Media-Ready Network Architecture

Executive Summary

Video applications are fueling a new wave of IP convergence, necessitating a fresh look at network architecture. There are several forces at work, including pressures on companies to be “green” while covering a broader global footprint and simultaneously increasing productivity. Social networking trends are also crossing over into corporate networks, creating exciting new collaboration and productivity opportunities.

Video applications are placing demanding requirements on networks, often necessitating more thorough consideration than voice-over-IP (VoIP) convergence alone. By embracing video as the next wave of convergence, IT departments can think holistically about their network architecture and its readiness to support the coming incursion of video applications and develop a networkwide strategy to provide high-quality end-user experiences.

Thinking about your video strategy now can help you take the first steps toward the next IP convergence wave and give your business competitive advantages, including the ability to harness the collective creativity and knowledge of your employees and create the capability to fundamentally change the experience your customers receive.

Video as a media is quickly taking hold, supplementing other forms of communication. As a result, a significant portion of know-how and intellectual property is migrating into video mediums. It is critical to get ahead of this trend in order to maintain control of the company assets and intellectual property.

Offering both compelling video applications such as Cisco® TelePresence and an end-to-end network design to support this next convergence wave, Cisco is in a unique position to provide a media-ready network architecture that can help ensure the experience well into the collaborative workforce, enabling strategic and competitive advantage.

Business Benefits of Video

IP video applications are increasing at a dramatic rate, and it is having significant effects on network traffic. A recent study and white paper by Cisco, “The Exabyte Era,” highlights the growth and provides a glimpse into the future. According to this paper, video traffic on the Internet in 2007 exceeded the level of traffic on the entire Internet in 2000 (see Figure 1).

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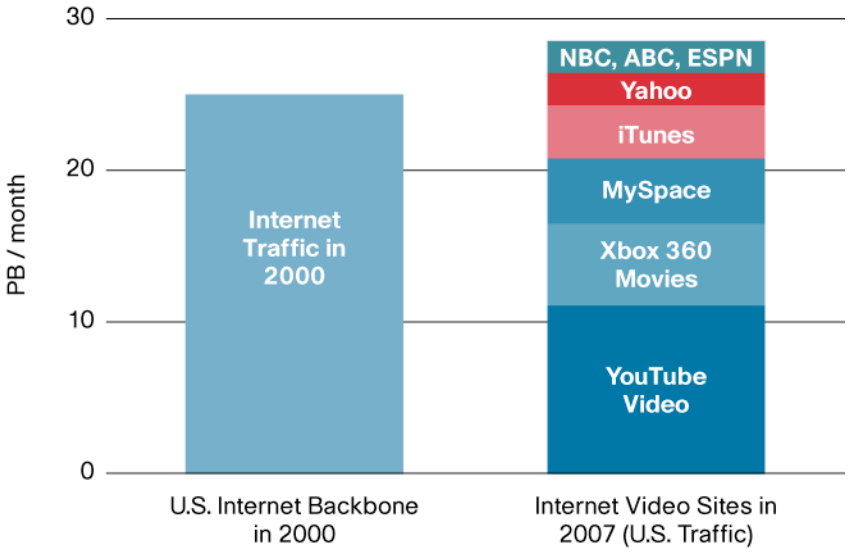
Figure 1. Internet Video Already Generates More Traffic than the Entire U.S. Backbone in 2000



Source: Public data, comScore, and Cisco estimates, 2007

Current estimates are that video traffic is already a significant portion of corporate networks, with some estimates placing the percentage of traffic at 20 to 40 percent or more. Cisco estimates that this percentage will significantly increase within the next five years. There are several business drivers and video trends driving the growth.

Global Workforce and the Need for Real-Time Collaboration

The first stage of productivity for most companies is acquiring and retaining the skilled and talented individuals in a single or few geographic locations. More recently the focus has been on finding technology solutions to enable a geographically distributed workforce to collaborate together as a team, enabling companies to more flexibly harness the talent “where it lives.” Although this approach has been moderately successful, there is a new wave of productivity on the horizon: harnessing collective and collaborative knowledge.

Future productivity gains will be achieved by creating collaborative teams that span geographies, national boundaries, and corporate boundaries. Full-time employees will collaborate with partners, research and educational institutions, and their customers to create a new level of collective knowledge.

To do so, real-time collaboration tools will be absolutely critical to the success of these virtual teams. Video offers a unique medium that simplifies the effectiveness of communications between members of such teams. For this reason, both real-time interactive video will become increasingly prevalent as a medium integrated with corporate communications systems.

Pressures to Be “Green”

For many reasons, companies are seeking to reduce employee travel. Travel creates expenses and has significant productivity effects while employees are in transit and away from their usual working environments. Many solutions have emerged to assist with productivity while traveling, including wireless LAN (WLAN) hotspots, remote access VPNs, and softphones, all attempting to keep the employee connected while traveling.

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More recently companies are under increasing pressures to demonstrate environmental responsibility, often referred to as being “green.” On the surface such initiatives might seem like a pop-culture trend, but lacking in tangible corporate returns. However, it is entirely possible to pursue “green” initiatives, simultaneously increasing productivity, while lowering expenses.

Video applications, such as Cisco TelePresence, offer real solutions to remote collaboration challenges and have demonstrable savings as well. During the first year of deployment, Cisco measured its usage of Cisco TelePresence in direct comparison to the employee travel that would otherwise have taken place. More than 80,000 hours of meetings were held by Cisco TelePresence instead of physical travel, avoiding $100 million of travel expenses, as well as thousands of tons of carbon emissions.

Being “green” does not have to be a tax. It can improve productivity and reduce corporate expenses, offering many dimensions of return on investment, while at the same time sending significant messages to the global community of environmental responsibility.

New Opportunities for IP Convergence

Many advantages were achieved through the convergence of voice onto IP networks. In addition to cost savings, new communications applications were made possible by the integration of VoIP with other applications on the IP network.

There is a new wave of IP convergence emerging for video applications. One source of convergence is from applications historically having dedicated video transmission and broadcast networks. For example, high-definition video collaboration, video surveillance systems, and video advertising signage typically had dedicated private systems for the creation and dissemination of video content. Increasingly, companies are further using the investment in their corporate network by converging these video applications onto the IP network. Cisco TelePresence, Cisco IP video surveillance, and Cisco Digital Media System (DMS) products all make this convergence a reality.

A second source of convergence is the integration of video as a medium into many other forms of corporate communications. For example, video cameras integrated with the VoIP system (such as Cisco Video Telephony Advantage) provide an easy way to add video to existing VoIP calling patterns. Further, collaboration tools such as Cisco MeetingPlace® and Cisco WebEx® add video media as a capability for simple conferencing and real-time collaboration.

Transition to High Definition

One of the reasons traditional room-to-room videoconferencing, and to some degree desktop webcam-style videoconferencing, is sometimes questioned as a less than effective communications system is the reliance on low-definition video formats.

Cisco TelePresence demonstrates how high-definition video can create an experience where meeting participants feel like they are in the same meeting room, enabling a more effective remote collaboration experience. IP video surveillance cameras are migrating to high-definition video in order to have digital resolutions needed for new functions such as pattern recognition and intelligent event triggering based on motion and visual characteristics. Cisco fully expects other video applications to migrate to high-definition in the near future, as people become accustomed to the format in their lives as consumers, as well as the experiences starting to appear in the corporate environment.

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High-definition video formats transmitted over IP networks create unique challenges and demands on the network that need to be planned for. Demands including not only bandwidth, but also transmission reliability and low delay become critical issues to address.

Media Growth

Another factor driving the demand for video on IP networks is a tremendous growth of video content. The barriers to video production, video distribution, and video viewing have been dramatically lowered. Five to 10 years ago video cameras became so affordable and prevalent that just about everyone bought one and became an amateur video producer. Video cameras are so common that almost every cell phone, personal digital assistant (PDA), laptop, and digital still camera provides a relatively high-quality video capture capability. However, it wasn't that easy to be a distributor, and distribution networks were not common.

Today, social networking sites such as YouTube, MySpace, and many others appearing every day have dramatically lowered the barrier to video publishing to the point where anyone can do it. Video editing software is also inexpensive and easy to use. Add to that a free, global video publishing and distribution system, and essentially anyone, anywhere can be a film studio. With little or no training, people are making movie shorts that rival those of dedicated video studios.

The resulting rapid proliferation of video content is now the overwhelming majority of consumer network traffic and is quickly crossing over to corporate networks. Few barriers remain to inhibit video communication, and so this incredibly effective medium is appearing in new and exciting applications every day.

Social Networking: Not Just For Consumers Anymore

Social networking started as a consumer phenomenon, with everyday people producing and sharing rich media communications such as blogs, photos, and videos. When considering the effect it might have on corporate networks, some IT analysts believed social networking would stay as a consumer trend, while others believed the appearance in corporate networks was inevitable.

Skeptics look at social networking sites such as Myspace, YouTube, and others and see them as fads primarily for the younger population. However, looking beyond the sites themselves, it is important to understand the new forms of communication and information sharing they are enabling. For example, with consumer social networking, typically people are sharing information about themselves, about subjects with which they have experience, and interact with others in real time who have similar interests. In the workplace, we already see the parallels happening, because the same types of communication and information sharing are just as effective.

The corporate directory used to consist of employee names, titles, and phone numbers. Companies embracing social networking are adding to that skill sets and experience, URL links to shared work spaces, blogs, and other useful information. The result is a more productive and effective workforce that can adapt and find the skill sets and people needed to accomplish dynamic projects.

Similarly, in the past information was primarily shared via text documents, email, and slide sets. Increasingly, we see employees filming short videos to share best practices with colleagues, provide updates to peers and reports, and provide visibility into projects and initiatives. Why have social networking trends zeroed in on video as the predominant communication medium? Simple: video is the most effective medium. People can show or demonstrate concepts much more effectively and easily using video than with any other medium.

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Just as the progression occurred from voice exchange to text, to graphical, to PowerPoint slides, video will start to supplant those forms of communications. Think about the time it would take to create a good set of slides describing how to set up one of your company's products. Now how much easier would it be just to film someone actually doing it? That's one of many examples that is happening.

At Cisco, we have seen the crossover with applications such as Cisco Vision. Started as an impromptu service by several employees, Cisco Vision provides a central location for employees to share all forms of media with one another, including audio and video clips. Cisco employees share information about projects, new products, competitive practices, and many other subjects. The service was used by so many employees, Cisco's IT department assumed ownership and scaled the service globally within Cisco. The result is a service where employees can become more effective and productive, quickly tapping into each other's experience and know-how.

Integration with Other Communications Applications

When discussing video, some assume and zero in on specific video applications such as videoconferencing. In reality, video is another media type that enables more effective communications.

Much like the integration of rich text and graphics into documentation, video will continue to be integrated into many forms of communication. Sharing of information with emailed slide sets will start to be replaced with video clips. The audio conference bridge will be supplanted with the video-enabled conference bridge. Collaboration tools designed to link together distributed employees will increasingly integrate desktop video to bring teams closer together.

Cisco WebEx is a prime example of such integration, providing text, audio, instant messaging, application sharing, and desktop videoconferencing easily to all meeting participants, regardless of their location. Instead of a cumbersome setup of a videoconference call, applications such as Cisco Video Telephony Advantage and Cisco WebEx greatly simplify the process, and video capability is added to the conference just as easily as any other type of media such as audio.

Demand for Universal Access

Much like the mobile phone and wireless networking, people want to extend communications everywhere they want to use them. The mobile phone unwired audio, making voice communications accessible virtually anywhere on the planet. Wireless networking untethered the laptop and PDA, extending high-speed data communications to nearly everywhere and many different devices.

Video will follow the same model. As video becomes increasingly utilized and integrated, the demands from users will be to access this effective communication tool wherever they are and on their device of choice. These demands will drive the need for new thinking about how employees work and how to deliver IT services to them.

Today employees extend the workplace using mobile phones and wireless networking to home offices, airports, hotels, and recreation venues. With increased reliance on video as a communication medium, how will video be extended to these same locations and with which devices? We already see the emergence of video clips filmed with mobile phones and sent to friends and colleagues. Participation in videoconferencing, viewing the latest executive communications, and collaborating with coworkers will need to be accessible to employees, regardless of their work location.

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Challenges

There are a number of challenges in designing an IP network with inherent video support. The typical approach followed is to acquire a video application, like IP videoconferencing, make the network improvements and upgrades needed to deliver that specific application, and then monitor the user feedback. While a good way to implement a single application, the next video application will likely require the same process, and repeated efforts, and often another round of network upgrades and changes.

A different way to approach the challenge is to realize from the beginning that there are going to be a number of video-enabled applications on the network and that these applications are likely to start consuming the majority of network resources in the future. Understanding the collection of these applications and their common requirements on the network can lead to a more comprehensive network design, better able to support new video-enabled applications as they are added. This design is what we term the "Media-Ready Network."

Considerations for the media-ready network include video delivery, content management, client access and security, mobility, as well as integration with other communications systems and applications.

Understanding Different Video Application Models

The first step in designing the media-ready network is to realize that video is not an application; it is a technology that enables or is included in many applications. As such, video applications will behave differently and put different requirements on the network. For example, Cisco TelePresence has relatively higher bandwidth requirements (because of the high-definition video streams being transmitted) and tight tolerances for delivery. Traffic patterns are somewhat predictable because of room-to-room calling characteristics. To contrast, Cisco Digital Signage typically has less stringent delivery tolerances, and the traffic flows are from a central location (or locations) out toward several or many endpoints (see Figure 2).

Figure 2. Understanding Video Application Behavior Models

	Application	Model	Direction of Flows	Traffic Trends
Interactive	**Telepresence Collaboration**	Many to Many	Client ↔ Client MCU ↔ Client	High-def video requires up to 4–12Mpbs per location Expansion down to the individual user
Interactive	**Desktop Collaboration**	Many to Many	Client ↔ Client MCU ↔ Client	Collaboration across geographies Growing peer-to-peer model driving higher on-demand bandwidth
Streaming	**Video Surveillance**	Many to Few	Source → Storage Storage → Client Source → Client	IP convergence opening up usage and applications Higher quality video requirements driving higher bandwidth (up to 3–4Mbps per camera)
Streaming	**Viewing Stored / Live Digital Media**	Few to Many	Storage → Client Source → Client	Tremendous increase in applications driving more streams Demand for higher quality video increases each stream

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The four video applications shown in Figure 2 cover a significant cross-section of models of video application behavior. To include additional applications in the inventory, critical questions to consider include:

- Where are the video sources, and where are the viewers?
- In which direction do the video flows traverse the network?
- Is the video stored and viewed (streaming) or real time (interactive)?
- How much bandwidth does the application require, static and burst?
- What are the service level tolerances (latency, jitter, loss)?
- What are the likely usage patterns?
- Are there requirements to connect to other companies (or customers)?
- In what direction is the application likely to go in the future?

With a fairly straightforward analysis, it is possible to gain tremendous understanding. One of the important differences is where is the video originating and where are the consumers. For example, with desktop conferencing, obviously the sources and consumers are both the desktop, so the effects on the network are very likely to be within the headquarters campus switching network, across the WAN, and to branch office networks. Provisioning might be challenging to predict as the likely usage will be fairly spontaneous conferences. Voice calling patterns might lend insight into likely video calling patterns.

To contrast, the sources of IP television (IPTV) streams are typically in the data center, from high-speed video storage servers. Because viewers can be essentially any employees, this will affect the headquarters campus switching network, WAN, branch offices, and possibly even remote workers over VPN. Since there will be many simultaneous viewers, it is inefficient to duplicate the video stream to each viewer, so wherever possible we would like to take advantage of broadcast optimization technologies such as IP Multicast and stream splitting.

In this simplistic example, you can see why its important to understand how different video applications behave in order to understand how they are likely to affect your network. Start by making a table with (at least) these questions in mind and inventory the applications using video today and in the future. Common requirements will emerge, such as the need to meet tight service levels, the need to optimize bandwidth, and the need to optimize broadcasts.

Delivery of Video

A fundamental challenge the converged IP network needs to address is delivery of video application traffic, in a reliable manner, while achieving the service levels required by each application. Video applications inherently consume significant amounts of network resources, including bandwidth. A common tendency is to add network bandwidth to existing IP networks and declare them ready for video applications. However, bandwidth is just one factor in delivering video applications.

Video applications, especially those that are real time or interactive, require reliable networks with maximum uptime. Consider a brief network outage of 500 milliseconds (ms). For a voice call on the IP network, such an outage would likely produce an audible click or pop. Because of packet loss concealment strategies within the VoIP codecs, it might produce no noticeable audio effect at all from the user's point of view. However, video applications can have even more stringent requirements. Because of the compression techniques inherent in video codecs such as H.264, loss of even a few packets can represent loss of a tremendous amount of visual information. While

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an audio click might or might not be apparent to the user, pixelization of a high-definition video screen during a Cisco TelePresence call can be quite noticeable, simply because it is visual.

Video applications also by their nature are typically bringing images of someone or something from one location to another, often distributed or remote locations. Similar to the above example, while users might become accustomed to 200 to 500 ms of delay during an audio call, such delays will be more noticeable with visual media.

For each video application, it is important to understand the delivery tolerances required in order to deliver a high-quality experience to the end user.

Prioritizing the Right Video Applications, Managing the Rest

With the first stage of IP convergence, Cisco AVVID (Architecture for Voice, Video and Integrated Data) provided the foundation for different applications to effectively share the same IP network. One of the challenges to overcome with converged networks is to be able to simultaneously meet different application requirements, prioritizing network resources accordingly. Quality of service (QoS) continues to be a critical set of functions relied upon in the network to provide differentiated service levels, assuring the highest priority applications can meet their delivery requirements.

The AVVID model defined best practices for adding VoIP and video over IP applications to the existing data IP network. Most QoS implementations assume a number of data applications, a single or few VoIP applications, and a single or few video applications.

Today there is a rapid proliferation of applications on the IP network with many different types of VoIP and video media. For example, VoIP streams can be standard IP telephony, high-definition audio, Internet VoIP, or others. Video streams can be relatively low-definition webcams, traditional video-over-IP room-to-room conferencing, or high-definition Cisco TelePresence. In addition, there are new IP convergence opportunities occurring, including IP video surveillance and digital signage, which further expand the number of video applications and streams on the IP network (see Figure 3).

Another source of new video streams on the network is unmanaged video applications, those applications that are primarily for consumers, but also used by corporate employees. Many of these applications might fall into a gray area for some companies in terms of usage policies. At first glance, consumer video sharing sites such as YouTube might appear to have clearly consumer-only applicability. But many of these same services also contain videos that can provide considerable know-how and information, useful to employees as well.

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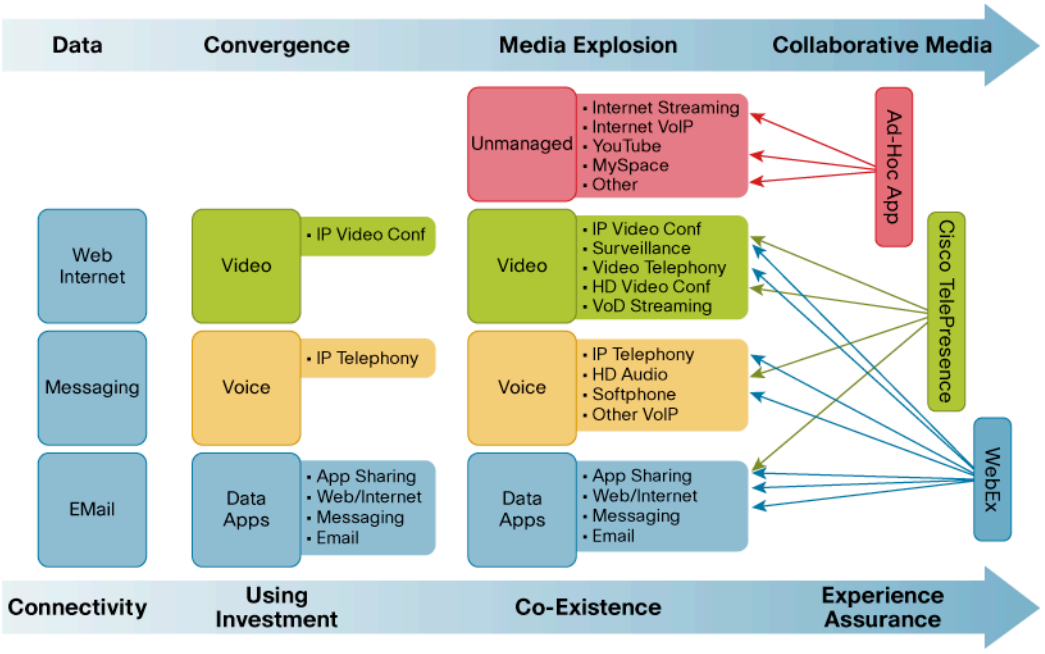
Figure 3. Media Growth Creating New Convergence Evolution



Beyond the current rapid proliferation of media, which is driving a new wave of IP convergence, new and exciting applications targeted at collaboration are integrating numerous types of streams and media into end-user applications. Cisco TelePresence is one example, combining high-definition video streams, high-definition audio, application sharing, and some level of interoperability with traditional videoconferencing, into an overall collaboration tool and near in-person meeting experience. Cisco WebEx is another example, combining many types of media sharing for web-based meetings. Such applications provide new challenges for prioritizing application streams.

The rapid growth of content and media types, both managed and unmanaged, as well as highly integrated collaboration applications requires network architects to take a new look at their application prioritization and QoS strategies. Without a clear strategy, the volume of video applications on the IP network could very well exceed the ability of the network administrator to manage them and meet service levels for business-critical applications.

Integration

As video applications increase on the IP network, integration will play a crucial role in two ways. First, video streams and endpoints will be increasingly used by multiple applications. For example, desktop video endpoints might be used for desktop videoconferencing, web conferencing, and viewing stored streaming video for training and executive communications.

In addition, many video applications will require common sets of functions, such as transcoding, recording, and content management. To avoid duplication of resources and higher implementation costs, common video services need to be integrated into the IP network so they can be used by multiple video and collaboration applications.

Securing Video Applications

Because of the effectiveness of video communications, many video applications are available for collaborations. Security of video endpoints and communications streams is an important part of the video strategy. Access controls for endpoints and users, encryption of video streams across the

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WAN, and securing video media files stored in the data center are all part of a required conprehensive security strategy.

Other specialized video applications, such as IP video surveillance and digital signage, might warrant additional security measures because of their sensitivity and more restricted user group. Placing such applications within private logical networks within the IP network can offer an additional layer of security to keep their endpoints and streams confidential.

Finally, as the level of corporate intellectual property migrates into stored and interactive video media, it is critical to have a strategy to manage the video content, setting and enforcing clear policies, and having the ability to protect intellectual property in secure and managed systems. Just as companies have policies and processes for handling intellectual property in document form, they also must develop and update these policies and procedures for intellectual property in video media formats.

Helping Ensure the Experience

With increasing numbers of video applications entering the IP network, it is increasingly important to be able to help ensure the end-user experience of those applications deemed business critical. The first step is to define which applications are important to the business and therefore need to be managed, and which video applications are best effort. Those deemed important then need to be actively monitored to help ensure the network is delivering these applications to the defined service levels they require.

Poorly performing video applications will frustrate employees trying to use them for collaboration with each other. It is critical for the network adminstrators to have the tools and capabilities to perform ongoing monitoring and be able to take actions to mitigate poor performance to meet defined service levels.

Solution

The Need for a Comprehensive Video Network Strategy

It is possible to pursue several different strategies for readying the IP network for video. One strategy is to embrace video entirely, seeing the technology as driving the next wave of productivity for businesses. Another strategy is to adopt a stance to manage and protect select video applications on the network. Still another strategy would be to not manage video applications at all. Which strategy should you pursue?

If we have learned anything from past technology waves that enable productivity, it is this: if corporate IT does not deploy or lags significantly in deployment, users will try and do it themselves, and usually poorly. Think about WLAN several years ago. Some IT departments were skeptical of the need, or questioned (rightly so) security, so deployments lagged. Users responded by purchasing their own consumer-grade WLAN access points and plugging them into corporate networks, creating holes in the network security strategy. Such rogue access points in your network, lacking proper WLAN security, were difficult for network administrators to locate and shut off.

The coming video application wave will be no different, and is already happening. IT departments lacking a video strategy might find themselves in the future trying to regain control of traffic on the network. It is advantageous to define a strategy now for how video applications will be managed on the network. Important questions the strategy should answer include:

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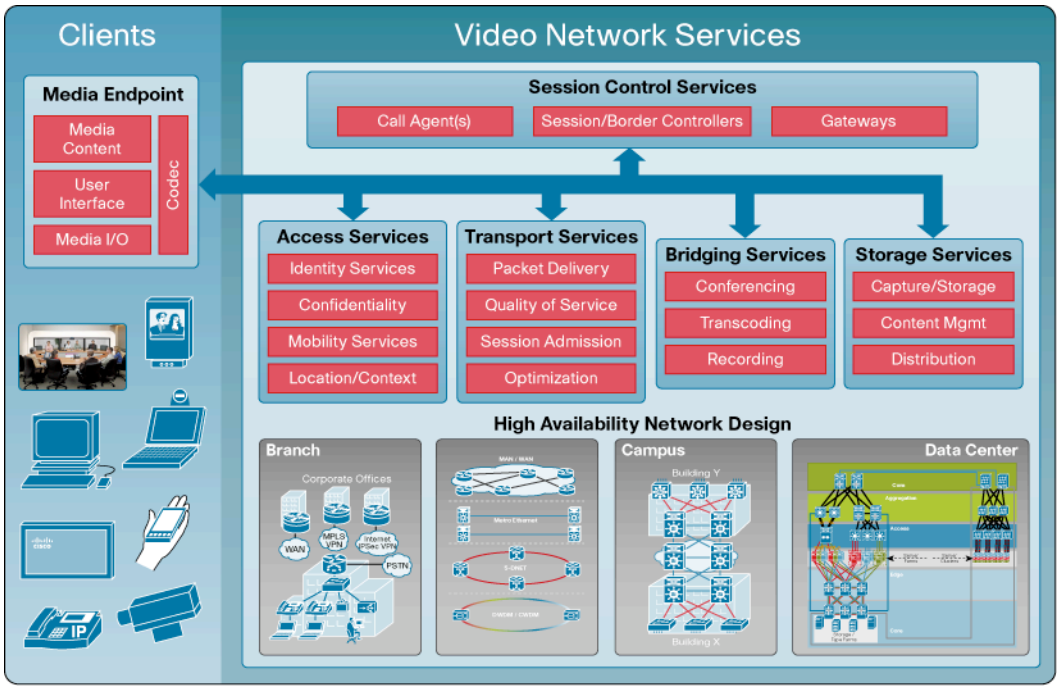
- Which applications will be managed or left unmanaged?
- Which are the critical video applications, and what service levels must be assured?
- What will usage policies be, and how will they be enforced?

As mentioned earlier, one approach to planning the network is to assess the network upgrades and changes required for each new video application acquired by the company. This could lead to a lot of repeated effort and change cycles by the IT staff and potentially incompatible network designs. It is a much better approach to consider all the types of video applications the company is using or might use in the future and design a networkwide architecture with video services in mind.

Media-Ready Network Architecture

Having a media-ready network requires definition of an architecture that supports the different models of video applications and optimizes their delivery, such as the framework shown in Figure 4.

Figure 4. Media-Ready Network Architectural Framework



The media-ready network framework starts with and end-to-end network infrastructure designed and built to achieve high availability, including the data center, campus, WAN, and branch office networks. The network provides a set of services to video applications, including:

- **Access services:** provide access control and identity of video clients, as well as mobility and location services
- **Transport services:** provide packet delivery, helping ensure the service levels with QoS and delivery optimization
- **Bridging services:** transcoding, conferencing, and recording services
- **Storage services:** content capture, storage, retrieval, distribution, and management services

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- **Session control services:** signaling and control to set up and tear down sessions, as well as gateways

When these services are made available within the network infrastructure, media endpoints can be multi purpose and rely upon the common services to join and leave sessions for multiple applications. Common functions such as transcoding and conferencing different video codecs within the same video session can be deployed and used by multiple video applications, instead of being duplicated for each new video application.

Where these different services are deployed within the network can also be customized for different business models or applications. For example, it might be advantageous to store all IP video surveillance feeds centrally in the data center, or for some companies it might be preferable to have distributed storage in branch office networks.

The next section in this chapter examines some of the common recommendations that can be deployed today to begin building a media-ready network. Subsequent sections look more specifically at the recommendations for each major architectural area of the network, including: campus, WAN, branch office, and data center.

Common Recommendations

After understanding the behavior of the different video applications in the network (or that might be on the network someday soon), there are common threads of requirements that can be derived. The top recommendations based on these common requirements are discussed in the next sections.

Network Design for High Availability

Data applications are tolerant of multisecond interruptions, while VoIP and video applications require tighter delivery requirements in order to achieve high-quality experiences for the end users.. Networks that have already implemented higher availability designs with VoIP convergence in mind are a step ahead. Especially with real-time interactive video applications, the user experience matters, and to achieve it, the network needs to deliver very low latency (100–150 ms end to end), very low jitter (0–10 ms), and low packet loss.

Loss of packets, whether because of network outage or other cause, necessitates particular attention. HDTV video formats carried over IP require billions of bytes to transmit and are not practical without compression codecs such as MPEG4 or H.264. When the equivalent information of several thousand packets is compressed into one packet and that single packet is lost, effectively thousands of packets are lost. Lost packets will lead to pixelation and other visual defects that will result in poor experiences for users.

For data applications, network designs might have targeted less than 1 to 2 percent loss. For VoIP, network designs were tightened to less than 0.5 to 1 percent loss. For video, especially high definition, network designs need to be tightened again by an order of magnitude reduction, targeting 0 to 0.05 percent loss.

When the underlying network architecture is designed for high availability, all applications on the converged network benefit, including voice, video, and data. In short, target a highly available network design with built-in low-latency, subsecond failure convergence, and as close to zero packet loss as possible.

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Bandwidth and Latency

Video applications require significant network bandwidth and also relatively low-latency packet delivery. An important step to implement a media-ready network is to assess current and future bandwidth requirements across the network. Consider current bandwidth utilization and add forecasts for video applications. Because video is in a relatively early stage of adoption, use aggressive estimates of possible bandwidth consumption. Consider bandwidth of different entry and transit points in the network. What bandwidth is needed at network access ports both in the campus as well as branch offices? What are the likely video streams needing transport across the WAN?

It is important to consider all types of video applications. For example, how many streaming video connections will be utilized for training and communications? These typically will flow from a central point such as the data center outward to employees in campus and branch offices. As another example, how many IP video surveillance cameras will exist on the network? These traffic flows will typically be from many sources at the edges of the network inward toward central monitoring and storage locations.

Map out the video applications that will be used, considering both managed and unmanaged. Understand the bandwidth required by each stream and endpoint, as well as which directions the streams will flow. Mapping those onto the network can lead to important bandwidth upgrade decisions at critical places in the network architecture, including campus switching as well as the WAN.

Latency can go hand in hand with bandwidth and corresponding access speeds. In general, the faster the connection speed, the lower the latency that component in the network will add to the overall end-to-end latency budget for a video connection. Accordingly, even if bandwidth is sufficient at a point in the network, upgrading to higher speed can have a positive effect on end-to-end latency in order to keep video applications within their desired tolerances.

Application Intelligence and QoS

Cisco QoS has been successfully applied to many converged IP networks to protect VoIP implementations as well as critical data applications. Networks with QoS already in place for VoIP are a step ahead and now need to be extended to include video applications.

Video applications consume significant bandwidth, far more than a typical VoIP implementation. One approach when adding one or more video applications to the network is simply to add more bandwidth to the network. Bandwidth alone is unlikely to address the problem. Think of the network like a freeway. On ramps control flow of new traffic; there are slow lanes and faster lanes and overall speed limits. All these controls work together to move the most amount of traffic safely through the highway. Without those controls, you are likely to have a free-for-all with major pileups. Adding more lanes is unlikely to improve the situation.

Implementation of a comprehensive QoS strategy requires the ability to identify the business-critical applications and set a QoS service policy to mark and prioritize their traffic. With the dramatic increase in types of VoIP and video applications and streams, it becomes increasingly difficult to identify the critical video application streams from those that are considered best-effort or unmanaged. Video streams using similar codecs might have similar packet construction and be difficult to classify using IP packet header information alone.

Packet classification and marking need to evolve to utilize deeper packet inspection in order to have the granularity needed to distinguish between different types of video streams. Developing

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additional application intelligence within the network infrastructure is a crucial requirement to build a media-ready network, especially at the edges of the network, where media endpoints first hand off packets into the network for transport.

Broadcast Optimization

Several video applications that utilize streaming, such as video-on-demand (VoD) training, corporate broadcast communications overIPTV, and IP video surveillance have a traffic model with a single or few video sources transmitting to many simultaneous viewers. With such video applications present on the network, it is advantageous to optimize these broadcasts so that preferably a single (or few) packet streams are carried on the network that multiple viewers can join, instead of each viewer requiring a dedicated packet stream.

IP Multicast is a good technology that can be used to optimize such video applications. IP Multicast might already be enabled in the network as other nonvideo applications also might rely on the broadcast optimization.

Stream splitting is an alternative starting to appear in products. Stream splitting behaves a lot like IP Multicast, only instead of a real multicast packet stream in the network, usually a proxy device receives the stream, then handles join requests, much like a rendezvous point in IP Multicast. Cisco's Wide Area Application Services (WAAS) product line is an example product that has an integrated stream splitting capability for certain types of video streams.

Visibility and Monitoring Service Levels

It is more important than ever to understand the applications running on your network, what resources they are consuming, and how they are performing. Whether you are trying to help ensure a high-quality experience for videoconferencing users or trying to understand how YouTube watchers might be affecting your network, its important to have visibility into the network.

Tools such as Cisco NetFlow and others like it can be essential to understanding what portion of traffic flows on the network are critical data applications, VoIP applications, managed video applications, and the unmanaged video (and other) applications. For example, if you discover that YouTube watchers are consuming 50 percent of the WAN bandwidth to your branch offices, potentially squeezing out other business-critical applications, network administrators might want to put usage policies into place or even more drastic measures such as network-based policing.

Another important aspect is to understand how the video applications deemed business critical are performing. What kind of experience are users receiving? One way to proactively monitor such apps are using network-based tools such as IP service level agreements (IP SLAs), which can be programmed to send periodic probes through the network to measure critical performance parameters such as latency, jitter, and loss. It can be helpful to discover trouble spots with long latency times, for example, and take actions with the service provider (or other root cause) to correct them before users get a bad experience and open trouble reports.

Media-Ready Campus Architecture

Deploying the media-ready network in the campus takes place on the standard campus design recommendations, following the access, distribution, and core architecture model (see Figure 5). The following sections give the top design recommendations for the campus switching architecture.

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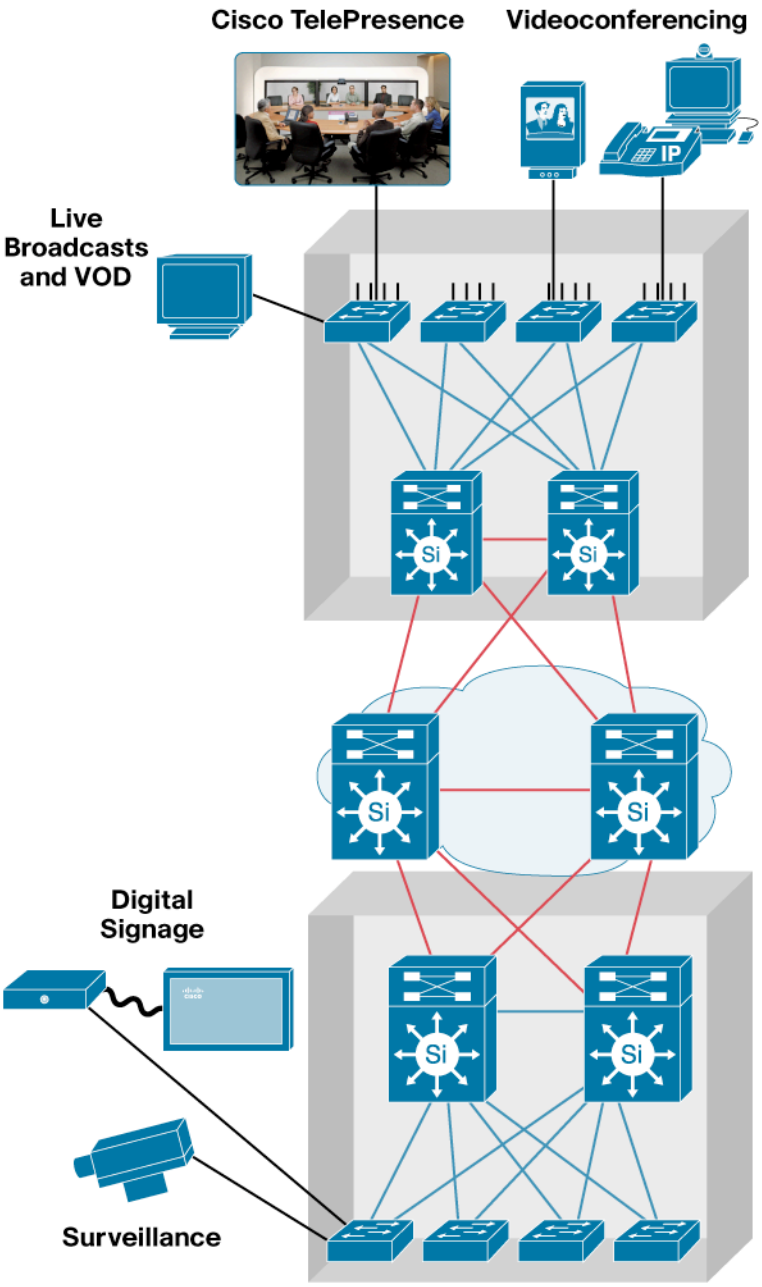
Figure 5. Media-Ready Campus Architecture



Design for Nonstop Communications in the Campus

For many reasons, the campus switching network must be designed with high availability in mind. Increasingly, this means design targets approaching zero packet loss and near-zero downtime. Networks obviously need to be designed to minimize failures and outages. In the event outages occur, convergence of the network needs to occur within milliseconds, not seconds.

Designs to consider for the campus include those that include the Cisco Virtual Switching System (VSS), which dramatically simplifies the core and distribution design and implementation, replacing more complex designs based on Spanning Tree Protocol. VSS implementations can increase network uptime by removing configuration errors, which cause lengthy convergence times.

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Cisco Nonstop Forwarding (NSF) with Stateful Switchover (SSO) is another feature to consider deploying in the campus switching network to increase network uptime and more gracefully handle failover scenarios if they occur.

Cisco Catalyst® switching product lines, including the Cisco Catalyst 6000 family, have industry-leading high-availability features including VSS and NSF/SSO. When deployed with best practices network design recommendations for the campus switching network, video applications with even the strictest tolerances can be readily supported.

Speed, Bandwidth, and Low Latency

As discussed earlier, minimizing latency is a primary objective when supporting many types of video applications, especially interactive real-time video applications such as desktop videoconferencing and Cisco TelePresence.

In the access layer of the campus switching network, consider upgrading switch ports to Gigabit Ethernet. This will provide sufficient bandwidth for video-capable endpoints, including Cisco TelePresence, while at the same time minimizing serialization delay at the entry point to the network.

In the distribution and core layers of the campus switching network, consider upgrading links to 10 Gigabit Ethernet, allowing aggregation points and the core switching backbone to handle the traffic loads as the number of video endpoints and streams increases.

Application Intelligence and QoS

Having a comprehensive QoS strategy can protect critical applications, including VoIP and video, as well as protect the campus switching network from the effects of worm outbreaks.

Cisco Catalyst switching products offer industry-leading QoS implementations, accelerated with low-latency hardware application-specific integrated circuits (ASICs), that are critical for helping ensure the service level for video applications.

QoS continues to evolve to include more granular queuing, as well as additional packet identification and classification technologies. One advance is the Cisco Programmable Intelligent Services Adapter (PISA), which employs deeper packet inspection techniques mappable to service policies. Intelligent features such as PISA will continue to evolve at the network edge to allow application intelligence, enabling the network administrator to prioritize critical applications while at the same time control and police unmanaged or unwanted applications that might consume network resources.

Broadcast Optimization with IP Multicast

IP Multicast is an important part of many campus switching network designs, optimizing the broadcast of one-to-many streams across the network. Cisco Catalyst switching products provide industry-leading IP Multicast proven in business-critical network implementations.

The IP Multicast foundation offers further value in networks in optimizing video broadcasts, such as IPTV and other streaming video applications.

Using Network Virtualization for Restricted Video Applications

The objective of many video applications is to improve effectiveness of communication and collaboration between groups of people. These applications typically have a fairly open usage policy, meaning that they are accessible by and available to a large number of employees in the company.

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Other video applications have more restrictive access requirements and are only available to a relatively small number of well-defined users. For example, IP video surveillance is typically available to the safety and security department. Access to digital signage might only be needed by the few content programmers and the sign endpoints themselves.

For these restricted access video applications, network virtualization technologies can be deployed to isolate the endpoints, servers, and application within a logical network partition, enhancing the security of the overall solution. Cisco Catalyst switching products offer a range of network virtualization technologies, including Virtual Routing and Forwarding (VRF) Lite and generic routing encapsulation (GRE), which are ideal for logical isolation of devices and traffic.

Media-Ready WAN and Branch Office Architecture

Many employees in the typical large company now work in satellite or branch offices away from the main headquarters. These employees expect access to the same set of video-enabled applications as your headquarters employees. In fact, they might rely on them even more because of the need to communicate effectively and productively with corporate.

Deploying the media-ready network in the WAN and branch office networks takes place on the standard design recommendations, following the services aggregation edge, service provider, and branch office architecture model (see Figures 6 and 7). The following sections give the top design recommendations for the WAN and branch office architecture.

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Figure 6. Media-Ready WAN Architecture

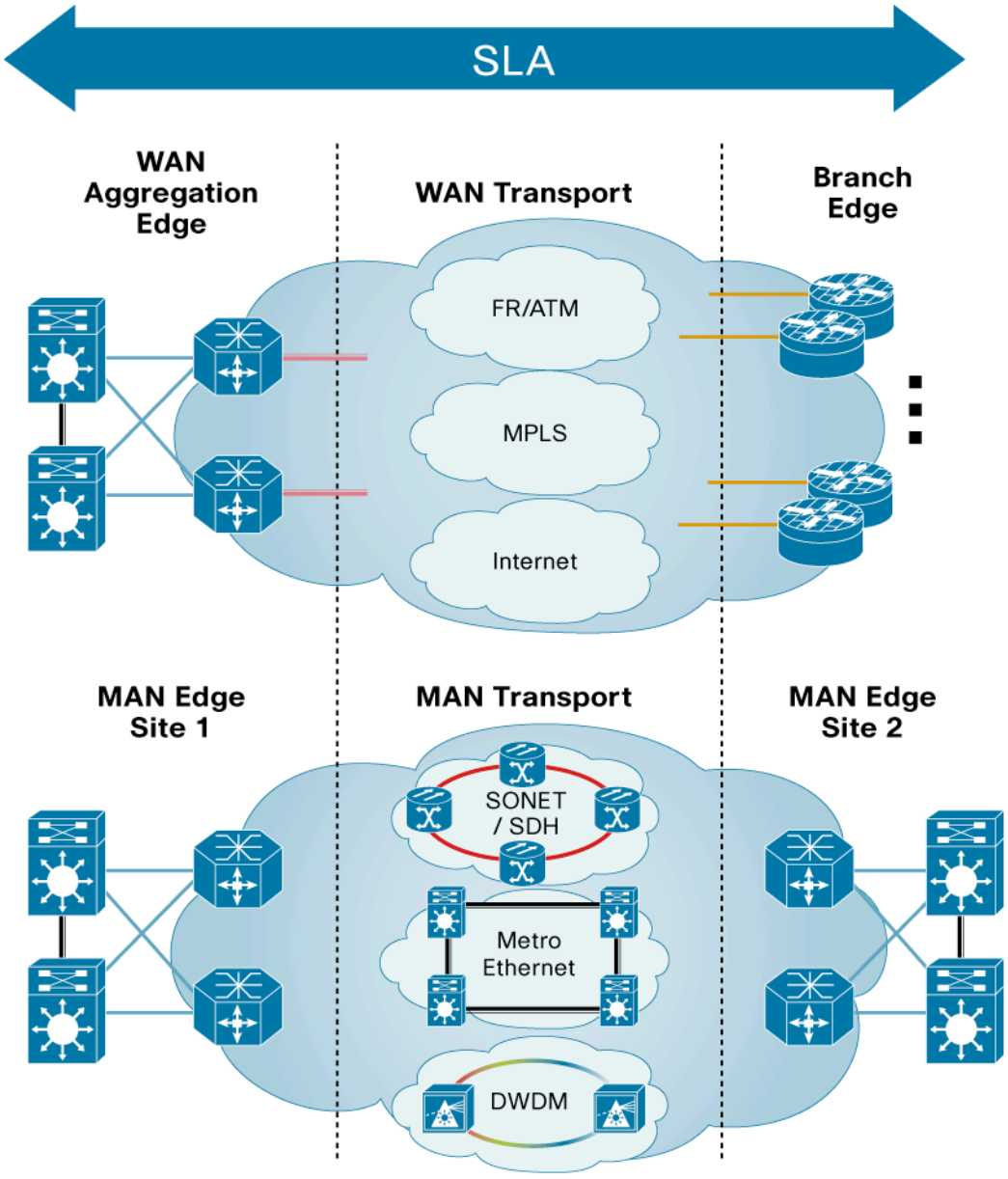

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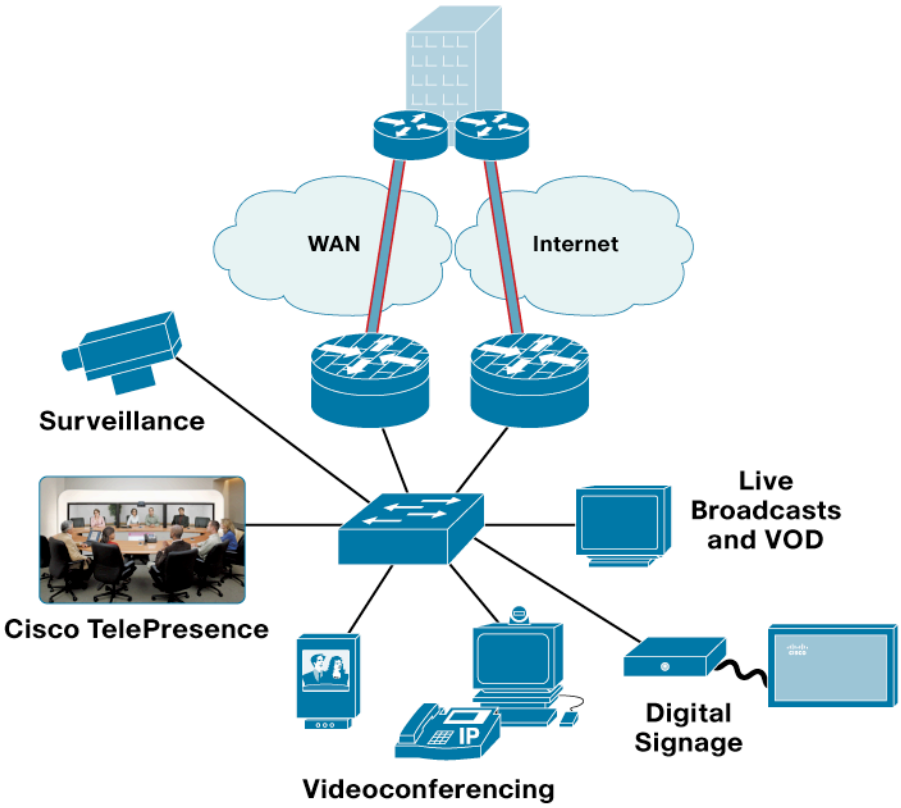
Figure 7. Media-Ready Branch Architecture



Design for Nonstop Communications over the WAN

For many reasons, the WAN and branch office networks must be designed with high availability in mind. Increasingly, this means design targets approaching zero packet loss and near-zero downtime. Networks obviously need to be designed to minimize failures and outages. In the event outages occur, convergence and rerouting of the network need to occur within milliseconds, not seconds.

Because branch offices need to stay consistently and reliably connected to the regional hub or central site, it is highly recommended that each branch office have dual WAN connections, using diverse service provider circuits. In the event of an outage on one WAN connection, the secondary WAN provides survivability. Designs for the WAN and branch office should deploy Cisco Performance Routing, which provides highly available utilization of the dual WAN connections, as well as fast convergence and rerouting in the event of lost connectivity.

At the branch office, consider designs with dual Cisco integrated services routers to offer redundancy in the event of an equipment failure.

At the services aggregation edge, deploy designs based on highly-available WAN aggregation, including SSO. The Cisco aggregation services router product line has industry-leading high-availability features, including built-in hardware and processor redundancy, In-Service Software Upgrade (ISSU), and NSF/SSO. When deployed with best practices network design recommendations for the WAN edge, video applications with even the strictest tolerances can be readily supported.

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Bandwidth Optimization over the WAN

When not properly planned and provisioned, the WAN might raise the largest challenge to overcome in terms of delivering simultaneous converged network services. Video applications in particular consume significant WAN resources, and understanding application requirements and usage patterns at the outset is critical.

Starting with a survey of current WAN speeds can assist in decisions regarding which branch offices need to be upgraded to higher speed and secondary WAN connections. Some quick calculations based on the number of seats in a branch office can give a quick indicator about bandwidth needs. For example, suppose there are 20 employees in a branch office, and the company relies on desktop videoconferencing for collaboration, streaming video for training and corporate communications broadcasts, and plans to install IP video surveillance cameras at all branches for security. Let us further assume a 5:1 oversubscription on conferencing. A quick calculation might look like the following:

- Desktop video = 4 simultaneous calls over the WAN to headquarters x 512kbps each
- Training VoDs = 2 simultaneous viewers x 384kbps each
- Video surveillance = 2 camera feeds x 512kbps each
- VoIP = 5 simultaneous calls over the WAN to headquarters x 128kbps each
- Data applications = 64kbps x 20 employees

With simple estimates, it is possible to see that this branch office might need 6Mbps or more combined WAN speed. If the branch currently has a single T1 connection, it will need to be upgraded to support the forecast video applications.

One technology that can aid the process is to harvest bandwidth using WAN optimization technologies such as Cisco WAAS. Using compression and optimization, Cisco WAAS can give us back 20 to 50 percent or more of our current WAN bandwidth, without sacrificing application speed. WAAS or any other WAN optimization technology is unlikely to save bandwidth of video applications themselves, because of the high degree of compression already built in to most video codecs. The point of implementing WAN optimization is to clear bandwidth from other applications to be reused by newer or expanding applications, such as video.

The question is often raised whether to optimize the WAN or upgrade the WAN bandwidth. The answer when adding significant video application support is both. Optimizing the WAN will typically allow the most conservative WAN upgrade path.

Application Intelligence and QoS

Having a comprehensive QoS strategy can protect critical applications, including VoIP and video, as well as protect the WAN and branch office networks from the effects of worm outbreaks.

Cisco integrated services router and aggregation services router product families offer industry-leading QoS implementations, accelerated with low-latency hardware ASICs, that are critical for helping ensure the service level for video applications. QoS continues to evolve to include more granular queuing, as well as additional packet identification and classification technologies.

Another critical aspect of the overall QoS strategy is the SLA contracted with the service provider (or providers) for the WAN connectivity. In general, for video applications an SLA needs to specify the lowest practical latency (such as less than 60 ms one-way), low jitter (such as less than 10 ms), and lowest practical packet loss (approaching 0 to 0.05 percent). Burst speed is also a factor to consider.

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When selecting service providers, the ability to map the company's QoS classes to those offered by the service provider is also essential. The service provider service should be able to preserve QoS markings and map as many classes as practical across the service provider network.

Broadcast Optimization for Branch Offices

IP Multicast is supported by the Cisco integrated services router and aggregation services router product families. Certain service provider WAN services might or might not support the capability to use IP Multicast over the WAN. For example, if utilizing a Multiprotocol Label Switching (MPLS) service, typically the provider must be able to offer a multicast VPN service to allow IP Multicast to continue to operate over the MPLS WAN topology. Contact the service provider to discuss options for multicast support.

Similarly, certain WAN topologies and integrated security designs also might preclude the use of IP Multicast. For example, IP Security (IPSec) VPNs cannot transport multicast packets natively. Cisco IPSec VPN WANs combined with Cisco GRE, Cisco Virtual Tunnel Interface (VTI), and Cisco Dynamic Multipoint VPN (DMVPN) do support multicast traffic.

Scalability of WANs with encryption enabled can suffer for multicast traffic because of the requirements to encrypt the same packet numerous times, once for each branch office connection. Cisco Group Encrypted Transport VPN offers a solution, allowing many branch office connections to share the same encryption key. This is an ideal solution for maintaining the secure connectivity that VPNs offer, while not compromising scalability when IP Multicast is required to be broadcast over the WAN.

Finally, for situations where multicast of the WAN is not possible, the Cisco WAAS product line also offers a stream splitting capability as an alternative to IP Multicast. The WAAS device in the branch office network acts as a proxy device, allowing multiple users to join the single video stream received over the WAN connection.

Media-Ready Data Center Architecture

Deploying the media-ready network in the data center takes place on the standard design recommendations, following the data center architecture model (see Figure 8). The following sections give the top design recommendations for the data center architecture.

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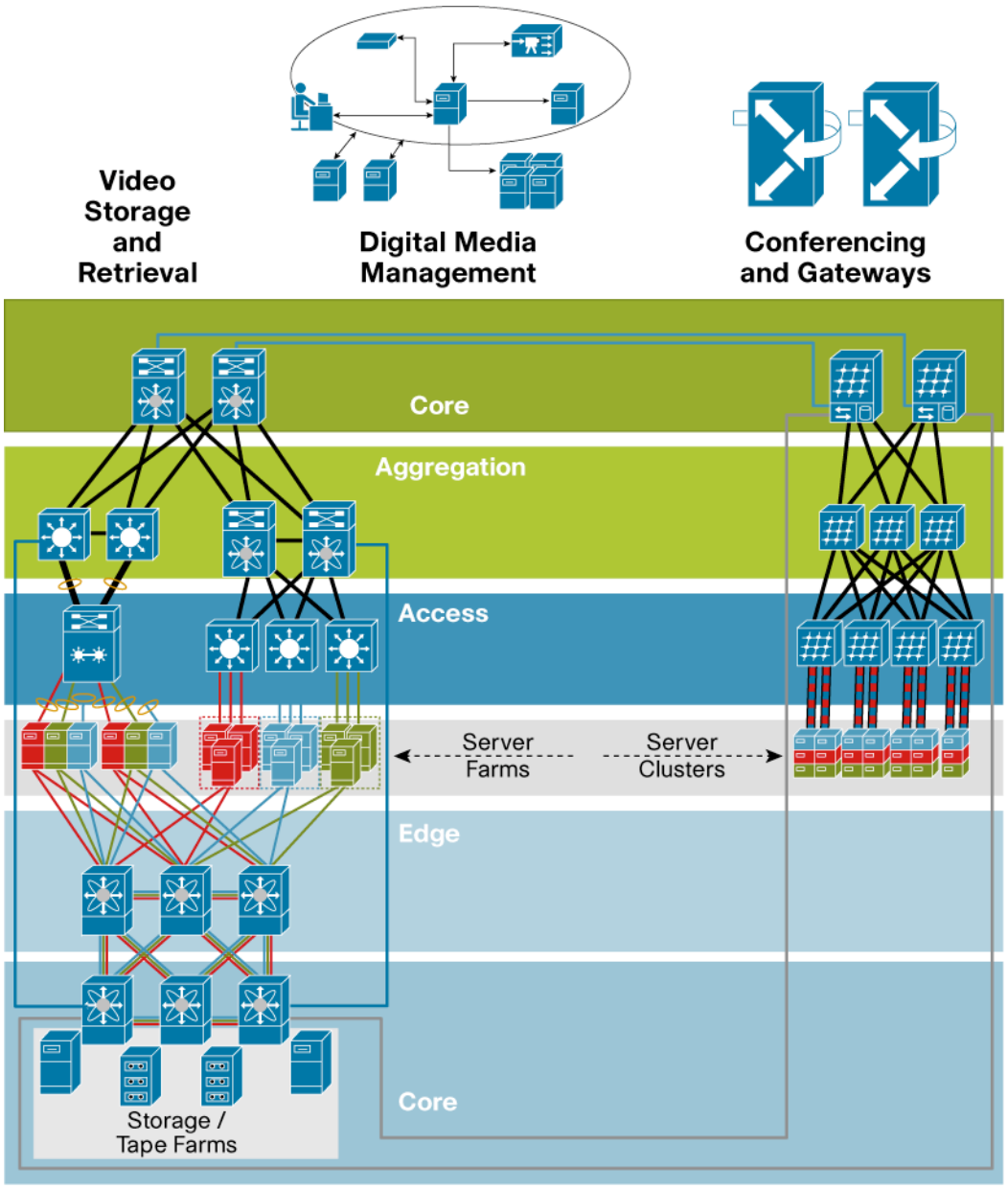
Figure 8. Media-Ready Data Center Architecture



Design for Nonstop Communications in the Data Center

For many reasons, the data center network must be designed with high availability in mind. Increasingly, this means design targets approaching zero packet loss and near-zero downtime. Networks obviously need to be designed to minimize failures and outages. In the event outages occur, convergence of the network needs to occur within milliseconds, not seconds.

Designs to consider for the data center include those that include Cisco NSF with SSO to increase network uptime and more gracefully handle failover scenarios if they occur.

Cisco Catalyst switching product lines, including the Cisco Catalyst 6000 family, and the Cisco Nexus® family have industry-leading high-availability features. When deployed with best practices network design recommendations for the data center switching network, video applications with even the strictest tolerances can be readily supported.

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High-Speed Video Server Access

As discussed earlier, minimizing latency is a primary objective when supporting many types of video applications, especially interactive real-time video applications such as desktop videoconferencing and Cisco TelePresence. If conferencing resources are located in the data center, it is important to provide high-speed, low-latency connections to minimize unnecessary additions to the latency budget.

In the aggregation layer of the data center switching network, consider upgrading links to 10 Gigabit Ethernet, allowing aggregation points and the core switching backbone to handle the traffic loads as the number of video endpoints and streams increases.

In the access layer of the data center switching network, consider upgrading targeted server cluster ports to 10 Gigabit Ethernet. This will provide sufficient speed and low latency for storage and retrieval needed for streaming intensive applications, including Cisco IP video surveillance and the Cisco DMS.

Video Storage Considerations

Several video applications need access to high-speed storage services in the data center, including IP video surveillance, digital signage, IPTV, and desktop streaming video. Video as a media consumes significantly more storage than many other types of media. Factor video storage requirements into data center planning. As the number and usage models of video increase, the anticipated effect on storage requirements is significant.

Another consideration is how to manage the increasing volume of video media that contain proprietary, confidential, or corporate intellectual property. Policies and regulatory compliance planning must be in place to manage video content as a company would manage any of its sensitive financial or customer information.

Conclusions

Video applications are increasing exponentially on the IP network. It is best to adopt a proactive strategy to understand how these applications will affect your network now and into the future. By taking an inventory of video-enabled applications and understanding the new and changing requirements they will place on the network, it is possible to successfully manage through this next evolution of IP convergence and take steps to enable your network to continue to be the converged platform for your company’s communications and collaborations.

By designing the deployment of an end-to-end media-ready network architecture, it is possible to enable faster adoption of new video applications, while enabling IT staff with the tools to proactively manage network resources and help ensure the overall user experience (see Figure 9). Those lacking a comprehensive network architecture plan for video might find themselves in a difficult situation, as the proportion of video application traffic consumes the majority of network resources.

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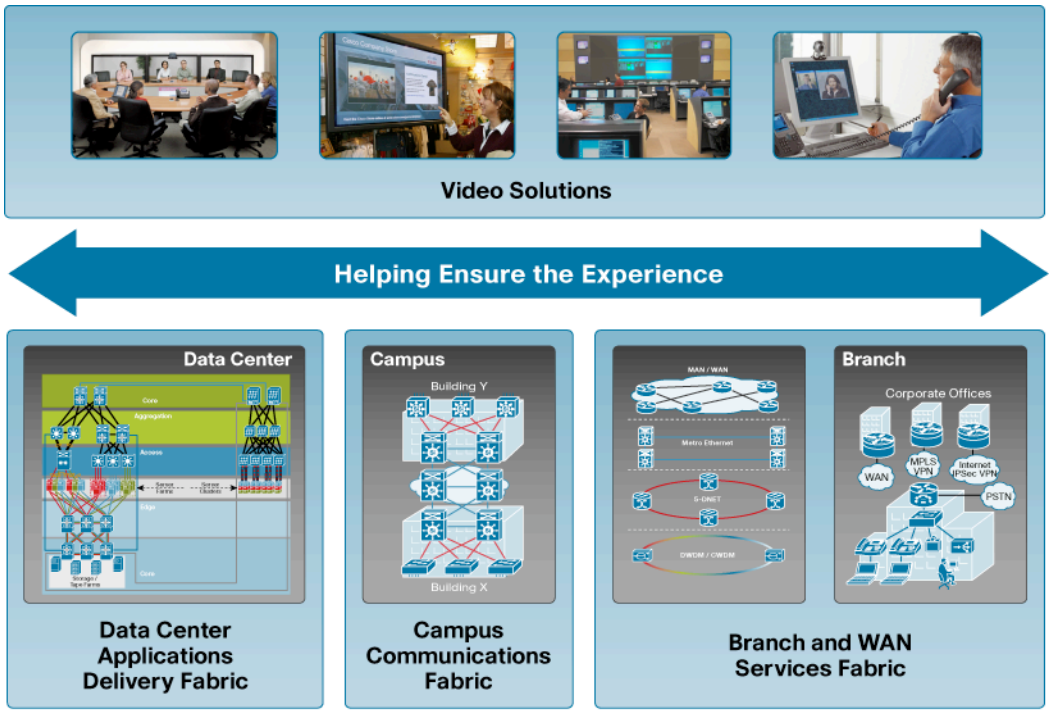
Figure 9. Bringing It All Together



Cisco is positioned to provide the media-ready network, offering a comprehensive set of products for the network infrastructure designed with built-in video support, as well as being a provider of industry-leading video-enabled applications, including Cisco TelePresence, Cisco IP video surveillance, and Cisco Unified Communications. Through this portfolio of business video solutions and network platform, Cisco leads the industry in the next wave of IP convergence and will lead the video revolution as companies move to the next wave of productivity and collaboration.

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