Report of the LHC Computing Grid Project. RTAG 12: Collaborative Tools

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Report of the LHC Computing Grid Project

RTAG 12: *Collaborative Tools*

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Abstract

This document is the final report of the LHC Computing Grid (LCG) Project's Requirements and Technical Assessment Group (RTAG 12) on Collaborative Tools. It presents a summary of the requirements of the LHC collaborations for Collaborative Tools, assesses the current status of those tools in common use, discusses likely relevant future development, and provides recommendations for action by the LCG, the collaborations, and CERN for the immediate and long-term future. The requirements and assessments were assembled from formal and informal interactions between members of the RTAG, representatives of the LHC collaborations, CERN IT, and experts in the field of Collaborative Tools.

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1 Executive Summary

1.1 Principal Findings

The RTAG has found a large and growing gap between the requirements of the LHC Collaborations for high quality, robust collaborative tools, and the availability of these tools at CERN and at the participating institutes. This gap is the result of increasing need for and growing popularity of the tools, as the experiments enter the critical stage of commissioning, assembly, and software development, and a lack of dedicated resources on the part of CERN and the collaborations to address this demand.

The shortcoming appears at all levels of organization, from the running and maintenance of existing phone and video conferencing facilities, to the planning and implementation of facilities at CERN and other participating institutes, to the coordination of activities between the institutes and other HENP (High Energy and Nuclear Physics) activities. It could be viewed as a natural consequence of the low priority given to this issue relative to the other urgent and pending activities for the LHC: the completion of detector production; commissioning, testing and integration at CERN; and the ramping of software development, to name a few. Yet, it is our belief that the price the collaborations currently pay due to this neglect, in terms of lost or inefficiently used manpower is enormous when compared to the modest cost of developing and maintaining an effective collaborative tool program for the LHC. In addition, an adequately funded and well-coordinated program would provide significant long-term savings, due to improvements in communication, training and coordination, in support of those programs.

The basic requirements of the LHC collaborations with respect to collaborative tools are discussed in Section 4; they are neither extensive nor complex. Concerning video conferencing, there is an urgent need for more and improved facilities at CERN, with an emphasis on reliability and ease of use. The same is true for phone conferencing, where demands include operator-free, 24/7 availability, a web-based booking system, and integration with the video conferencing systems. Other synchronous collaborative technologies, such as web casting, remote document presentation, or application sharing, are not yet widely used, but popularity and need are growing. Asynchronous tools, such as the web archival of lectures, meetings and tutorials, have been in use for some time, but lack central support and coordination.

Minimal support and poor infrastructure at CERN and other institutes have had the effect of discouraging potential users from taking advantage of the collaborative tools at hand. Users have become frustrated by the lack of tools (many rooms are still not equipped for audio or video conferencing) or by the unreliability or complexity of the existing tools.

Finally, the absence of well-defined management and coordination of collaborative tool activities among CERN and the LHC collaborations has had the effect of discouraging potential resource providers from contributing manpower, equipment, and/or funding to solve the existing problems. Various well-intended efforts have been and are still being made by individual LHC participants to try to solve localized problems. But, without central coordination, these efforts risk to fail, further deterring the resource providers, or to result in incoherent solutions, which can tax the limited support and add to the overall problem in the long term.

1.2 Primary Recommendations

In Section 8, we present a list of recommendations assembled during the course of our research and provide guidelines for their implementation. Arguments leading to the recommendations are constructed in the preceding sections, which address the requirements of the LHC collaborations (Section 4), assess their current usage of collaborative tools (Section 5), and describe relevant network and Grid issues (Section 6). The following are the key recommendations.

Rec 1	We recommend that CERN establish and maintain a Collaborative Tool Service (CTS) to support the needs of the LHC collaborations.
Rec 2	We recommend that the CTS maintain and support VRVS as a standard video conferencing service for the LHC collaborations.
Rec 3	We recommend that the CTS establish, maintain and support an industry standard H.323 MCU-based video conferencing service for the LHC collaborations, complementary to and interoperable with VRVS.
Rec 4	We recommend that the CTS provide user support for desktop/laptop phone and video conferencing for LHC collaborators situated at CERN, at their home institutes or elsewhere, as appropriate.
Rec 5	We recommend that the CTS install, maintain and support a 24/7 operator-free phone conferencing system at CERN.
Rec 6	We recommend that the CTS equip and maintain all auditoria and meeting rooms in building 40, as well as those located elsewhere at CERN, commonly used by the LHC collaborations, for integrated phone and video conferencing.
Rec 7	We recommend that the CTS extend current web casting and web archiving services to include all auditoria and meeting rooms in building 40, as well as those located elsewhere at CERN, commonly used by the LHC collaborations.
Rec 8	We recommend that the CTS take on the leading role in the development of a global Computer Supported Collaborative Work Environment for the LHC community.
Rec 9	We recommend that the CTS support development to equip IP-based tools used by the LHC collaborations, such as VRVS, with a Grid certificate authentication and authorization mechanism.

Additional recommendations, as well as detailed explanations of these recommendations, are included in the relevant sections of the text.

2 Introduction

The technical complexity, scale, duration and global distribution of the LHC experiments at CERN [1] present new challenges to their working models and collaborative environments. While the distributed construction of detector components is not new to HENP, the complexity and scale of the LHC projects have created a new and growing demand for the ability to coordinate large efforts, such as detector design, software development, and technical training in a diverse and global environment. In addition, the long expected duration of the experiments makes it impractical for all operational and maintenance activities to be located at CERN, as much of the physics and computing expertise will be located at the home institutes, due to academic constraints on the participating faculty and the need to maintain facilities for the vast LHC computing needs, the majority of which will be located outside of CERN.

To address these new challenges and others, it is unavoidable that collaborative tools will play a major role throughout the lifetime of the LHC collaborations. For the purpose of this document, we define collaborative tools to be those hardware technologies and software applications used by a collaboration to facilitate communication and the sharing of information among its members. For example, collaborative tools already in common use by the LHC collaborations, and HENP in general, include phone and video conferencing, remote documentation presentation, application sharing, web casting and archiving, e-mail and instant messaging, computer supported conference management, and document repositories.

This document examines the status of collaborative tool usage in the LHC environment, presents the current and future requirements of the collaborations, describes the status of tools in use at CERN and the member institutes, and then proposes a set of recommendations to address shortcomings in the current program. We begin with a description of the RTAG in Section 3, including the mandate, a list of the participants, and a summary of the activities leading to the completion of this document. The LHC collaborations are presented in Section 4, along with a summary of usage scenarios and comments on the evolution of the usage with the LHC timetable. In Section 5, we provide a description of those collaborative tools currently in use by the LHC collaborations at CERN and at the home institutes, assess the existing facilities, and discuss potential future developments. Requirements on the network infrastructure and issues pertinent to integration with the Grid [2] are discussed in Section 6. Other existing initiatives addressing collaborative tool usage in HENP and in science, in general, are presented in Section 7. In Section 8, we present a detailed list of recommendations to the PEB, based on our findings. Finally, Section 9 presents a discussion of the funding and resources needed to implement the recommendations, providing rough estimates of the initial equipment costs and the human resources required to install, maintain, and operate the service.

3 Description of the RTAG

3.1 Mandate to the RTAG by the PEB

The mandate of LCG RTAG 12 was proposed to the PEB [3] in January 2004 and accepted shortly thereafter. In brief, the RTAG was expected to assess the current requirements of the LHC collaborations for Collaborative Tools, assess the current usage, investigate future developments, and provide recommendations. Specifically, the RTAG was requested to:

- *assess the needs for collaborative tools of all LHC collaboration members, located at CERN, major labs or smaller institutes, including isolated ("laptop") users;*
- *survey the existing technologies and consider costs, performance, hardware and bandwidth requirements, interconnectivity;*
- *make concrete proposals about how CERN videoconferencing facilities and support organization might be consolidated, improved and better supported in the immediate future, with strong emphasis on the performance as perceived by remote users.*

In particular, the RTAG was asked to address the following topics:

- *working venues (type of room, equipment, ease of use);*
- *integration (where possible) of existing infrastructure (e.g.audio/video transmission between auditoria, re-use of local audio/projection systems,...) where feasible;*
- *which systems [to adopt] (VRVS, Access Grid, etc.);*
- *collaboration on desktop (CERN LAN, general support);*
- *relationship to networking;*
- *future integration into "grid-based analysis".*

The mandate, including the specific topics, was used by the RTAG as its principle guideline and all of its points are addressed in this document.

3.2 Composition of the RTAG

The RTAG comprised one or two representatives from each of the four LHC experiments, representatives from CERN (IT and HR), several specialized experts in collaborative tool usage and research in HENP, and the LCG PEB chairperson. The complete list of participants is presented in Table 3-1.

Participant	**Institute**	**Representation / Expertise**
Peter Hristov	CERN-PH/AIP	ALICE
Steven Goldfarb (chair)	University of Michigan	ATLAS
Roger Jones	Lancaster University	ATLAS
Bolek Wyslouch	MIT	CMS
Ian McArthur	University of Oxford	LHCb
Gerhard Raven	NIKHEF	LHCb
Alberto Pace	CERN-IT/IS	CERN-IT/IS
David Foster	CERN-IT/CS	CERN-IT/CS
Mick Storr	CERN-HR/PMD	CERN Training
Mick Draper	CERN-IT/UDS	CERN Video Conference Facilities
Tony Doyle	University of Glasgow	GridPP
Philippe Galvez	Caltech	VRVS / Video Conferencing
Christian Helft	LAL - IN2P3 (Orsay)	HTASC-CSMM / Video Conferencing
Les Robertson (ex-officio)	CERN-IT/DI	LCG-PEB Chairperson

Table 3-1: List of RTAG participants. Blue background indicates LHC representatives; green background indicates CERN IT representatives; orange background indicates specialized collaborative tool experts.

3.3 RTAG Activities

The RTAG first convened on 31 March 2004 to discuss the mandate of the PEB, to establish common ground, and to plot a strategy for producing the requested document. The mandate was unanimously adapted, with the exception of expanding point 3 to include not only video conferencing, but all collaborative tools commonly used by the LHC. The RTAG chose to cover this larger scope because of the expertise of the group, the tight coupling of a variety of tools with video conferencing, and the belief that a comprehensive program is needed to optimally address the needs of the LHC community.

Following the initial discussion, the RTAG held weekly meetings to discuss the various issues, including the situation at CERN and the home institutes, commonly used tools and services, expected future developments and finally, the recommendations to be made to the PEB. A record of these meetings, including presentations and shared documents can be found on the RTAG 12 web page [4]. Slides of interim reports made by the RTAG chair to the PEB on 1 June 2004 and on 30 November 2004 can also be found on that site.

In general, the RTAG weekly meetings focused on understanding the needs of the collaborations, finding common trends in their experiences with collaborative tools at CERN and elsewhere, and on seeking and examining possible solutions. A variety of information sources were called upon, including:

- weekly, in-depth discussions between representatives of the LHC collaborations and experts in the RTAG;
- informal interaction with the CERN video and phone conferencing staffs;
- analysis of formal and informal surveys of LHC collaboration members;
- basic tests of equipment and video conferencing systems using the facilities installed in various CERN conference rooms.

While time and resources were insufficient for detailed technical analysis of the various tools, the members of the RTAG brought a significant amount of experience and expertise to the table, forming the basis for most decisions.

In addition to interaction among the RTAG participants, a variety of experts on collaborative tools, communication, and networking were consulted either during the meetings or in private discussion with the RTAG members. Several of the RTAG members participated simultaneously in other working groups and sub-committees dedicated to addressing the issues of video conferencing for HENP, including RCWG (Remote Collaboration Working Group) [5] and HTASC-CSMM (HEP-CCC Technical Advisory Sub-Committee on Computer Supported Meeting Management) [6], among them Christian Helft, chair of that sub-committee. Synergy between the work of these groups, other projects dedicated to Collaborative Tool development for HENP, and the RTAG is described in Section 7.

4 The LHC and Collaborative Tools

4.1 The LHC Collaborations

There are five experiments that will collect data at the LHC: ALICE, ATLAS, CMS, LHCb, and TOTEM.

The ALICE Collaboration (A Large Ion Collider Experiment) [7] is building a dedicated heavy-ion detector to exploit the unique physics potential of nucleus-nucleus interactions at LHC energies. ALICE intends to carry out a comprehensive study of the hadrons, electrons, muons and photons produced in the collision of heavy nuclei. It will also study proton-proton collisions both as a comparison with lead-lead collisions and in physics areas where ALICE is competitive with other LHC experiments. The ALICE collaboration includes 1000 physicists from 90 Institutes in 30 countries.

ATLAS (A Toroidal LHC ApparatuS) [8] and CMS (Compact Muon Solenoid) [9] are general purpose detectors designed to search for new discoveries in the head-on collisions of protons at the LHC. Their main physics objectives are the search for Higgs particles, super-symmetry, and extra dimensions. In addition, the experiments will exploit the physics of quark-gluon plasma in heavy ion collisions. ATLAS and CMS are two of the largest, globally distributed, collaborative efforts ever attempted in the physical sciences. In ATLAS there are approximately 1800 physicists participating from more than 150 universities and laboratories in 34 countries. In CMS there are 2300 participants, 2000 of who are scientists and engineers from 160 institutes in 36 countries.

The LHCb [10] experiment is dedicated to studying the physics of b quark decays, with a strong focus on CP violation. It will explore the question of matter-antimatter asymmetry and the creation of the universe in the big bang. Some 565 scientists from 47 universities and laboratories in 15 countries are involved in the design and construction of LHCb, with the support of hundreds of technicians and engineers.

TOTEM [11] is an experiment dedicated to the measurement of total cross section, elastic scattering and diffractive processes at the LHC. The total cross section will be measured using the luminosity independent method, based on the simultaneous detection of elastic scattering at low momentum transfer and of the inelastic interactions. The collaboration comprises 43 physicists from 11 institutes in 8 countries.

A relatively small fraction (perhaps 15-25%) of the participants of the LHC collaborations are currently present at CERN. Although this fraction can be expected to increase in the coming years, it will always be the case that the majority of the participants will be located at their home institutes. This fact, coupled with the increasing number of group and collaboration meetings required to coordinate activities as we approach LHC turn-on, makes evident the need for remote collaboration facilities.

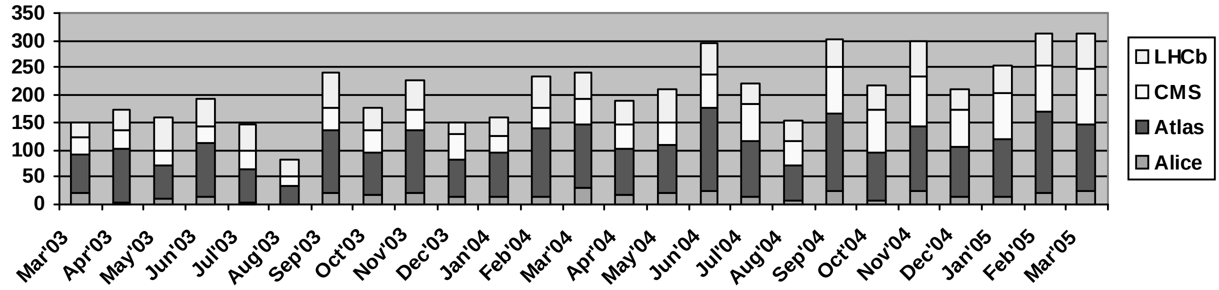


Figure 4-1: **Number of meetings per month listed on the CDS Agenda Server for each LHC collaboration from March 2003 – March 2005.**

In Figure 4-1, we present data from the CDS Agenda indicating the number of meetings listed for the LHC collaborations for each month from March 2003 through March 2005. Many collaboration meetings are not entered in the system, so the absolute numbers are underestimated. However, one can see the general trend, which indicates a steady increase over the past two years. As the Agenda Server has been in use for many years, now, and has become a standard tool for all of the collaborations, this trend can be attributed to a steady increase in the number of meetings. The trend is expected to continue or even accelerate in the next two years, as the LHC approaches start-up.

4.2 Typical Collaborative Use-Cases for the LHC Collaborations

Collaborative tools are currently in use at CERN and the LHC member institutes to address the communication needs of the globally dispersed communities described above. The following list presents a few typical use-cases for the collaborations:

- A construction team finds a problem during the physical assembly of the detector. The team that built the component is 12 hours displaced from CERN. Meetings must be arranged to resolve the problem giving full access to the design documents and visual inspection of the actual component, as well as audio-video communication within the team.
- A physics team is considering an analysis by one of its members. The team is globally distributed, with facilities ranging from video conferencing suites to laptops with cameras to telephones. They must meet on as even a basis as possible, with access to the presentations and where possible interactive shared data handling.
- The management team of an experiment holds periodic meetings to coordinate projects and define long-term planning. While much of the team is located at CERN, traveling often forces some remote participation, so phone and video conferencing is required on a frequent basis, with both synchronous and asynchronous access to presentation material and minutes.
- The management team wishes to distribute electronic documents to targeted groups of people, with controlled access.
- A software developer prepares a tutorial to teach new users how to install, run, and eventually contribute to a new application. She would like to avoid traveling to each and every institute to present the tutorial by having it recorded and archived for the users to access via a web browser.
- The shift team running an accelerator may be distributed around the world, either for practical reasons or to access remote expertise. Close interaction between the workers at the various sites must be possible, coupled with remote sensor/remote control Grids.
- The computing resources local to a CERN experiment may require remote facilities to be run as if they were co-located with the experiment. Again, remote sensors and control need to be coupled with audio/video/whiteboard tools to allow local and remote site managers to inter-work.
- A professor takes sabbatical to work at CERN on her experiment. She needs to be able to record lectures for a class she shares remotely with a colleague, and to be able to communicate frequently with her graduate student performing analysis at the home institute, using one-to-one laptop-based video conferencing, with the sharing of files and presentation material.

These cases are illustrative and by no means exclusive nor comprehensive. All share the common need for intelligible communication by audio and/or video over a range of platforms to access a meeting or an archive. No single technology may be assumed. Layered over these are various different interactive functionalities: real-time visualization of objects, shared control over applications, computational models, etc. Underpinning these interactions are document repositories and exchanges (mailing lists, web pages and archives, etc.)

Perhaps the biggest challenge in the above list of use-cases is the admixture of technologies needed for their realization. Not only must telephone integrate with audio-video systems and web presentations but, even within a single system, the technologies can be mixed. Further assessment of these tools, the technologies behind them, and their usage by the LHC collaborations is presented in Section 5. First, however, we take a more detailed look at the variety of communication scenarios frequently required by the LHC collaborations.

4.3 Communication Scenarios Common to the LHC Collaborations

A fairly complete list of potential meeting scenarios can be found in the Videoconferencing Cookbook [12] prepared by ViDe (Video Development Initiative) [13]. The cookbook, in addition to presenting a broad overview of video conferencing, with valuable historical and technical information, has a section devoted to uses of video conferencing for various meeting environments. Here, we focus on those environments frequently incurred in HENP, especially for large collaborations, such as those in the LHC.

There are several possible scenarios where remote physicists collaborate in LHC related activities. Examples of several of these are presented in the previous section. Most involve the conduction of meetings or discussions with the simultaneous dissemination of electronic content. In many cases, presentation material is archived beforehand for reference during a meeting or afterwards for future reference, training or outreach. The various scenarios, however, differ significantly in the requirements and complexity of required tools. Below, we expand on the following list of typical communication categories:

- Person to person meeting
- Small to medium size meeting
    - Single remote person joins the meeting
    - Several remote people join the meeting
    - Meeting of several small to medium remote groups or individuals
- Large plenary session, conference or seminar with multiple remote observers
- Lecture archive
    - Recording of plenary session, conference or seminar
    - Recording of specialized tutorial

Discussion below is primarily focused on the conduction of these types of communication in the LHC context, typically with the main meeting or activity located at CERN and with remote participation coming from the collaborators located at their home institutes or on the road. We present requirements for tools needed to facilitate this communication and provide some examples of collaborative tools commonly in use today.

4.3.1 Person to Person Meeting

This is an extension of the traditional telephone conversation or visit to a neighboring office. Usually unscheduled, it is often intended for interactive work on software, plots, figures, or other documents. At times it is similar to two people developing ideas in front of a blackboard or a computer display. It requires rapid exchange of small chunks of data, screen content, images, and perhaps the simultaneous editing of source code or text.

There are several commercial or free examples of systems that facilitate such interactions: AOL Instant Messenger [14], MSN Messenger [15], Skype [16], Apple iChat [17], VRVS [18], or direct connection between H.323 [19] compliant video conferencing units. The applications differ in quality, reliability of connection, functionality, operating system dependence, and cost. They are described in more detail in Section 5.

The primary requirements for a quality person-to-person meeting include:

- Audio with echo suppression microphone or headphones for multi-user offices;
- Video;
- Desktop sharing capability;
- Easy exchange of electronic images and files;
- Possibility of simultaneous editing of text and source code.

In addition, it is desirable for the service to have the following features:

- Continuous presence or presence detection;
- Phonebook or directory with possibility of connections independent of physical location of the addressee.

This mode of remote collaboration should be optimized to work from a participant's office, using a desktop PC and a camera or small H.323 video conferencing system, or from a portable computer, often connected through the relatively slow networks available at airports or homes.

4.3.2 Remote Participants Joining a Small or Medium Group Meeting

This is an extension of the usual small or medium group meeting. Most activity is taking place in a physical meeting room somewhere (e.g. at CERN). Formal talks are intermixed with discussion. Remote participants may give talks or simply participate in comments and discussions. Good audio connections and access to transparencies is essential. The meetings are scheduled and usually have prepared agenda and minutes. The archival of agenda and talks is important. It is particularly useful for the agenda to be available to all parties beforehand and during the meeting. The number of remote participants or remote groups affects the level of complication of audio and video transmission (switching streams, phone connections, management of discussions).

Requirements for the remote participants are similar to those described above in Section 4.3.1. If all participants are using H.323 compliant video conferencing units to connect, then the meeting can be held over an MCU or via a VRVS virtual room (discussed in detail in Section 5.3). If any one participant does not have an H.323 compliant unit, then VRVS is used. It is highly desirable for remote participants to be able to call in to a meeting using a telephone. This audio should be integrated with the audio of the video conference, so that all participants hear each other on a similar level, regardless of the device used for connection.

The meeting room itself must be equipped for high quality audio transmission and reception. Echo cancellation is imperative. Remote participants must either mute, use headsets, or have quality echo cancellation on their end. At least two screens are needed in the conference room, with one dedicated to viewing the remote participants and another for viewing the presentations. A display of the local video is also useful for directing the conference, ensuring that the remote participants are viewing what is desired.

The audio and video equipment of the room must be started up and tested well before the actual conference, so as to avoid lost time of the participants and to allow the external participants also to test their equipment beforehand. This test should be obligatory, with each person who is expecting to speak during the meeting trying her/his microphone at least once before the meeting starts. The chair of the meeting is the last person who should be selected to run the video conference, as the job requires too much attention.

Unless an expert is available to run the video conferencing equipment for each meeting (highly unlikely), the equipment chosen should be both easy to use and nearly equivalent in all facilities used for such meetings. Already, nearly all regular meetings held by the LHC collaborations are carried out in this manner, and the frequency of these types of meetings is increasing as we approach the LHC start-up date.

4.3.3 Meeting with Several Remote Groups

These meetings are similar to the ones described above in Section 4.3.2, with the exception that several meeting rooms are connected together. It is common for presentations to be made from each of the rooms. This is typical for group meetings, for which members of an institute might want to meet periodically with a team that has been sent to CERN for a long stay.

The requirements are similar, but can be slightly complicated by the need for high quality echo cancellation in each of the participating meeting rooms and also the need to be able to project presentation from each of the rooms. When the meeting is between two facilities only, it can be held reliably using direct IP connection between two video conferencing units. Adding more rooms requires either a multi-point conference license for one of the units or connection via an MCU [20] or VRVS. Adding remote participants using non-H.323 units, as noted above, requires usage of VRVS for video conferencing.

4.3.4 Plenary Meeting, Conference, or Seminar

The broadcast of large plenary meetings, conferences or seminars to remote viewers or participants requires wide bandwidth transmission of video and audio and simultaneous transmission of transparencies. In this case, it is common to have operator support to guide camera and local sound. There can be a limited need for remote participants to ask questions and occasionally a remote participant might be required to make a presentation. This is never an easy task, as it is very difficult for the speaker to have a “feel” for the audience reaction or for the audience to receive the complete “experience” of a presentation without excellent audio and video transmission.

In addition to the audio and video requirements described for the previous types of meetings, it is necessary to have either ceiling microphones or a wireless hand-held microphone to pick up questions from the audience. The latter requires quite a bit of discipline on the part of the audience and thus works only questionably well for HENP audiences (realism and humor intended). The speaker must have either a podium or lapel microphone. It is desirable for this microphone to provide the audio feed for both the room and remote participants and, if the lectures are recorded, for that archive.

These events are typically scheduled well in advance and announced through paper or electronic postings. As with the other multi-participant meeting described above, it is useful for the agenda to be posted ahead of time, using a system such as the CERN Agenda Server. Archival of audio, video and transparencies is often very important.

Often the system needs to handle a large number of remote viewers. There are several commercial systems that allow broadcasting of conferences (Microsoft Media Player [21], Real Player [22], Quicktime [23]]), as well as VRVS or an H.323 MCU. While using a commercial broadcasting system is likely to guarantee good quality and compatibility with multiple clients, the scheduling and archival should use the same system as for the other types of meetings. It is preferable for the audio and video archives to be made available alongside the electronic copies of the presentations, synchronized, if possible.

4.3.5 Lecture Archive of Plenary Session, Conference or Seminar

As mentioned in the previous section, it is often desirable to record presentations made during plenary meetings, conferences and seminars. If the room is equipped for video conferencing, a high quality camera and sound equipment are usually available. Examples might include the CERN Main Auditorium and the Council Chamber. Other commonly used sites for these types of meetings, such as the Building 40 conference rooms or the CERN Technical Training facilities, do not have such equipment available, so a portable camera and sound system need to be installed for the talks to be recorded.

Software used to synchronize the audio and video with the electronic presentations to create a web lecture for publication are described below in Section 5.5. What is essential during the meeting is the capture of high quality audio and video of the speaker. This can require the addition of specialized lighting in the front of the room, directed on the speaker, something surprisingly absent in most of the CERN auditoria. In addition, as mentioned above, ceiling microphones or hand-held wireless microphones are needed for the audience and a podium or lapel microphone is required for the speaker.

4.3.6 Lecture Archive of Specialized Tutorial

The recording of a tutorial session takes place in a slightly different environment. The archive can be made during a live event or in a studio at the leisure of the speaker. In both cases, as with the plenary recording, high quality audio and video of the speaker must be captured. In the former case, it is also desirable for the questions and comments of the audience to be recorded.

Often, however, a tutorial is a much more than just a narrated electronic presentation. Frequently, tutorials require participation of the audience and/or the teacher might demonstrate the results of typing certain commands or clicking on the buttons of software interfaces on a screen. As one can imagine, capturing the complete environment of such a tutorial can be quite difficult, if not carefully planned with a pre-defined and restricted scenario. In many cases, however, it is possible to use screen captures to create a high quality synchronized archive.

The production of these tutorials and of lecture archives in general requires a certain amount of post-event processing work. The amount of effort depends on the software used, the quality required, and the type of event. For archives expected to last for the long-term (at least several years), one can typically dedicate several days of work to ensuring the quality of the product. The choice of non-proprietary standards for the archive also helps to ensure longevity, sometimes at the cost of effort. A web server, database, and perhaps a video server are required for remote viewing of the archives.

4.3.7 General Comments

It should be noted that practically all usage scenarios require meeting management software that includes scheduling, agenda posting, storage of electronic documents and a globally accessible address book (such as H.350 [24]). Presence detection could become critical and the ability to reserve rooms at CERN and perhaps in the remote institutes quite useful. Integration of all of these features into one multi-platform distributable interface is highly desirable. It is important that current activities in industry be followed closely, as new systems are under development to integrate video conferencing (human presence), web conferencing (remote document presentation), and presence detection (meeting preparation, notification and triggering).

4.4 The LHC Timetable

The LHC accelerator is scheduled to start operation in summer of 2007. The startup of beams will be preceded by an intense period of preparation and installation activities of the hardware equipment and commissioning of multiple hardware and software systems. Most of the large elements of the LHC experiments are completing construction and they are being tested and commissioned already now. The commissioning activities are likely to intensify in years 2005-2007.

In the years 2007 and beyond, and as soon as the first collisions occur, the LHC collaborations will be verifying the data, applying calibrations and extracting physics results. The increasing luminosity and the delivery of additional types of beams (e.g. heavy ion beams in 2008) will result in continuing changes to the apparatus, improvements and adjustments for many years and well beyond the initial startup date.

The activities leading to and following the start of LHC will require an unprecedented level of collaboration between the physicists and engineers. Those stationed at CERN will need to coordinate their activities with remote experts. The size and complexity of the apparati will demand worldwide communication. In addition, members of the collaboration previously involved mainly in detector construction will require a significant amount of training to prepare for the new challenges of software development and analysis.

There will be a large demand for long distance scheduled meetings, person-to-person communications and continuous presence at important offices and experimental areas. A set of conference rooms equipped with quality video conferencing capabilities will need to be available near the experimental areas and near office clusters on the CERN site in advance of the LHC startup. Computers with remote conferencing capabilities will need to be installed near to vital elements of the LHC detectors and in collaboration members' offices. Software and analysis tutorials will need to be recorded, archived, and made available to new users and developers. Many of these capabilities need to be installed very soon to coincide with the preparations of the LHC.

5 Assessment of Current Collaborative Tool Usage in the LHC

5.1 Introduction

This section describes a variety of tools currently in use by the LHC collaborations at CERN and at the member institutes. It assesses both the technology and the common usage of that technology in the LHC, presenting both positive and negative aspects of current practices. While it was not the charge of the RTAG to provide a complete technical report or user's guide, some effort is made to give a layman's overview for each tool, with enough technical information to derive recommendations for future development.

The primary tools in use by the LHC collaborations include phone and video conferencing, application and document sharing, web casting and archiving, e-mail and instant messaging, and computer supported conference management. We address tools used for each of these domains in a sections 5.2 - 5.7, each of which also include discussion of integration issues, as appropriate. Section 5.8 discusses the common underlying issue of conference room management, to support the usage of these tools at CERN and at the member institutes.

5.2 Phone Conferencing

5.2.1 Existing Facilities

Phone conferencing is a popular means of communication for the LHC collaborations for small and medium-sized meetings, either to allow remote participation of a meeting located at CERN or with all participants joining from separate locations, even if many are located in nearby offices. Most of these conferences use the CERN system [25], in which users call the operator at CERN at a standard number (+41.22.767.7000) and ask to join a specific meeting. The meetings are reserved using a simple phone call to the same number or by sending e-mail to Standard.Telephone@cern.ch specifying the name, time and duration of the meeting.

The main advantage of the system is that it is very simple to use, requiring no special equipment or expertise. The main limitations are that the system is only available during CERN working hours and requires operator assistance. This is an especially important constraint, considering the abundance of transatlantic connections and the need for calls to be held in the late afternoon to compensate for time zone differences. There are procedures available with the CERN telephones that allow a participant to effectively run a phone conference with up to 29 participants without operator assistance. These procedures, however, are not well known and require that a CERN participant accept or make phone calls to each participant, adding them to the conference one by one.

When more than one of the participants of a phone conference meet together in a room, it is necessary for them to locate a speakerphone, with echo cancellation. Most of the collaborations have speakerphones available for reservation from the secretariats and in some cases a speakerphone is available in the meeting room already. For CERN building 40, there are meeting rooms with both video conferencing equipment and speakerphones, and users often "integrate" the two systems by placing the sound devices adjacent on the desktop. Needless to say, the sound quality for remote participants is less than perfect and direct, electronic integration would be preferable. In addition, the general quality of acoustics in many of the standard meeting rooms in building 40 is terrible, as some rooms are constructed with mainly glass walls, hard floors and furniture. This issue is addressed in more detail in Section 5.8. However, it is important note that many of the sound difficulties incurred from the CERN end can be attributed to poor room acoustics, rather than problems with the audio equipment.

CERN meeting rooms aside, the quality of a phone conference is only as good as its weakest link and these meetings often suffer from participants with either poor equipment, poor acoustic surroundings or poor etiquette. It is important for the person directing a phone conference to request that participants wear headsets, mute unless speaking, or use a quality speaker phone. This person, who need not be the chair of the meeting, should feel free to interrupt at any time to identify problems and solve them, as persistent problems can lead to poor communication and much greater loss of time.

Other shortcomings are similar to all phone conferences: long-distance tariffs, lack of visual contact for clear communication, no document or application sharing capabilities, no archival. The lack of visual contact might not seem vital, but it does make it challenging to maintain the same sense of "remote presence" that one gets from a quality video conference. The need for document and application sharing can be addressed by the circulation of agenda and documents ahead of time and by using appropriate web-based tools in addition to the telephone. Long-distance tariffs can be exceedingly high for the globally distributed users when one considers the cost of weekly 1-2 hour international phone calls. These costs could be addressed with the usage of Voice Over IP (VOIP), discussed in the next section.

5.2.2 The CERN Phone System and VOIP

Much of the CERN phone system (including all lines in building 40) is relatively new and based on digital protocol. While this can present some annoyances (special analogue lines are required to use standard speakerphones, one must enter "98" before typing in digits for keypad menus, etc.), it means that the phone lines have the potential to be integrated with VOIP in a straightforward manner. Nothing prevents this other than the absence of a gateway at CERN.

With the installation of a gateway between VOIP and the standard telephone network, there are no technical reasons that would prevent "soft phones" running on local PC's to be used as telephones. The remaining issues are those of policy and resources. That is, the "free" communication model of the Internet cannot be mapped to the "pay per call" model of traditional telephones. Bridging VOIP to the standard telephone network is straightforward in one direction (telephone → internet) because it is free. But in the other direction (internet → telephone) the accounting procedure can be complicated (pay per call, user registration, user billing, etc.) and the prices exorbitant. In this case, it would be advisable for to CERN to negotiate rates with its telephone service provider and to set up an appropriate billing system.

5.2.3 Future Development

The global trend in phone conferencing, perhaps better labeled now as audio conferencing, is toward VOIP. Local wired telephones will continue to exist but they will be only connected to the nearest VOIP gateway from where they will be able to place long distance calls to any VOIP connected phone. Until this occurs, or until CERN has installed a gateway and made VOIP software and licenses available to its community, participants can use web-based systems, such as VRVS or Skype[1] for "free" audio conferencing or other systems, such as AOL Instant Messenger, MSN Messenger, or Apple iChat for person-to-person audio communication.

[1] Skype usage not permitted at CERN at the moment for security reasons.

In addition to the move to VOIP for the CERN phone conferencing system, it is desirable that a high quality solution be found for the integration of phone and video conferences. Commercial equipment exists to handle this electronically, using audio integration and echo cancellation hardware. Video conferencing equipment suppliers, such as Polycom [26], offer such devices as features or add-ons to many of their H.323 compliant units, but they require analogue telephone lines as input. For systems such as VRVS, software solutions are possible, but have not yet been implemented.

5.3 Video Conferencing

5.3.1 Existing Systems

There are three major types of video conferencing services commonly used today within the research and academic community: VRVS [18], developed and maintained by Caltech, H.323 services based on the ITU (International Telecommunication Union [27]) video conferencing standard over IP networks, and Access Grid [28], initially developed by Argonne National Laboratory [29]. Below we describe these systems in detail.

5.3.1.1 The VRVS Video Conferencing Service

VRVS (Virtual Room Videoconferencing System) is a unique, globally scalable next-generation system for real-time collaboration by small workgroups, medium and large teams engaged in research, education and outreach. VRVS operates over an ensemble of national and international networks. The system was initially built as a limited-scale prototype-production system serving the high energy and nuclear physics (HENP) community and some other data-intensive science and engineering sectors. Since then, the system has been continuously extended by adding more functionality and by redesigning the architecture to benefit from the latest software developments, so providing the collaboration infrastructure and Web-enabled user interfaces required to meet the research and education needs of many fields. VRVS is global in scope: it covers the full range of existing and emerging protocols and the full range of client devices for collaboration, from mobile systems through desktops to installations in large auditoria. The VRVS software will be integrated with the Grid-enabled Analysis Environment (GAE) [30] now under development at Caltech in partnership with the GRIDs projects in the US and Europe.

Since it went into production service in early 1997, VRVS has become a standard part of the toolset used daily by a large sector of HENP. More than 56,000 registered hosts running the VRVS software in 120 countries world wide regularly access the service. There are currently 82 VRVS “reflectors” that create the interconnections and manage the traffic flow, in the Americas, Europe and Asia. New reflectors recently have been installed in Brazil, China, Pakistan, Australia and Slovakia.

The Caltech CMS group manages the VRVS system. At the writing of this document, around 15,500 users have been registered with the system (this number is expanding by an average of 2X per year) and around 1100 worldwide collaborative sessions are performed each month between 4000 users representing a cumulative time of 6000 hours of research collaboration over the Internet per month.

The quick adoption of VRVS as a standard tool confirms the need within the research and academic community for easy-to-use collaborative tools with high performance. Integration with Access Grid has been also successful. The VRVS/AG gateway -- VAGRID (Virtual Access Grid) -- that allows one to join any Access Grid Virtual Venue from a desktop or laptop, is heavily used by the community. It is developed in partnership with Grid projects and incorporates the latest Grid monitoring software into the VRVS infrastructure. It has an innovative technical development roadmap that will be very beneficial for the end user.

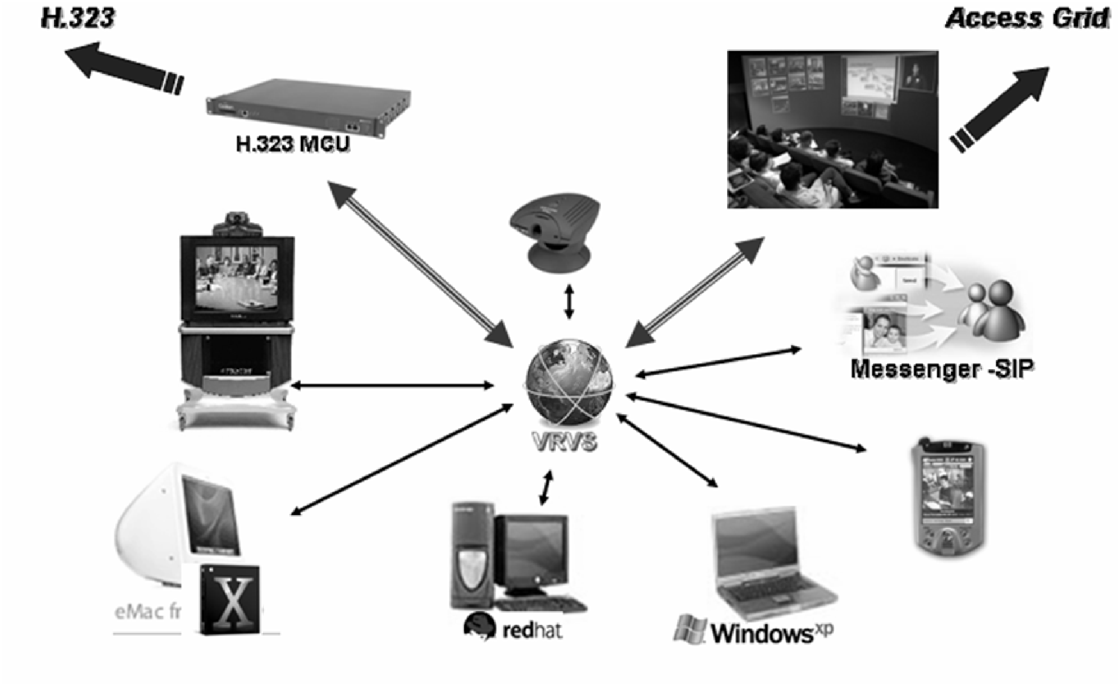


Figure 5-1: Schematic diagram of the VRVS infrastructure

Figure 5-1 presents a schematic diagram of the VRVS infrastructure, illustrating its multi-platform, multi-protocol support and bridging capabilities to H.323 MCU and Access Grid technologies. The main purpose of VRVS is to provide a unified, efficient and reliable real-time network infrastructure to facilitate collaboration meeting over the Internet. The provision of gateways to other technologies and/or protocols such as Access Grid, H.323 MCU is an important part of the development roadmap.

5.3.1.2 H.323 Video Conferencing Services

H.323 is a communication standard produced by the ITU, initiated in late 1996, and aimed at the emerging area of multimedia communication over LAN's (local area networks). It is an outgrowth of the traditional H.320 technology but optimized instead for the Internet. H.323 has since been revised to include voice-over IP and IP telephony, as well as gatekeeper-to-gatekeeper communications and other data communications that involve packet-based networks. These networks include IP-based networks like the Internet, Internet Packet Exchange (IPX) LAN's, and WAN's (wide area networks). The H.323 standard is supported by many commercial vendors and used throughout the world in commercial and educational markets.

The H.323 standard specifies a great deal of information about the properties and components that interact within the environment. It specifies the pieces that combine to provide a complete communication service:

- **Terminals**. These are either PC based or stand alone devices. They are the endpoints of the communication lines.
- **Gatekeepers**. These are the brains of the network. They provide services like addressing / identification, authorization, and bandwidth management.

- **Gateways**. These serve as translators when connecting to a dissimilar environment (such as an H.324 network, for example).
- **MCU's** (multipoint control units). These allow multipoint conferencing, or communication between more than two parties at once (much like a traditional conference call on a telephone).

In addition to component types, H.323 also describes protocol standards, permissible audio and video codecs, RAS (registration, admission, and status), call signaling, and control signaling. H.323 specifies a mandatory level of compliance and support for the above specifications for all terminals on the network.

An example of an H.323 based video conferencing service is ECS (ESnet Collaborative Service) [31]. ESnet (Energy Sciences Network) [32] is funded by the United States DOE/OS (Department of Energy Office of Science). In order to be authorized to use this service (for free), the user must conform to the Acceptable Use Policy [33].

According to that documentation, acceptable usage of ECS includes:

- Official communication among Office of Science (OS) funded principal investigators and their collaborators, regardless of location.
- Approved usages for the purpose of conducting OS funded and/or approved research and education activities.
- Any digital collaborations that either originates or terminates within an approved ESnet site and that is also compliant with the other rules and regulations of this (AUP).

For several years now, ECS has been available to researchers affiliated with a DOE program. This service has been very successful in providing an H.320 (ISDN [34]) MCU (Multiple Control Unit) facility for the authorized community to connect and perform multi-site collaboration meetings free of charge. Only the ISDN communication cost was charged to the user. With the emergence of the H.323 protocol, video conferencing hardware equipment has evolved away from ISDN, and the ESnet collaborative group has acquired several H.323 MCUs, allowing multi-site collaboration between H.323 devices in the same way they performed the H.320 service.

For the users or groups who initially used the H.320 ESnet service, the new H.323 service appears to be very well adapted since it does not change the way they collaborate. For new users, the support for H.323 protocol is certainly more appealing than the old H.320 protocol. Today, one can find relatively cheap commercial H.323 desktop devices. A recent upgrade provides users with the possibility to start “ad-hoc” conferences (no need to schedule the meeting in advance). Popularity of this video conferencing service is gaining momentum since it has been put in production several months ago; it is already very popular within the U.S. HENP community.

In general, the VRVS and ECS systems are currently hosting pretty much all of the multi-point video conferences of the LHC community.

5.3.1.3 The Access Grid Video conferencing Service

The Access Grid (AG) is an ensemble of resources including multimedia large-format displays, presentation and interactive environments, and interfaces to Grid middleware and to visualization environments. These resources are used to support group-to-group interactions across the Grid. For example, the Access Grid is used for large-scale distributed meetings, collaborative work sessions, seminars, lectures, tutorials, and training. The Access Grid thus differs from desktop-to-desktop tools that focus on individual communication and can be considered as a complementary service.

The Access Grid is now used at over 150 institutions worldwide. Each institution has one or more AG nodes, or "designed spaces," that contain the high-end audio and visual technology needed to provide a high-quality compelling user experience. The nodes are also used as a research environment for the development of distributed data and visualization corridors and for the study of issues relating to collaborative work in distributed environments.

The AG technology was developed by the Futures Laboratory at Argonne National Laboratory and is deployed by the NCSA PACI Alliance. The Futures Lab continues to conduct research into ways to improve the Access Grid, for example, to increase the scalability and to enhance the user interfaces.

The Access Grid is not widely used within the LHC experiments, although it is by a number of Grid projects. There are several reasons for the lack of popularity:

- Access Grid meetings require dedicated operator support. This is not currently common practice for HENP, mainly due to the added cost of manpower.
- Access Grid nodes require multicast deployment. Many institutes, including CERN, do not support multicasting, primarily for reasons of security and cost. Nevertheless, several techniques to bridge a multicast Access Grid meeting into a unicast tunnel have been developed. One such bridge is provided by the VRVS service, allowing users to login to the VRVS server and click to access an AG meeting. The current VRVS AG Gateway (PC/Linux) is located in Ann Arbor, Michigan, USA. It is important to note that the high bandwidth required an Access Grid meeting poses potential scaling problems for the multicast/unicast bridge (e.g. a 10 Mbps AG meeting could overload a 100BaseT connection (100Mbps) with only a few unicast connections.
- An Access Grid node has significant installation and maintenance costs beyond that of a typical HENP video conferencing facility.

Access Grid nodes provide a high quality video conferencing solution optimized for group-to-group interactions. While the complexity of the system requires operator assistance, it is our opinion that, for important events, this is desirable and should not be dismissed as inevitably unaffordable for the LHC community. The cost of lost time and imperfect communication due to the improper conduction of a video conference can easily become equally or more important. Higher installation and maintenance costs could, in some cases, be worthwhile and ought to be weighed against the gains in functionality and quality. In addition, many of these equipment costs have already begun to decrease, as commercial vendors develop competing solutions.

It is our opinion that the Access Grid warrants consideration for limited usage at CERN and at external institutes with adequate video conferencing budgets. It is not yet, however, the optimal solution for the majority of the LHC requirements. For this, we focus our discussion and recommendations on the usage of VRVS and H.323 MCU-based systems for general group meetings. The next section will first, however, discuss the growing usage of commercial one-on-one video conferencing tools.

5.3.1.4 Other Video Conferencing Tools

The tools described above have been developed specifically for HENP or similar scientific communities. All three provide either dedicated schedulers or ad-hoc services and well-defined interfaces for organizing meetings in conference rooms and/or from the desktop. In addition to these services, a growing number of users are turning toward commercial or public domain tools that provide quick, reliable desktop-to-desktop audio and/or video communication. Some commonly used examples (AIM, Windows Messenger, Skype, iChat) are listed in Section 4.3.1.

Installation and maintenance of these tools is currently the responsibility of the user, a primary reason for their success. Support for their usage ought to be limited to the provision of necessary network bandwidth, security infrastructure, and common download repositories and licenses. While these tools do not yet satisfy the full requirements of the LHC collaborations, especially concerning meeting room and auditorium based conferences, they benefit from an enormous user base and are typically robust, easy to use and maintain. It is our opinion that the development of these tools ought to be closely monitored, with an eye toward complementing the current set of dedicated tools.

5.3.1.5 More Information on Video Conferencing Technology

Many technical documents can be found these days describing the growing abundance of video conferencing tools and services. A Google search for “Video Conferencing”+”Technical Paper” today produces over a thousand hits. The following two documents provide descriptions of current technologies, including assessments of advantages and disadvantages:

- For general video conferencing information, we suggest the Videoconferencing Cookbook [12] prepared by ViDe [13].
- For a detailed discussion of the LHC requirements for video conferencing, we suggest the technical document prepared in 2002 for the e-science Grid program in the U.K. [35].

5.3.2 Assessment and Comparison of VRVS and H.323 Services (ECS)

In this section we assess the strengths and weaknesses of the two primary video conferencing services described above: VRVS and H.323 MCU-based services, such as ECS. This technical comparison is provided with a focus on the expected requirements of the LHC collaborations.

5.3.2.1 VRVS

In our opinion, the main strengths of VRVS are:

- The equipment and software are affordable and easy to install and maintain. With the recent addition of MacOS X to the list of supported platforms, virtually any modern personal computer can be used effectively as a VRVS end point, at the cost of a webcam and a headset.
- Its interface provides extensive functionality and control of the conference. Each participating site is able to simultaneously monitor every other site, to chat privately or publicly, and to share her/his screen with other participants, providing the potential for a very rich video conferencing experience.

- The system supports a wide range of end point technology, including H.323 systems, as well as other peripheral audio and video equipment
- Deployment of the system infrastructure is cost-efficient (a standard modern PC/Linux makes a good reflector) and easy. New reflector installation is performed remotely by the VRVS team without requiring local expertise;
- The next generation architecture (currently under validation) promises to guarantee virtually endless scalability, thanks to effective load balancing and a self-configuring routing mechanism.
- VRVS provides a streaming facility for all meetings. Those users choosing to participate passively or who do not have access to a webcam or microphone can still use the Mbone tools or QuickTime to watch and listen to a conference from any device supporting those applications (e.g. PocketPC).
- VRVS provides an elegant and unique firewall solution. If one installs a VRVS reflector within the secure site, all the internal users are able to join a VRVS conference using the supported protocols (H.323, SIP [36], and Mbone [37]). The traffic will cross the firewall using only one known port (UDP or TCP) to/from the peer external reflector (e.g. as deployed at CERN, BNL, JLAB, etc.)
- VRVS works in a NAT (Network Address Translation) [38] environment. This is the default set-up for users connecting from home via xDSL or Cable Modem.

The main weaknesses of VRVS are:

- The principal disadvantage is that the system is dependant on the local hardware installation. Any one participant's poorly configured node can easily disturb the entire conference. This is particularly true for conferences integrating Mbone tools and H.323 clients. Although the VRVS team provides a set of recommendations for software and hardware, they are not enforced. The most common problems are lack of echo cancellation equipment or poorly configured audio settings. While such problems could be debugged before meetings, they frequently are not and it is often VRVS that bears the brunt of criticism, whether or not it is to blame. Regardless, the quality of a VRVS video conference is limited to that of its weakest participant.
- While VRVS allows one to connect H.323 devices, software development is required for each new video standard supported for this standard.
- Because VRVS is built on a distributed architecture and supports a large diversity of configurations, it can be difficult for the end user to diagnose problems (local system configuration, network, Java virtual machine version, OS upgrade, etc.) without requesting advice from the VRVS team.
- Some features are still missing. Perhaps the most requested is the ability to easily join a conference by telephone. Other examples of potential useful features include: more scheduling paradigms (e.g. the capability to call another party by name for point-to-point sessions, as in private, auto-opening conferences), the ability to record a session, detailed network monitoring for each participant, and the ability to quickly identify and possibly drop problematic end nodes.

5.3.2.2 H.323 Services (ECS)

Several institutions offer standard H.323 MCU-based service to the LHC community, generally at the national level (e.g. ESnet for the U.S., IN2P3 for France [39], INFN for Italy [40], JANET for the U.K. [41], and DFN for Germany [42]). The facilities offered by these services vary in capacity, performance and scheduling systems. Here, we focus our assessment on ECS (ESnet Collaboration Services), as it is the system most commonly used by the LHC collaborations.

In our opinion, the main strengths of ECS are:

- It provides a stable, robust service based on MCU's and gatekeepers. The infrastructure comprises three production MCU's (two Radvision [43] and one Codian [44])
- The quality achieved in H.323 multipoint sessions is more or less equivalent to that of point-to-point sessions. In general, depending on the devices in use, this implies high-quality audio and video transmission, certainly sufficient for the vast majority of expected LHC use cases.[2] Most H.323 units offer echo suppression and noise reduction hardware and are easy to install and maintain, requiring only the addition of a video monitor (typically a television) for the simplest configurations. No PC is necessary.
- The availability of an ad-hoc (non scheduled) mode of operation makes accessibility to video conferencing trivial, on par with that provided by the telephone.
- The system allows for integration of telephone, with the user simply calling a number to join a conference.
- The infrastructure is relatively easy to upgrade, allowing the facilities to keep pace with current "state of the art" technology. In general, only commercially available hardware or software upgrades are required, not software development. Recent examples include support of the emerging H.264 video codec and evaluation of a new MCU with features, such as conference streaming and continuous presence mode.
- The system is scalable, with growth depending primarily on hardware and maintenance support for that hardware. The 70 H.323 ports available at present on the main MCU (between 50 to 60 users can be counted during busy hours) can be upgraded to 140 or 210 by adding one or two cards. As corresponding network bandwidth and gatekeeper capacity are already, or could easily be, available, this guarantees (according to the vendors) that up to 500 users could be served with the same quality of service for the price of the required hardware.
- The system is based on an industry standard. As such, it has, and will continue to, benefit from the rapid pace of commercial development, including continuous improvements in quality and added functionality.

The main weaknesses of ECS are:

- It addresses only the H.323 video conferencing environment. Nevertheless, recent enhancements to VRVS allow one to connect to ECS (in fact, any H.323 MCU) from VRVS using other clients, including Mbone.
- Each user must register with ESnet. Current policy requires that the user be affiliated with a DoE sponsored experiment. This would normally exclude consideration of ECS as an LHC-wide solution, as many institutes (even one of the experiments) have no

[2] The importance of high quality audio and video can not be overemphasized in the international context, where participants of different mother tongue might rely strongly on clear audio and visual queues to obtain full comprehension.

DoE affiliation. Discussions with the ESnet management, however, indicate flexibility to this policy. In fact, given adequate funding and resources, international collaboration is not only possible, but welcome.[3]

- The H.323 infrastructure is hardware based, and can thus be more expensive to deploy than a software-based system. Upgrades and scaling require the purchasing of relatively expensive equipment and subsequent maintenance of that equipment.
- The original design focused on supporting the meeting room environment, not the desktop. Although H.323 devices are becoming more affordable and common for the desktop, ECS does not yet take full advantage of the flexibility that a PC-based system can provide, but is heading in that direction. The rapid increase in scaling that could accompany a migration to desktop usage might also present some challenges.
- It is based on a centralized architecture, which can be vulnerable to system failure, if not adequately maintained. In addition, although the current MCU's can provide a large number of ports, scaling to the LHC level will most likely require the deployment and maintenance of additional MCU's, preferably distributed worldwide, to scope with the IP network topology. This will also require increased complexity of cascading between MCUs, distributed scheduling, and distributed ports resource allocations.
- Only 1.5 FTE are dedicated to running and maintaining the current service. This is arguably insufficient and will certainly be inadequate for any future increases in scope. Additional resources and manpower will need to be located quickly.
- The current main system offers a small range of continuous presence modes (full screen or 4 x quarter screen) and the 4 x quarter screen mode uses the QCIF format (176x144), with half the usual resolution (a factor of 4 worse than TV resolution).
- In general, the visual interface lacks the richness and functionality of a VRVS or Access Grid session.
- The system lacks an integrated remote document presentation facility. A web conferencing system that can be used for application or desktop sharing is provided, but it must be managed by the end-user, independently of the audio-visual system.
- The system does not offer per se solutions for Firewall and NAT environments.
- The system lacks advanced network monitoring and troubleshooting capabilities, available to the end-user.
- The main system lacks control and monitoring of the session (list of participants) by the end-user.

It should be noted that several of the weaknesses mentioned above are being addressed by the new Codian MCU recently put into production, which also provides new features, such as Quicktime and Real streaming and the securing of streams with a PIN code.

5.3.2.3 General Comments

Figure 5-2 plots the monthly usage of VRVS and ECS, in terms of connection hours or port hours, between November 2003 and March 2005. Both systems have seen a rapid increase in usage, essentially doubling each year. During that time period, VRVS has dramatically

[3] Private communication with William Johnston, ESnet Manager, Nov. 2004.

increased the number of available virtual rooms and ECS has added ports to keep up with demand. More detailed usage statistics of VRVS are provided in Appendix I.

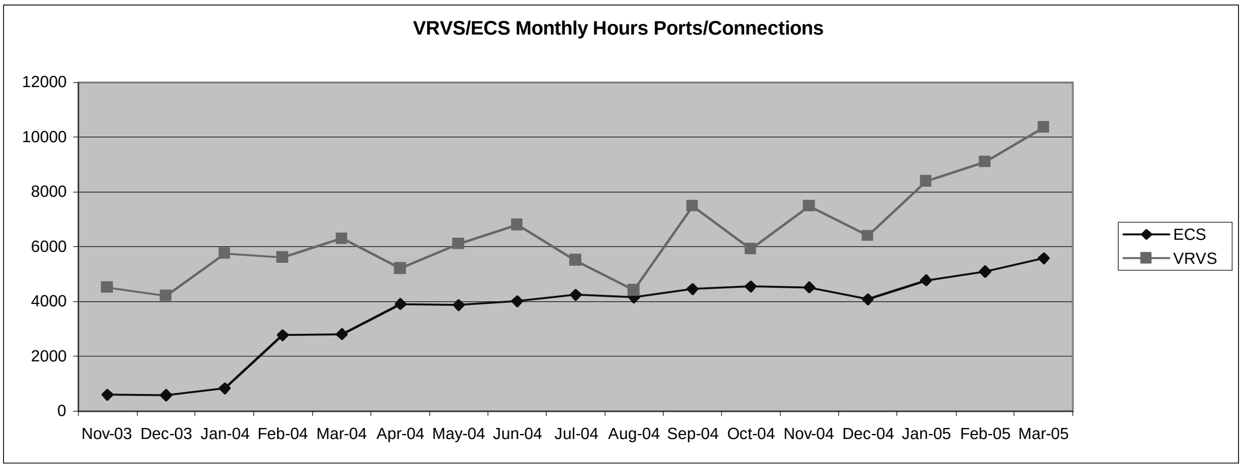


Figure 5-2: Monthly usage of VRVS and ECS in terms of connection hours since November 2003.

While both VRVS and ECS are heavily used by the LHC collaborations, there is a striking division in the community over which system is preferred. Often, users of one system have either never tried the other system or have tried and failed on one or few occasions. In many cases, prejudice is unwarranted and due to the attempted usage of poorly configured systems. In other cases, the requirements of the conference were more suitably addressed by the system that was chosen. Other reasons for the split in usage include:

- ECS has never really been advertised at CERN as an alternative to VRVS. In particular, non-U.S. institutes might not know of the system or might not be aware that they could register to use it.
- There could be reluctance on the part of some users to try to maintain expertise in two systems. Once a user understands one system, if it solves the basic communication needs, there is little motivation to learn the other system.
- Efforts have only begun recently to integrate the two systems.

5.3.3 Conclusions

There are three major video conferencing systems in use by the LHC collaborations today: VRVS, ECS and Access Grid. The Access Grid system provides a high-end solution to the meeting room environment and should be considered for one or two key facilities at CERN, but its current price, in terms of equipment, maintenance and usage, excludes its choice as the standard. VRVS and ECS are complementary and compatible in many ways, including their functionality, the use cases they handle, equipment requirements, and the preferences of the user communities. Neither system, on its own, solves the full set of requirements of the LHC collaborations. The two systems together, if given adequate support, have the potential to do just that, with only minimal additional development.

It is our opinion that choosing to support one system over the other would not only cheat the community out of the quality of service it requires, but would also be financially short-sighted, and impossible politically, given the realities of the current usage. Rather, the LHC ought to seek a solution that supports the adoption, development and integration of VRVS and ECS (or equivalent H.323 based system), with the focus on achieving the full functionality required by its community as quickly as possible.

5.4 Document and Application Sharing

5.4.1 Document Viewing

During face-to face meetings, it is common for speakers to display written material, plots and/or pictures in the form of slides or transparencies. Over the past few years, video projection of electronically rendered slides, typically formatted in Microsoft PowerPoint [45] or Adobe PDF (Portable Document Format) [46] has pretty much overtaken the traditional overhead display, although the latter has not yet disappeared. For a phone or video conference, the challenge is to provide clear and easy access to the material being displayed locally or by remote participants.

5.4.1.1 Current Practice

A variety of solutions are currently employed, with varying degrees of success, to allow the remote viewing of slides. These include:

1. Distribution of documents before or during the conference;
2. Posting of documents to a publicized location;
3. Video transmission from camera pointed at local display screen;
4. Direct VGA transmission of video signal;
5. Screen sharing via VNC or other application-sharing tools.

The primary advantages of methods 1 and 2 are that they do not depend strongly on remote client software and they place little strain on network resources. The participants receive or download documents at their own convenience and view them with local applications. Nearly all users have access to PowerPoint or Acrobat Reader and, if not, conversion is easily made from proprietary PowerPoint to PDF (performed automatically in the CDS Agenda [47] environment). In fact, even if presentations are viewed in a different manner during a conference, we believe it is good practice to make them available for the public record before or after the meeting.

The disadvantage of these two methods is that the viewer must know when to change slides during a presentation. Depending on the speaker, this is not always obvious and loss of synchronization is very distracting to the viewer. In addition, any slide pointing or edits during the presentation are missed remotely.

Method 3, has the advantage that the remote viewer sees the presentation in essentially the same manner as locally, provided the quality is sufficient. That is the key. Loss of quality is inevitable, to some degree, when pointing a camera at a screen image. With high resolution, sufficient luminosity of the projector, and good lighting in the room, this method is acceptable. In addition, all viewers benefit from pointing and live editing.

A chief disadvantage of method 3 is that the requirements for bandwidth are unreasonably high, as one is sending a video of what is essentially (with the exception of pointing, editing, and animation) a fixed image. In addition, it is rare that the resolution, luminosity, lighting and bandwidth are sufficient for success.

Method 4, direct transmission of the VGA signal, is currently available in a variety of forms. Commercial video conferencing hardware providers, such as Polycom or Tandberg [48], now offer options to their standard equipment, providing the simultaneous transmission of the video signal and the image of the slides. Depending on the remote equipment configuration, one can choose between the images to view or, better yet, view them both on either separate screens or on the same screen, with one image smaller and embedded in the other. The ITU protocol H.239 [49] has evolved in an attempt to allow such functionality across various technologies. It is just now becoming standard on the more recent models, although it is not yet available on VRVS.

The principal advantages of method 4 include the possibility of simultaneous viewing of the lecturer or conference room with the slides. The slides are presented in a clear, high-resolution, format, requiring minimal bandwidth, and change remotely in time with the presentation. Pointing or on-line editing can be viewed if the speaker does this using electronic means on the presentation computer. In addition, overhead projectors with VGA output are now common and reasonably priced, allowing for the remote presentation of paper or transparent slides or even small objects, a potentially powerful tool during the commissioning and debugging of detector components.

Method 5, the usage of screen sharing via VNC or other application-sharing tools, provides similar functionality as VGA transmission, with the addition of the potential for remote users to actually take control of a program or entire computer. Unlike method 4, the slide signal is transmitted from computer to computer, rather than between video conferencing units. There is often a higher overhead for network bandwidth and users might be required to install client software before the session begins. More on the usage of application-sharing tools, such as VNC, which has been integrated to VRVS for several years now, is presented below in Section 5.4.2.

5.4.1.2 Conclusions

The remote viewing of documents during meetings, tutorials or colloquia is a primary requirement for any phone or video conferencing facility. Whenever possible, it is suggested that the direct transmission of electronic presentations be employed to make optimal usage of bandwidth and to give the clearest possible image to remote participants. If the popularity of H.239 continues to increase, it is recommended that compliant equipment be installed and maintained in all conference facilities. It is also suggested to the VRVS development team that implementation of an H.239 or equivalent service be considered in addition to its current VNC capabilities.

5.4.2 Application Sharing

5.4.2.1 In the Meeting Environment

The possibility to remotely share an application interface, a software window, or a desktop has become a common component of the collaborative environment. Such activity typically accompanies communication in the form of a phone call or video conference and attempts to replace common conventional actions, such as scribbling on a black (or white) board, pointing to a display, or viewing the output or results of a running program.

There are several tools available in the public and commercial sectors offering application-sharing capabilities. We discuss a few of them here. As of yet, none of these tools can really be labeled as the “killer app” for application sharing. Often, they fail to address issues important to the LHC environment, including interoperability, ease of deployment, scalability, and multi-operating system support. In addition, proprietary and licensing issues can hinder integration and distribution of the applications with video conferencing systems, such as VRVS. For these reasons, application-sharing tools currently have limited popularity with the LHC collaborations. Solving these problems, however, would provide the collaborations with some important and useful tools for communication.

Below, we describe the two most commonly used technologies for application sharing: those based on the T.120 [50] protocol and VNC.

5.4.2.1.1 The T.120 Protocol

T.120 is the ITU standard covering data collaboration (including application sharing) over IP networks. Microsoft has driven development of this protocol with its Netmeeting [51] software client. Although, several other vendors claim to be T.120 compliant, they often use a subset of the Netmeeting application, integrated into their own application. Other video conferencing hardware manufacturers (e.g. Radvision, Cisco MeetingPlace [52]) have offered integration with T.120 protocol, but with a relatively low success up to now. Although T.120, as an ITU protocol, could have formed the basis for interoperability between vendors, the standard is now 10 years old and has not really taken off in popularity. In addition, Microsoft has cut support for Netmeeting, which is not included in its most recent OS (Windows XP).

5.4.2.1.2 VNC

VNC (Virtual Network Computer), initially developed by AT&T Laboratories in Cambridge [53], is now supported and developed by RealVNC [54]. The open source version of VNC has been freely available since 1998, which has helped to enhance the technology and increase the popularity of the tool. It is actively used in industry, commerce, education and privately.

VNC uses client-server architecture to allow the user to open a local view of a remote desktop or device. Its greatest strength is its availability for all major operating systems and languages (MacOS, Linux, Windows, Java, PalmOS, etc.). While the original technical focus was the control of a remote desktop, users quickly exploited it as an application-sharing tool, as it allows multiple remote clients to control or view (part of) a desktop. Because VNC was not designed as an application-sharing tool, it lacks a commercial-grade user interface or advanced session management features. Its modularity and functionality, however, make it common for VNC to be included as a component of other software tools. For example, VNC technology is used within VRVS. VNC/VRVS multipoint software, available on the VRVS web site, provides multi site connectivity. A VRVS user wishing to share her/his desktop starts the VNC server locally then, using the VRVS control applet when connected to a Virtual Room, selects the sharing mode and clicks on “SHARE”. Any remote user clicks on the SHARE button (on the VRVS applet) to download a JAVA applet to see and/or control the shared desktop. As another example, Tandberg [48] a major video conference equipment manufacturer, has adopted the VNC technology for its application sharing components.

5.4.2.2 Outside of the Meeting Environment

We did not attempt to make a complete survey of application sharing tools on the market, as their popularity is currently limited with regard to the LHC applications. This situation might change dramatically, as we begin to explore the potential usage of these tools for the remote running and maintenance of detectors, and for the analysis of data. For the former, one can envision the power of allowing detector or accelerator experts to manipulate, test, diagnose and run major hardware or software components remotely. This could become vital, as much of the expertise from the construction of the LHC accelerator and detectors will be located outside of CERN, once the LHC has begun running. Such usage is not new to HENP, and some accelerators, such as the Tevatron in Fermilab [55], currently employ methods of remote monitoring and control to a limited degree.

For data analysis, application-sharing tools integrated to a Grid analysis environment have been proposed recently [56] as part of an overall collaborative toolkit. Earlier investigations demonstrated the effectiveness of remote manipulation of software applications, such as the WIRED [57] event viewer over transatlantic networks to and from CERN.

5.4.2.3 Conclusions

Usage of application-sharing tools with or without accompanied video conferencing is certainly expected to increase as we approach the commissioning, installation and running stages of the LHC. We recommend that the development and evolution of those tools on the market that address the needs of the collaborations be closely monitored. Support should be provided, as needed, in the form of common software installation sites and group licenses.

5.4.3 Document Writing

5.4.3.1 Overview

There are a variety of tools available for writing documents (this report, for example) in a collaborative manner. Word processors, such as Microsoft Word [58] or Adobe FrameMaker [59], allow users to track changes to text, using color coding and other symbols to identify contributing authors and the changes they have made. Web tools, such as WiKis [60], allow a number of authors to contribute to a document, formatted on the web, and include the ability to add comments and to be informed when text has been edited and by whom. Another web-based tool, Xerox DocuShare [61], provides a repository for shared documents with access to documents via a “check-out” system that allows parallel viewing but restricts editing to one author at a time.

5.4.3.2 Recommendations

There is no reason, at this time, for the RTAG to recommend any one word processor or document repository over the others. In our opinion, the development of these tools should be monitored and periodically evaluated for their effectiveness in addressing the LHC collaboration requirements. As needed, support should be provided in the form of common download repositories, documentation and group licenses.

5.5 Web Casting and Archiving

5.5.1 Introduction

Web casting and web archiving are respectively synchronous and asynchronous means of broadcasting presentations using a mix of media, typically including at least one audio/video stream, accompanied by images and/or text, and presented to the viewer via web-based client applications. Both have been established as powerful collaborative tools that can greatly facilitate the dissemination of information and knowledge within a collaboration and outside, in the form of educational outreach. Use case scenarios include events and activities for which there is a greater potential audience than is physically capable of attending due to geographical, time, budget or other constraints. Examples are the real time broadcasting and/or archiving of plenary collaboration meetings, seminars, colloquia, training courses and tutorials. In addition to improved communication, documentation and outreach, the benefits include considerable savings of time and money, with respect to collaboration training.

5.5.2 Web Casting

Web casting permits real time, online, viewing of events via a web interface and streaming video player, such as RealPlayer, Quicktime, or Microsoft MediaPlayer. This process is unidirectional, with remote participation limited to passive attendance, unless additional communication methods are employed, such as telephone or e-mail. The usage of web casting at CERN has been limited, up until now, to important colloquia (e.g. Nobel speeches), public announcements or outreach events (e.g. CERN 50th anniversary festivities). But, it is potentially available for any event, taking place in the CERN Auditorium.

Special equipment required to web cast includes a high quality video camera, with audio feed from the local sound system. The camera must be connected to a computer or computers capable of real time encoding of the data and with an Internet connection of sufficient bandwidth to handle the load. The cost of the server software and licenses depends on the type and number of streams to be broadcast, but the client software is usually freely available, easily downloaded and installed from the providers.

5.5.3 Web Archiving

Web archiving permits offline viewing of events via a web interface and streaming video player plus access to additional visual support and reference material. This process is also unidirectional, but, depending on the nature of the archive, users might have the capability of searching recorded lectures, viewing only relevant parts, with the possibility of rewind, fast forward and pause, similar to the viewing of a video cassette or DVD.

The equipment necessary for web archiving is similar to that of web casting; pretty much any web cast event can be archived for future reference. The computing and networking demands can be somewhat reduced if one does not require the lectures to be available immediately following the event, thus eliminating the need for real time encoding. However, additional resources, in terms of database and video server software, are required, depending on the size of the archive to be maintained.

Experience has found that the exact resource requirements depend on the type of event being recorded and on the intended usage and longevity of the archive. For example, peak viewing for the archives of a plenary session typically occurs within a few days after the event took place. In some cases, collaboration members located in a different time zone benefit from the ability to view the lectures at a convenient time before holding discussions with their colleagues to provide input for the following day's meetings. In this case, the requirement of quick access to the archives outweighs the need for features that require processing time, such as enhanced video and audio quality or the ability to search metadata, although these can be achieved with subsequent re-processing. On the other hand, viewing of software tutorials is typically spread over a period of months or years following their recording. In this case, it is worthwhile to put resources and time into the production of a high-quality archive, complete with search capabilities and other features to ensure its longevity and utility.

5.5.4 Current Practices

The archival of lectures at CERN has been supported in a variety of manners over the years. Before the development of web archiving, important seminars and colloquia in the Main Auditorium were recorded on videotape and archived with paper copies of the lecture's transparencies in the CERN library. In more recent years, a real time encoding system has been set up in the auditorium, along with several cameras and mixing hardware, to allow for both web casting and for the immediate production of web lectures. Academic Training lectures held in the auditorium are archived using this system.

Simultaneous to these developments, a project was launched by the University of Michigan, in coordination with CERN IT and the 1999 CERN Summer Student Program, to record and archive lectures of that year's program. This project, called the Web Lecture Archive Project (WLAP) [62], was based on software developed to synchronize images of the presentation slides to a video of the lecturer. The goals of the pilot project, supported by the NSF (U.S. National Science Foundation), were to test the archiving method in the CERN environment, but the success and popularity of the lectures led to the recording of nearly all of that year's lectures, and raised the interest and subsequent participation of CERN Technical Training and the ATLAS Collaboration [63]. Since that time, the project has produced a database of several hundred lectures, plenary sessions and tutorials, accessible via the WLAP web site [62]. A CERN publication describing the project in more detail is available as CERN-OPEN-2001-066 [64]. Support for the recording of ATLAS plenary sessions, physics and software tutorials, has been provided by CERN and U.S. ATLAS [65].

The main difference between the WLAP lectures and those produced for Academic Training is the usage of synchronized slide images instead of high-resolution video of the projected slides. The Academic Training lectures are available more quickly and require fewer resources for production than the WLAP lectures. The WLAP lectures, on the other hand, contain meta-data, are searchable, and require less bandwidth for viewing. Post-production of the Academic Training lectures into synchronized lectures could be possible if the independent video streams were both recorded. Unfortunately, only the pre-mixed video is currently archived.

5.5.5 General Comments and Conclusions

There are clear benefits to the web casting and/or archiving of important plenary meetings, seminars, and colloquia at CERN, in that they provide a means of participation for collaboration members unable to attend, due to time or location constraints, and a historical record of important events. In addition, the archival of tutorials provides a valuable tool for disseminating information to a globally distributed collaboration. Experts in particular fields, such as computing or physics, are often in high demand by their colleagues to present tutorials. Yet, those very experts typically have the least amount of disposable time, and it would be inefficient to send them to all parts of the world whenever new collaboration members require their expertise. Web lectures do not necessarily replace live tutorials, but do provide a powerful learning tool and complement live events.

It is our opinion that CERN should continue its program of recording seminars and training events for web archives. We also feel it should expand this program to cover events taking place in locations outside of the CERN Auditorium, such as the Council Chamber, the TH Auditorium, the auditoria in building 40, and the CERN Training Centre. For the larger auditoria, this might require the installation of facilities similar to those in the Main Auditorium. However, it would also be useful to have one or more portable units, designed to record lectures in smaller locations, as requested. The service, in addition to the equipment, would require several camera operators (perhaps hired on demand), and a software team for publishing the final lectures and maintaining the database, software and servers.

Concerning the technology, it is our opinion that the collaboration between CERN and experts in the field, such as the University of Michigan (and/or any of the many other institutes now involved in lecture archiving), should be fostered. Common projects designed to provide the functionality of synchronized lectures, while working to reduce the required resources for publication, should be supported, with the primary goal of addressing the requirements of the LHC collaborations. Specialized services, such as the recording of lectures for limited audiences, for small working groups, or even on a periodic basis for communication between students and mentors or for a professor giving a remote lecture, could also be provided, with support coming on a pay-per-event basis by the interested parties.

It can be concluded from the combined experience of the WLAP and CERN programs, that the value of the archived content far outweighs the costs of maintaining the necessary databases, software and servers. Lectures of general interest are being viewed not only by members of the collaborations, but increasingly by the public outside of CERN, making evident the value of the archives for educational outreach. For these reasons, we recommend that CERN continue to maintain and actively publicize its database of web lectures, and to consider the possibility of hosting lectures from domains other than those specific to CERN or HENP, if funding for these activities can be secured.

To ensure the longevity of the lectures and allow for viewing from a variety of computing platforms with a variety of tools, we recommend that non-proprietary formats be employed whenever possible for the archive formats. Finally, we recommend that this database be monitored for external access and mirrored at one or more external institutes, located in strategic geographical locations, to ensure continuous, stable access to the archives, and to avoid network bandwidth and server constraints.

5.6 E-Mail and Instant Messaging

5.6.1 E-Mail

Over the past 20 years or so, electronic mail (e-mail) has rapidly become a leading communication tool for HENP and pretty much every other scientific or non-scientific field in the developed world. Its usage has approached and perhaps surpassed that of the telephone for one-on-one communication and, with the advent of mailing lists, asynchronous communication within groups or collaborations. Its popularity has followed (and in some ways led) the proliferation of personal computers and usage of the Internet. As with the world-wide web, the quick rise of e-mail tools followed the development of a protocol (in this case, SMTP) and the availability of a network infrastructure that is relatively inexpensive to access.

CERN currently maintains a mail server for handling incoming and outgoing mail, and provides adequate disk space for CERN accounts. There is a web interface [66] which allows users to sign in from any domain, using their NICE username/password, to access their mail, and pretty much any commonly used mail client can be configured to use the IMAP server. The server provides a variety of utilities, including spam filtering, forwarding, and vacation messaging.

In addition to the mail server, CERN supports a tool for the maintenance of mailing lists, called "listbox", which can be accessed and configured via the SIMBA web-based interface. Addresses included in the mailing lists are required to be associated with registered CERN Users or External Users. The latter are easily registered via the interface by one of the former, logged in to SIMBA. This system is basically a security measure and helps to prevent mass mailings and other common mailing list abuses.

One of the more important features of the mailing lists is the ability to archive messages sent to the list and to view them ordered by date or subject thread. For lists dedicated to technical issues, an archive can present users with a useful database of information, as an informal, dynamic FAQ (Frequently Asked Questions) file. Although a recent upgrade to the interface (SIMBA2) has prevented the searching of archive content, this problem is expected to be resolved shortly.

5.6.2 Instant Messaging

Instant messaging is a slightly more recent development than e-mail, allowing users to send short messages over the Internet in a nearly synchronous manner. Typically, a user sends a colleague a short text message and awaits a reply in a form of dialogue, delayed essentially only by typing speed. Example applications include AOL Instant Messenger [14], MSN Messenger [15], and Apple iChat [17].

Instant messaging differs from e-mail, in that it does not usually involve the archival of messages and the necessary software is typically installed locally, as applications or applets, rather than on a server. Additional features include the creation of lists of allowed participants or “buddies” and the usage of on-line presence notification. Most of the applications are evolving to include some form of audio or video conferencing capabilities, as mentioned in Section 5.2.3.

5.6.3 Future Development

Future development focuses on the integration of e-mail client software with other technologies, such as instant messaging tools, mobile and fixed telephones, and PDA’s (Personal Digital Assistants). The addition of “presence information” to e-mail, instant messaging or even video conferencing applications, allows a user to know when a colleague is available for (or prefers) direct communication, and when that person is “out of the office”. By organizing lists of colleagues according to membership in various physics or detector collaboration groups, this information can be valuable for the ad-hoc organization of conferences.

It is important to note that proper management of this information is necessary to address concerns of privacy or the perceived invasiveness of these forms of electronic communication. Participants must ultimately control the ability of applications to announce their “presence” at appropriate and desired times, and to restrict dissemination of that information to their colleagues. New developments in “buddy list” management are beginning to address these issues.

5.6.4 Recommendations

The RTAG recommends continued support of the current CERN e-mail server, web interface and its associated tools. Any future development should focus on integration of those tools with other technologies, as described above, keeping an eye toward activities in the commercial and public sectors. The current “listbox” mailing list server should also receive continued support and any missing features, such as the ability to search archived mail content, should be addressed promptly.

Concerning instant messaging tools, there is no reason to recommend any one tool over the other for the LHC community. Each has various strengths and weaknesses and offers a variety of useful functionality. Efforts here should focus primarily on fostering the usage of these tools, by providing central software repositories, licenses and documentation, as needed.

Finally, the RTAG believes that current network security issues ought to be examined and weighed against the needs of the community and the practicality of enforcing policy. It is understood that applications, such as Skype, come with the risk of network abuse. However, the growing popularity of such tools, due to their low cost and ease of use, might be considered as a clear sign of their usefulness to the community. If such a tool is determined to pose a serious threat to the functioning of the network, then alternatives should be sought and presented to the community, as quickly as possible.

5.7 Computer Supported Conference Management

5.7.1 Introduction

In this section, we present collaborative tools developed and in common use at CERN to support various organizational tasks required by conferences, whether entirely local or including remote participation. These tools were developed at CERN to handle the specific needs of the community, such as conference room reservations or agenda management, but have since been successfully installed at external institutes, because of their utility and popularity.

5.7.2 CRBS – The CERN Conference Booking System

5.7.2.1 Description

CRBS [67] is a web-based room reservation system in use at CERN. It is used to manage more than 70% of the conference rooms at CERN. Anyone can make a request to book a room – access from outside of the CERN is controlled via a username/password. Each room has a designated contact person who is required to authorize all booking requests. In the current CRBS version there is very limited support for video-conferencing rooms. Rooms equipped for VRVS or ISDN video conferencing are flagged and informative pop-up messages appear when you try to book one of these rooms. There is, however, no automatic link between reserving a room for a VRVS video conference on CRBS and booking a virtual VRVS room, which must be performed through the VRVS interface.

5.7.2.2 Recommendation

Integration of the CRBS and VRVS services to allow simultaneous reservation of a local facility with a VRVS virtual room appears relatively straightforward and would certainly be beneficial to the users at CERN. Such a service, mapping group meetings with facilities and infrastructure could potentially be expanded to include the reservation of facilities in other participating institutes. This would allow a single user to locate available facilities at all institutes and to map their capacities and accessibility to the needs of the group. We highly recommend the development of a single interface that can handle at least the local CERN requirements and that the possibility of an integrated remote room reservation system be investigated.

5.7.3 CDS Agenda

The CDS (CERN Document Server) Agenda software [47] was initially developed in 1999 by the CDS team following a request by the ATLAS experiment. The initial software has been greatly enhanced and improved since the first version thanks to the comments and feedback from its users. CDS Agenda v4.2.7 is the current version and is in wide spread use within CERN and at several other external sites. CDS Agenda allows one to create, modify and store agendas of meetings, conferences or workshops together with all the documents (transparencies, minutes, pictures, videos, etc.) associated with them. The CDS Software suite, of which CDS Agenda is a part, is free software, licensed under GNU General Public License (GPL).

Currently there are more than 10,000 agendas inside CERN's CDS Agenda system with some 70,000 associated talks. At CERN, CDS Agenda has doubled in usage every year since its introduction. There is currently no link between CDS Agenda and the CRBS (see 5.7.2). This will be addressed in a future version of InDiCo (see below).

5.7.4 InDiCo

In 2002, the InDiCo (Integrated Digital Conference) project [68] was approved as an IST (Information Society Technologies) project under the auspices of the 6th Framework Programme of the European Union. The aim of this project was to build on the experience of CDS Agenda to develop a more general tool which would be able to provide a complete conference management system on top of the CDS agenda software while at the same time satisfy the needs of CDS Agenda users.

5.7.4.1 Key features of InDiCo

The InDiCo facility is expected to go into complete operation in 2005, replacing CDS and adding significant features and functionality. At that time, it will have the ability to

- Create and maintain a conference web site, be it a single talk or a whole workshop;
- Schedule sessions and contributions;
- Attach material to conferences and contributions, be it text or multimedia content;
- Make categories to organize conferences according to a hierarchy;
- Review papers with web application and email notifications;
- Protect items based on user authentication;
- Delegate responsibilities to others according to roles;
- Archive a conference to specialized repository services, currently being developed by partners within the frame of InDiCo.

The tool is aimed at being easily extensible, so as to handle all aspects of conferences, including participant registration, reservations, etc.

As an important organizer of lectures and conferences, CERN is providing its development partners with audio and video content for that part of the project dealing with multimedia analysis. For example, an experimental, yet important part of InDiCo is the automatic indexing of multimedia content using voice and pattern recognition technologies. This is done in the Netherlands at TNO TPD, TNO TM and the University of Amsterdam. See the project web site [69] for contacts in these institutions.

In 2004, InDiCo launched a major and highly successful pilot project, as it was utilized by the conveners of CHEP'04 -- a major conference on Computing in HEP – to handle nearly all aspects of the conference organization. An example of InDiCo in use can be found on the CHEP'04 conference home page [70].

5.7.4.2 Recommendations

The RTAG recommends that the InDiCo project be fully supported by CERN as an essential tool for the LHC community. Initial indications are that it will be at least as useful and important a tool as its highly successful predecessor, CDS Agenda. The comments in Sections 5.7.2.2 and 5.7.3, concerning integration with the CRBS and with the booking system of VRVS, are relevant and should be pursued. We would also like to add that the successful work model, involving a variety of developers and including expertise from other organizations, as part of a common project, is highly commendable, and should be looked at as an example for other collaborative tool development.

5.8 Conference Room Facilities

5.8.1 Introduction

Perhaps the most critical component of any remote conferencing facility is one that has commonly received the least amount of planning or attention at CERN: the room, itself. Many of the complaints and technical problems reported by audio and video conference facility users at CERN can be traced to poor configuration or usage of the facilities, rather than to the choice of equipment or system. In many cases, relatively trivial (but not necessarily inexpensive) solutions could be found. This subsection will discuss some of these issues and provide recommendations to address the more general problems.

5.8.2 Lack of Facilities

One common complaint voiced in surveys and discussions with the LHC collaboration members is that there is a lack of facilities at CERN for audio and video conferencing. Currently, only one auditorium (out of four) in Building 40, the primary office building at CERN for the LHC collaborations, is equipped for video conferencing. One of those rooms does not even contain an analogue phone line suitable for holding a phone conference. In addition, only about half of the other smaller meeting rooms in the building are equipped for video conferencing and nearly none in a coherent manner.

5.8.3 Sound and Light

In the existing facilities at CERN, it is often the case that, while adequate equipment has been installed for phone and/or video conferencing, only minimal attention was made to the quality of the room's lighting or acoustics. In CERN Building 40, for example, several rooms equipped for video conferencing are surrounded with large areas of window and hard floors, causing echoing and background noise problems that even high-quality equipment is incapable of compensating. Phone and video conferences made from those rooms suffer from very poor audio quality and speakers are often forced to leave their seats in order to speak loudly into a microphone situated only half a table length away. Simple solutions, such as the mounting of curtains or installation of carpets are not even attempted due to lack of coordination and the ambiguous nature of the "ownership" of the rooms.

In addition to the acoustic problems mentioned above, lighting in the facilities is often inadequate or poorly situated, with shadows falling over the faces of participants. Such details might be considered of lower priority to the problem of sound, but studies indicate that facial expressions and gestures by a speaker during a meeting can provide a very important component of communication. In addition, the recording of lectures in these rooms would be greatly facilitated by the provision of a few inexpensive, but well situated, light fixtures.

5.8.4 Laptop Facilities

Like it or not, it has recently become common practice for conference rooms to be equipped with wireless networking and for meeting participants to come equipped with laptops. While it can be arguably distracting to make presentations to the tops of heads and the covers of laptops, the trend is apparently here to stay, and there are important advantages to the practice. Participants with laptops, for example, have the opportunity to examine presentations more closely, even as they are being made, and can better prepare to ask questions on particular slides at the end of the talk. In addition, the participants have easy access to supportive (or contrary) material relevant to the talk or discussion. To facilitate this, we recommend that all conference rooms be equipped with wireless networks and, whenever possible, with electrical power strips or outlets conveniently located.

5.8.5 Recommendations

Above all, it is critical to solve the question of "ownership" of the meeting rooms, auditoria, and other conference facilities. This is a problem somewhat unique to CERN and it has been arguably one of the most important obstacles in the construction of adequate collaborative tool facilities at the laboratory. It is our opinion that the equipping and maintenance of all aspects of a meeting room, including phone, video conferencing, and recording equipment, network infrastructure, lighting, carpeting, etc. ought to be handled by one single entity. This is the only way to ensure the development of coherent solutions to address all the requirements of a successful conference facility.

Once ownership is determined, facilities can be constructed according the constraints of budget and the needs of the owners. However, it is important that the installations maintain a certain degree of uniformity, in order to minimize overall maintenance costs and simplify the necessary training of operators. It is thus desirable for all facilities in Building 40 and other rooms commonly used by the LHC collaborations to come under the control of a common LHC Collaborative Tool Service, the charge of which would be to equip, maintain (and operate) the rooms. Usage of the facilities must be shared in a fair and equitable manner, enforced by pre-determined policy (not necessarily first come – first serve).

The importance of room preparation, apart from technology choices and system preferences, cannot be over-emphasized. Meeting rooms to be equipped for phone and video conferencing and/or for the recording of web lectures must be evaluated for acoustics and lighting, and equipped appropriately. Improvements such as carpeting, curtains, and lighting, should be considered as essential to the room's equipment as the video conferencing unit, itself, and must be part of the initial installation. While there is a clear lack of conference facilities at CERN, the existence of poorly equipped facilities is an obstacle to clear communication and a waste of vital resources, posing a serious problem to the collaborations.

6 Network and Grid Support

6.1 Introduction

The network is an "invisible" but vital component of the real-time infrastructure necessary for collaboration. Quality, secure networking is essential for the usage of all the tools discussed in Section 5. In this section we describe key aspects of networking, discuss changes brought about by security and Grid related issues, and provide some general recommendations for improving both the network infrastructure and the collaborative tools that rely on it.

6.2 Network Quality

The quality of communication over the network depends not only of the bandwidth available but also on the round trip time (RTT) and Jitter (fluctuation in arrival time of the packet). Most of the real-time (i.e. video/audio) packets used by collaborative applications are based on the UDP protocol, which is lossless since it does not assure that the packets reach their destination successfully. It is therefore extremely important that the network quality between the different components and participants of a conference are well connected and deployed to the adequate location, in order to provide optimal quality.

We consider network quality acceptable when the packet loss is near 0% and the RTT is less than 300ms with a jitter up to 30ms. Taking these parameters into account, the design of a network infrastructure for real-time communication is crucial. For example, it is not recommended to use an MCU located in the U.S. or Asia to perform a conference between Europeans participants, since the RTT will be high and the probability for packet loss important, as several backbones will be crossed. Today the national research and academic backbones generally provide satisfactory network connectivity and quality by over-provisioning their network capacity. However, network degradation can and still does originate from the LAN (Local Area Network) -- often due to poor deployment, bad configurations, or simply inadequate bandwidth – and/or its interconnection to the WAN (Wide Area Network) -- typically due firewall restrictions or poor configurations.

6.3 Network Security

Internet security is a real concern for universities, laboratories and private corporations. Although the need for advanced collaborative tools within national and international institutions has been steadily increasing, there has been a simultaneous tendency in universities and laboratories to consolidate their Internet security infrastructure. A large number of sites have installed firewalls, which prevent unauthorized IP packets to reach any host in the protected site, and/or NAT's (Network Address Translations), which hide the original IP address to the rest of the world and use an internal non-routable IP address. Unfortunately, these security mechanisms are often incompatible with open communication and collaboration between geographically separated sites.

When a user connects to a video conferencing session (using SIP or H.323 standard protocols), one or several TCP ports are used to establish the connection to the remote end point and to dynamically negotiate the UDP ports in order for the video and audio streams to communicate. Opening multiple TCP ports and dynamically changing UDP ports on the firewall, however, is not a viable option to complete a single audio or video session across the Internet. Doing so could compromise the security of the institute.

Until IPv6 (Internet Protocol version 6) is widely embraced and deployed across the Internet, there will be issues involving NAT. The combination of a firewall and NAT achieves the goal of keeping outsiders from unauthorized access or entry into the secured enterprise, and provides a means for insiders to access the outside world. Although this is acceptable for non real-time applications, most collaborative tools, such as IP-based video conferencing, seek to create a real-time session between two or more endpoints at more than one secure location.

Today's firewall technology does not address these issues and alternative solutions must be sought.

Several techniques for IP video conferencing exist in the industry, including:

- Full Proxy[4];
- Application Level Gateways (ALG)[5];
- DMZ MCU[6].

Unfortunately, none of them are scalable, easy to use or implement, and none completely address the scenario of several remote end nodes at different protected locations.

We recommend that the CERN LAN and its connections to the WAN be investigated for bottlenecks, which might impede the usage of collaborative tools by the LHC collaborations. Proper scaling factors should be taken into consideration for the dramatic increase expected for usage in the next few years, as we head toward LHC turn on. A balance between network security and network quality needs to be maintained at CERN and at the member institutes, with the implementation choices for firewall technology limited to those that allow free passage of the most commonly used collaborative tools. All institutes are recommended to migrate to IPv6, as quickly as possible.

6.4 Integration with the Grid

The emergence of the Grid as the principal analysis vehicle for the LHC experiments will raise a new set of demands for the collaborative tools described in Section 5. From our perspective, the key common component required is the re-use of the authentication and authorization mechanisms for the Grid, adapted to meet the particular environments of these tools. This essentially amounts to the user requirement of a single sign-on at her/his desktop for both the experiment analysis environment and the collaborative environment, within which the physics analysis is performed.

As a first step in this direction, we recommend the enhancement of all existing web-based tools with Grid authentication and authorization mechanisms. The first obvious candidate for this development is VRVS, and a first implementation has already been completed. We recommend continued support for these developments and also suggest that implementation methods be shared with other web-based tools in use by the LHC.

An example open source product providing the required functionality is Gridsite [71], which handles the required user authentication via the web. This must be combined with authorization mechanisms adopted by the experiments e.g. the VOMS (Virtual Organization Membership Service) system [72] to ensure participation is limited to those within a given VO (expansion of VO), such as a physics working group or software development team.

[4] The proxy has the knowledge of both the public and private networks and makes the IP call which effectively looks like two separate calls (one from the endpoint in the private network to the proxy and a second call from the proxy to the endpoint in the public network)

[5] which are firewalls that are programmed to understand specific IP protocol like H.323 and SIP but need support or upgrades to all firewalls in the path

[6] One can overcome NAT and Firewall traversal issue by placing a multipoint control unit (MCU) in what is known as the demilitarized zone, or DMZ

7 Synergy with Existing Initiatives

In earlier sections, we have referred to several ongoing initiatives focusing on the deployment of a collaborative work infrastructure for HENP. In this section, we describe two of these initiatives in more detail: RCWG and HTASC-CSMM. The scope, composition and goals of these groups overlap with those of the RTAG, leading to frequent exchanges of information and opinions, as well as surprisingly similar conclusions to their investigations.

7.1 RCWG

RCWG (Remote Collaboration Working Group) works with the ECS (ESNet Collaboration Service) at NERSC [73] to coordinate video conferencing activities in the ESNet Community. It is a long established working group, which has monitored video conferencing infrastructure deployment within the US HENP community since its inception in the 1990's. The RCWG was chaired by Ed May of ANL at the onset of the RTAG, and is now chaired by Sheila Cisko of FNAL.

The working group meets every week via video conference, alternating formal and technical sessions. Formal sessions have prepared agenda and might feature invited guests, while technical sessions allow participants to present any material of interest, including informational talks, test reports, user feed-back, or suggestions on improvements or potential evolution, etc.). In addition, RCWG occasionally organizes and performs debugging and integration tests of new ESNet video conferencing services.

Members of RCWG are generally in charge of providing video conferencing support at main HENP institutions (e.g. FNAL, LBNL, SLAC). ESNet Collaboration Service staff and European institution (e.g. LAL, DESY, CERN) representatives regularly attend. This includes two members of the RTAG.

The chair of the RTAG and the chair of RCWG have attended each other's meetings, presenting participants with the goals of their respective working groups and participating in subsequent discussions on numerous occasions. Both groups share the common vision of greatly improved implementation and deployment of video conferencing tools for all of HENP. Although RCWG originates from ECS, key members of the VRVS development team participate actively in meetings and in the group's mailing list discussions, and there is strong synergy between these two groups, as well. In general, we find that the recommendations provided in this report are in line with those of the RCWG.

We highly recommend that the LHC and/or CERN appoint representatives to regularly attend the meetings of the RCWG and any similar national groups addressing common issues for video conferencing services for the HENP community.

7.2 CSMM

The HEP-CCC (Computing Coordinating Committee) comprises directors of major HEP computing sites in the CERN Member States, as well as representation from the United States. Its HTASC (HEP-CCC Technical Advisory Sub-Committee) set up the CSMM (Computer Supported Meeting Management) working group in 2003 with the following mandate:

> *The HTASC CSMM Subgroup should advise HTASC and HEP-CCC on current and future needs for CSMM within the HEP community. "CSMM" in this context refers to*

all means used to enhance traditional meeting experience with digital technologies, notably scheduling, video conferencing video streaming and document sharing.

For this purpose, the current situation with respect to available technologies and trends in this area as well as usage profiles should be reviewed. As a first step the specific topic of videoconferencing should be addressed. The group should

- *survey present practices within the HEP community;*
- *review available technologies and their use and applicability within HEP;*
- *make recommendations concerning coordination between different laboratories and institutes.*

The group should report back to HTASC and HEP-CCC on the topic of videoconferencing within no more than one year and produce a written report.

Although the CSMM focuses on meeting management, its scope is relatively broad when compared to that of the RTAG, in that it covers the whole HEP community, and is more technically oriented. Membership includes representatives from UK, France, Germany, Spain, Italy, US and CERN. Three 1.5-day meetings have been held and input has been received from presentations by DFN (Deutsches Forschungsnetz, Germany), RedIRIS [74] (Spain), Renater [75] (France), ViDe (Video Development Initiative, USA). There have also been numerous discussions with industry and with video conferencing end users.

Christian Helft is the chair of the CSMM subgroup and a member of the RTAG. As such, information and discussion has flowed frequently between the two groups. The RTAG shares many common viewpoints with the CSMM concerning the need for advancement in the implementation and employment of quality collaborative tools for meeting management in HENP. In particular, both groups embrace the EU InDiCo project currently being implemented by the CDS team at CERN, with cooperation from industry and as an open source program.

The RTAG and CSMM strongly agree on the need for dramatic improvement in the deployment of video conferencing facilities at CERN and at the home institutes and encourage the quick establishment of an LHC-wide collaborative tool service to oversee the installation, maintenance and running of the equipment. Finally, both groups agree on the need for the development of a common collaborative environment for the LHC and the HENP community that would include the integration of meeting management tools, such as phone and video conferencing, virtual and real room scheduling, meeting reservation based on common working groups, presence detection, Grid certification and authentication, and document archiving.

It should be noted during the mandate of CSMM, HEPCCC and HTASC came to an end and that CSMM has been on hold since June 2004. There are currently considerations to revive CSMM under the newly formed iHEPCCC [76].

8 Recommendations to the PEB

In this section we present key recommendations to the LCG PEB to address current and expected future needs of the LHC collaborations. The RTAG recognizes that the field of collaborative tools is a new and rapidly growing one, and that a certain degree of flexibility will be expected for any successful implementation. We therefore stress that emphasis be placed on achieving the first recommendation (the establishment of a Collaborative Tool

Service for the LHC) as quickly as possible, and that this body be given the funding and authority to make the more detailed decisions on the hardware and infrastructure plans, including the ability to purchase and evaluate equipment.

We also note that there are a number of recommendations not appearing in this section, but included in other relevant sections of this document. Although those recommendations are considered equally important, it was decided to focus this section on major recommendations having the largest impact on budgetary considerations for CERN and the LHC.

Rec 1	We recommend that CERN establish and maintain a Collaborative Tool Service to support the needs of the LHC collaborations.

This service must provide:

- coordination between the LHC collaborations and CERN concerning the development, installation and maintenance of collaborative tools for the LHC;
- management of a coherent project designed to address the requirements of the LHC collaborations, to set priorities, and to design, plan and conduct the implementation;
- help for external institutes, in the form of suggestions for standard infrastructure, advice on installation and utilization, documentation and "help desk" type facilities;
- participation in other collaborative tool initiatives of interest to the LHC and HENP community, in general;
- sufficient research and development to maintain expertise in the various fields of collaborative tools, to provide solutions to LHC-specific problems, and to keep the facilities in step with the rapidly changing environment.

Direction for this service must receive oversight from each of the LHC collaborations.

Rec 2	We recommend that the CTS maintain and support VRVS as a standard video conferencing service for the LHC collaborations.

Adequate resources should be provided to guarantee that

- CERN conferencing rooms be fully functional for the usage of VRVS for the entire LHC physics life cycle;
- operational aspects (reflector set up and maintenance, end point equipment choice and usage recommendations, end user support) of VRVS for the LHC community be taken on by CERN in collaboration with the VRVS team;
- documentation be provided for the recommended installation, maintenance and usage of video conferencing facilities at CERN and at the participating institutes. Integration of this documentation with the existing documentation of VRVS is highly recommended

CERN should define and sign a Memorandum of Understanding with the VRVS team in order to ensure that missing functionality be implemented and that access to VRVS remain free and efficient for the LHC community.

Rec 3	We recommend that the CTS establish, maintain and support an industry standard H.323 MCU-based video conferencing service for the LHC collaborations, complementary to and interoperable with VRVS.

This service might take various forms in its implementation (co-funding of ECS, of other national facilities, installation of infrastructure at CERN, or a mix), but its operation should appear to the end-user as being under CERN's responsibility, and be as close as possible to the state of the art without impinging its stability.

If CERN chooses to operate its own infrastructure, this service should be deployed in close cooperation, and interoperate with existing ones in other countries, particularly ECS.

Adequate resources should be provided to guarantee that

- CERN conferencing rooms be fully functional for the usage of this system for the entire LHC physics life cycle;
- the system be interoperable with VRVS;
- a common interface be developed and maintained for the two systems.

Interoperability with VRVS at least at the user interface level will be a goal of its deployment.

Rec 4	We recommend that the CTS provide user support for desktop/laptop phone and video conferencing for LHC collaborators situated at CERN, at their home institutes or elsewhere, as appropriate.

The support would include

- software downloads and group licenses , as needed;
- hardware recommendations, equipment installation and usage guidelines;
- a reasonable level of on-line support;
- a web site with a portal, HowTo's, FAQ's, etc., as appropriate.

The LHC Collaborative Tool Service would provide the guidelines and compliance would be a requirement for support.

Rec 5	We recommend that the CTS install, maintain and support a 24/7 operator-free phone conferencing system at CERN.

The system should provide

- a web-based booking system;
- an optional remote documentation system providing users with the equivalent of Web Conferencing functionality;
- possibility of CERN-originated calls, as needed (and paid for);
- definition of a Voice Over IP interface so as to provide the possibility of interoperation with video conferencing systems, such as VRVS.

Rec 6	We recommend that the CTS equip and maintain all auditoria and meeting rooms in building 40, as well as those located elsewhere at CERN, commonly used by the LHC collaborations, for integrated phone and video conferencing.

The equipping and maintenance of the rooms is to be coordinated by the LHC Collaborative Tool Service and should provide at least:

- quality audio and video transmission to and from the facility for phone and/or video conference participants;

- ability to share documents remotely in a clear format;
- ability to record presentations made in the facility to produce archived web lectures.

The rooms, which are to be shared by the collaborations appropriately, should be equipped in a manner that is as standardized as possible. That is, same or similar equipment should be used, accounting for small necessary changes due to room size, dimension, and usage, with the goal of:

- reducing initial purchasing and maintenance costs;
- simplifying usage and reducing user training.

While technical support and maintenance should be provided by the service, operator support could be provided for a fee, depending on the needs.

Rec 7	We recommend that the CTS extend current web casting and web archiving services to include all auditoria and meeting rooms in building 40, as well as those located elsewhere at CERN, commonly used by the LHC collaborations.

These services, as appropriate, will include

- fixed installations (in large auditoria, recording studio);
- a portable pool of equipment (for meeting rooms);
- recording and archival support, possibly on a pay-on-command basis.

It is expected that the necessary technical infrastructure, including web cast server hardware, streaming licenses, archive database and portal, be provided by CERN.

Rec 8	We recommend that the CTS take on the leading role in the development of a global Computer Supported Collaborative Work Environment for the LHC community.

Missing pieces of an LHC-wide collaborative work environment would be developed and integrated with existing systems, including video, phone and web conferencing, document sharing, and presentation archiving systems. Some additional features, particularly useful for the meeting environment, could include:

- meeting organization;
- global video and audio conferencing room booking system;
- meeting management;
- recording and archival of documents, presentations and sessions.

More generally, a particular effort will be targeted at defining and implementing an integrated environment that presents the various collaborative tools to the end user with a consistent user interface.

Rec 9	We recommend that the CTS support development to equip IP-based tools used by the LHC collaborations, such as VRVS, with a Grid certificate authentication and authorization mechanism.

This mechanism ought to be integrated with the existing infrastructure to provide the capability of single sign-on at a user's desktop for both the experiment analysis environment and the collaborative environment within which the physics analysis is performed.

9 Funding and Resources

9.1 Introduction

The mandate of the RTAG does not directly address the issue of funding for any future project based on its recommendations. The PEB requested only that the RTAG concentrate on summarizing the requirements of the LHC collaborations, examining potential solutions to those needs, and on providing recommendations on which of these solutions to pursue. It would be naïve, however, to pretend that funding is infinite or that it could be effectively ignored in constructing the recommendations. In fact, the need to find solutions that make efficient use of existing resources and which can satisfy the very broad financial spectrum of the participants and institutes making up the collaborations, is perhaps one of the most important driving forces behind the choices of recommendations.

9.2 Optimization of Long-Term, Overall Cost

It is difficult to quantify the effect of high-quality collaborative tools on the overall costs of an experiment. Calculations of potential savings due to reduced travel, for example, can be deceiving. Some collaborators might travel less due to their usage of phone and video conferencing facilities, but others might travel more, as the improved communication might deepen their involvement in central collaboration matters. It is clear, however, that participation increases as more and more people are able to collaborate and to contribute to the experiment, and this benefits the experiments significantly. In addition, the improvements to communication help to avoid costly errors during the construction and running of the experiment. We believe that any estimation of the costs of providing a Collaborative Tool Service for the LHC, at least as far as equipment and software are concerned, are small when compared with the potential savings that would be provided.

Regardless, it is still important that any service provided for the LHC, work in an economically efficient matter, keeping a focus on long-term, overall cost efficiency. It is our opinion that the emphasis ought to be on providing tools and services that are both easy to use and easy to maintain, thus minimizing the required manpower at CERN. For this to happen, there will need to be a balance between research and development, maintenance, and service provision. Eliminating the R & D sector, as has been the case at CERN over the past several years, is not a workable solution. Effort on R & D is necessary to develop tools specific to the needs of the LHC, to investigate trends in the private and public sectors that could be useful for future upgrades, and to monitor usage of the current facilities to provide corrections and improvements, as needed. Finally, an active R & D sector also provides a potential interface to activities outside of the LHC, such as initiatives by the European Union or other national or international entities, which might eventually provide additional resources.

9.3 Estimates of Initial Material Purchases

It is a challenging task to estimate the costs involved in implementing the recommendations of this document, without actually embarking on a detailed pricing survey. Factors contributing to the uncertainty include current rapid advancements of the technology, changing ground in the marketplace, and the ever-varying nature of our demands. In addition, the choices of technology are highly interdependent. Nevertheless, we make an attempt here to provide rough estimates in the form of cost ranges for several of the key infrastructure recommendations for CERN.

In the following tables, we give price range estimates for three common and essential hardware installations at CERN: video conference facilities for a small to medium-sized meeting room, additional facilities for an auditorium, and recording facilities for lecture and tutorial archiving. For the video conferencing facilities, the following basic criteria are assumed:

- Ability to use both VRVS and an H.323-based MCU, such as ECS;
- Integration with phone conferencing;
- Ability to transmit slide images simultaneous to video;
- No dedicated operator (operation by participants).

Table 9-1 presents estimates for equipping a small to medium-sized meeting room at CERN for phone and video conferencing.

Material for Small – Medium Video Conferencing Facility at CERN	Cost Range (kCHF)
H.323 Video Conferencing Unit	6.0 – 15.0
Phone Bridge	2.0 – 3.0
Slide Transmission Add-On (a la H.239)	2.0 – 3.0
Video Monitor (TV)	1.0 – 2.0
PC with Display, Peripherals	4.0 – 6.0
Document Projector with VGA Output	4.0 – 6.0
2 Projectors with Screens	6.0 – 10.0
Ceiling Microphones + 1 or 2 Standard Microphones	2.0 – 3.0
Carpeting, Curtains, Sound Tiles, Lights	2.0 – 8.0
Lights, Speakers	1.0 – 2.0
Wireless Transmitter, Ethernet Fanout, Plugs & Cables	0.5 – 1.0
Total Material Expenses	**30.5 – 59.0**

Table 9-1: Estimated material cost ranges for equipping a small – medium meeting room for phone and video conferencing at CERN. A typical example would be 40-R-D10.

Table 9-2 presents additional costs to equip an auditorium. These costs must be added to the totals from Table 9-1 to obtain the final cost.

Additional Material for Equipping an Auditorium at CERN	**Cost Range (kCHF)**
Audio Integration and Mixing System	6.0 – 20.0
Additional Speakers	1.0 – 2.0
Additional Lights	1.0 – 2.0
Additional Microphones	2.0 – 5.0
Additional Expenses for Projectors with Screens	5.0 – 20.0
Ceiling Microphones + 1 or 2 Standard Microphones	2.0 – 3.0
Additional Expenses for Carpeting, Curtains, Sound Tiles, Lights	5.0 – 15.0
Miscellaneous Expenses for Room Control Integration	5.0 – 20.0
Total Additional Material Expenses	**27.0 – 87.0**

Table 9-2: Estimated additional material cost ranges for equipping an auditorium for phone and video conferencing at CERN. A typical example would be 40-SS-D01.

For the lecture and tutorial recording and archiving facility, presented in Table 9-3, we assume these basic criteria:

- Ability to capture live lectures, during the course of a public presentation;
- Ability to capture private recording sessions in a studio;
- Archival of recordings using non-proprietary standards on a central server;
- Free CERN Web server access.

Material for Lecture Recording & Archiving Facility at CERN	**Cost Range (kCHF)**
Video Camera, Tripod, Accessories	3.0 – 10.0
Remote Presentation Microphones	0.5 – 1.5
Portable Audience (Wall or Ceiling) Microphones	0.5 – 2.0
Portable Light Units	0.2 – 1.0
Laptop, Peripherals for Remote Presentations	5.0 – 10.0
PC with Display, Peripherals, Encoding Capabilities	10.0 – 15.0
High Quality In-House Lighting for Studio	0.3 – 1.0
Carpeting, Curtains, Sound Tiles in Recording Studio	5.0 – 15.0
Lecture Database Storage and Server	25.0 – 50.0
Total Material Expenses	**49.5 – 101.0**

Table 9-3: Estimated material cost ranges for equipping a facility at CERN for lecture and tutorial recording and archiving. The table does not include costs to equip meeting rooms and auditoria for adequate lighting and sound. It is expected that several such facilities would be required to handle demand for simultaneous recording sessions. One potential location would be the CERN Training Centre (593).

From these tables, one can make a rough estimate of the initial material costs required to get all commonly used LHC meeting rooms equipped for phone and video conferencing and to set up initial lecture-recording facilities. In CERN Building 40, there are at least 4 small meeting rooms, 3 medium-sized meeting rooms, and 4 auditoria that could be equipped for phone and video conferencing. We estimate there are 6 other small to medium-sized meeting rooms and 3 more auditoria, commonly used by the LHC collaborations, that could be equipped (or re-equipped). In addition, we will assume the initial construction of 2 lecture-recording facilities, one at technical training, and one located near the main auditorium. Taking approximate median costs of 50 kCHF per meeting room, 100 kCHF per auditorium, and 60 kCHF per recording facility (only one database and server), leads to an initial total material cost of about 1.5 MCHF. To this one must add the cost of joining or creating an H.323 MCU service (perhaps 100-200 kCHF) and the human resource costs, including salaries, offices, computing facilities, and other overhead. Equipment costs in subsequent years will, of course, decrease, as installation gives way to maintenance and operations.

9.3.1 Prioritization

It is the firm belief of the RTAG that all of the equipment listed above is necessary and essential for the LHC collaborations to function effectively. The more quickly the equipment can be put into service, the more quickly the collaborations can improve communication and put an end to the current waste of resources (see Sect 9.6). If, however, it is deemed essential to phase in the installation of equipment, due to limited immediate resources, we recommend that priority be placed on properly and completely equipping fewer installations, rather than on partially equipping many installations.

9.4 Estimates of Human Resources

9.4.1 Rough Estimates

Installation of the material described above is essentially a one-time expense, followed by a certain level of maintenance, operation, and upgrade or replacement costs, as components age. The real persistent costs for the LHC collaborations and for CERN come in terms of human resources.

There are a variety of job profiles that will need to be filled to construct a well-coordinated and well-managed Collaborative Tool Service (CTS) for the LHC (Rec 1). These positions can come from a re-organization of existing CERN staff, new personnel, and/or in-kind contributions from the collaborations. In Table 9-4 we specify the most likely source of personnel, although flexibility will certainly be needed to account for availability of resources and qualified candidates. Responsibilities corresponding to the job titles are detailed in the paragraphs that follow.

Job Title	Profile	Source	FTE
Coordinator of the CTS	Senior Physicist or Engineer	CERN	1.0
Conferencing Facility Staff	Engineer or Technician	CERN	3.0
Lecture Archive Staff	Engineer or Technician	CERN	1.5
Camera Operators	Engineer or Technician	CERN	1.5
Software Development & Support	Software Engineers or Programmers	CERN/LHC	4.0
Collaboration Liaison (1 each)	Physicist	LHC	2.0
Total Personnel			**13.0**

Table 9-4: Estimated personnel required to install, maintain and operate a Collaborative Tool Service for the LHC. FTE (Full-Time Equivalent) represents the total resources, not necessarily the number of persons involved in the task. Sources labeled LHC refer to collaboration members.

It is important to note that a significant amount of the personnel listed in Table 9-4 already exist and, in some cases, are already performing the specified duties (camera operators, conference facility staff, software developers). As such, the total does not represent only new personnel. In addition, however, one should also consider this only as an estimate for current collaborative tool usage estimates. Usage could rapidly increase as we approach LHC startup and resources will be required to ramp up accordingly. Demand for conference support staff will differ dramatically, for example, if the average number of simultaneous meetings changes from 3-4 to 10-15.

9.4.2 Job Descriptions

The CTS Coordinator is a senior physicist or engineer who will oversee the planning and coordination of all aspects of the service. She/He is most likely a permanent member of the CERN Staff, providing a degree of stability throughout the long lifetime of the project. The CTS Coordinator will also be the point of contact for CERN participation in external projects and will represent CERN and the LHC in appropriate working groups, such as the RCWG.

The Conferencing Facility Staff are responsible for researching, testing and installing video and phone conferencing facilities with the appropriate electronic equipment, lighting and sound proofing materials. They maintain the equipment and repair, replace, or upgrade components as needed. They are on-call to assist and trouble shoot conference operations at CERN or remotely, on occasion. The staff might be asked to act as operators for important meetings or conferences.

The Lecture Archiving Staff installs and maintains facilities for recording and archiving web lectures either in studio or in one of the conference rooms. For events in the larger CERN auditoria, it is preferable for the video recording to be handled by the Camera Operators, as they are most familiar with the facilities and are trained for this function. However, the staff will handle the construction of synchronized lectures, the archival of these lectures in a database, and the web portal for access. Studio recordings, such as the recording of specialized tutorial sessions for CERN Training or for the LHC collaborations, will require reservation of the facility. The staff will be on hand to help set up equipment, train the presenter to make the recording, as necessary, and then to construct and publish the web archive.

The Camera Operators are essentially the trained staff already working for CERN in the auditoria, for recording or web casting. They will record or broadcast events on request and provide the media required by the Lecture Archive Staff to prepare web lectures. Additional operators might be required on occasion for special events, such as collaboration meetings or conferences. They should be reserved ahead of time and hired from sources external to CERN for the occasion.

The Software Development and Support Team is charged with providing and maintaining the software for all aspects of the LHC collaborative tool environment. This includes maintenance and support for existing conference systems, such as InDiCo, VRVS, and CRBS, as well as archival software for recorded lectures. Concerning development, the primary goal of this team will be the implementation of Rec 8, a global Computer Supported Collaborative Work Environment for the LHC community. This will include the integration of phone and video conferencing systems with meeting support systems, including reservation and agenda systems, presence detection, and Grid authentication, with a single user interface. This team will most likely be a mix of CERN Staff and developers from the collaborations and the LCG.

The Collaboration Liaison will act as a point of contact between a collaboration and the CTS. This individual or individuals will receive requests or suggestions from colleagues concerning conferencing equipment and lecture archiving opportunities, set priorities for the collaboration, and communicate requirements to the CTS Coordinator. She or he will most likely be a physicist or engineer participating on one of the experiments and dedicating a 25% effort toward collaborative tool support. A certain degree of expertise in collaborative tools will be required for the liaison, and they might be expected to provide a first line of trouble shooting for common problems. The Liaison will represent the experiment on an oversight committee that serves to develop and oversee the plans of the CTS Coordinator.

9.4.3 Reporting Lines

It is expected that details of the organizational structure of the CTS and of the reporting lines to LCG and CERN will be worked out by the PEB. Here, we provide some general comments and suggestions, mainly to clarify the expectations of the personnel.

It is expected that the CTS Coordinator is the project leader, responsible for the planning of resources for the Conferencing Facility Staff, Lecture Archive Staff, Camera Operators, and Software Development and Support Team. As such, members of these teams report on their activities to her/him. The Collaboration Liaisons operate independently from this structure, prioritizing the requirements of the collaborations and conveying them to the CTS Coordinator. An oversight board comprising representatives from the PEB, CERN-IT, CERN Training, and each of the LHC Collaborations will periodically review the status and plans of the CTS and help to set the overall priorities. Others, such as CERN Outreach or Users Office representatives, or external experts, might also be invited to join in the reviews.

9.5 Potential Funding Scenarios

As the host laboratory for the LHC and a major participant in the collaborations, it is recognized that most of the hardware installation, maintenance, operations, software development and support will take place at CERN. It is thus natural to expect CERN to play a leading role in the creation and maintenance of a Collaborative Tool Service for the LHC. In addition, CERN's guidance and leadership will be necessary to insure close coordination between efforts by the collaborations and to prevent wasteful replication of effort or the development of programs that run counter to the CERN site policy for networking and security. Finally, it should be noted that all CERN activities will naturally benefit directly from the facilities installed on site, not only those related to the LHC.

These considerations do not, however, imply that CERN must take on all costs and/or control all spending, even regarding facilities and support located at CERN. In fact, in many cases, some of these costs may be better shared by the LHC experiments in a pre-determined and equitable manner. Furthermore, we believe it would be of interest to all parties if certain services were provided on a pay-per-use basis. Examples of such activities could include: provision of technical operators for important video conferences (à la AccessGrid), private lecture-recording sessions for teachers on sabbatical, or the recording of day or weeklong workshops or plenary sessions. In these cases, reservations and a budget code would be required ahead of time, to arrange the service.

Finally, we would like to emphasize once more that the existence of a coherent and central Collaborative Tool Service will not only economize through cost efficiency and coherence, but will also provide a clear path for the coordination of activities between the LHC and other national or international activities in the field. Funding from entities, such as the European

Union, through the participation in projects of interest to the greater community should be continually investigated and considered in terms of the needs of the LHC.

9.6 Conclusion

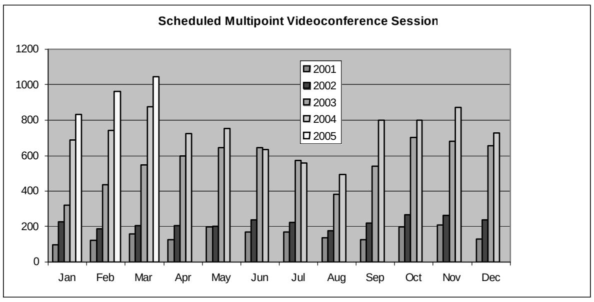
One cannot overstate the fact that the absence or inadequacy of high quality, robust and coherent collaborative tools at CERN and the other member institutes has been and continues to be very costly to the LHC collaborations. Quantification of these losses in terms of resources is nearly impossible to estimate, but one can consider some very concrete and familiar cases and then try to extrapolate.

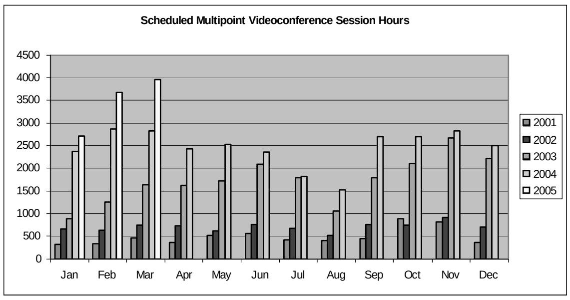
Imagine, for example, that during a typical meeting, there is an average down time of 10 minutes per hour, due to a combination of faults in the hardware, its configuration, its usage, and /or support infrastructure, such as the network. If an average of 200 members of each collaboration attends three hours of such meetings every week for a total of 45 weeks, approximately 4500 FTE-hours are lost per collaboration each year. In simplistic monetary terms, this is equivalent to throwing away the salaries of 2-3 scientists or engineers per experiment which, when summed over the LHC collaborations, represents a loss of several million CHF every year. Moreover, that number does not include the costly effects of the incomplete or incorrect communication resulting from such meetings, a critical factor as we enter the installation, commissioning and running phases of our detectors. Keeping this in mind, even the largest estimates provided in this section for equipping the required facilities at CERN are small in comparison.

Appendix I: Usage Statistics for VRVS

Schedule Statistics	Scheduled Multipoint Meetings											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	96	122	159	125	195	167	169	136	126	195	207	128
2002	226	187	203	205	202	235	222	175	220	266	264	238
2003	318	436	548	600	646	646	571	380	539	700	682	655
2004	690	743	875	723	751	634	557	493	800	800	871	729
2005	833	960	1045									

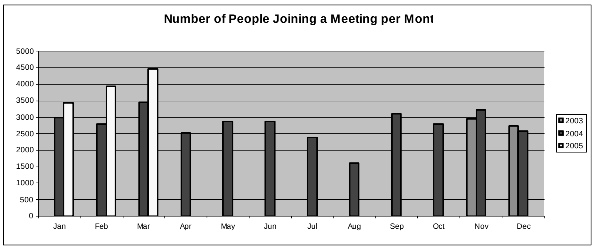
Schedule Statistics	Scheduled Multipoint Meetings Hours											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	320	337	463	361	514	552	419	410	441	896	816	360
2002	660	628	744	729	626	761	678	528	758	753	912	701
2003	896	1252	1642	1627	1728	2084	1785	1060	1790	2100	2672	2219
2004	2367	2865	2829	2426	2531	2362	1818	1523	2700	2700	2817	2508
2005	2711	3666	3950									

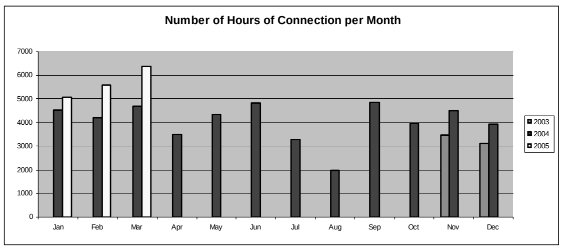




Schedule Statistics	Number of Participants Joining Sessions											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003											2951	2734
2004	2980	2797	3461	2519	2873	2863	2392	1608	3105	2795	3232	2590
2005	3439	3930	4474									

Schedule Statistics	Total Number of Hours Session											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003											3473	3114
2004	4540	4208	4703	3505	4342	4831	3289	1994	4863	3958	4507	3934



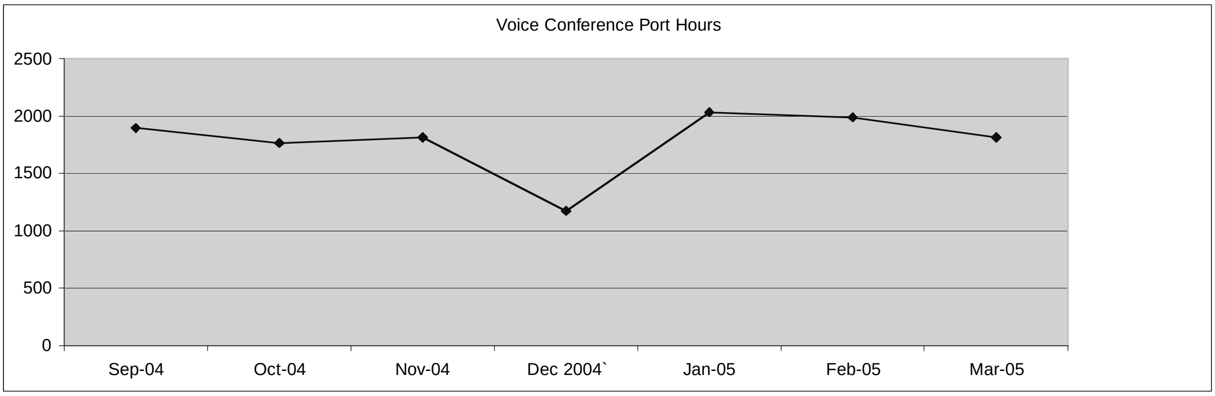


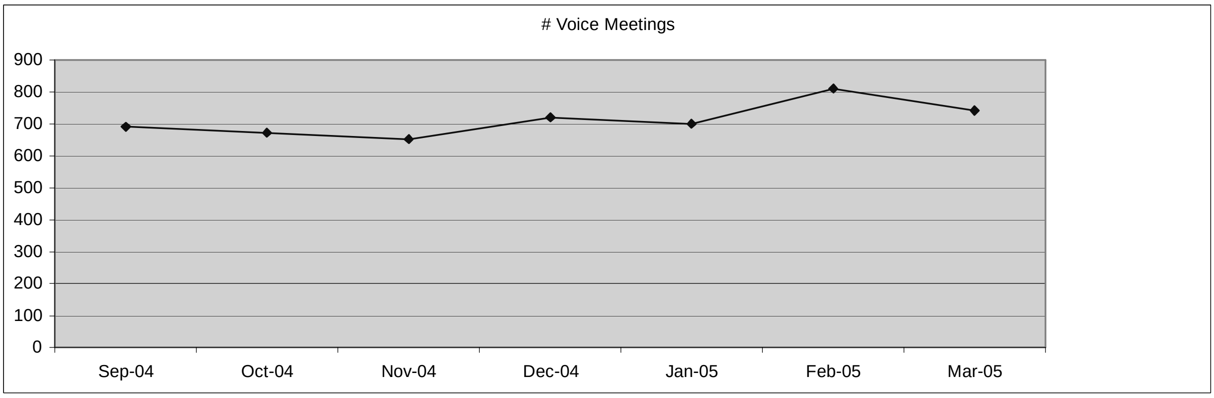
Statistics do not include users of Permanent Virtual Room.

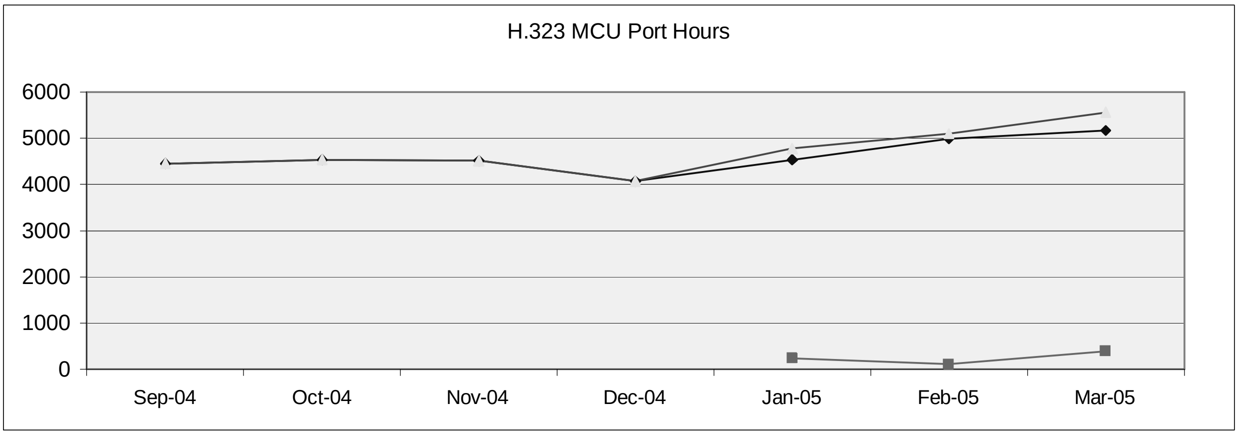
Statistics include non-LHC related activities.

Appendix II: Usage Statistics for ECS

	Pt-to-Pt Call Hours		Rad Port Hours	Codian	Total
Nov-03	19	Nov-03	602		602
Dec-03	28	Dec-03	587		587
Jan-04	14	Jan-04	824		824
Feb-04	1	Feb-04	2767		2767
Mar-04	0.1	Mar-04	2810		2810
Apr-04	344	Apr-04	3898		3898
May-04	417	May-04	3878		3878
Jun-04	482	Jun-04	4009		4009
Jul-04	401	Jul-04	4238		4238
Aug-04	374	Aug-04	4156		4156
Sep-04	522	Sep-04	4459		4459
Oct-04	527	Oct-04	4536		4536
Nov-04	552	Nov-04	4513		4513
Dec-04	381	Dec-04	4076		4076
Jan-05	330	Jan-05	4537	240	4777
Feb-05	352	Feb-05	4990	108	5098
Mar-05	460	Mar-05	5172	394	5566







Statistics include non-LHC related activities.

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See also EGEE http://egee-intranet.web.cern.ch/egee-intranet/gateway.html

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[5] RCWG (Remote Collaboration Working Group) http://www1.es.net/hypertext/committees/rcwg.html

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[8] ATLAS: A Toroidal LHC ApparatuS http://cern.ch/Atlas

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[14] AOL Instant Messenger http://www.aim.com/

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[16] Skype http://www.skype.com/

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[18] VRVS: The Virtual Room Videoconferencing System http://www.vrvs.org/

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[20] MCU Multipoint Control Unit see for instance http://commons.internet2.edu/mcus.html

[21] Microsoft Media Player http://www.microsoft.com/windows/windowsmedia/mp10/

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[25] CERN Audio Conference Service http://it-cs.web.cern.ch/it-cs/Audio_conference/emploi_ana.en.asp

[26] Polycom http://www.polycom.com

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[29] ANL Argonne National Laboratory http://www.anl.gov/

[30] Grid-enabled Analysis Environment http://ultralight.caltech.edu/gaeweb/

[31] ESnet Collaboration Service ECS http://www.ecs.es.net

[32] ESnet http://www.es.net/

[33] AUP Acceptable Use Policy http://www.ecs.es.net/ecs_reg/aup.htm

[34] ISDN Integrated Service Digital Network See http://en.wikipedia.org/wiki/ISDN

[35] Multi-Site Videoconferencing for the UK e-Science Programme http://www.nesc.ac.uk/technical_papers/VCReport_FINAL_Oct2.pdf.

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[41] JANET Videoconferencing Service (JVCS) http://www.jvcs.ja.net/

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[70] CHEP'04 http://cern.ch/chep2004/

[71] GridSite http://www.gridsite.org/

[72] Virtual Organization Membership Service http://cern.ch/hep-project-grid-scg/voms.html

[73] National Energy Research Scientific Computing Center http://www.nersc.gov

[74] RedIRIS http://www.rediris.es/

[75] RENATER http://www.renater.fr/Services/Visio/Index.htm

[76] iHEPCCC http://www.fnal.gov/directorate/icfa/Int'l_HEPCCC.html