White Paper

Interactive Multicast Technology

Changing the Rules of Enterprise Streaming Video

A Technical Perspective

VCON
VISUAL COMMUNICATIONS

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Introduction

Time is probably the most valuable resource that businesses today consume in quantities, and there never seems to be enough of it. In a paper published by MCI, referencing a recent National Statistics Council survey about meeting behavior in America, they claim that 37% of employee time is spent in meetings, and that there are 11 million business meetings every day. This survey also indicates that attending a four-hour meeting in person can cost overall more than 16 hours of planning, traveling, meeting and follow-up. According to this report, traveling is the most expensive aspect of these personal meetings.

Many companies and institutions are turning to video-based applications to reduce travel costs, improve efficiency and extend the reach and range of all types of services. For years, videoconferencing has been the video application of choice for most companies. Videoconferencing is fully interactive, and is certainly the technology of choice for point-to-point conferences between two locations. However, when multiple locations must participate simultaneously (like a conference call), special networking equipment is required to bridge the participants together, similar to an audio bridge.

Many companies are searching for a complementary technology that is better suited for broad-based video communications. This technology is needed to reach hundreds or thousands of participants simultaneously - without complex configuration or management requirements. The technology they are turning to for enterprise deployment is IP Multicast. As an industry standard, IP Multicast exploits the ubiquity of the Internet Protocol (IP), which is by far the dominant networking protocol for data communication.

One of the biggest benefits of IP Multicast is its ability to stream audio and video to hundreds or thousands of users. The biggest pitfall is that all of these users must be passive participants. In other words, IP Multicast does not have a built-in mechanism for active interaction among the participants. This is where traditional videoconferencing has its biggest advantage - the ability to fully interact with the other parties in the videoconference.

VCON has changed all of this with an exclusive new technology called Interactive Multicast. It allows users, for the first time, to enjoy IP multicast, or streaming video with the true interaction that a videoconference gives. Interactive Multicast delivers the ability to multicast audio and video to participants using VCON endpoints or standard multicast viewers, while allowing any participant using a VCON system to fully interact during the conference. With Interactive Multicast, the source for an audio/video stream can be moved among the various participants during the multicast, allowing interactivity on an unprecedented scale. This award-winning technology from VCON delivers new, cost-effective opportunities for communication applications, and is particularly beneficial in corporate communications, training and distance learning settings.

This white paper describes the key technologies surrounding IP Multicasting & streaming video, and the solutions associated with deploying video applications on an IP network. As such, it is targeted primarily at the executive either considering or implementing an IP video deployment. As both a market share and technology leader in IP videoconferencing, VCON knows a great deal about deploying video applications on an IP network. This white paper breaks down the various deployment issues by describing how they apply to IP multicasted video and how they can be resolved. However, like many network design and deployment issues, there is no single solution that addresses all network topologies and configurations. Therefore, the issues and solutions described in this white paper should be treated as guidelines or design considerations. Ultimately, it is up to the network manager to make the final decision about how to best meet the service level commitments to his/her end user constituency.

IP Multicast Technology in a Nutshell

When sending the same data to multiple users, IP Multicast is a technology that provides a workable solution to a real problem. Any form of network communication that involves the transmission of information to multiple recipients can benefit from the bandwidth efficiency of multicast technology.

IP Multicasting is defined (RFC 1112, 'Host Extension for IP Multicasting', Steve Deering, 1989) as the transmission of datagrams (UDP packets) to a set of hosts through a single IP destination address. Each member of the set, known as a host group, then picks up the datagrams from the host-group address. Because IP Multicasting uses a virtual IP destination address to reach the host group, the sender does not need to know the connection details of, or have a direct connection to, all the members. Unicast, on the other hand, requires that the identification of each connection be known.

Comparing the two methods of transferring data to multiple users emphasizes the benefits of IP Multicasting. While the Unicast method sends multiple copies of data, one copy for each receiver, IP Multicast sends only one copy for all of the receivers at once (see Fig 1). Thus, multicast transmission reduces traffic load significantly, allowing multi-point conferencing to occur over any existing network infrastructure, typically with little extra cost or replacement of equipment. Bandwidth is more efficiently utilized, resources are saved, and datagrams are transmitted with less processing.

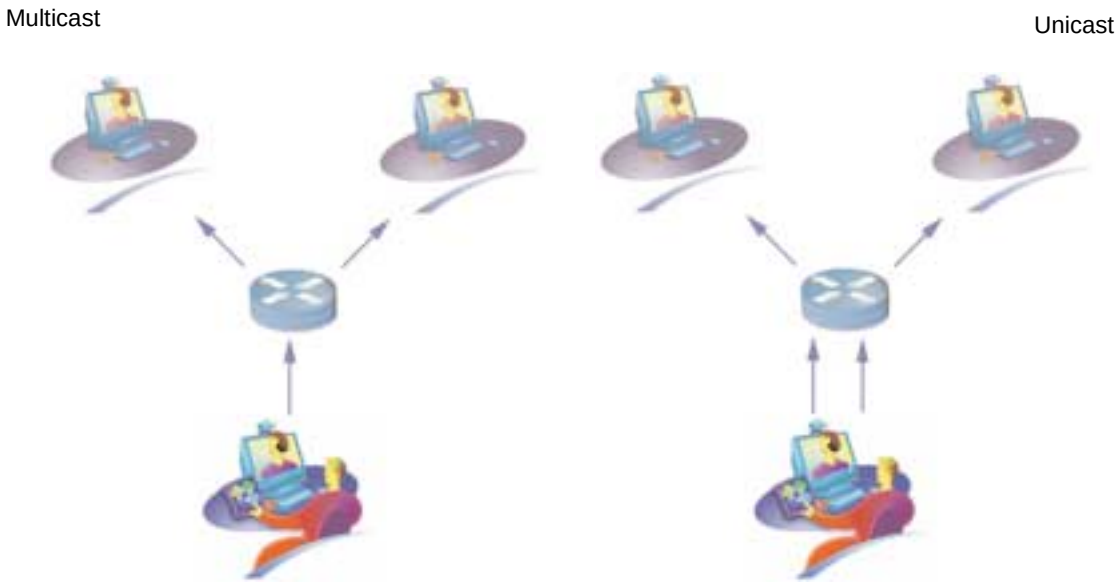


Fig 1: IP Multicast provides more bandwidth economy than Unicasts

IP Multicast Requirements

According to Stardust Technologies, Inc. the following are the requirements for the sending and receiving endpoints and the network infrastructure needed for IP Multicasting over a LAN segment:

- Support for IP Multicast transmission and reception in the TCP/IP protocol stack
- Network Interface Cards (NIC) and drivers, which efficiently filter for LAN Data Link Layer (layer 2) addresses mapped from Network Layer (layer 3) IP Multicast addresses
- IP Multicast application software, such as for video communications.

To run IP Multicast on a LAN segment, only the above are needed. No routers need be involved for a host's adapter to create or join a multicast group, and share multicast data with other hosts on that LAN segment.

To expand IP Multicast traffic from a single LAN segment to a WAN or to a complex LAN environment requires the following:

- All intermediate routers between the sender(s) and receiver(s) must be IP Multicast-capable. Many new routers support IP Multicast. Older ones may require more memory before they can be upgraded.
- Firewalls may need to be reconfigured to permit IP Multicast traffic.

IP Multicast has a broad and growing industry backing, and is supported by many vendors of network infrastructure elements such as routers, switches, TCP/IP stacks, Network Interface Cards, Desktop Operating Systems and Application software. Your vendor can help you select appropriate hardware and software.

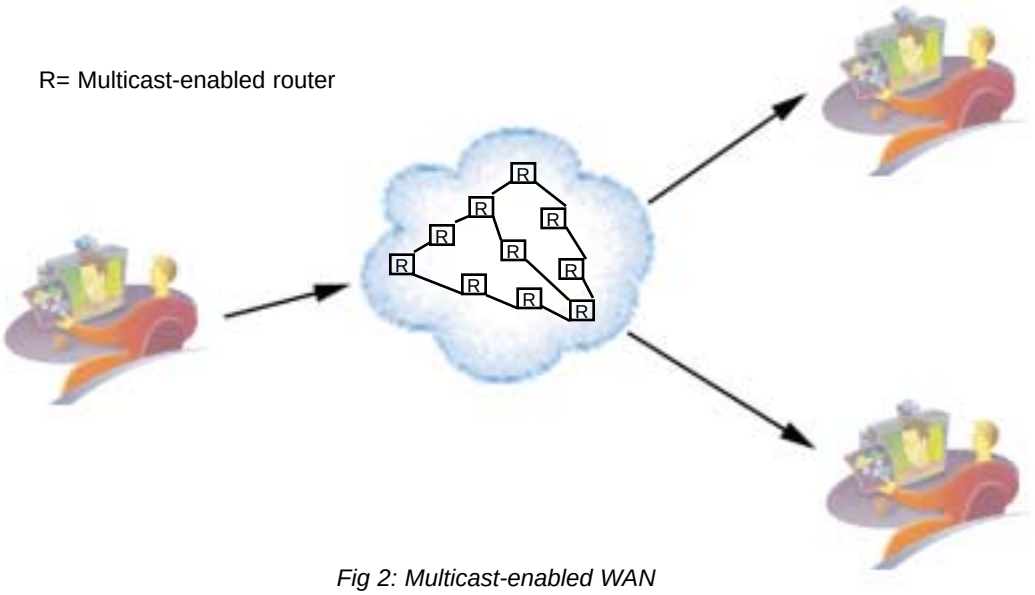


Fig 2: Multicast-enabled WAN

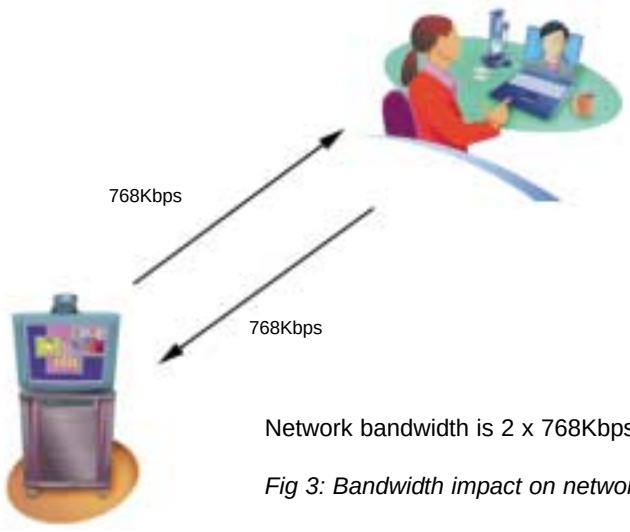
Bandwidth and Traffic Load

In a Circuit-Switched telephony environment, users in a conference need not be network-aware, since they are not sharing resources with other subscribers. They own resources for the duration of the conference. At the end of the call, they free these resources for other conferences. However, in packet-switched IP-based networks the story is different. In most IP-based networks, endpoints are nodes on the same network and therefore, they share resources. The overall network has a well-known (and in most cases, limited) capacity to carry traffic, also referred to as bandwidth. All nodes that are on the same network share the overall bandwidth of the network. Therefore, the sum of the traffic streams generated by all nodes on the same network cannot exceed the total capacity. In practice, however, the nodes should not use more than 40% of the 'prescribed' bandwidth for the overall network. Typical IP-based networks today will carry either 10 Mbps or 100 Mbps in a shared or switched topology.

When the network is utilized beyond its reasonable capacity to carry traffic, collisions of transmitted packets may occur and these packets are immediately discarded. Thus, the sending endpoint re-transmits its lost packets again (and again) until the receiving endpoint acknowledges the acceptance of the complete transmission. Depending on network design and topology, transmitting and re-transmitting may take a while, in which time the user experiences a delay. As long as the applications that generate traffic are not real-time applications, collisions are permitted up to a certain degree and are neither noticeable by the users nor considered to be disturbing. Examples of non real-time applications are sending/receiving e-mail messages by employees, web surfing, sending print jobs to network printers, etc. In all of these cases, users experience random delays while completing a task, but generally don't mind waiting for a while. Real-time applications, such as conferencing and especially audio and video applications pose different challenges and demand that stricter criteria be met. The following are a few examples.

- Delays, which are commonplace in non real-time applications, are unacceptable in real-time network communication.
- Lip synchronization (audio and video streams arriving together) is imperative.
- Retransmission of audio streams is unacceptable.
- Packets must arrive in an orderly sequence.

When two endpoints (or users) are videoconferencing, they are duplicating the allocation of bandwidth separately on the network, leaving much fewer resources for other endpoints. In the following example, the videoconferencing is symmetric (sender and receiver use the same bandwidth) and is set to 768 Kbps at each endpoint. We refer to it as a 768 Kbps videoconference. The total bandwidth impact on the network is 2 x 768, or 1.5 Mbps. (plus standard IP overhead of 10-20%).



Network bandwidth is 2 x 768Kbps or 1.5Mbps

Fig 3: Bandwidth impact on network

When three or more endpoints (or users) wish to conference at a certain bandwidth, say 768 Kbps, they all subtract usable bandwidth from the other nodes on the network at a rate of 1.5 Mbps per endpoint. Quick calculation reveals that multipoint videoconferencing over the IP network is not only an issue of audio and video quality, but also an issue of bandwidth management that every network manager must carefully consider.

Remember that with IP Multicast, only a single stream of audio and video packets is placed on the network. Every participant in the multicast receives a "copy" of this same stream. Therefore, the bandwidth impact of IP Multicast applications is considerably less than multipoint videoconferencing.

Time To Live (TTL)

Each IP Multicast packet uses the Time-To-Live (TTL) field of its IP header as a scope-limiting parameter. This mechanism prevents messages from needless transmission to regions of the worldwide Internet that lie beyond the subnet containing the Multicast group members. The TTL field controls the numbers of hops that an IP Multicast packet is allowed to propagate. Each time a router forwards a packet, its TTL decrements. A multicast packet whose TTL has expired (is 0) is dropped, without an error notification being sent to the sender.
A local network multicast reaches all immediately neighboring members of the destination host group (that IP TTL is 1 by default). If a multicast datagram has a TTL greater than 1, the multicast router(s) attached to the local network takes responsibility for internetwork forwarding. The datagram is forwarded to other networks that have members of the destination group. Multicast-enabled routers on member networks that are reachable within the IP time-to-live complete delivery transmit the datagram as a local multicast.

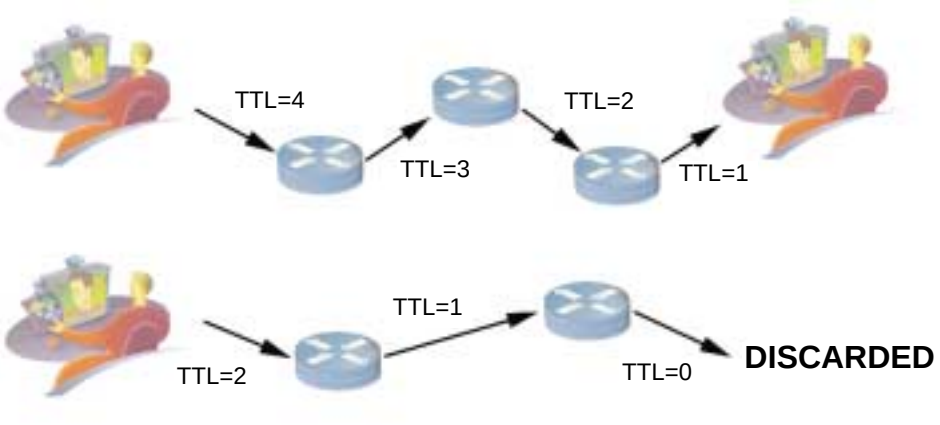


Fig 4: The TTL field controls number of hops

Internet Group Management Protocol (IGMP)

Internet Group Management Protocol (IGMP) is the vehicle by which host systems communicate over IP Multicast technology. IGMP manages the processes (specialized communication programs executed by the operating system of their host) which join a host to a multicast group on a given interface. Additionally, multicast-enabled routers use IGMP messages to keep track of group membership on each of the routers' physically attached networks. According to W. Richard Stevens, author of the well-known series of 'TCP/IP Illustrated', the following rules apply:

- A host sends an IGMP report when the first process joins a group. If multiple processes on a given host join the same group, only one report is sent for the first time a process joins the group. This report is sent out on the same interface that the process joined the group.
- A host does not send a report when processes leave a group, even when the last process leaves the group. The host knows that there are no members in a given group, so it doesn't report the group when

it receives the next query (next step).

- A multicast-enabled router sends an IGMP query at regular intervals to see if any hosts still have processes belonging to any group. The router must send one query out for each interface. The group address in the query is 0 since the router expects one response from a host for every group that contains one or more members on that host.
- A host responds to an IGMP query by sending one IGMP report for each group that still contains at least one process.

Using these queries and reports, each multicast-enabled router keeps a table of its interfaces with hosts in a multicast group. Thus, when the router receives a multicast datagram to forward, it is able to forward the datagram only out to the interface that still has hosts with processes belonging to that group.

IGMP updates are used by multicast routing protocols to communicate host group membership to neighboring routers and to propagate group information through the internetwork. IGMP is used to identify the designated router in the LAN for this purpose. Thus, multicast-enabled routers are aware of the current status of the other routers, in terms of their abilities to carry multicast traffic.

A router can support IP Multicast using one of several routing protocols: the Distance Vector Multicast Routing Protocol (DVMRP); the Multicast Open Shortest Path First protocol (MOSPF); or Protocol Independent Multicast (PIM). In this document, we only briefly mention the technical issues surrounding IP Multicast routing, as our main interest is currently the overall concept and the endpoints that participate in an IP Multicast videoconferencing.

The Missing Interactivity: VCON's Interactive Multicast

Applications such as all-employee announcements, corporate training and video-on-demand (VoD), are good examples for the immediate use and implementation of IP Multicast technology. However, videoconferencing is an interactive application by its nature. Participants in a multipoint meeting, a corporate training session, or in other distance learning applications, expect to be able to interrupt the speaker and voice their opinions, or to raise a question from time to time. Even in the most organized meeting or well-behaved class the interaction between participants is desired and constructive. Therefore, any true multipoint conferencing solution should consider this need as well. Unfortunately, IP Multicast does not include this service in its standard form. VCON decided to keep the advantages of IP Multicasting, while enabling the missing interactivity for true visual meeting technology. The result is VCON's Interactive Multicast technology.

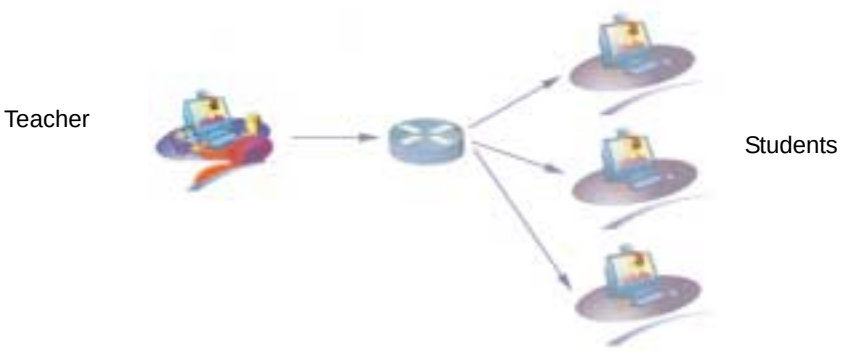


Fig 2: Interactive meeting, such as distance learning

A Meeting Anatomy

In any organized meeting, there is a chairperson that controls and facilitates the flow of the meeting. We will use the terms, 'chair' and 'participants', to distinguish the role of the meeting's chairperson from that of the other participants. When the chair speaks, everyone else is quiet. Participants who wish to speak, gesture to the chair, such as raising a hand, to get the chair's attention without interrupting the flow of the meeting, and without drawing special attention to themselves. Sometimes this can be done by passing a note, with a short purpose statement or an explanation for the request to speak. The chair may receive, in short intervals, a number of requests to speak from different participants. The chair has both the responsibility and the authority to decide who will be permitted to speak next. We will use the term 'floor' to signify that the chair gives permission to a participant in a meeting to speak. The chair's role is, therefore, to pass the floor between participants. Taking back the floor from a participant and passing it on to someone else is included in this role. In extreme cases, the chair is entitled to remove a participant from the meeting. The chair can also summon additional staff members that were not present when the meeting was initiated. Finally, such a meeting may include participants from different locations by means of audio-conferencing and videoconferencing. Now, using VCON Interactive Multicast, the interaction between a large group of people over video can occur in a very similar way.

In Interactive Multicast, there is a Chair - the person that started the conference and is ultimately in control of who speaks, who joins the discussion and when the conference begins and ends. In many cases the Chair will also be themain speaker during the Interactive Multicast. The Participants in the conference have the ability to ask questions via text chat or to "raise their hands" by pushing a button and letting the Chair know they want to talk. The conference can be password protected, so that only authorized participants may attend. The conference can be open to multicast viewers, which allows a user with a multicast viewer on their desktop to dial the IP address of the conference, give the password if needed, then join the conference as a passive participant - able to see the "podium" being moved from Participant to Participant and back to the Chair - but unable to ask a question or speak in the conference. VCON's Interactive Multicast technology allows all of this within the confines of a video-based conference.

Illustrated Case Study - Weekly Staff Meeting

In a multicast conference, identical video streams, audio streams, and data packets are sent from one site. The initiating site (Chair) calls other sites (Participants) at the start of the conference and controls its progression. Other Participants may join in a multicast conference while it is in progress.

At the time of the meeting, the Participants join the meeting by calling David. David can also call others and invite them directly to participate. At the start of the conference, the Participants receive audio and video from the Chair.

The Chair controls the conference. The Chair determines if other Participants can contribute questions, join in discussions, and have their video displayed. The Chair can disconnect any participant or terminate the conference.

Suppose that a Participant wants to ask the Chair a question, speak to everyone, or send a short message to the Chair.

1. The Participant clicks one of the following:

Request Floor	The Participant wants to speak and be seen by the other participants. In the Chair dialog box, the Video icon appears next to the name in the Request column. To cancel the request, the participant clicks this button again.

Request Audio	The Participant wants to speak without being seen. In the Chair dialog box, the Audio icon appears next to the name in the Request column. To cancel the request, the participant clicks this button again.
Send Message	In the text box of the Participant dialog box, the participant may type a short message to the Chair, such as the reason for requesting the floor. Clicking Send Message displays the message in the dialog box on the Chair's screen. In the Chair dialog box, the Message icon appears next to the name in the Request column. It is not necessary to request the floor or audio to send a message to the Chair.
Willing to Accept Floor Anytime	If this condition is selected, the Participant automatically accepts the floor or audio anytime the request is granted. If this condition is not selected, the Participant must accept or reject the floor or audio every time it's granted (see Fig 10 and 11).

2. To agree to the Participant's request, the Chair simply selects the Participant's name in the Chair dialog box and then clicks Grant Floor or Grant Audio, accordingly.

   The Participant can now speak to everyone else in the conference, with his/her audio and video being transmitted in place of the Chair's.

3. After the Participant finishes speaking, the floor or audio should be returned to the Chair.

   - The Participant clicks Return Floor or Return Audio, accordingly.

     -or-

   - The Chair clicks Reclaim Floor.

Suppose that David, in his role as the Chair, wants the conference to proceed as a free discussion. In Auto Grant mode, all Participants can contribute to the discussion without having to receive David's permission.

At the end of the multicast conference, the Chair can disconnect all the Participants and terminate the session at the same time.

Convergence of One-way Streaming Video and Interactive Videoconferencing

VCON is committed to improving the quality and manageability of Video over IP for group meetings. With this general goal in mind, VCON developed an interactive multipoint conference technology to be integrated with IP Multicast protocols – an approach enabling group meetings as part of a networked multimedia solution for an enterprise. VCON's Interactive Multicast technology is firmly embedded into VCON's 4th generation H.323 technology.

Interactive Multicast technology meets the following objectives:

- Enables group meetings over IP without decreasing network bandwidth as more participants join.
- Makes group meetings over IP as easy as setting audio-only conference calls, free of considerations such as the maximum number of users, or the total amount of parallel sessions that are running on a given network.
- Is a low-cost software option that is supported by all VCON endpoints, so anyone on a VCON network can participate.
- Allows efficient training over IP to remote users. With Interactive Multicast, VCON is enabling corporate training and distance learning over the global Intranet (such as university courses, virtual schooling, etc.).
- Converges one-to-many streaming video with real-time interactive videoconferencing. By doing so, VCON delivers two products in a single package, and the users can switch between these two modes of communication at will.

The five design objectives outlined above address many of the most significant inhibitors to mass volume deployment of video applications over IP-based networks. By applying VCON's Interactive Multicast technology, users can now, for the first time ever, ask the question 'when to deploy?' rather than 'should we deploy at all?' The benefits of doing business over IP with networked multimedia as its transport and front-end have been acknowledged. The convergence of one-way streaming video with two-way and interactive videoconferencing is the next logical step for any competitive enterprise today.

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