Ending the Multipoint Videoconferencing Compromise

Delivering a Superior Meeting Experience through Universal Connection & Encoding
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**Table of Contents**

Introduction ................................................................................................................................................. 1

Understanding Universal Connection & Encoding (UCE) ........................................................................ 2

No Compromise Multipoint Videoconferencing ...................................................................................... 3
  - Universal Connectivity .......................................................................................................................... 3
  - Consistent Capacity .............................................................................................................................. 6
  - Universal Encoding .............................................................................................................................. 7
  - Meeting Reliability ............................................................................................................................ 10

Conclusion ................................................................................................................................................. 12

About Wainhouse Research ......................................................................................................................... 13
  - About the Author ............................................................................................................................... 13

About Codian ............................................................................................................................................. 13

**List of Figures**

- Figure 1: Comparison of Point to Point and Multi-Point Meetings .......................................................... 1
- Figure 2: The Universal Connection and Encoding Process ..................................................................... 2
- Figure 3: Sample Connection Profiles .................................................................................................. 4
- Figure 4: Steps for Connecting Video Systems .................................................................................... 4
- Figure 5: Example 1 - Preconfigured Connection Profiles ................................................................... 5
- Figure 6: Example 1 - Connection Compromises ................................................................................. 5
- Figure 7: Voice Activated Switching (VAS) vs. Continuous Presence (CP) ............................................. 8
- Figure 8: Impact of Fixed Layouts and Inefficient Screen Usage ............................................................. 9
- Figure 9: Probability of a Trouble Free Multipoint Meeting .................................................................. 11
- Figure 10: Effect of Universal Encoding on Meeting Reliability ............................................................ 11
Introduction

In its most basic form, videoconferencing is quite simple. One location (or video system) calls another location, and a few seconds later the meeting begins. This type of two party video session, which is often called a point-to-point video call, is conducted in a manner similar to a typical phone call. Hundreds of thousands of point-to-point video calls are placed each and every day around the world.

For sessions that include three or more locations, which are called multipoint or multi-site meetings, things become slightly more complex. Instead of one site reaching out to the other, in a multipoint meeting each site typically connects to a single device, called a video bridge or MCU. In a manner similar to a traditional multi-person audio conference, the video bridge mixes and combines the audio and video signals together to form a single, multi-location, fully interactive meeting. The architecture of both a point-to-point and multipoint meeting is shown below.

![Figure 1: Comparison of Point to Point and Multi-Point Meetings](image)

Unfortunately, in some cases the ability to add more locations and people to a video session is realized at the cost of image and sound quality, meeting reliability, and a compromised end user experience. In extreme cases, the ability for the participants to communicate may be hampered or even blocked, which shifts the meeting focus away from the topic at hand and over to the video technology itself.

This white paper focuses on the benefits of Universal Connection & Encoding (UCE), a capability offered by next-generation video bridges that automatically - and transparently - maximizes the overall videoconferencing experience for each meeting participant during multipoint meetings, resulting in multipoint performance that rivals that of point-to-point sessions.

Note that while the text and examples within this document reference only IP-based video systems and network connections, the majority of the concepts presented apply equally well to ISDN-based video environments.
Understanding Universal Connection & Encoding (UCE)

The concept of UCE includes two distinct parts; universal connection (UC) and universal encoding (UE).

Universal connection (UC) is the ability for a video bridge to a) accept incoming connection requests from any compatible endpoint (video system, IP phone, analog phone, etc.), and once connected, to b) accept and use the audio, video, content, and control data provided by that endpoint.

Universal encoding (UE) is the ability for a video bridge to create a unique screen layout for each site by a) mixing the audio, video, and content data provided by all of the participating endpoints and b) encoding the data into a site-specific digital format appropriate for re-transmission to each endpoint.

In addition, UCE allow the bridge to offer consistent capacity, regardless of the speeds, protocols, and features used by the connected endpoints.

Although some vendors refer to the above as transcoding\(^1\), support for signal conversion between formats is just one of the elements necessary to host superior multi-site video sessions. It is the combination of universal connection support (the ability to connect to any compatible endpoint and decode the signals that each system provides) and universal encoding capabilities (the ability to mix the signals to create an optimal layout for each site and then encode those images as required) that enables a no-compromise multipoint videoconferencing experience.

\(^1\) Transcoding is the conversion of a data stream or file from one digital format to another.
No Compromise Multipoint Videoconferencing

In order to host a multipoint video meeting, a video bridge, whether external or internal / embedded, must perform several challenging tasks including:

- Connect to numerous video systems, from a variety of manufacturers, potentially on different data networks (IP, ISDN), using different call speeds, running different communication protocols, capable of sourcing / receiving / displaying different video resolutions, and able to support different advanced features (H.239, etc.)
- Combine the signals from all connected systems, and re-package them into a form suitable for retransmission to each of the other systems participating in the meeting
- Transmit the newly generated video signals to each connected site

Throughout the session, the bridge must also monitor the quality of each connection and respond accordingly should network issues arise. Although every video bridge, whether internal or external, performs the same basic tasks listed above, a seemingly trivial difference in how those tasks are performed can mean the difference between a comfortable, effective face-to-face communication session and a failed meeting.

Universal Connectivity

In order to host “no-compromise” multipoint video sessions, a video bridge must be able to make “no-compromise” connections that fully leverage the capabilities of the endpoint in each location. Key areas of focus include:

- Connection rates – each location should be able to connect to any multipoint meeting at any supported speed (up to the limits of the endpoint and the network)
- Audio and video protocols – each location should be able to connect to any multipoint meeting using the audio and video protocols that yield the best possible experience for the end user participants
- Video resolutions – each participating video system should be able to send and receive video images at the best resolution for that particular location
- Special features – each video system should be able to use any supported power feature in any multipoint meeting

Some video bridges are unable to offer universal connection support for reasons including:
1) Connection Profiles

Some video bridges support a limited number of connection profiles (combinations of network type, connection speed, and audio/video settings) per meeting. The table below includes a few examples of connection profiles.

<table>
<thead>
<tr>
<th>Profile</th>
<th>Network</th>
<th>Speed</th>
<th>Audio Protocol</th>
<th>Video Protocol</th>
<th>Video Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IP</td>
<td>256 kbps</td>
<td>G.728</td>
<td>H.264</td>
<td>CIF - In and Out</td>
</tr>
<tr>
<td>2</td>
<td>IP</td>
<td>512 kbps</td>
<td>G.722.1</td>
<td>H.263</td>
<td>CIF – In and Out</td>
</tr>
<tr>
<td>3</td>
<td>IP</td>
<td>1 mbps</td>
<td>G.722.1 Annex C</td>
<td>H.264</td>
<td>4CIF</td>
</tr>
</tbody>
</table>

Figure 3: Sample Connection Profiles

As video systems connect to a profile-limited video bridge, the bridge tries to add each new endpoint to the meeting in the best possible manner by following the process shown below.

Step 1 – If the system’s connection request matches an existing connection profile, that endpoint will be added to the meeting using the appropriate profile.

Step 2 – If no compatible profile already exists and the meeting connection profile limit has not been reached, the bridge will create a new connection profile for the video system.

Step 3 – If the bridge is unable to create a new connection profile, the bridge will “ask” the video system to alter its connection request to match an existing profile, resulting in a compromised connection for this endpoint.

Step 4 – As a last resort, the bridge will check to see if an existing connection profile can be modified to accommodate the new video system. This would mean that each video system currently using that profile would have to downgrade its connection to match the profile’s new settings. If this is possible, the bridge will modify the profile and the user experience for all systems currently using that profile will be impacted.

Finally, if none of the above can be accomplished, the bridge will be forced to reject the video connection request and divert to an audio-only connection.

Figure 4: Steps for Connecting Video Systems
Example #1 – The Impact of Limited Connection Profiles

This example assumes that a five-location meeting will be hosted on a two connection profile video bridge configured with the following connection profiles;

<table>
<thead>
<tr>
<th>Profile</th>
<th>Network</th>
<th>Speed</th>
<th>Audio Protocol</th>
<th>Video Protocol</th>
<th>Video Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IP</td>
<td>256 kbps</td>
<td>G.728</td>
<td>H.264</td>
<td>CIF - In and Out</td>
</tr>
<tr>
<td>2</td>
<td>IP</td>
<td>512 kbps</td>
<td>G.722.1</td>
<td>H.263</td>
<td>CIF – In and Out</td>
</tr>
</tbody>
</table>

Figure 5: Example 1 - Preconfigured Connection Profiles

As the systems listed below connect to the meeting, the results range from an easy, no compromise connection to a 50% drop in bandwidth and a 9 times decrease in video resolution from the ideal (preferred) connection for the system.

<table>
<thead>
<tr>
<th>System</th>
<th>Ideal Connection</th>
<th>Closest Profile</th>
<th>Compromise Connection</th>
<th>Result / Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td># 1</td>
<td>IP, 384 kbps, G.722 audio, H.264 video, CIF resolution</td>
<td># 1</td>
<td>IP, 256 kbps, G.728 audio, H.264 video, CIF resolution</td>
<td>33% drop in bandwidth Inferior audio protocol</td>
</tr>
<tr>
<td># 2</td>
<td>IP, 512 kbps, G.722.1 audio, H.263 video, CIF resolution</td>
<td># 2</td>
<td>IP, 512 kbps, G.722.1 audio, H.263 video, CIF resolution</td>
<td>No compromise</td>
</tr>
<tr>
<td># 3</td>
<td>IP, 1 mbps, G.722.1 Annex C audio, H.264 video, HD resolution</td>
<td># 2</td>
<td>IP, 512 kbps, G.722.1 audio, H.263 video, CIF resolution</td>
<td>50% drop in bandwidth Inferior audio protocol 9x decrease in video resolution</td>
</tr>
<tr>
<td># 4</td>
<td>IP, 256 kbps, G.728 audio, H.264 video, CIF resolution</td>
<td># 1</td>
<td>IP, 256 kbps, G.728 audio, H.264 video, CIF resolution</td>
<td>No compromise</td>
</tr>
<tr>
<td># 5</td>
<td>IP, 128 kbps, G.728 audio, H.264 video, QCIF resolution</td>
<td>NONE</td>
<td>NONE</td>
<td>Two possible results: 1) System rejects video connection and diverts to audio. 2) Bridge adjusts profile #1 and downgrades systems # 1 and # 4</td>
</tr>
</tbody>
</table>

Figure 6: Example 1 - Connection Compromises

Forcing a video system (or a group of systems) to use a less than ideal connection profile means that the user experience in those sites will be compromised. In extreme cases, the audio and video quality of all participating locations will be dragged down to the level of the least capable system in the video meeting. In the above example, in order to add system #5 to the meeting, the bridge had to downgrade connection profile #1, downgrading the user experience for systems #1 and #4 in the process. Imagine the impact adding a mobile user at 64 kbps would have on the meeting experience.
2) Manual Configurations

Some video bridges must be pre-configured on a per-meeting basis to accept certain kinds of incoming video connection requests. For example, a meeting might be set to accept video calls as follows: a) 256 kbps, H.264 video, and G.728 audio, and b) 512 kbps, H.263 video, and G.722 audio. Incoming calls that do not follow these profiles are automatically rejected.

By avoiding the need for transcoding between different call speeds and protocols, which tends to be extremely processor intensive, bridges with this pre-configuration requirement often support large numbers of video systems for a relatively low cost. But, the need to configure each meeting in advance and the ability to connect to systems following only a limited number of connection profiles severely limits the utility of these video bridges in the real world.

Universal Connection & Encoding Benefits

UCE bridges support a connection profile for each video system in each meeting. In other words, if twelve (12) video systems are connected to a meeting, the bridge is actually managing twelve connection profiles simultaneously. This means that each video system can connect to each meeting using the speed, audio and video protocol, and resolution that offers the best experience for its local users. Had the meeting in example #1 been hosted on a UCE bridge, all five endpoints would have connected at each system’s ideal speed, using its preferred audio protocol, video protocol, and resolution.

In addition, UCE bridges do not require system administrators to pre-configure video meetings to accept specific types of video calls. Once a meeting is activated, the meeting can accept incoming calls from any compatible system using any supported connection speed, protocol, and resolution.

Consistent Capacity

As far as capacity is concerned, not all video bridges behave the same way. Depending upon the bridge involved and the meetings and systems hosted on the bridge, the actual port / system capacity may be significantly lower than the specified capacity. In other words, a bridge has a specified capacity of 48-ports may not be able to connect to 48 video systems simultaneously. The actual port capacity may change dynamically based on a variety of factors including:

- Number of meetings – some video bridges support only a limited number of meetings simultaneously. For example, one leading manufacturer’s video bridge currently supports only five (5) simultaneous meetings.
- Connection speeds – on some video bridges, the actual capacity depends upon the connection speed of the already connected video systems.
- Video protocols and resolutions – some video bridges support fewer connections when certain video protocols (e.g. H.264) or certain video resolutions (e.g. HD) are utilized.
- Advanced features – in some cases the use of advanced meeting features, like H.239, might impact the actual port capacity

The above results in two types of problems:

1) Rejected Connections

As if the loss of capacity was not enough, often the host organization is not aware that the bridge’s capacity has been compromised. This means that a video connection that should have been accepted by the bridge into one meeting could be rejected due to the call speed, protocols, resolutions, or features used by a different endpoint in another meeting.

2) Compromised Connections

Capacity limitations caused by the above items may force a bridge to make compromised connections to certain systems or otherwise limit an endpoint’s access to use advanced features.

Universal Connection & Encoding Benefits

UCE video bridges do not allow the activities of individual meetings or video systems to impact the bridge’s overall performance or capacity. This means that a 48-port bridge will support 48 “no-compromise” connections at all times, regardless of the number of meetings already in progress or the connection profiles used by each of the connected systems.

Universal Encoding

An important part of a “no-compromise” multipoint meeting experience is the ability for each participating location to utilize a meeting layout / view that is well suited for the local environment and participating users. Unfortunately, many video bridges, and especially those with limited connection profiles, do not allow each site to select its own meeting view. Instead, the bridges create a few (or sometimes only one) screen layouts (or encodes) that are shared by multiple users as described below.

- Meeting mode limitations – many bridges require that each meeting be set (either in advance or during the meeting) to one specific viewing mode – either VAS (voice activated switching) or Continuous Presence – for all sites. This means that all sites will receive images of the same layout, regardless of their ability to effectively display that layout.
Figure 7: Voice Activated Switching (VAS) vs. Continuous Presence (CP)

In VAS mode (L above), a full-screen view of the last site to speak is sent to all participating locations, making this view ideal for locations with smaller displays (small monitors, computer displays). In CP mode (R above), several sites are shown on screen simultaneously which allows sites with large displays (projectors, plasma screens, etc.) to maintain visual contact with several sites simultaneously.

- Limited connection profile meetings – in most cases, bridges with limited connection profiles provide identical layout views to all sites using the same connection profile, regardless of each individual site’s specific configuration or capabilities.

Depending upon the sites involved, the impact of layout limitations can range from a minor nuisance to a major communication deterrent. For example, let’s assume that a meeting layout has been set to the nine-way CP view as shown above. This layout might work well for locations with very large displays (projectors, 60” plasma screens, etc.), but sites with smaller displays (computer screens or mobile phones / PDAs for example) might find such a layout unusable due to the small size of each video window.

Another common problem associated with layout limitations is that in continuous presence (CP) meetings the bridges often send each site a delayed version of its own camera image as a part of the overall video image. This is not only an inefficient use of screen real estate and bandwidth (all video processing and screen space used to display a site’s own image is wasted), but seeing a delayed and lower quality version of their own camera image on screen tends to distract meeting participants or make them self-conscious.

The “compromised meeting view” in the image below highlights the impact of inflexible meeting layouts and inefficient screen usage.
Issue #1: Each site sees itself in one screen quadrant, effectively wasting 25% of the screen real-estate.

Issue #2: All sites are receiving the 4-way continuous presence view, regardless of the screen size. This layout is well suited for the large displays used in locations 1 and 2, but the smaller displays in locations 3 and 4 make the quad-screen layout less than ideal. In location 4, the compromised meeting view would likely be unusable.

Universal Connection & Encoding Benefits

The “optimal meeting view” images shown above illustrate the benefits of hosting this same multi-point meeting on a universal connection and encoding bridge. The flexible meeting modes and layouts afforded by these bridges allows each site (or the operator managing the meeting) to choose a meeting view that is well suited for that specific location. For example, location 3 above has chosen to display large views of the last two sites that spoke during the meeting. Similarly, due to the extremely limited display size, location 4 has opted to see a full-screen view of the last site to speak (a.k.a. voice activated mode).

In addition, in the optimal meeting view, sites do not have to see themselves on the meeting screen, resulting in a better meeting experience for all involved.
Meeting Reliability

An important part of a no-compromise meeting experience is the ability to protect the meeting from video system issues, network errors, or other potential problems. Ideally, the bridge would provide two levels of performance protection:

Error Recovery – the bridge should be able to compensate in real time for some degree of video system and/or network related errors. For example, should a system’s IP connection experience a limited percent of packet loss, the bridge should be able to mask those errors in order to provide the meeting participants with a consistent level of performance.

Error Isolation – superior bridges are able to isolate the impact of video system and/or network issues to the system experiencing the problem.

Due primarily to the connectivity and layout compromises described earlier, most non-universal encoding bridges provide only a limited amount of performance protection. In these situations, a network issue that impacts the quality of the connection for one endpoint is likely to impact the meeting experience for several (or even) all other connected systems.

Example #2 – The Impact of Compounded Network Issues

To illustrate the impact of error recovery and isolation, let’s consider a one-hour video meeting, involving 20 locations, using a variety of different IP networks supporting varying levels of performance. For this example, let’s assume that the chance any one endpoint will experience a problem that reduces the quality of the call (packet loss, jitter, other network / video system issue) during that hour is 5 %.

On a single connection profile bridge, since each endpoint must receive exactly the same image from the video bridge, a network / connection problem that impacts one user will impact all users in one or both of the following ways:

1) Performance Issues – As it tries to help the impacted video system compensate for the network issues, the bridge will resend complete video frames to all participating endpoints (called a fast update response or FUR), resulting in decreased video quality for ALL users. The Catch-22 is that fast update responses tend to momentarily max out the available bandwidth, often causing further packet loss (and the need for another fast update response) and downward spiraling video quality.

2) Connection Downgrade – In hopes of improving the meeting experience for all participants, the video bridge will downgrade the connection speed of the connection profile in use by the impacted video system.

Since an issue that impacts one endpoint will impact all connected endpoints, the probability of a trouble free conference for any particular endpoint on a single connection profile bridge is only 36 % as shown by the calculation below.

\[
\text{Probability of a trouble free conference: } (95\%)^{20} = 35.8\%
\]
The table below shows the probability of a trouble free meeting for different numbers of participating endpoints, connection profiles, and network reliability assumptions (assuming that the video systems are divided evenly between connection profiles).

<table>
<thead>
<tr>
<th># of Sites</th>
<th>95% Reliability</th>
<th>90% Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of Connection Profiles</td>
<td># of Connection Profiles</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>81%</td>
<td>90%</td>
</tr>
<tr>
<td>8</td>
<td>66%</td>
<td>81%</td>
</tr>
<tr>
<td>12</td>
<td>54%</td>
<td>74%</td>
</tr>
<tr>
<td>20</td>
<td>36%</td>
<td>60%</td>
</tr>
</tbody>
</table>

**Figure 9: Probability of a Trouble Free Multipoint Meeting**

As shown above, hosting this conference on a two connection profile bridge increases the probability of a trouble free conference from 36% to 60%. As one would expect, if the chance that an individual endpoint has some form of network issue during the meeting is increased from 5% to 10%, the probability of a trouble free meeting is drastically reduced.

**Example #3 – The Impact of a Single Problem System**

Another common occurrence is that all but one of the participating video system are on reliable networks (perhaps with 99.9% performance guarantees), and the last system is on a poor network or is mis-configured with a duplex mismatch resulting in a 99% chance of problems during the call. For a 20 site meeting of this type hosted on a single connection profile bridge, the chance of a trouble free call is less than 1% (99.9% ^ 19 x 1%). This illustrates the major impact that network and endpoint issues can have on meeting hosted on limited connection profile bridges.

The above explains why such a large percentage of multipoint meetings are impacted by network issues, even if high performance and reliable networks are used by many or even all of the participating systems.

**Universal Connection & Encoding Benefits**

The use of an individual connection profile and encode for each system allows UCE bridges to isolate the performance of each video system, drastically increasing the probability of a trouble free meeting for all participating users.

<table>
<thead>
<tr>
<th>Example</th>
<th># of Sites</th>
<th>Bridge Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>One Profile</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>36%</td>
</tr>
<tr>
<td>3</td>
<td>Sites 1 - 19</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td></td>
<td>Site 20</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Figure 10: Effect of Universal Encoding on Meeting Reliability**

Ending the Multipoint Videoconferencing Compromise

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As shown above, migrating the meeting from example #2 above from a one connection profile bridge to a UCE bridge with unlimited connection profiles increases the probability of a flawless experience from 36 % to 95 %. Migrating the meeting from example #3 above yields even more sensational results, increasing the flawless experience probability for 19 of the 20 sites from < 1 % to 99.9 %.

Conclusion

Due to hardware limitations, and in some cases an ISDN-centric design architecture, many internal (embedded) and external video bridges are unable to host a “no-compromise” multi-site video meeting in which each site enjoys the best possible user experience and a degree of isolation (in terms of network / system errors) from other participating systems.

Wainhouse Research categorizes bridges able to host “no-compromise” multi-site video meetings as universal connection and encoding (UCE) bridges due to their support for universal connection (UC) and universal encoding (UE). Such bridges provide four key benefits including:

**Easy Connectivity** – UCE bridges can connect to any compatible video system using any supported connection speed, audio / video protocol, and resolution without regard for the systems already connected to the same meeting or bridge.

**Consistent Capacity** – UCE bridges include the necessary horsepower to maintain their specified port capacity without regard for the bandwidth, protocols, resolutions, or features used by other connected systems.

**Mode / Layout Flexibility** – UCE bridges allow each participating site to select the meeting mode (voice activated switching or continuous presence) and screen layout best suited for the local environment.

**Meeting Reliability** – UCE bridges isolate the performance and functionality of each site in the meeting from all other participating sites, resulting in much higher meeting success rates.

Finally, UCE bridges provide the above benefits without the need for the system administrators or users to pre-configure the meetings for specific connection profiles, audio / video protocols, resolutions, or features.

In summary, universal connection and encoding bridges automatically and transparently maximize the user experience for all participating video locations, thus allowing all systems to leverage their full capabilities and potential.
About Wainhouse Research

Wainhouse Research (www.wainhouse.com) is an independent market research firm that focuses on critical issues in rich media communications, videoconferencing, teleconferencing, and streaming media. The company conducts multi-client and custom research studies, consults with end users on key implementation issues, publishes white papers and market statistics, and delivers public and private seminars as well as speaker presentations at industry group meetings. Wainhouse Research publishes Conferencing Markets & Strategies, a three-volume study that details the current market trends and major vendor strategies in the multimedia networking infrastructure, endpoints, and services markets, as well as a variety of segment reports, the free newsletter, The Wainhouse Research Bulletin, and the PLATINUM (www.wrplatinum.com) content website.

About the Author

Ira M. Weinstein is a Partner at Wainhouse Research, and a 15-year veteran of the conferencing, collaboration and audio-visual industries. Prior to joining Wainhouse Research, Ira was the VP of Marketing and Business Development at IVCi, managed a technology consulting company, and ran the global conferencing department for a Fortune 50 investment bank. Ira’s current focus includes IP video conferencing, network service providers, global management systems, scheduling and automation platforms, ROI and technology justification programs, and audio-visual integration. Mr. Weinstein holds a B.S. in Engineering from Lehigh University and is currently pursuing an MBA in Management and Marketing. He can be reached at iweinstein@wainhouse.com.

About Codian

Codian designs and manufactures the most advanced video conferencing infrastructure products available, bringing the best in IP voice, video and data conferencing. Codian’s product line includes: Multipoint Control Units, Video Conference Recorders, Streaming Servers and ISDN Video Gateways. Using an innovative architecture and state-of-the-art hardware technology, Codian products are both powerful and easy to use, supporting enterprise and service provider customers worldwide. Codian has offices in San Jose, California; New York; Washington D.C.; London, UK; Frankfurt, Germany; Hong Kong; and Sydney, Australia. For a product demonstration or to learn more about Codian products please visit www.codian.com.