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CONTRIBUTIONS TO THE MANAGEMENT OF LOCAL AND PERSONAL AREA NETWORKS

by
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1. INTRODUCTION

The management of telecommunications networks means coordinating all resources necessary for the design, planning, control, simulation, generation, implementation, analysis, monitoring, measuring and testing telecommunications networks, in order to ensure the end user with a degree of services to an appropriate cost using an optimal distribution of capacity.

Network management can be seen as a process of monitoring (surveillance) and control of large, medium and small distributed systems where errors or defects occur normally. It has the following components:

- Network control
- Network monitoring
- Network maintenance
- Network operating

Before implementing a management strategy it is very important to know the management system objectives to be achieved.

The following targets should be taken into account:
1. System complexity
2. Availability
3. Dependence
4. Price

In terms of OSI reference model, network management provides a way to keep networks running according to the parameters configured. It also provides command and control facilities. Network management can be divided into the following components:

- *Fault management* - all equipment could be damaged at some point, interfaces and connections might stop. All these together can cause the appearance of wrong information within the network. Events can be considered defects, but this does not necessarily mean that some entities have damaged inside the network. Events exist to inform the management system of the occurrence of something in the system.
- *Configuration management* - all equipment could get some configuration or settings from the network. Configuration settings can be read from or recorded into equipment.
- *Financial management* - billing for services offered is an important component of the management system. This will be used for taxing resources spent by each department, user, etc. and also to verify the accuracy of charge performed by the service provider.

- *Performance Management* - as the number of users and the need for bandwidth increases, it is essential to measure the performance, especially to meet a given SLA (Service Level Agreement). Verification of performances can be used to predict possible congestion.
- *Security Management* - Network attacks can include unauthorized access, modification or theft of data, etc... Security is intended to ensure that both data and network itself are protected.

An acronym that identifies the components of a management system is FCAPS (Fault, Configuration, Accounting, Performance, and Security).

2. ORIGINAL CONTRIBUTIONS OF THIS THESIS

This section presents the contributions to the management of local and personal networks contained in the thesis, as well as the conclusions. All the results were published in journals and at international conferences in the field of networking.

1. **Implementing a hardware SNMP agent for IEEE 802.3.** After analyzing existing implementations of SNMP agents for IEEE 802.3, I found that these implementations are dependent on the producers (Allied Telesyn, Cisco, 3Com, etc). There are cases where there is no support for SNMP implementations. I wanted to implement a generic hardware agent that can be embedded on any type of equipment, regardless of manufacturer. Connecting to equipment was designed to be via asynchronous serial interface (SCI), synchronous serial interface (SPI) or parallel interface (GPIO 8-bit). Connection to the network involved MII interface type EPHY (Medium-Independent Interface), according to IEEE 802.3, IEEE 802.3u. The solution was based on Freescale's MC9S12NE64 microcontroller (used later for other contributions too) and MIB-II. The software modules that collect data and store it into the MIB-II are actually the only ones equipment dependent.

   References: [Van05b], [Van05c]

2. **Implementing a hardware SNMP agent for IEEE 802.15.4.** During the standardization phases the implementation of SNMP inside personal networks (IEEE 802.15.4 compliant) was not considered at all. Thus there were no solutions available for devices such as FFD (Full-Function Device) and RFD (Reduced-Function Device). Therefore a mechanism was developed for introducing communication between FFD (with the role of PAN coordinator) and SNMP manager. Note that the exchange of information between FFDs and RFDs (i.e. sensors, actuators or security features) remained unchanged. In addition to the hardware solution proposed within *Contribution No.1,* the Texas Instruments's transceiver module CC2420 was connected using synchronous serial interface SPI. Thus I managed the generalize SNMP within personal area networks as a step towards their integration into a complete management system.

   References: [Van07a], [Van07b]

3. **Realization of MIB for IEEE 802.15.4.** *Contribution No. 2* highly depended on the implementation of a MIB dedicated to IEEE 802.15.4 (which was not envisaged by the standardization bodies). Based on traffic analysis, 32 objects were defined (characterized by the type and value) to provide relevant information, such as: a) at

Physical Layer: transmission power and frequency bandwidth used; b) at MAC Sub-Layer: PAN ID, number of packets sent, number of packages received; c) information for associated equipment: type, name, short/ extended address, value, transmission power level; d) thresholds for notifications (depending on the value and/ or erroneous packets).

References: [Van07a], [Van07b]

4. **Implementing a software SNMP agent for IEEE 802.11.** Managing a WLAN with existing SNMP implementation does not allow a comprehensive vision of the status of all stations and access points. I designed a generic software agent to be independent to IEEE 802.11 version (i.e. a, b, g, n, s etc.) and to provide statistical information about captured traffic from the wireless network. The solution was based on the acquiring of data with Cace Technologies's specialized interface AirPcap and data interpretation performed by the Wireshark protocol analyzer, running under Windows. The results were stored in .xml files and accessed by the agent implementing messages based on communication with SNMP manager (version 1 and 3). The existing solution of SNMP agent provided by Windows could not be used because it was based on MIB-II.

   References: [Van09b]

5. **Realization of MIB for IEEE 802.11.** The current standard for SNMP in wireless networks is based on MIB-II, but is does not provide specific information about WLAN. Therefore I created a MIB based on 20 items (characterized by type and value) to provide relevant information about: the number of frames (total, Beacon, ACK, data, ProbeRequest, wrong and others), the instantaneous values (number beacon frames/s, ACK/s, ProbeRequest/s, data/s), number of different destination addresses, number of different source addresses, number of access points. The management information can be used to improve network design, to justify the enlargement/ reduction of the network and to improve network security.

   References: [Van09b]

6. **Extension of software SNMP agent for Asterisk.** The idea to integrate multiple SNMP agents was based on splitting the communication with SNMP manager into two parts: the IETF's AgentX protocol was enabled between sub-agents and the master agent, whilst the SNMP protocol remained for communication between the master agent and the manager. Choosing Asterisk IP-Based PBX, the information management related to Application Layer (toll calls) were collected into a .log file, parsed and after that stored into an .xml file. This was used by the implemented SNMP sub-agent communicating with the master agent. The solution chosen is in conjunction with *Contribution No. 8.*

   References: [Van09a]

7. **Realization of MIB for Asterisk.** This time the contribution does not cover new technologies for access networks, being focused on expanding the MIB for VoIP-based applications. Seven objects were defined (characterized by type and value) to provide relevant information such as: the total number of calls, the number of calls answered, the number of calls not answered, the number of busy calls, the charging range, the monitoring interval. Even if the information obtained served to a specific situation (calls

within Asterisk), actually I wanted to demonstrate the feasibility of integration of the applications management with network access management.

References: [Van09a]

8. **Proposed transition to the integrated management.** The thesis was focused mainly on agents, without insisting on the part of the NMS (Network Management Station) that typically runs the manager application. I analyzed the legacy solutions (HP Open View, NetSNMP, PRTG Network Monitor, Open NMS). However a new flexible solution called SNMP Manager was implemented to allow extensions, according to the newly defined agents within this thesis. Furthermore, the Asterisk platform under Linux was used for integration of all proposed agents (from *Contribution No.1* up to *Contribution No.7*), acting as a multi-agent architecture based on AgentX. Thus the transition to integrated management required by the Future Internet becomes possible following the steps proposed: a) merging the manager and the agent software; b) replacing the centralized management by a distributed one; c) replacing/ elimination of transport protocols (TCP, UDP) and even the network layer protocol (IP); d) moving management on top of the MAC Sub-Layer for any network access technology; e) replacing the SNMP protocol with a new protocol enabling the integrated management.

   References: [Bik06], [Dob04], [Van05a], [Van05b]

CONCLUDING REMARKS

The extended doctoral research phase (about 10 years) imposed reorientation of the thesis towards new concepts (distributed integrated/inherent management) along with the new technologies developed in recent years (both in local and personal are networks).

The particular interest on this issue is proven by including the topic as a priority in international research projects, such as FP7-4WARD (pronounced like the word "Forward") is entitled "Architecture and Design for the Future Internet". This is an example of project responding to the challenges of tomorrow's Internet. The current network architectures allow innovations only at the applications level, but on the other hand radical changes in the structure and the principles are required. 4WARD does not aim to create evolutionary solutions but to **redesign the philosophy of the entire Internet**, from the growing requirements for mobility and wireless access. Several types of networks will coexist on a common platform on which virtualization plays an essential role. Networks must be self-managing (see In-Network Management concept) and applications must be focused on information objects rather than network nodes. The solutions will include all types of networks, from those based on optical fiber, to wireless and sensor networks.

PUBLICATIONS REFERENCED IN THIS THESIS

[Bik06] A.Bikfalvi, P.Patras, **C.M.Vancea** & V.Dobrota, "The Management Infrastructure of a Network Measurement System for QoS Parameters", *14th International Conference on Software, Telecommunications & Computer Networks SOFTCOM 2006*, Split-Dubrovnik, Croatia, September 29–October 1, 2006, S6-6128-2909, ISBN 953-6114-87-9, pp.242-246

[Dob02] V.Dobrota, D.Zinca, **C.M.Vancea** & G.Lazar, "Voice over IP Solutions for

CAMAN: H.323 versus SIP", *First RoEduNet International Conference "Networking in Education and Research"*, Cluj-Napoca, 18-19 April 2002
[Dob04] V.Dobrota, D.Zinca, **C.M.Vancea**, B.Moraru, T.Blaga, F.Copaciu & G.Lazar, "PSTN/ ISDN/ VoIP-Based Solution for Voice Communications within Cluj-Napoca Academic MAN", 3rd RoEduNet International Conference "Networking in Education and Research", Timisoara, 27-29 May 2004, *Scientific Bulletin of the "POLITEHNICA" University of Timisoara, Romania, Transactions on AUTOMATIC CONTROL and COMPUTER SCIENCE,* Vol. 49(63) 2004 No. 5, pp. 107-112, ISSN 1224-600X
[Van07a] **C.M.Vancea** & V.Dobrota, "Monitoring Low-Rate Wireless Personal Area Networks Using SNMP", *ACTA TECHNICA NAPOCENSIS, Electronics and Telecommunications,* ISSN 1221-6542, Vol.48, No.3, 2007, pp.5-8
[Van07b] **C.M.Vancea** & V.Dobrota, "Enabling SNMP for IEEE 802.15.4: A Practical Architecture", *6th RoEduNet International Conference "Networking in Education and Research",* Craiova, Romania, November 23-24, 2007, pp.49 -53, ISBN 978-973-746-581-8
[Van09a] **C.M.Vancea** & V.Dobrota, "Retrieving Call Detail Records from Asterisk Using SNMP", *ACTA TECHNICA NAPOCENSIS, Electronics and Telecommunications,* ISSN 1221-6542, Vol.50, No.3, 2009
[Van09b] **C.M.Vancea** & V.Dobrota, "SNMP Agent for WLAN networks", *8th RoEduNet International Conference "Networking in Education and Research",* Galati, Romania, 2009
[Zin02a] D.Zinca, V.Dobrota, **C.M.Vancea** & G.Lazar, "A Practical Evaluation of QoS for Voice over IP", *Proceedings of the 12th IEEE Workshop on Local and Metropolitan Area Networks, LANMAN 2002*, 11-14 August 2002, Stockholm-Kista, Sweden, pp.65-69
[Zin02b] D.Zinca, V.Dobrota, **C.M.Vancea** & G.Lazar, "Protocols for Communication Between QoS Agents: COPS and SDP", *Proceedings of the 3rd COST #276 Workshop on Information and Knowledge Management for Integrated Media Communication,* Budapest, Hungary, 11-12 October 2002, pp.53-58
[Zin02c] D.Zinca, V.Dobrota, **C.M.Vancea** & G.Lazar, "A Practical Quality of Service Evaluation for Voice over IP: IntServ Approach versus DiffServ Approach", *Proceedings of the IEEE International Conference "Communications 2002",* Bucharest, 5-7 December 2002, ISBN 973-8290-67-8, pp. 73-78

PH.D. REPORTS

[Van05a] **C.M.Vancea**, Referat de doctorat I: „Analiza reţelelor de telecomuncaţii în vederea gestionării", *Universitatea Tehnică din Cluj-Napoca,* 2005.
[Van05b] **C.M.Vancea**, Referat de doctorat II: „Algoritmi de gestionare a calităţii serviciilor", *Universitatea Tehnică din Cluj-Napoca,* 2005.
[Van05c] **C.M.Vancea,** Referat de doctorat III: „Rezultate experimentale în gestionarea calităţii serviciilor", *Universitatea Tehnică din Cluj-Napoca,* 2005.

PUBLICATIONS OUT OF THE SCOPE OF THIS THESIS

[Bla03] T.Blaga, V.Dobrota, D.Zinca & **C.M.Vancea**, "Mobile IPv6: Configuration and Trials", *2nd RoEduNet International Conference "Networking in Education and Research"*, Iasi, Romania, June 5-6, 2003, pp.27-34, ISBN

973-85791-9-8

[Dob99] V.Dobrota, D.Zinca, **C.M.Vancea** & A.Vlaicu, “Layer 4 Switching Experiments for Burst Traffic and Video Sources in ATM”, 10th *IEEE Workshop on Local and Metropolitan Area Networks, LANMAN’99*, 21-24 November 1999, Sydney, Australia, pp.66-69

[Dob00a] V.Dobrota, D.Zinca, **C.M.Vancea** & A.Vlaicu, “Layer 4 Switching in a TCP/IP Environment for the ATM Sources”, *ACTA TECHNICA NAPOCENSIS, Electronics and Telecommunications,* ISSN 1221-6542, Vol.40, No.1, 2000, pp. 13-18

[Dob00b] V.Dobrota, D.Zinca & **C.M.Vancea**, “Layer 4 Switching Experiments with IPv6 versus IPv4”, *Proceedings of the International Conference “Communications 2000”,* Bucharest, Military Technical Academy, “Politehnica” University of Bucharest and IEEE Romanian Section, 7-9 December 2000, pp.300-303.

[Zin01a] D.Zinca, V.Dobrota & **C.M.Vancea**, “Estimating the Optimal Model for Layer 4 Switching in IPv6 and IPv4”, *11th IEEE Workshop on Local and Metropolitan Area Networks LANMAN’2001*, Boulder, Colorado, USA, pp.68-71.

[Zin01b] D.Zinca, V.Dobrota & **C.M.Vancea**, “Performance Evaluation of Layer 4 Switching in IPv6 versus IPv4”, *ACTA TECHNICA NAPOCENSIS, Electronics and Telecommunications, ISSN 1221-6542,* Vol.41, No.1, 2001, pp. 29-34