Utilization of Internet Protocol-Based Voice Systems in Remote Payload Operations

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Purpose of Presentation

• Describe an innovative and cost-effective voice communications system
  ✷ Internet Voice Distribution System (IVoDS)
  ✷ Supports International Space Station (ISS) payload operations
• Provide Overview of IVoDS Architecture
• Share Lessons Learned
  ✷ COTS, Standards, Customization for Unique Requirements
  ✷ MSFC’s Influence on Marketable Products
• Technology Transfer To Other Applications
• Summary
Payload Operations and Integration Center (POIC) Background

• Ground support facility that manages the execution of on-orbit ISS payloads and payload support systems in coordination with:
  • Mission Control Center in Houston
  • Distributed International Partner Payload Control Centers
  • Telescience Support Centers
  • Payload-unique facilities at universities, corporations, etc.

• Primary ISS users:
  • Internal POIC Cadre: management and integration of payload operations
  • Remote payload users: remote site operation and control of payloads and experiments

• Primary ISS services:
  • Telemetry and command processing
  • External data communication interfaces
  • Video distribution
  • Voice communications
POIC Voice Communications
System Architecture

Remote Payload User Sites

Existing EVoDS Telephony System

Dedicated Circuit-Switched T-1 Lines

EVoDS Keysets

New IVoDS Voice over IP System

NASA, Research, and Public IP Networks

IVoDS PC’s

JSC Mission Control Center

Crew Voice Loops

Crew + Ops Voice Loops

International Space Station

MSFC Payload Operations & Integration Center

MSFC Voice Switch

IVoDS Server And Gateways

International Space Station

Remote Payload User Sites
Rationale for New Voice System for Remote Users

- EVoDS is expensive for remote sites
  - Custom keyset, headset, and communications equipment
  - T-1 leased line to remote site
- EVoDS is nearing end-of-life (utilized for 12 years)
- Large number of remote users
  - Initial support for 50 remote users
  - Expansion to 200 remote users
  - Potential additional remote voice hub sites (e.g., European Space Agency)
- Seeking cost-effective alternative utilizing:
  - Commercial-off-the-Shelf (COTS) voice equipment
  - Existing high-speed, reliable internets
- Estimated costs per user (50-user system):

<table>
<thead>
<tr>
<th>Service</th>
<th>EVoDS Cost</th>
<th>IVoDS Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Bandwidth</td>
<td>$9,000/year</td>
<td>$2,000/year</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$1,000/year</td>
<td>$1,800/year</td>
</tr>
<tr>
<td>Hardware</td>
<td>$25,000</td>
<td>$1,000</td>
</tr>
</tbody>
</table>
Internet Voice Distribution System (IVoDS) Overview

- Extends the existing telephony-based EVoDS voice switch utilizing Voice over Internet Protocol (VoIP) technology
- Remote users located at NASA centers, universities, and companies throughout North America
- Three major components:
  1. IVoDS user client PC’s at remote sites
  2. Internet Protocol network connections to the POIC
  3. Voice, administrator, and encryption servers located in the POIC
IVoDS User Client

MSFC Payload Operations and Integration Center

- EVoDS Voice Switch
- VOIP Telephony Gateways
- Conference Servers
- LAN
- Virtual Private Network Server
- Administrator Server
- PAYCOM Client PC
- Administrator Client PC
- Encrypted IP Voice Packets

Remote Sites

- NASA, Research, and Public IP Networks
- IVoDS User Client PC’s

- Windows NT/2000 PC with COTS sound card and headset
- Web-based for easy installation and use
- PC location very mobile – anywhere on LAN
- Challenge: minor variations in PC hardware and software configurations at remote sites
IVoDS User Client

Capabilities

• Monitor 8 conferences simultaneously, talk on one
• User selects from authorized subset of available voice conferences
• Volume control/mute for individual conferences
• Assign talk and monitor privileges per user and conference
• Show lighted talk traffic per conference
• Talk to crew on Space (Air) to Ground if enabled by PAYCOM
IP Network Connections to POIC

MSFC Payload Operations and Integration Center

- EVoDS Voice Switch
- Voice Loops
- VoIP Telephony Gateways
- Conference Servers
- LAN
- Virtual Private Network Server
- Administrator Server
- PAYCOM Client PC
- Administrator Client PC
- EVoDS Keysets

Remote Sites

- NASA, Research, and Public IP Networks
- Encrypted IP Voice Packets
- IVoDS User Client PC’s

- Primary: Internet 2 Abilene network
- Secondary: Public internets
  - Good results to-date in testing
  - Depends on path, congestion

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IP Network Connections to POIC

- Most ISS remote sites have Internet 2 Abilene access
- Hundreds of universities and agencies are members
- High-speed 2 Gigabit per second connections to backbone
- Reliable, closely managed
IVoDS Servers

MSFC Payload Operations and Integration Center

EVoDS Voice Switch

PAYCOM Client PC

Administrator Client PC

Encrypted IP Voice Packets

NASA, Research, and Public IP Networks

Remote Sites

EVoDS Keysets

Voice Loops

VoIP Telephony Gateways

LAN

Conference Servers

Virtual Private Network Server

Administrator Server

Vendors
Conference Servers: First Virtual Communications
Administrator Server: AZTek
Telephony Gateway: VoIP Group
IVoDS Servers

- Virtual Private Network (VPN) Server
  - Provides user authentication and strong encryption
  - Connects to VPN client on remote IVoDS PC
- Conference Servers
  - Host conferences to which clients connect. Provide mixing of incoming audio streams and output of mixed stream to clients
  - Servers can be chained to scale processing power required
- Administrator Server
  - Manages the users and conferences, controls Conference Servers
- Telephony Gateways
  - Convert EVoDS telephony traffic to IP packets
Design: Mixing COTS and Custom Components

- System design options:
  1. COTS-only products. Not possible – IVoDS-unique requirements.
  2. Build “from scratch”. Difficultly finding right developer for complex system with limited marketability. Expensive.
  3. **Modified COTS.** IVoDS approach taken. Systems integrator selects component vendors who will modify their COTS products to meet requirements.

- Goals: 100% COTS. When custom code required, well-defined custom-COTS interfaces utilizing standards and toolkits/ Application Programming Interfaces (API)

- Results - estimated percentage of COTS vs. custom code:

<table>
<thead>
<tr>
<th>IVoDS Component</th>
<th>% COTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPN Server</td>
<td>100</td>
</tr>
<tr>
<td>Conference Server</td>
<td>100</td>
</tr>
<tr>
<td>Administrator Server</td>
<td>80</td>
</tr>
<tr>
<td>Telephony Gateways</td>
<td>90</td>
</tr>
<tr>
<td>IVoDS User Client PC Hardware</td>
<td>100</td>
</tr>
<tr>
<td>IVoDS User Client PC Software</td>
<td>50</td>
</tr>
</tbody>
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IVoDS Requirements Driving COTS Changes

• Virtual private networks
  - Challenge: COTS VPN’s are optimized for large packet, non-time sensitive traffic. Small voice packet size causes performance problems.
  - VPN vendor rewrote the driver for the Intel EtherExpress 1000 card
  - IVoDS requirements helped drive a better product which is now on the market

• First Virtual Communications - Voice servers and client toolkit
  - Challenge: COTS conferencing products are designed for business use. User participates in only one conference at a time, not eight.
  - FVC enhancements: client toolkit, support for multiple conference streaming
  - IVoDS requirements drove:
    - CUWeb Client 2.0 toolkit release
    - Conference Server Version 6 voice performance improvements

• Goal: insure enhancements are included in future COTS product releases
  - Avoid “one off”, “step child” version that doesn’t get COTS vendor attention
  - Be able to upgrade to/benefit from new releases
Lessons Learned: “Modified COTS” Approach

• Suggestions for customer:
  • Require close systems integrator and operations organization communications during systems development to minimize long-term maintenance costs
  • Modified COTS products invariably require long-term engineering support from the vendor
    ▪ Make an agreement up-front on fixed or per-hour fees
  • Insure rights to licenses, source code, designs, etc.
    ▪ Require delivery of source code in event COTS vendor discontinues support for product. “Third-party escrow” is most secure method but expensive.

• Suggestions for system integrator:
  • Clearly define role of COTS in subcontracts and purchase agreements with vendors
    ▪ Even if not “required”, have customer review and approve all subcontracts and purchase agreements that impact long-term maintenance.
  • Utilize toolkits/API’s for custom-COTS interfaces
  • Utilize standards to extent possible
  • Identify second sources for COTS products when possible

• Suggestions for COTS vendors
  • Define modified-COTS product descriptions, part #’s, special configurations, and ordering information in a price list that can be used by customer procurement and vendor sales organizations for future purchases and maintenance
Potential IVoDS Future Enhancements

• Short-term:
  - Additional real-time collaboration capabilities:
    - Video teleconferencing
    - Instant messaging
    - Application sharing

• Long-term:
  - IP multicast transmission
  - Guaranteed quality-of-service
  - VoIP industry trends, standards

Future IVoDS: video, instant messaging,…

Unicast: one talker + three listeners = three redundant streams
Technology Transfer To Other Applications

- IVoDS technology transfer aspects
  - Use of Internet Protocol networks/devices provides great flexibility for voice/video applications
  - Software-based architecture allows enhancements for special requirements not possible with hardware-based voice systems
- Voice hubs for other NASA centers and ISS International Partners
  - Italy: ASI
  - European Space Agency
  - Canada
- Space Launch Initiative test site communications (NASA)
  - Mobile: laptops, wireless IP network
- Emergency response systems (AZTek, Lockheed-Martin)
  - Integrate voice/video communications from a variety of vendor systems and organizations (e.g., local police, state police, FBI)
Summary

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