

Is Video Finally Ready For Prime Time?

Joe Weinman

Bandwidth-hungry videoconferencing may finally be ready. What's on the program guide for the next few years?

Videoconferencing has had, at best, a checkered history. Almost half a century has passed since it was introduced by AT&T as the “PicturePhone” in 1964 at the World’s Fair. In that intervening time it has become, well, less than ubiquitous.

Over those 40+ years, videoconferencing rooms gradually came to be deployed by many enterprises attracted by the promise of travel cost reductions. However, in the simple equation of value divided by hassle, videoconferencing failed in both the numerator and denominator: Viewing a grainy image at some distance failed on the value side, since low-resolution images did not provide any compelling communication, collaboration or trust-building benefit over audio conferencing. And driving to a special room to use equipment that needed a live on-site technical support staff to set up video calls and overcome connectivity issues was hardly the model of convenience.

Today, however, videoconferencing has entered a revolutionary period. Systems from vendors such as Cisco, Polycom, LifeSize and Tandberg, and services from providers such as AT&T that leverage these systems into end-to-end services are redefining the nature of videoconferencing, creating an immersive experience that sustains the illusion that all participants are physically collocated. Specific technologies, such as spatial audio, where sound emanates from the on-screen location of the speaker instead of an indefinite location, help preserve that experience.

Early results are showing extremely high utilization, and, although these so-called “telepresence” systems and services are not inexpensive, payback can be extremely rapid, in terms of quantifiable travel cost reduction. But even more than a cost reduction play, these immersive telepresence

systems are becoming strategic: helping to drive revenue growth, build and support customer relationships, streamline today’s globalized and virtualized enterprises, accelerate decision-making, enhance collaboration, improve engineering designs and facilitate mergers and acquisitions.

There are a number of key considerations in selecting among various vendor and provider solutions—for example, features, total cost, usability and network concerns. In this article we will detail some of these considerations. In addition, we will predict how these services are likely to evolve over the next few years.

Perhaps more than any other service, immersive videoconferencing requires the highest quality endpoints and the highest performance network. A total solution also requires other elements such as installation, video concierge, maintenance and support services, but endpoints and the network are the most important building blocks.

Drivers And Enablers

Several forces are driving the accelerated interest in and adoption of immersive videoconferencing solutions. On the enabling side, essential technologies and services are now here. These include the rapidly declining prices of flat screen plasma and LCD displays, high-definition (HD) cameras, and processing components in codecs and bridges. Enterprise technologies used to trickle down to the consumer segment; now, the tables have been turned, with high quality, affordable consumer flat-screen HDTVs and video cameras driving expectations for the enterprise segment.

Second, converged network services such as AT&T’s global MPLS services have the reach, performance, quality, price points and cost effectiveness, through multiuse convergence with quality of service enabled by differentiated classes of service, to enable connections of these endpoints. Ancillary services that complete the ecosystem, such as video concierge, certification, installation and support, are also becoming available, typically bundled in as part of an entire solution.

A number of drivers are also pulling these enablers into use. One, no doubt, is the “coolness” factor. Many sales have been closed on sheer curb

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appeal of the solution. All it takes is one demo for senior executives to want one for their office suite.

But there is much more than glamour at work—there is also a compelling fit with many enterprise initiatives and mandates. For example, businesses are increasingly global: customers may be global, whether the product is soft drinks, coffee, fast food or automobiles and jet planes. Suppliers may be global, whether for engineering services or manufacturing. Or tasks may be outsourced to global providers, whether call centers, legal services or software development. Globalization is a double-edged sword, because increasing numbers of participants in markets also drives accelerated hyper-competition. This in turn is driving a requirement for enhanced collaboration and interaction—with customers, suppliers and partners that may be located virtually anywhere—to accelerate decision-making and drive collaborative results in Internet time. And, in the face of this, CIOs are being asked to cut capital expenditures and operating expenses while delivering the same or enhanced results and service levels.

Into this mix, immersive videoconferencing has the appeal of increasing global collaboration while reducing costs.

Consider a typical high-end room, let's assume

it is \$300,000. This is the list price of some complete rooms on the market, including screens, cameras, codecs, even furniture. Some rooms will go into existing space, and, of course, one could construct new or renovate at additional location- and contractor-dependent charges. If we assume a five-year life and zero residual, that works out to about \$5,000 a month in straight-line depreciation. One can add to that a few thousand dollars in network services. Allocating an exact amount for connectivity depends partly on the location for deployment, and also whether one is getting the pricing benefit of converged network services.

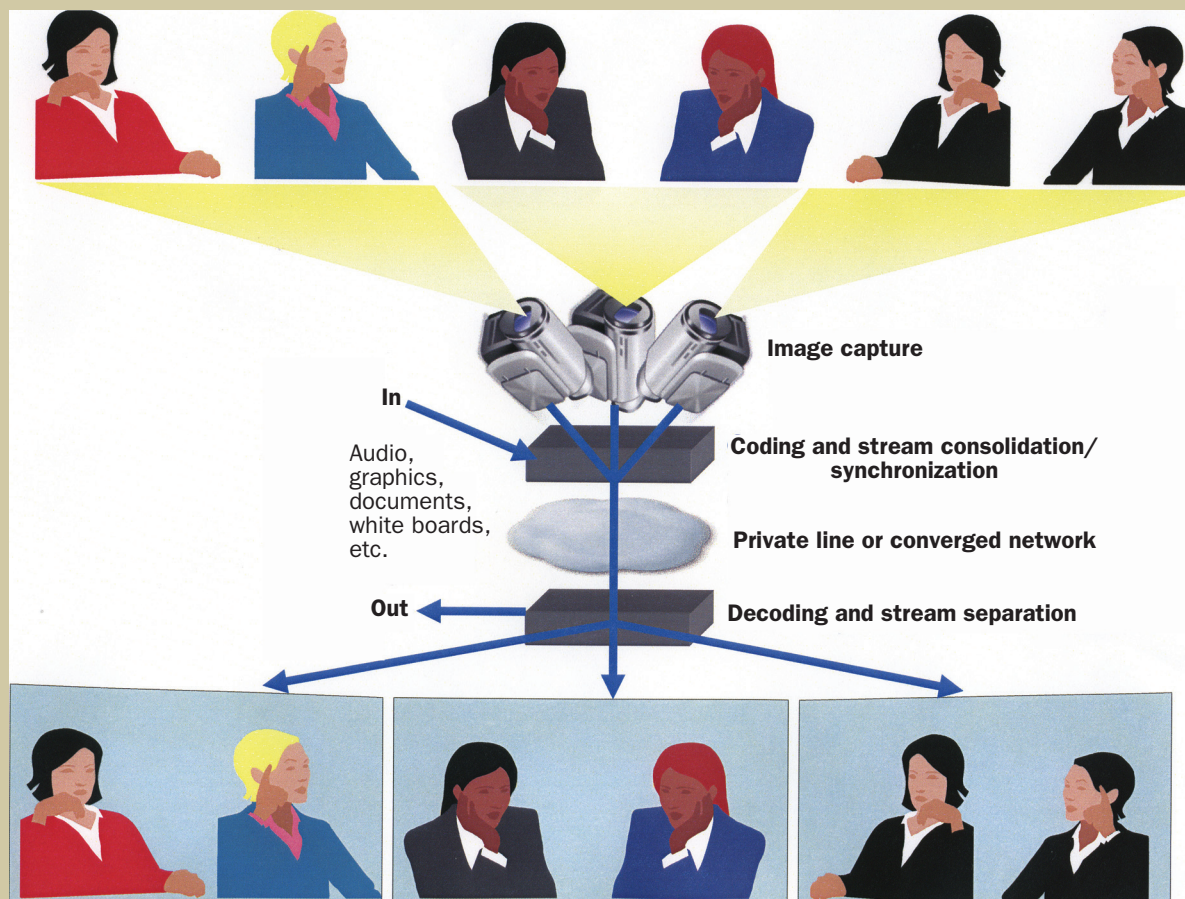
For example, if only a third of the bandwidth of an access link is being used, it would be proper to allocate one-third of its cost to the videoconferencing application—but only if the other two-thirds of the bandwidth is being used for other applications. But let's assume a worst case where the line is dedicated, and add in some other expenses like real estate, cost of capital, amortized one-time installation costs, power for lighting, maintenance and so forth. That might work out to \$12,000 to \$15,000 per room per month, or \$24,000 to \$30,000 per pair of rooms.

That may sound expensive, but consider the costs being avoided. For one person to go on a trip



Avoiding a single round-trip flight from New York to Hong Kong could save \$15,000

FIGURE 1 Sample Telepresence Meeting



from New York to Hong Kong business class might cost, in itself \$12,000 to \$15,000—just for airfare! That does not include other hard costs, such as hotel room, limos, rental cars and meals. But add in other easily quantified costs, such as pro rata loaded salary for the individual, then consider other qualitative costs such as loss of productivity—packing and unpacking, waiting in the security line, on the plane or as they try to recover from jet lag—and increased risk, whether due to terrorism or avian flu. And this is for one individual: Multiply whatever number you calculate by the number of participants.

And that's just for a single meeting. In fact, two telepresence endpoints can be used for hundreds of meetings each month: 4 40-hour weeks equates to 160 one-hour meetings, but actually, meeting rooms in practice turn out to be used not just 9 to 5, but also in early mornings and after hours, especially for global meetings.

And even if travel savings were ignored, there are many additional benefits, including accelerated decision-making, enhanced collaboration, improved work results, employee/family satisfaction, carbon reduction and so forth.

Endpoint Quality Is Key

Achieving these benefits was difficult with traditional videoconferencing systems, because these systems couldn't truly re-create the face-to-face experience, so in practice they tended not to be used as a substitute for corporate travel. Today's systems, however, are much more likely to create the collaborative environment that can actually serve to replace face-to-face meetings. However, to achieve this requires the highest-quality endpoints and the highest-quality network.

A system such as Cisco TelePresence is a great example. A fully configured room includes three screens, each of which is a 65-inch diagonal plasma display with 1080p resolution. This provides enough width across the three screens to easily display six people (two per screen) in life size. A high-level schematic of the architecture to virtually transport six people across distance is shown in Figure 1. (A real solution would take two such half-duplex transmissions). Viewed from several feet away, across the narrow dimension of an oval conference table, the resolution is so great that the people displayed on the plasma screens appear to be there in the room. Subliminal factors, such as consistent room colors, lighting, and the exact shape of the conference table have been engineered to preserve that illusion.

Some vendors, such as Cisco, use displays with a cinematic letterbox (16:9) format. These are par-

ticularly well suited to meetings where participants are seated at conference tables, and human perception has evolved to prefer horizontal panoramas. Some vendors, such as Polycom, also offer multiscreen displays built out of more traditional 4:3 aspect ratio displays. In this instance, the assembled screens provide a panorama, and the additional screen height enables participants who are standing or in multiple tiers of rows to be viewed as well.

Behind the scenes, cameras, codecs, and auxiliary equipment such as microphones, speakers, voice over IP (VOIP) phones, and graphics displays support multimedia viewing.

Network Performance Is Essential

Studies have shown that delays of less than 200 to 250 milliseconds are essentially imperceptible during conversation. Delays longer than that would result in gaps in an interactive conversation. Such gaps would create unnatural delays such as

are found in satellite-based video reporting from overseas, where the anchor asks a question and the reporter appears to stare blankly at the viewing audience for a second or two before answering.

This short time budget is rapidly used up by factors other than the network. At 30 frames per second, it takes 33.3 milliseconds to capture a frame on the originating end, some time to encode (just how much time depends on the codec), and then on the receiving end, some time to decode, and finally 33.3 milliseconds to display a frame. So 70 to 100 milliseconds, or roughly one half to one third of the time budget is consumed before the network even comes into play. The relatively small remaining time budget drives requirements for low-latency packet queuing and transmission and therefore a high-performing class of service, as well as stringent jitter (variation in delay) constraints, since jitter buffers must be kept very small or they will add to the latency.

Besides propagation delay in the network, other characteristics of video over IP transmission are subtly different than voice over IP. The human ear, or more precisely, the human auditory cortex in the brain, has the ability to fill in many missing elements in a voice transmission. Consequently, voice over IP quality tends to be relatively robust against packet loss. Packet loss in video over IP, on the other hand, may create noticeable artifacts on a screen. These may include freezes, pixilation, and other highly visible issues. And, since, like audio-conferencing, videoconferencing is a real-time service, packet retransmission is not useful, since the video frame will already have been dis-

Much of the delay budget is used up before the network is even taken into account

played to participants. Some forward error correction is possible, but at the expense of increased bandwidth requirements. Also, not all packets are alike: Those with key frame information can cause more noticeable artifacts when dropped. Therefore, packet loss requirements are fairly stringent, e.g., below 1 packet of every 2,000.

In other words, the goal of preserving a top-quality experience does not afford the network the luxury of congestion, lost packets or out-of-order delivery. And bandwidth requirements are not trivial. Depending on the vendor, resolution (standard definition, 720p; or 1080p), selection of interleaved or progressive scan, frame rate and color depth, bandwidth requirements can be 1 Mbps, 1.5 Mbps, 2 Mbps or 3.5 Mbps, peaking up to 5 Mbps—per screen! A multiscreen system therefore may need up to 15 to 20 Mbps of bandwidth.

Network Architecture Considerations

While one could do an immersive videoconference within a building, the value increases as other participants are across town, in another state, or, in today's global economy, intercontinental. In fact, the value is probably superlinear as a function of distance—the value from avoiding a 12,000 mile trip may be more than twice that of avoiding a 6,000 mile trip, what with airline costs, jet lag, security issues, travel delays, overnight stay requirements, etc.

Consequently, a balance is required between longer separation distances creating more value for conference participants, but shorter distances being better for network latency and cost.

One approach is to use dedicated private lines for connecting videoconferencing rooms. However, this can be cost prohibitive. One vendor/service provider that manufactures rooms as well as providing video services, dedicates a DS3 to each video endpoint. At any given point in video codec evolution, lower bandwidth requirements may reduce network expenses, but at the expense of video quality. If only 15 Mbps are used, though, that means that two thirds of the DS3, or even more of a 50-Mbps Metro Ethernet service are wasted.

Consequently, converged network services leveraging Multi-Protocol Label Switching (MPLS) services would appear to be ideal—as long as they meet the stringent latency, jitter and packet loss requirements.

AT&T has conducted extensive domestic and international testing—in the lab with simulated links and traffic load injection, over live production networks, and with early international customer deployments. Results show that immersive

videoconferencing and MPLS are a perfect fit. The highest class of service, with guaranteed low latency queues, is perfect for voice over IP, with its smaller packet sizes. A second class of service, for multiscreen HD video over IP, meets the stringent latency and packet loss requirements. Third and lower classes of service can then be used, variously, for corporate applications, streaming video, file transfer, etc. And a 45 Mbps or 50 Mbps access pipe can then be fully utilized.

For example, 18 Mbps of voice over IP in CoS 1 can co-exist with 15 Mbps of video in CoS 2 and another 12 - 17 or so Mbps of lower classes of service traffic. The VOIP traffic does not cause issues for video, the video does not interfere with VOIP, and lower priority services with less stringent requirements should be transported just fine. However, the extreme demands that telepresence traffic can place on the network mean that the complex interplay of distances, traffic patterns, packet sizes, packet loss, jitter and routing can sometimes require network performance assessments and professional engineering.

**Flexible bandwidth
will be more economical
than dedicated lines**

Evolution

How are immersive services evolving? In many different dimensions:

■ **Point-to-Point → Multi-point:** The early systems were point-to-point. In other words, only two locations could talk to each other at a given time. All the major vendors have since come out with variations for getting multiple endpoints to be able to converse by leveraging privately-deployed premises-based or service provider cloud-based multipoint conference bridges...now becoming either 720p or 1080p capable.

In one variation, the site with the current or most recent active speaker is displayed. In another, screens are switched between active speakers. In yet another, images are shrunk down—through digital processing or electro-mechanically reconfigurable cameras—to enable a greater number of people to appear on each screen.

While two points can connect to each other across a “dumb” (but high performance and capacity) network, efficiently connecting multiple endpoints requires a multipoint conference bridge. Such a bridge can handle the interconnection switching, but also will be called upon to provide additional functions over time, such as transcoding, protocol conversion and trans-rating (for example, from 30 frames per second to 10). While point-to-point solutions alone provided value, multipoint solutions greatly enhance flexibility and expand the variety of usage scenarios.

Big screens are great, but users will also demand the convenience of portable video

■ **Private Line → MPLS:** Some early implementations and some providers use dedicated private line connections to connect their immersive video-conferencing rooms. However, as mentioned above, MPLS services such as AT&T VPN (AVPN) offer many advantages, since MPLS offers the opportunity to converge various types of traffic, such as voice over IP, video over IP, HTTP/Web, and file transfer, while guaranteeing the right quality of service for each type of traffic. This convergence, in turn enables sharing of bandwidth and other network resources, which reduces the cost to carry the traffic.

■ **Intranet → Extranet → Internet:** Initial solutions are architected for use within a company, either on a private line or MPLS VPN network. Of course, users will want to converse not just with other employees of the same firm, but with employees of other firms as well. This typically requires an extranet architecture, using session border controllers, as have become available from a variety of the video solution vendors, to securely enable video, audio and presentation interchanges across corporate VPN boundaries. (In an alternate solution architecture, available from HP, the endpoint actually is a point of presence on HP's network, so there is no extranet requirement—every video room is on the HP Video Exchange Network (HVEN). This may simplify inter-company communications, but potentially not be as interoperable or cost-effective as other approaches).

Ultimately, communications over the Internet may be possible. In the short term, the challenge will be how to ensure that the quality of service required by these solutions can be met by an open network such as the Internet. Until QOS mechanisms are provided end-to-end, the high bandwidth and low latency required would be extremely challenging, to say the least.

■ **Private Deployment → Public Utility:** Matching the evolution from Intranet to Extranet to the evolution of use cases and ultimately, provisioning of utility services. Although a common rule of thumb is that 80 percent of enterprise phone calls are within a company, usage of high-end immersive video rooms is likely to increasingly be outside the company. Consequently, usage scenarios will be intra-enterprise and inter-company. Whether within or between companies, rooms may not just be dedicated, but used like video pay-phones. The Regus Group has announced that it will deploy 50 rooms based on Cisco TelePresence for customers to use, presumably paying by the hour for calls.

■ **Intra-Provider → Inter-Provider:** Currently, two or more companies on the same service provider network can connect and collaborate as long as their networks are provisioned by that service provider. Clearly, though, interoperability must not just be for heterogeneous devices from different vendors at different companies, but

extend to connecting across service provider networks. Optimally, these solutions will take advantage of IP Multimedia Subsystem (IMS) inter-carrier peering enabled by session border controllers.

■ **Static → Dynamic:** Providing secure connections across corporate and carrier boundaries can currently be done to a large extent, but only through fixed connections. Being able to dynamically assign resources and connections, and bill for them, will be a challenging next step for the industry.

■ **3 Screen → *n* Screens or No Screens:** Current solutions have one to three screens. Like the evolution from single-blade razors to the Gillette Trac II dual-blade and Mach3 triple-blade to the Wilkinson Sword quadruple-blade Quattro to the Gillette quintuple-blade Fusion razor, one can anticipate the same evolution in the video conferencing space. One likely step is a true video room—including all walls and perhaps even the ceiling and floor. A completely different approach might be to replace screens with wearable video-glasses such as MyVu, enhanced with position-sensing technologies as developed for virtual reality. And eventually, direct electronic interfaces to the visual cortex will eliminate the need for screens. (Don't laugh, systems such as the Dobbelle artificial vision system do just this, although currently at very low resolution). The visual processing capacity of the human brain represents the final limit for bandwidth required...after which there is no point in sending more visual information.

■ **2D → 3D:** Current systems use 2-dimensional image capture and 2-dimensional displays. One can imagine how they will evolve to 3D over the coming years. First, multiple cameras will capture and process multiple angles on the sending end. Second, three-dimensional displays will produce an image on the receiving end. Autostereoscopic displays, that is, 3D displays that do not require special glasses, are appearing on the market from a variety of start-up and established vendors. And even holographic displays, such as R2-D2 uses to display Obi-Wan Kenobi in Star Wars may not be that far off. Researchers have already demonstrated small monochromatic holographic video displays, and claim to be ready to build full-color ones.

■ **Homogeneous Vendor → Vendor Interoperability:** Some vendors initially produced systems that would only interoperate with other endpoints from the same vendor. However, everyone appears to be moving now to standards-based interoperability, the key standard in this case being H.264, also known as MPEG-4. However, anyone with experience in the network and IT industry knows that old standards seem to never die, they just lose share asymptotically.

■ **Homogeneous Endpoint → Endpoint Interoperability:** Even within a given vendor's offering portfolio, interoperability may not always be

possible. Some vendors originally had design goals oriented towards preserving the experience and illusion of being present in the same location. Blowing up a low-resolution cell phone image capture into a 65-inch 1080p display would not meet that objective. However, it has become clear that people want to communicate wherever and however they can. Consequently, vendors are expanding their portfolios to provide a spectrum of solutions, from desktop to moderately large (25" to 45" diagonal) to immersive screens.

■ **Large Screen → Small Screen → Giant Screen:** And even if systems are not available from the same vendor, users will want interoperability with displays at both extremes of the spectrum: Mobile and portable device screens on the low end, which might have a 2" to 16" or 17" diagonal, and 100" + diagonal LCD screens. LCD and plasma screens keep increasing in size as manufacturing costs and yields are continuously improved. Some current systems sometimes trade off the enhanced clarity of LCD or plasma screens for a barely noticeable bevel surrounding the screen, which can cause a seam where screens are abutted. Other vendors and users may prefer the seamlessness of rear-projection systems, but at the possible expense of image crispness. Larger flat-panel screens mean fewer seams for a given area of coverage. Even beyond that, digital cinema projectors on the high end are now being mass produced. It is only a matter of time before they become part of a solution. In fact, as digital cinema projectors become deployed in the 30,000 or so movie theaters in the U.S. and perhaps 100,000 or more globally, it is only a matter of time before they start being used in theaters for group video events: not just live concert broadcasts, but new communities with two-way interaction. Right now, the only limit is access bandwidth to theaters, but this is likely to change over the next few years as content companies look to fully network and digitize their distribution into theater venues using not just satellite, but also low latency, terrestrial wireline services.

■ **Planar → Curvilinear:** Organic Light Emitting Diodes displays (OLED) provide extremely thin panels which may be curved. These are now being produced in prototype form even for the consumer space, with production displays planned for the next 12–24 months by such vendors as Sony. Although initial prototypes are relatively small (10" diagonal), it will probably be only 5 to 10 years before one OLED screen can replace the multiple 65" plasma monitors with a single large curved display.

■ **Transient → Archived → Streamable → Searchable:** Videoconferences, like audio calls, have traditionally been viewed as transient, ephemeral events. However, archiving can complement a real-time video call by enabling later playback via streaming, use of VPN multicast functions, or a content delivery network. Then,

using either collaborative tagging, or automated speech-to-text engines and meta-data tagging and content-based information extraction, such as provided by AT&T's MIRACLE Video Search Engine, enterprise search engines will be used to handle requests like "find me the video call with Acme, Inc. where they committed to have the new Model 37 widget delivered to Sao Paulo by March 1."

■ **Fixed → Portable → Mobile:** There are about 3 billion cell phones in use on the planet. Roughly 100 million of the 250 million or so PCs sold each year are mobile, and the percentage increases each year. A new category, ultra-mobile PCs, has the potential to catch on, providing all the functionality of a PC in a form factor approaching a PDA. Between cell phones, PDAs, ultra-mobiles and laptops, mobile access to videoconferencing through 3G network services provides a mix of great convenience with good quality. And it is clear that convenience can trump quality in users' criteria: Consider the ubiquitous use of cell phones in general (which traditionally have not had the call quality of fixed landline services) and cell phone cameras in particular (which have been lower resolution than dedicated digital cameras). If the CEO of the company wants to participate in an immersive room-based videoconference from his or her cell phone, who is going to say no?

■ **Moderate Quality Mobile → High Quality Mobile:** GSM (Global System for Mobile communications) is the de facto market leader for mobility, available in 220 countries and territories and with more than 80 percent of the global market for mobile communications. In the U.S., the largest mobile carrier, AT&T, leverages the standard, with benefits ranging from seamless global roaming to better customer price points for mobile devices due to scale economies from handset vendors.

GSM is evolving, thanks to the work of the Third Generation Partnership Project (3GPP) and related industry standards bodies, to leverage Wideband- Code Division Multiple Access (CDMA) through High-Speed Packet Access, with multi-megabit uplink and downlink speeds, and, by the year 2011, to "Long Term Evolution", or LTE which will leverage Orthogonal Frequency Division Multiplexing (OFDM) to provide peak uplink and downlink speeds of 100 Mbps or more.

This means that shortly, there will not need to be a tradeoff between convenience and quality: Wireless connectivity will provide more than enough bandwidth to feed multiple high-definition screens. Although a typical usage scenario is not likely to be an executive in a taxicab with three plasma screens on his or her lap, there are real applications. For example, emergency mobile responders may need to show a high definition live video from an accident scene to a specialist physician in real time to make life-or-death deci-

**Searchable video
is also
in the offing**

Social networking will have a video aspect for the enterprise

sions. Polycom, for example, has such a solution built into a ruggedized box. Other applications, such as videoconferencing using a 3G+ wireless network from a hotel room, will increasingly become commonplace.

■ **Native → Composited → Augmented Reality:** Current solutions transport a faithful copy of the captured image to a remote end or conference bridge. In fact, the accuracy and exactness of the copy is a measure of the quality of the video transmission. However, a next step that may be predicted is simple compositing, e.g., “green screen” or “chroma key” capture: Why have a boring beige conference room wall behind you when discussing new cover sheets for TPS reports, when the exciting and dramatic sheer cliffs of Kauai’s Na Pali coastline could be present? And, taking this to the extreme, all kinds of compositing could be done, with digital information augmenting video images for war room and emergency operations applications.

■ **Passive → Interactive:** Displays have traditionally been one-way. However, interactive “displays,” whether touch-screen or based on motion capture in free space in front of the screen, are now coming on the market, possibly leveraging a handheld device. Popular examples are Apple’s iPhone and iPod Touch, Nintendo’s Wii, and Microsoft’s Surface. As videoconferencing displays show not just captured talking-head video, but additional information, they will also be used to enable interaction using touch and motion. This will enable new paradigms in conferencing, collaboration and interaction, with natural gestures being used to interact with other individuals, three-dimensional data sets, and everything in between.

■ **Complex → Usable & Convenient:** Apple’s iPod and iPhone, the TiVo user interface, Motorola’s first RAZR and similar contemporary design icons show the market advantage that simplicity and elegance in design can achieve. Since one of the issues with traditional videoconferencing has been the complexity of initiating and sustaining a connection, that has become a clear design goal of latest generation solutions.

For example, Cisco TelePresence features full integration with Cisco Call Manager and Microsoft Outlook. When a meeting is scheduled in Outlook and the TelePresence rooms are listed as resources, a (soft) one touch push-button option will appear on the in-room VOIP phone display to start the call at the designated time. Or, if it’s an ad hoc meeting, just dialing the phone number of the remote room in Cisco or Polycom solutions will create a connection, which at the touch of a button morphs into a video connection. The interface couldn’t be much easier than that to use.

■ **Connection → Collaboration → Community:** With Microsoft’s recent \$240 million investment, Facebook’s valuation recently became a de facto \$15 billion. Other Web 2.0 and social networking

sites from MySpace to Second Life are equally creating a lot of interest in the venture capital and M&A community due to the absolute number of users, user growth, and the time these users spend on line.

Several observations can be drawn from this. First, these sites are not just for consumers, but have entered the radar screens of enterprises, not just for advertising, but also to experiment with enhanced employee and supply chain collaboration. Second, people are social creatures, and remain so in the on-line world. Third, as millennials (those coming of age as digital natives in the year 2000 and later), who have grown up with high-speed Internet access, webcams, mobile phones with cameras and social networking sites enter and become an increasing proportion of the workforce, their desire to maintain community membership and leverage enterprise video tools will converge.

Summary

Videoconferencing rooms have had limited acceptance and use in the past. However, today’s solutions, enabled by high-definition cameras and displays, high performance codecs and multipoint conference bridges, and latest-generation and emerging converged wireline and wireless global network services, are ushering in a dramatic acceleration of adoption and use. Driven by fundamental enterprise imperatives, such as cost reduction, virtual networked enterprises and globalization, video is now ready for prime time □

Companies Mentioned In This Article

- Apple (www.apple.com)
- Cisco (www.cisco.com)
- Dobelle (www.seeingwithsound.com/dobelle)
- Facebook (www.facebook.com)
- Hewlett-Packard (www.hp.com)
- Lifesize (www.lifesize.com)
- Microsoft (www.microsoft.com)
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- The Regus Group (www.regusgroup.com)
- Second Life (www.secondlife.com)
- Sony (www.sony.com)
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