IP Based Videoconferencing

Software vs. Hardware MCUs

Table of Contents

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Introduction

To conduct an in-person meeting, you need a place where people can gather – a conference room. Web conferencing and collaboration is similar except the meeting is held in a virtual conference room. A key component of conferencing is what actually hosts and powers the meeting itself: a multipoint control unit (MCU). Think of the MCU as the virtual conference room where all user video, audio, and data collaboration is managed.

An IP based MCU or Conference Server allows you to create a virtual conference room over any IP network where users can connect with interactive voice, video, and data collaboration.

Conference Server[1], from First Virtual Communications, Inc., is a fully self-contained application for H.323, SIP, and T.120-based conferencing. It encompasses not only videoconferencing but also high performance Voice over Internet Protocol (VoIP) and web collaboration applications. Extremely low audio latency, scaleable distributed architecture, high performance audio and video mixing, support for Microsoft® Windows NT® and Windows® 2000, Sun® Solaris™, and Red Hat® Linux® environments, as well as options for Continuous Presence video and integrated streaming technology, are a few of Conference Server's advanced features.

This document, in addition to comparing the chief differences among software and hardware MCUs, will provide background information to assist you in understanding the key design features and market benefits they provide. There is room in this market for both software and hardware products; however, when there is a strong IP focus, the Conference Server (software MCU) positions itself very strongly, competitively, and cost-effectively.

Strengths of Software MCUs in H.323 / IP Conferencing Applications

The economic life of a hardware box is three years. This illustrates that the tax-man understands the life expectancy of technological improvements and computer hardware. Technology advances occur daily. Simply put, specialized hardware cannot keep pace with hardware technological advances as a software-only application can and does.

Upgrades in software are more easily accomplished and are less expensive than “forklift” upgrades of hardware. The cost of new or replacement specialized hardware modules can be quite expensive when compared to software upgrades. And although the chassis remains (and its years-old technology), the modules change and that can be very expensive. Modules in hardware based MCUs can range in cost from $10,000 to $95,000, with most being around $30,000. You can purchase a new high-performance conference server license for a similar amount of money. This simply spells out the reality that a hardware MCU and its hardware related features are expensive for the intial deployment as well as add-ons and upgrades.

What was “fast” 4 years ago quickly loses ground to the innovation in hardware technology that’s delivered weekly by Intel, Sun, Compaq/HP, and Motorola.

Video quality and user experience is equivalent: Comparable quality and user experience is the norm when comparing both software and hardware MCUs. This is evident especially when customers can see the performance side-by-side.In fact, in a large United States Department of Defense deployment, the Conference Server was selected as the “standard” MCU for the Defense Collaboration Tool Set.

Software is very easy to deploy: Some hardware MCUs are complicated to configure, order, and deploy. With the Conference Server you can order in the morning and install in the afternoon. This is exactly what has been done following the recent terrorist acts in New York City.

The Department of Defense called and we delivered via FTP. The software was deployed the same day it was ordered. You can’t do that with customized hardware!

Collaboration features are included in software solutions: The Conference Server contains embedded T.120 support and these T.120 collaboration features are included at no extra cost with the Conference Server.

T.120 is not supported in the IP (H.323) implementation of one of the market leader’s hardware MCU vendors. Therefore, there is no whiteboard, application sharing, or text chat available to conference participants. Other market leaders require special modules in the their systems that duplicate the functionality that would have normally been provided by a standard PC server to support T.120.

Software provides no Continuous Presence limitations: The Conference Server has no limit to the number of Continuous Presence conferences on the server as with some hardware based products available today. The Conference Server also has no limit on the number of sites in a Continuous Presence conference as long as the server(s) support the appropriate number of simultaneous users in general.

Cascading functionality far superior with software: Cascading, sometimes referred to as “linking,” allows organizations to use extra server capacity on remote machines when needed, without having to purchase potentially idle capacity until it’s needed.

The Conference Server does not have a limit on the number of linked or cascaded conferences either in Continuous Presence

[1] Conference Server is a trademark, and CUseeMe and First Virtual are registered trademarks of First Virtual Communications. All other products are trademarks or registered trademarks of their respective manufacturers.

or not as most hardware platforms do. Most hardware MCUs support a concept called simple cascading. Simple cascading provides for linking a conference between MCUs with each MCU mixing audio and video and sending the signal to the other MCU. No information about individual users is passed between systems in simple cascading.

The Conference Server supports cascading between conferences on the same or different servers. This cascading is supported in both Continuous Presence and non-Continuous Presence conferences. Each MCU knows about all individuals in the linked conference across MCUs. Any user on any MCU can pick which users to see and hear on any of the other linked MCUs.

The Conference Server is the only H.323 MCU that supports multicast cascading. This allows a domain of MCUs to communicate with a one-to-many transmission of media between servers without duplicated unicast streams. The Conference Server has deployments with satellite companies such as Nortel and Comsat, utilizing this technology.

Software scalability: Additionally, there is the cascading and linking between the conferences and the servers as described previously. Conference Server software runs on a variety of hardware platforms and operating systems thereby giving customers: deployment options, greater scalability, and higher port density.

Superior conference management with software: With the software based Conference Server, the administrative web-based user interface can run on the same or a separate machine, and supports multiple platforms: Windows 2000, Windows NT, Linux, and Solaris. Proprietary hardware based products typically require a separate server for conference management. The reason is that web-based management software typically requires a standard operating system and platform for operation. Most hardware platforms run on proprietary operating systems.

Performance advantages of software: Proprietary architecture, hardware platform, and operating system limits some vendor's ability to take advantages of hardware technology improvements and provide the best value to the customer. This is particularly evidenced in the video latency experienced in Continuous Presence conferences with a leading hardware vendor's product.

Distributed Software MCU Philosophy

The Conference Server has enjoyed six years of software development and continues to be enhanced with new features and architectural enhancements.

From its inception, the Conference Server was designed with an IP-centric viewpoint. Support for international conferencing and collaboration standards was always a key part of the implementation strategy.

The Conference Server has been designed and implemented such that the software has been written to be portable and deployed on a variety of platforms including: Windows 2000, Windows NT, Solaris, and Linux.

Software versus hardware is a long-standing debate, as is, where does the computing power and application software reside. There are essentially two choices: provide computing power in a centralized location or put it where the user is located, at the edge of the network. This is a philosophical approach, but it helps to explain a key difference in the hardware versus software debate and it directly relates to the hardware MCU versus software MCU debate.

IBM built its business promoting very large and expensive systems that connected large numbers of people to a central computer. Then a competitor comes along suggesting, why not put the computers where the people need them, base the connectivity on industry networking standards, deploy appropriately sized systems that talk to each other over a peer-to-peer network but provide gateways to other (IBM) networks thereby reducing points of failure and eliminating a single point of failure.

That's how distributed computing was born. It's the legacy of Digital Equipment, Compaq, and now, HP. But the overall philosophical comparison is the same. This distributed computing analogy applies to the Conference Server. This philosophy allows software to be deployed where it is needed, closest to the people that use it.

The Case for Software vs. Hardware

More flexible platform choice: With hardware-based MCUs, you're tied to specialized hardware and software. The Conference Server software MCU works with a variety of hardware and operating systems.

Flexible deployment: Hardware limits where and how an MCU can be deployed. The Conference Server lets you deploy either at a centralized data center or where users are located at the edge of the network.

Simpler, faster upgrades: Hardware upgrades mean swapping expensive boxes or adding boards inside the hardware. Upgrading with the Conference Server means a simple software installation.

Cost-effective T.120 collaboration: Hardware requires external support, if available at all. With the Conference Server, T.120 collaboration comes standard.

Lower-cost processing power: Hardware requires expensive boards that make configuration more complex and reduce capacity. The Conference Server exhibits none of the chassis restrictions that are inherent to hardware.

Better performance: Hardware-based MCUs introduce significantly higher latency, exhibit longer call set-up times, and require more bandwidth for similar video quality. The Conference Server uses widely available multiprocessor, multi-threaded technology providing the additional advantage of greater scalability. The Conference Server's non-proprietary approach allows it to take advantage of technology improvements providing the best value to the customer.

Today, with over 1,000 customer installations worldwide in enterprises, governments, service providers and portals, the Conference Server is a proven, market-tested solution.

Conference Server Features

Standards-based Multimedia Conference Server

Multipoint audio and video MCU: Conference Server is a full H.323 Multipoint Control Unit (MCU) that supports H.323 standards. It enables the hosting of multiple simultaneous multipoint conferences with audio and video mixing and switching.

SIP protocol: Session Initiation Protocol (SIP) support is provided in the Conference Server supporting clients including Microsoft's Windows XP Messenger as well as other conferencing endpoints (in particular VoIP) using the SIP protocol for connectivity.

Conference Server is designed to handle Intranet networks as well as the Internet, including sophisticated static and dynamic cascading of servers for distributed conferences. It provides the option to deploy complete audio, video, and data conferencing applications, or a subset such as data conferencing on its own.

Multipoint data sharing: Conference Server includes a full T.120 MCU. It supports the complete T.120 protocol specification for hosting group collaboration conferences with application sharing, whiteboard, and file transfer.

Integrated H.323 gatekeeper: Conference Server includes an integrated H.323 protocol gatekeeper that supports the registration of endpoints and conferences. It is capable of disabling and registering with third party gatekeepers, and supports alias connection routing.

H.323 endpoint agnostic: First Virtual Communications has performed significant interoperability testing and study to ensure that Conference Server accommodates the majority of H.323 protocol endpoints in use today.

H.320 to H.323 gateway interoperable: Conference Server has been tested and deployed with third party gateways supporting Public Switched Telephone Network (PSTN), the H.320 standard, etc. Tight integration with gatekeeper and gateway Interactive Voice Response (IVR) features enables users to select conferences by entering the conference ID from their Touch Tone™ keypad for VoIP applications.

Software and IP-centric Solution

Windows and UNIX™ software solutions: Conference Server is a software solution designed to run on Microsoft Windows NT and 2000 Servers, Sun Solaris, and Red Hat Linux. Network performance has been optimized for each platform and structured Conference Server as a software solution that can grow with hardware improvements.

Multi-processor support: Increasing the processing power of a Conference Server installation is simply a matter of adding additional standard processors (CPUs) to the server that the Conference Server is installed on. The Conference Server has robust support for multi-processor environments providing high performance handling of the audio and video media. Multi-processor support is accomplished via the Conference Server utilizing the inherent capabilities of the standard supported operating systems.

IP-based product for the Intranet and Internet: Conference Server is an IP-centric solution that solves problems associated with packet networks and integration into the Web-based, distributed client/server paradigm. It is optimized for packet networks and leverages IP technologies, such as multicast, to address network saturation.

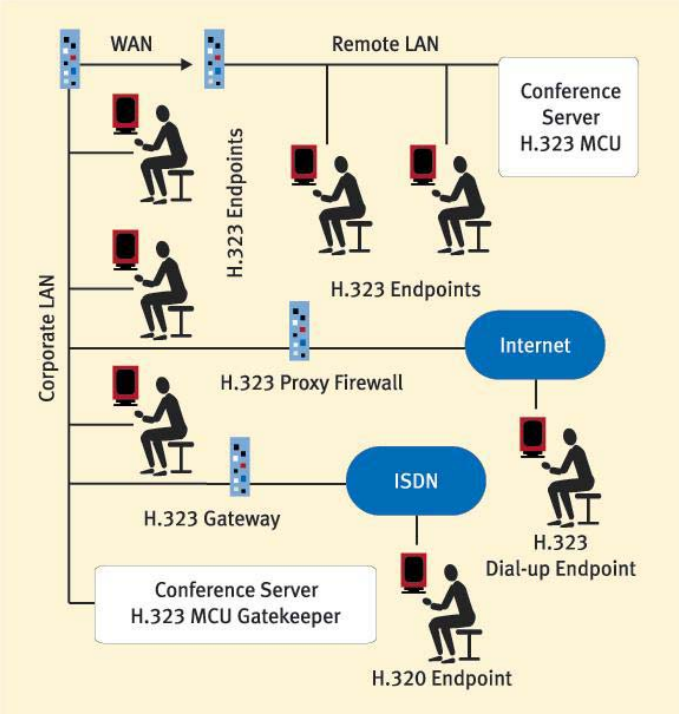

Figure 1: Example of Conference Server Application

Intelligent, Distributed Group Conferencing

Supports centralized conferencing model: Conference Server provides full support for the H.323/T.120 protocol centralized MCU model. Audio, video, and data streams from individual endpoints are distributed to other endpoints connected to the same MCU.

Supports and promotes distributed conferencing model: A decentralized conferencing model, with distributed server linking and/or multicast, takes into consideration the major factors that affect bandwidth use and network performance in the IP environment. Multiple, distributed Conference Server MCUs balance the conferencing load on a network — routing audio, video, and data streams from distributed endpoints through appropriate local paths.

Static and dynamic linking/cascading: Through MCU static linking, you can create a topology of Conference Servers to minimize the distribution of multiple copies of media across lower bandwidth-capable segments of a WAN or the Internet. Dynamic cascading allows new servers to dynamically join conferences to redistribute data within the scope of a network segment to avoid WAN saturation.

Multicast linking and unicast hybrids: Conference Server can be configured to send media between servers via multicast. Endpoints that only support unicast can connect into a conference at any of the servers and Conference Server will rebroadcast their data, via multicast, to other servers. This will, in turn, deliver unicast streams to the locally connected endpoints. This is a critical feature in a number of deployment scenarios. The most applicable of these scenarios is distributed conferencing, where you have three or more servers hosting a conference connected with a multicast-enabled WAN — very common in satellite deployments. You can also use this feature when deploying a server farm of Conference Servers for hosting large conferences. Additionally, unicast-linked servers can be mixed into a multicast conference. Note that Conference Server supports unicast connections to CUseeMe-protocol endpoints and H.323-protocol endpoints.

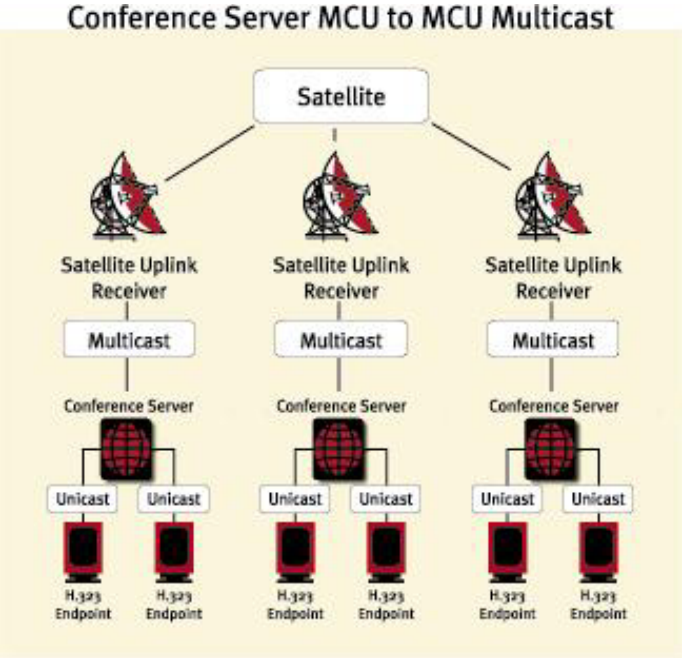

Figure 2: Conference Server Multicast Linking and Unicast Hybrids

H.323 simple cascading: Conference Server supports H.323 simple cascading, which allows Conference Server to connect to other MCUs to extend a conference. In this mode, Conference Server is viewed by the other MCUs as a single endpoint; and likewise the other MCUs directly connected to Conference Server are viewed as a single endpoint. What this means is that the connected MCUs will decide which audio and video stream to send to Conference Server, and users connected to Conference Server will only see this composite data.

Multicast and unicast hybrid conferences: Conference Server can negotiate and manage client or server multicast, enabling any hybrid of unicast and multicast per conference. It can receive media from unicast clients and distribute it via multicast to multicast-capable endpoints.

Mixing data rates (bandwidth management): Per the H.323 specification, Conference Server negotiates bandwidth limits with clients when they connect. Conference Server makes dynamic adjustments to allotted bandwidth based on network traffic congestion that is detected and reported by clients. Conference Server gives audio first priority to assure minimum latency of audio delivery, even during congested high-usage periods.

In video applications, Conference Server's bandwidth manager intelligently prunes video streams — eliminating intra-frames and key frames to individual endpoints as necessary. Each endpoint receives a coherent stream based on its bandwidth consumption capabilities. Performance for higher-bandwidth clients is not scaled down to the sending or receiving capabilities of lower-bandwidth endpoints. In addition, data that cannot be used by lower-bandwidth recipients is not sent over the network.

QOS (Quality of Service): Quality of Service options in conference configurations allow administrators to prioritize real-time conferencing network traffic from other traffic on their networks. The Conference Server also provides network error handling allowing it to perform well even when network conditions as sub-optimal.

Audio Intelligence

Low audio latency: Very low audio delay facilitates the interactive nature of videoconferencing so participants don't step on each other as dialog goes back and forth between them.

Intelligent routing and prioritizing: As stated, the bandwidth manager in Conference Server is multimedia aware. Conference Server prioritizes audio streams to each client to minimize latency. Data gets second priority and video is reduced to fill the rest of the available bandwidth. With linked/cascaded servers, media is only delivered to the servers that require it to deliver to the local endpoints.

Silence detection / background noise suppression: Conference Server decodes each audio stream it receives and decides which streams are most active and, therefore, candidates for mixing and re-distribution. With this intelligence, endpoints sending background noise do not take up bandwidth to other endpoints or solicit valuable mixing slots.

Extensive: audio support for G.711, G.722, G.723, G.722.1, G.729A, and PictureTel's Siren 7. The most recent additions to the suite of audio protocols supported each have their own benefits.

G.722 – providing excellent speech quality wideband audio (sometimes referred to as FM-quality speech).

G.722.1 – providing the same excellent speech quality as G.722 at half the required bandwidth of G.722 (24 – 32 kbps).

PictureTel's Siren 7 – providing the audio quality of G.722 and G.722.1 with even lower bits rates as low as 16 kbps.

G.729A – enhancing Conference Server's capability to support VoIP applications.

Sophisticated audio mixing: Conference Server supports mixing of multiple audio streams into a single stream, which is then distributed to each endpoint. Conference Server mixes up to eight different audio streams in the audio element of a conference. It dynamically adjusts the number of audio streams mixed based on the conferencing application. This eliminates audio clipping when dialog is taking place and minimizes CPU load on the server.

Individual endpoint audio control: Each client endpoint can select to receive:

The mixed audio stream constructed by Conference Server

The audio from a single, selected endpoint

Endpoints with multi-channel audio mixing capabilities can select none or any subset of the audio streams sent via Conference Server.

H.323/H.320 audio-requiring endpoints: Most H.320 protocol endpoints and some H.323 protocol endpoints need to receive a constant audio stream from the moment they connect to a conference. To support these clients, Conference Server generates a silent audio stream when no other endpoint is sending audio.

Audio transcoding option: An upcoming software option for Conference Server is advanced technology that enables transcoding between audio codecs for mixed capability endpoints.

Video Intelligence

H.263+ video: This leading edge codec technology is supported in the Conference Server significantly improving the video performance of conferences. The endpoints in the conference must have H.263+ support for these benefits.

PictureTel's "People and Content": support in the Conference Server represents a significant change in pure "talking heads" conferencing methodology. People and Content was designed to be a powerful collaboration platform incorporating the best support for both people-to-people interaction and the sharing of content. In its simplest form, the rule for people is "I see you and you see me." The rule for content is "we both see the same content."

Support for Full CIF video in addition to QCIF: Conference Server supports CIF (Common Intermediate Format; 352 x 288 pixels) and QCIF (Quarter Common Intermediate Format; 176 x 144 pixels) video formats. Sub-QCIF variants are supported only for the H.263 video codec.

Switched video: Conference Server supports the traditional H.320 method of video distribution in a group conference, that is, delivering each endpoint a single video stream, as it would receive in a point-to-point session. Conference Server provides the following methods for determining how video will be switched between multiple participants in a conference:

Voice activated: By default, Conference Server uses *audio* to determine which *video* H.323-protocol participants receive. The participant whose audio is most active/dominant, or has the greatest amplitude delta, is displayed to other participants. The participant, whose audio is being sent, sees the video of the last active speaker.

Time activated: Conference Server can also switch video at a predetermined time interval. The video of each video-enabled client is displayed in a constant loop, independent of who is speaking.

***Note*:** If there is only one video endpoint sending video, then everyone – including the sender – will see that video. If only two persons are connected and each has video, they will see only each other and no switching takes place.

Multi-channel video: Participants can receive multiple video streams simultaneously while connected to a Conference Server conference when they use a CUseeMe-protocol client from First Virtual Communications. Conference Server distributes allotted bandwidth equally across the selected video streams and performs video pruning on each stream when bandwidth consumption reaches set limits.

Continuous Presence video: Continuous Presence is an add-on option you can purchase for your Conference Server. It allows H.323 protocol endpoints that can receive

only one video stream at a time to receive a stream that is a composite mix of up to four video streams. With this method, an endpoint can view more of the active conference than their conferencing client normally allows.

Continuous Presence has been recently enhanced to minimize the amount of network overhead required providing a noticeable and significant improvement in video quality.

4 x QCIF mix into single CIF stream: To achieve video mixing, Conference Server requires each video-enabled endpoint to send a QCIF video stream. It then selects the video streams of up to four endpoints and mixes them to form a single composite video stream. The CIF stream is divided into four equal quadrants. Each endpoint must agree to send QCIF and receive CIF to participate in the conference.

Voice-activated dynamically displays last four speakers: By default, Conference Server fills the quadrants of a Continuous Presence stream with the videos of the last four most active speakers in the conference. However, Conference Server also allows you to anchor (or pin) an endpoint to a particular quadrant at the time that endpoint enters the conference or dynamically during the conference.

Single video mix per conference: Conference Server performs one video mix per conference and distributes that stream to each endpoint. This minimizes confusion for conference participants and simplifies conference setup and usage complexity.

Video suppression: Conference Server will automatically detect whose video is not being watched by another endpoint and signal the endpoint to stop sending video. This has been implemented to work with a range of H.323 protocol endpoints, as not all support the standards-defined way of implementing this via flow control. This enables huge bandwidth and CPU savings when hosting large conferences.

Video pruning for mixed bandwidth endpoints: As stated in the Bandwidth Management description, Conference Server intelligently prunes the video data it distributes to each endpoint. It determines how much video data to prune from a video stream based on how much bandwidth a receiving endpoint has available during a given time sample (available bandwidth based on negotiated limits and bandwidth left after audio and data usage).

For a Continuous Presence conference the send and receive rates are automatically negotiated by the Conference Server. The conference creator determines the bandwidth and frame rate that the endpoints receive.

Conference Control

Exposed by API or Web Java applets: Conference Server comes with an extensive Telnet API command set. Conference Server's Web-based GUI serves as a front end to this command set, providing for the administration of servers in a Conference Server domain. (You can use either the Web-based GUI or the Telnet commands to administer your Conference Server.) Conference Server also comes with a variety of Java applets that access the per-endpoint commands. These applets allow each browser-enabled participant to control creating, selecting, and connecting to a Conference Server conference, as well as to determine which videos to view once connected (if video-enabled).

Individual endpoint controls for audio and video: As described in the *Audio and Video Intelligence* section, Conference Server supports control per endpoint of the conferencing experience. A Telnet API for this functionality is available.

Conference creation and invitation tools: Conference Server supports an extensive number of dynamic command options that can be authorized for individual users to create conferences on-the-fly and invite other endpoints into conferences.

Authentication & Security

Encrypted T.120 data: The data element of meetings is secure using the Conference Server's capability to provide an encrypted T.120 data collaboration session with Microsoft NetMeeting.

Per user and group authentication: Conference Server can securely authenticate individual endpoints for conference admittance with name/password pairs over Web-based connections (which can be secured via SSL). In upcoming releases the Conference Server will support Secure/Encrypted NetMeeting style authentication and data collaboration.

Per IP and subnet authorization: You can configure Conference Server to allow or disallow any IP address or subnet from all or any individual conference.

Per-conference password: Independent of other security schemes, Conference Server supports CuseeMe protocol, H.323 protocol, and T.120 protocol per-conference password schemes.

RADIUS authentication and billing & tracking: Conference Server supports the RADIUS (Remote Authentication Dial-In User Service) protocol to authenticate and generate billing and tracking records for an organization.

Administration

Domain administrative server: Conference Servers can be associated with a domain. One Conference Server stores and propagates conference configuration information for the entire domain. You can select any Conference Server in your domain to be the administrative server.

Central configuration point: You can install Conference Server's Conference Administrator Web pages (Web-based GUI) on a Microsoft Internet Information Services (IIS), Netscape Enterprise, or Apache Web Server requiring and utilizing servlet engines for fast performance. These pages provide a central location to define a domain of Conference Servers, and to create the profile for that domain and the conferences it will host. Installation of the Conference Administrator Web pages includes a database for user authentication and authorization. Although you can install multiple instances of the Conference Administrator Web pages to balance the HTTP load, only a single database can serve your Conference Server domain.

Backup and recovery for domain: The centralized administrative server allows for automatic backup and recovery schemes for the Conference Server domain.

Caching per-server of conference info: The administrative server pushes the per conference information/configuration to each server in the domain and assures that each server is up-to-date. Each server has a local cache of the configuration for quick startup.

Conference templates: Conference Server allows you to create conference templates that govern the settings of conferences that end users create with Conference Server's MeetingPlanner applet. This de-centralizes the conference creation process, extending it to the end user while leaving ultimate control over network resources in the hands of the administrator.

Topology control: Conference Server allows for a default topology for the domain of servers (cascading hierarchy), as well as a per-conference topology. This allows an administrator to create a topology that best fits the network infrastructure. Conference Server automatically deploys a topology for end user-created conferences based on the conference template or defaults for the domain.

User & group privileges controls: Conference Server has levels of privileges based on username/password combinations. These privileges include overall administrator, conference moderator, conference creator, and general user.

Overall and per-user bandwidth limitations: Each Conference Server conference can have its own per-user bandwidth limitations.

Web-based interface: Conference Server's interface is a combination of HTTP, Servlets, Java, Java scripts, and CGI scripts. This allows a user or administrator access from any machine on the network.

Ability to install administration console independently from the Conference Server: The ability to install Conference Server's Administrator Web pages on an independent Windows NT/2000 or UNIX server lets you distribute the HTTP load and access.

Third-party HTTP servers: Conference Server's Administrator Web pages can be hosted by Microsoft IIS, Netscape Enterprise, or Apache Web servers. Conference Server should work with most Web servers available today; First Virtual Communications has performed tests with Microsoft IIS, Netscape Enterprise, and Apache servers. The only additional requirement is that a Servlet engine is installed with the HTTP server.

Ease of Use and Deployment

As referenced earlier, Conference Server was designed for easy deployment on Intranets or the Internet. Conference Server allows administrators or end users to create, control, and access multimedia conferences using tools common to most PCs and workstations — without having to pre-load additional software. The following is a list of available tools that use Conference Server's Telnet API to enrich the conferencing and collaboration experience:

Conference Administrator Web pages: Conference Server's Web-based Graphical User Interface (GUI) with predefined conferences installed as a starting point for Conference Server administrators.

Conference Server MeetingPlanner™: Java-based wizard that allows authorized end users to create and schedule Conference Server conferences and invite others to participate. For more information see the Dynamic Conference Scheduler section that follows.

User Authentication Web page: Facilitates user authentication, billing, and the routing of H.323-protocol clients.

H.323 CallOut Applet: Java applet that enables end users to instruct Conference Server to make callouts, or invitations, to potential conference participants.

Continuous Presence Mode applet: Java applet that allows a conference moderator or Conference Server administrator to control how video is displayed in each cell of an H.323-based continuous presence video window. Applies to the H.261 video codec. Requires Conference Server's Continuous Presence option.

Dynamic Conference Scheduler

As described in the preceding section, Conference Server MeetingPlanner is a Java applet that gives end users the ability to create, schedule, edit and delete Conference Server conferences. It is designed to help service providers roll out large-scale videoconferencing services without the need to hire human operators to configure conferences for customers.

MeetingPlanner can also be used by other organizations that would like to give certain users the ability to create conferences on their own, without giving them access to Conference

Server's more powerful Conference Administrator Web pages. A busy system administrator may set up one or more Conference Servers on the company LAN, configure template conferences for his users, and allow the users to schedule their own conferences. With MeetingPlanner end users can:

Schedule meetings without going through the Conference Server Conference Administrator Web pages

Create, change, and delete meetings via a Web browser

Set passwords per endpoint invited

Send e-mail notification to meeting participants (with a pointer to the Conference Server authentication page URL)

Streaming Media Integration

Streaming Media is an add-on option you can purchase for your Conference Server. The option enables you to route audio and video from a Conference Server conference to a third-party streaming media encoder, which in turn allows the stream to be distributed live or on demand by a third-party streaming media encoder or server**.** This provides you with the ability to integrate two-way interactive videoconferences with streaming media distribution technology. The first phase of this integration includes:

Conference recording and playback via a third-party streaming media service such as Apple QuickTime, RealNetworks™ RealProducer™, Microsoft Windows Media or Cisco® IP/TV®.

Hybrid interactive CUseeMe-based, H.323-based, and live streaming media conferences.

Enables conferences with very large numbers of participants.

When you use the Streaming Media option, the following applies:

Conference Server routes live media streams from an interactive CUseeMe-based or H.323-based conference to Conference Server audio record and video capture drivers. These drivers receive the audio/video from Conference Server, decode it, and forward it to a third-party streaming media encoding application when requested. This virtual video driver is only available on NT and Windows 2000 platforms. Conference Server directs the streaming media encoding application to re-encode the audio and video media streams into an appropriate streaming format such as MPEG2.

The re-encoded streams are distributed to end users via a third-party streaming media server. Endpoints listen to and view the conference from pre-installed, third party, streaming media player software.

Active CuseeMe and H.323 protocol conference participants connect to the Conference Server. Passive participants see and hear the conference via broadcast streaming but do not participate directly in it.

Streaming media players, which access the streaming media server defined for the conference, receive the video of the active speaker and the mixed audio from all speakers. Depending on the conference configuration users can see switched video or Continuous Presence. Endpoints that want to become interactive members of the conference can use Web-based controls to join the interactive Conference Server conference.

Figure3 shows how Conference Server integrates with streaming media technology.

Figure 3: Conference Server Streaming Media Integration

Solution and Integration Capabilities

Conference Server is designed to be integrated into other solutions and to be extended by those solutions. Some examples of that design include:

Click to Meet™ is a complete end-to-end solution for rich media communications providing a framework for group communications using live, interactive voice, video, and data collaboration as well as streaming technologies

Web Endpoint Server enables business quality desktop rich media communications to be easily deployed across the corporate network and integrated into a variety of enterprise workflow environments

Meeting Controller™ controls meeting interaction features with H.323-protocol endpoints

Completely documented Telnet API for third-party developers

Web-based and network-based controls for easy integration

Back-end database that is simple and flexible

Log files for billing and tracking

Support for RADIUS billing, tracking, and authentication

Conference Server Components

Conference Server has many software components, but is constructed around three main standards-based components that offer conferencing and collaboration services to end users. These three main components are:

An H.323 based MCU

An H.323 based Gatekeeper

A T.120based MCU

Conference Server's core technology and the services for its deployment are depicted in Figure 4 and described in the information that follows.

Endpoint Connectivity

Any H.323 protocol, SIP protocol, and/or T.120 protocol endpoint can group conference with Conference Server.

Conference Server supports POTS / PSTN and H.320 protocol gateways to bring legacy conferencing endpoints into Internet (IP) group conferencing.

Solution products, such as First Virtual Communications' Web Endpoint option for Conference Server, can easily coexist on the same server under different controls and constraints.

Endpoints gain access to conferences through Conference Server conference control centers and conferencing applications. The mode of access depends on the restrictions of the conference and the feature set of the conferencing application.

H.323 protocol endpoints can connect to a Conference Server conference via standard H.323 protocol methods. They can connect through Conference Server's integrated gatekeeper or a third-party gatekeeper controlling the zone. Endpoints can also connect directly to a Conference Server if allowed. If increased security is desired (going beyond the basic H.323 standards), users can be required to access Conference Server's User Authentication Web page for username/password authorization before entering a conference. Conference Server can also call out to H.323 protocol clients.

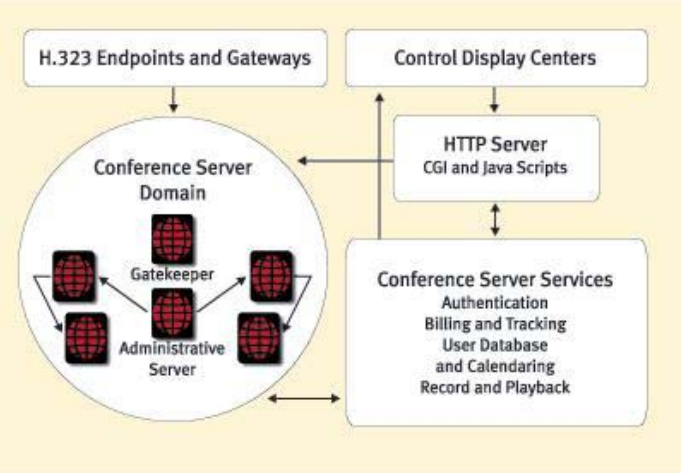

Figure 4: Conference Server Top-level View

Conference Server registers its conferences via aliases to the gatekeeper. This provides a way for endpoints to join a particular conference to attend.

Many H.323-protocol endpoints act differently during the connection sequence between the H.323 and T.120 protocols. To assure connection and proper conference selection, Conference Server supports multiple lead first and callout scenarios. How the endpoints act during connection has been clarified in the H.323 Version 2 standard, which Conference Server has supported since release 4.0.

Conference Server Domain

A Conference Server domain consists of one or more Conference Servers and, optionally, a gatekeeper.

One Conference Server in the domain must be designated as the administrative server. The administrative server stores and propagates conference configuration information to all servers in the Conference Server domain. Any server in the domain can be designated the administrative server. A stand-alone Conference Server serves as its own administrative server.

Conference Server's domain is scaleable to any number of Conference Servers managed by a single administrative server.

Endpoints access Conference Server by connecting to a conference on the server. Conferences can include any or all part of group interactive audio, video, and multimedia data.

The Conference Server domain can support any number of conferences. Each conference can be distributed to any subset of the servers in the domain with any linkage.

Individual Conference Servers in the domain are automatically configured to interact with third-party services to fulfill the defined conference settings, such as recording and billing/tracking. (This is very important when a conference is hosted across multiple servers.)

Client connections can be distributed over multiple servers via authentication.

Control Display Centers

The HTML, Java, and CGI scripts added to the Conference Server domain of servers make up the available control centers. These control centers can easily be updated or extended at any time. Each can contain its own control and feature set of the services offered, as the MeetingPlanner applet demonstrates.

Access to these control centers is available anywhere on the network via HTTP communication from a Web browser to an HTTP server. HTTP communications invoke Java and CGI scripts, which access Conference Server's databases and the individual Conference Servers in the domain.

The administrative control center (Conference Server's Conference Administrator Web pages or Web-based GUI) allows for overall Conference Server domain control, layout, conference setup, user/group privileges assignment, and monitoring.

Moderator control centers are configurable by administrators to allow end user-based conference creation, invitation, control, and monitoring.

Endpoint control centers allow for user authentication, directory services, conference listing, and connection. Conference Server's User Authentication Web page is an endpoint control center that can automatically direct endpoints to a Conference Server based on heuristics such as server location, CPU utilization, and functionality matching.

Conference Server Services

A Conference Server domain is configured to include and interface via control centers with the following services:

Authentication: Username/password authentication and restrictions via the user database controlled by Conference Server's Conference Administrator Web pages and optionally tied into RADIUS services.

Billing and tracking: Billing of authenticated users based on tracking parameters such as connection time and bandwidth used, as reported by individual Conference Servers. This information can be logged or reported to a RADIUS server or to Conference Server for automated billing.

User database: A database that gives or restricts Conference Server access to users based on username/password pairs. This includes per-conference access and rights such as administrator, moderator, or general user. This can be the Conference Server database or a RADIUS database.

Conference database: Conference configuration information for all the conferences in the Conference Server domain. This data is cached on each of the servers in the domain. The administrative server is responsible for distributing and synchronizing all the servers in the domain.

Scheduling and calendaring: Conference scheduling information is stored in the conference database and optionally with a third-party calendaring system. Each Conference Server knows to initiate a conference based on information in the conference database.

Record/playback and real-time streaming services: A selected server in the Conference Server domain accesses streaming services to record a session for later playback or for real-time streaming broadcast to non-interactive viewers.

Conference Server H.323 MCU and Gatekeeper

The H.323 specification describes the H.323 protocol as follows:

"H.323 allows multimedia streaming over current packet-switched networks. To counter the effects of LAN latency, H.323 uses as a foundation the Real-time Transport Protocol (RTP), designed to handle the requirements of streaming real-time audio and video over the Internet."

The H.323 standard specifies the three command and control protocols as:

H.245 protocol for call control: Responsible for control messages governing operation of the H.323 protocol terminal, including capability exchanges, opening and closing logical channels, and communicating preference requests, flow control messages, and general commands and indications.

Q.931 protocol for call signaling: Used to set up a connection between two terminals.

RAS (Registration, Admissions, and Status) signaling function: Used for gatekeeper control. RAS governs registration, admission, bandwidth changes, status, and disengage functions between endpoints and gatekeepers. RAS is not used if a gatekeeper is not present.

The H.323 specification defines four major components for a network-based communications system:

Terminals: Terminals are the client endpoints on a network that provide real-time, two-way communications. All terminals must support voice communications; video and data support are optional.

Gateways: A gateway is an optional element in an H.323-based conference. Gateways bridge H.323-based conferences to other networks, communications protocols, and multimedia formats. Gateways are not required if connections to other networks or non-H.323-compliant terminals are not needed. A gateway usually consists of a unique hardware component that allows PSTN, ISDN, or ATM and LAN Ethernet connections, along with the software that supports the alternate connections (such as H.320 or H.321 based connections). Conference

Server is designed to work seamlessly with gateways that implement the H.323 standards.

Gatekeepers: Gatekeepers perform two important functions that help maintain the robustness of the network — address translation and bandwidth management. Gatekeepers map LAN aliases to IP addresses and provide address lookups. Gatekeepers also exercise call control functions to limit the number of H.323 based connections, and the total bandwidth used by these connections, in an H.323 “zone”. A gatekeeper is not required by the H.323 standard. However, if a gatekeeper is present, it is mandatory that terminals should make use of the services it offers.

Multipoint Control Units (MCUs): Supports conferences between three or more endpoints. An MCU consists of a Multipoint Controller, which is required, and zero or more Multipoint Processors.

- **Multipoint Controller (MC):** Handles H.245 negotiations between all terminals to determine common capabilities for audio and video processing. The MC also controls conference resources by determining which, if any, of the audio and video streams will be re-distributed via unicast or multicast.
- **Multipoint Processor (MP):** Handles multimedia data manipulation such as mixing, switching, conversions, prioritization, etc. This is optional. Most servers mix the audio into one stream, or video from multiple sources into one source, or switch between video sources, for endpoints that only support one video stream.
- Conference Server is a full H.323 based MCU including both the MC and MP components and an integrated gatekeeper. The following information describes Conference Server and its H.323 based components. Figure 5 illustrates this information.

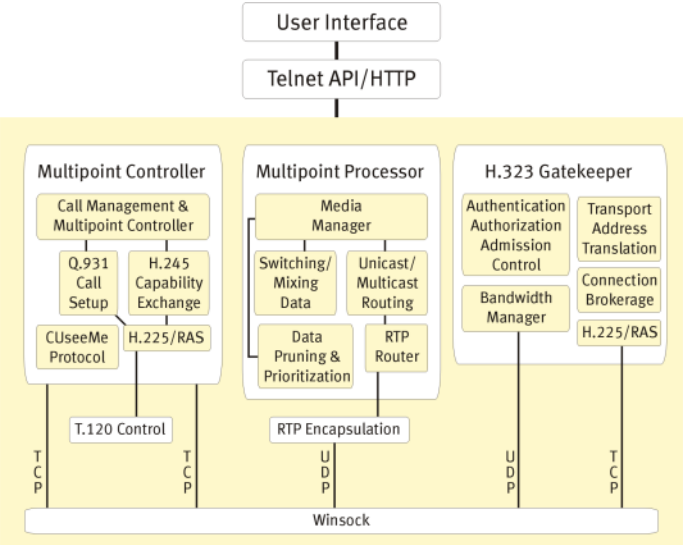

Figure 5: Conference Server H.323 MCU

Conference Server **Multipoint Controller (MC):** The MC built into Conference Server adheres to all the requirements of the H.323 standard. Its basic functionality is to process incoming connections and create outgoing invitations to endpoints. During the connection process it is responsible for determining the capabilities of the endpoint versus the settings of the conference. It then sets up the appropriate media channels based on those matching requirements. Conference Server's MC is also responsible for interacting with the endpoint to list and select which conference to connect to. It reports these findings to Conference Server's Multipoint Processor (MP) so that the MP knows how to handle data from the negotiated channels.

In addition, Conference Server's MC contains protocols that enable backward compatibility and protocol conversions to allow older versions of CUseeMe protocol clients to participate in a conference with or without other H.323 protocol endpoints. The Call Management and Multipoint Controller module manages, via the Telnet API and CUseeMe protocol, additional multipoint conference controls to allow for individual or moderator control of a conference. As conferencing clients progress towards full support of the H.323 standard, and the H.323 implementation guide is further clarified, Conference Server will add H.323 standards-based conference control. The Call Management and Multipoint Controller will manage this via H.225 based mechanisms.

Implemented, but not depicted in the diagram, is access by the Call Management and Multipoint Controller to a subset of the same authentication schemes used by the gatekeeper. This allows or denies entry to a conference when a gatekeeper is not used.

Conference Server Multipoint Processor (MP): The MP built into the Conference Server contains all the media control and manipulation features for a group conference. The main functions, as shown in Figure 5, are:

Media routing: Unicast and multicast control of media. This object insures that Conference Server routes the correct media to each endpoint in a method the endpoint expects. This could mean a direct unicast stream, an indirect unicast stream to another MCU, a unicast-to-multicast conversion, or a multicast stream created by another endpoint. Note that Conference Server supports unicast and multicast connections to CUseeMe protocol client endpoints, and only unicast connections to H.323 protocol endpoints.

Switching and mixing of media: Before routing a media stream, Conference Server's MP identifies and processes the incoming source based on media type, conference settings, and the dynamic status of the data (e.g., active speaker). The MP then categorizes and buffers the processed data for delivery to the associated endpoints.

Media pruning and prioritization: After the MP processes the data, but before it is delivered to each endpoint, the data is passed through Conference Server's Bandwidth Manager for prioritization and pruning based on current network dynamics.

Media Manager: Depending on the conference settings, and the feedback loops on the media processor objects, the Media Manager routes the data through the different processor objects and schedules it for delivery to the endpoints through the RTP encapsulate.

RTP Encapsulate: The RTP Encapsulate creates packets with the RTP headers appropriate to the media type. It also decodes incoming packets and directs them to the appropriate media processor.

Conference Server Gatekeeper: The Conference Server gatekeeper and its interface to remote third-party gatekeepers does basic connection brokering. The gatekeeper allows endpoints to register for invitations, and Conference Server to register conferences, by way of terminal aliases. After deciphering a request to join a conference via an alias, Conference Server's gatekeeper authenticates and authorizes the endpoint and then pre-negotiates bandwidth constraints on the endpoint. The gatekeeper then routes the connection to the MC for processing.

T.120 MCU

The T.120-based MCU built into Conference Server is compliant with T.120 standards as described below.

T.120 system model: The T.120 model is comprised of a communications infrastructure and the application protocols that make use of it. Figure 6 shows the full model with both standardized and non-standardized applications. The model serves to show both the scope of the T.120 suite of recommendations (indicated by the shaded background) and the relationship between each of the recommendations and other components in the system.

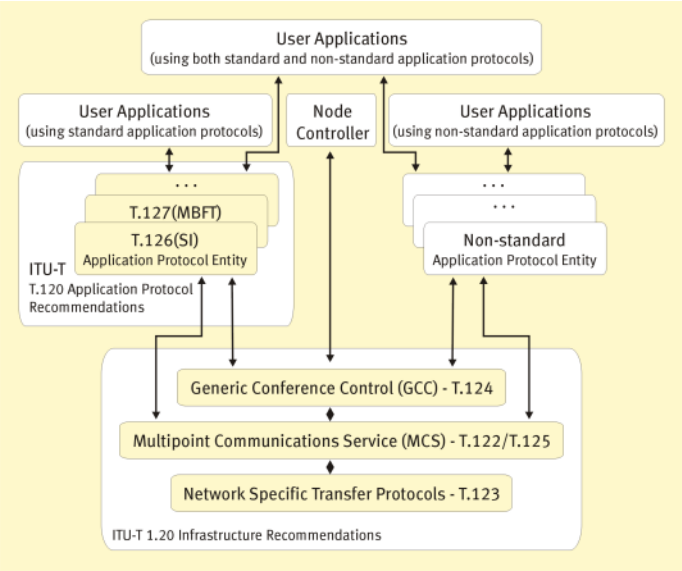

Figure 6: T.120 Protocol Layers

User applications: Applications, as such, are not the subject of standardization in the T.120 series of standards. Applications that use the services offered by the T.120 series will generally be multipoint aware and be designed to use the T.120 based services provided by Generic Conference Control and Multipoint Communications Service (defined below). These applications are termed User Applications and they may use any combination of standard and non-standard protocols to communicate with peer-user applications. The T.120 protocol environment supports multiple user applications concurrently operating in the same conference by providing mechanisms for the applications to coordinate the use of communications resources. The Generic Application Template (T.121 standard) provides guidance to user application developers on how to utilize the T.120 based infrastructure in a coherent and consistent way.

Application protocols: Application protocols comprise a set of Protocol Data Units (PDUs) and associated actions for application peer-to-peer(s) communication. The T.120 series of standards includes a set of application protocols designed to meet the needs of multipoint conferencing. These protocols define minimum requirements in order to ensure interoperability between different implementations.

The T.121 standard presents templates and guidelines that may assist in the definition of new application protocols. The T.127 standard provides simultaneous multipoint file transfer. The T.126 standard provides still image viewing and annotation, shared whiteboard, and facsimile. A given application may use any combination of standard and proprietary application protocols.

An Application Protocol Entity is an instance of an Application Protocol. It is made up of two functional components: the Application Resource Manager (ARM) that provides the generic functionality relevant to all protocols and the Application Service Element (ASE) that provides the application specific functionality.

Node Controller: The Node Controller provides the T.120 management role at a terminal or MCU. It issues primitives to the Generic Conference Control (GCC), which starts and controls the communication session. The Node Controller itself is outside the scope of the T.120 series recommendations, and only where it communicates to GCC are its interfaces defined.

Communications infrastructure: The communications infrastructure provides multipoint connectivity with reliable data delivery. It can accommodate multiple independent applications concurrently using the same multipoint environment. Connections between nodes can be any combination of circuit-switched telecommunications networks and packet-based LANs and data networks. The T.120 based infrastructure is composed of three standardized components: Generic Conference Control (GCC), Multipoint Communication Service (MCS) and Transport Protocol Profiles for each of the supported networks.

- **Generic Conference Control (GCC; T.124 standard):** GCC provides a set of services for setting up and managing the multipoint conference. It provides access control and arbitration of capabilities. GCC facilities are used by applications to coordinate the use of MCS

channels and tokens within the same multipoint domain. Nodes can join and leave meetings at any time and GCC facilities can be used to query an MCU or multiport terminal node to find a desired conference. Multiple applications can be running on any given node and can be dynamically launched, used, and shut down during a meeting. As part of the management role, peer GCC providers exchange information about the applications present and their capabilities. GCC also makes a centralized registry facility available to applications in order to identify dynamically assigned channels and tokens.

- **Multipoint Communications Service (MCS; T.122/125 standards):** MCS provides a general multipoint connection-oriented data service. It collects point-to-point transport connections and combines them to form a multipoint domain. Within that domain a large number of logical channels are provided that can provide one-to-one, one-to-many and many-to-one data delivery. Nodes within an MCS Domain are hierarchically organized in a tree structure. Data delivery normally follows the most efficient path to the nodes that are to receive the data, but a mechanism is provided to guarantee that data originating from different nodes is received in the same sequence at all nodes. MCS acts as a resource provider to the layers above, independent of the underlying network, providing channels and token resources on demand. A large number of tokens are provided for applications to use for coordinating events and processes.
- **Transport Protocol Stack Profiles (T.123 standard):** MCS expects its underlying transport connections to provide reliable point-to-point sequenced data delivery of its PDUs and to segment that data if necessary. The T.123 standard specifies a protocol stack for each particular network supported. This standard presents a uniform OSI Transport Service interface to the MCS layer above.

Not all of the T.120 protocol provisions are mandatory: the T.123, T.122/125, and T.124 protocols are mandatory for conferencing and group-working environments. The remainder are conditional: where functionality covered by the standards is provided, the standard protocols of the T.120 series must be implemented. This ensures that it is always possible to achieve a basic level of interoperability, and does not prohibit customized enhancements and negotiation of proprietary modes if (and only if) all participating elements are able to support such modes.

Summary

The Conference Server is, the IP solution of choice. Conference Server has been available for six years, has a great track record and a tremendous number of deployments worldwide, especially in the Department of Defense. It runs on multiple platforms and operating systems, and provides for centralized as well as distributed deployment scenarios.

Glossary

Administrative server – The Conference Server that maintains the conference configuration file for all Conference Servers in your Conference Server domain.

Administrator – The person responsible for setting up and monitoring the Conference Server(s).

Application sharing – A feature in some T.120-based conferencing programs that allows users on different computers to simultaneously use an application that resides on only one of the computers.

Backbone – High-speed lines or connections that link networks together.

Bandwidth – The amount of information a connection can handle. It is usually measured in bits per second (bps) or thousands of bits per second (kbps).

CIF – Common Intermediate Format (also known as Full Common Intermediate Format, or FCIF); a 352 x 288 pixel video format that is described by the International Telecommunications Union's (ITU) H.323 standards.

Client – The conferencing application that a person uses to connect to a Conference Server.

Codec – COmpression/DECompression; Any hardware device or software algorithm that converts analog video or audio between uncompressed analog and compressed digital formats.

Conference – Any type of group interaction that Conference Server hosts, such as cybercasts, small-group videoconferences, or large group interactive discussions.

Conference server – Server software providing multimedia group interaction across IP networks; specifically, First Virtual's Conference Server software.

Continuous Presence – Combining multiple participant video streams into a single composite video.

Data compression – A technique that systems use to save bandwidth by eliminating empty fields, gaps, redundancies, and unnecessary data, to reduce the amount of information being sent.

Data sharing – See Document sharing

Data stream – The audio, video, and/or text information that participants generate when taking part in a conference.

Document sharing (document conferencing) – the process by which users on different computers share applications and/or jointly edit text and graphics files.

Endpoint – For the H.323 standard, an endpoint is an element capable of receiving or initiating calls, such as a terminal, gateway, or multipoint control unit (MCU).

Firewall – Networking software that controls the type of protocol messages that pass back and forth across a software "wall".

Gatekeeper – A gatekeeper is an H.323-protocol entity that provides address translation and controls access to the local area network for H.323-protocol terminals, gateways and multipoint controls units.

Gateway – Provides for H.320- to H.323-based communications. A gateway translates the streaming media from a switched circuit network (H.320-protocol clients) to the packetized data required by an IP or packet-based network (H.323-protocol clients).

H.320 standard – A suite of ITU standards that define real-time multimedia communications and conferencing over switched digital services such as ISDN, Fractional T1, and Switched 56 service.

H.323 standard – A suite of ITU standards that define real-time multimedia communications and conferencing for packet-based networks.

Internet – A global network that uses the TCP/IP protocol.

Internet Service Provider – A company that provides a connection to the Internet for a fee.

ISDN – Integrated Services Digital Network; a high bandwidth network used to move large amounts of data over phone lines.

LAN – Local Area Network; a network made up of two or more computers connected together. They are usually within the same building or within a very short distance (a mile or less) to each other.

MBONE – Multicast Backbone; a multicast network layered on top of the Internet. It connects multicast routers separated by links that do not support IP Multicast.

MCU – See Multipoint Control Unit.

Conference Server domain – A group of Conference Servers that share a central user database and master configuration file.

Multicast – The transmission of data to a group IP address. Multicast configurations send one stream of information (audio, video, or data) across the Internet instead of multiple streams to a specific destination.

Multipoint Controller (MC) – Handles H.245-based negotiations between all terminals to determine common capabilities for audio and video processing.

Multipoint Control Unit (MCU) – A multipoint control unit is an endpoint on the local area network that provides support for multipoint conferences between three or more endpoints. An MCU manages conference resources, negotiates capabilities between endpoints, and more. Conference Server is a multipoint control unit.

Multipoint Processor (MP) – Handles multimedia data manipulation such as mixing, switching, conversions, prioritization, etc.

Observer – A conference participant who cannot interact with other observers in the conference.

Packet switched – A method of moving packets of data along the network. Each packet contains the address of where it is from and where it is going.

Participants – Anyone taking part in a Conference Server conference.

Point-to-point – A connection between two users without the use of a Conference Server.

Port – A specific location within a computer's TCP/IP stack.

POTS – Plain Old Telephone System.

PPP – Point-to-Point Protocol; a protocol that allows the computer to make a TCP/IP connection using a telephone line and a modem.

Protocol – Allows programs on different computers to communicate.

PSTN – Public Switched Telephone Network.

QCIF – Quarter Common Intermediate Format; a 176 x 144 pixel video format defined by the ITU's H.323 standards.

RADIUS – Remote Authentication Dial-In User Service (RADIUS) protocol is used for carrying authentication, authorization, and configuration information between a Network Access Server and a shared Authentication Server.

RAS messaging – Registration, Admission, and Status messages sent between an H.323-protocol gatekeeper and H.323-protocol endpoints.

Router – A computer system or software package that connects two or more networks. Routers look at the destination addresses of the IP packets and forward them to the correct address.

Secondary Conference Server – A Conference Server that receives data streams from a primary Conference Server in a one-way multi-server conference.

SLIP – Serial Line Interface Protocol; a protocol that allows a computer to use a telephone line and a modem to connect to the Internet.

SQCIF – Sub-Quarter Common Intermediate Format; a 128 x 96 pixel video format defined by the ITU's H.323 standards.

Stream – The audio, video, and/or text information that participants generate when taking part in a conference. Also called data stream.

Streaming media technology – An encoding and delivery system for broadcasting live or on-demand multimedia streams over IP-based networks.

T.120 standard – The ITU standard that defines the document-sharing (data conferencing) portion of a multimedia conference.

TCP/IP – Transmission Control Protocol/Internet Protocol; the protocol that defines the Internet.

Telnet – Communications network that allows computers to exchange information. It allows you to login from one Internet site to another.

Terminal – An H.323-protocol terminal is an endpoint on the local area network that provides real-time voice and, optionally, video and data communications with another H.323-protocol terminal, gateway, or multipoint control unit.

Unicast – A point-to-point connection, where data is sent from one sender to one receiver over an IP network. Conference Server manages multiple unicast connections simultaneously.

URL – Uniform Resource Locator; an "address" used to locate information on the Internet.

Videoconferencing – Software and hardware that allows users to see and hear each other using various computer and communication systems.

WAN – Wide Area Network; a network made up of two or more networks located in different locations using telephone lines.

Whiteboard – A document conferencing function that allows multiple users on different computers to simultaneously view and annotate a document with pens, highlighters, and drawing tools.

World Wide Web – www; resources available using Internet tools such as FTP, browsers, etc. to gain access to the information.

Zone – The collection of all terminals, gateways, and multipoint control units managed by a single H.323-protocol gatekeeper.

Legal and Contact Information

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