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Towards the integrated Configuration and Management of Multicast Teleconferences based on IP over ATM

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Abstract

The management of ad-hoc international networks temporarily deployed to support teleconference events faces specific problems that may concern both standardization organizations and management application design. This paper addresses such problems, met in a 3-year experience of teleconference service delivery on real scenarios, and how the development of a SNMP-based platform closer to the network intrinsics can ease the set-up, QoS monitoring and fault location tasks in such an environment. A statement about the subsystems potentially capable of configuration via snmp is also made.

1. Introduction

The Dept. of Telematic Engineering at the Technical University of Madrid is engaged in several research projects within ACTS whose main targets are the experimentation of advanced networks through the provision of services like tele-education (e.g. BONAPARTE [1]), tele-conferencing (e.g. NICE [2]) and tele-meeting (e.g. TECODIS [3]).

The platform typically deployed to carry out these experiments consists of a CSCW application (ISABEL [4] see annex) on top of a TCP-UDP/IP/ATM stack, including IP multicast and ATM multipoint features, running on a number of multimedia workstations (up to 20). The ISABEL stations are usually scattered all over the world and are linked together by means of a wide variety of media, mainly:

- the VP-based service of the Pan-European ATM Network
- E1 satellite links.
- n x BRI ISDN circuits (inverse multiplexed), usually concentrated on a Primary rate Interface.
- public Internet

Clearly the most manpower-consuming tasks in the implementation of these kind of distributed events are the configuration of the network together with the location of failures, diagnosis and fixing operations. This high cost is due to well-known factors like complexity and novelty of equipment, heterogeneity of subsystems, use of third-party-operated subsystems subject to instabilities, costly WAN links available upon demand, ad-hoc platforms, the fact that end-systems are owned by different entities with drastically different network management policies, QoS monitoring requirements, limited use of SNMP [7], need for transport level configuration, existence of three separate ATM network topologies for different IP traffic (unicast, multicast upstream, multicast downstream), lack of support of IP multicast by SNMP, etc.

In this paper we address these and other key factors to be solved in practice by the management scheme being planned which tries to integrate configuration and monitoring based on SNMP. The approach proposed includes the development of a subagent for the multimedia application, and an OpenView management application to deal with ISABEL application management information, that will help to simplify the management and reconfiguration of these experimental networks.

2. Target Network: ISABEL

ISABEL [4] (see annex) is a CSCW application (Computer-Supported Cooperative Work) specifically designed to run **synchronous distributed events** involving tens of sites, namely teleconference, telemeeting and teleteaching. ISABEL provides **integrated control** of several multimedia components: Audio, Video, Overhead Display, Pointer/Pen, Text Editor, Whiteboard, Display sharing, Application sharing, Question/Answer dispatcher, multicast file transmission, Session Manager, etc. These components generate a complex multimedia flow bundling a number of data streams with different transport service requirements which must be supported by the target ISABEL network that we shall describe briefly.

2.1 Description of the network

The ISABEL application generates two different kinds of IP traffic: unicast and multicast traffic. Due to the simpler routing requirements of multicast traffic (when using static routing) and for efficiency reasons, in general multicast traffic, unlike unicast traffic, won't traverse routers. Several other devices are employed to process multicast traffic. Therefore, two separate networks are usually devised for each type of traffic. The first one is used to transmit application protocol data units (e.g. control commands), and makes use of the connection-oriented transport service TCP/IP. The second one, running on the connection-less transport service UDP/IP, carries most of the multimedia stream (like audio, video, pointer data,...) interchanged among users. This multicast traffic is routed to a root site which aggregates the different streams into a single global stream and distributes this global multimedia flow to all attached nodes. Therefore, we can differentiate the multicast traffic into two different streams, the **UPSTREAM** and the **DOWNSTREAM**. The former is generated at each station and flows from each station to its Network Node towards a root node, and the latter is the output of the root Network Node station traveling to all end-point stations. If there is a considerable number of partners, tree hierarchy of adder stations is built (Figure 2).

In outline, there are actually three independent networks needed to run the application:

- *Unicast network:* it provides N to N bi-directional communications. The connection between the different machines is made with IP routing . Each machine must know the IP-address of the other participants, and the gateway to reach them.

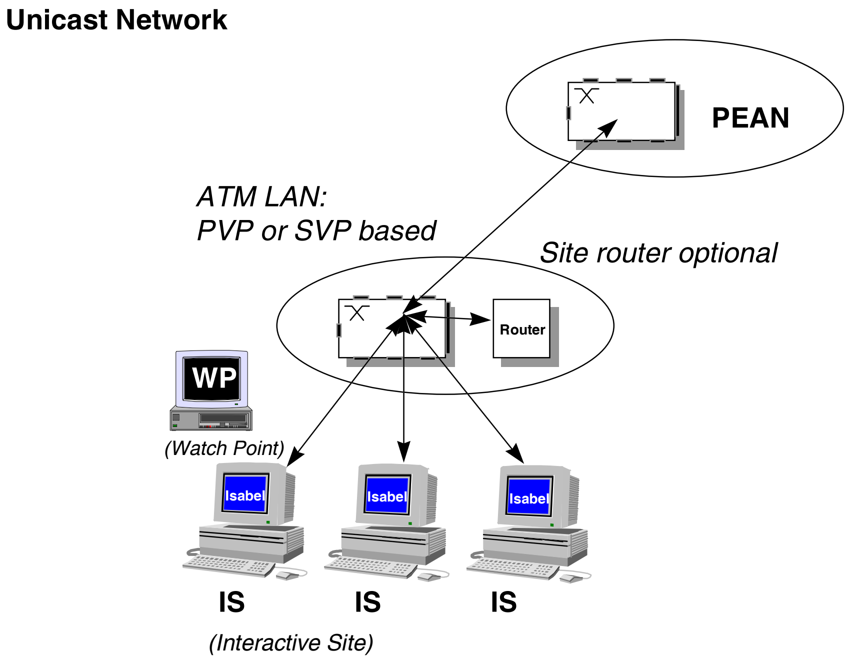

Figure 1 Unicast Network

- *Downstream network:* it carries the aggregated global multimedia output flow from the root network node to all the sites.

- *Upstream network:* it carries the multicast IP traffic, originated at each Isabel workstation, towards the root flow adder.

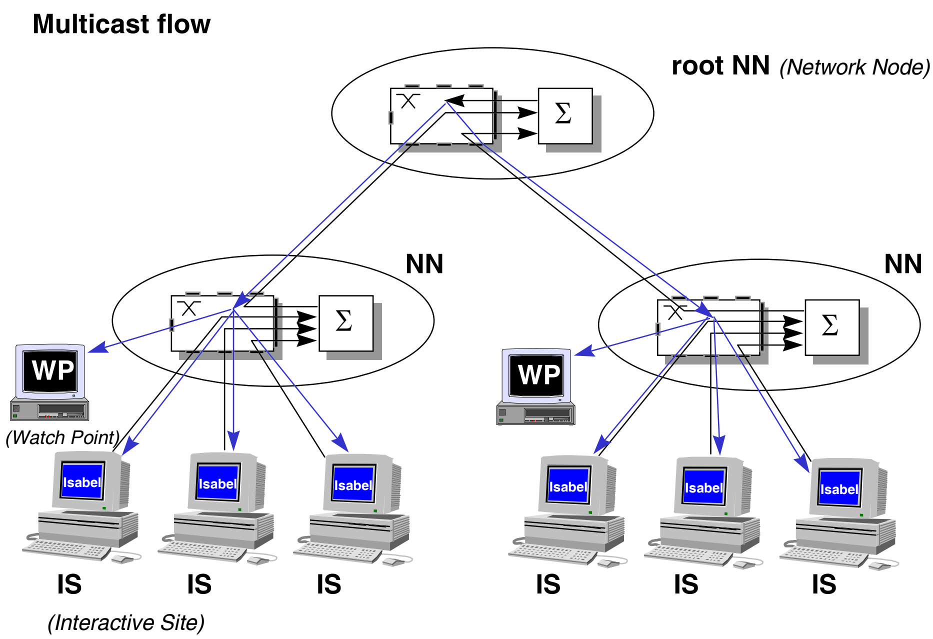

Figure 2 Multicast Network

Each station has a low bandwidth bi-directional channel to support unicast traffic, and two unidirectional circuits for the multicast traffic (upstream and downstream). Furthermore, receive-only ISABEL sessions can be started (WatchPoint mode) to gain access to an ISABEL conference without the added complexity of being a fully interactive entity, and without the need to have an return channel (neither unicast nor multicast upstream).

Regarding Wide Area Networking infrastructure used, although it is clear that ATM is the transmission/switching technology best suited for this task, tested environments include:

- **ATM**. The configuration of the ATM network comprises ATM LANs and the Pan European ATM Network (PEAN), using IP/AAL5/ATM with multicast both at the IP level (IP multicast routers) and at the ATM level (high performance point to multipoint connections).

- **ISDN.** In the ISDN configuration one B channel (64 Kbps) of an ISDN Basic Rate Interface (BRI) is enough to support all ASFs (application support functions) of ISABEL at a minimum quality. However, this quality is only satisfactory for desktop telemeetings and teleworking; the inverse multiplexing of at least 6B channels is necessary to provide a quality acceptable to support a conference service. The main use of ISDN made in an ISABEL session has been using it as a back-up network.

- **Satellite.** E1 satellite links have also been used and interconnected to the ATM network through a router with G.703 and an AAL1-capable equipment: the ATM adaptor from Telefónica I+D.

- **Internet.** Using TCP-UDP/IP directly through LANs and the public Internet. The current average throughput and jitter of Internet is not enough to support but a little of ISABEL's functionality.

2.2 Description of a local network node

Although the configuration of an interactive site is as simple as setting up an ISABEL WS and an ATM connection, Network Nodes can be rather complex, involving the following pieces of equipment (Figure 3).

- *ISABEL WorkStation (WS).*- They are at the Interactive site (sites that can interact (send and receive audio/video/data) which each other by means of ISABEL). These WS must have one bi-directional channel (usually at 100Kbps) to support the unicast traffic that carries the control commands and two unidirectional channels for the upstream and downstream traffic (ranging from 0.4 to 5 Mbps). For this purpose the machines used are Sun Sparc computers with a Parallax video board and an ATM interface adapter running ISABEL.

- *ISABEL WatchPoint (WP)* .- Stations that can only receive audio/video/data sent from the interactive sites. The configuration is similar to the WS, but now the upstream circuit is not needed nor the unicast one.

- *Control WS* .- An optional station to remotely operate the ISABEL application in large events.

- *Management WS* .- Station running OpenView to manage the ISABEL network.

- *Flow Adder* .- Devices located at the Network Nodes which aggregate multicast traffic from the leaves towards the root. One node in the network is the root Network Node. These nodes can be either a Sun WS running ISABEL in adder mode or an ATM adaptor.

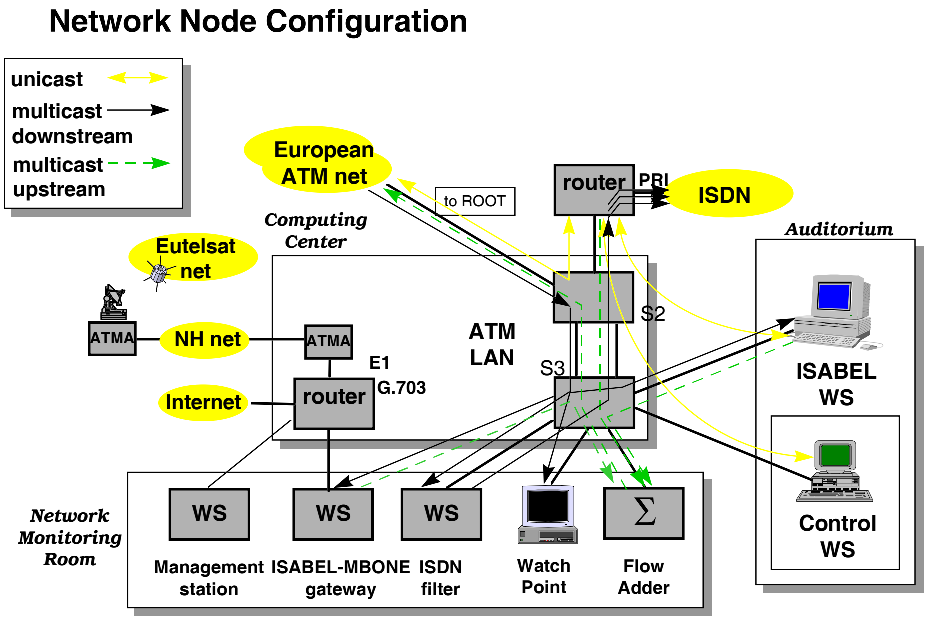

Figure 3 A complex Network Node with gateways to several networks

- *ATM switch* .- Currently all the ATM channels and paths are established using Permanent Virtual Channels (PVC) on CBR Permanent Virtual Paths (PVP), because the public network does not support the standard signalling for automatic circuit setup.

- *Router* .- IP routers with an ATM interface and optionally ISDN PRI or nxBRI, G703, .. with routes to all interactive sites. CISCO 7000 routers are usually used.

- *ATMA (ATM Adaptor)*.- It is a network device designed and implemented at Telefónica I+D (R&D) of Spain. It is conceptually a UNIX machine extensible with a number of subsystems enabling advanced ATM switching functions, protocol adaptation, etc. One of these capabilities is interfacing G703 with ATM by AAL1.

- *ISABEL-MBONE gateway* .- This software device -developed by U. of Naples and Politecnico di Torino- is necessary if the connection of an ISABEL session to Internet's MBONE conferences is required. IP multicast tunnels are then set up and managed.

- *ISDN filter* .- When the backup ISDN network is working, this device forwards traffic to the connected ISDN stations.

3. Management challenge

Clearly the most manpower-consuming tasks in the implementation of these kind of distributed events are the configuration of the network together with the location of failures, diagnosis and fixing operations. This high cost is due to well-known factors:

- Complexity and novelty of equipment. This factor applies to all the components of the network. Routers' operating systems implementing new protocols, like ATM signaling, ATM ARP service, etc., usually suffer from bugs which are a source of unstability. It's quite frequent to find a router running out of resources or in a deadlock state when advanced features -not to mention those in standardization state- are enabled. Furthermore, processes implementing new features always run on CPU, instead of on peripheral co-processors in interface boards with the subsequent overhead on the global operation of the router. For instance, multipoint of IP multicast in most routers is usually not efficient enough over ISDN interfaces (this is not relevant for ATM since multipoint is performed at the switches). Video processes in multimedia workstations are also a likely failure point.

- QoS monitoring is required. Networked multimedia applications introduce strong real-time requirements. Resource reservation protocols can become a simple wish list declaration without a network capable to react to user's requirements and without the chance to find out the node that needs reallocation of bandwidth, flow priority assignment, etc. Management applications should provide solutions covering remote application QoS monitoring and location of bottlenecks or network congestion detection.

- Heterogeneity of subsystems. This factor hinders both the implementation of a uniform management architecture and the real usefulness of management schemes with so many non-manageable or, in the best case, transparent components.

- Use of third-party operated subsystems subject to unstabilities. This is the case of distributed events run by organizations of heterogeneous nature (in our case, universities, research laboratories, telecom and non-telecom enterprises, national hosts, etc.) usually sharing networking resources with other projects,...

- Costly WAN links available upon demand. Current operation of the pan-European ATM network is based on Virtual Path reservation, and the connections are set by the PNOs semi-automatically providing a service quite unpredictable. This VP service is international, what means in practice several long delays in getting the path through.

- Since links, and hence remote systems, are only accessible temporarily, networks become dramatically dynamic. This potentially implies having brandnew subnetworks every time a connection comes up and further reason for automatic management, although not all management platforms like so many changes.

- The fact that end-systems are owned and managed by different entities, with different management and security policies is also an enormous drawback for the introduction of a global management scheme. This is a fact difficult to deal with, although it might be overcome if the technical solutions are light and secure enough.

- Usage of public networks like Internet, or even the fact that most end-systems have an interface to Internet, make traffic routing control paramount. It is well-known that IP routing management is one of the nightmares of IP. It's no surprise to find packets having round-trip paths different on the ways forth and back, nor having one of them coming through Internet with its corresponding unpredictable behaviour. Add to this security factors.

- Firewalls limiting systematically UDP packets can also be a major drawback in this heterogeneously managed environment.

- Ad-hoc platforms, rarely provide SNMP management. For example, the ATM adaptor (ATMA) is urgently demanding this feature.

- Limited use of SNMP even when it is available. Although the main target axiom of SNMP is to have the lightest agents as possible, the technical causes for resistance to adopt SNMP comes from heavy agent implementations -agents need CPU-, existence of prior approaches usually based on scheduled scripts that may not justify the development of management applications views.

- Need for transport level information and configuration. As explained above the implementation of a multicast network over non-broadcast networks like ATM or ISDN requires the configuration and monitoring of the component multicast servers (whatever the specific approach followed is like e.g. BUS in LANE) and flow adders. As a matter of fact, having so many new networking devices processing IP datagrams stands out the need to remove their transparency. These elements should become more manageable as more ATM switches with built-in IP-enabled CPUs appear.

- The existence of three separate ATM network topologies for different IP traffic (unicast, multicast upstream, multicast downstream) actually implies managing three networks. This implies that unicast connectivity is simply not enough to have a good idea of the real status of the network. One would also like to know of multicast connectivity, both upstream and downstream, and the points where it is eventually broken or where the QoS comes down.

4. Approach

Up to date the only management scheme for small-scale events (less than 5 sites) consisted of ad-hoc IP tools, like ping, traceroute, spray, snoop, ifconfig,.., and ATM device commands, like atmarp, atmstat, atmconfig..,, for network interface adapters, and console sessions for ATM switches. For large-scale events, with a high number of participants and steady utilization e.g. a week (see ABC96 [5]) the approach followed included the utilization of a management station running OpenView [6]. However, although the use of such standard solution provided clear benefit in the overall management of the network, the single functionality used was "unicast connectivity monitoring" which is simply not enough for our 3-networks scheme. Needless to say that much more useful information about the network could be obtained -and consequently a more effective management approach- if a more specific SNMP-based application development was implemented .

The approach proposed to enhance management capabilities consists of (Figure 4):

1. Usage of a **Master Agent** to allow the simultaneous activation of all SNMP subagents carrying relevant information to set up and run a teleconference: Workstation info (kernel,IP network), ATM interface board info, and ISABEL application info. The master agent is in charge of interfacing with the manager process at the standard SNMP port, delivering each message to the involved subagents via UDP at different ports.

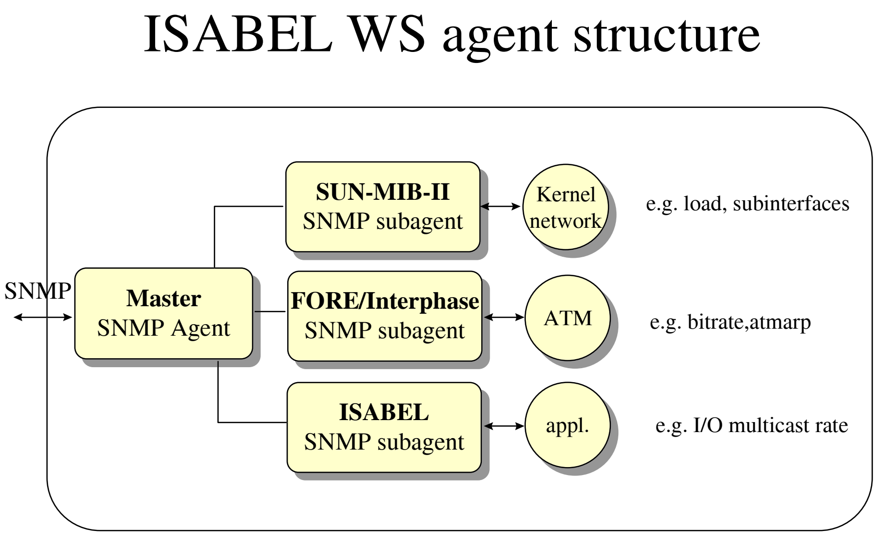

Figure 4 ISABEL SNMP agent structure

2. Development of an **ISABEL application Agent** (Figure 5). It will execute and reply SNMP requests from any manager, about information relevant to the proper delivery of the conference: connectivity at the 3 plains, QoS at end points, network congestion, etc. Several options exist for its implementation. One is the usage of an extensible SNMP subagent either programmatically, or non-programmatically if fast prototyping is necessary; and another possibility is to start from an existing freeware standard agent. The subagent will communicate directly with the application's Irouter - which is a middleware layer designed to provide shared network service for all multimedia components (priorities, IP traffic shaping, early packet discard, QoS adaptation,..)- and optionally with the application session controller (Figure 8).

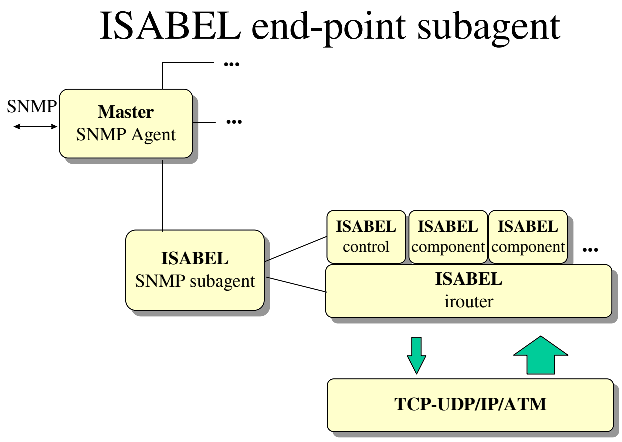

Figure 5 ISABEL Station SNMP subagent

3. Development of an **ISABEL network node application Agent** (Figure 6). The ISABEL private MIB extension will contain specific variables about multicast network status (that may require implementation of signaling). When ISABEL's irouter is started in traffic adder mode (network node), it must be aware of how many sources are being aggregated, its input and output quality statistics, and which multimedia flows are being forwarded.

   It will also assume, if implemented that way, that an external device is multicasting the output flow to at least as many remote nodes as sources are being added towards the root. Therefore, in this approach, the multicast device e.g. an ATM switch, is regarded as a non-SNMP system which is proxied by the agent in the adder workstation (Figure 6).

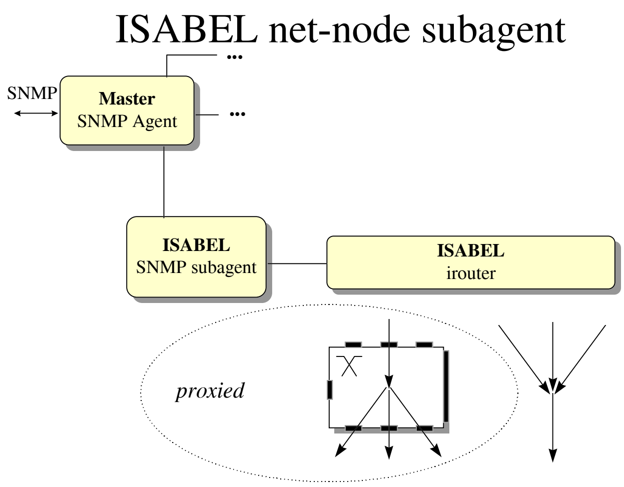

Figure 6 ISABEL network node SNMP subagent

The reason for this is that there are too many different ways to implement multipoint (there is a high diversity of equipment and of vendor private-MIB's) that makes impossible an homogeneous direct management of these devices. Furthermore, it is not our target to manage third-party ATM network resources: only the application stuff is accessible to us.

4. The usage of a SNMP management platform, HP OpenView, with an API supporting management application development and integration. This application should be able to display graphically all relevant information about the three networks served by the agents running on network nodes and conference workstations. The station running this application will be located in the conference global control centre, as close to the multicast network root as possible.

The target is that, once the network is running, the management platform does not only provide alarm detection but further meaningful feedback on QoS to the persons running the multimedia application in order to take maximum profit of the available bandwidth.

It is also important that management traffic does not interfere with application traffic. This can be accomplished at the agents by means of the irouter, and laboratory measurements will be necessary to check that traffic generated from the manager application (usually lesser than that from the agent) does cause negligible jam.

5. Configuration

From the user's point of view, it is quite desirable to have a network monitored and configured from a single management application. Problems could then be located and fixed at the same time, and the set up of a new network could be done even graphically. However, the only common language understood for most network devices is SNMP, but the configuration capabilities of agents are quite constrained - depending on vendors, and models-. Furthermore it is not clear that SNMP SET/GET scheme provides enough semantic power to enable the configuration of complex devices (unless through machine specific script activation), nor that a connectionless protocol is the best approach to configuration. In fact, there is a number of elements which can't be configured without a telnet session as root.

Nevertheless, some advance can be achieved in the local area with the purpose of easing the management and configuration of the devices typically found in an ISABEL teleconference network, namely in ATM switches. This type of graphical configuration applications are proprietary and are able to manage equipment from a single-vendor with limited graphical capabilities (e.g. no graphic representation of PVCs, no interswitch physical connections, no predefined views).

An Internet draft on a proposal for a standard RMON MIB for ATM switches [13] (originated by from Madge Networks and Cabletron Systems) is being circulated among the members of the IETF RMON Working Group in Network Management. However this draft only addresses monitoring only, not configuration issues, but it is interesting to bear it in mind when designing our application. Another important point of reference is rfc1695 [12]

The configuration and monitoring of complex ATM LANs can be facilitated by a graphical application with the architecture shown in Figure 7.

Configuration+Management Application Architecture

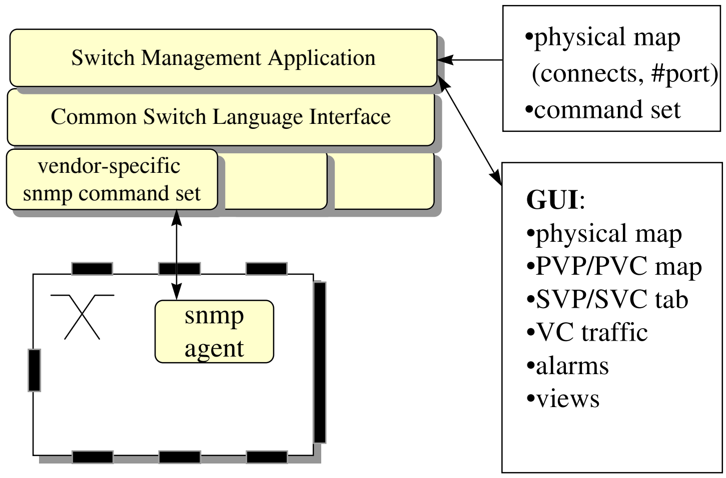

Figure 7 ATM LAN Configuration and Management Application Architecture

It will consist of a TCL-TK module that takes as input a file denoting the physical connectivity of nodes by fibers and the type of switch to be managed. This information is used to display the LAN at physical level on top of which the current VP/VC map will be drawn (selection of views is also foreseen). The switches communicate with the application using a common switch language to set & remove circuits. Operation across different vendors will be achieved by means of simple translator modules which address the proper object identifier in the vendor's private mib.

6. Conclusions and future work

In this paper we have presented an extensive plan to include SNMP-based management to support a validated configuration of a IP over ATM multicast network used in many WAN teleconferencing experiments. It is clear to us that even a standard-based management solution will provide rather a limited benefit given the diversity of entities managing the involved network equipment -with their respective management policies- the diversity of equipment used and other extra-technical problems. However, the SNMP management framework can reduce substantially the IP part of the problem, streamlining fault detection (even in the WAN border) and earning knowledge about the QoS at each IP node in the network. How can this be achieved given the premises? The answer is implanting management wherever control is within our reach i.e. at the application level, distributing agents with the multimedia application, running both on the users' workstations and on the network nodes performing traffic aggregation. The target is make end-to-end management easier and effective using a standard low cost solution.

One of the most important issues, which might be addressed in next-generation protocols, is the prevention of interference of SNMP traffic with real-time multimedia traffic. Given the type of service provided and the behavior of network adapters with AAL5, it is not good practice to devote a single VC for management, so that this kind of side-effects have to be held back at higher levels.

Future evolution of this network configuration must be studied too. For instance, given the problems raised by unicast routing configuration, the future trend in the architecture of the multimedia applications is going toward a single UDP/IP multicast data flow. How well will this fit with SNMP management is not clear at all. This is an empty hole unsupported by SNMP nowadays. The presented approach assumes the existence of a unicast network.

New networking features of operating systems at workstations can also limit the effect of heterogeneous equipment, as they can perform functions carried out only by routers so far. For example, performing routing functions by subinterfacing mechanisms. This can avoid both the technical bother of having different routes for unicast and multicast data, and the procedural difficulty of allowing SNMP access to private routers at remote organizations.

A careful design should also be flexible enough to allow changes in the multicast scheme, for example using BUS (Broadcast & Unknown Server) in LANE (LAN Emulation), and other ATM signaling protocols as they appear. In this sense, SNMP can help in keeping track of connection set-up's specially in the local area, if a standard MIB for switches is agreed, in such a way that SNMP constitutes the homogeneous language for switch monitoring and, quite likely, for configuration.

References

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ANNEX: Overview of ISABEL

ISABEL is a CSCW application (Computer-Supported Cooperative Work) specifically designed to run **synchronous distributed events** involving a high number of participants (up to **16 sites** have been connected in a fully interactive distributed session with real users), namely teleconference, telemeeting and teleteaching. ISABEL provides **integrated control** of all its multimedia components -e.g. one-touch video layout and audio selection, automuting, control passing, question management- being prepared to run in several interaction modes according to the activity selected. This control operation can also be optionally carried out in a separate **control workstation** in a TV-studio fashion for large events (Figure 8 **ISABEL control display**).

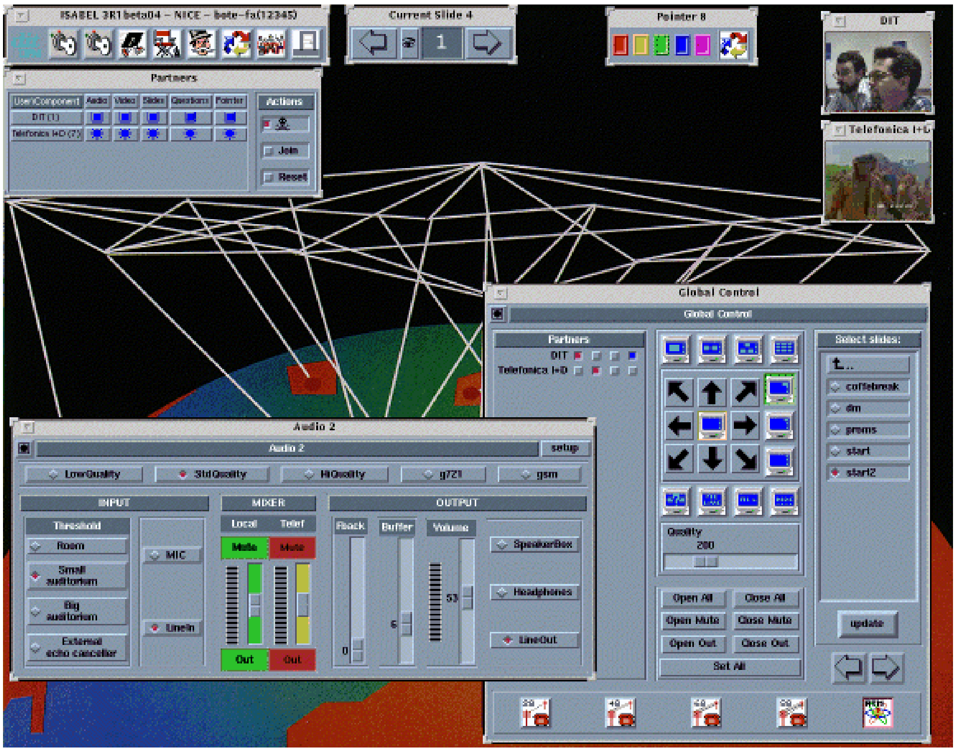

Figure 8 ISABEL control display

ISABEL provides a **shared workspace service** - i.e. all participants share the same view of the event while playing different roles in the interaction - composed of the following cooperative components:

- **Session Manager**: provides **activity management** (selected interaction mode), **floor control** for N to N users interaction, and **layout selector**, featuring integrated control of all components with flexible predefined layouts plus global group role management. Interaction modes are fully configurable.
- **High Quality Audio**: highly tunable, featuring vu-meters for all channels, several pcm qualities and standard compression algorithms (g.703,gsm), echo cancelling, buffering.
- **Digital Video**: highly customizable **N to N video conferencing**. ISABEL has been tested with up to 16 sites with simultaneous transmission of 16 videos to all sites.
- **Overhead Display** (gif format, ppt conversion supported).

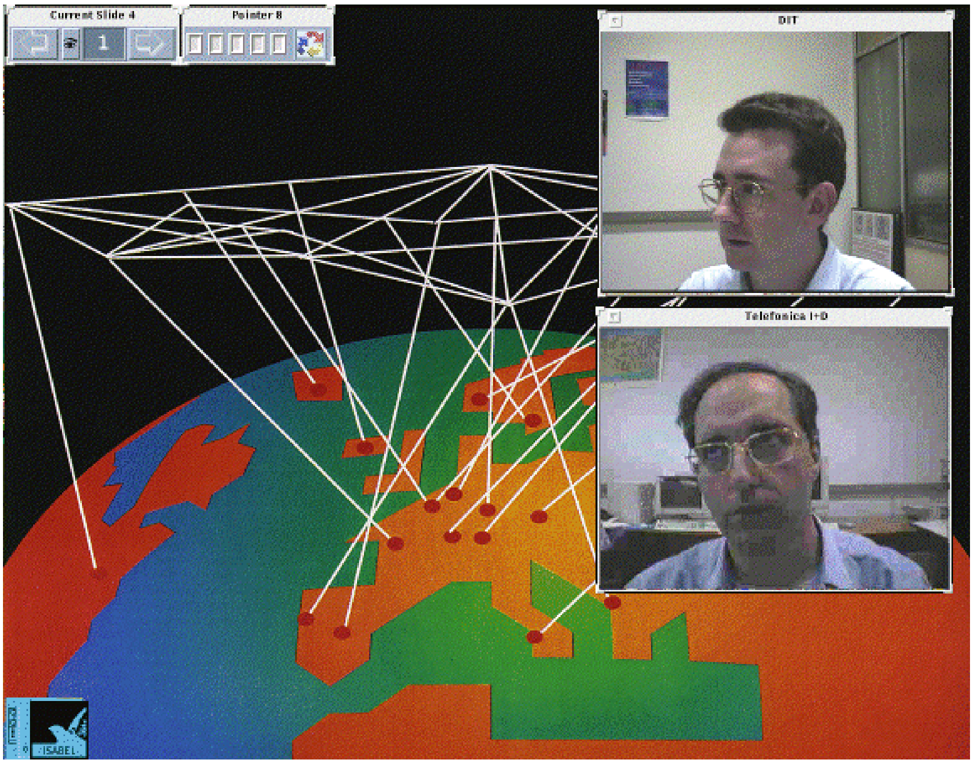

Figure 9 ISABEL user screen

- **Pointer/Pen**: a pen to draw in the shared workspace.
- **Text Editor**.
- **Whiteboard**: cooperative graphical editor.
- **Display sharing**: static pixmap-level window sharer.
- **Application sharing**: real-time pixmap-level application sharer.
- **Question/Answer dispatcher**: click-away question queuing and dispatching with one-touch selection of question plus automatic questioner's/lecturer's video layout.
- **File transmission**: high speed multicast file transmission.

This service is enabled by two alternative network configurations: IP unicast (full-mesh) and **IP multicast** for high performance fully scalable operation. ISABEL provides software functions for flow aggregation and multipoint distribution. Besides full interactive mode ISABEL can also run in passive mode as **watchpoint** (like a TV set) over unidirectional channels.

Hardware/Software requirements

ISABEL's end-point minimum required wares include:

- a Sun workstation with Solaris 2.5 (SparcStation 10 (SS10/40 minimum recommended), SS20, SS5, UltraSparc 1,..) . There is also available a release of ISABEL for SunOS, Linux, and expected soon, a SGI-IRIX version.

- a Parallax video MJPEG board (PowerVideo or XV-24SVC series) plus OpenWindows. ISABEL can also run with a plain video board using software decompression (at lower framerates).

- a network adapter. Preferably an ATM board (FORE SBA-200,Interphase,..) - FDDI, ethernet, or ISDN- .

- HiFi audiovisual equipment providing microphone, loudspeakers and video camera functions.

Further information at: **`http://www.dit.upm.es/~proy/isabel`**

ISABEL Networking

ISABEL´s transport layer is based on standard internet protocols TCP-UDP/IP and it can therefore interconnect end users through any network providing this service. As a matter of fact, the current widespread of the Internet protocols suite is a guarantee for the internetworking possibilities of ISABEL, being easily configurable to work on top of most platforms. The most experienced systems are ATM, ISDN, satellite networks, and even public Internet, obviously constrained to conferences with a small number of participants and low quality audio and video. ISABEL makes use of the connection-oriented transport service **TCP/IP** to carry **control** information and the connection-less transport service **UDP/IP** for video, audio, and in any **bulk data** transfer in general. This makes it possible to use the multicast[1] capabilities of IP for data intensive multimedia streams and the efficient -in terms of bandwidth- realization of large video conferences.

Regarding Local Area Networks, the large bandwidth requirements of High Quality audio and video recommend the usage of a broadband system like ATM or FDDI. However, a load-free ethernet or token ring is perfectly able to cope with the current needs of the maximum quality of service available (provided that multicast capabilities are employed when more than 3 stations are linked). Network configurations which have been experienced in the wide area are:

- **ATM.** This is the most usual network configuration for ISABEL: an ATM network comprising ATM LANs and the Pan European ATM Network (PEAN) using IP on top of AAL5 with multicast both at the IP level (IP multicast routers) and at the ATM level (high performance point to multipoint connections) [5,6,9]. The set-up of such a network is depicted in this document.
- **ISDN** . One B channel (64Kbps) of an ISDN Basic Rate Interface is enough to support all ASFs of ISABEL at minimum quality. However, this quality is only satisfactory for desktop telemeetings and teleworking; the inverse multiplexing of at least 6 B channels is necessary to provide a quality acceptable to support a Conference Service. Hence, nowadays this option can be considered only as a back-up alternative. The set-up of this network is depicted in this document.
- **Internet.** Using TCP-UDP/IP directly throughout LANs and the public internet. The average throughput and jitter of internet is not enough to support but a few of ISABEL functionalities. Past experiments of conference delivery required the use of reserved network resources within internet (e.g. broadcast of ABC'96 using MBONE network infrastructure). Proposed protocol standards like IPng, RTP, RTCP, RSVP, intend to automate the reservation of resources on shared networks based on Internet protocol stack.

Why using ISABEL to set up a Conference Service?

The rationale for using ISABEL as the basic application for putting up a Conference Service Platform is the following:

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[1] Multicast support can be added to the kernel of SparcStations running SunOS 4.x and DECstations running Ultrix 3.1 with extensions that can be got at URL:

ftp://gregorio.stanford.edu:/vmtp-ip/ipmulti-*.tar.Z

SGI, and Sun stations running Solaris 2.x, or Dec Alphas running OSF V2.0 already have the necessary support in the kernel, so the above extension is not necessary.

- ISABEL provides **N to N bidirectional communication** for all the media exchanged. Thus, it is structurally conceived to support the full variety of interactions among users, including all of a conference.
- ISABEL has been designed specifically to support **auditorium interconnection** and has specific modes for distributing the different types of interactions existing in a Conference, Workshop or Congress.
- ISABEL features **multicast** efficiently: the impact of increasing the number of sites on network resources is minimal. Events become scalable. Furthermore, there exists the possibility to start ISABEL in receive-only mode (WatchPoint) in order to spread the contents of the conference to an unbounded number of non-interactive sites, at the expense of no extra bandwidth.
- ISABEL is a mature product, which keeps growing in performance, functions and supported platforms, and that has been **successfully used to distribute major real events**: 4 Summer Schools and several workshops. The largest event was the 4th Distributed RACE Summer School on Advanced Broadband Communications ABC´96 -organized by project NICE- where 20 sites across Europe and Canada were seamlessly interconnected for one week.
- ISABEL includes an effective **distributed event management** function which enables the interconnection of a large number of sites.
- ISABEL can be run even with no special video or networking hardware, over any IP-capable network (ATM,ISDN,FDDI,ethernet, etc)

Contact

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ftp://ftp2.dit.upm.es/pub/Isabel/
ISABEL home page: http://www.dit.upm.es/~proy/isabel