University of California
Larry L. Sautter Award Submission

High Definition Video Conferencing Project -
Innovation in Communication and Collaboration across
Multiple Organizations
At the University of California, San Francisco

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1. **Project Title**

   High Definition Video Conferencing Deployment

   Enhanced Scientific Communication and Collaboration at the University of California, San Francisco

2. **Submitter’s Details**

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4. **Project Significance**

The use of video conferencing has dramatically improved the way people do business and has resulted in significant productivity gains and incredible cost savings for the university. No matter how you calculate it, video conferencing is inexpensive compared to the three major costs of travel:

- **Money** – travel expenses such as gasoline, parking, or even airfare
- **Time** – from 30 minutes one-way to an office to a full day of travel time to go cross-country
- **Environment** – auto emissions and fuel consumption are significant now more than ever.

![Table comparing costs of travel vs. video conferencing](source: carboncounter.org)

This videoconferencing technology has provided a near complete simulation of a normal meeting environment, enabling both parties to see, hear and present material, just as if they were in the same room. Videoconferencing has sped up business processes and procedures in the same way that the fax and the e-mail revolutionized the way we share information.
There have been many intangible benefits too which include:
- Greatly improved communication between remote sites both within the university and external institutions.
- Reduced pressure, stress and fatigue from travel
- Shorter project development times
- Reduced time of meetings as the principle often applies when visiting
- Immediacy of contact between people
- Rapid face to face resolution of urgent situations
- Faster and better decision making

Video conferencing has become a vital communication and collaboration tool for ARCAMIS and our customers. Our service offering has grown from the legacy ISDN based point-to-point conference room call to high definition IP based video calls involving multiple participants from multiple geographies. In the past 18 months we have deployed over 35 high definition video conferencing systems that are configured to use our high definition video conferencing MCU and VOIP gateway. What used to be a once-a-month occurrence is now used daily for ad-hoc meetings between various project teams and several times a week for scheduled VIP conferences with shared presentations. This project implementation involved both technical and logistical challenges that ultimately resulted in allowing our end-users to utilize videoconferencing in much the same way as just making a phone call.
5. Project Description

5.1. Overview

Video conferencing is an evolving technology that has long been associated with high complexity, high cost, and a less than satisfactory end user experience. For many organizations it is used only under carefully orchestrated conditions, utilizing high cost networks and dedicated personnel. There is usually a “video conferencing room” or perhaps two, but the idea of participating in a high quality conference from virtually anywhere seems out of reach for most private companies, much less an academic research organization.

5.2. Background Information

ARCAMIS supports several research organizations which utilize video conferencing to bring together geographically dispersed teams and individuals on a daily basis. Three organizations came together to sponsor the initial deployment and rollout of high definition video conferencing at UCSF:

The Immune Tolerance Network (ITN)

The mission of the Immune Tolerance Network (ITN) is to prevent and cure human disease. Based at the University of California, San Francisco (UCSF), the ITN is a collaborative research project that seeks out, develops and performs clinical trials and biological assays of immune tolerance. ITN supported researchers are developing new approaches to induce, maintain, and monitor tolerance with the goal of designing new immune therapies for kidney and islet transplantation, autoimmune diseases and allergy and asthma. The ITN is a geographically dispersed organization with offices in Bethesda Maryland, Pittsburgh Pennsylvania, as well as 3 UCSF campus locations. The ITN also collaborates with clinical researchers from many universities around the country and even has one study based
in London. Effective face to face communication and collaboration are crucial to the efficient operation of the ITN

The Epilepsy Phenome/Genome Project (EPGP)
The Epilepsy Phenome/Genome Project (EPGP) studies the complex genetic factors that underlie some of the most common forms of epilepsy; bringing together 50 researchers and clinicians from 15 medical centers throughout the US. Based at UCSF, this initial 5 year grant is being funded by the NIH, National Institute of Neurological Disorders and Stroke (NINDS). Core leaders and sites come together on a weekly basis via video conferencing. The video conferencing technology is being used very effectively by study PIs at various clinical sites to communicate and collaborate better.

Clinical and Translational Science Institute (CTSI)
The mission of the Clinical and Translational Institute (CTSI) at UCSF is to create a comprehensive, integrated academic home that promotes research and education in clinical and translational science at UCSF, affiliated institutions, and in participating communities. The Virtual Home for CTSI program is dedicated to providing tools, resources and a rich environment to facilitate collaborative efforts in idea generation, funding, design, implementation, analysis and communication of findings. With the national stature of UCSF, the size of its research community and geographical distribution of the brick-and-mortar multiple ‘homes’ for research, Virtual Home’s charge is essential for CTSI to carry out its mission, but is also forward-looking and focused on innovation. High definition video conferencing is one of the key technologies in creating the Virtual Home and has been deployed at Parnassus Heights, SF General Hospital, Mount Zion, Laurel Heights, Mission Center Building, and China Basin Landing.

The ARCAMIS Team
The ARCAMIS team itself has become dependent on video conferencing to bring our team together on a daily basis. Our engineers are based not only in multiple campus locations at UCSF, the ITN offices in Bethesda MD and Pittsburgh PA, but also telecommute regularly from video. This benefits the university by increasing the productivity of the team by allowing them work from anywhere anytime. It also benefits the environment by reducing commutes and benefits the staff by providing a flexible work environment.

The ARCAMIS team has demonstrated the collaborative power of video conferencing in several instances. Our applications team coordinated the work of developers and contractors located in San Francisco, Pittsburgh, Minnesota, Raleigh, San Diego and India by conducting daily video conferencing meetings that allowed team members to be virtually present to each other as needed in real-time. Our infrastructure engineering team was able to produce over 1800 pages of system documentation required for FISMA compliance, by using video conferencing and desktop sharing. Our customer engineering team uses video conferencing daily to coordinate
support issues across the country and to allow our customers and engineers to “put a face” to the people we might otherwise only interact with via email and phone.

5.3. **Challenges with Existing Technology**

Prior to implementing high definition video conferencing, the typical experience was less than ideal. Users were often dissatisfied with audio and video quality. Setting up a meeting required a high degree of technical support to setup and maintain connections. Higher quality connections were available using ISDN lines, but at an exorbitant cost. Even when calls seemed to be going well, the whole experience could be disrupted by equipment or network issues at one site.

Ease of use, particularly the ease of contacting another person or site, was something else that needed to be addressed. Typically setting up a call involved determining the answer to the following questions:

- what endpoint each site had
- whether ISDN or IP based connectivity would be used
- which site would call which
- what IP address to call
- what call speed to use
- how many video participants would attend
- how many audio participants would attend

The limits of the existing technology also served as a barrier to more widespread use among all users:

- ISDN calls cost the organization over $500 per hour including usage rates and long distance.
- IP Calls could use a maximum of 768 kbps which would further be subdivided based on the number of participating sites in a multi-site call.
- Multipoint calls were limited to no more than 5 sites (audio or video) primarily due to the overall bandwidth limitations of standard definition video conferencing endpoints and multi-site devices.
- The worst endpoint/network combination determined the overall quality of a conference.

This last point should not be taken lightly. Existing multipoint conference units were only capable of a single encode for the conference which was determined by the lowest common denominator. If the least capable endpoint could encode at only 256 kbps, then all participants would receive at that rate. Additionally, if one site experience packet loss...
during a call, it would appear to all participants as if they were also experiencing packet loss. In the next section, we discuss how a high definition MCU overcomes this problem.

5.4. **High Definition Video Conferencing Improved the End-User Experience**

The ARCAMIS video conferencing implementation addressed both the quality of the call and the ease of making a call. By presenting a face to face communication that feels as natural as being in someone’s office, participants are less concerned with the technology and more engaged in the actual meeting.

Standard definition video conferencing was limited to providing video resolutions of only 352x288 pixels (FCIF) at 15-30 frames per second. In a two-way call with sufficient bandwidth it was possible to recognize participants, but less so as more sites were added to the call. High-definition video conferencing, on the other hand, is capable of 1280x720 (720p) resolutions at 30 FPS which is effectively 10 times better than before. In English callers in multi-site meeting experience an astounding improvement in video realism such that facial details and expressions are fully recognizable as if everyone was in the same room.

While the visual realism of a two-way high definition video conference is impressive, the real improvement was demonstrated in multi-site conferences. As mentioned in the previous section, the previous technology limited all participants to experience the lowest resolution video stream that was compatible with all participating sites. The high definition video conferencing MCU generates a separate encode for each participant. Therefore, unlike with other MCUs, all participants will see the best possible combination of bitrate, codec and
resolution that they can without being affected by anyone else who subsequently joins the call.

A the above diagram shows, a home user might connect using low speed DSL connection, while an office based participant will have access to higher network speeds. Each participant will receive an appropriate encode from the MCU. Also if one site suffers from a network issue...
during the call, the MCU will adjust the encode for only that site, without affecting the experience of the other participants.

5.5. **Video Conference Bridges - Virtual Conference Rooms**

When two or more people have a meeting, one of the first things they need to determine, is where to have the meeting. This may be an individual office or a conference room inside a particular building. If all participants are in close physical proximity, such as being in the same campus building, this usually does not pose too much of a challenge. But in the case where attendees could come from one or more campus locations, other issues need to be factored in, such as travel time and parking. With meetings involving people from multiple geographic locations, the cost of the meeting increases drastically, as one considers travel costs (airfare, meals, lodging) and the total amount of time spent getting to the meeting, participating in the meeting, and returning from the meeting.

ARCAMIS Video conferencing solves this by creating a virtual conference room where participants can meet in real time and see and talk among themselves as if they are the same physical room. Virtual conference rooms are created when two or more participants connect to the video conferencing system by calling a specific room number or conference bridge. By using pre-defined conference bridges the question becomes not “how do I call you?” but “where do I meet you?” ARCAMIS hosts video conferencing bridges for several organizations at UCSF. Although the Codian MCU supports dynamic bridge creation, most conferences are held on pre-defined H.323 Bridge IDs. All conference bridges begin with a two-digit prefix (86) followed by a three-digit extension. These bridge numbers are organized into ranges as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>H.323 ID</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCAMIS MCU</td>
<td>86000</td>
<td>Virtual Lobby</td>
</tr>
<tr>
<td>ITN Lobby</td>
<td>86200</td>
<td>ITN – Auto Attendant 86001 – 86299</td>
</tr>
<tr>
<td>CTSI Lobby</td>
<td>86300</td>
<td>CTSI – Auto Attendant 86301 – 86309</td>
</tr>
<tr>
<td>EPGP Lobby</td>
<td>86400</td>
<td>EPGP – Auto Attendant 86401 – 86409</td>
</tr>
<tr>
<td>Ad-Hoc Conferences</td>
<td>N/A</td>
<td>86501 - 86899</td>
</tr>
<tr>
<td>Training and Testing</td>
<td>86900</td>
<td>Used by ARCAMIS IT Staff 86901 - 86999</td>
</tr>
</tbody>
</table>

As the above table shows, conference bridges are generally grouped by organizational use, with 86900-86999 used for administrative and testing purposes. Video Endpoint users need only dial the five-digit ID of the conference to attend while voice only callers may dial an audio bridge and then provide the same 5 digit code to access video conferences via voice. We provide customers with dedicated bridge numbers for specific meetings, reservable bridge numbers, and the ability to create dynamic conference bridge numbers as needed.
Video conference users may be called directly, both by other end users and by the MCU itself. However, better performance is achieved by routing calls through the MCU, even when the conference will only involve two parties. This is because the MCU performs bandwidth optimization and offers a stable known-good network endpoint.

Video conferencing endpoints which are managed by ARCAMIS are registered with the video conferencing gatekeeper which provides dynamic access to the virtual video conference bridges. However, in some cases we need to connect with endpoints which we do not manage. In this case we can pre-configure endpoints within the MCU which makes it easier to contact an endpoint in future calls. The pre-configuration will include the IP address of the endpoint, the preferred send and receive rates, and the preferred call layout for that site. These users may be called by the MCU at the beginning of scheduled conferences. As additional endpoints are deployed, the MCU is updated to include them. This has been done for endpoints from CTSI, EPGP, and the ITN that are registered with the ARCAMIS video conferencing system and are located on the UCSF campus as well as many sites that are not registered with the gatekeeper but need to be included in videoconference calls with one of our primary customer groups.

Network Considerations

One of the primary technology challenges that needed to be addressed was dealing with the network connections required to setup and maintain a call. When an organization controls the network from end-to-end this can be somewhat challenging, but when endpoints are geographically dispersed and with network connections managed by different vendors, it would seem almost impossible to connect multiple sites and not experience problems during the call.

Calls initiated from video conferencing endpoints may originate from the UCSF Medical Center IP space or from any other routable IP space. Calls from private (NAT) IP addresses often work, but success is highly dependent on the specific type and configuration of the NAT router and other elements which are beyond the control of ARCAMIS. Local IT policies may require that Video Conference Endpoints are protected by a Firewall. In our early testing phases we learned that the following rules must be in place for basic conferencing operation.

<table>
<thead>
<tr>
<th>Port</th>
<th>Required/Opt</th>
<th>Port Type</th>
<th>Usage</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>Required</td>
<td>TCP</td>
<td>Remote Maintenance and firmware updates</td>
<td>HTTP</td>
</tr>
<tr>
<td>443</td>
<td>Required</td>
<td>TCP</td>
<td>Remote Maintenance and firmware updates</td>
<td>HTTPS</td>
</tr>
<tr>
<td>1718</td>
<td>Required</td>
<td>Static UDP</td>
<td>Gatekeeper Discovery</td>
<td>Must be bidirectional</td>
</tr>
<tr>
<td>1719</td>
<td>Required</td>
<td>Static UDP</td>
<td>Gatekeeper RAS</td>
<td>Must be</td>
</tr>
</tbody>
</table>
6. Technology Utilized

The ARCAMIS video conferencing system is comprised of the following technology components:

- A centrally managed high-definition multipoint control unit
- Standardized high definition video conferencing endpoints
- Integrated infrastructure and for managing endpoints and calls
- Continued support for legacy systems that is transparent to all participants

The ARCAMIS video conferencing system is used by several UCSF departments, extends to every office within the organization, and allows users to conduct secure, voice and video sessions. The system operates primarily over IP, with ISDN for analog voice connections. It is bridged via a Codian 4510 High Definition MCU with a RadVision Gateway for analog voice services and RadVision Gatekeeper for registration and directory services. The High Definition conference units deployed by ARCAMIS are manufactured by LifeSize with Standard Definition units by Polycom and Tandberg.

The Codian/LifeSize/RadVision combination is extremely powerful, allowing many different combinations of participants to communicate in the highest fidelity achievable with a given network and connectivity set.

6.1. Centrally Managed Multipoint Conferencing Unit (MCU)

ARCAMIS uses a high-definition video conferencing MCU to host multipoint conference calls. The Codian MCU 4510 supports both high definition and standard definition video conferencing endpoints which enables seamless calls between older legacy endpoints and newer High Definition systems. The Codian MCU provides:

<table>
<thead>
<tr>
<th>Port Range</th>
<th>Status</th>
<th>Protocol(s)</th>
<th>H.323 Call Setup</th>
<th>Requirement</th>
<th>Bidirectional Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1720</td>
<td>Required</td>
<td>Static TCP</td>
<td>H.323 Call Setup</td>
<td>Must be bidirectional</td>
<td></td>
</tr>
<tr>
<td>1731</td>
<td>Optional</td>
<td>Static TCP</td>
<td>Audio Call Control</td>
<td>Must be bidirectional</td>
<td></td>
</tr>
<tr>
<td>60000-60499</td>
<td>Required</td>
<td>Dynamic UDP</td>
<td>H.245, RTP, TCP</td>
<td>Must be bidirectional</td>
<td></td>
</tr>
</tbody>
</table>
- HD Performance – 720p H.264 at 30 frames per second continuous presence
- High Capacity – 20 dedicated video ports independently supporting call speeds from 64 Kbps up to 4 Mbps as well as 20 dedicated audio ports to allow non-video participants to join a meeting.
- Consistent call experience for each participant – if one endpoint experiences network issues or requires a lower call speed, other participants are not affected.
- Compatible with standards based video conferencing systems using IP networks

Additionally the MCU is very easy to manage using the web based interface. It supports both scheduled and ad-hoc conferences, and allows us to monitor and manage calls in real time.

The MCU is hosted in our San Francisco data center which provides a full 100 mbps connection to the Internet enabling us to host several multi-site conferences concurrently and still leave significant bandwidth available for other applications. While in theory it is possible to have 20 simultaneous 4 Mbps connections to the MCU, in practice most do not exceed 1.5 mbps which is determined by the endpoints local network bandwidth and device capabilities.
A conference call may involve many transactions, but the end result should be a seamless experience for the participants. In a typical scheduled call, the MCU may initiate calls at the start of the conference to registered endpoints. These users will merely have to accept the call on their endpoints to join the conference. Other users may dial in using the conference ID, such as 86101. In this method of connection, the Gatekeeper resolves the conference ID to a given address and service offered by the MCU. With this information, the endpoint connects to the proper conference on the MCU. If adding on voice only participants is required, the MCU resolves the service needed with the Gatekeeper and then connects to the Gateway. The Gateway initiates the call to the analog user and acts as a bridge to the MCU. Alternatively, the voice participant may call the Gateway via a pre-defined number unique to the conference.

6.2. **Standardized High Definition Video Conferencing Endpoints**

ARCAMIS supports both high-definition and standard definition video conference endpoints. For High Definition video conferencing we have standardized on the LifeSize Team system consisting of:

- A High Definition Video CODEC which supports 1280 x 720 resolution at 30 frames per second
- A High Definition Point and Zoom Camera with a 70 degree field of view
- A High Definition audio conference phone which serves as the primary microphone for the endpoint and makes it easy for end-users to join a call by dialing our pre-configured bridge numbers
- A wireless remote to allow callers to control the camera and display layouts during the call.

ARCAMIS has deployed nearly 40 LifeSize Team systems across the country. The advantage of a standardized endpoint is that setup and training are consistent for all end users. We have been able to define standard configurations for small office and large conference room settings.

In addition to the LifeSize our infrastructure supports endpoints from many other vendors that follow the H.323 protocol. The ability to interoperate with legacy products and devices at other institutions provides the most flexibility to our customers.
6.3. **Integrated Infrastructure**

To allow endpoints to work effectively with the MCU, we employ additional infrastructure components that provide advances conferencing features not available to stand-alone devices. Two key components of the infrastructure are:

a. **323 Gatekeeper** – the gatekeeper is responsible for registering endpoints and conference bridges so that meetings can be created simply by dialing a 5-digit number.

b. **ISDN Gateway** – to support legacy video conferencing systems and also allow audio-only participants to join a call. The Gateway is also registered with the gatekeeper so that the MCU can call out to any 10-digit phone number.

The Gateway enables audio, video and data communication between H.320 endpoints that connect through ISDN or serial connections, and H.323 endpoints that connect through a packet-based network. For voice-over-IP, the Gateway enables PSTN voice callers to connect from the ISDN network to IP voice callers. Currently we are able to support up to 20 simultaneous high definition video participants across multiple meetings and connect up to 6 audio-only callers. In instances where a larger number of audio participation is needed, we allocate audio-ports to dedicated audio bridge numbers which support 50 or more callers.

The combination of the multipoint conferencing unit, H.323 gatekeeper, ISDN gateway, and standardized endpoint configurations managed by ARCAMIS, removes the complexity from the end-users. Meetings start on time and participants focus on sharing information and collaborating on ideas, rather than the logistics of the call.
7. The timeframe of implementation

8. Customer Usage Data

The following graphs illustrate actual usage statistics by each customer group over a six month period following the rollout.

**Figure 1 – Total Monthly Video Calls by Organization**
FIGURE 2 – TOTAL MONTHLY VIDEO CONFERENCING USAGE IN HOURS BY ORGANIZATION

FIGURE 3 – AVERAGE MONTHLY VIDEO CONFERENCING USAGE IN MINUTES BY ORGANIZATION