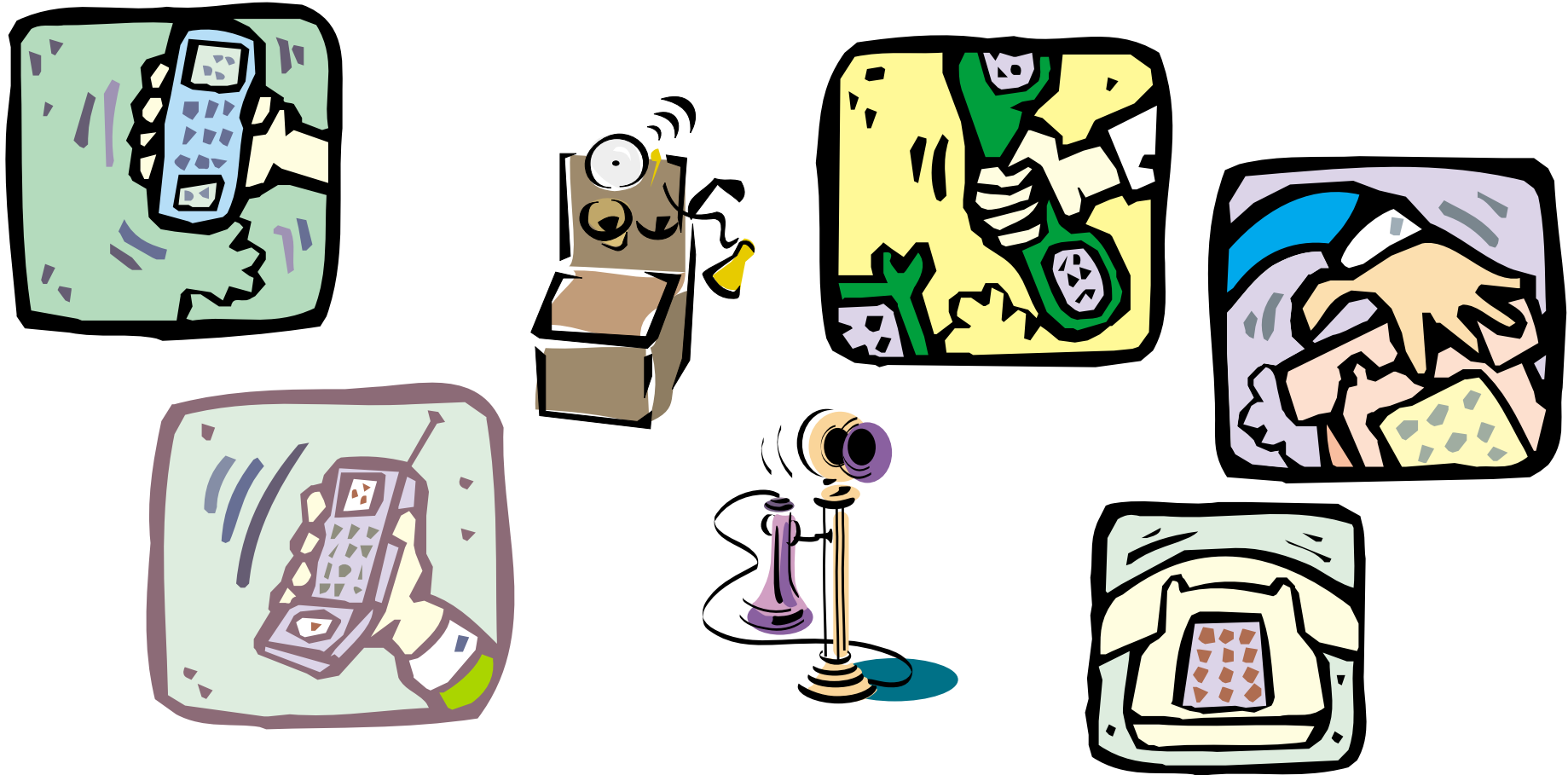


# *Voice Concepts for the Data Professional*



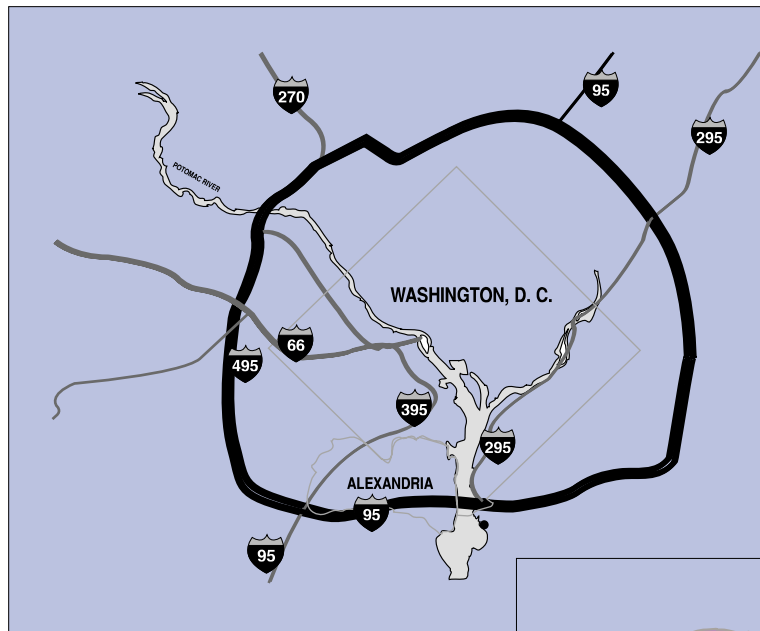
**Laura J. Knapp**  
**IBM/Tivoli Technical Evangelist**  
**1-919-224-2205**  
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**[www.lauraknapp.com](http://www.lauraknapp.com)**

# *Communications*

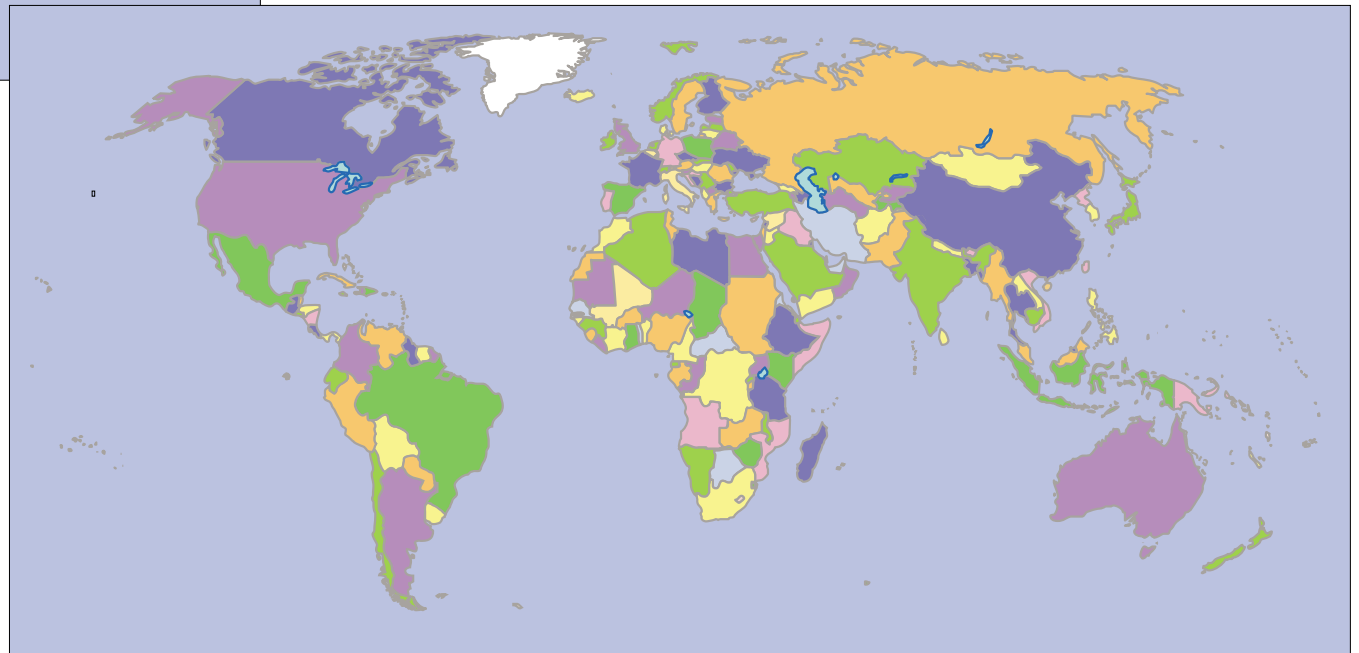


**As we move to combining voice and data over a single network  
- a data network -  
it is important to know the basics of the voice system**

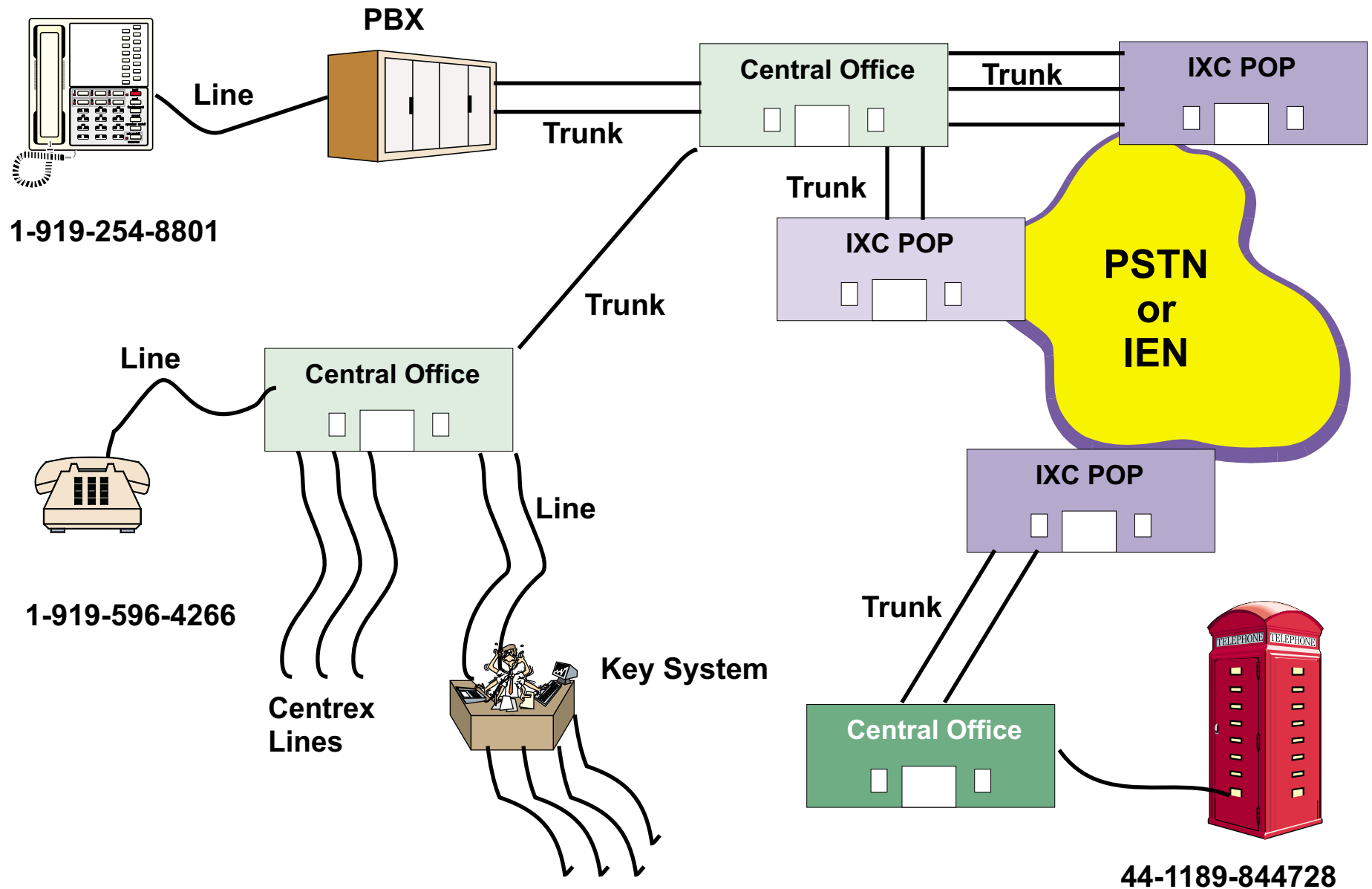
# Telephone Industry Structure



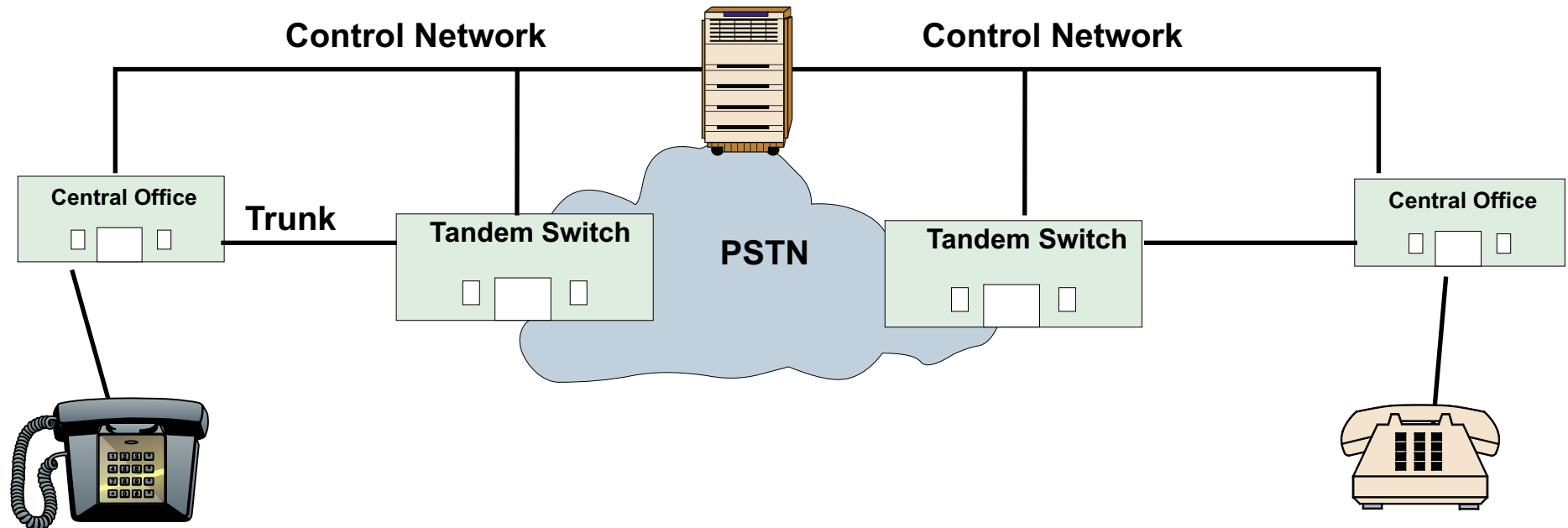
**Local Exchange Carriers (LEC)**  
**Interexchange Carriers (IXC)**  
**Competitive Local Exchange Carriers (CLEC)**  
**Global Exchange Carriers (GEC)**  
**Postal, Telegraph and Telephone (PTT)**



# Telephony Infrastructure



# *PSTN Hierarchy*

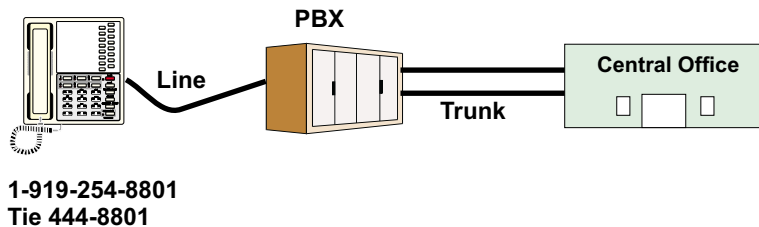


## **PSTN - Public Switched Telephone Network**

**The hierarchy is going through a lot of change with the advent of CLECs and global carriers**

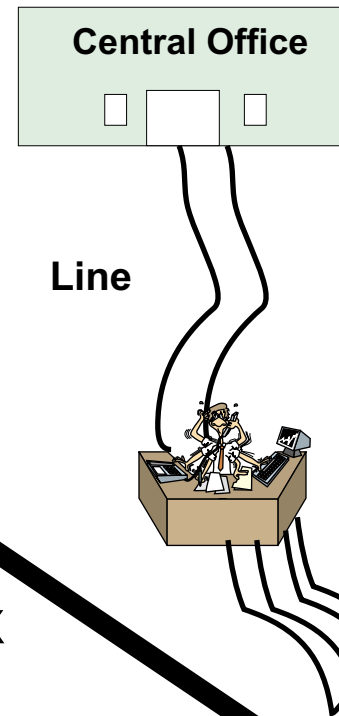
# PBX, Centrex and Key Systems

## PBX Private Branch Exchange



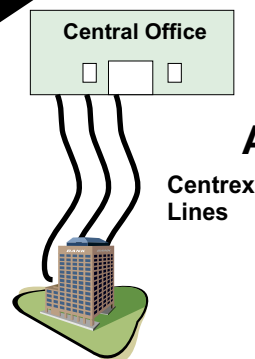
- Resource sharing
- Provide CO functions locally
- Digital or analog
- Trunk interface to CO
- Regenerate signals
- Local switching
- Digital/analog conversion
- Wide range of services

## Key System



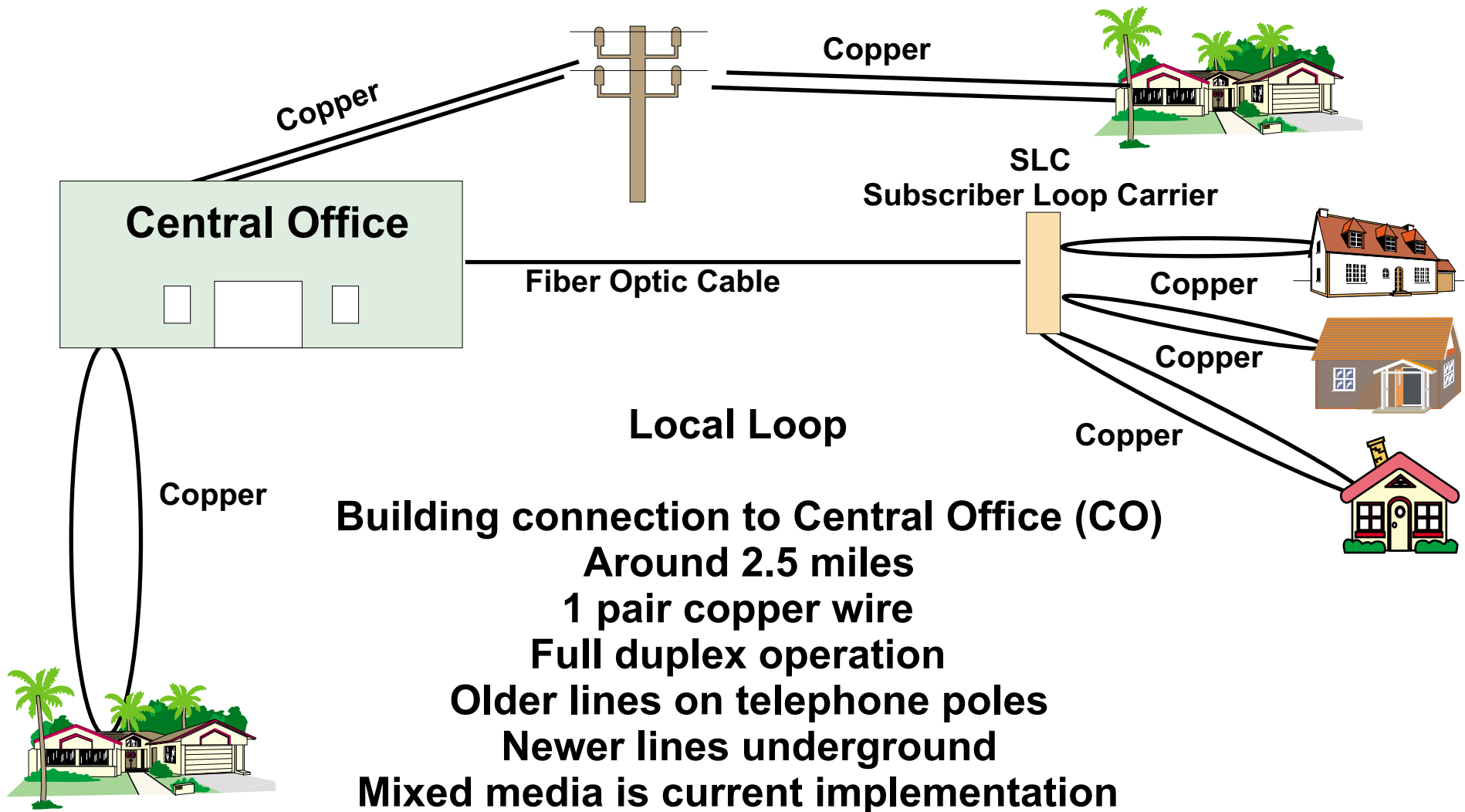
- Small business PBX
- Lines (not trunks) to CO
- Limited range of services

## Centrex

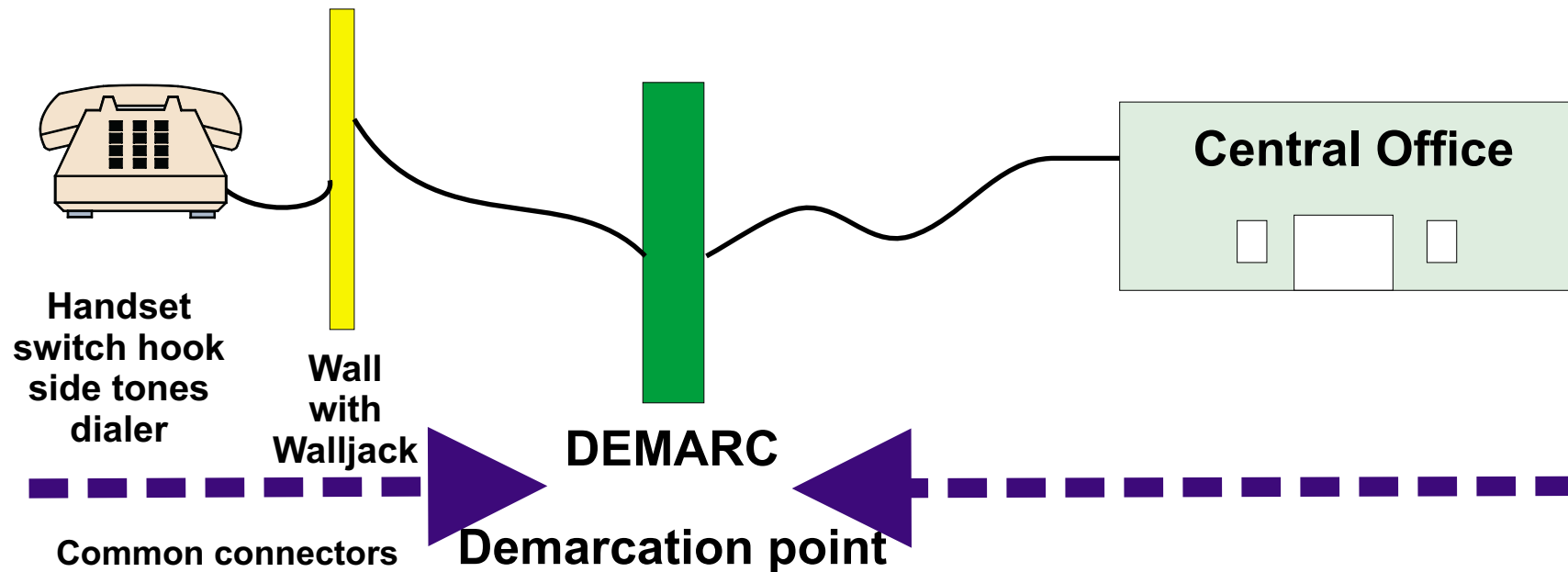


- PBX services for companies
- Offered by LEC, CLEC, etc
- Automatic call distribution (ACD)
- Voice mail
- Modem pool
- Paging
- etc

# Local Loop



# Single Line Telephone Operations



RJ21X - 66 blocks/multiline  
RJ45X - 4 pair for voice/data  
RJ18X - 4 pair for digital  
RJ11C - 2 pair for voice

## Basic functions

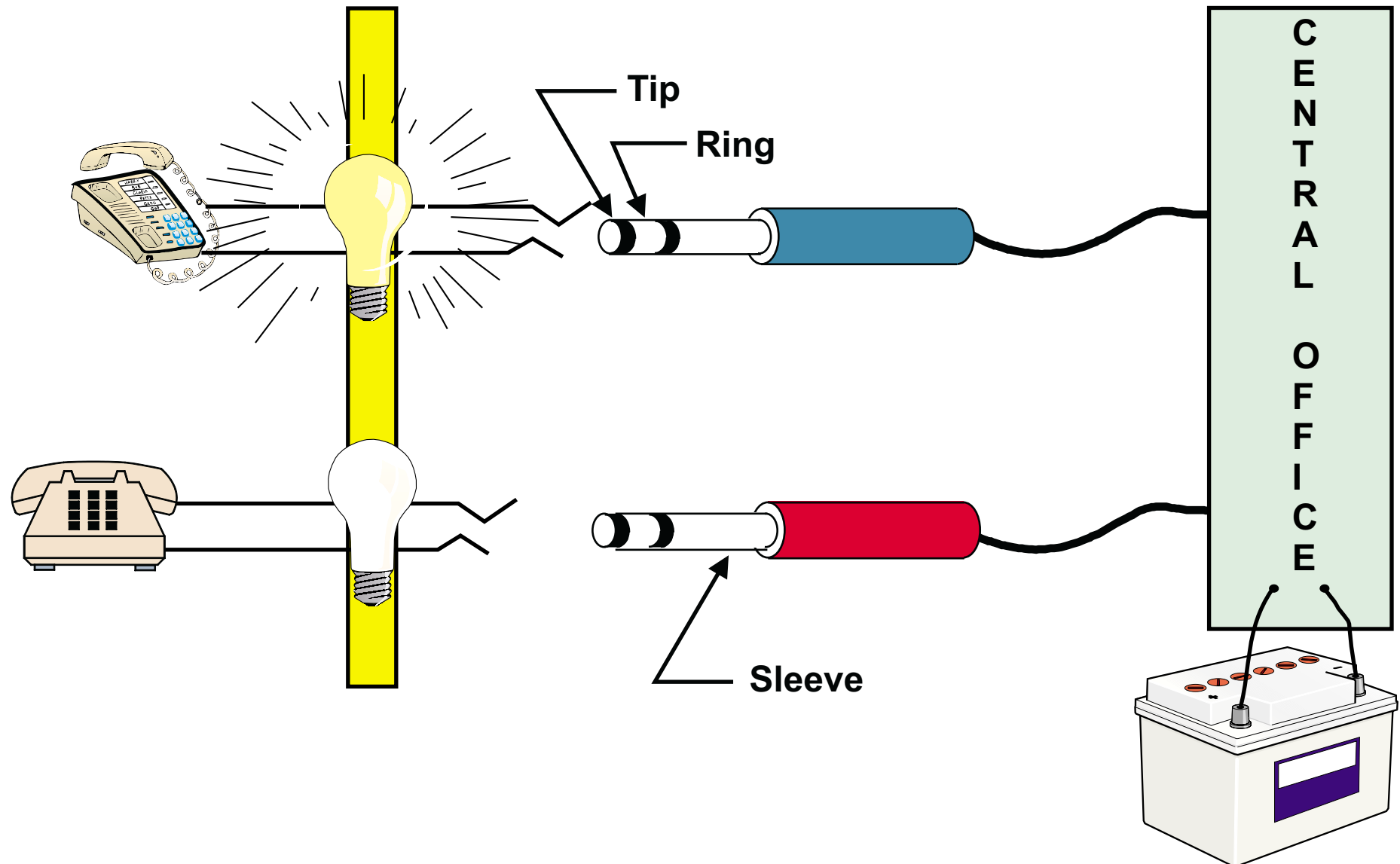
- Ringer current
- Clocking
- Dial tone
- Switching
  - Long distance calls
  - Local calls
- Billing information

## Advanced functions

- Call forwarding
- Conference call
- Reduced digit dialing
- Caller-ID
- Busy redial
- Redial last call in
- ...



# Plain Old Telephone System - POTS



# Analog and Digital Circuits

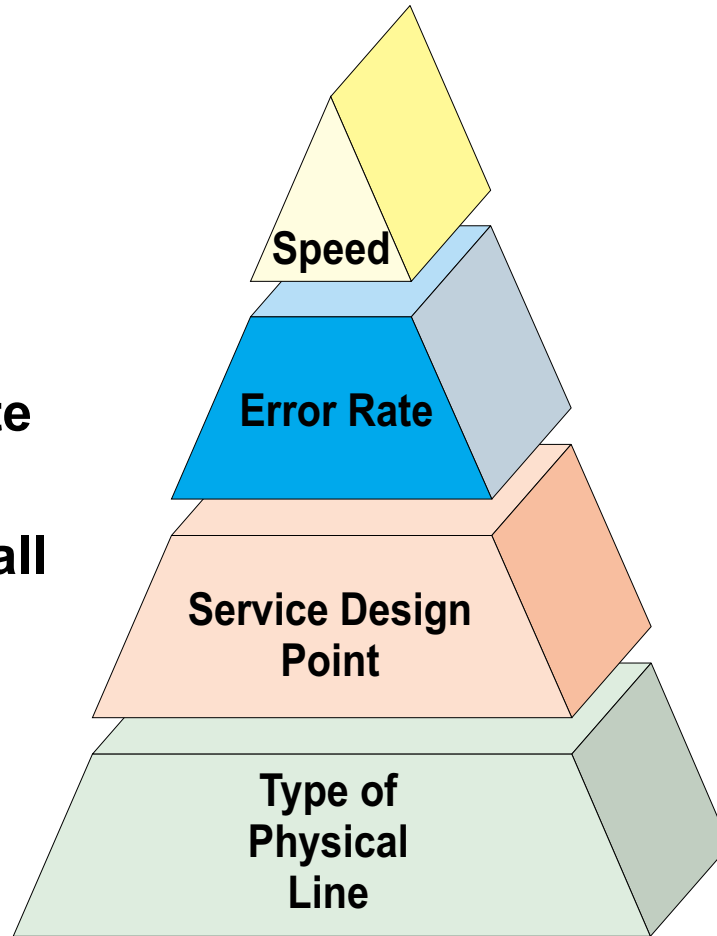
## Analog

<35 kbps

$1 \times 10^{-2}$  error rate

3 minute phone call

Copper :  
sound waves  
and modems



## Digital

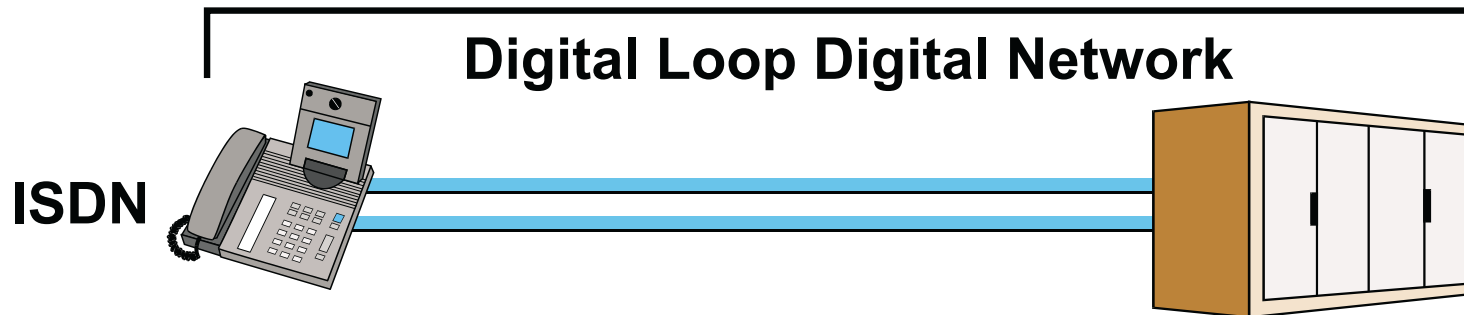
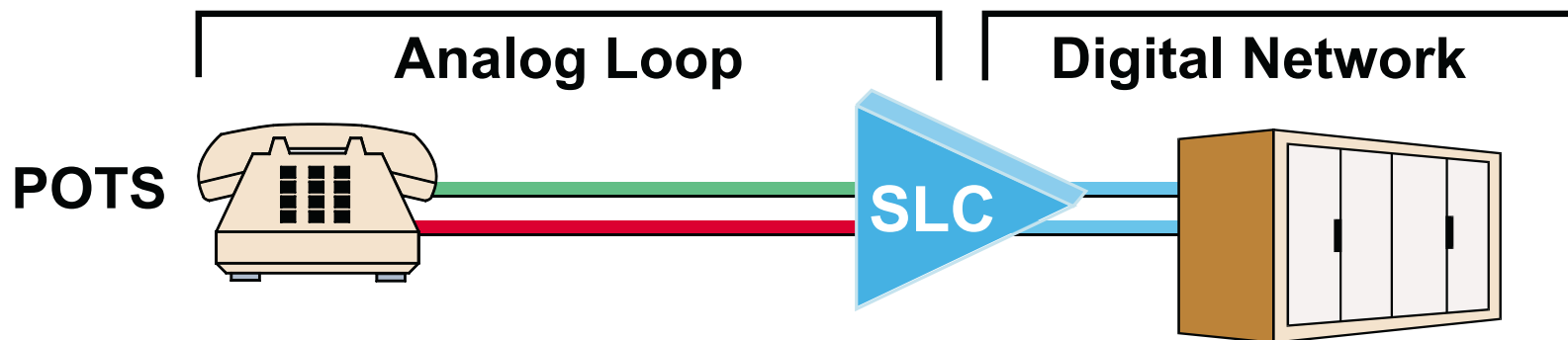
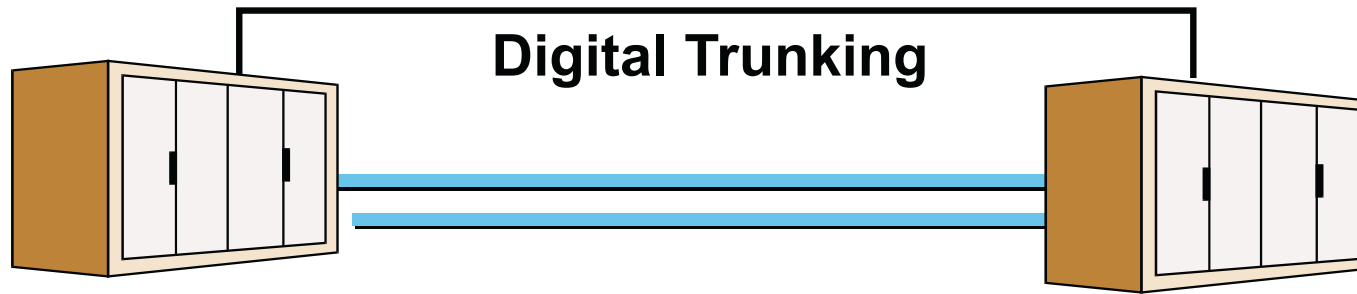
35 kbps - gbps

$1 \times 10^{-15}$  error rate

Longer data  
communication  
calls

Fiber Optic or copper :  
Digitizes voice to '1  
and 0' CSU/DSU

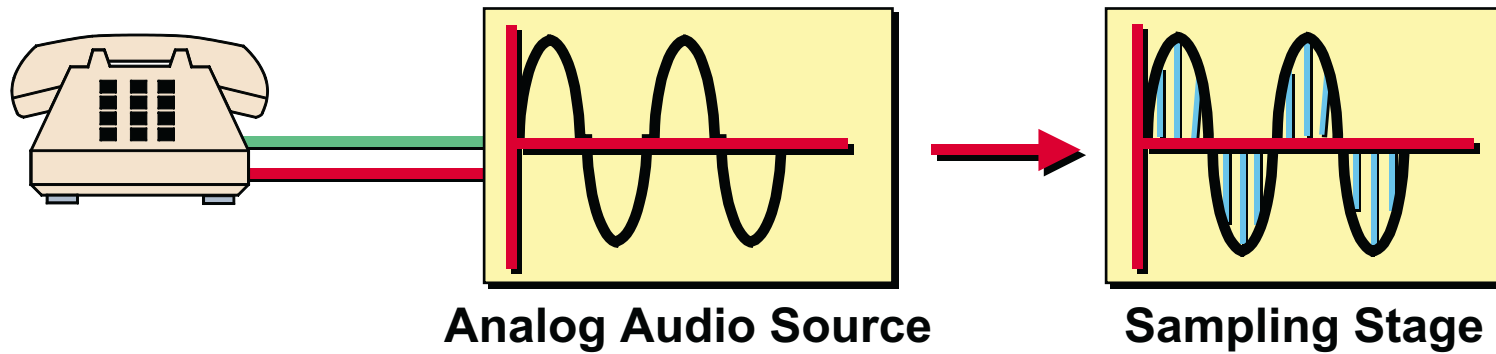
# Digital Telephony



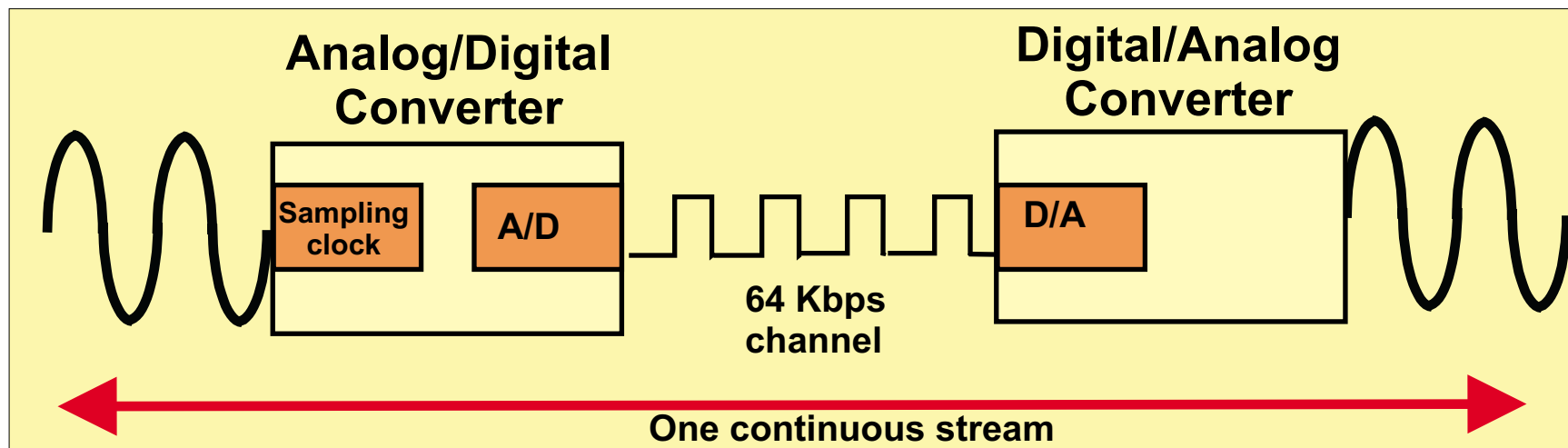
SLC Subscriber Loop Carrier : Beige box at newer subdivisions

# Digitally Encoding Speech

## Pulse Code Modulation



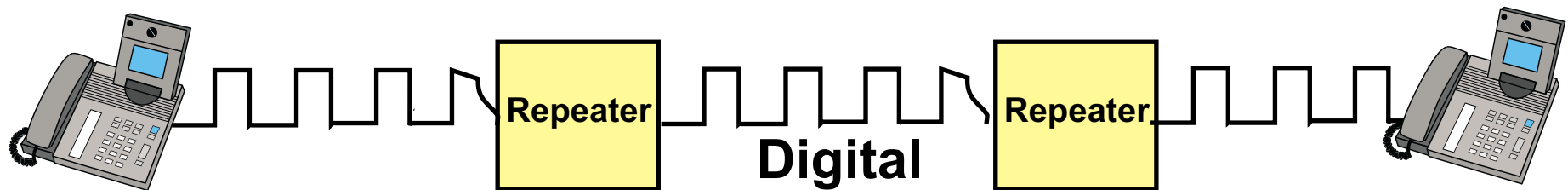
## Codec Technique



**PCM - 8000 samples/second x 8 bits = 64 Kbps**  
**Vocoding and hybrid technologies also exist**

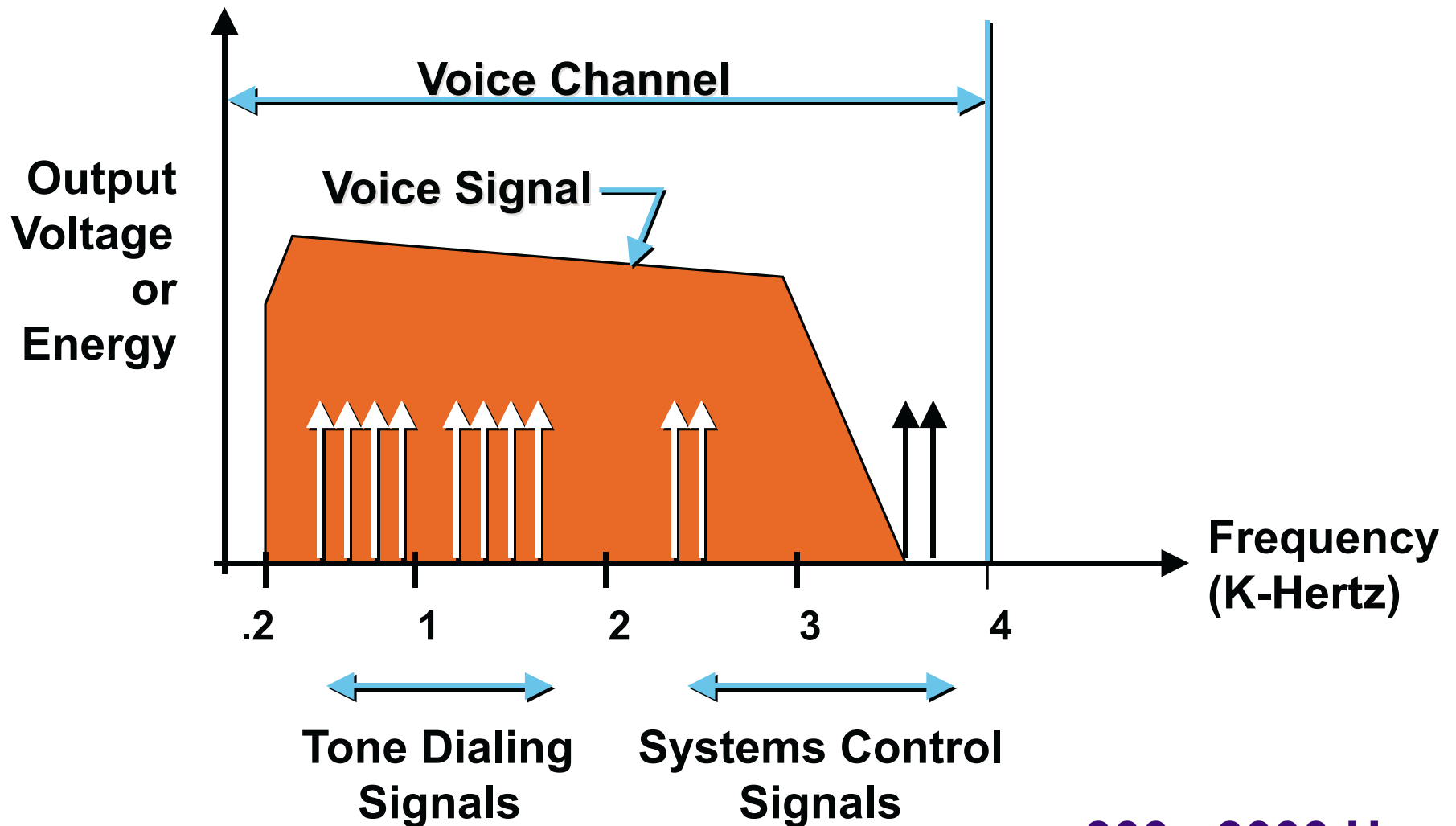
# *Analog vs. Digital Transmission*

**Noise is amplified  
Noise can become stronger than signal**



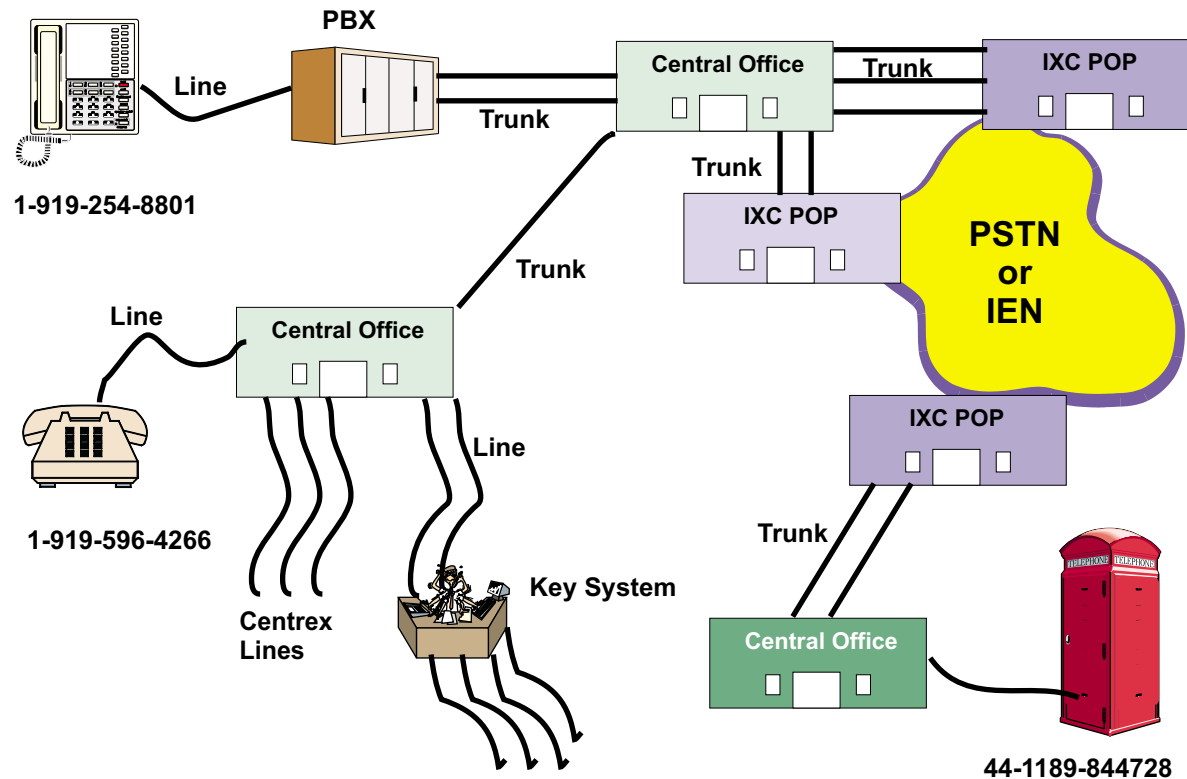
**Regenerated at regular intervals  
Noise dropped at repeater**

# Voice Bandwidth



**300 - 3000 Hz**

# Voice Networking Operations

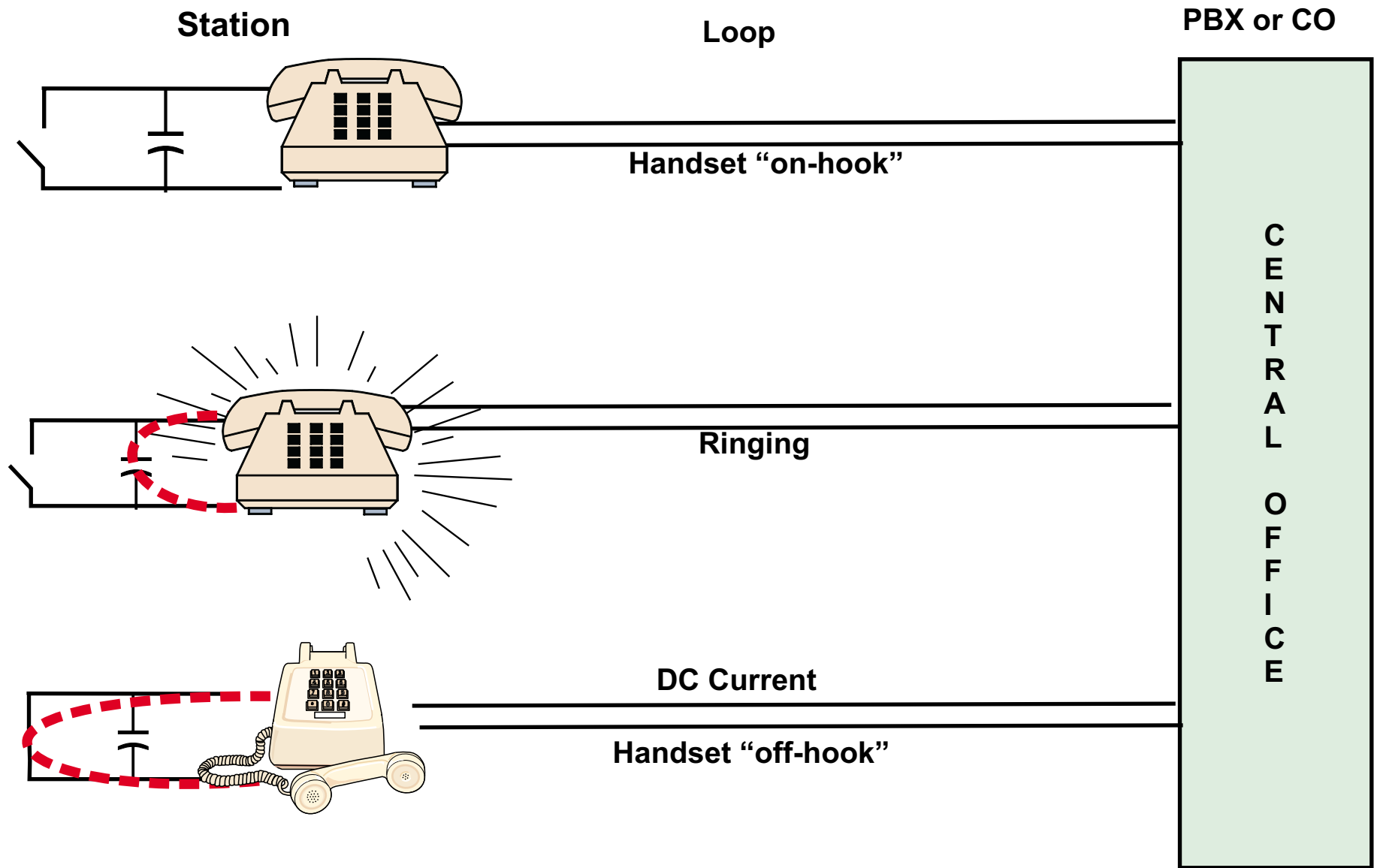


**Signaling**  
Supervisory, address, call progress  
Local loop and trunk very different

**Addressing**

**Routing**

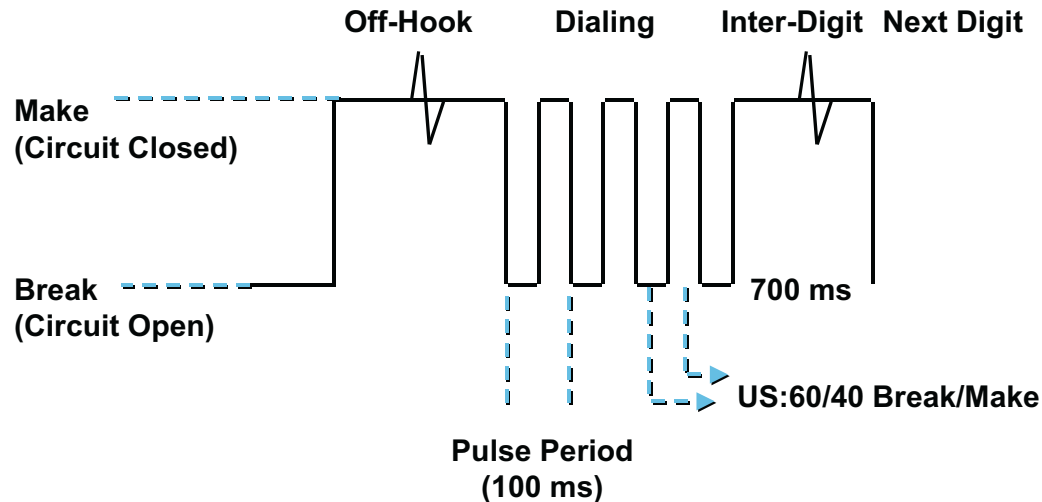
# Analog Telephony - Loop Start Signaling



**PBXs actually use "Ground Start" with "off hook" detection via grounded wire**



# Address Signaling Dial Pulse and Tone Dialing



|     |      |      |      |      |
|-----|------|------|------|------|
|     | 1209 | 1336 | 1477 | 1633 |
| 697 | 1    | 2    | 3    | A    |
| 770 | 4    | 5    | 6    | B    |
| 852 | 7    | 8    | 9    | C    |
| 941 | *    | 0    | #    | D    |

US frequencies

Other countries have different frequencies they use for similar functions

A B C D unused

## Dual Tone Multifrequency (DTMF) Timing : 60ms break : 40ms make

| Tone              | Frequency (Hz)           | On Time                   | Off Time |
|-------------------|--------------------------|---------------------------|----------|
| Dial              | 350 + 440                | Continuous                |          |
| Busy              | 480 + 620                | 0.5                       | 0.5      |
| Ringback, Normal  | 440 + 480                | 2                         | 4        |
| Ringback, PBX     | 440 + 480                | 1                         | 3        |
| Congestion (Toll) | 480 + 620                | 0.2                       | 0.3      |
| Reorder (local)   | 480 + 620                | 0.3                       | 0.2      |
| Receiver Off-hook | 1400 + 2060 + 2450 +2600 | 0.1                       | 0.1      |
| No Such Number    | 200 to 400               | Continuous, Freq. Mod 1Hz |          |

# Trunk Side Signaling

## Start Dial

### Wink-start

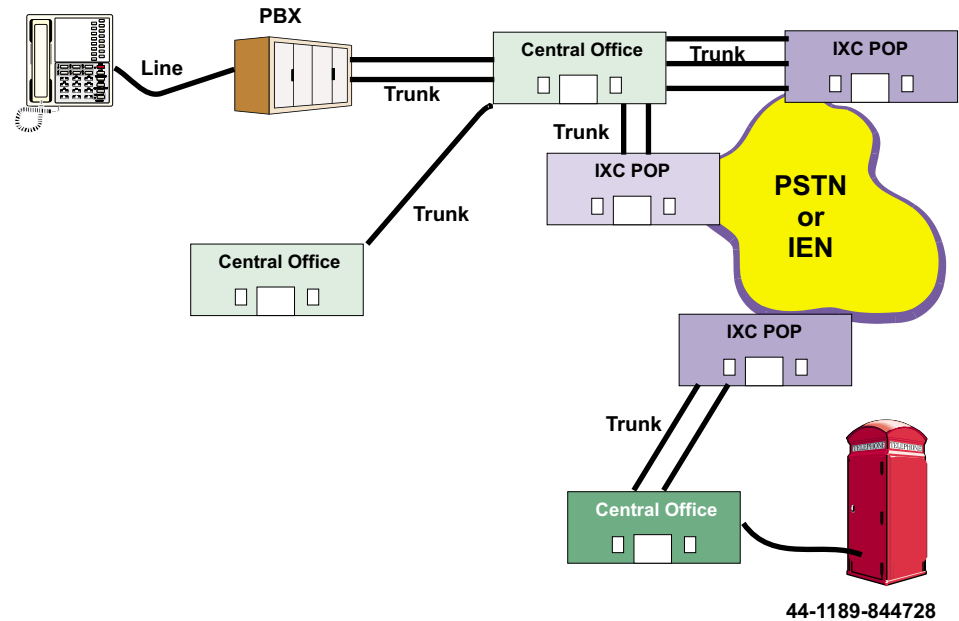
- Originating trunk goes off-hook
- Remote switch transmit off-hook pulse
- Originating switch transmits dial digits

### Immediate-start

- Originating switch places trunk off-hook
- Originating switch transmits dial digits

### Tone-Start

- Originating trunk placed in off-hook
- Receiving switch generates dial tone
- Dial digits transmitted



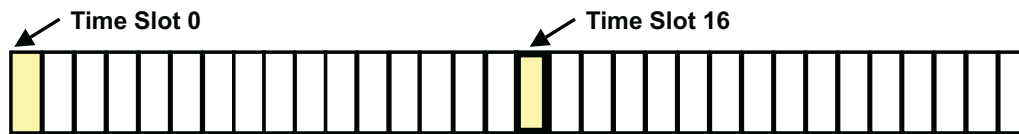
## E&M

- Most commonly used
- Separate paths for voice and signaling
- M lead transmit signaling
- E lead receives signaling
- E&M = ear and mouth
- Originating switch requests trunk by raising M lead
- Remote switch honors requests by raising the E lead

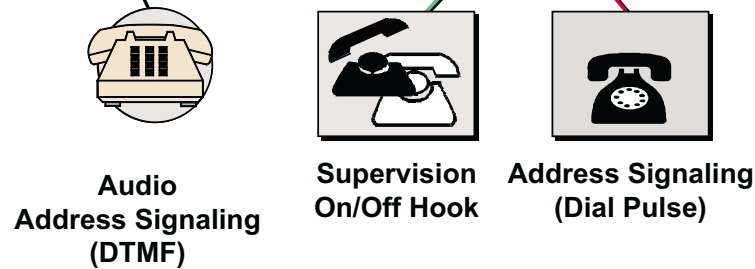
## Ground Start

- Modified local loop signaling
- Eliminates potential for two switches to seize control of the trunk
- Provides current detection mechanism

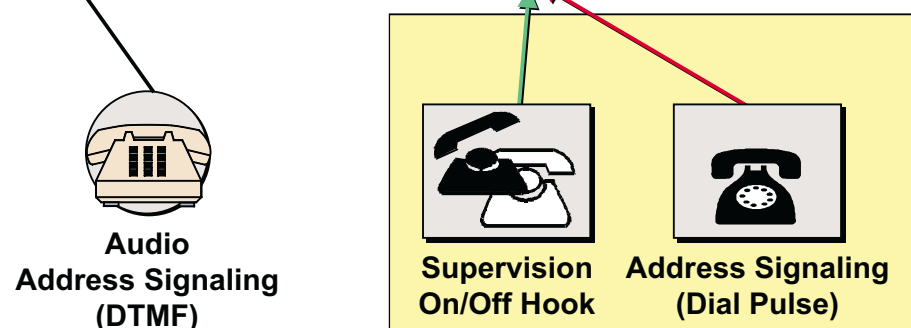
# Trunk Side T1/E1 Signaling



## Common Channel Signaling CCS



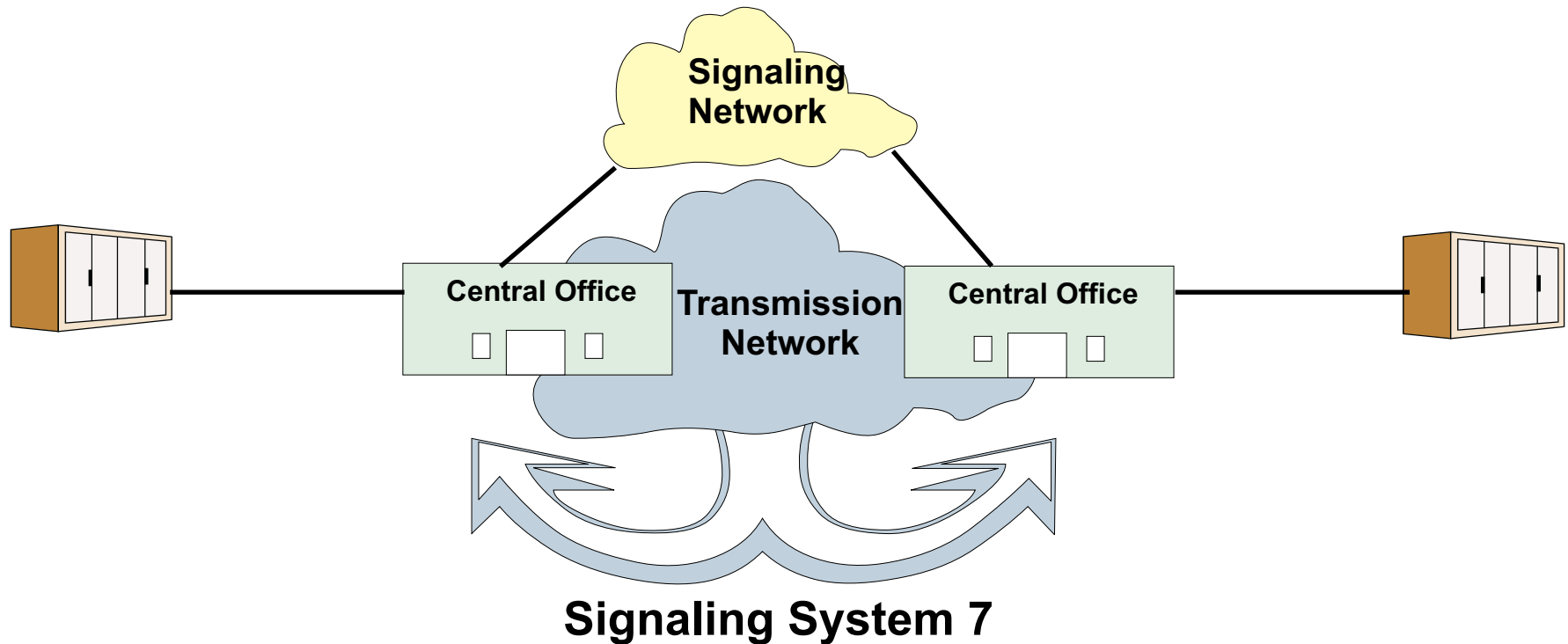
Dedicated voice slot for supervisory signaling  
16 time slot in E1  
24 time slot in T1  
Easier to handle new functions  
(call waiting, caller ID, camp-on...)



## Channel Associated Signaling CAS

In band supervisory signaling  
Rob bit for supervisory signaling  
16 time slot robbed in E1  
6 and 12 time slot rob bit '7' in T1  
Extended superframe format (ESF)  
E&M is an example

# *Signaling System 7 (SS7)*

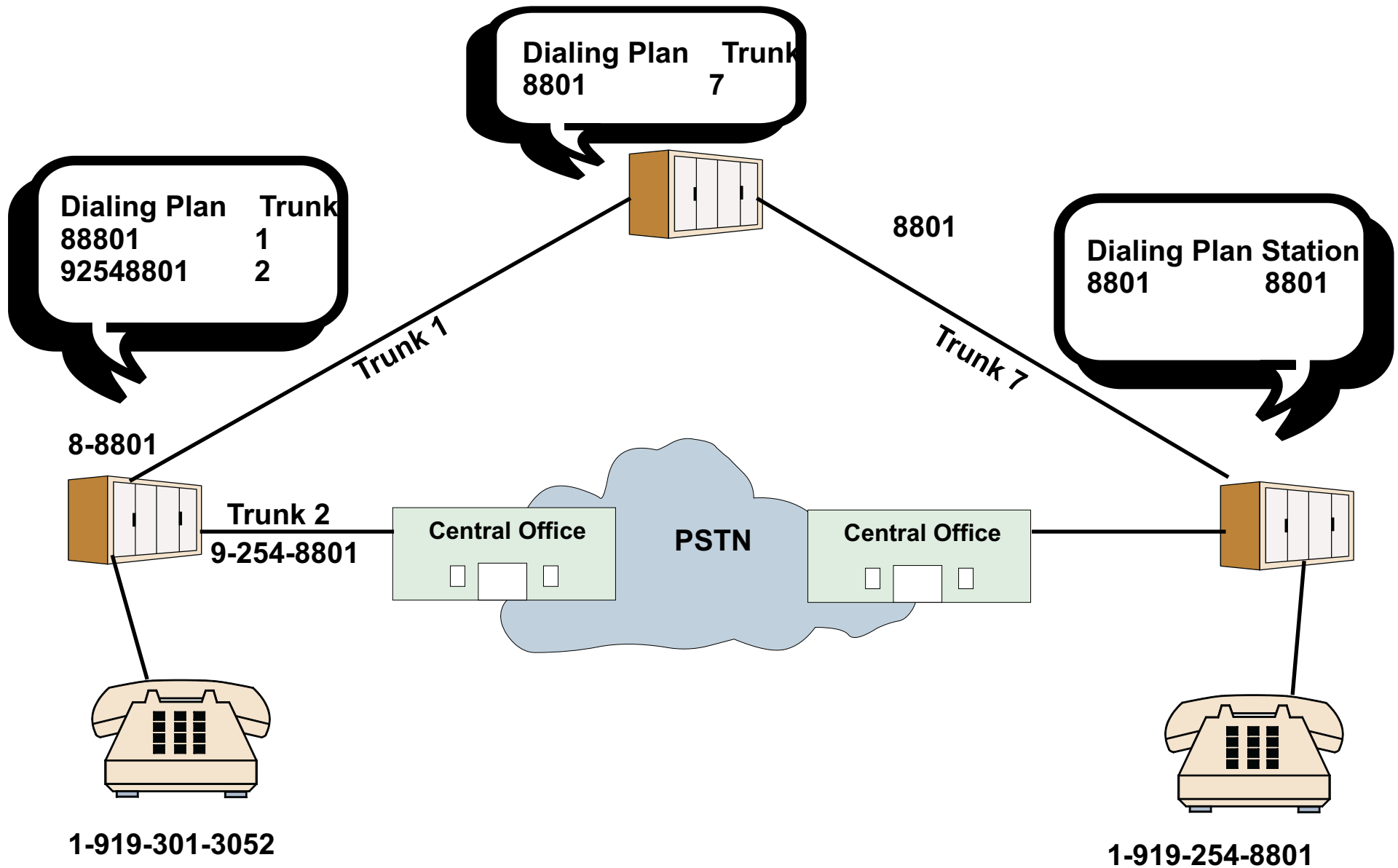


**Used internally in PSTN network worldwide**

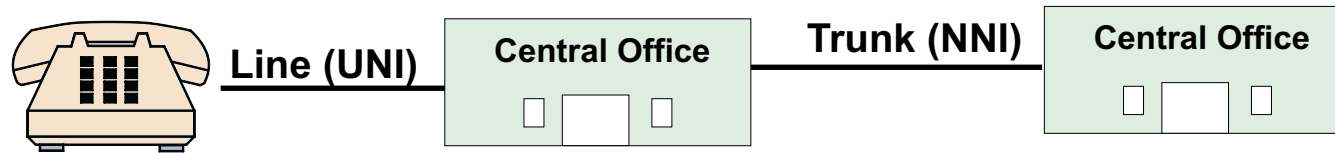
**Only VERY LARGE customers may directly attach PBX's to SS7**

**Basic call control, signaling procedures, supplementary services**

# Voice Routing and Addressing

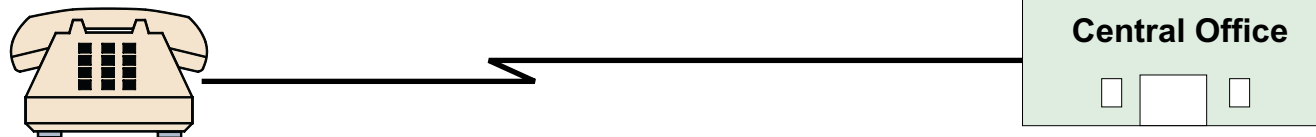


# Common Voice Circuit Interfaces

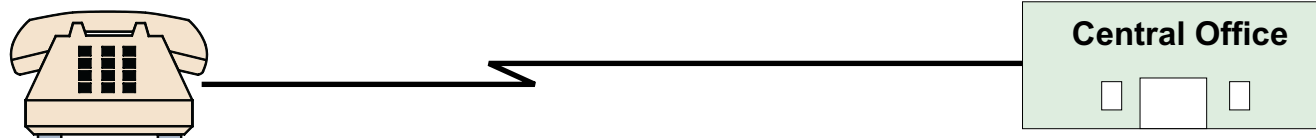


**FX - Foreign Exchange Repeater Network**

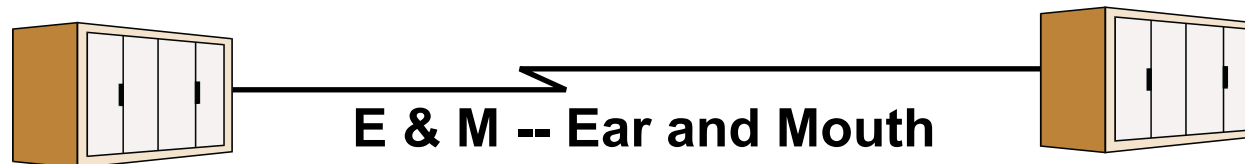
**Defines what device plugs into**



**FXO -- Foreign Exchange Office**



**FXS -- Foreign Exchange Station**



**E & M -- Ear and Mouth**

# *Key Factors Impacting Voice*

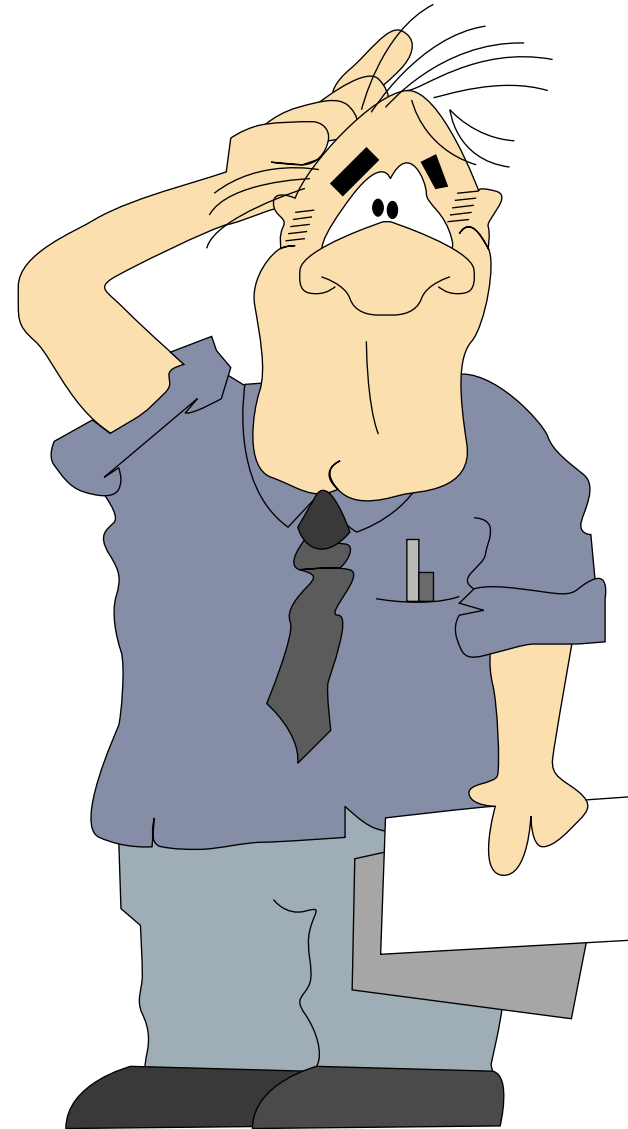
**Delay**

**Distortion of analog signals**

**Jitter**

**Noise**

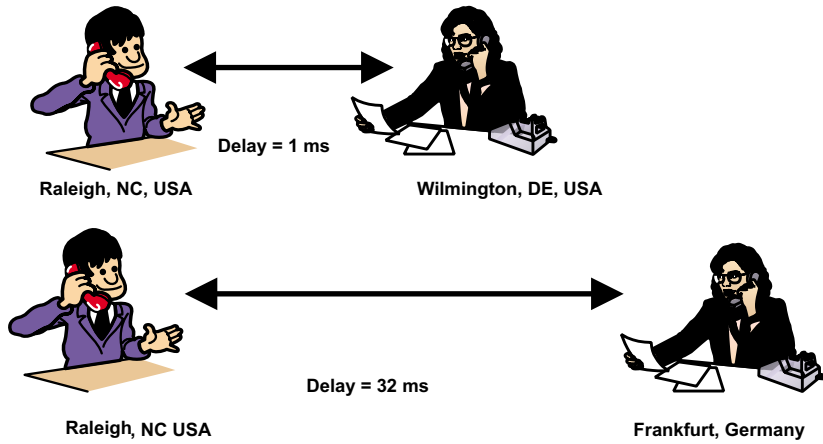
**Echo**



**Especially over a data network**

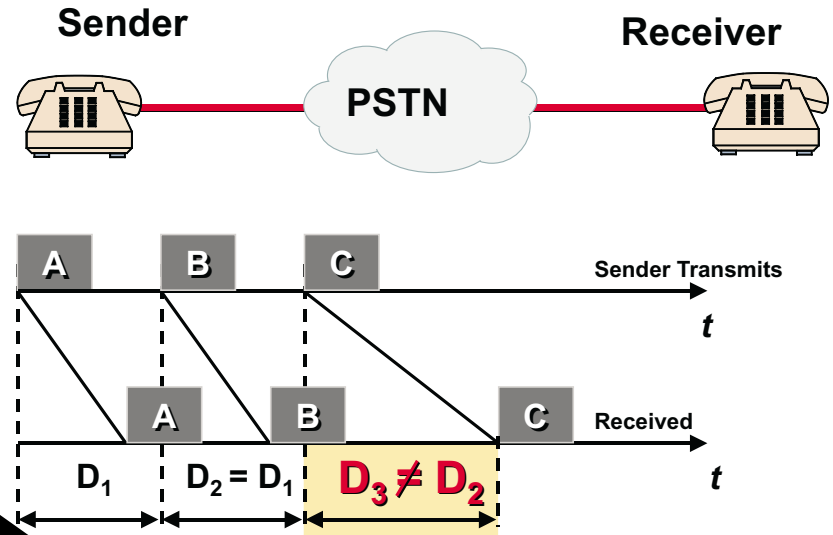
# Delay - Jitter - Echo

## Delay

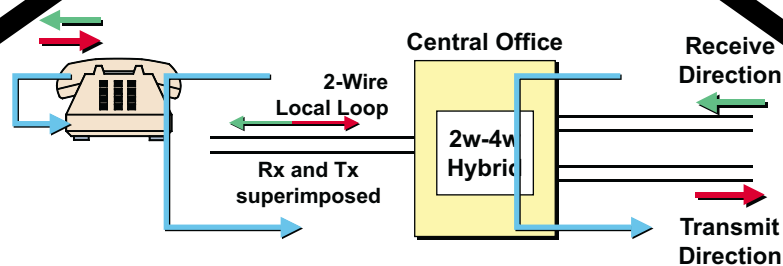


Humans have an inherent "time delay" around 300 ms

## Jitter



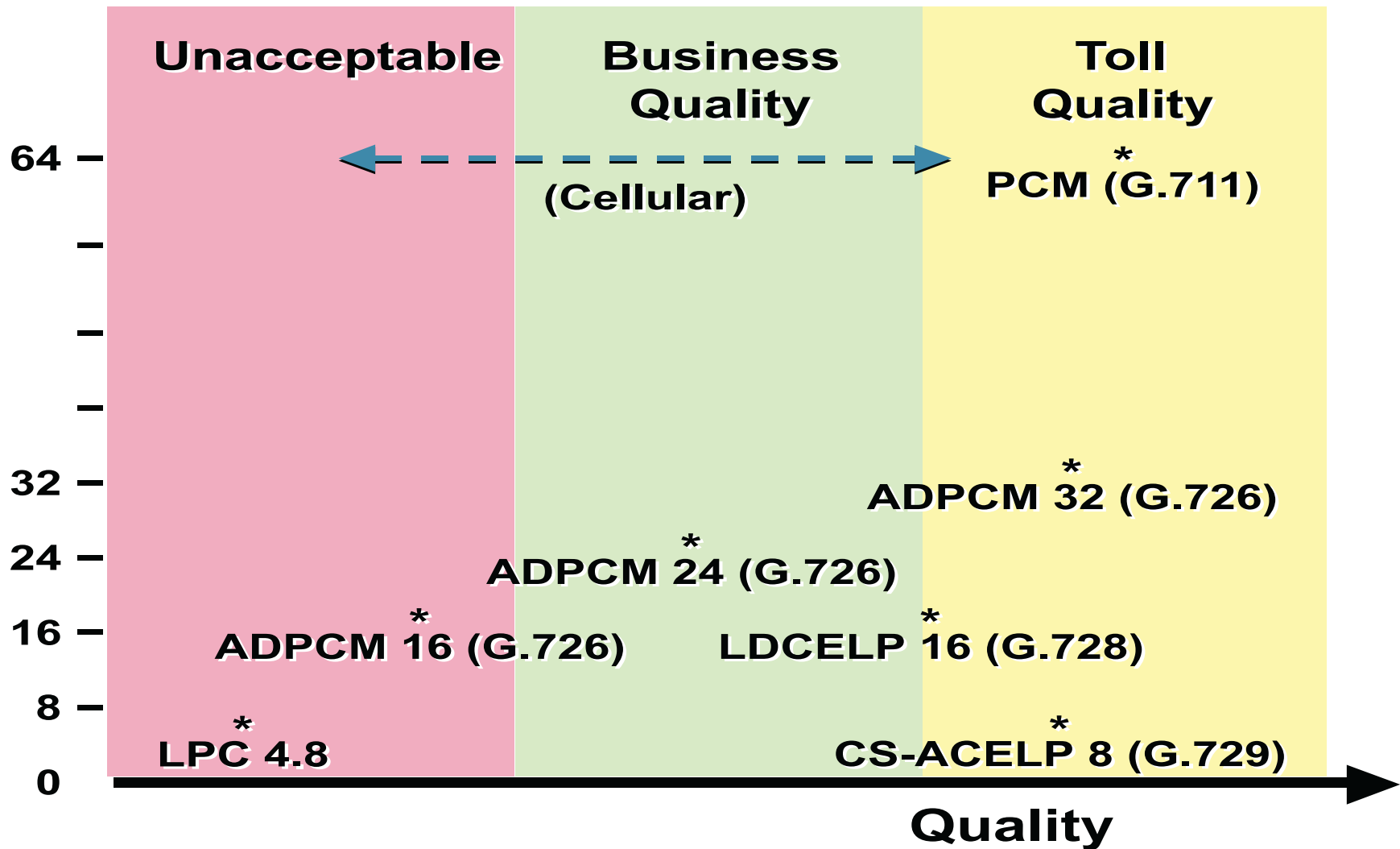
## Echo



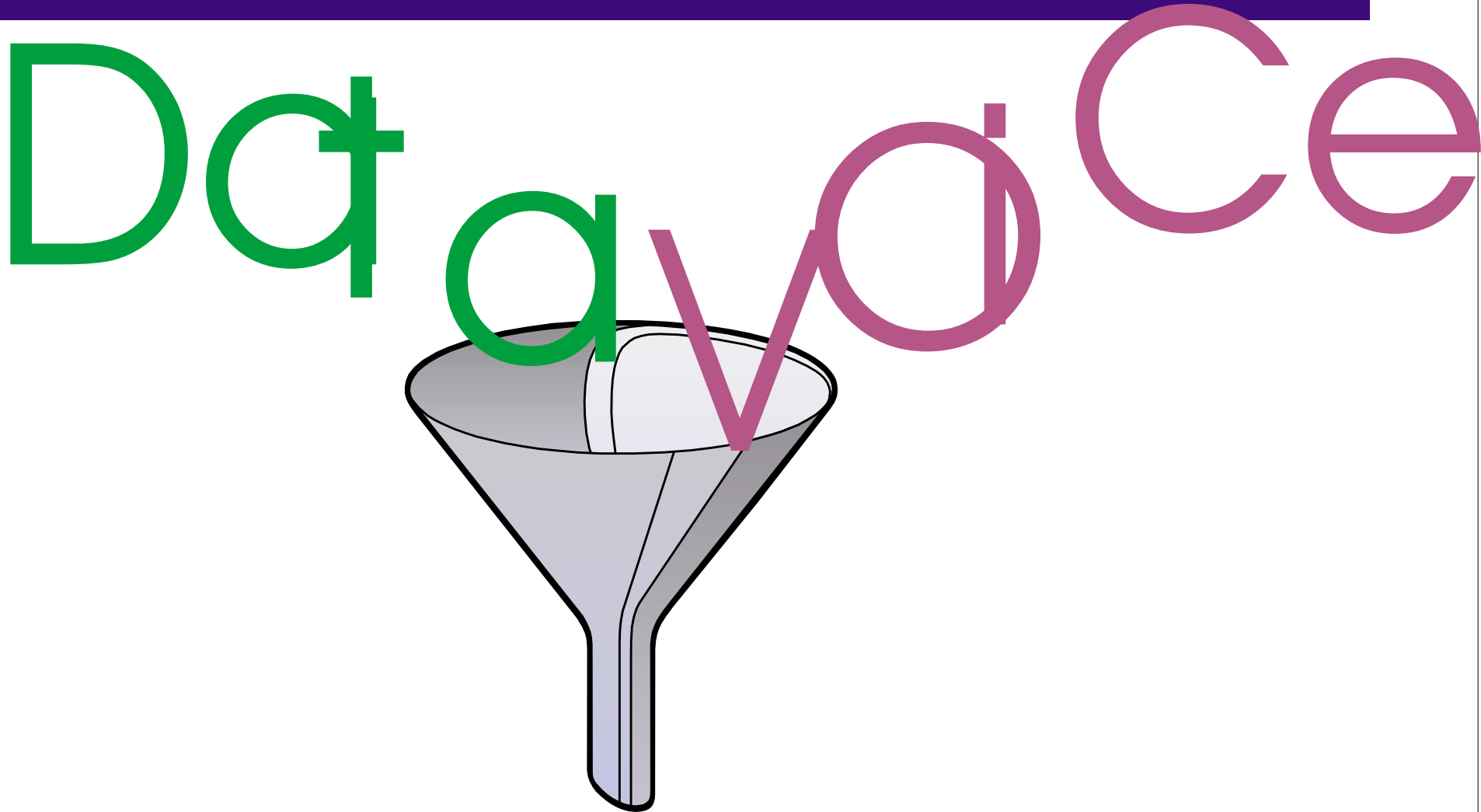
Echo is reflection  
Impedance mismatch at CO between 2 wire local loop and 4 wire trunk



# Voice Compression Technologies

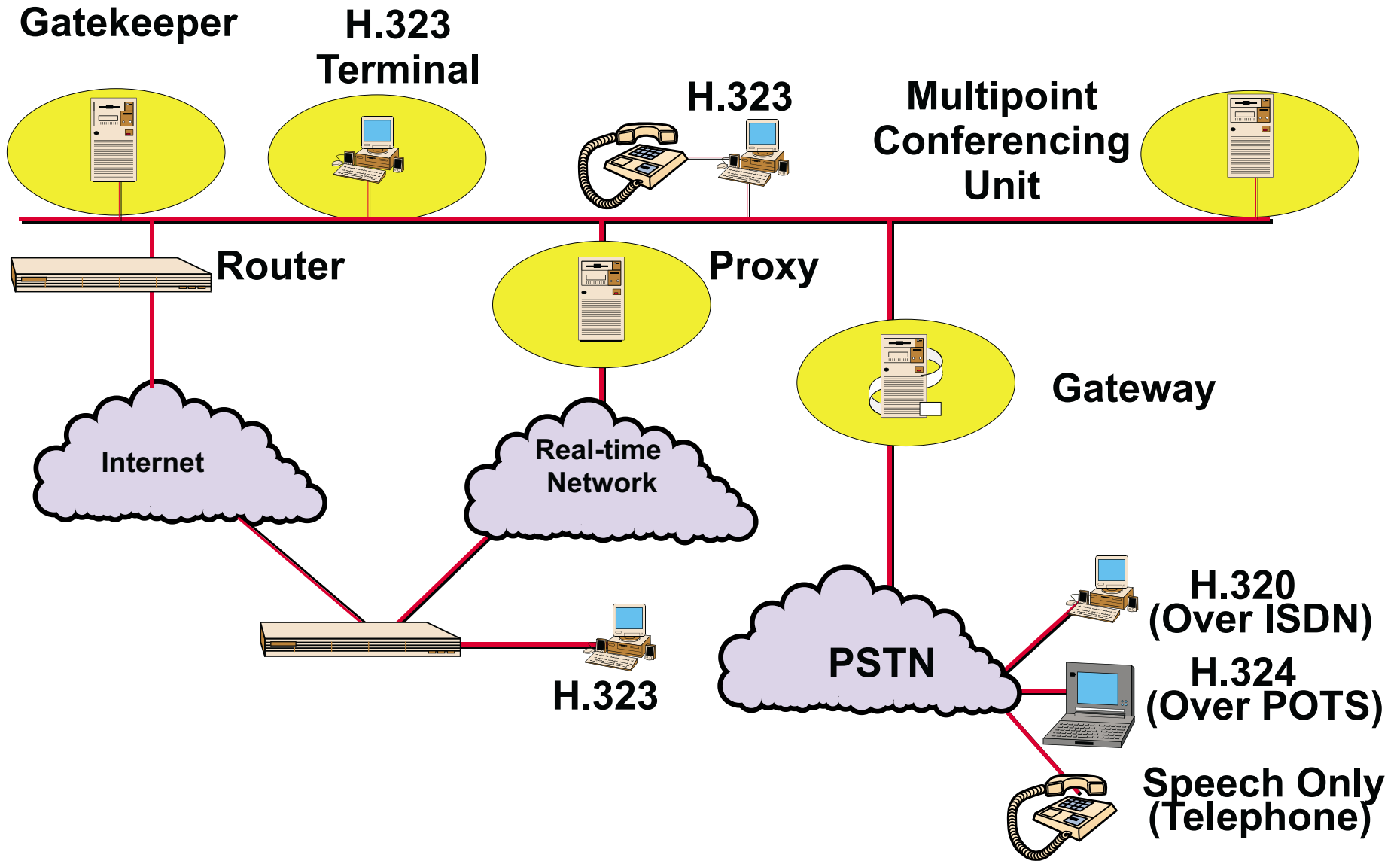


# *Why Voice Concepts are Important*



**As we begin to look at moving this to the Data Network Infrastructure many challenges are before us. At the heart of the matter is offering Quality of Service (QOS) to voice traffic**

# H.323 Infrastructure



# *Sooner or Later !!!*

**Pieces emerging to finally allow for converged voice/data networks?**

**Complex**

**How will billing be handled?**

**QoS still a major stumbling block**

**Many application issues still to be resolved**

**Interoperability issues being resolved, but it will take time**

**Over time.....should change our communications significantly**

