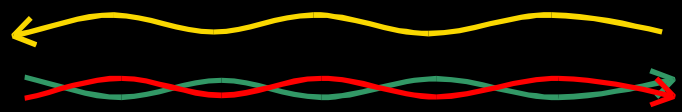
Transporting Voice over xDSL



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V2.1

History

- **Digital telephony grew out of T1/E1 design**
  - T1 was originally used for trunking between COs
  - Offered as a private network service in the 1970's resulting in widespread deployment to business subscribers
- **Limitations make T1 impractical for residential use**
  - requires repeaters (3,000 to 6,000 foot intervals)
    - Expensive to install
  - requires bandwidth of 1.5 MHz to deliver 1.54 Mbps
    - Limited to 1 T1 per 50 pair cable - No T1s in adjacent cables

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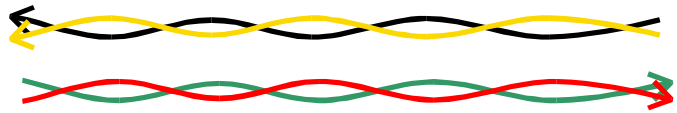
History

- **High bandwidth residential applications emerging**
  - Internet Access
  - Video on on demand
    - Inherently asymmetrical
      - small requests from the residence to the service provider or Internet
      - high volume response, WEB Graphics, Movies etc.
- **ISDN BRI - The original Digital Subscriber Line**
  - Inadequate bandwidth for emerging applications

xDSL Solutions

- **Advances in signal processing allow the creation of digital modems that take optimum advantage of the characteristics of existing copper local loops**
- **Tradeoff between distance and data rate**
  - Short local loops allow high data rates
  - Data rate decreases as loop length increases
  - Approximately 80% of US residences are within 18,000 loop-feet of their serving central office

Symmetric xDSL



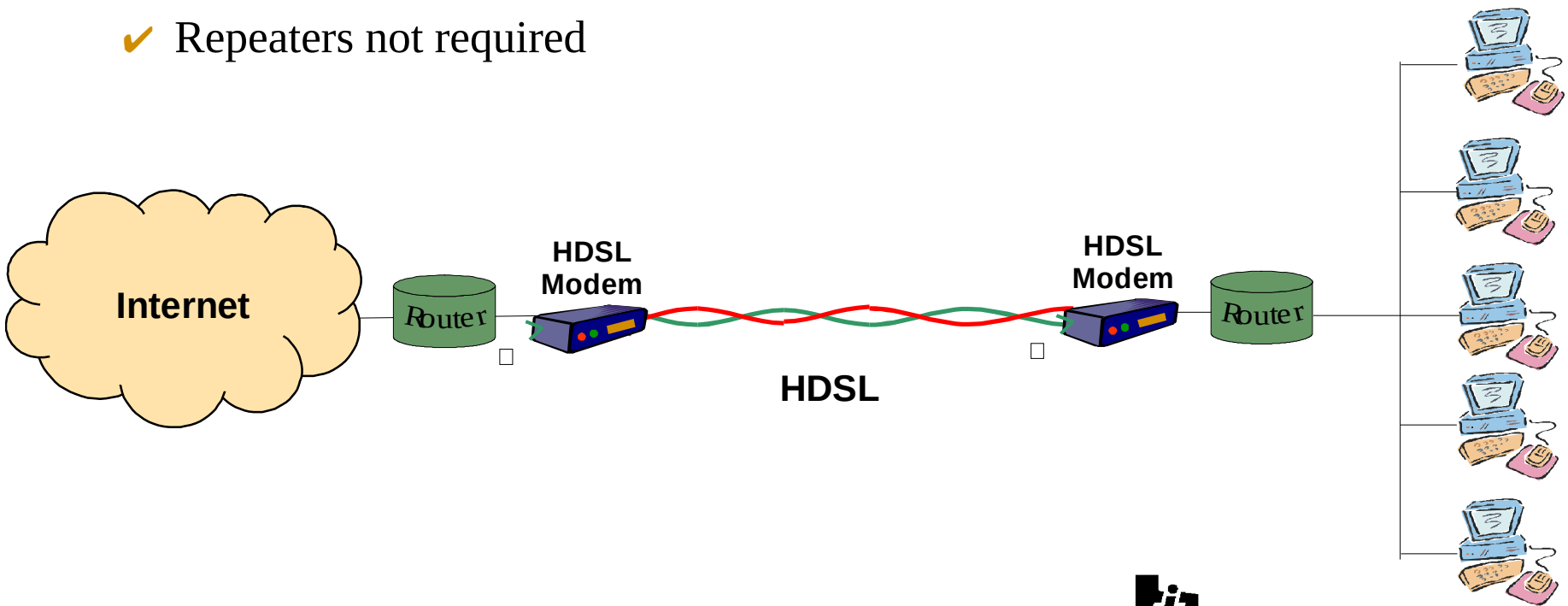
- **HDSL (High Data rate Digital Subscriber Line)**
  - Created as a more economical way to deploy T1 service to business
    - No repeaters or line conditioning required
    - Multiple HDSL lines permitted in the same cable
  - Characteristics:

Data rate:	1.544 Mbps Symmetrical
Loop Length:	Up to 12,000 feet
Transmission Band	80 kHz to 240 kHz (Compared to 1.54 MHz for T1)
Media	Requires 2 twisted pairs
POTS Support	None

TEXAS INSTRUMENTS

Traditional HDSL Application

- **T1 Replacement for Data Connectivity**
  - Simple Installation
  - Repeaters not required



Symmetric xDSL

- **SDSL (Single Line Digital Subscriber Line)**
  - Consider SDSL to be a single pair version of HDSL
    - More appropriate for residential use - most homes have a single line
  - Characteristics:

Data rate:	1.544 Mbps Symmetrical
Loop Length:	Up to 10,000 feet (2,000 less than HDSL)
Transmission Band	80 kHz to 240 kHz (Compared to 1.54 MHz for T1)
Media	1 twisted pair
POTS Support	None

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The Need for ADSL

- **HDSL and SDSL do not support POTS service**
  - Requiring an additional line for phone service
- **10,000 to 12,000 feet does not adequately serve the residential market**
- **1.544 Mbps marginal for MPEG Video**
  - 3Mbps preferred
- ***Capacitive Coupling limits the ability to address these requirements using the existing Copper wiring***

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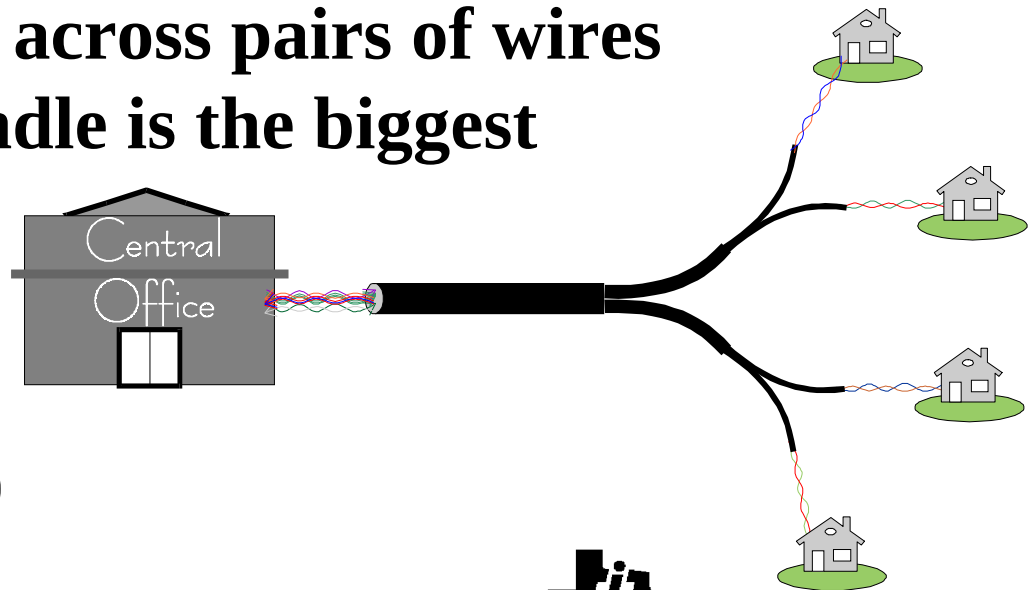
In the Local Loop

- **Cable pairs are spliced and combined in sheaths on their way to the central office**
  - The average loop has 22 splices in the US
  - Thousands of pairs will co-exist in a cable sheath at the CO
- ***Capacitive Coupling*** **across pairs of wires within the same bundle is the biggest factor limiting transmission capacity and distance (Crosstalk)**



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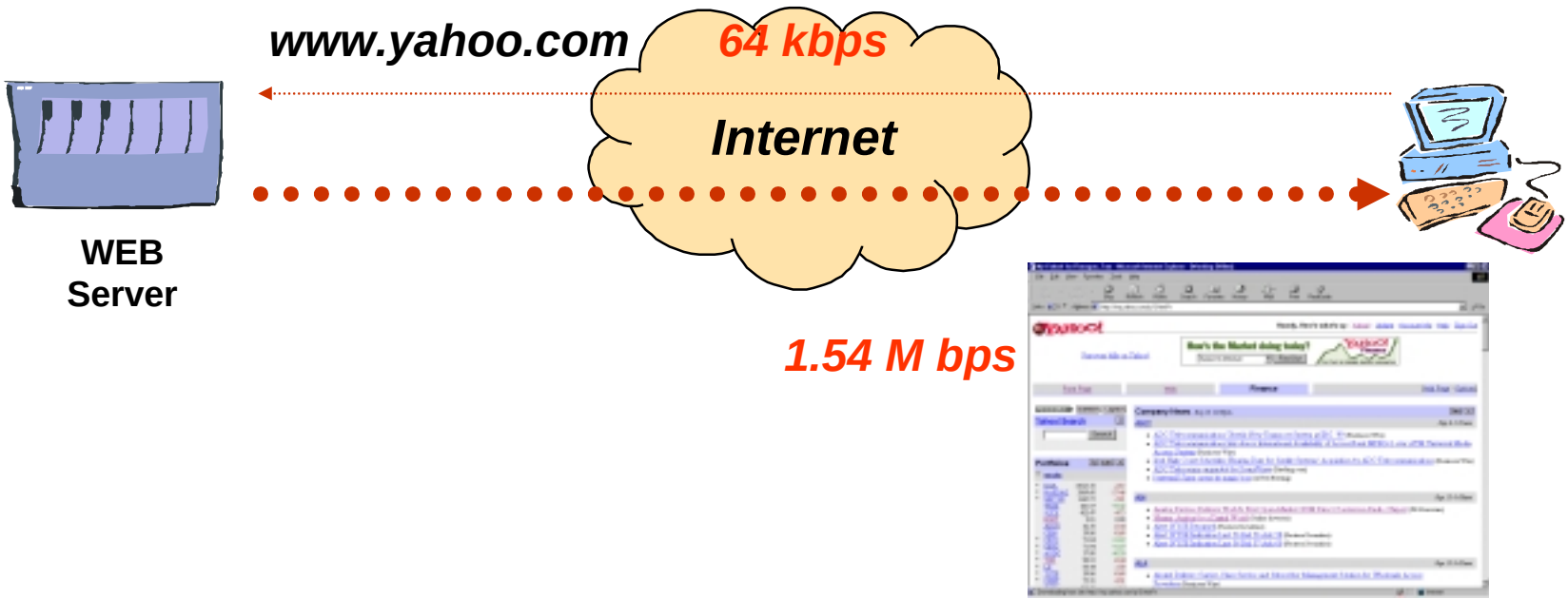
The Asymetrical Solution

- **Transmitting at different rates in each direction greatly diminishes the effect of crosstalk.**
  - Target residential applications are inherently asymmetrical



TEXAS INSTRUMENTS

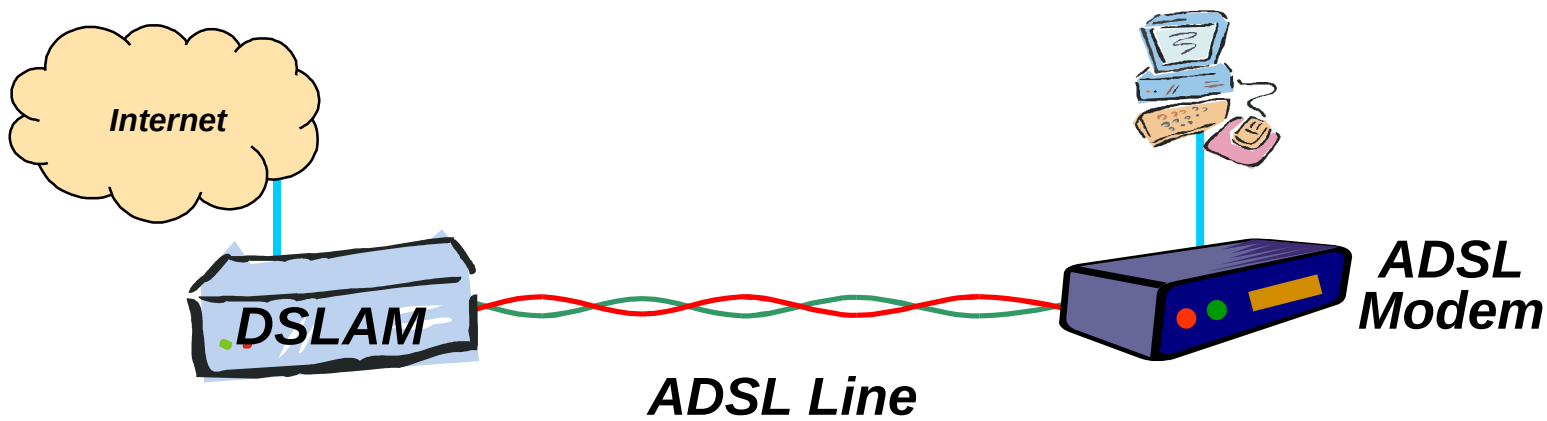
ADSL

- **ADSL (Asymmetric Digital Subscriber Line)**
  - Resistant to crosstalk due to the differing transmit and receive data rates
    - More appropriate for residential use - most homes have a single line
  - Characteristics:

Loop Length (feet)	Typical Data Rates		POTS
	Upstream	Downstream	
18,000	64 kbps	1.544 Mbps	Yes
16,000	65 kbps	2.048 Mbps	Yes
12,000	256 kbps	6.312 Mbps	Yes
9,000	640 kbps	8.448 Mbps	Yes

Equipment

- **A typical DSL service uses a DSL modem as CPE and a DSLAM at the Central Office**
  (Digital Subscriber Line Access Multiplexer)
- **Data is transmitted in ATM cells**



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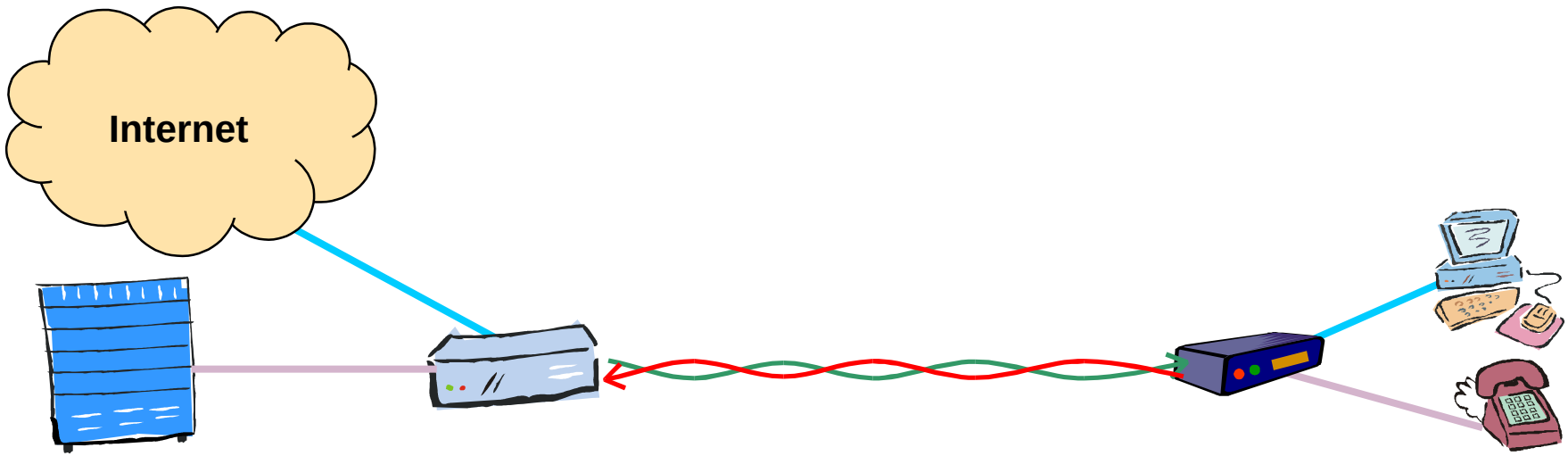
Traditional ADSL Application (ILEC)

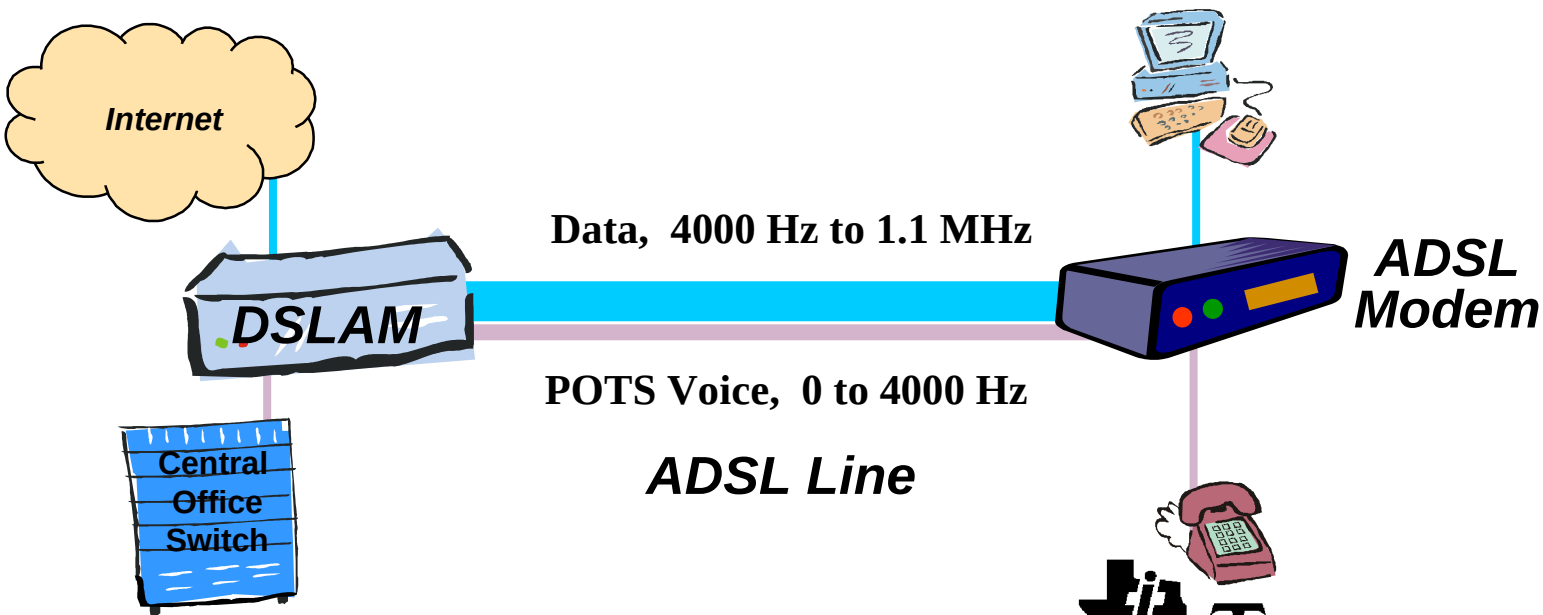
- **Provides a single POTS voice line and simultaneous high data rate Internet Connection**
  - Frees switch ports from long hold time Internet calls
  - Competes with Cable Modem offerings



TEXAS INSTRUMENTS

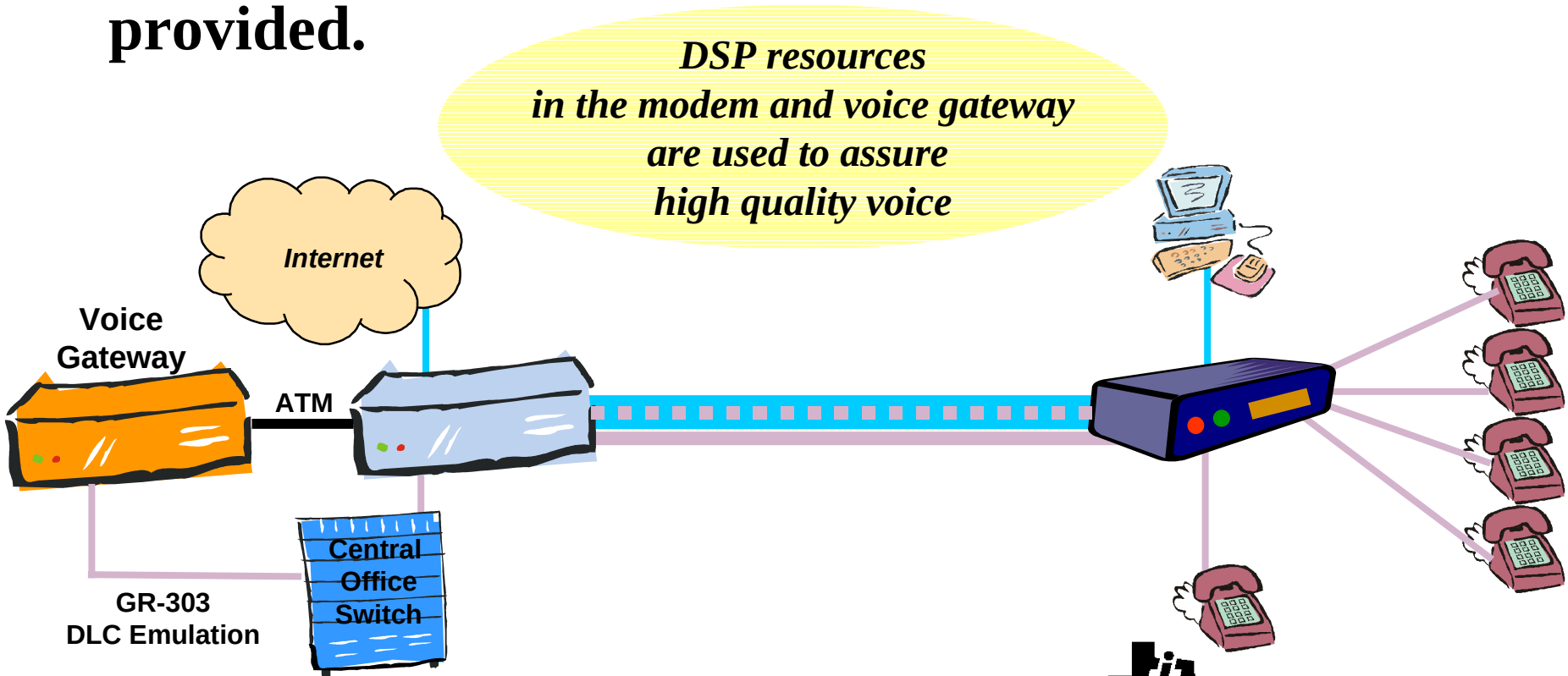
ADSL & POTS

- **ADSL modems divide the line into two channels**
  - Frequencies below 4000 Hz are allocated to POTS voice
  - Frequencies from 4000 Hz to 1.1 MHz are used for data transmission



Derived Voice Service

- **Integrating Voice over Packet into the ADSL equipment allows additional voice services to be provided.**



DSL & CLECs

- **8 million US Business with less than 100 employees**
  - Average $520 per month for 4 to 16 lines
  - NorthPoint charges $165 for 8 lines

- **CopperMountian CLEC ROI analysis:**
  - Assumes metropolitan build out to 20 Cos
  - 200 customers per CO (20% churn, “S” curve adoption model)
  - 2.5 year payback
  - 94% Internal Rate of Return

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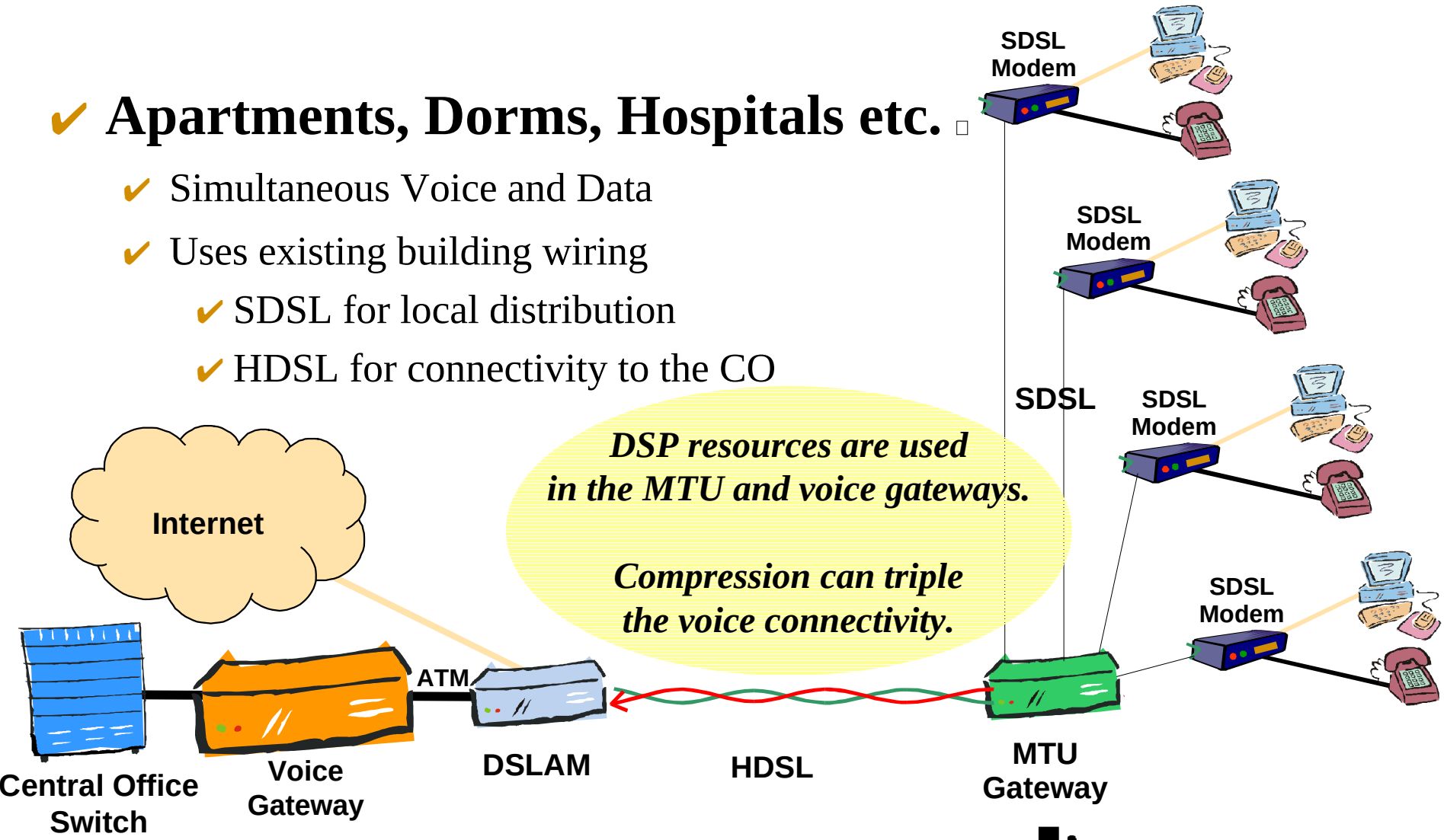
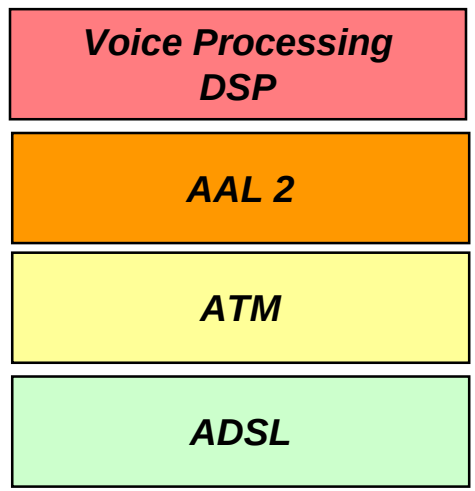
Multi-Tenant Unit

- **Apartments, Dorms, Hospitals etc.**
  - Simultaneous Voice and Data
  - Uses existing building wiring
    - SDSL for local distribution
    - HDSL for connectivity to the CO



Protocols
BLES

- **Basic Loop Emulation Service**
  - Voice Processing in DSP
    - Compression
    - Echo Cancellation
    - VAD/Comfort Noise
    - Jitter Lost Packets etc.
  - AAL 2 Signaling
  - ATM Transport
  - ADSL Physical



Protocols
VoIP

- **VoIP over ADSL**
  - Voice Processing in DSP
    - Compression
    - Echo Cancellation
    - VAD/Comfort Noise
    - Jitter Lost Packets etc.
  - Voice over UDP/IP
  - Encapsulation is either PPP or IP over ATM
  - AAL 5 circuit emulation
  - ATM Transport
  - ADSL Physical