Network Convergence Through Advanced Data Services

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Biographical Information - The seminar will be led by Steven Taylor, President of Distributed Networking Associates and Publisher/Editor in Chief of Webtorials.Com, a premier source of on-line telecommunications seminars and market research.   An independent consultant, planner, author, and teacher since 1984, Mr. Taylor is frequently quoted in the trade press and is one of the industry's most published authors on high bandwidth networking techniques. Distributed Networking Associates may be contacted at 2707 Lake Forest Drive, Greensboro, NC 27408; (336) 288-3858. E-mail: taylor@distributed-networking.com.

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Network Convergence Through Advanced Data Services

- Background
- Application Models
- Do Converged Applications "Work"?
- Do Converged Networks Make Business Sense for the Enterprise?
- Summary

Network Convergence Through Advanced Data Services

➡ Background

What is Network Convergence?

- *"The integration of all types of information - voice, data, video, and image - into a single network infrastructure."*
- This integration involves both technology **and** people
- Defining both terminology and technology is key to a successful implementation

Convergence Timeline

Voice and Data on Circuit-Switched Network
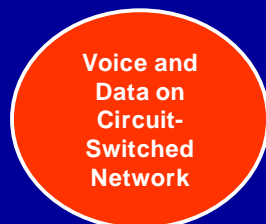
- Pre-Broadband network
  - Data over the voice network
  - Based on circuit switching
  - Voice network as the building block for data networks

Yesterday

Digital Voice Example (PCM)

- 8000 Samples per second
- 255 code levels (8 bits per sample)
- 64,000 bits per second

Source: Screen capture from "CoolEdit" - http://www.syntrillium.com/
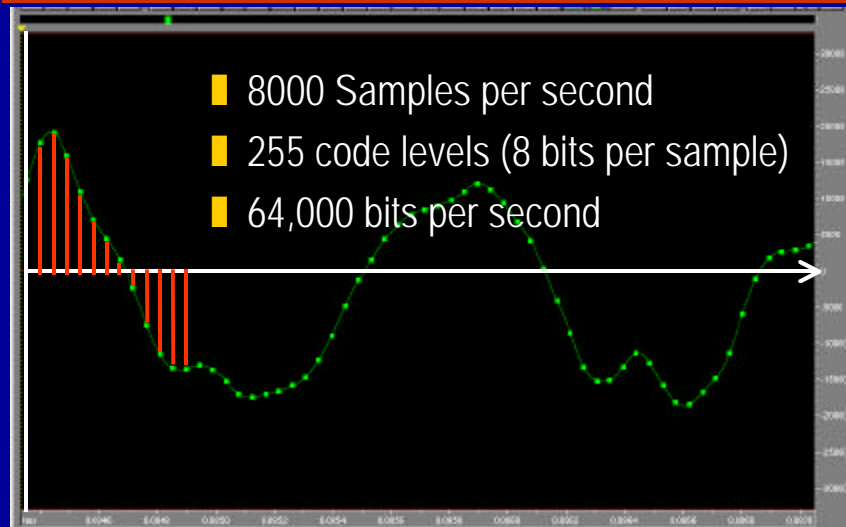
Traditional Digital Hierarchy

- 64 kbps (DS0) is the fundamental building block
  - DS1 (T1) carries 24 DS0s in 1.544 Mbps
  - DS3 (T3) carries 28 T1s in ~45 Mbps
  - OC1 carries 3 T3s on ~150 Mbps
- Data speeds have been adapted to fit into this hierarchy
  - "Low speed" data at 56 kbps due to timing considerations
    - Can only use seven bits per "voice sample" timeslot

Voice "versus" Data

- Key information characteristics
  - "Real time" versus "Non Real Time"
  - Continuous versus sporadic (bursty) information flow
  - Actual characteristics versus implementation

Traffic	Real Time	Bursty?
Voice	Yes	No / Yes
Data	No	Yes
Video (Conference)	Yes	No
Video (Stored)	No	N/A
Image	No	Yes

Circuit Switched Service Characteristics

- Circuit Switched
  - Bandwidth dedicated to each connection / call
  - Constant bandwidth allocation
  - Great for PCM voice

Bandwidth

256 kbps (Channel 4)

512 kbps (Channel 3)

512 kbps (Channel 2)

256 kbps (Channel 1)

Time

Full T1
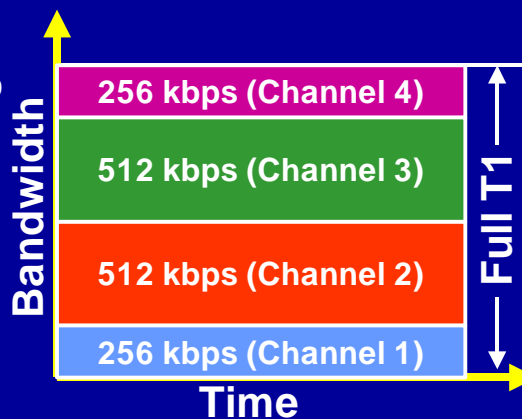
Packet Switched Service Characteristics

▌ Packet Switched
  ▌ Bandwidth allocated from a shared pool as needed
  ▌ "All of the bandwidth part of the time"
  ▌ Great for Data

Bandwidth

Time

Full T1
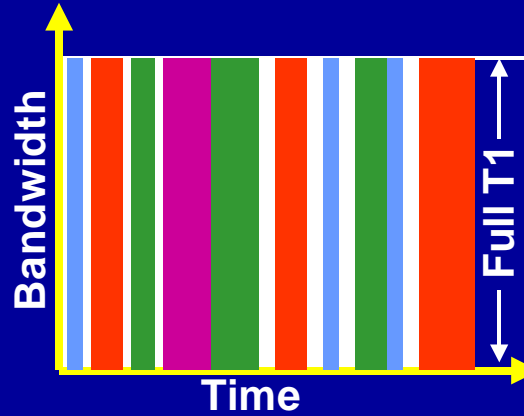
| Channel 1 | Channel 2 | Channel 3 | Channel 4 |

Convergence Timeline

Voice and Data on Circuit-Switched Network

Voice on Circuit Network

Data on Broadband Packet Network

Yesterday   **Today**
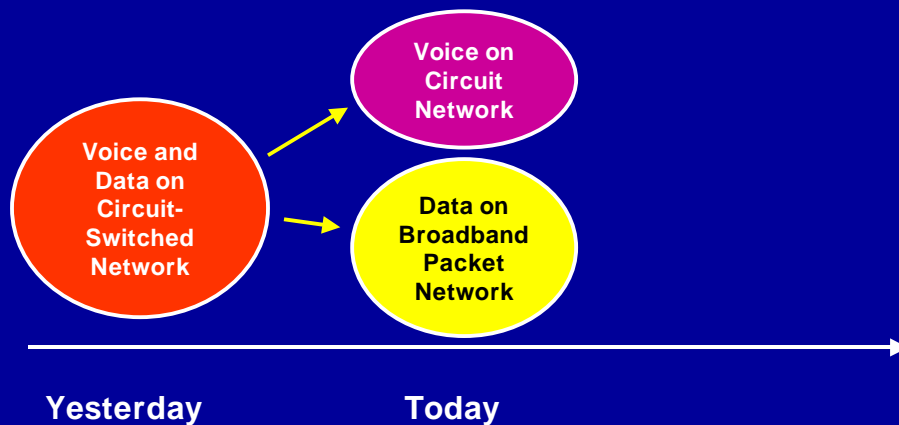
What is "Broadband Packet"

❚ Packet switching for bandwidth efficiency
  ❚ Data is "bursty"
❚ High transmission speeds
  ❚ Fast throughput, with guaranteed transmission (if desired) left to higher layers
  ❚ Multimedia-enabled infrastructure
❚ Currently in three "flavors"
  ❚ IP, Frame Relay, and ATM

Broadband Packet Service Types

❚ Frame Relay, IP and ATM are becoming widespread and are more similar than different
❚ Key differences:
  ❚ Fixed vs. variable packet length
  ❚ Connection vs. connectionless

| Delimiter | Trailer (opt.) | Payload | Header | Delimiter |
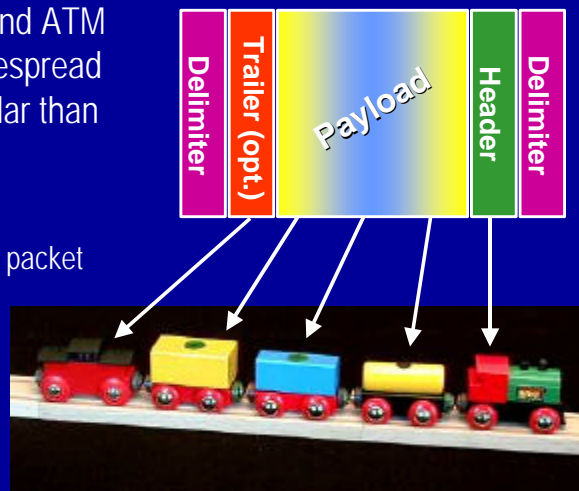
Generic Packet Format: Payload

❚ Variable: Frames
  ❚ Efficient use of bandwidth
  ❚ "Frame Relay" & IP

Generic Packet Format: Payload

❚ Variable: Frames
  ❚ Efficient use of bandwidth
  ❚ "Frame Relay" & IP

❚ Fixed length: Cells (ATM)
  ❚ Easy to process with Predictable delay

8
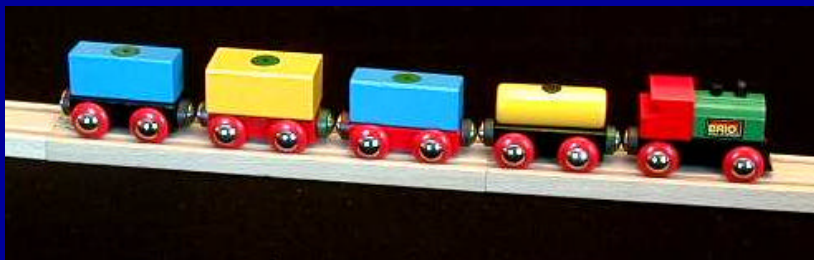
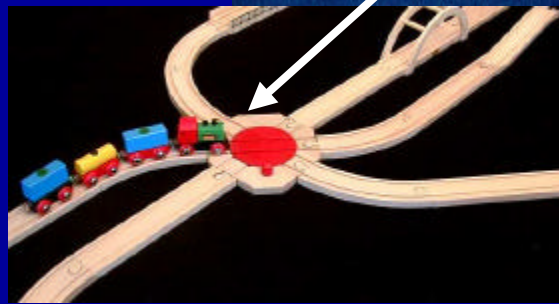# Generic Packet Format: Payload

❚ Variable: Frames
  - ❚ Efficient use of bandwidth
  - ❚ "Frame Relay" & IP

❚ Fixed length: Cells (ATM)
  - ❚ Easy to process with Predictable delay
  - ❚ *Always* the same size

Generic Packet Format: Header

❚ Connection oriented
  - ❚ Virtual Circuit number
  - ❚ Conserves address space
  - ❚ ATM and Frame Relay

Generic Packet Format: Header

- Connection oriented
  - Virtual Circuit number
  - Conserves address space
  - ATM and Frame Relay

Generic Packet Format: Header

- Connection oriented
  - Virtual Circuit number
  - Conserves address space
  - ATM and Frame Relay
- Connectionless (IP)
  - "Universal," unique address
  - Needs large address space
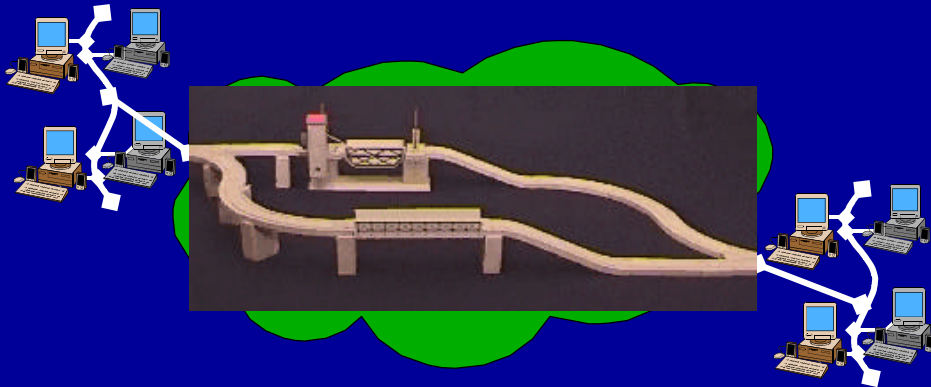   - Is this a problem?

Generic Packet Format: Header

▮ Connectionless (IP)
  ▮ "Universal," unique address
  ▮ Needs large address space
    ▮ Is this a problem?

Connection-oriented vs. Connectionless Architectures

▮ Common misconception: Connection-oriented architectures are "nailed-up" within the network.

Broadband Packet Types

- Bottom Line: All three "work"
    - Single-technology world view misses the big picture
        - Great for marketing, selling magazines, and creating editorial content and controversy
        - Promotes the "Technology of the Month Club"
    - "Broadband Packet" looks at the bigger picture

	Fixed length	Variable length
Connection	ATM	Frame Relay
Connectionless	N/A	IP

Convergence Timeline

Voice and Data on Circuit-Switched Network

Voice on Circuit Network

Data on Broadband Packet Network

Voice and Data on Broadband Packet Network

Yesterday   Today   Tomorrow
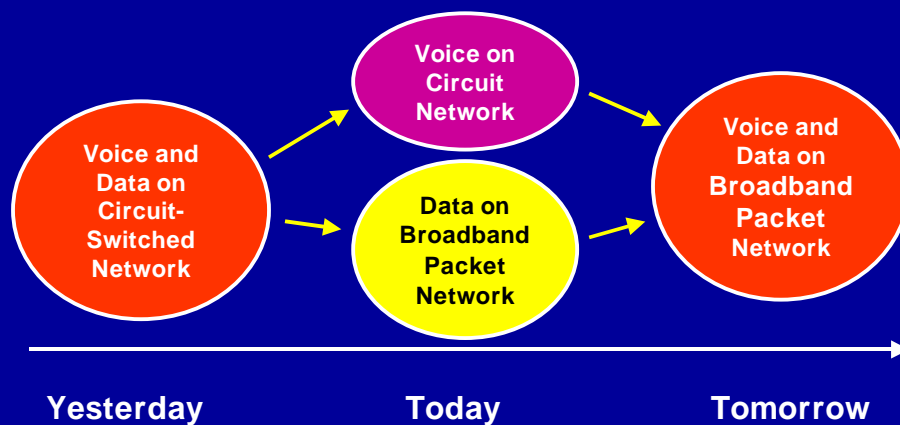
Voice vs. Data Bandwidth

❚ Typical speeds for a single "conversation"
  ❚ Note that the scale is logarithmic

Source: SWAGs by Taylor — Voice kbps, Data kbps
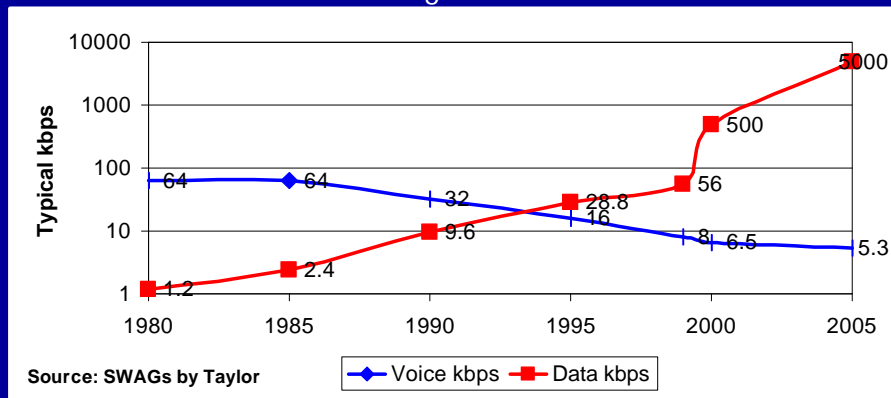
Converged Broadband Networks

❚ Voice is added to the "data network"
❚ Implies:
  ❚ Voice over IP (VoIP)
  ❚ Voice over Frame Relay (VoFR)
  ❚ Voice over ATM (VoATM)
❚ Voice over IP, Frame Relay and ATM implies:
 ❚ Packet voice
  ❚ Compressed voice

Why packet voice?

➡ Effective bandwidth utilization and control

▮ Only send info that is actually needed

▮ Voice Activity Detection (VAD)

▮ No "clipping" as in prior Digital Speech Interpolation (DSI) mechanisms

Source: Screen capture from "CoolEdit" - http://www.syntrillium.com/

Today's Compressed Voice

▮ 5 - 8 kbps "CELP" Algorithms reproduce "sounds"

▮ Less than 10% of traditional bandwidth

▮ Excellent quality

▮ Lots of processing, but processing is cheap

Source: Screen capture from "CoolEdit" - http://www.syntrillium.com/
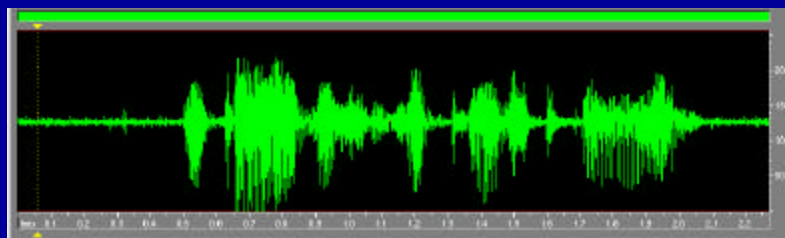
When is Compressed Voice Important?

✔ If you pay a lot for facilities

✔ If you have a high density of calls

✔ If facilities are scarce or don't exist

✔ Key Trade-off: Processing and reduced bandwidth versus simplicity and compatibility

Network Convergence Through Advanced Data Services

▮ Background

➡ Application Models

Application Models

➡️ Packet Telephony Service Providers
- ❚ Carriers who provide standard telephony services over a "Broadband Packet" infrastructure
- ❚ ITSP (IP Telephony Service Providers)
  - ❙ Usually an ISP offering VoIP
- ❚ Could be a Frame Relay or ATM service provider
  - ❙ The exact type of "packet" is relatively unimportant

Carrier Infrastructure (ITSP)

- ❚ "Normal" telephony interfaces to customers
  - ❚ 1+ or 1010xxx+ service; direct access, or 800 access
- ❚ POTS, plus normal enhanced telephony features

ISP or other Compressed Voice Carrier

Application Models

❙ Packet Telephony Service Providers

➡ Integrated Voice/Data Service

　　❙ Corporate "Enterprise WAN" Architecture

　　❙ Primary carrier service is IP, Frame Relay, or ATM

Integrated Voice/Data Infrastructure

❙ Corporate intranetwork transport of voice from PBXs
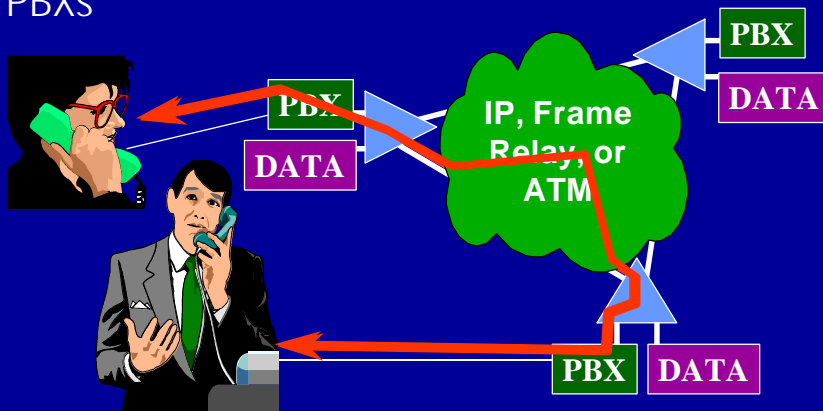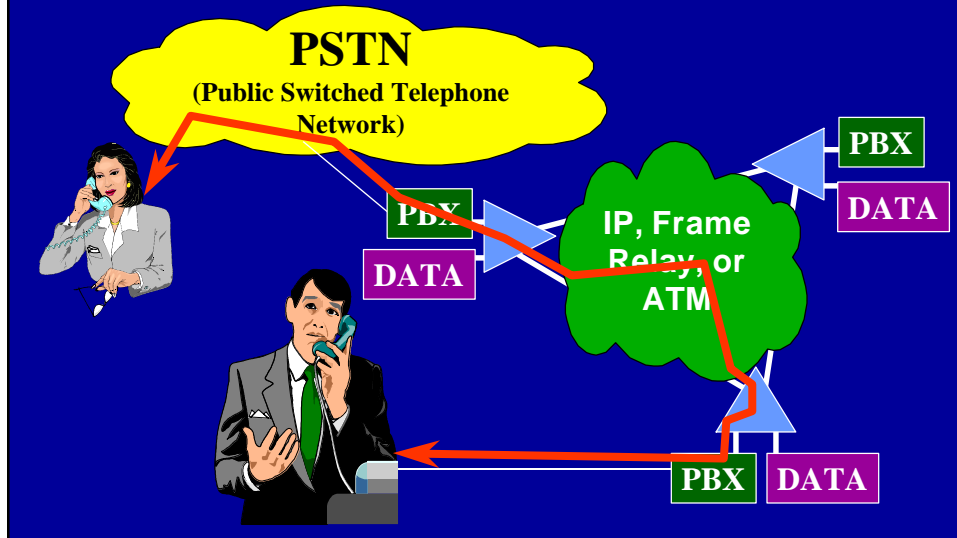
PBX

DATA

PBX

DATA

IP, Frame Relay, or ATM

PBX DATA

PBX DATA

Also for Remote Off-Net

PSTN
(Public Switched Telephone Network)

PBX

DATA

IP, Frame Relay, or ATM

PBX

DATA

PBX

DATA

PBX DATA

Reference Architectures

❚ Packet Telephony Service Providers
❚ Integrated Voice/Data Service
➡ Workstation-to-Workstation
   ❚ "PC-to-PC" communications
   ❚ Always works on the LAN; Plenty of bandwidth
   ❚ May be creeping into the WAN

Workstation-to-Workstation

❚ Primarily IP
  ❚ Provides the feature set originally envisioned for ATM
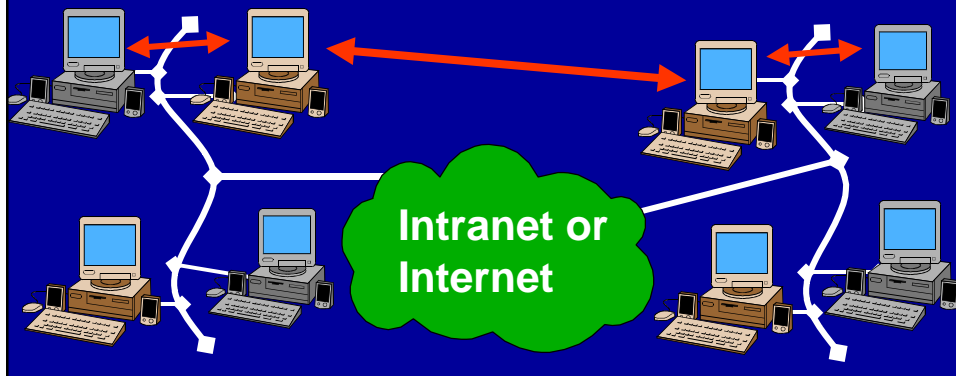
Intranet or Internet

Reference Architectures

❚ Packet Telephony Service Providers
❚ Integrated Voice/Data Service
❚ Workstation-to-Workstation
➡ Any-to-Any
  ❚ Workstation to PSTN is particularly key (and difficult)
  ❚ "Gateway Services" will provide interworking

Any-to-Any Applications
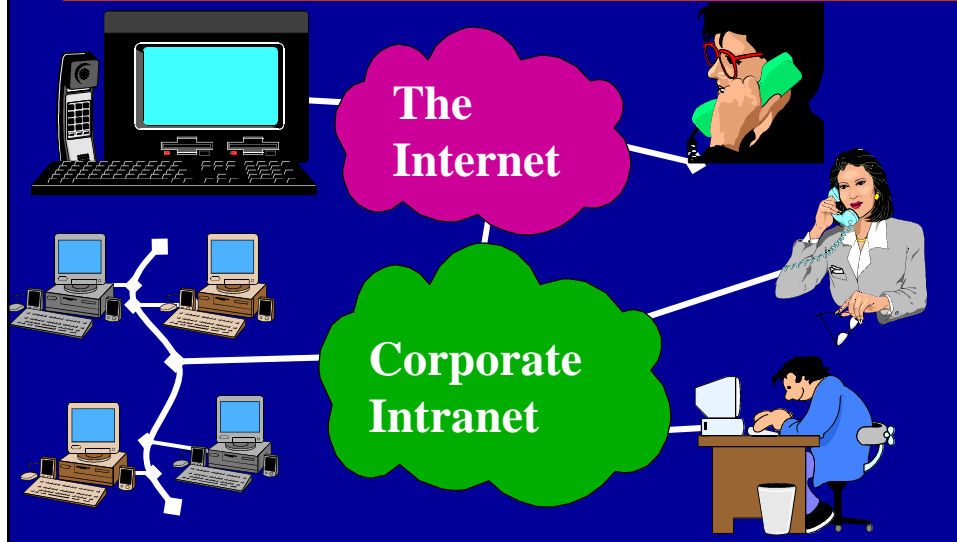
The Internet

Corporate Intranet

Network Convergence Through Advanced Data Services

▌ Background

▌ Application Models

➡ Do Converged Applications "Work"?

Packet Voice Sound Quality

- Primary algorithms are "CELP" based
  - VoIP uses G.723.1 at 5.3 and 6.3 kbps (default)
  - VoFR uses G.729 at 8 kbps (default)
- Quantitative measurements show "near toll quality"
- Mean Opinion Scores (MOS) measurements
  - 4.0 is "toll quality"

"Mean Opinion Score" Values
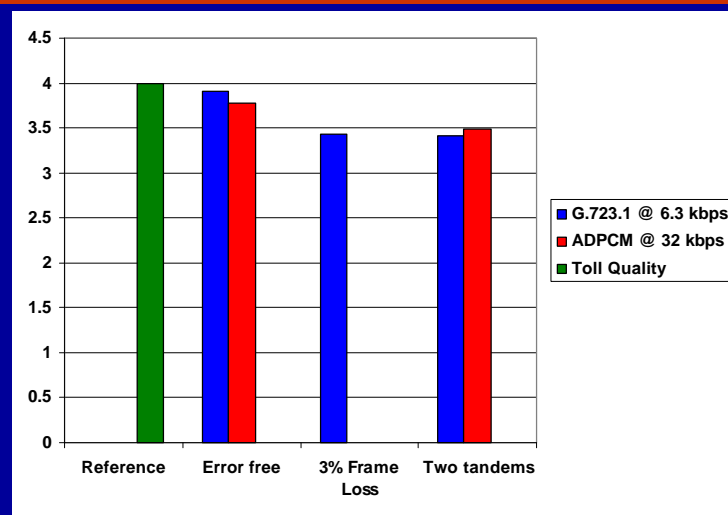
Data Source: IEEE at http://www.comsoc.org.mx/std_7231.htm

How do you think it sounds?

❚ Actual samples of phonetically balanced sentence at various bit rates
   ❚ "Add salt before you fry the egg."

Source: Screen capture from "CoolEdit" - http://www.syntrillium.com/
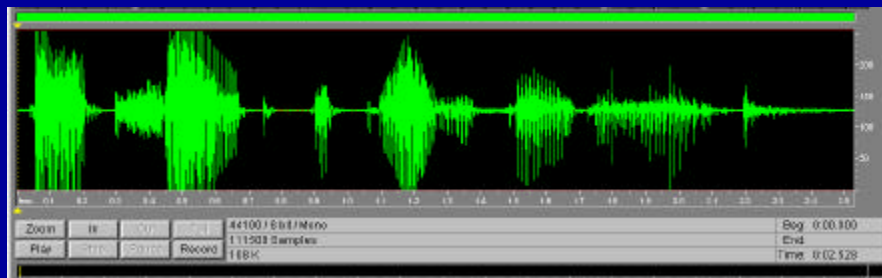
Voice Samples

❚ Prepared by Sipro Lab Telecom Inc.

❚ For more information, visit http://www.sipro.com.

❚ Reference Samples
   ❚ 44 kHz
   ❚ 8khz
   ❚ 64 kbps PCM

Algorithm	No Errors	1% Bit Errors	3% Bit Errors	1% Frame Loss	3% Frame Loss
ITU G723.1 at 5.3 kbps (ACELP)	🔊	🔊	🔊	🔊	🔊
ITU G723.1 at 6.3 kbps (MP-MLQ)	🔊	🔊	🔊	🔊	🔊
ITU G729A at 8 kbps (CS-ACELP)	🔊	🔊	🔊	🔊	🔊

Delay

- Voice & data are usually combined for economics
- Issue is avoiding adverse impact from data
- Data is tolerant of delay
- Voice isn't...

Public/ Private Frame Relay Network

Switch or Voice Frad

Router
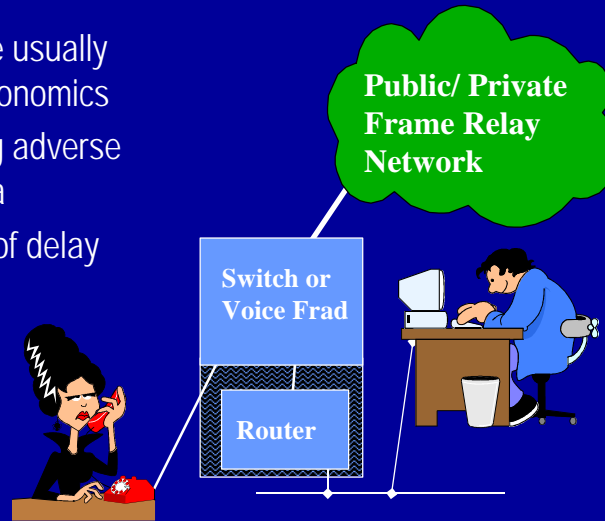
Freeze-Out: Frames

- Only one PDU (frame or cell) can occupy the transmission line at a time.

Frames

Watch for Freeze-out here
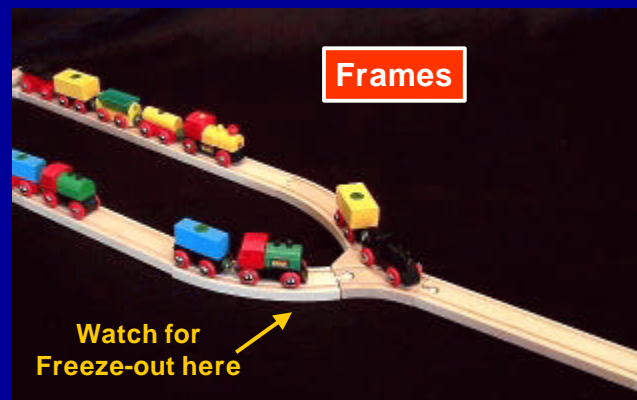
Freeze-Out: Cells

❚ With frames *OR* cells, only one PDU (frame or cell) can occupy the transmission line at a time.

Cells
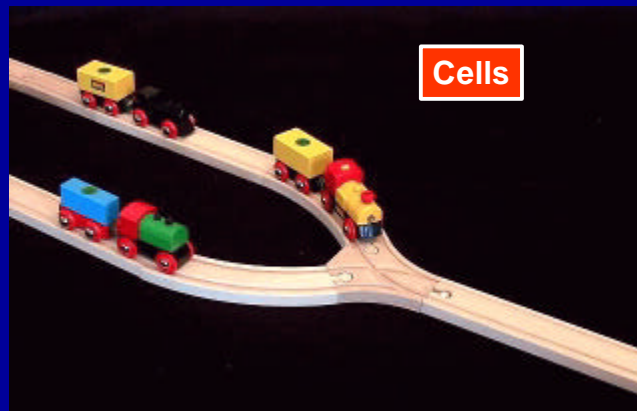
Delay Summary

❚ Delay is generally related to the "packet time"
  ❚ Packet Time = (Packet Size) / Speed
❚ VoIP, VoFR, and VoATM all work well if:
  ❚ Packets aren't too long
  ❚ Transmission speeds are fast
  ❚ Voice is given priority

Delay Summary

▌ Delay i
  ▌ Pack
▌ VoIP, \
  ▌ Pack
  ▌ Tran
  ▌ Voice
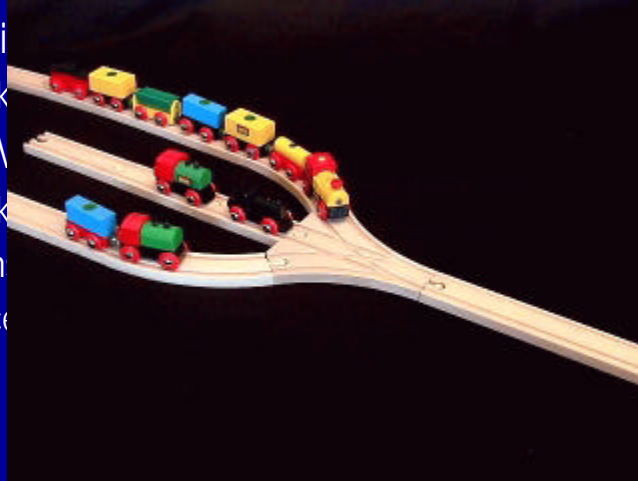
Does it work?

✓ Sounds good
✓ Some types of delay can be controlled
▌ Other issues
  ▌ Are other delay issues addressed?
  ▌ Is there SS7 signaling to provide a full telephony feature set?
  ▌ Are fax problems are solved?
  ▌ Standards are sufficiently in place?
✓ Check out http://www.webtorials.com for more technical information

Does it work?

✓ Sounds good

✓ Some types of delay can be comp...

❚ Other is...

  ❚ Are ...ss...sed?

  ❚ Is the...na...d...tel...g feature set?

  ❚ Are fa...ns a...ed?

  ❚ Standa...e suf...ace?

✓ Check ou...www...is.com for more technical information

YES!

Network Convergence Through Advanced Data Services

❚ Background

❚ Application Models

❚ Do Converged Applications "Work"?

➡ Do Converged Networks Make Business Sense for the Enterprise?

Enterprise Business Case: ITSP (VoIP) Model

❚ Economics: Price per minute versus voice quality
  ❚ Currently price is about two-thirds as much as circuit switched
  ❚ Largely due to "Enhanced Service Provider" status and access costs
    ❙ This is a regulatory anomaly that may disappear
  ❚ But the carrier's use of a converged infrastructure will keep this option attractive

Enterprise Business Case: Workstation-Workstation Model

❚ Integrated into operating system of most workstations
  ❚ Integral feature of "Windows" operating systems
❚ Extra cost in network transport facilities if the call leaves the LAN
  ❚ But should be a marginal incremental cost
❚ Watch for impact on long-term volume commitments for voice

Enterprise Business Case: Integrated Voice/Data

- Price for enterprise-based VoIP/FR/ATM
- Analysis uses representative Frame Relay prices
  - IP and ATM prices should be QUITE similar
- Compressed voice at 5.3 to 8 kbps for IP or FR
  - Assume 100% overhead for Frame Relay; 200% for IP
  - Result is 16 kbps per call; 4:1 statistical advantage
- Voice Activity Detection (VAD)
  - 2:1 statistical advantage
- Result is 8:1 statistical advantage

Comparison with Dial Voice: Fixed Cost Comparison

- Assume the following typical situation
  - 3 hours a day
  - 20 days a month
  - 5 cents per minute
  - Eight lines
- Result: $1440 per month

- For Frame Relay:
  - One 64 kbps PVC
    - Additional / new
    - Representative price: $648 MRC
- Saves $792 (55%)
- Admittedly ignores
  - Access lines for both
    - Roughly the same
  - Equipment prices

Yet Another Option: Usage Rates

- Usage CIR PVC/SVC Rates
  - Within specified CIR - 5.5 cents per Mbyte
  - Discard Eligible - 4.5 cents per Mbyte
- Details
  - Each simplex circuit priced separately
  - Prices per megabyte received (egress)
  - Monthly minimum per PVC: $5.00; capped at 125%
  - Plus usual port and access charges

Usage CIR and Voice

- Assume 16 kbps for a conversation
  - Lots for overhead
  - Assumes half duplex (only one part speaking at a time)
  - Assumes no pauses in conversation
- 16 kbps * 60 sec/min = 960 kb/min
- 960 kb/min ÷ 8 bits/byte = 120 kbytes/min
- 120 kbytes/min = .12 Mbytes/min
- .12 Mbytes/min * 5.5 cents/Mbyte = 0.66 ¢/minute

Summary: Enterprise Business Case

▮ Voice over Frame Relay, IP and ATM is very cost effective for users

▮ Bottom Line:
  ▮ Financial
    ▎ Lower cost for multimedia transmission
    ▎ Reduce/contain operation costs
  ▮ Flexibility
    ▎ Add multiple applications to a single network infrastructure

Network Convergence Through Advanced Data Services

▮ Background

▮ Application Models

▮ Do Converged Applications "Work"?

▮ Do Converged Networks Make Business Sense for the Enterprise?

➡Summary

Summary

- ✔ The technology works
- ✔ Enterprises save money
- ✔ *SOME* carriers will offer a range of services to exploit this technology
  - ✔ Voice services
  - ✔ Data services
- ✔ Packet technology will ultimately reign

The End is Here

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