PSTN/ ISDN/ VoIP - Based Solution for Voice Communications within Cluj-Napoca Academic MAN

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Abstract ***- The Technical University of Cluj-Napoca funded a project based on PSTN/ ISDN/ VoIP to realize a digital telephone exchange network of seven Alcatel OmniPCX 4400. The paper presents the architecture, the digital/ISDN services and the VoIP integration. There were two approaches for a centralized management: CMIP-based, provided by Alcatel OmniVista 4760, and SNMP-based, provided by HP OpenView. The study case discussed herein is important also for future developments, including interconnections within Cluj-Napoca Academic MAN between all universities in the city, as well as support for IP-based calls through RoEduNet or other service providers.***

Keywords: ***CMIP, HP OpenView, OmniPCX 4400, OmniVista 4760, SNMP***

I. INTRODUCTION

CAMAN (Cluj-Napoca Academic MAN) was officially launched in March 1999, based on the state-of-the-art technologies available by that time (ATM and Fast Ethernet) [3]. The Consortium of 6 universities in the city decided to put together the resources and to offer Internet access to the 39 sites interconnected by single-mode optical fiber. The County Council and the Local Council buildings were included too. However, only the data communications part of the academic network was solved, the voice communications solution being postponed.

The Technical University of Cluj-Napoca funded a project based on PSTN/ ISDN/ VoIP to realize a digital telephone exchange network for its seven main buildings: Baritiu 26, Baritiu 25, Daicoviciu 15, Dorobantilor 71, Muncii 103, Observator 2, Observator 72. Following the tender, the selected provider was Alcatel (through Romtelecom) and the equipment installed were seven Alcatel OmniPCX 4400 units (three main and four remote cabinets). Comparing to similar solutions implemented, the paper presents the particularities of the system's architecture. The centralized management and accounting system tested was based on Alcatel OmniVista 4760, whilst an SNMP-based interface interconnected to HP OpenView was also evaluated.

II. VOICE COMMUNICATIONS SYSTEM'S ARCHITECTURE

The new coming technologies, mainly VoIP over high-speed networks, changed the requirements for a voice communications system. This should have a flexible and scalable architecture, anticipating the future developments of the company. On the other hand the potential return of investment (ROI) may limit the complete movement towards IP telephony and imposes a balance between the existing technologies.

Telecommunications equipment is currently implementing industrial data communications standards, i.e. client-server model and openness. However the best characteristics of legacy private branch exchanges (PBXs), such as reliability and resilience, are maintained too.

Alcatel OmniPCX 4400 proved to be a good choice, as the classical PSTN and ISDN accesses are combined with IP-based interfaces. The ratio between analog and digital subscribers was highly dependent on the particular geographical spreading of the buildings belonging to the Technical University of Cluj-Napoca (see Fig. 1).

Three main nodes with CPU6 modules were installed in *Node A* (Baritiu 26, Muncii 103) and *Node D* (Observator 2) in a star topology. Primary rate ISDN accesses over single-mode optical fiber are provided through PRA2 interfaces (30 B channels and one D channel for SS7 signalling), whilst the remote cabinets are connected over SMF through INTOF (4 primary rate accesses each).

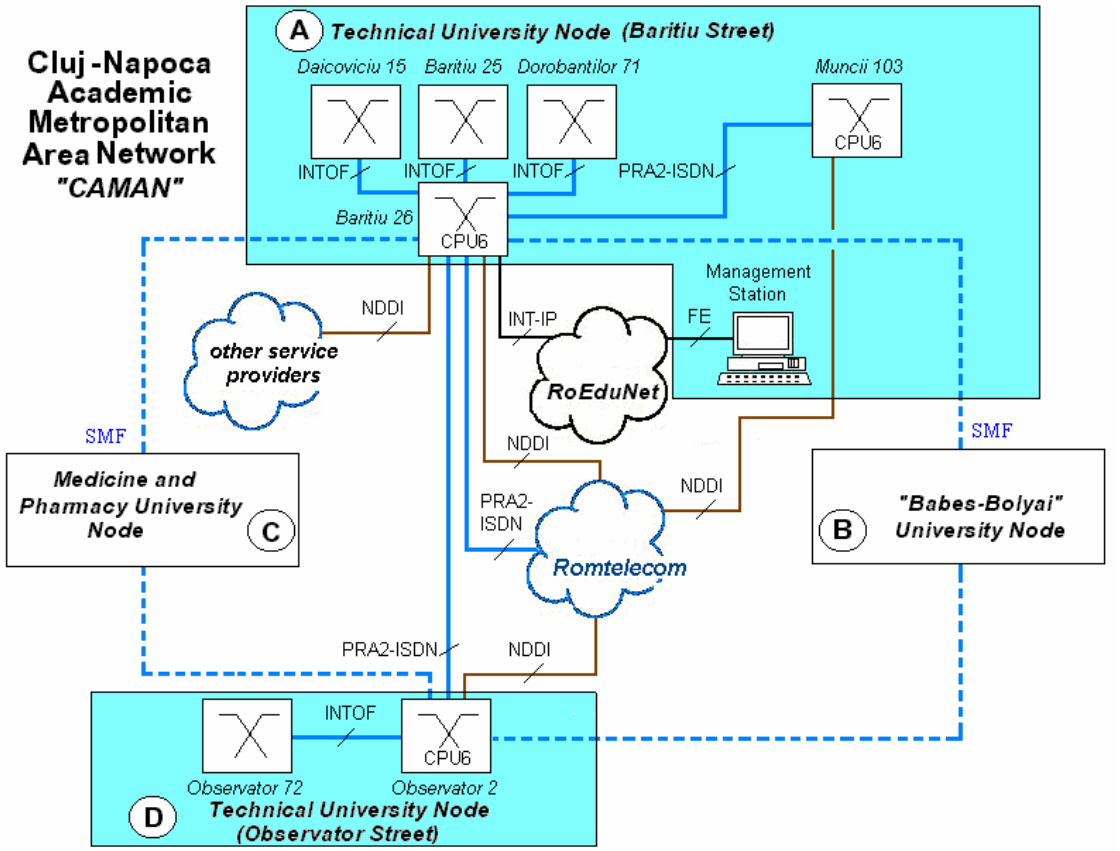

Fig.1 Voice Communications System's Architecture

The digital access to ISDN is provided by Romtelecom through PRA2-ISDN. As a backup, the analog access to the public switched telephone network is performed by NDDI *(Not Direct Dial In)* interfaces. The interconnection to *Node B* ("Babes-Bolyai" University) and *Node C* ("Iuliu Hatieganu" Medicine and Pharmacy University) within CAMAN is under progress, and could be done either through *Node A* (Baritiu 26), either through *Node D* (Observator 2).

The paper is referring to the voice communications solution chosen by the Technical University only, but the study case discussed herein demonstrates that the system's architecture is fully compatible to other universities' equipment. Furthermore the IP-based access for IP phones (Alcatel 4035IP) or PC-based management station proves that the convergence between computers and telecommunications worlds is becoming reality. Any classical telephone, usually connected to a circuit-switching network, could use the same infrastructure to reach a packet-switching network too. This means it could establish a connection with a registered IP phone or use the VoIP trunks offered by the INT-IP card to get services from Internet Service Providers, such as RoEduNet or others.

III. CMIP-BASED MANAGEMENT

The management station, placed in *Node A*, uses a Fast-Ethernet interface and runs Alcatel OmniVista 4760 R2.0. This software offers a CMIP-based centralized management, a typical telecommunications approach. CMIP *(Common Management Information Protocol)* is specified by ITU-T X.711-X.712 | ISO/IEC 9596-1,2 using the notation ASN.1 *(Abstract Syntax Notation One)*. The protocol was defined for exchanging the management information according to the services described by CMISE *(Common Management Information Service Element),* as in ITU-T X.710 | ISO/IEC 9595. The central concepts in information modeling are the managed objects, created in a system to represent the resources managed according to the managed object class definitions. The repository of these managed objects and the information contained in them is called MIB *(Management Information Base).*

Alcatel OmniVista 4760 consists on a set of management applications for a PCX network, using client-server architecture and LDAP *(Lightweight Directory Access Protocol)* directory (based on Netscape Directory Server). Data stored on the server application (running under Windows NT Server/Workstation with SP4 and 2000 Server/Professional) is automatically synchronized with network data and contains the database needed for system's administration. The OmniVista 4760 client application (running under any Windows-based operating system) accesses server resources through LAN/WAN, intranet or web. Depending on licenses and rights the following applications are included into the modular software:

- *Directory:* to consult the company directory, perform searches, modify data and export/import directory files
- *Configuration:* to configure and manage PCXs declared in the *Directory*
- *Accounting and Traffic Observation*: uses tickets (accounting records) to calculate the costs to the chargeable outputs (usually trunks to the service providers). The statistics available are related to costs for trunk groups/ extensions/attendants, call duration, carrier use etc.
- *Reports:* is dedicated to *Accounting and Traffic Observation* report management. However it is considered that data contained in the accounting reports has no legal value.
- *Alarms:* allows authorized personnel to manage PCXs alarms/events and the alarms generated by 4760 applications.
- *Topology:* is an option for *Alarms* and is used to locate the alarms in the network topology, view the shelves and boards, filter alarms etc.
- *Scheduler:* runs both scheduled tasks linked with OmniVista 4760 operation & maintenance and external tasks (i.e. anti-virus or archiving programs)
- *Maintenance:* contains all predefined maintenance tasks required by OmniVista 4760 itself or by the network
- *Security:* is used by the administrator to manage the user access rights

IV. SNMP-BASED MANAGEMENT

The following discussion is data communications management oriented, because SNMP *(Simple Network Management Protocol)* was clearly defined for Internet protocols rather than for OSI protocols (as CMIP). The term MIB has been used in another context here, because the modeling principles are simpler and do not distinguish between an object class and instances of a class. MIB represents in this case a collection of data items (object types) instead of a collection of properties.

The management model includes four components: the network management station (known as manager), the managed nodes (each containing a processing entity called agent), the network management protocol (see *Table 1*) and the management information (specified by the SMI, the structure of management information, and MIB, the collection of managed objects).

TABLE 1. SNMP versions

Version	Request for Comments
SNMPv1	RFC 1155, RFC 1157, RFC 1212
SNMPv2	RFC 1441 … RFC 1452
SNMPv3	RFC 2271 … RFC 2275

For non-SNMP managed devices (for example the Alcatel nodes) a proxy agent will act on behalf of them.

The SNMP manager can retrieve management information from the agent by sending requests (`get, getNext, getBulk`). In order to modify the management information on the agent's system, it can send `set`. On the other side, the agent is able to send information to the SNMP manager without any request by using a `trap` (SNMPv1) or `notification` (SNMPv2). The requests from an agent are accompanied by a `community name`, that acts as a password.

HP OpenView Network Node Manager (NNM) is actually an SNMP manager that discovers the objects according to the following levels [5]:

1) *Internet* (IP networks, gateways, routers and multi-homed workstations)

2) *network* (bus, star and ring segments, hubs, bridges, switches, routers, gateways)

3) *segment* (hubs, bridges, switches, routers, gateways, hosts)

4) *node* (network interface cards)

TABLE 2. Basic SNMP operations

SNMP Services	Request/Response	Role
`Get`	Request	Reads a value from a specific variable
`GetNext`	Request	Traverses information from a table of specific variables
`GetBulk`	Request	
`Get`	Response	Replies to a `get` or `set` request
`Set`	Request	Writes a value into a specific variable
`Trap` or `Notification`	-	Message initiated by the SNMP agent without requiring the SNMP manager to send a request

V. EXPERIMENTAL RESULTS

According to the previous approaches presented the experiments were carried out as follows:

1) CMIP-based trials: using Alcatel OmniVista 4760 (see Fig. 2 and Fig. 6)

2) SNMP-based trials: using HP OpenView 7.0 (see Fig. 3-5 and Fig. 7)

Concerning the CMIP-based proprietary software developed by Alcatel, according to the available licenses, the trials envisaged the following applications: *Directory,*

Configuration, Accounting, Reports, Alarms, Scheduler, Maintenance, Security.

Fig.2 presents the API for configuring an IP-phone. It has a name (extension number) and is configured more or less in same way as any analog/digital telephone device (except the fact that may require additional information such as IP and MAC addresses).

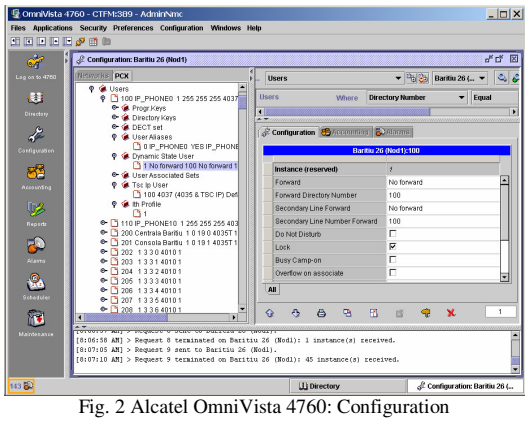

Fig. 2 Alcatel OmniVista 4760: Configuration

The paper cannot cover in details all the client applications tested, considering that one example is relevant enough.

A bit more attention was paid to SNMP-based approach is order to test the use of HP OpenView as a common management application for both data and telecommunications networks. However the support provided by Alcatel was inconsistent. Fig. 3 shows that the software discovered only the Nod1 (Baritiu 26), as belonging to Internet (and not to the Voice Network).

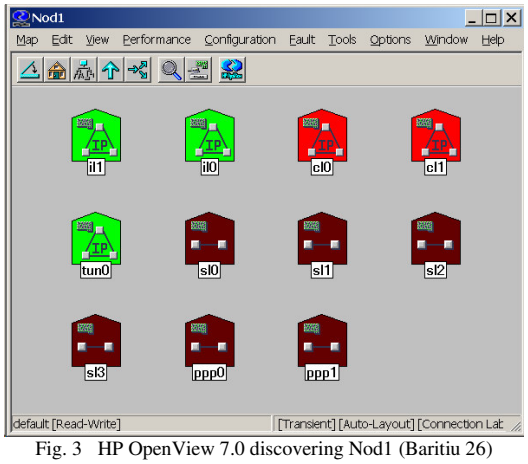

Fig. 3 HP OpenView 7.0 discovering Nod1 (Baritiu 26)

On the other hand, the `snmpd` (SNMP daemon) was properly started on all three main nodes (having CPU6). This was demonstrated within Fig. 4

```
(102)ob001002> snmpwalk -v1 10.1.2.1 public ip
ip.ipForwarding.0 = forwarding(1)
ip.ipDefaultTTL.0 = 64
ip.ipInReceives.0 = 21806
ip.ipInHdrErrors.0 = 0
ip.ipInAddrErrors.0 = 70
ip.ipForwDatagrams.0 = 0
ip.ipInUnknownProtos.0 = 0
ip.ipInDiscards.0 = 0
ip.ipInDelivers.0 = 21818
ip.ipOutRequests.0 = 0
ip.ipOutDiscards.0 = 0
ip.ipOutNoRoutes.0 = 70
ip.ipReasmTimeout.0 = 60
ip.ipReasmReqds.0 = 0
ip.ipReasmOKs.0 = 0
ip.ipReasmFails.0 = 0
ip.ipFragOKs.0 = 0
ip.ipFragFails.0 = 0
ip.ipFragCreates.0 = 0
ip.ipAddrTable.ipAddrEntry.ipAdEntAddr.10.1.2.1 = IpAddress: 10.1.2.1
ip.ipAddrTable.ipAddrEntry.ipAdEntAddr.127.0.0.1 = IpAddress: 127.0.0.1
ip.ipAddrTable.ipAddrEntry.ipAdEntAddr.172.30.1.2 = IpAddress: 172.30.1.2
ip.ipAddrTable.ipAddrEntry.ipAdEntIfIndex.10.1.2.1 = 11
ip.ipAddrTable.ipAddrEntry.ipAdEntIfIndex.127.0.0.1 = 3
```

Fig. 4 snmpwalk

As the license for HP OpenView was temporary, not all the facilities were available by the time the experiments were realized. However some of them (such as local network polling statistics) were studied, as in Fig. 5.

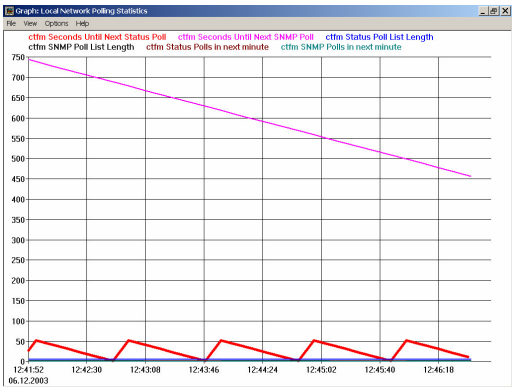

Fig. 5 Local Network Polling Statistics

For a better comparison between CMIP-based approach versus SNMP-based one, Fig. 6 and Fig. 7 are devoted to the same task: alarms analysis. Both applications are offering enough details about the severity (warning, clear, minor, major, critical etc), the managed object and the notification date. From this point of view, Alcatel OmniVista 4760 and HP OpenView are equally satisfying the needs of the system's administrator.

VI. CONCLUSIONS AND FURTHER WORK

The paper presented a study case of implementing a voice communications system for Technical University of Cluj-Napoca. Using the existing single-mode optical fiber infrastructure provided by the Cluj-Napoca Academic MAN, the adopted solution involved both circuit and packet switching techniques.

The reliability and resilience of the legacy PBXs (PSTN and ISDN accesses) were combined with the client-server and openness of the IP-based equipment (IP access for voice and management). The best choice was Alcatel OmniPCX 4400 with CMIP-based management offered by Alcatel OmniVista 4760.

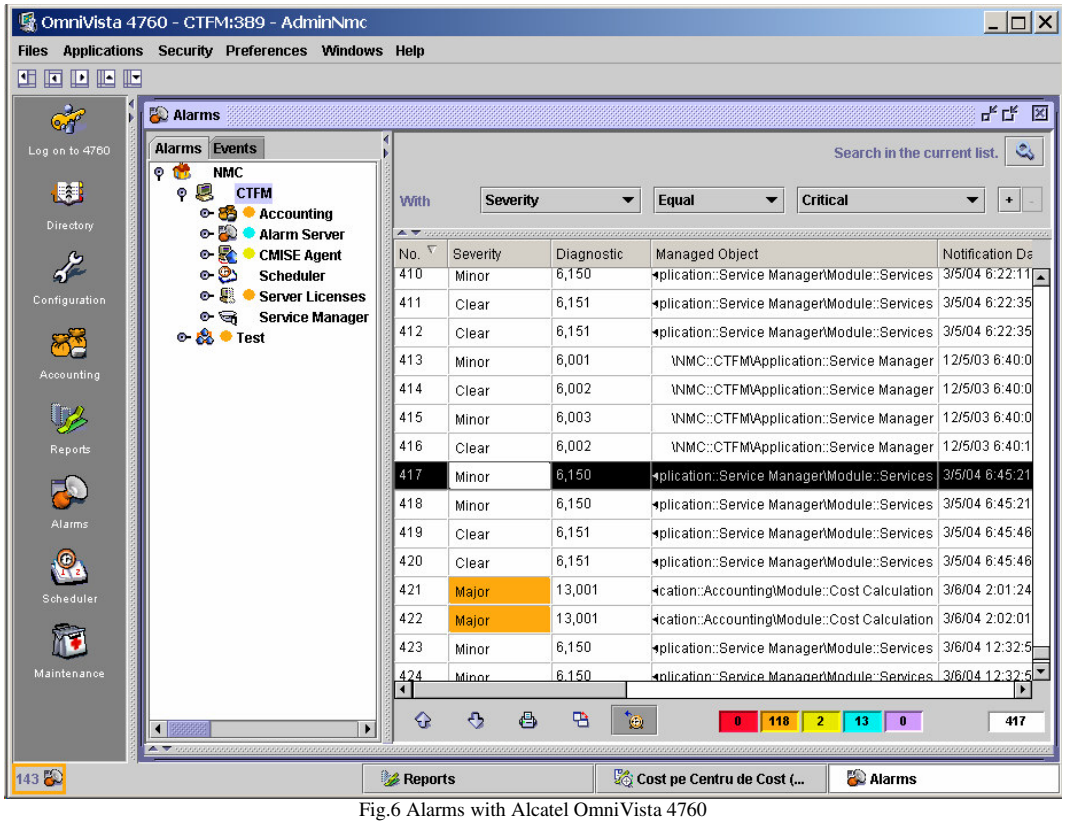

Fig.6 Alarms with Alcatel OmniVista 4760

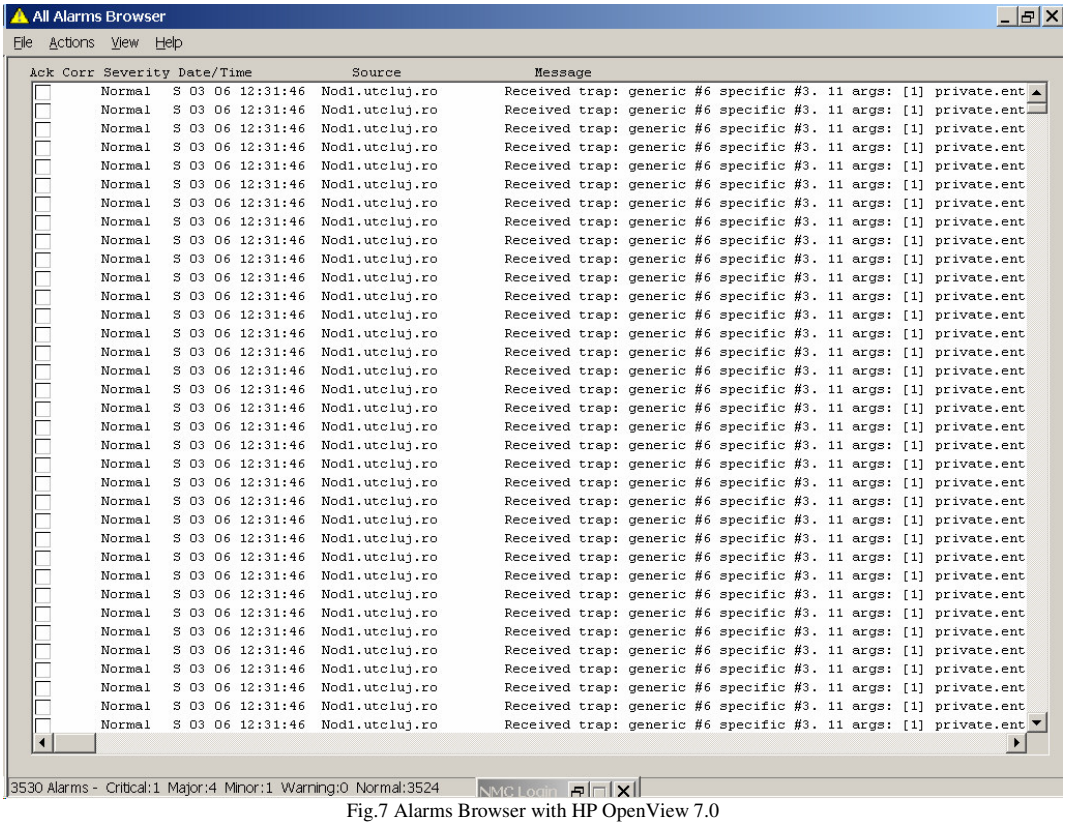

Fig.7 Alarms Browser with HP OpenView 7.0

Unfortunately the manufacturer did not continue the investments in SNMP-based management (despite the temptation to have a unique management application, such as HP OpenView, for both telecommunications and data communications networks).

Further work will be carried out to accommodate future developments, including interconnections within CAMAN between all universities in Cluj-Napoca, as well as support for IP-based long-distance calls through RoEduNet or other service providers.

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