Journal of Universal Computer Science, vol. 7, no. 5 (2001), 355-365
submitted: 14/4/01, accepted: 14/5/01, appeared: 28/5/01

Telecommunication Services and Service Management Challenges

John Buford
(Verizon, USA
john.buford@verizon.com)

Abstract: Trends in telecommunications networks including network convergence, requirements for QoS and service level agreements, and open service architectures are impacting the service management systems and processes. New results in three areas of IP service management are described. The architecture of a new platform for service management is presented. This is the first reported service assurance platform to use ASP technology as its infrastructure. A new performance management suite is described. This suite currently supports measurement and reporting of web and stream servers and VoIP softswitches. Finally, a recent result in customer care automation for processing large volumes of email sent to a customer care center is reviewed.

Keywords: Service Management, Network Management, IP Services, Telecommunications

1 Introduction

Large telecommunications service providers are facing significant changes in service definition and service management due to network technology convergence, deregulation and the growing importance of IP networking. Service management functions impacted by these changes include service fulfillment, service provisioning, and service assurance. Service providers have a considerable investment in business process and operation support systems (OSS) for their existing network. Both process and systems were developed over many years to support a range of service offerings including voice (PSTN), centrex, wireless voice, point-to-point data circuits (T1, T3, etc.), and broadband (SONET, ATM, Frame Relay).

OSS requirements for IP service management must include some new considerations. First, the network technology and the market place change at an increasingly rapid pace, meaning that the end-to-end service management suite must be easily adapted. This is a particular challenge since the suite of systems is quite large, their lifecycle spans many years, and the network technologies are diverse. Second, there is increased competitive emphasis on quality of service (QoS) and the use of service level agreements (SLA) is becoming more critical. This is one of the most important areas of evolution of the Internet protocols and related management platforms, and there is much that can be done using existing technology. Third, service ordering must be available through web interfaces and electronic data interchange (EDI) interfaces. There has been considerable progress in this area during the past five years including the availability of ecommerce platforms and enterprise integration middleware, and the rise of extensible markup language (XML) as an interchange format. Fourth, an open service architecture is proposed for new voice services mediated by softswitch technology. This is expected to lead to voice services which involve both third party and service provider support, complicating the service management function.

The demarcation line between the service provider and the customer is changing as services move to the application layer. In the residential context, residential gateways are being developed by which home networks and services will be mediated. In the business context, service offerings must integrate with the enterprise network. Further, single service provider is unlikely to control the entire facility needed to implement the service, making it difficult to offer end-to-end service guarantees.

Trends in service management have been widely discussed [see Mitra (00)]. The impact of QoS is discussed [see Jiang (00)]; the impact of artificial intelligence techniques is discussed [see Fuller (99)]; the role of network convergence [see Moyer (01), Modarressi (00), Garg (98)]; the emerging area of policy-based management is described [see Wright (99)]. This paper surveys recent work we have performed in IP service management for a large service provider and a Tier-1 ISP. In particular we have developed a new service management platform based on Java Application Service Platform (ASP) technology. We have also developed a performance management suite for IP services. Finally, we have developed a system for automatic processing of a large volume of customer care email.

In the next section we describe in more detail the concepts of IP services. Subsequent sections describe, respectively, the new management platform, the performance management suite, and the customer care automation. The paper concludes with a summary section.

2 The Nature of IP Services

We consider IP Services to refer to session and application layer behavior and protocols that rely on IP internetworking for end-to-end connectivity and provide generic functionality. Examples of well-known IP services include:

- Web servers and streaming servers
- Application Service Platforms (ASP) and ecommerce platforms [see Papavassiliou (00)]
- Softswitch-enabled packet telephony [see Huitema (99)]
- Content Distribution Networks (CDN) [see Baentsch (97), Wang (99)]

Web hosting is the most prevalent such service in use today. Large scale deployment of other services is underway, driven by economies of scale of the Internet and related technologies, improved capacity of backbone and access networks, and the evolution of internet protocols towards scalable QOS-capable transport. Services are typically implemented and operated by organizations, which are not network service providers (NSPs). In many cases the use of standard protocols and data formats leads to interoperability of service implementations and device-independent access.

One of the difficulties in defining what an IP service is relates to the gray line between generic services (e.g. DNS and LDAP) and specialized services built from these building blocks. For example, DNS entry modification is used as a load-balancing component in web server and web caching systems. LDAP is used in some softswitch implementations. The fact that many services are built as an aggregation of various systems, dedicated switching devices, and software components, each with its own management and configuration interfaces, complicates the creation of large-scale services. Today this is dealt with by vendor-specific monitoring and configuration tools. From the service provider perspective, proprietary management tools and techniques are more costly to operate and integrate with other operations processes and operations support systems.

Efficient configuration and management of such services is critical for ensuring rapid time to market and uniform service quality as the service availability expands. From a monitoring perspective, aggregation of fault information relative to an end-to-end service view is needed for a number of reasons, including simplifying operations processes, providing quantitative relationship between service degradation and customer billing and SLAs, and scalability for all aspects of OAM&P for the service.

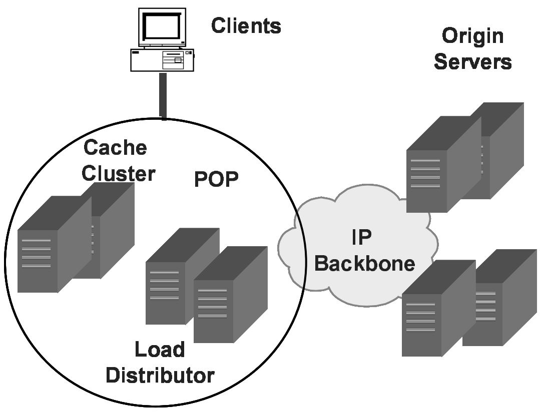

Figure 1: Simplified caching system for a content distribution network

Two examples of emerging IP services are content distribution networks (CDN) and softswitch technology. CDNs [see Fig. 1] are designed for improved delivery performance of web content, streaming media, and mp3 files. CDNs are frequently implemented as dedicated high performance networks with content caching at the terminating points. The caches improve response time by reducing retrieval time compared to direct access to the origin server. For large loads, a cluster of caches can be implemented. The techniques for load distribution for cache clusters are similar to those used for web server clustering. However, some cache architectures have special protocols (e.g., ICP) for cache-to-cache lookups. From an end-to-end perspective, management of the CDN requires an integrated view of the caches, the load distribution component, the network, and the origin servers. Content management is an area of growing importance in CDNs.

"Softswitch" is a widely used term for emerging IP-based communications systems that employ open standards to create integrated networks with a decoupled service intelligence capable of carrying voice, video and data traffic [see Huitema (99)]. Softswitch is representative of the migration from circuit switching to packet/frame/cell-based networks for voice and video communications. The standards-based approach taken to date suggests that many voice applications will emerge that leverage the softswitch platform.

The basic components of a softswitch configuration [see Fig. 2] include the Call Manager, Gatekeeper, and Gateway, which work together to permit end-to-end signaling, authorization, and connectivity for IP to PSTN and IP to IP telephony. Other components include aggregation equipment, billing record creation, and different types of signaling and media gateways. From an end-to-end perspective, management of the softswitch-enabled telephony service requires an integrated view of the signaling and transmission components. Additionally, gateway mediated service means that calls may involve two or more management domains, and in the case of IP to PSTN, different management systems and processes for different portions of the connection.

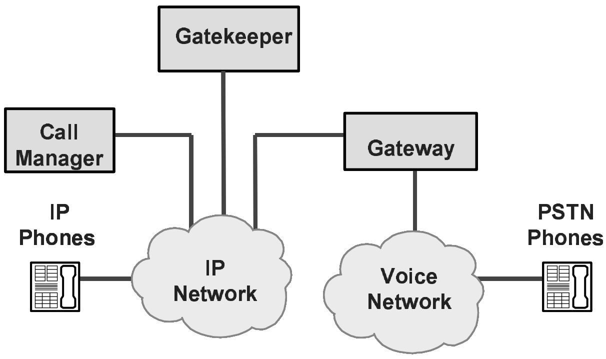

Figure 2: Simplified softswitch configuration

As these examples illustrate, end-to-end management is vital to IP service management as it has been in traditional network management. The use of event correlation for service assurance is such networks is discussed in previous work [see Buford (01)].

3 Management Framework

The use of modular platforms is well established in the network management industry. This approach is intended to address the needs of both service providers and enterprises to incrementally upgrade and scale the management platform as the network functionality evolves and grows.

In recent years there has been trend to provide CORBA (Common Object Request Broker Architecture) and messaging oriented middleware interfaces to simplify integration with other operations support systems. It has also become common to provide web-based application clients [see Tsai (98), Ahn (99)] because of the wide use of web technology.

There have also been extensive efforts to define standard network models that would promote interoperability between vendor products and simplify the effort to support new types of network elements. Although consortium and standards for network models have proliferated, the goals of interoperability and simplified upgrades have only modest results.

An important area in network element research is to support mobile code in the software platform of the device, referred to as active networks. Although limited commercial adoption of this approach has occurred to date, the impact of active networks on network management is receiving considerable research interest [see Schwartz (00)].

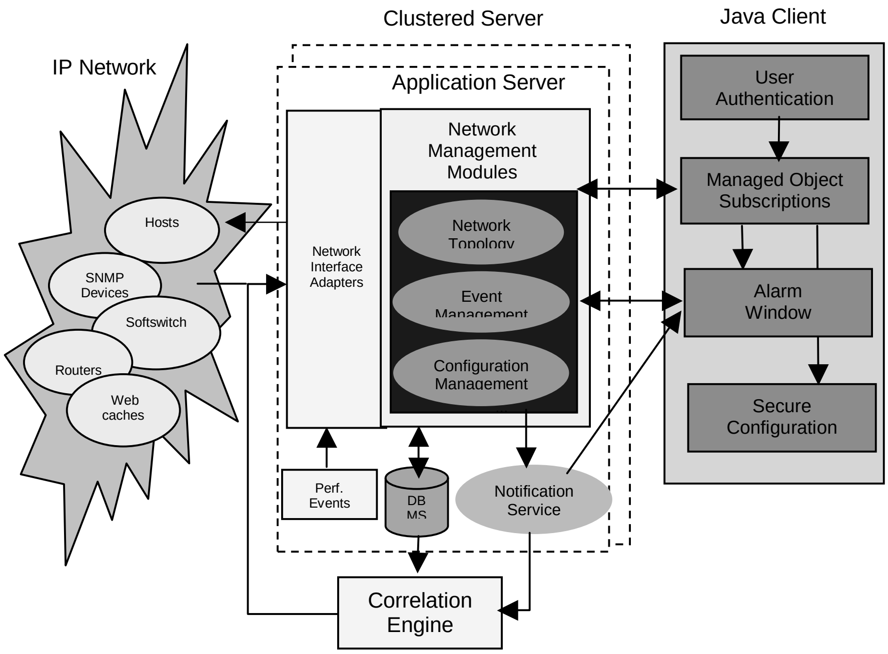

Figure 3: Architecture of the Noventra service management system using application service platform (ASP) infrastructure.

3.1 Noventra™ ASP-Based Management Platform Architecture

Noventra is the first network management platform to use a Java Application Server Platform (ASP) for its infrastructure. Many of the features of today's Java APSes were standardized by the Object Management Group (OMG) but never fully realized in the vendor products. The Enterprise Java Bean (EJB) products available today provide object-to-relational containers, server clustering and load balancing, web-server integration, Java applet integration, name servers, reliable messaging, integrated development environments including Unified Modeling Language (UML), and extensible markup language (XML) support. New EJBs can be dynamically loaded, simplifying the upgrading the application. These benefits have to date come at the cost of working with a new and evolving software technology that has a performance handicap when compared with more established approaches.

The Noventra architecture [see Fig. 3] is designed for efficient fault management including event collection, persistence, subscription, and forwarding operations. It also provides for network topology viewing and selection. Network elements can be securely configured, using SNMP version 3 security features, or a patented secure remote shell technique for host-based configuration of network elements.

Events can be received from various sources including SNMP traps, host log file monitors, and Java remote method invocation (RMI) sources. The GRACE correlation engine [see Jakobson (00)] integrates with Noventra using the CORBA Notification Service. QoS threshold events detected for IP services [see section 4] can also be received.

4 Performance Measurement of Services

Performance measurement of networks and services is used for:

- Service Level Agreement (SLA) measurement and tracking [see Muller (99)]
- Service benchmarking against other service providers
- Performance reporting for infrastructure capacity planning

At the transport layer, measurement can be either end-to-end or by segment [see Jiang (00)]. Performance statistics can be aggregated, or packet and cell level measurements can be captured. Although measurement can be made at the network element, usually probes or agents are used to avoid impacting the performance of the network. Probe techniques are typically transparent to the network, but require insertion at the network links at which measurement is needed. Since the probe sees every bit moving over the physical media, there is a great deal of flexibility in selecting which flows and protocols to measure. When segment by segment measurements are made of an end-to-end flow, synchronization of the measurements is an important issue.

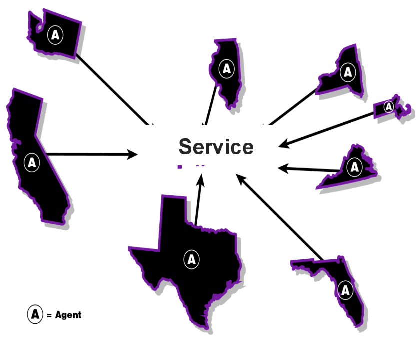

Figure 4: Topological placement of measurement agents is intended to cover the usage pattern of the user community.

In cases where intermediate networks may be under control of multiple service providers, such as many internet services, agent-based measurement is useful. Agents are distributed topologically in the network [see Fig. 4], and measure the service by either generating service requests or intercepting (via an instrumented proxy) actual client requests.

Characterization of the performance of the Internet continues to be a challenging area [see Paxson (98), Murray (01)] due to lack of instrumentation of the infrastructure, the many domains that need to participate, and the growth and evolution of the network. There are many research projects and commercial products for measurement, analysis, reporting and visualization.

We have developed an agent architecture for IP service measurement. Several types of agents have been created, which measure the delivery of web servers and caches (SiteRadar™), streaming media servers (StreamMeter™), and VoIP (voice over IP) softswitches (CallMeter™). The architecture also includes an SNMP (Simple Network Management Protocol) poller for collecting performance statistics through MIB (Management Information Base) queries. The agents reside on low-cost computing platforms that can be placed at multiple sites through out the network. The placement of the agents should reflect the service traffic that is being measured.

4.1 Agent Architecture

The agent architecture [see Fig. 5] is modular and scalable. Each agent is configurable to produce synthetic transactions and record protocol level service measurements. The agents produce periodic reports encoded in XML, which are automatically uploaded to a master server and stored in the performance database. All transfers to the master are encrypted using SSL (secure socket layer). A web-based interface is used to present performance reports.

The architecture is designed to be integrated with Noventra™ and other management platforms. QoS events such as performance thresholds exceeded can be triggered and forwarded.

4.2 Web Service Management

SiteRadar™ uses geographically distributed measurement agents to measure the response time of web sites and web caches and distinguish the contributions of networks, servers, and cache systems to the download time. SiteRadar is comprised of both user and administrator web-based interfaces, geographically distributed monitoring agents, an agent manager, and a database that can be accessed by a report engine for querying and viewing reports. Each agent has a list of sites to measure; these would include benchmark sites as well sites covered by SLA.

4.3 VoIP SLA Management

CallMeter™ creates a synthetic call load to collect QOS information for VoIP services, including end-to-end per packet (round-trip) delay, jitter, and lost packet. Each agent makes periodic calls to other agents, and each pair of agents in a call record the performance statistics. The flow in each direction is measured. The sampled approach provides a profile of QOS for voice calls on the network where the agents are connected. The current implementation supports H.323 and has been tested against several commercial softswitches. Support for SIP (Session Initial Protocol) is planned.

4.4 Streaming Service Measurement

StreamMeter™ agents request stream delivery using the RTSP (Real-Time Stream control Protocol). Per packet measurements are made for streaming servers supporting RTP (Real-time Transport Protocol); measurements of Real's streaming proprietary encoded streaming servers can be made at an aggregate level.

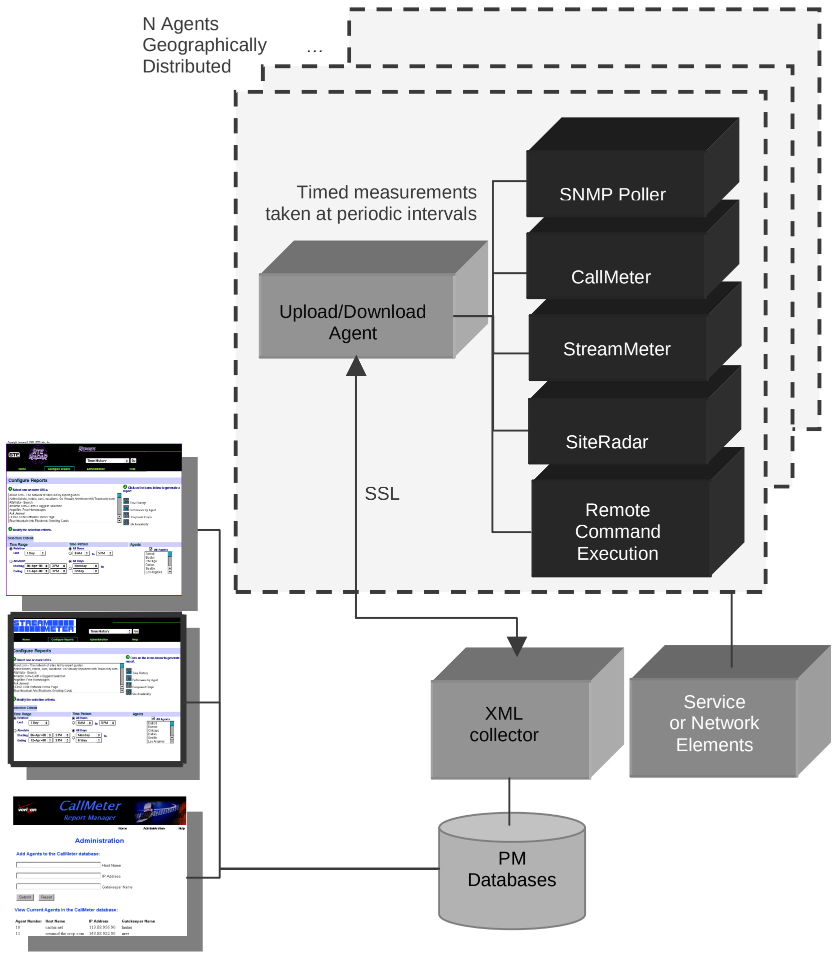

Figure 5: Modular agent architecture for measurement agent suite.

5 Customer Care Automation

Email is emerging as an important channel for ISP customer care. In general, some amount of automatic processing for routing and ticketing can be done by keyword analysis. Specific information (e.g., URL's, IP addresses, etc.) can be gathered to facilitate subsequent diagnostics. System utilities can also be automatically invoked to save time for Level 2 and 3 customer-care specialists. The results of the utilities can be stored in the ticket with the complaint. Further automation could be obtained by the use of natural language processing of incoming complaints, but there is limited use of NLP for customer care email processing today.

The Customer Support Center (CSC) for a Tier-1 ISP [Bowie (01)] receives about 30,000 email complaints per month. The majority is forwarded complaints from individuals on the internet who have received UCE (unsolicited commercial email) or spam from sources that may be in ISP's network. Another significant portion is from customers who have detected a security issue. The ISP needs to validate each complaint and take corrective action if the problem is within the ISP's network. A system SpamCheck™ was developed to replace the manual process.

The SpamCheck system is concerned with categorizing the complaint so that it can be properly ticketed and remedies taken. There is an extensive set of business rules for this processing. Each email is multiple embedded or forwarded emails. Special processing beyond that normally needed for internet email is needed, and this processing is not done by any commercial email tools or spam analyzers today. There are many structural variations in the incoming email, and a portion of the embedded spam has frequently been manipulated by the spammer to make analysis and therefore tracing difficult. SpamCheck also performs keyword analysis.

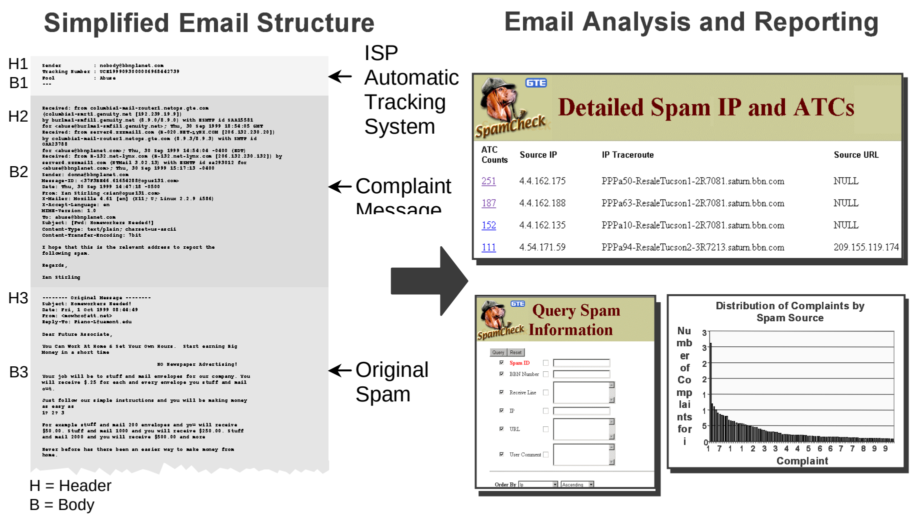

Figure 6: SpamCheck receives email service complaints, identifies embedded email structure, checks for header manipulation, extracts key fields for analysis and reporting, and correlates related occurrences to create a single ticketing event.

Email automation of email complaint processing is complicated by a number of factors including: 1) complaints concatenate multiple text paragraphs and RFC 822 headers, 2) some spammers camouflage their messages to circumvent detection or correlation, 3) spam categorization depends in part on analysis of the content of the spam message. The system is designed to work correctly on 90% of the cases, and provides facilities for manual review of each instance.

A high level view of the system is shown [see Fig. 6]. On the left is a email forwarded by the ISP email server

6 Conclusion

OSSes and associated business processes represent a significant part of the cost of providing network services. Manual processes, though flexible and relatively easy to implement, do not scale. On the other hand, OSSes may be well-designed for the original function but are frequently difficult to change, particularly in the face of unexpected network evolution and later in the lifecycle of the system. As long as the telecommunications industry faces rapid technology evolution, these will be continued challenges for service management.

Acknowledgements

Contributors to the Noventra management framework include: J. McCann, T. Collins, Y. Liu, and I. Behar. Contributors to the service measurement suite include: J. Zhang, S. Chang, H. Shang, and M. Li. Contributors to the customer care tool set include: X. Huang and M. Mady. Collaboration with G. Jakobson is appreciated. The following are trademarks of Verizon: SpamCheck, SiteRadar, StreamMeter, CallMeter, Noventra.

References

[Ahn (99)] Ahn, S. J., Yoo, S. K., Chung, J. W.: “Design and Implementation of a Web-Based Internet Performance Management System Using SNMP MIB-II”; IJNM (Intl. J. of Network Management), 9 (1999), 309-321.

[Baentsch (97)] Baentsch, M., Baum, L., Molter, G., Rothkugel, S., Sturm, P.: “World Wide Web Caching: The Application Level View of the Internet”; IEEE Communications Magazine, (1997), 170-178.

[Buford (01)] Buford, J., Jakobson, G.: “Managing Dynamic IP Services: Correlation-Based Scenarios and Architecture”; Proc. Enterprise Networking 2001. Atlanta (2001).

[Bowie (01)] Bowie, D., Buford, J., Huang, X., Mady, M.: “Automated Email Ticketing For ISP Customer-Care”; Technical Report, Verizon Laboratories, March 2001.

[Fuller (99)] W. Fuller: Network Management Using Expert Diagnostics”; IJNM (Intl. J. of Network Management), 9 (1999), 199-208.

[Garg (98)] Garg, V., Ness-Cohn, D., Powers, T., and Schenkel, L.: “Directions for Element Managers and Network Managers”; IEEE Communications Magazine, 10 (1998), 132-138.

[Huitema (99)] Huitema, C., Cameron, J., Mouchtaris, P., Smyk, D.: “Architecture for Internet Telephony Service for Residential Customers”; Bellcore Technical Report, (1999).

[Jakobson (00)] Jakobson, G., Weissman, M., Brenner, L., Lafond, C., Matheus, C.: “Building Next Generation Event Correlation Services”; Proc. NOMS 2000, Honolulu (2000).

[Jiang (00)] Jiang, Y., Tham, C.-K., Ko., C.-C.: "Challenges and Approaches in Providing QoS Monitoring"; IJNM (Intl. J. of Network Management), 10 (2000), 323-334.

[Mitra (00)] Mitra, D., Sahin, K. E., Sethi, R., Silberschatz, A.: "New Directions in Service Management"; Bell Labs Technical Journal, Jan-Mar (2000), 17-34.

[Modarressi (00)] Modarressi, A., Mohan, S.: "Control and Management in Next Generation Networks: Challenges and Opportunities"; IEEE Communications Magazine, 10 (2000), 94-102.

[Moyer (01)] Moyer, S., Umar, A.: "The Impact of Network Convergence on Telecommunications Software"; IEEE Communications Magazine, 1 (2001), 78-84.

[Muller (99)] Muller, N.: "Managing Service Level Agreements"; IJNM (Intl. J. of Network Management), 9 (1999), 155-166.

[Murray (01)] Murray, M., Claffy, K.C.: "Measuring the Immeasurable: Global Internet Measurement Infrastructure"; PAM 2001 (Workshop on Passive and Active Measurements), Amsterdam (2001).

[Papavassiliou (00)] Papavassiliou, S., and Pace, M.: "From Service Configuration Through Performance Monitoring to Fault Detection: Implementing An Integrated and Automated Network Maintenance Platform For Enhancing Wide Area Transaction Access Services"; IJNM (Intl. J. of Network Management), 10 (2000), 241-269.

[Paxson (98)] Paxson, V., Mahdavi, J.: "An Architecture for Large-Scale Internet Measurement"; IEEE Communications Magazine, 8 (1998), 48-54.

[Schwartz (00)] Schwartz, B., Jackson, A., Strayer, W.T., Zhou, W., Rockwell, R. D., Partridge, C.: "Smart Packets: Applying Active Networks to Network Management"; ACM Trans. On Computer Systems. 18, 1 (2000), 67-88.

[Tsai (98)] Tsai, C.-W., Chang, R.-S.: "SNMP through WWW"; IJNM (Intl. J. of Network Management), 8 (1998), 104-119.

[Wang (99)] J. Wang: "A Survey of Web Caching Schemes for the Internet"; Computer Communications Review, (1999), 36-46.

[Wright (99)] Wright, M.: "Using Policies for Effective Network Management"; IJNM (Intl. J. of Network Management), 9 (1999), 118-125.