Realising Inter-enterprise Remotely Synchronous Collaborative Design and Planning within Multi-platform Environment

Z. Deng, J. Pettersen, E. N. Jensen, B. Bang, and R. Davidrajuh
Narvik Institute of Technology, 8505 Narvik, Norway

Abstract

Enterprises are nowadays increasingly concerning with inter-enterprise collaboration. To obtain efficient inter-enterprise collaboration, one of the methodologies is to make use of Internet/Intranet communication and net-meeting technologies to support inter-enterprise remotely collaborative product design, production planning, manufacturing, supply-chain management, etc.

However, different enterprises often install different vendors' applications on different vendors' computing platforms. Thus, the collaborative net-meeting among enterprises has to be run in the multi-vendor and multi-platform environment.

For realising such kind of methodology, it is necessary to study: (1) how the inter-enterprise collaborative net-meeting can run in multi-platform environment, and (2) how the net-meeting can run much efficiently based on limited band-width capability of existing communication network. This paper has explored those two problems and the results are given.

1 Introduction

Manufacturing enterprises today are faced with challenges globally. These challenges cannot be effectively met by isolated effort within a single enterprise. Therefore, enterprises are nowadays increasingly concerning with *inter-enterprise collaboration*.

The architecture for inter-enterprise collaboration consists of a *communication layer*, a *collaboration layer*, and an *application layer* as shown in Figure 1 below[1].

The *communication layer* functions to enable multi-point inter-enterprise communication. Based on its support, the collaborative application tasks can be as follows (refer to upper part of Figure 1):

- Collaborative product design by means of computer aided design (CAD) *applications*,
- Collaborative process planning by means of computer aided process planning (CAPP) *applications*,
- Collaborative production planning and control (PP&C) by means of computer aided PP&C *applications*,
- Collaborative manufacturing by means of computer aided manufacturing (CAM) *applications*,
- Collaborative logistics management by means of computer aided logistics system (CALS) applications,
- Etc.

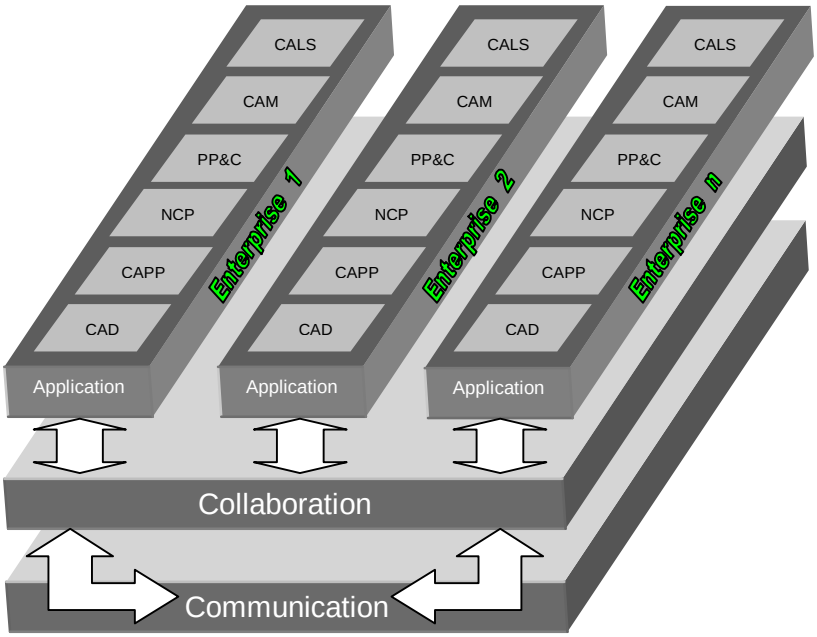

Figure 1 Three layers' architecture of inter-enterprise collaboration

To enable inter-enterprise collaborative tasks (design, planning, etc), we need not only the communication layer to provide multi-point communication service, but also the collaboration layer (shown in the middle of Figure 1) to provide multi-point collaboration tools to realise the collaboration within multi-vendor-product environment.

In practices, synchronous and asynchronous collaborations are encountered. *Synchronous collaboration* means that geographically dispersed partners are working in an *on-line* mode. They are working collaboratively at different locations but *at same time*. It is sometimes called a net-meeting or a net-conference. Thus, we *need tools to realise the synchronous multi-point collaboration.* By means of those tools, the partners can work together and exchange ideas via text chat or white board drawings and annotations on the screens, and share the applications (CAD, PP&C, etc) on the screens. Even more, they can make use of the multimedia means to see each other via video display on the screens, talk with each other via audio phones. *Asynchronous collaboration* means that the collaborative partners work in an *off-line* mode, i.e. the partners *do not work at the same time*[1]. This paper focuses only on the study of synchronous collaborations.

Often, different enterprises install different vendor's applications on different vendor's computing platforms such as PCs with Windows platform or with Macintosh OS platform; HP, SGI, SUN and DEC workstations with their various UNIX-like platforms. In reality, collaborative enterprises often work together in such a multi-vendor and multi-platform environment.

For the purpose of realising collaboration in the multi-platform environment, it is necessary to study: (1) how the inter-enterprise remotely synchronous collaboration (net-meeting) can be realised, and (2) how the net-meeting can run much efficiently based on limited band-width capability of existing communication network. Those problems will be studied in sections 2 and 3 of this paper respectively.

2 Realising Inter-enterprise Synchronous Collaborative Design and Planning in the Multi-platform Environment

2.1 Requirements for running an inter-enterprise net-meetings

Inter-enterprise collaboration possesses dynamically changeable feature. The individual enterprise in the collaboration is independent with each other. They are combined for a common product to market. Whenever market situation of the product has changed, the product must be changed, and the combination of enterprises should also be changed. Thus, it is not feasible to build up a dedicated communication network to permanently support a dynamically changeable inter-enterprise collaboration. Due to such kind of dynamic feature, reasonably, realising multi-point communication via the Internet/Intranet is the natural solution for the communication layer of the three layers' architecture (Figure 1).

As mentioned above, without the help of the collaboration layer of Figure 1, it is impossible to realise the multi-point inter-enterprise net-meetings within a multi-vendor and multi-platform environment. If an application is supported only multi-point communication service from the communication layer (Figure 1), users can only host a multi-point inter-enterprise conference only if every one in the net-meeting is using the exact same product. For example, if a user at enterprise *A* is running its CAD application on a HP workstation, and a collaborating user at distant enterprise *B*, who is running a PC, will be unable to see and participate in the design process at the enterprise *A* remotely, or say, unable to share the CAD application running at enterprise *A*. Thus, we need multi-vendor and multi-platform application sharing tool to realise the application sharing requirement.

In addition to the requirement of application sharing, furthermore in a net-meeting, naturally people want to exchange ideas by means of whiteboard drawings and annotations, to chat with each other by means of text, to exchange files by means of multi-point file transfer, to talk with each other by means of audio multimedia tool, to see each other by means of video multimedia tool. Thus, to run an inter-enterprise net-meeting, followings are basic requirements:

- Multi-point communication,
- Multi-point application sharing,
- Multi-point interoperable whiteboarding,
- Multi-point file transfer,
- Multi-point interoperable chat,
- Multi-point audio multimedia talking,
- Multi-point/multicast video multimedia seeing,

Where the first item, multi-point communication, is the task of communication layer of Figure 1; the other six items are the tasks of the collaboration layer of Figure 1.

2.2 Detailed architecture for inter-enterprise synchronous collaboration

From the discussion above, we can re-depict Figure 1 into a detailed one (Figure 2) where the multi-point communication service function is depicted in communication layer and the application sharing, whiteboarding, file transfer, chat, audio and video functions are depicted in collaboration layer.

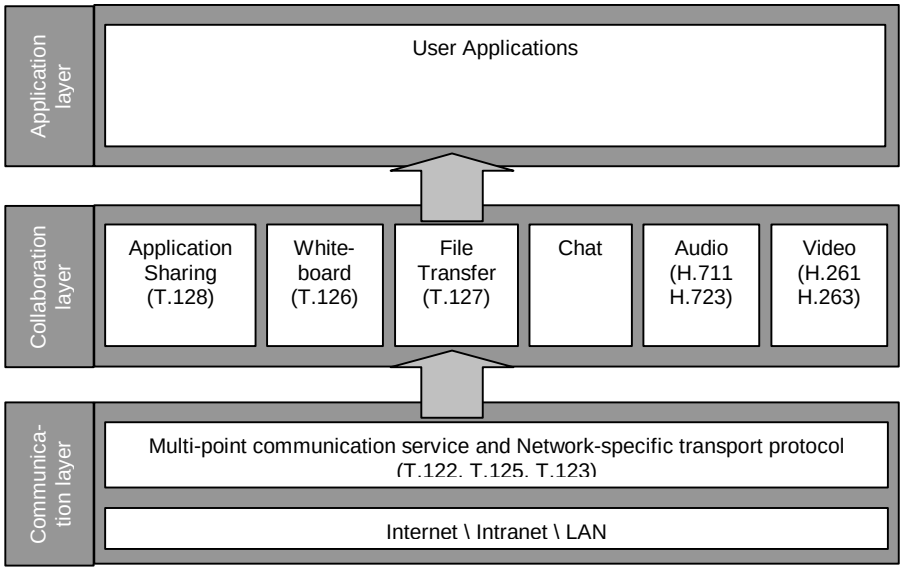

Figure 2 Detailed architecture of inter-enterprise collaboration

2.3 Necessity of standardisation and the T.120 and H.323 standards

As mentioned above, Inter-enterprise net-meeting involves in a multi-platform and multi-vendor environment. To realise such net-meetings, there are needs to standardise the protocols and services for the seven items, which are listed in section 2.1 and depicted in the communication layer and collaboration layer of Figure 2.

The International Telecommunication Union (ITU) has worked out the T.120 series standard in which its components of T.122, T.125 and T.123 define the multi-point communication service and the network-specific transport protocol (see lower part of Figure 2). As well, its components of T.128, T.126 and T.127 define the protocols and means for the application sharing, whiteboarding and file transfer respectively (see middle left of Figure 2)[2][3]. Also, the International Multimedia Teleconferencing Consortium (IMTC) has worked out the H.323 series standard in which its components H.261, H.263, H.711 and H.723 define the protocols for audio and video multimedia teleconferencing protocols (see middle right of Figure 2)[4].

If developers of net-meeting products, developed from multi-vendors and supported by multi-platform, implement those standards into their products, then we can realise inter-enterprise remotely synchronous collaboration upon those standard-implemented multi-vendor net-meeting products in the multi-platform environment.

Over 100 key international vendors, including Apple, AT&T, British Telecom, Cisco Systems, Intel, MCI, Microsoft and PictureTel have committed to implement T.120-based products and services[2]. In next section, we shall have a survey on the state-of-the-art of some leading net-meeting tools. From this survey, it will give us a hint of how we can establish the inter-enterprise synchronous collaborations within a multi-vendor and multi-platform environment.

2.4 State-of-the-art of some existing leading net-meeting tools

2.4.1 Microsoft NetMeeting

Microsoft NetMeeting runs on PCs with Windows 95, Windows 98 or Windows NT 4.0. Architecture components of Microsoft NetMeeting are implemented upon T.120 and H.323 standards (shown in Figure 3). Its capabilities include[5][6][7]:

- Application sharing/Collaboration (T.128 standard),
- Electronic whiteboarding (T.126 standard),

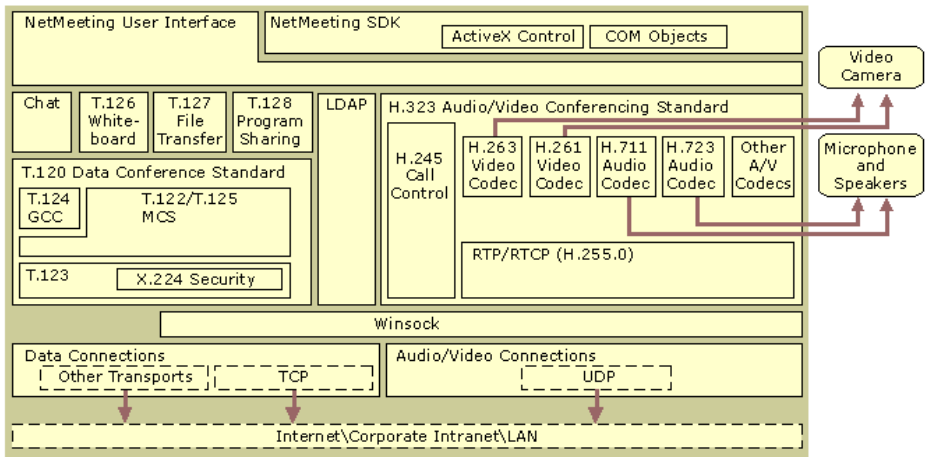

Figure 3 Architecture components of Microsoft NetMeeting

- Text-based chat,
- File transfer(T.127 standard),
- Audio & video capable (H.323 standard),
- Internet or intranet access,
- Multi-platform support.

2.4.2 HP VISUALIZE Conference

HP VISUALIZE Conference (HPVC) runs on HP VISUALIZE Workstations with only the HP-UX 10.20 ACE version is supported. It is implemented only with T.120 standard and does not support the H.323 standard. Its capabilities include[8][9]:

- Application sharing (T.128 standard),
- Whiteboarding (T.126 standard),
- Text-based chat,
- File transfer (T.127 standard).

2.4.3 SGImeeting

SGImeeting runs on SGI workstations with IRIX 6.5.2, 6.5.3 or 6.5.4. It is implemented upon T.120. Its capabilities include[10]:

- Application sharing (T.128 standard),
- Whiteboarding (T.126 standard),
- Text-based chat,
- File transfer (T.127 standard).

In addition, users can transmit video input to the whiteboard through live video capture. Sharing video input enables users to position a video camera on a factory floor and transmit a potential line problem to a remote user, enabling distributed problem solving.

2.4.4 SunForum

SunForum runs on SUN workstations with Solaris 2.6 and Solaris 7. It is implemented upon T.120 and H.323 standards. Its capabilities include[11]:

- Application sharing (T.128 standard),
- Whiteboarding (T.126 standard),
- Text-based chat,
- File transfer (T.127 standard),
- Audio and video conferencing (H.323 standard across standard TCP/IP networks).

2.4.5 DC-Share for UNIX

DC-Share for UNIX runs on UNIX workstation (Sun, SGI and HP). It is implemented upon T.120 and H.323 standards. Its capabilities include[12]:

- Application sharing (T.128 standard),
- Whiteboarding (T.126 standard),
- File transfer (T.127 standard),
- Text-based chat,
- Multipoint communications over TCP/IP,
- H.323 audio and video.

2.4.6 Timbuktu Conference

The Timbuktu Conference is a conferencing tool for Macintosh OS 8.0 or later. It is implemented upon T.120 standard. Its capabilities include[13]:

- Application sharing,
- Communications over TCP/IP.

Table 1 Summary of some existing leading net-meeting tools

	Microsoft NetMeeting	HP VISUALIZE Conference	SGImeeting	SunForum	DC-Share for UNIX	Timbuktu Conference
Application sharing (T.128)	X	X	X	X	X	X
Whiteboarding (T.126)	X	X	X	X	X	
File transfer (T.127)	X	X	X	X	X	
Text-based chat	X	X	X	X	X	
Audio \ video (H.323)	X			X	X	

2.4.7 Summary

Above surveys can be summarised and compared as shown in Table 1 where we find that Microsoft NetMeeting, SunForum and DC-Share for UNIX net-meeting tools can support all functions listed in Table 1 for multi-platform net-meetings. The HP VISUALIZE Conference and SGImeeting net-meeting tools can support most functions but without audio and video multimedia conferencing capabilities. As for the Timbuktu Conference net-meeting tool, it provides only multi-platform application sharing capability, but this is the most important capability for inter-enterprise synchronous collaboration.

2.5 An example of net-meeting in the multi-platform environment

Figure 4 gives an example of how the net-meetings can run upon the multi-platform environment. The screen shots shown in Figure 4 show a Windows NT system running NetMeeting 2.1 (on the left) and a UNIX system running DC-Share 2.1 (on the right) in a net-meeting[12].

The NetMeeting and DC-Share user interfaces are visible at the top right of the respective screens (Figure 4). The Windows user has shared Word (see bottom right of the left screen of Figure 4) into the net-meeting with the result that the UNIX user can view and control the shadow Word window (see bottom right of the right screen of Figure 4) as if it was running locally (even though it is actually running remotely on the hosting Windows system).

Microsoft NetMeeting 2.1 on Windows NT **DC-Share 2.1 on UNIX workstation**

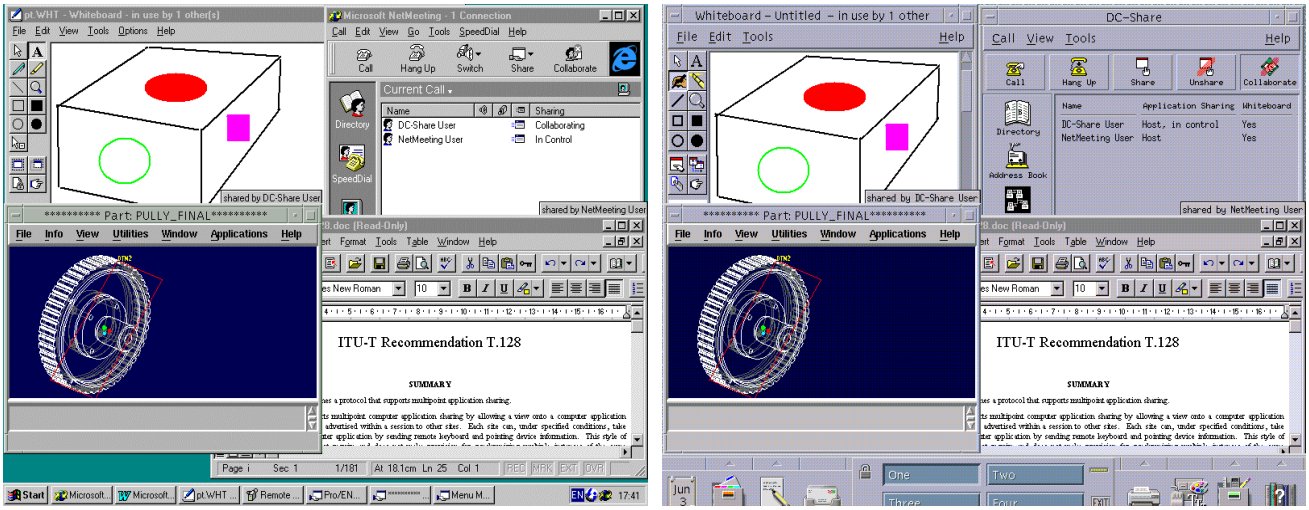

Figure 4 Example of net-meeting in the multi-platform environment

The UNIX user has shared CAD application, Pro/Engineer (see bottom left of right screen of Figure 4), into the net-meeting with the result that the Windows user can view and control the Pro/Engineer 3D model (see bottom left of right screen of Figure 4) as if it was running locally (even though it is actually running remotely on the hosting UNIX system).

The users have also started whiteboards and have loaded up a simple drawing with annotations (see top left of screens of Figure 4).

While the two screens are shown here side by side, in practice they might be very far apart (e.g. across the Atlantic), yet NetMeeting and DC-Share allow the users to collaborate irrespective of platform or location.

3 How to Run Net-meeting More Efficiently Based on Limited Bandwidth Capability of Existing Communication Network

3.1 Analysis on bandwidth requirement of various net-meeting functions

It is well known that the multimedia based net-meeting takes up a great amount of communication network bandwidth. This problem often remarkably delays the interaction among the multi-point net-meeting participants during the net-meeting, and makes the net-meeting's quality poor. In order to see the problem quantitatively, a calculation on bandwidth requirement of application sharing, video and audio conferencing functions are given below.

One experimental example is taken as calculation example shown in Figure 5[1]. The screen shots of Figure 5 show that two distantly collaborative product designers (the user of left screen and the user of right screen) are sharing the CAD application, ProEngineer, to design the part shown in the lower left of screens. They are using also the video and audio multimedia means to communicate with each other in the collaboration. By means of the video function and camera, they can see each other via movable photos as shown in the lower right of screens. By means of the audio function and microphones and speakers, they can talk with each other at the real time (see upper left of screens where microphone symbols and volume regulators are shown, and upper right of screens where speakers symbols and regulators are shown).

Thus, the calculation involves in the bandwidth requirements of CAD application sharing, video and audio multimedia communication.

3.1.1 Bandwidth requirement of CAD application sharing

Given following assumptions with respect to data requirements: a vertex is composed of 6 floating point values ((x, y, z) co-ordinate data and (nx, ny, nz) normal data) in a typical CAD application, primitives are composed of triangle strips of, on the average, seven triangles per strip (this strip contains 9 vertices which adds up to 54 floats as opposed to 126 floats for 7 individual triangles with 21 vertices)[14].

Assume that the CAD application sharing function transfers 30 triangle strips (i.e. 210 triangles) per second. Then, we get

54 floats/tri-strip = 1 620 floats/sec (30 tri-strips/sec) =
6 480 bytes/sec (4 bytes/float) =
51 840 bits/sec (8 bits/byte).

It means that for transferring 30 triangle strips per second, ***50 Kbps*** bandwidth is required.

3.1.2 Bandwidth requirement of video multimedia communication

Assume that the resolution of full screen is configured as 1024 pixels horizontal and 768 pixels vertical with 24 bits of colour palette. The size of full screen is 310 mm horizontal and 235 mm vertical. The size of each photo (lower right of screens in Figures 5) is 40 mm horizontal and 30 mm vertical. We use MPEG standard for motion video compression. Thus,

- Pixels for each photo (motion picture): [(40 x 30) / (310 x 235)] x (1024 x 768) = 12 954 pixels,
- Bits of data while using 24 bits of colour palette: 12 954 x 24 = 310 896 bits,
- Bit-rate for each motion picture at 25 frames per second, MPEG standard[15]: 310 896 x 25 = 7 772 400 bps (~7 772 Kbps),
- Bandwidth needed at compression rate, 130:1, MPEG standard[15]: 7 772 / 130 ˜ 60 Kbps,
- Then bandwidth needed for two movable pictures is ***120 Kbps***.

3.1.3 Bandwidth requirement of audio multimedia communication

Assume that the audio system is configured as stereo (2 channels and 44.1 KHz sampling rate). Thus, the necessity of communication bandwidth can be calculated as follows (herein, we use MUSICAM standard for stereo audio compression):

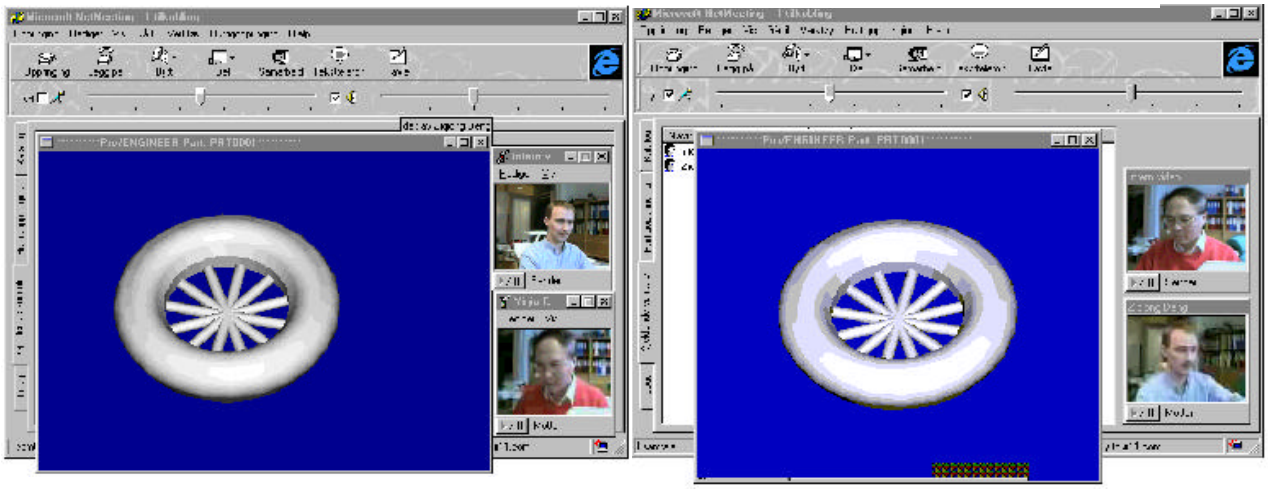

Figure 5 Collaborative product design with application sharing, audio and video functions

- Bit-rate of each channel while using 16 bits for each sampling: 44 100 x 16 = 705 600 bps,
- Bit-rate for 2 channels: 705 600 x 2 = 1 411 200 bps (1 411.2 Kbps),
- Then, bandwidth needed at compression rate, 7:1 (MUSICAM standard[15]): 1 411.2 / 7 ˜ ***200 Kbps***.

3.1.4 Summary

To summary, in the example above, the total bandwidth needed is ***370 Kbps*** (50 + 120 + 200). If we take the ***2 Mbps*** bandwidth capability of outlet line from our Institute

campus LAN to UNINETT (Norwegian university Internet) as example, collaborative design of Figure 5 has used up a rather large part of the line capability (18.5 %). Here we know why we often encounter remarkable delay in the video and audio conferencing.

3.2 Proposals on combination of existing net-meeting tools with telephone conference tool for efficient net-meeting

Notice that in the example of Figure 5, the size of the photo is so small as if a stamp. If we increase the size of photo three times of both width and height (i.e. 120 mm x 90 mm), then the total bandwidth needed will increase to 1.33 Mbps (50 + (120 x 9) + 200 = 1330 Kbps). Thus, 66.5 % capability of the outlet line of our Institute would be used by this example. Then, a terrible delay would make the net-meeting actually unable to be going on.

However, if we still use the small photo (40 x 30 mm) in the net-meeting, it is too small to well see each other. Using video you might want to look in the remote partners' eyes, but you can't, because the resolution is so poor you can't see their eyes. That isn't all. We have experienced, in best cases, the video have a one-second transmission delay. This makes a lot of confusion. Therefore, the small size of video is not quite helpful, but takes up a lot of bandwidth. So, one of our proposals is to shut down the video function while the net-meeting delay getting worse while a net-meeting is in the quick and large amount of inter-operation status. (At the beginning of a net-meeting, you may use it to introduce the participants each other to see whoever is attending.)

Audio communication is essential to ensure the net-meeting discussions. However, the audio multimedia communication also takes a lot of bandwidth and makes the application sharing to be delayed remarkably. So the other proposal we suggest is to use telephone meeting function in normal telephone system (e.g. ISDN telephone system) simultaneously with the net-meeting system. Thus, we can focally use bandwidth capability in the application sharing, whiteboarding, and test-based chat in case of limited bandwidth capability of the communication network.

4 Conclusions

This paper has explored of how to realise inter-enterprise remotely synchronous collaborative collaboration within multi-platform environment. After a survey of existing net-meeting standards and the state-of-the-art of some leading net-meeting tools, a conclusion is made that existing leading net-meeting tools are basically functioned at supporting the multi-platform inter-enterprise remote collaboration.

However, because of limited bandwidth capability of existing communication network, remarkable delay happens often in a net-meeting. Therefore, for efficient net-meeting, proposals on restrictive use of video and combinational use of net-meeting tools (T.120 based) with telephone conference tool are given by the authors.

For running net-meeting successfully, tool support is only one aspect, which we have discussed in this paper. However, you need also to well organise and manage the meeting process, and to pertinently use tools in different stage of the process. This is a organisation philosophy problem. The authors have done some preliminary research on this problem and further work will be done in the future.

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