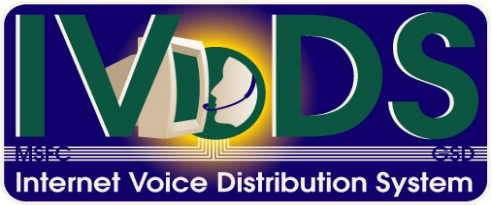
Utilization of Internet Protocol-Based Voice Systems in Remote Payload Operations



GSAW 2003

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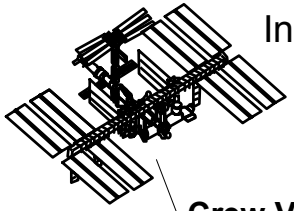
Purpose of Presentation

- 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



International Space Station

Crew Voice Loops

JSC Mission Control Center

Crew + Ops Voice Loops

MSFC Payload Operations & Integration Center

MSFC Voice Switch

IVoDS Server And Gateways

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

Rationale for New Voice System for Remote Users

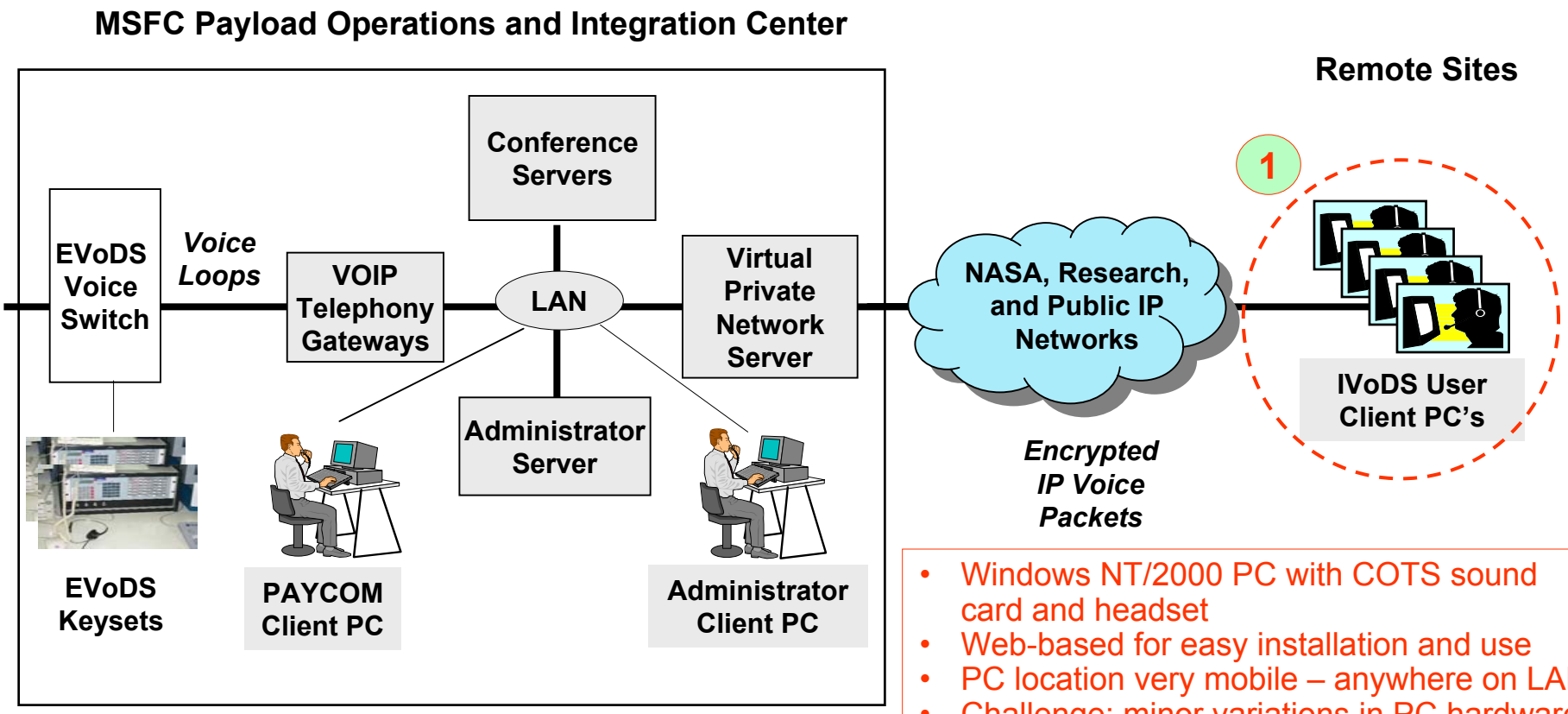
- EVoDS is expensive for remote sites
  - Custom keyset, headset, and communications equipment
  - T-1 leased line to remote site
- EVoDS is nearing end-of-life (utilized for 12 years)
- Large number of remote users
  - Initial support for 50 remote users
  - Expansion to 200 remote users
  - Potential 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):

Service	EVoDS Cost	IVoDS Cost
Network Bandwidth	$9,000/year	$2,000/year
Maintenance	$1,000/year	$1,800/year
Hardware	$25,000	$1,000

Internet Voice Distribution System (IVoDS) Overview

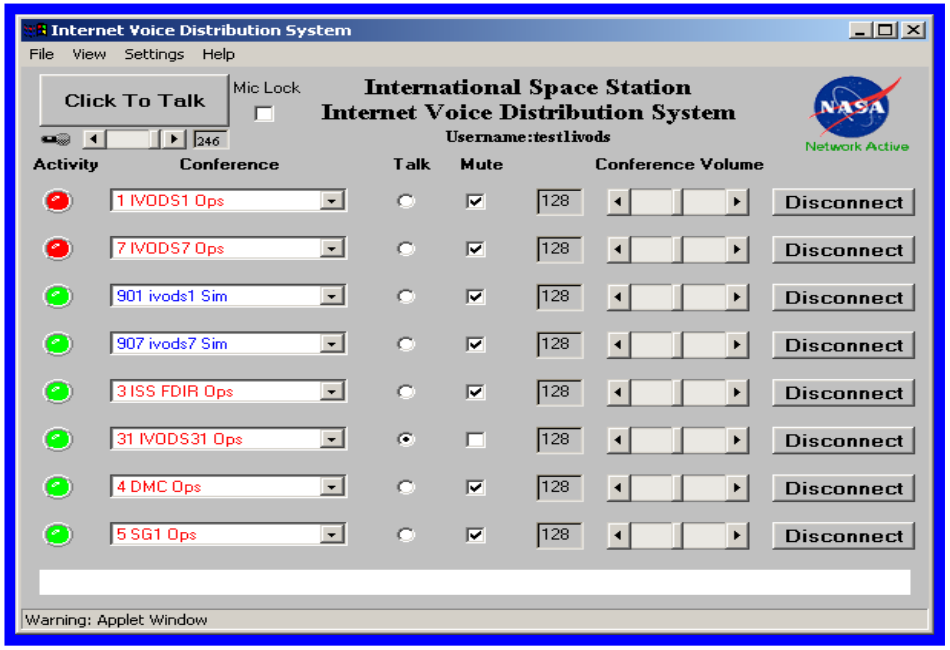
- Extends the existing telephony-based EVoDS voice switch utilizing Voice over Internet Protocol (VoIP) technology
- Remote users located at NASA centers, universities, and companies throughout North America
- Three major components:
  1. IVoDS user client PC's at remote sites
  2. Internet Protocol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

IVoDS User Client



- 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

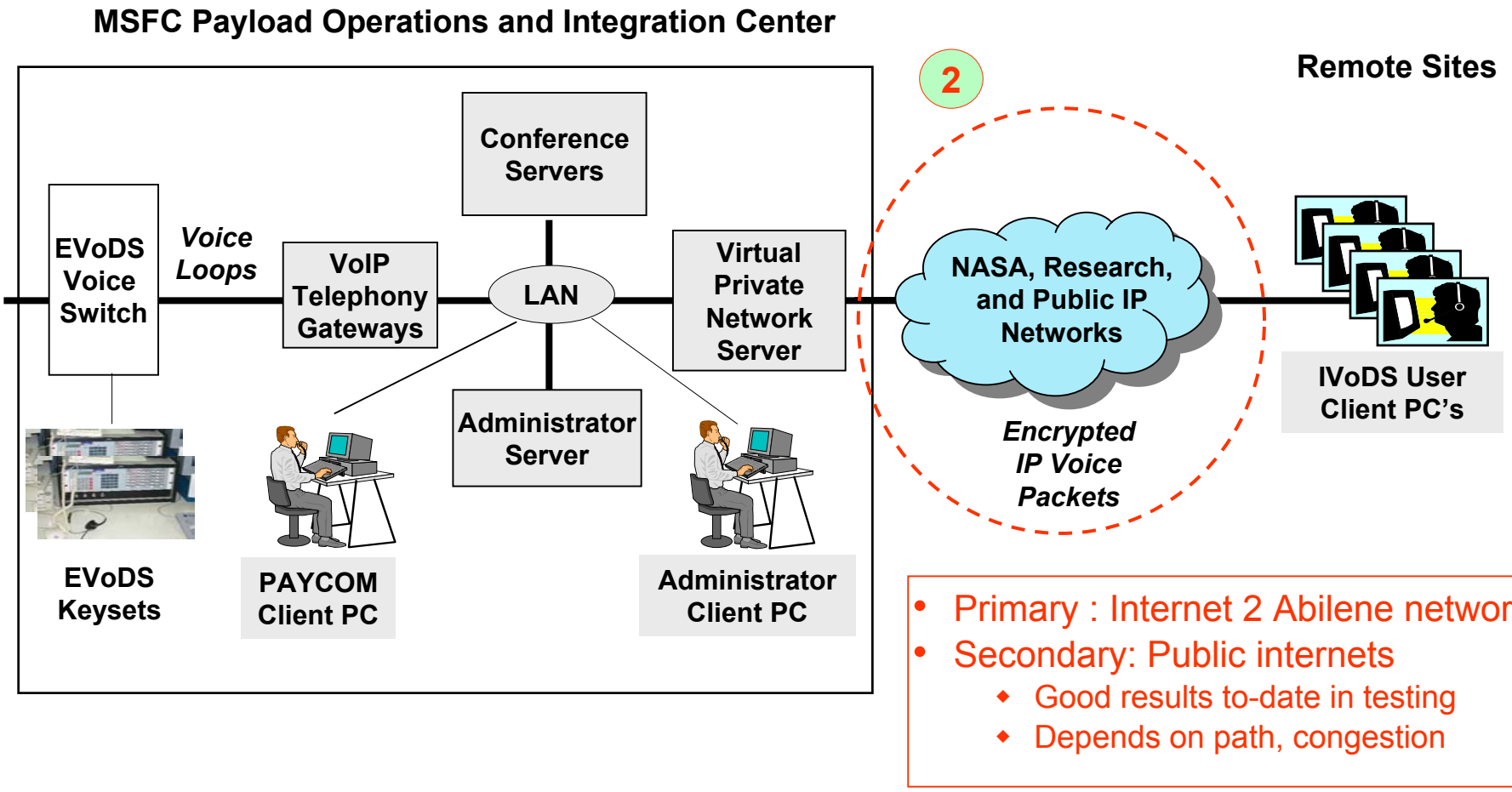
IVoDS User Client



Capabilities

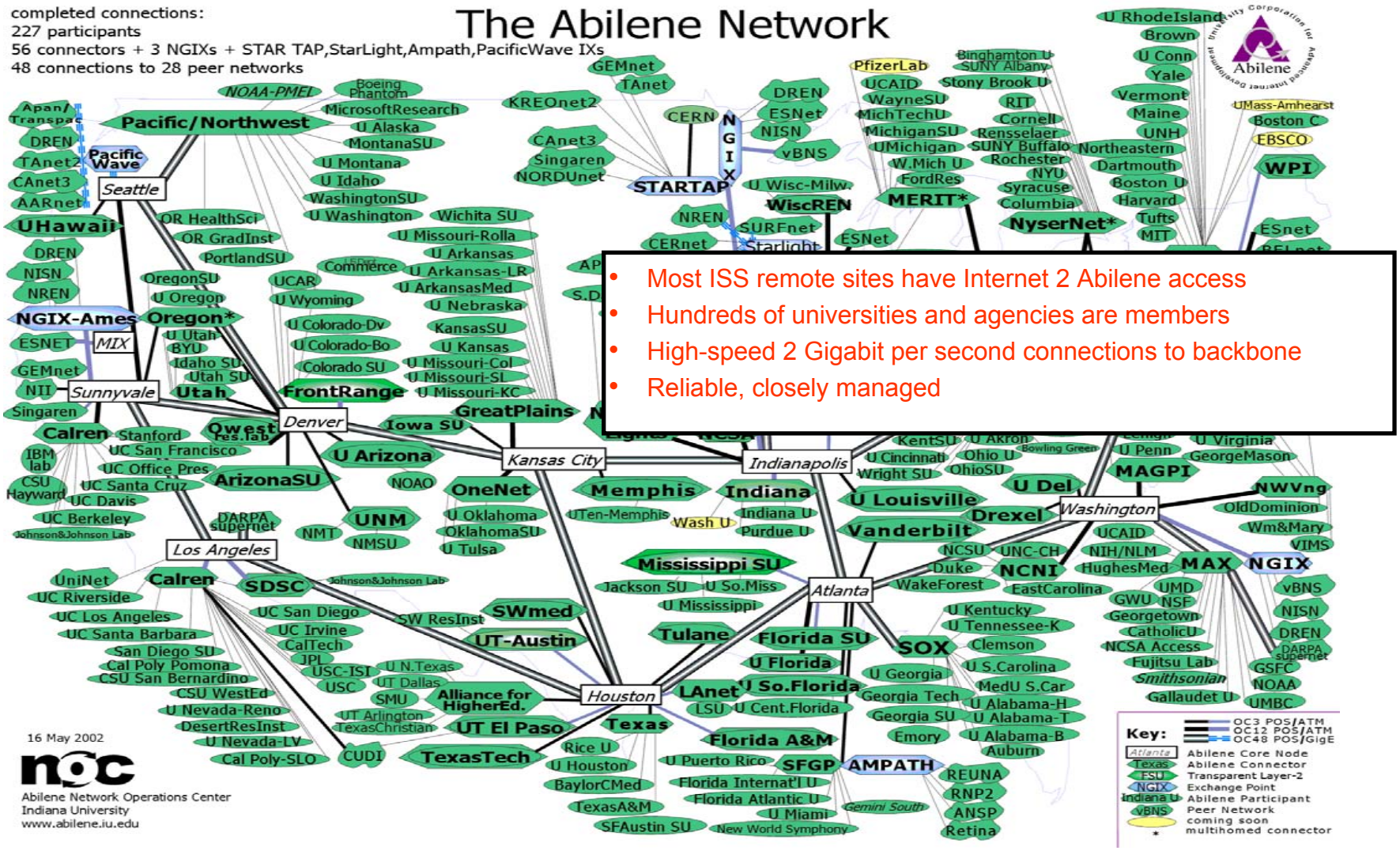
- Monitor 8 conferences simultaneously, talk on one
- User selects from authorized subset of available voice conferences
- Volume control/mute for individual conferences
- Assign talk and monitor privileges per user and conference
- Show lighted talk traffic per conference
- Talk to crew on Space (Air)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

IP Network Connections to POIC

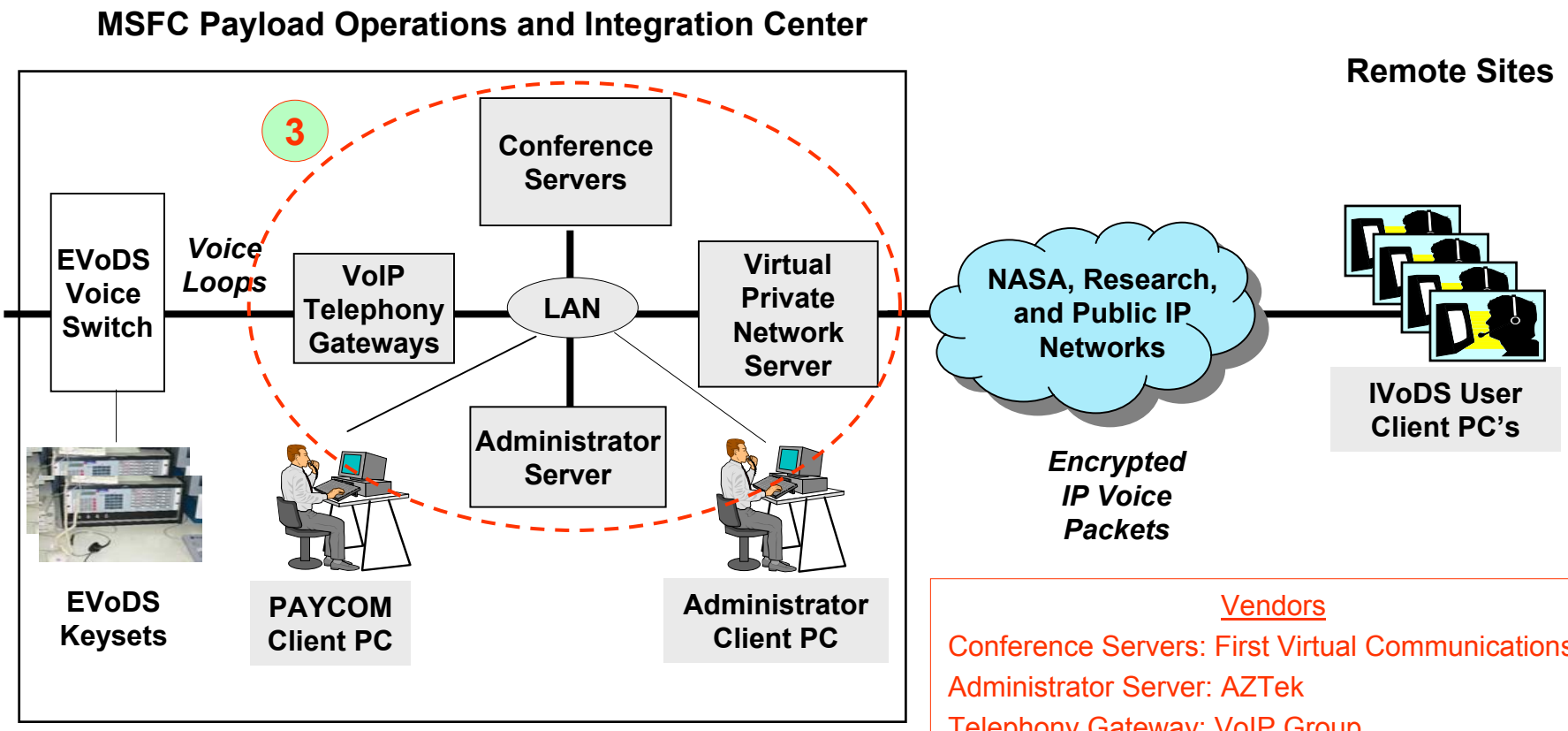


- Primary : Internet 2 Abilene network
- Secondary: Public internets
  - Good results to-date in testing
  - Depends on path, congestion

IP Network Connections to POIC



IVoDS Servers



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:

IVoDS Component	% COTS
VPN Server	100
Conference Server	100
Administrator Server	80
Telephony Gateways	90
IVoDS User Client PC Hardware	100
IVoDS User Client PC Software	50

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

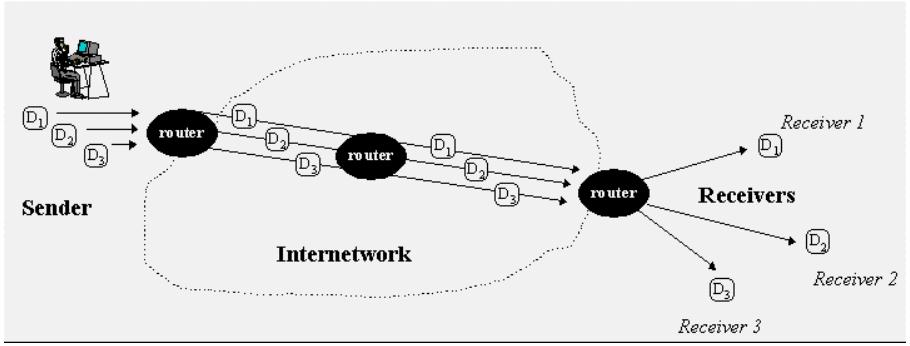
Lessons Learned: "Modified COTS" Approach

- 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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