The Art of Teleworking

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INTRODUCTION

There is a new class of workers out there—working from their homes nearly autonomously. Some call them teleworkers, some telecommuters. Armed with remote access to their organization's network, with toll-free numbers, VPN's and mobile phones, they escape traffic jams, bad weather, and high fuel prices, and are able to find the right balance between personal and professional life.

But when does teleworking really work? How can a teleworker be equally or even more productive than an employee in the office? This paper analyzes the teleworker's primary challenges and offers ideas for overcoming them. It highlights the advances of technology that make teleworking truly successful and of greater benefit to both teleworkers and their organizations.

BUSINESS DRIVERS FOR TELEWORKING

Why has teleworking become so attractive to millions of people? Organizations, especially enterprises, are trying to reduce costs in hard economic times, and that includes real estate costs. As a result of globalization, organizations are also becoming more distributed, and the actual locations of their employees or members is not as important as it once was. In fact, some government organizations mandate a certain number of employees to work remotely as part of the organization's recovery planning.

Individuals want to telework for variety of reasons. Some want to stay in their home town and work for the same company after the local company office has closed. Others work on a temporary basis for different companies, which makes physically moving to be near a company office impractical and unnecessary.

Internet Service Providers are also interested in teleworking; they want to increase the value of their Internet access service and sell premium broadband packages. For them, a teleworking solution is a good way to add value and capture a larger piece of the enterprise business.

THE KEY CHALLENGES OF TELEWORKING

Teleworking—variously referred to as telecommuting, e-commuting, e-work, telework, working at home (WAH), or working from home (WFH)—is a work arrangement in which employees enjoy flexibility in working location and hours. In other words, the daily physical commute to a central place of work is replaced by telecommunication links[1].

However, this is only the beginning of the story. Teleworking is not just an arrangement; it is a way of life. It requires changes in behavioral patterns that go beyond the usual. It also requires a lot of creativity to stay in touch with people inside and outside the organization. Most teleworkers have two lifelines to their organization—remote VPN access (for access to e-mail, calendar, and Intranet documents) and a telephone (for real-time communication). With no technical on-site support, a failure of even one of these lifelines leads to serious problems. Experienced teleworkers therefore prepare for the worst case scenario while all systems are working. For example, workers frequently:

- Add redundancy to their communication links
- Configure multiple VPN servers
- Make sure they get e-mail on their PDAs (in case VPN over Internet fails).
- Prepare for worst-case scenarios, such as a computer crash, due to a virus, bad configuration, or hardware failure by backing up data religiously and even keeping a backup computer in case something goes wrong with their primary one.

Distance

As a teleworker, you face several major challenges. First, obviously, is the distance between your colleagues. If your team is distributed around the globe—which frequently is the case today in large companies—teleworking is very natural. Even if you work in your organization's local office, you will meet a very small portion of the team and will already be using technology to connect to the others anyway. But sometimes you are a part of a project in which almost everyone is at a certain location and you are one of the few "remote participants" linked to the team by phone. The feeling of being disconnected is clearly there, especially when all team members are jumping into a heated discussion, interrupting each other, raising voices, referring to some drawing on a white board… It is astounding how easy it is for the participants in the main location to completely forget about the existence of remote participants.

Teleworking with a telephone feels like meeting everybody in the dark. It works well for one-on-one conversations, when you have certain background information about the person on the other side; this allows you to focus on the voice and capture emotions.

[1] http://en.wikipedia.org/wiki/Teleworking

Use of wideband audio[2] can improve the teleworking experience; however, audio-only connections fall short if you are talking to a large group of people who you have never had the chance to meet in person. Most of the time during the call, you just struggle to associate participants' voices with their names and roles in the organization.

Years ago, I was involved in such virtual meetings and it was a humbling experience. I ended up taking notes (meeting minutes) of everything I heard during the meeting, and subsequently asking colleagues in the main office to review the minutes and correct any misunderstandings. Even with highest level of concentration, I could not capture more than 70-80% of the content.

Fatigue

The second big issue for teleworkers is the fatigue from spending hours on the phone. Psychologists explain the fatigue with missing audio information: traditional telephones transmit only a small portion of the audio frequencies that we humans generate when speaking and a lot of speech sounds, for example, fricatives, can get lost in the transmission.[3] Teleworkers also miss the nonverbal communication (body language) and can leave the virtual meeting with a completely inaccurate impression about participants' reactions and their level of agreement with—or "buy-in"—concerning decisions or actions taken. This, in turn, may make the teleworkers appear to be lacking emotional intelligence and social skills.

Probably the least efficient and most strenuous form is teleworking over a mobile phone. While the quality of mobile phones today is sufficient for a call lasting several minutes, mobile phones are not designed for prolonged team meetings. Quality degradation and frequent disconnects lead to the need to reconnect and to repeat parts of the discussion, which decreases team efficiency and performance. Even if the wireless connection works well, mobile phones do not support wideband audio; in fact, they do not even support 'toll quality', that is, the quality of the Public Switched Telephone Network (PSTN). Finally, mobile phones rarely have good speaker phone capabilities and require a headset for use even in relatively quiet environments. While headsets are an acceptable solution for few calls a day, they do cause strain to the human ear when used for extended periods.

If traditional teleworking leads to deceased performance and exhausted team members, is there a "right" way to telework?

TELEWORKING OVER HD VIDEO AND HD VOICE

Recent advances in audio and especially in video technology have solved many of the issues listed above. The fatigue from missed audio information can be overcome by deploying wideband and super-wideband audio technologies, such as the ones available in the Polycom HD Voice portfolio. Conceptually, these new audio technologies allow for transmission of larger portions of the audio frequencies in the human voice, as well as natural sounds and even music. Much has been done to improve intelligibility of difficult sounds, such as fricatives in speech and transient sounds, for example, sounds that include jumps of the audio energy level. More information about the recent advances in audio technology can be found in "Music Performance and Instruction over High-Speed Networks," a Polycom white paper.[4]

Improved audio however does not solve some of the issues with nonverbal communication and a good deal of room for improvement remains. Can video fill the gap?

Video is vastly superior for removing distance and creating high-performance teams. It provides the context of communication that is missing in a voice call —as a participant, you are not meeting in the dark any longer and, more fully engaged, you not only better understand the team members' reactions, but also can play a more prominent role in meetings.

There are caveats. Old fashioned video conferencing at low quality (CIF resolution, for the more technically aware) does not provide the transparency necessary for meaningful team interaction. This can be felt immediately if the "other side" is a large room with, for example, a dozen people. A teleworker using CIF-quality video will not be able to recognize who in the room is talking, and may be able only to vaguely recognize the people close to the camera. The next quality level known as 4CIF is more appropriate for

[2] Wideband audio eliminates the bandwidth limitations of toll quality voice (audio frequencies from 300 to 3400 Hertz) and covers the range from 30 Hertz to 7000 Hertz or higher.

[3] White paper 'The Effect of Bandwidth on Speech Intelligibility', http://www.polycom.com/global/documents/whitepapers/effect_of_bandwidth_on_speech_intelligibility_2.pdf

[4] White paper 'Music Performance and Instruction over High-Speed Networks' http://www.polycom.com/global/documents/whitepapers/music_performance_and_instruction_over_highspeed_networks.pdf

teleworkers; the quality of a standard definition television is good enough for recognizing people in a fairly large room. High definition (HD) is obviously best for team interaction; however, it is rarely possible for the teleworker due to the network bandwidth limitations and limited throughput of legacy intermediaries—gateways, conferencing servers, and so on. However, this limitation is temporary and within a few years teleworking over HD video will become a viable alternative. Figure 11 in the network requirement section below provides more information about the different video formats.

We cannot over stress the importance of audio in visual communications. Higher video quality leads to greater user expectations regarding audio. True representation of the full acoustic spectrum (up to the coveted 20 kHz) and stereo are fast becoming a requirement. Fortunately, even the highest quality audio, such as ITU-T G.719,[5] requires far less bandwidth than high quality video, and can therefore be used by teleworkers with limited broadband access.

Another argument for deploying video in the teleworking environment is the inherent ability to share content using video equipment. Since video equipment handles content as just another audio-video channel, there are no limitations on the type of content that can be shared, and sharing the full gamut from static slides and spreadsheets to animation and video clips to full-length feature movies in HD quality are all possible. This technology is far superior to alternative methods of content sharing, which work well for static content but fail once the content "starts moving."

Finally, features such as Polycom People on Content™ technology allow the teleworker to apply any kind of background and truly look as a part of the organization. Because of its particular importance in the teleworking application, this feature will be discussed in detail below in this paper.

RECOMMENDATIONS FOR TELEWORKING OVER VIDEO

Even for experienced teleworkers, teleworking over video has its peculiarities and requires some guidance. This paper should be able to save you most—if not all—of the pain going through this learning process.

Teleworking with a phone—and especially with a mobile one—allows you to move around the house and work in every room. The appearance of your home office or even having a formal home office is not particularly important. Teleworking over video is very different because people will be looking into your home, maybe even in HD quality. It therefore requires more work preparing your home office: from selecting a room for a home office to setting up the best light to controlling the background.

Planning Your Home Office Space

Having a room dedicated for your work equipment—not only video, but also computer, printer, Wi-Fi router, and other office equipment—is always a good idea because it contains the electromagnetic sources in one part of the house and keeps the noise from early morning or late evening calls—which you will need to make at some point—away from the rest of your sleeping family.

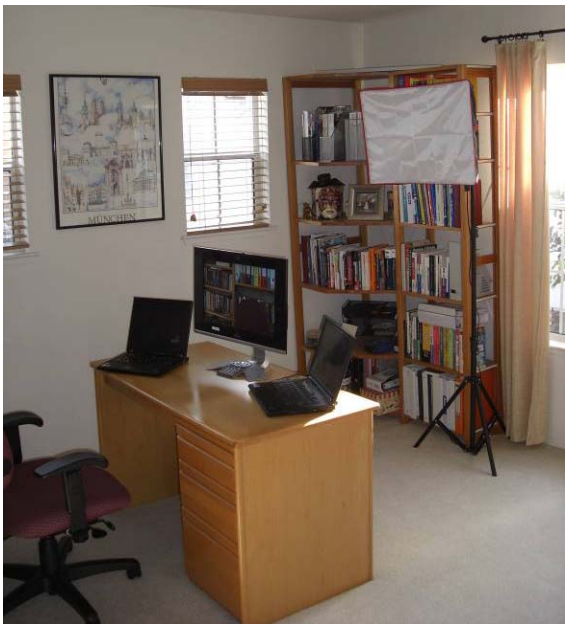

Figure 1 – Home office

Since light is very important for the video quality, the brightest room in your house is probably the best one for a video home office. Figure 1 is a picture of my home office. Although it was taken in mid-February, the four windows on two walls let sufficient light into the room, and the natural light is sufficient for using video during most of the day. You can also see a video tour of my home office on YouTube.[6]

[5] White paper 'G.719 – The First ITU-T Standard for Full-band Audio' http://www.polycom.com/global/documents/whitepapers/g719-the-first-itut-standard-for-full-band-audio.pdf

[6] http://www.youtube.com/watch?v=gTeH2bu-yOA

Natural versus Artificial Light

While light is important for writing and reading in general, it has an extremely strong impact on video quality. As with photography, light is the most important element of a high-quality video experience. If there is not enough light in the room, the video camera will pick up noise and you will appear grainy. Improving the light is the best way to improve the way you look on video.

Even in very well-lit rooms, the sun does not provide enough natural light in early morning and late evenings. This calls for use of artificial light; the photo in Figure 2 shows the lighting kit[7] that I use. The kit came with two bulbs, two soft boxes and two poles; I am currently using only half of it and am satisfied with the video quality results. Rooms with fewer or smaller windows may require a second light.

Figure 2 – Artificial light

Light is also very important for deployment of green screen technologies such as Polycom People On Content™. Sufficient light must be falling on the green screen itself to ensure the best background capturing, and this may require a second artificial light on the left or on the right side of the workstation.

[7] http://www.backdropsource.com/

Workstation Location and Background

Most people put their office desk in a room corner, and when they use video, the camera ends up looking at the opposite corner of the room. Therefore, when you call most teleworkers over video, they will have an entry or a closet door as background. The problems with this setup are that first, you should make your background best represent you and the company you work for so thought should be given to it, and second, you cannot always control who enters the room through the door. And unexpected interruptions by others—which can negate the professional impression you are trying to make—can be halted when it is clear to anyone opening the door that you are "in a meeting." I therefore strongly recommend a wall right behind your video workstation. I had to move my desk away from the window to achieve that. See Figure 3.

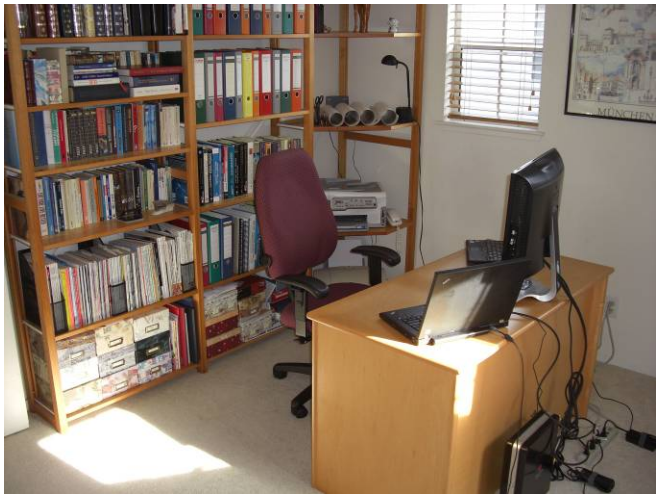

Figure 3 – Video workstation

Whether you are using a video endpoint, such as the Polycom HDX 4000 video system, or a software client, such as the Polycom CMA Desktop application, the video camera will show your background to remote participants; therefore, you have to make sure this background is exactly what you want the other people to see. I like having books around me and the shelves allow me to keep printer, phone, fax, and like tools, within reach. When you start spending several hours a day on video calls, you will appreciate the ability to print, scan, and fax while you are on camera.

But the background can be anything you want. You may want—or your organization may expect you—to put a large poster that includes your organization's logo as your background. If you are using the People On Content feature, your background is a green screen, and while it is possible to put up the green

screen on the two poles that come with the kit, attaching it to a solid wall make the setup more stable and saves space. My green screen is hanging from the bookcase, and it takes only few seconds to put it up and remove it.

People On Content

Green screen technology allows for more flexibility with regard to your background. The technology is widely used in broadcasting, in particular in the well-known weather announcer application, and was formerly available only in high-end broadcasting equipment. Polycom is the first vendor to bring this functionality into video endpoints, and make it available for everyone. The People On Content feature is supported in the entire Polycom HDX™ family of products.

Why is this feature so important to teleworkers? Few home offices are perfect. Not all homes have a room dedicated as a home office, and frequently a mixed-purpose room is used instead. People On Content allows teleworkers to fully control their background, look professional, and be seen by their colleagues as an integral part of the organization. The extra effort of setting the feature up translates into a much better teleworking experience and into improved interaction with your colleagues. For example, I use a picture from Paris when I talk to my colleagues in France and use a photograph of Singapore when I am on a video call with colleagues from the Polycom APAC headquarters in Singapore.

If you use video to communicate with partners and customers—as I do—the value of this feature is even greater. Based on the information you have about your customer or partner, you can select a background that fits the occasion. For example, Figure 4 shows the New York skyline I use as background when I am on a video call with our team or with customer in New York.

Figure 4 – People On Content

One interesting application for the People On Content feature is content sharing. I have given several presentations using this feature instead the alternative Polycom People+Content™ feature which requires a second monitor for displaying content at the remote side. If the remote side has only one monitor, using People On Content is often a better option than splitting the screen in two windows (one for live call and one for shared content).

The background in People On Content does not need be static; it can be an animation or a video clip. I use slow moving videos as background whenever appropriate. Fast movements however can be rather distracting in a conversation, unless you are showing a specific video to the remote side. Please keep in mind your own organization's standards for professional conduct when meeting with customers and partners. For example, organizations frequently ask their employees to represent the company in meetings by using a professionally designed and appropriately lit backdrop that displays their organization's logo.

Polycom People On Content technology continues to be improved. A glimpse into some possible future uses is provided in the Virtual Office video clip[8].

Your Video Wardrobe

Video technology has improved a lot and can display any color in high quality. For example, Polycom video endpoints differ from other products in the market in that they truly represent the colors of the original

[8] http://www.youtube.com/watch?v=yzZInI8FSoq

image instead of warming them up. However, some colors look better than others when using any video endpoint or soft client. In the office, you have little choice and must stick with the same clothes for the entire day, but one of the benefits of working from home is that you can test the color of your clothing, and if it does not look good on video, you can change it prior to the conference. Your video endpoint or soft client shows your own image when you are not on a live call and you will see what the remote side will see. If you are using the green screen, you should not wear anything green since the video system would not be able to distinguish between your clothing and the background; your body would “disappear." Blue clothing is acceptable, but white and red provide much better contrast and visibility in a green screen environment.

SELECTING YOUR VIDEO EQUIPMENT

Other than price, the key considerations when selecting the video equipment are the quality and features that you require, the space you have, and the number of cables you can tolerate.

Video Endpoints

Video endpoints such as the Polycom HDX system are specifically designed for video communication and provide the highest video quality (up to HD 1080p) and audio quality (up to 22 kHz, stereo). Since they operate independently from your computer, video endpoints are not susceptible to computer viruses, computer operation system crash, or computer hardware failure. This benefit is very important to teleworkers who—as noted above—are more vulnerable to technical issues, and value redundancy in communication systems. An additional bonus is the fast startup time of the video endpoint, which you will value if you are late for an early morning call.

On the downside, most video endpoints have separate cameras, microphones, speakers, and monitors, and therefore require numerous cables. Unless you are planning to remodel your home office to hide all cabling in the walls and mount monitors and cameras on walls, too, I recommend the using personal endpoints such as the Polycom HDX 4000 video system, shown in Figure 5. This endpoint integrates the camera, microphones and speakers into its 21" monitor and delivers a form factor that fits the ergonomics of a regular desk.

Figure 5 – Tabletop with Polycom HDX 4000

While other video endpoints require a remote control, the Polycom HDX 4000 system does not require one and can be operated through the integrated keypad. The HDX 4000 system can be used as a high-quality monitor for your computer and save space on your desk. It also delivers impressive sound quality which allows it to do double duty as a high-quality sound system.

Video Soft Clients

Video soft clients—such as the Polycom CMA Desktop™—are applications that run on a computer and therefore share the computer’s resources with other applications. Soft clients are less expensive and reuse hardware that a teleworker already has. Soft clients use the same VPN tunnel that other applications—e-mail, IM, Web—use, and do not therefore have problems with firewall traversal. Content sharing works very naturally with soft clients since the shared content in most cases originates from the same computer.

One general issue with soft clients is their less deterministic behavior and performance due to competition for resources with other computer applications. The Polycom CMA Desktop application therefore runs an evaluation of the computer hardware during installation and lists the functions that can be supported and disables those functions that cannot. Video soft clients are not created equal. Many soft clients are created for the consumer market and deliver lower quality audio and video that are really not acceptable for business communication. The Polycom CMA Desktop application leverages many of the technologies used in Polycom video endpoints to deliver a high-quality business-class user experience. Since soft clients rely on computer speakers and

microphones for the audio as well as on USB cameras for the video, the quality of these external components directly impacts the quality of the user experience.

Audio is a specific concern for video soft clients. USB camera manufacturers often include basic-quality microphones in their USB cameras. While better than the built-in microphones in most new laptop PCs, microphones in USB cameras generally do not provide a high quality audio input source. I would therefore recommend using the Polycom Communicator C100, a USB 'speakerphone' and that delivers HD Voice quality with excellent echo cancellation and full-duplex technology.

The inherent drawback of soft clients is the lack of redundancy: when the computer fails, the video client cannot be used.

PUTTING IT ALL TOGETHER

Since teleworkers cannot rely on on-site technical support, it is important to cover the installation of the Polycom HDX 4000 video system and CMA Desktop application in this paper.

Installing a Polycom HDX 4000 Video System

The Polycom HDX 4000 system consists of two units: the tabletop unit shown in Figure 5 and the codec box depicted in Figure 6. The codec includes powerful chips that compress and decompress video and audio; the resulting heat leads to the need for built-in cooling fans. The fans are very quiet—in fact, quieter than the fans in my laptop—and do not disturb a teleworker's creativity. For the fans to work efficiently, however, it is necessary to leave space around the HDX 4000 codec to allow free air flow. Hiding the codec in an enclosure could limit the air flow and lead to overheating and failure of the codec. Since I have space in my home office, I have installed the codec next to my desk, Figure 6; however, the codec location can be selected based on the design and ergonomics of your office.

Figure 6 – HDX 4000 codec

All components necessary for setting up the Polycom HDX 4000 system come in a single box. A black cable with yellow connectors is shipped with the HDX 4000 system and connects the codec with the tabletop unit. When plugged-in, the cable allows you to place the two units about 5.5 feet or 1.70 meters apart. Each unit has a separate power supply, so you need two power outlets for the HDX 4000 system.

The other two power supplies in Figure 6 run the two computers. One of these computers is used to generate static or moving images for the background of the People On Content feature, as well as for playing audio files into a video call. The thick black cable with black connectors in Figure 6 connects the codec's "Camera 2" port with the computer generating background images. The thin black audio cable in Figure 6 connects the codec with the device used to play back audio files. Since I often use People On Content with video clips that have audio tracks, I connected my codec's audio port to the computer used for People On Content background images.

The white LAN cable in Figure 6 connects the codec to the home broadband gateway. Using a home gateway reduces the number of connecting LAN and power cables in the home office because the gateway combines router, firewall/NAT, and cable (or xDSL) modem in one unit with a single power supply.

Another good way to cut the number of USB and power cables in your home office is by replacing your printer, scanner, copier, and fax machine with an all-in-one unit. Using Wi-Fi to connect this all-in-one unit with your computers helps you get rid of the LAN cables. However, I would not recommend connecting your video endpoint over a Wi-Fi network since this

would inject a lot of traffic into the home Wi-Fi network and introduce unnecessary delay and jitter.

Setting Up Polycom People On Content

The first step to using Polycom's green-screen technology, People On Content, is putting up a green screen behind your chair and making sure it covers the entire area seen by the video camera, Figure 7.

Figure 7 – Green screen

Use the HDX 4000 keypad to zoom in and out or move the entire tabletop unit until the green screen covers the entire viewing area of the camera, Figure 8.

Figure 8 – Tabletop with green screen

Next you must "train" the system to distinguish foreground (you and your chair) from the background (the green screen). You will need administrator access to the HDX 4000 system to accomplish that. Press the **Home** key on the HDX 4000 keypad and scroll to **System**, then **Admin Settings**. You will be prompted for an ID and password to enter the system. Use **admin** as the ID. If you are installing a new HDX 4000 system, the default admin password is the serial number which you will find on a sticker on the back of the codec. If you are not the first user of the video endpoint, ask the IT department for the room password configured for that video endpoint. (Note: The user password or conference password configured on that system will not give you the administrator access that you need to calibrate the camera for POC.)

When you enter the ID and password, use the dial pad to enter letters and numbers—similar to a mobile phone—or, for longer passwords with a lot of letters, you can press the **Keyboard** key (on the HDX 4000 keypad) and use the on-screen keyboard for entering letters while using the keypad to enter numbers. Once you realize that the letters are on the screen and the numbers on the keypad, entering the passwords is easy.

In the **Admin Settings** menu, select **General Settings** and then **Options** to verify that the People On Content feature is enabled on your system. This is a good opportunity to verify whether Polycom People+Content technology is also enabled; you can use it to share content with other participants using a separate content window. If the green checkmark is missing, you will need to go online to the Polycom Resource Center[9] Web page, log in, and use the serial number of your system to generate a key code, which you then enter in the **Options** menu.

Once the People On Content feature is enabled, go to **Admin Settings** > **Cameras** > **People On Content**. The foreground source should be Camera 1. This is the camera built into the tabletop unit, and connected to the codec via the thick black cable with the yellow connector. The background content source should be Camera 2. We connected the Camera 2 port to the computer generating the background image using the black cable with black connector.

The camera calibration for People On Content is in the second page of the menu. Because this calibration requires you to be at the HDX 4000, it is only available through the HDX on-screen menus and not available using the HDX 4000 Web-based management interface. The camera calibration screen will instruct you to frame the view and then prompts you to step out of the picture. You must also remove your chair if the camera can see its back; otherwise the calibration

[9] http://portal.polycom.com/portal_web/login.jsp

will fail. Pressing the **Select** key executes the calibration.

You can now activate the People On Content feature at any time. Make sure the content you want to use as background is running in **Full Screen** mode on the computer generating background; then press the **Options** key (HDX 4000 keypad), scroll and select **People On Content**. The result is shown in Figure 4.

While setting up People On Content requires some time and equipment, once you start using it you will realize how powerful this feature is. You will also start thinking in terms of pictures, videos, and other visuals that you want to use as your background during the conversation and this will have an impact on the way you take pictures and shoot video clips.

Installing CMA Desktop Application

If possible, install the USB camera first and the CMA Desktop application second; this will help connect the two. USB cameras come with a lot of additional software and selecting the default **Full/Complete** installation option means installing hundreds of megabytes of software for anything from video capture to Web cam applications. Use the **Custom** installation option and only pick the components that you need. Whether I install a camera or a printer, I try to install the bare-bone driver first, and see if it is enough for the device to operate—in the case of my web camera, the driver itself was more than 130MB.

The CMA Desktop application is designed for easy installation and updates. There is no installation CD and instead the software is downloaded from the CMA server itself. The only information you need is the URL of the server which comes in the format http://www.server.com/ or http://12.23.34.45/. This is very convenient and simple because the CMA Desktop application then registers and exchanges presence information with the same CMA server. Naturally, any future software updates are delivered from the same server. The application will check for new software versions every time it starts, and will prompt you to download and install an update if one is available.

A convenient feature when accessing the CMA server is its integration with Active Directory. This allows you to log on using your Windows network credentials—user name, domain, and password. When you log on for the first time, go to the **Downloads** menu and select **Polycom CMA Desktop** as in Figure 9.

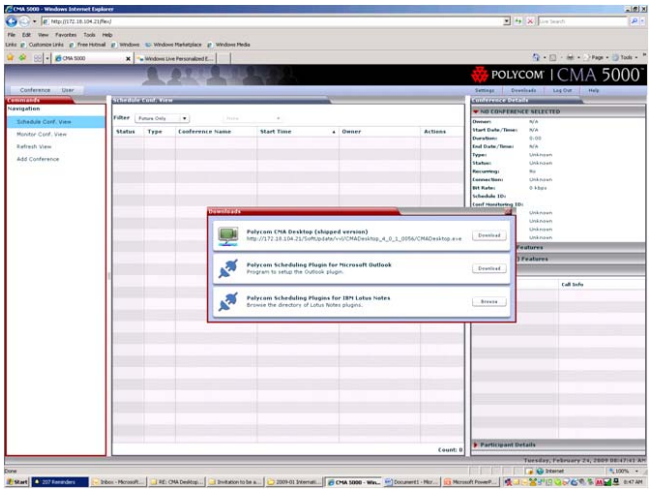

Figure 9 - Logging into CMA 5000

Download and installation on a Windows computer is fast and smooth; other operating systems will be supported in the future.

If you installed the CMA Desktop application first and then installed the USB video camera, it may take a while to pair the two. Restarting the computer may not help. I recommend physically disconnecting the camera and then connecting it again to a USB port of the computer. Windows should be then able to find the new camera driver, and an image should emerge in the CMA Desktop video window.

NETWORK REQUIREMENTS

All video equipment in this paper uses the IP network to set up and tear down calls and to transmit voice and video packets between the communication partners. This section will analyze the requirements for running a video teleworking application on the IP network, which extends from the home LAN and Wi-Fi networks to the broadband access network (cable, DSL, FTTH), the public Internet, and the organization's (corporate) LAN.

Network Diagram

The network configuration for teleworking includes the home office LAN, the organization's LAN and the Internet Service Provider's (ISP) networks connecting the two as illustrated in Figure 10.

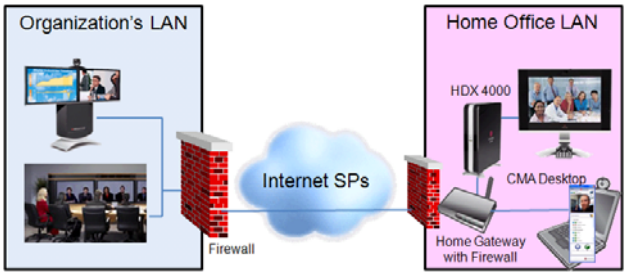

Figure 10 – Teleworking network diagram

The home gateway or router has LAN and Wi-Fi interfaces to support numerous wired and wireless IP devices. The HDX 4000 system connects via LAN while the CMA Desktop application runs on a computer that can be connected either via LAN or via Wi-Fi to the home gateway.

The home gateway includes Internet access technology such as cable or xDSL that it uses to send and receive IP packets from the ISP. Home routers usually do not have this access technology component and require an additional modem. This complicates the network configuration.

The home gateway (or modem or router) includes a firewall function that can be configured through the device's Web management interface. The firewall protects the home LAN from unauthorized access from the Internet. The firewall can be configured to allow specific traffic from the Internet into the home LAN.

The service provider(s) deliver IP packets between the home LAN and the organization's demarcation point (organization's firewall) using public IP addresses. For example, the home LAN may have an IP address 76.102.135.12 (assigned by the ISP and usually changed periodically) while the organization may have an IP address 140.242.26.241. The organization's LAN is behind the organizations' firewall.
The main challenge of any real-time communication, including voice and video is to traverse (that is, securely go through) the two firewalls depicted in Figure 10. This paper describes the methods for achieving that.

Bandwidth Requirements

Raw digital video is a bit stream of more than one gigabit per second. This bandwidth is rarely available in IP networks today, and video has to be compressed to somewhere around 1 megabit per second—a bandwidth that can be handled by most IP networks today.

Video compression technology has greatly improved over time and the current state-of-the-art compression standard H.264 allows High Definition (HD) video, Standard Definition (SD) video and low definition (CIF for Common Intermediate Format) video to be transmitted at relatively low bit rates. Figure 11 summarizes the bandwidth requirements for video.

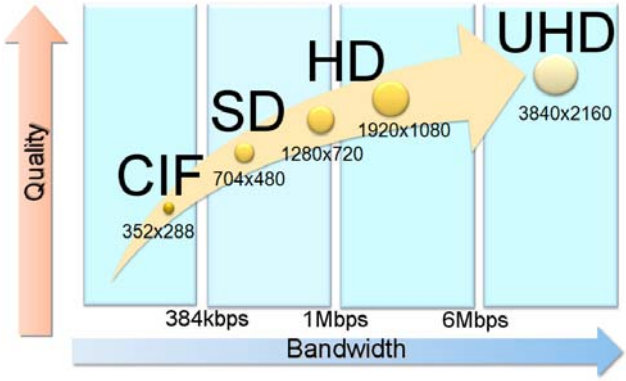

Figure 11 – Bandwidth Requirements for Video

SD calls from 512 to 768 kilobits per second are probably most realistic and practical for video teleworkers today. The bit rates fluctuate based on the amount of motion in the video and the advances of video compression technology keep pushing the minimum required bandwidth lower and lower. HD calls may be possible for parts of the day but should not be expected to always work. Video endpoints will automatically adjust the bit rate and the quality to deliver the best quality possible with the available network resource.

While the home LAN and the organization's LAN are less of a problem in most configurations, broadband access and the public Internet do create a bottleneck, especially upstream. Since broadband access networks are designed primarily for downloading content from the Internet, they are asymmetric. The downstream flow (from service provider to home) may be many megabits per second while the upstream flow (from home to service provider) may be limited to 512 kilobits per second[10]. Since video communication is bidirectional, the bandwidth shown in Figure 11 is required for both upstream and downstream.

Both the HDX 4000 video system and the Polycom CMA Desktop application support asymmetric

[10] Broadband IP access is sold by service providers as X megabits per second downstream and Y megabits per second upstream. While most consumers see this as a guaranteed amount of bandwidth, it should really be viewed as a 'guarantee not to exceed' bandwidth.

bandwidth. They can, for example, negotiate higher bit rate and higher quality downstream (the teleworker sees better quality video from the organization) and lower bit rate upstream (the people in the organization's network see lower quality video from the teleworker).

Premium broadband service (upstream maximum of 768 kilobits per second or higher) is recommended for video teleworking. Due to fluctuations in bandwidth, this allows SD and HD calls. Fast broadband (maximum 512 kilobits per second upstream) is sufficient for SD calls and provides a good teleworking experience. Lower speeds do not really work well for video teleworkers. Note that the IP protocol adds about 20 percent overhead and you will need 615 kilobits per second from your ISP to run video calls at 512 kilobits per second.

Packet Loss

IP networks lose packets by nature and this does not create a problem for applications that can afford retransmitting information. Real-time applications such as voice and video do not allow retransmission. In addition, video compression algorithms minimize the amount of traffic by sending only few full frames (images) and describing the difference between a full frame and subsequent frames. Therefore, losing an IP packet that contains a full frame has serious impact on the video quality for long period of time.

Packet loss is the single most important quality of service issue for video, and Polycom has addressed it by implementing its Lost Packet Recovery (LPR) algorithm in video endpoints, MCUs and other video network elements that process the video and audio media. Figure 12 shows an example of the quality improvement by using LPR when the IP network is losing 5 percent of the IP packets.

Figure 12 – LPR for Combating Packet Loss

The algorithm is adaptive and can address different rates of packet loss. It automatically adjusts the video quality (resolution and frame rate) to minimize packet loss and best utilize the available bandwidth.

LPR is supported in both Polycom video endpoints such as the HDX 4000 system, and in video soft clients, such as the CMA Desktop application.

Recommendations for LAN Configuration

Home networks are getting bigger as more LAN and Wi-Fi devices are connected—devices such as computers, video games, IPTV boxes, iPods Touch, IP phones, and now video endpoints. Newer home gateways and routers usually have 100 Mbps or higher speeds and are capable of handling the traffic. If your home gateway or router is old (more than 3 years) and/or if you suspect that it cannot handle video in addition to the other traffic on your home LAN, the best option is to replace the home gateway/router. In addition to better throughput, look for an all–in-one gateway to reduce cabling and power consumption.

Recommendations for WAN SP Selection

Selecting your broadband Internet Service Provider (ISP) is very critical for video teleworkers. If your home is far away from a central office, you will probably get relatively basic broadband via xDSL and would be better off using cable. Service providers such as AT&T and Verizon have started installing alternative broadband access networks in certain areas. Technologies such as Fiber To The Home (FTTH) promise higher speeds than DSL and cable can offer, and should be used if available. The only way to truly find out what speed you get from a service provider is to sign up and run some online speed measurement tool[11] at different times of the day and on different days of the week, and analyze the statistics.

This is critical because broadband access is a shared resource and depending on how many people in your community are online and how heavy their applications are, you may get higher or lower bandwidth. For example, I am using cable, and the speed is very high during the day but goes down in the late afternoon when my neighbors' children come home from school and start doing homework, playing interactive games, or downloading YouTube videos. The result is that I can place HD calls around lunchtime but can only connect at SD in the evening.

[11] I use http://www.dslreports.com/stest?flash=1

Video endpoints are very good at adjusting when bandwidth fluctuates, for example, a call that started as HD 720p at 1 megabits per second will automatically become a 4CIF (similar to SD) call if the available bandwidth goes down to 700 kilobits per second. A couple of minutes later, the bandwidth may become 1 megabit per second again and the endpoint will automatically adjust the quality back to HD 720p.

Firewall Traversal and Quality of Service (QOS)

Firewalls—and the Network Address Translation (NAT) function that usually is part of them—are designed to defend private networks such as home and organizations' networks from Internet intruders. There are usually two firewalls between a teleworker and a worker in the office: a home firewall which is integrated in the home router or home gateway, and a corporate firewall which is a larger usually stand-alone box that polices the traffic between the organization and the Internet.

Scenario 1: CMA Desktop Using VPN

The easiest way to traverse the firewall is by using Virtual Private Network (VPN). This solution has been around for a while and is well understood and managed by IT departments. The IT department installs VPN software on laptops (or the user goes to a public Web page to download the VPN client) and manages one or more VPN servers at different geographic locations. These are the doors to the organization's IP network for teleworkers and remote workers.

Once the teleworker sets up a VPN tunnel from his/her computer, all applications—e-mail, Web browser, and CMA Desktop—communicate through this tunnel to the organization's network, Figure 13.

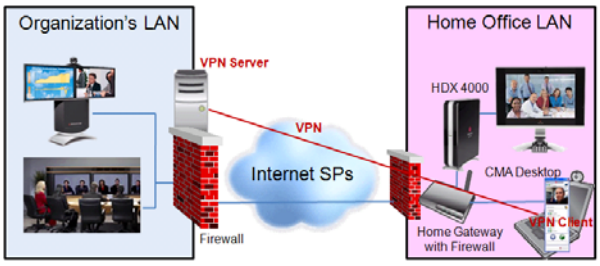

Figure 13 – Video teleworking over VPN

The Polycom CMA Desktop application can therefore connect to the CMA server and use its directory, software update capabilities, and presence information.

This scenario cannot guarantee end-to-end QOS for the video application (Polycom CMA Desktop). All traffic—video, audio, e-mail and Web—is in the same VPN pipe and is encrypted so that routers and gateways cannot distinguish the type of traffic. Once the VPN server decrypts the traffic and lets it in the organization's network, QOS mechanisms on the organization's LAN kick in.

Another drawback of this scenario is that the increased use of video over VPN can overwhelm the processor (CPU) of the router terminating the VPN on the Enterprise side (labeled VPN Server in Figure 13). The problem is that the VPN has to be handled by the router CPU and not by the fast-path Application-Specific Integrated Circuit (ASIC) chips. When more teleworkers start using video over VPN, the CPU—as a shared resource—can be overloaded.

Scenario 2: HDX and CMA Desktop Using H.460

The ITU-T standard H.460 defines a standard way for H.323 signaling and RTP media to traverse firewalls. The H.460 client function is supported in HDX (4000) video systems and in CMA Desktop application V4.1 or higher while Polycom VBP (Video Border Proxy) supports the H.460 server side, as shown in Figure 14.

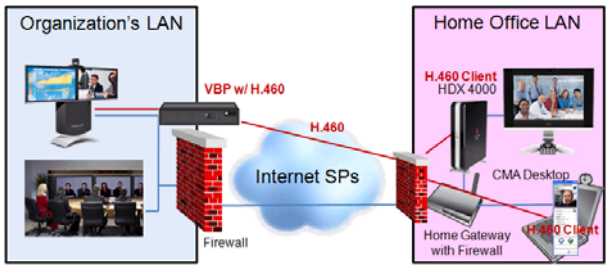

Figure 14 – Video teleworking over H.460

VBP will also support Transport Level Security for signaling security. HDX 4000 and Polycom CMA Desktop will therefore be able to not only place and receive calls but also access the organization's directory, exchange presence information, and get provisioning through firewalls.

This scenario cannot guarantee any QOS.

Scenario 3: Using Video Border Proxy at the Organization

While the H.460 solution above is very elegant, it is supported only in the VBP 5300 ST and 6400 ST models. If your organization uses another VBP model, for example, the VBP 4350, your Polycom HDX 4000

can be configured to use the VBP for outgoing calls while using a port forwarding configuration in the home gateway/router for incoming calls. Figure 15 shows the network configuration.

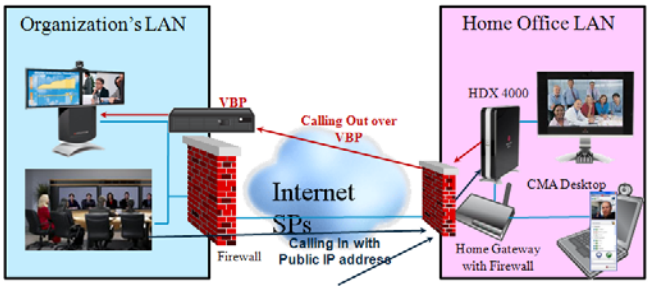

Figure 15 - Using VBP at the organization

I have been using this scenario for a while and it works well. For outgoing calls, I dial [IP address of the VBP]##[video extension] using the public IP address of the VBP at Polycom, or, as an example, 140.242.26.241##5230. I can call other organizations that have VBP by dialing their VBP's public IP address. Other VBP configurations support dialing in the format [video extension]@[IP address of the VBP] (for example, 5230@140.242.26.241) or in the format [video extension]@[DNS name of the VBP] (for instance, 5230@video.polycom.com).

The limitation of this approach is that I cannot access the corporate directory with all video users, and have to use e-mail or IM to find out their video extensions. Once you connect successfully, you can add the contact to the HDX 4000 local directory, and use it to dial in the future. Presence is not possible in this scenario.

For incoming calls, I assign a fixed internal IP address, e.g. 192.168.0.8, to my HDX 4000 and configured my home gateway to forward all IP packets carrying voice, video, and signaling to this IP address. More specifically, ports 1719 and 1720 are used by the H.323 signaling protocol and have to be forwarded as well as ports 3230 – 3254 which are used by the Real Time Protocol that carries the voice and video packets, as shown in Figure 16.

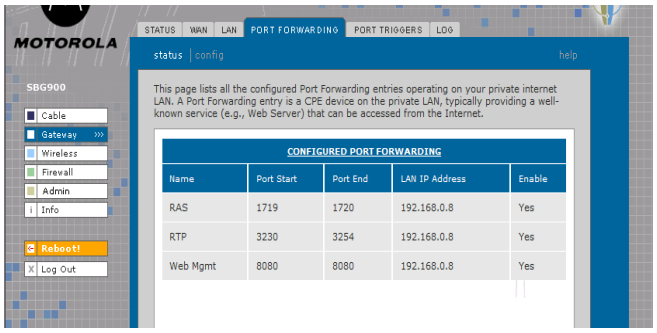

Figure 16 – Port forwarding setup in home gateway

The disadvantage of using port forwarding is that callers have to use the public IP address of the teleworker. One idea is to manually add this IP address and the teleworker's name into the video directory but service providers periodically change the public IP addresses (my ISP does that approximately once every 2 to 3 months), and does not give me notification about the change. A workaround is to periodically go to http://whatismyipaddress.com/ to check your public IP address.

Another configuration option is to identify the static IP address of the video system (HDX 4000) as being the De-Militarized Zone (DMZ) server; this causes all incoming traffic to be routed to the video unit. This is not a good solution for a software-based endpoint; only for an appliance. QOS is not guaranteed in this scenario.

Scenario 4: Using Video Border Proxy in a Home Office

In this scenario, a smaller version of the VBP—such as VBP 200 EW or VBP 4350—is placed in the home office and communicates with the VBP at the organization. There are several options for connecting VBP in the home office: it can be operated in parallel to the home router (Figure 17) or replace the home router.

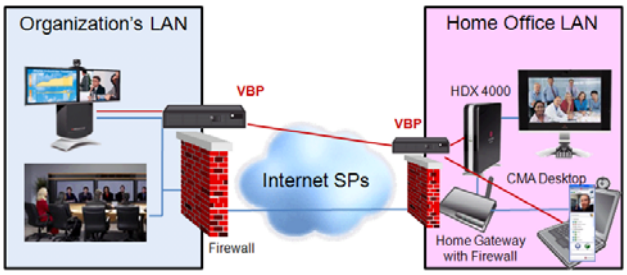

Figure 17 - VBP in home office

Routing calls across VBPs is very basic and can be based on prefixes. For example, you dial '1' in front of the number to reach the corporate video network of organization A, '2' to connect to organization B, and so on. This configuration also supports the dialing format 5230@video.polycom.com discussed in Scenario 3.

If you are looking for more control over the traffic between your home office and your organization, VBP in the home office is an excellent choice. It communicates with the VBP at the organization, detects the network conditions, tags all traffic and makes sure that video traffic gets higher priority than data. However, true QOS is only possible if the Internet Service Provider supports them, and end-to-end QOS is even more difficult if there are several service providers between the home office and the organization.

Scenario 5: Using Application Level Gateway

The scenarios described above are based on the use of the H.323 protocol. Video endpoints such as the HDX 4000 also support the SIP protocol and can connect to standards-compliant SIP servers. In this case, firewall traversal today requires a so-called Application Level Gateway (ALG) which behaves similarly to VBP. Most ALGs today are deployed in VoIP networks and can be used to support video calls as well. This scenario will become more important as more SIP video endpoints get deployed.

The ultimate solution for the firewall traversal problem will be the implementation of the new Interactive Connectivity Establishment (ICE) standard. ICE is in final stages of the standardization process at the Internet Engineering Task Force (IETF)[12].

CONCLUSION

Successful teleworking is about overcoming the distance between teleworker and organization and making the teleworker part of a high performance team. Recent advances of video technology have improved the quality of experience for teleworkers, and video now enables efficient collaboration between teleworkers and the rest of the team.

Video teleworking is first and foremost about home office setup and selecting the right set of technologies to meet the teleworker's requirements. Firewalls are still a substantial challenge but there are several viable approaches for firewall traversal that allow not only placing and receiving calls but also accessing directories and presence information as well as centralized management of teleworker systems.

Teleworking provides tangible benefits to organizations and users, and creates new opportunities for ISPs.

ABOUT THE AUTHOR

Stefan Karapetkov is Emerging Technologies Director at Polycom, Inc. where he focuses on the visual communications market and technology. He has MBA from Santa Clara University (USA) and an MS degree in Engineering from the University of Chemnitz (Germany). He has spent more than 13 years in product management, new technology development, and product definition. His blog is http://videonetworker.blogspot.com/.

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[12] The latest version of the Internet Draft is http://www.ietf.org/internet-drafts/draft-ietf-mmusic-ice-19.txt. Note that the version number can change.