journal for Network and Systems Management, Vol 7, No 3, 1999.

[12] FIPA, "FIPA 97 Specification, Version 1.0, Part 7: Network Management and Provisioning", 1997 (available for download at http://www.fipa.org/).

[13] FIPA. "FIPA 97 Specification, Version 2.0, Part 2: Agent Communication Language", 1998 (available for download at http://www.fipa.org/).

[14] B. Jennings, "Distributed Resource Allocation using Agent Technology", CLIMATE Industrial Agent Workshop, Barcelona, Spain, April, 1999.

[15] OMG, Mobile Agent System Interoperability Facilities Specification. ftp://ftp.omg.org/pub/docs/orbos/97-10-05.pdf

[16] X. Xiao and L.M. Ni, "Internet QoS: The Big Picture", IEEE Network Magazine, March 1999.

[17] R.L. Aguiar and J.L.Oliveira, "New Services on an Advanced Internet", in Multimedia Applications, Services and Techniques, Helmut Leopold, Narciso Garcia (Eds.), Springer-Verlang, ISBN 3-540-66082-8, pp.197-211, 1999.