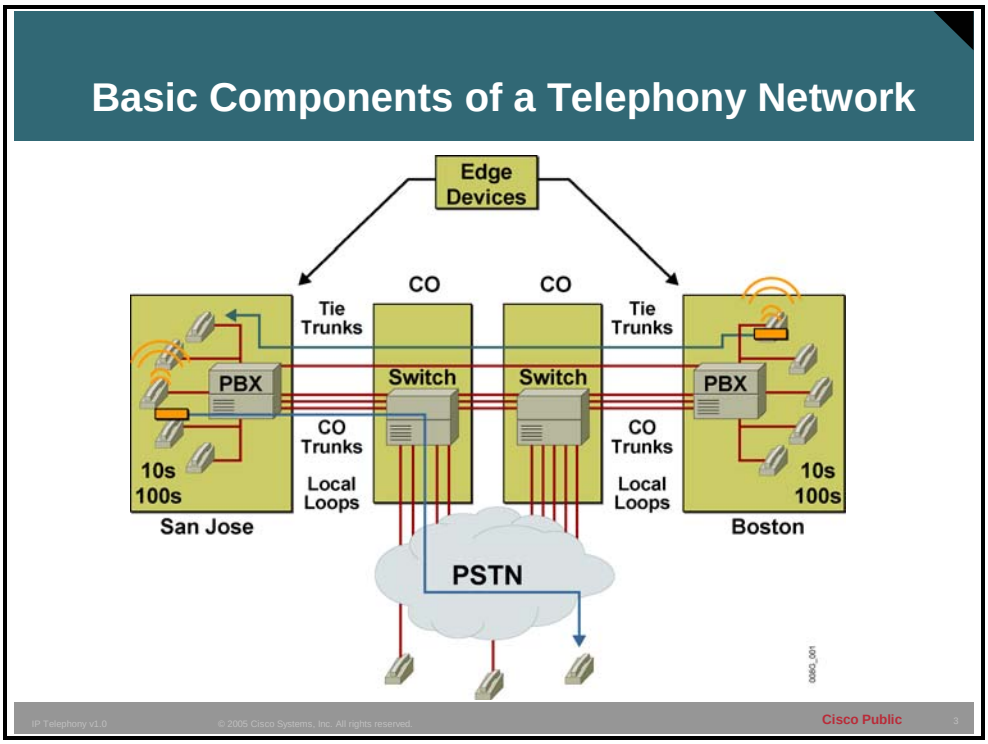
Traditional Telephony

Basic Components of a Telephony Network

This topic introduces the components of traditional telephony networks.



A number of components must be in place for an end-to-end call to succeed. These components are shown in the figure and include the following:

- Edge devices
- Local loops
- Private or central office (CO) switches
- Trunks

Edge Devices

The two types of edge devices that are used in a telephony network include:

- **Analog telephones:** Analog telephones are most common in home, small office/home office (SOHO), and small business environments. Direct connection to the PSTN is usually made by using analog telephones. Proprietary analog telephones are occasionally used in conjunction with a PBX. These telephones provide additional functions such as speakerphone, volume control, PBX message-waiting indicator, call on hold, and personalized ringing.
- **Digital telephones:** Digital telephones contain hardware to convert analog voice into a digitized stream. Larger corporate environments with PBXs generally use digital

telephones. Digital telephones are typically proprietary, meaning that they work with the PBX or key system of that vendor only.

Local Loops

A local loop is the interface to the telephone company network. Typically, it is a single pair of wires that carry a single conversation. A home or small business may have multiple local loops.

Private or CO Switches

The CO switch terminates the local loop and handles signaling, digit collection, call routing, call setup, and call teardown.

A PBX switch is a privately owned switch located at the customer site. A PBX typically interfaces with other components to provide additional services, such as voice mail.

Trunks

The primary function of a trunk is to provide the path between two switches. There are several common trunk types, including:

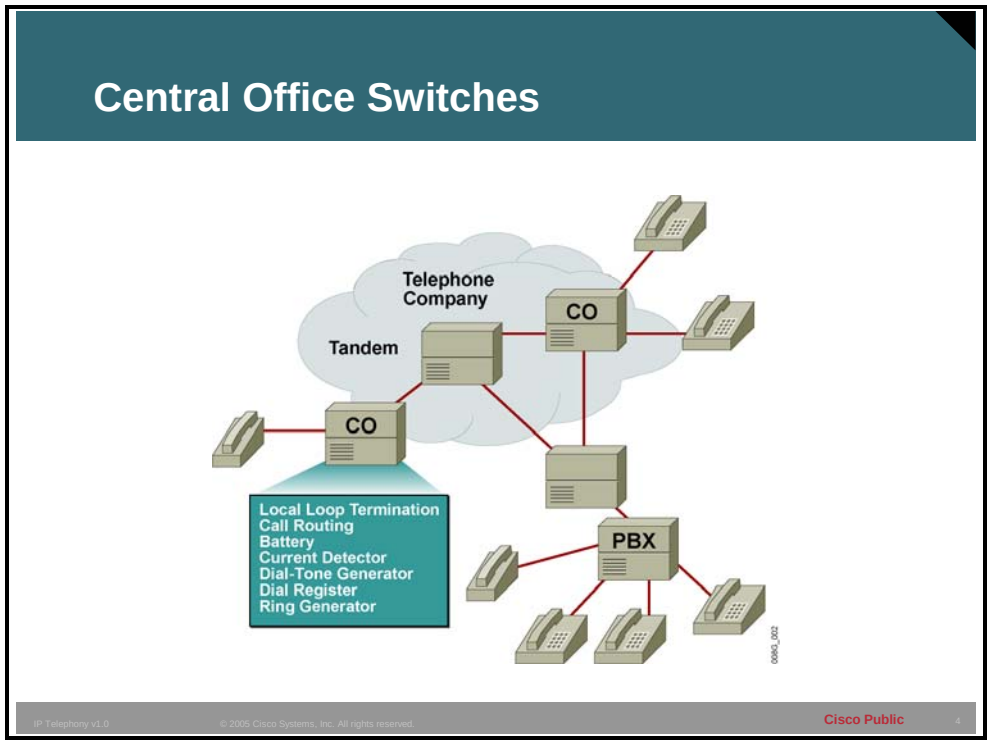
- **Tie trunk:** A dedicated circuit that connects PBXs directly
- **CO trunk:** A direct connection between a local CO and a PBX
- **Interoffice trunk:** A circuit that connects two local telephone company COs

Example: Telephony Components

The telephone installed in your home is considered an edge device because it terminates the service provided by your local telephone company. PBXs or key systems installed in a business would also be considered edge devices. The local loop is the pair of wires that come to your house to provide residential telephone service. Trunks are the interconnections between telephone switches. They can be between private switches or telephone company switches.

CO Switches

This topic describes how CO switches function and make switching decisions.



The figure shows a typical CO switch environment. The CO switch terminates the local loop and makes the initial call-routing decision.

The call-routing function forwards the call to one of the following:

- Another end-user telephone, if it is connected to the same CO
- Another CO switch
- A tandem switch

The CO switch makes the telephone work with the following components:

- **Battery:** The battery is the source of power to both the circuit and the telephone. It determines the status of the circuit. When the handset is lifted to let current flow, the telephone company provides the source that powers the circuit and the telephone. Because the telephone company powers the telephone from the CO, electrical power outages should not affect the basic telephone.

Note	Some telephones on the market offer additional features that require a supplementary power source that the subscriber supplies; for example, cordless telephones. Some cordless telephones may lose function during a power outage.

- **Current detector:** The current detector monitors the status of a circuit by detecting whether it is open or closed. The table here describes current flow in a typical telephone.

Current Flow in a Typical Telephone

Handset	Circuit	Current Flow
On cradle	On hook/open circuit	No
Off cradle	Off hook/closed circuit	Yes

- **Dial-tone generator:** When the digit register is ready, the dial-tone generator produces a dial tone to acknowledge the request for service.
- **Dial register:** The digit register receives the dialed digits.
- **Ring generator:** When the switch detects a call for a specific subscriber, the ring generator alerts the called party by sending a ring signal to that subscriber.

You must configure a PBX connection to a CO switch that matches the signaling of the CO switch. This configuration ensures that the switch and the PBX can detect on hook, off hook, and dialed digits coming from either direction.

CO Switching Systems

Switching systems provide three primary functions:

- Call setup, routing, and teardown
- Call supervision
- Customer ID and telephone numbers

CO switches switch calls between locally terminated telephones. If a call recipient is not locally connected, the CO switch decides where to send the call based on its call-routing table. The call then travels over a trunk to another CO or to an intermediate switch that may belong to an inter-exchange carrier (IXC). Although intermediate switches do not provide dial tone, they act as hubs to connect other switches and provide interswitch call routing.

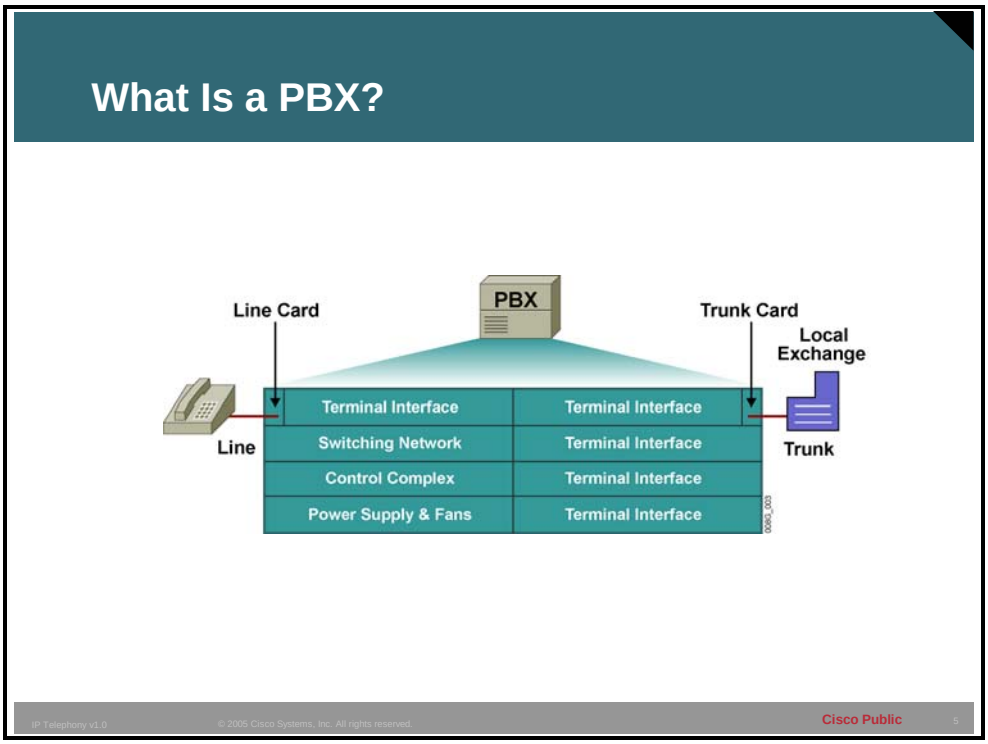
PSTN calls are traditionally circuit-switched, which guarantees end-to-end path and resources. Therefore, as the PSTN sends a call from one switch to another, the same resource is associated with the call until the call is terminated.

Example: CO Switches

CO switches provide local service to your residential telephone. The CO switch provides dial tone, indicating that the switch is ready to receive digits. When you dial your phone, the CO switch receives the digits, then routes your call. The call routing may involve more than one switch as the call progresses through the network.

Private Switching Systems

In a corporate environment, where large numbers of staff need access to each other and the outside, individual telephone lines are not economically viable. This topic explores PBX and key telephone system functionality in environments today.



A PBX is a smaller, privately owned version of the CO switches used by telephone companies.

Most businesses have a PBX telephone system, a key telephone system, or Centrex service. Large offices with more than 50 telephones or handsets choose a PBX to connect users, both in-house and to the PSTN.

PBXs come in a variety of sizes, from 20 to 20,000 stations. The selection of a PBX is important to most companies because a PBX has a typical life span of seven to ten years.

All PBXs offer a standard, basic set of calling features. Optional software provides additional capabilities.

The figure illustrates the internal components of a PBX. It connects to telephone handsets using line cards and to the local exchange using trunk cards.

A PBX has three major components:

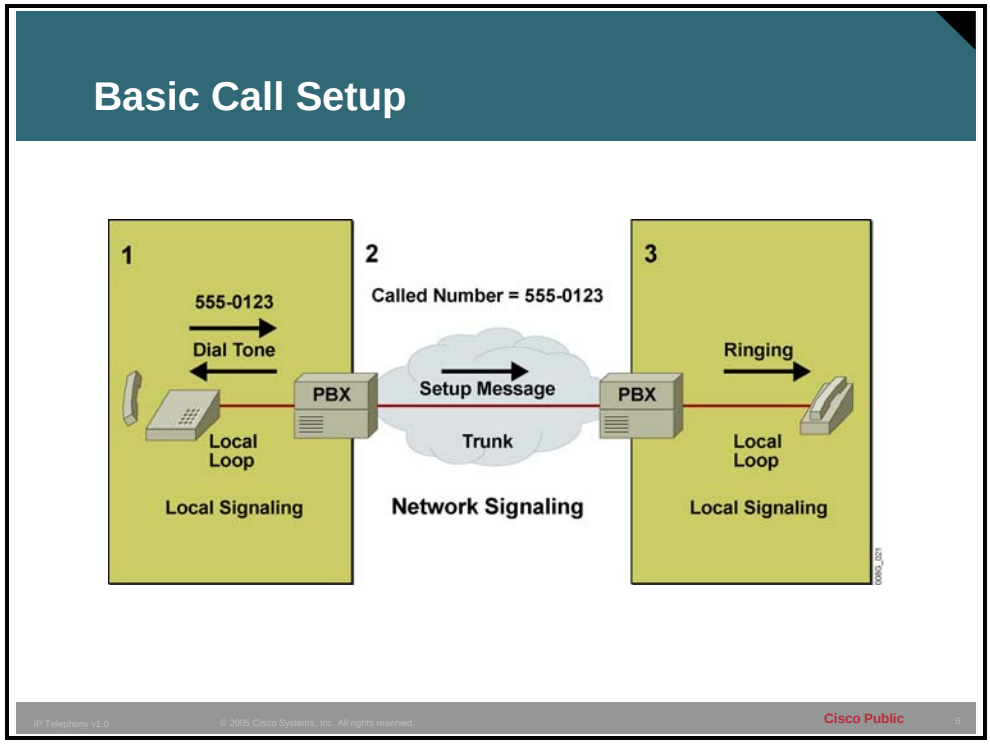
- **Terminal interface:** The terminal interface provides the connection between terminals and PBX features that reside in the control complex. Terminals can include telephone handsets, trunks, and lines. Common PBX features include dial tone and ringing.
- **Switching network:** The switching network provides the transmission path between two or more terminals in a conversation. For example, two telephones within an office communicate over the switching network.
- **Control complex:** The control complex provides the logic, memory, and processing for call setup, call supervision, and call disconnection.

Example: PBX Installations

PBX switches are installed in large business campuses to relieve the public telephone company switches from having to switch local calls. When you call a coworker locally in your office campus, the PBX switches the call locally instead of having to rely on the public CO switch. The existence of PBX switches also limits the number of trunks needed to connect to the telephone company's CO switch. With a PBX installed, every office desktop telephone does not need its own trunk to the CO switch. Rather, the trunks are shared among all users.

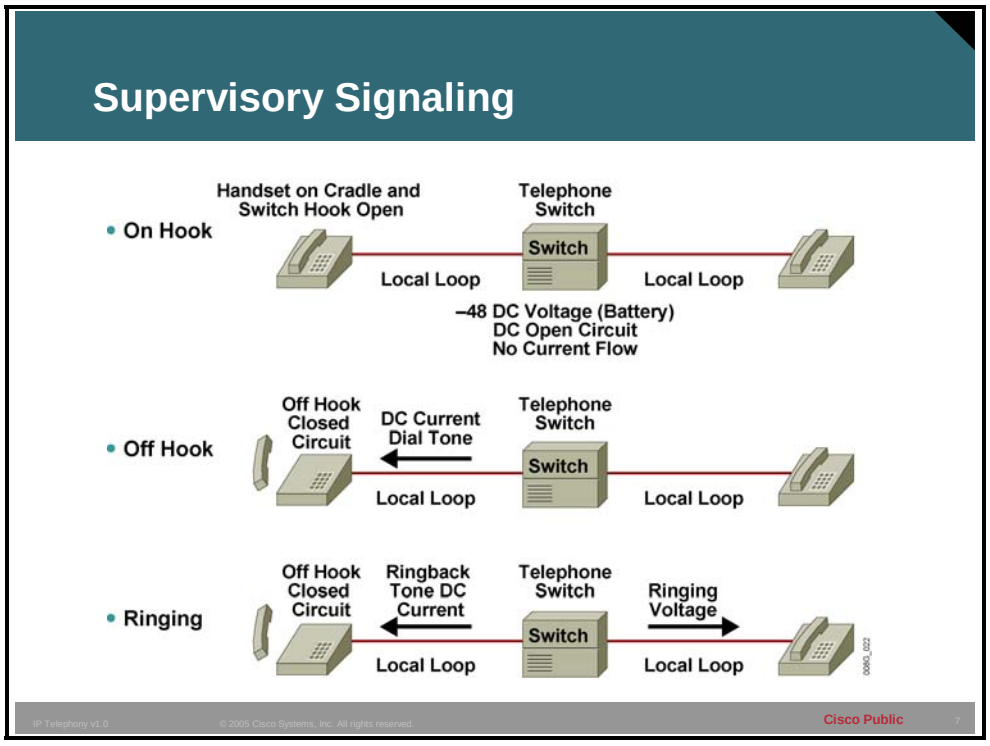
Call Signaling

Call signaling, in its most basic form, is the capacity of a user to communicate a need for service to a network. The call-signaling process requires the ability to detect a request for service and termination of service, send addressing information, and provide progress reports to the initiating party. This functionality corresponds to the three call-signaling types discussed in this topic: supervisory, address, and informational signaling.



The figure shows the three major steps in an end-to-end call. These steps include:

1. **Local signaling — originating side:** The user signals the switch by going off hook and sending dialed digits through the local loop.
2. **Network signaling:** The switch makes a routing decision and signals the next, or terminating, switch through the use of setup messages sent across a trunk.
3. **Local signaling — terminating side:** The terminating switch signals the call recipient by sending ringing voltage through the local loop to the recipient telephone.



A subscriber and telephone company notify each other of call status with audible tones and an exchange of electrical current. This exchange of information is called supervisory signaling.

There are three different types of supervisory signaling:

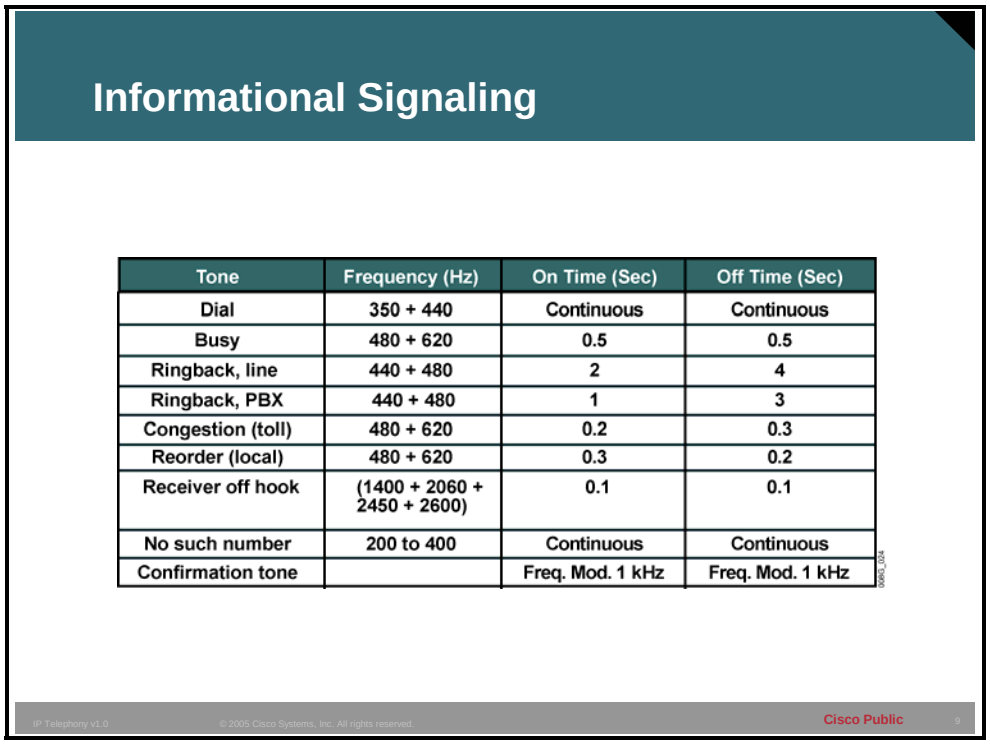
- **On hook:** When the handset rests on the cradle, the circuit is on hook. The switch prevents current from flowing through the telephone. Regardless of the signaling type, a circuit goes on hook when the handset is placed on the telephone cradle and the switch hook is toggled to an open state. This prevents the current from flowing through the telephone. Only the ringer is active when the telephone is in this position.
- **Off hook:** When the handset is removed from the telephone cradle, the circuit is off hook. The switch hook toggles to a closed state, causing circuit current to flow through the electrical loop. The current notifies the telephone company equipment that someone is requesting to place a telephone call. When the telephone network senses the off-hook connection by the flow of current, it provides a signal in the form of a dial tone to indicate that it is ready.
- **Ringing:** When a subscriber makes a call, the telephone sends voltage to the ringer to notify the other subscriber of an inbound call. The telephone company also sends a ringback tone to the caller alerting the caller that it is sending ringing voltage to the recipient telephone. Although the ringback tone sounds similar to ringing, it is a call-progress tone and not part of supervisory signaling.

Note	The ringing tone in the United States is 2 seconds of tone followed by 4 seconds of silence. Europe uses a double ring followed by 2 seconds of silence.

There are two types of telephones: a rotary-dial telephone and a push-button (tone) telephone. These telephones use two different types of address signaling to notify the telephone company where a subscriber is calling:

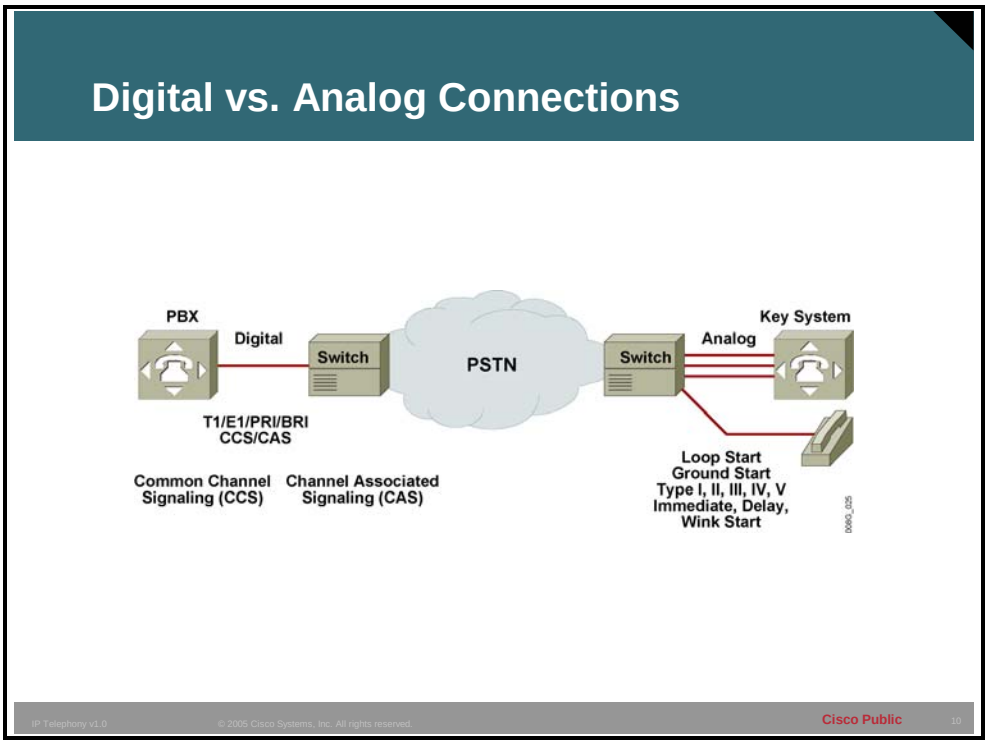
- **Dual tone multifrequency:** Each button on the keypad of a touch-tone pad or push-button telephone is associated with a set of high and low frequencies. On the keypad, each row of keys is identified by a low-frequency tone and each column is associated with a high-frequency tone. The combination of both tones notifies the telephone company of the number being called, thus the term “dual tone multifrequency” (DTMF).
- **Pulse:** The large numeric dial-wheel on a rotary-dial telephone spins to send digits to place a call. These digits must be produced at a specific rate and within a certain level of tolerance. Each pulse consists of a “break” and a “make,” which are achieved by opening and closing the local loop circuit. The break segment is the time during which the circuit is open. The make segment is the time during which the circuit is closed. The break-and-make cycle must correspond to a ratio of 60 percent break to 40 percent make.

  A governor inside the dial controls the rate at which the digits are pulsed; for example, when a subscriber calls someone by dialing a digit on the rotary dial, a spring winds. When the dial is released, the spring rotates the dial back to its original position. While the spring rotates the dial back to its original position, a cam-driven switch opens and closes the connection to the telephone company. The number of consecutive opens and closes, or breaks and makes, represents the dialed digit.



Tone combinations indicate call progress and are used to notify subscribers of call status. Each combination of tones represents a different event in the call process. These events include the following:

- **Dial tone:** Indicates that the telephone company is ready to receive digits from the user telephone
- **Busy:** Indicates that a call cannot be completed because the telephone at the remote end is already in use
- **Ringback (normal or PBX):** Indicates that the telephone company is attempting to complete a call on behalf of a subscriber
- **Congestion:** Indicates that congestion in the long-distance telephone network is preventing a telephone call from being processed
- **Reorder tone:** Indicates that all the local telephone circuits are busy, thus preventing a telephone call from being processed
- **Receiver off hook:** Indicates that a receiver has been off hook for an extended period of time without placing a call
- **No such number:** Indicates that a subscriber has placed a call to a nonexistent number
- **Confirmation tone:** Indicates that the telephone company is attempting to complete a call



Supervisory, address, and informational signaling must be carried across both analog and digital connections. Depending on your connection to the network, you must configure specific signaling to match the type of signaling required by the service provider.

Digital PBX connections to the network are common in many countries. They may be a T1 or E1 line carrying channel associated signaling (CAS) or a PRI using common channel signaling (CCS).

CAS is a signaling method that allows passing on-hook or off-hook status by setting bits that are associated with each specific voice channel. These bits are carried in band for T1 and out of band for E1.

An ISDN connection uses the D channel as the common channel to carry signaling messages for all other channels. CCS carries the signaling out of band, meaning that the signaling and the voice path do not share the same channel.

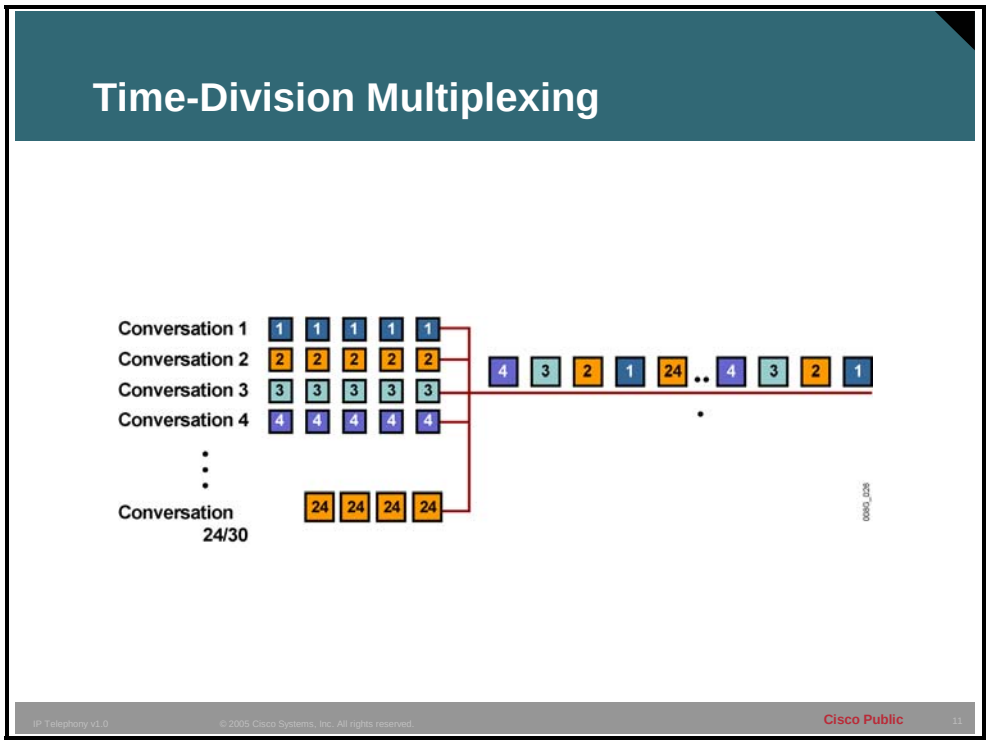
Analog interfaces require configuration of a specific signaling type to match the provider requirement. For interfaces that connect to the PSTN or to a telephone or similar edge device, the signaling is configured for either loop start or ground start. For analog trunk interfaces that connect two PBXs to each other, or a PBX to a CO switch, the signaling is either Wink Start, immediate start, or delay start with the signaling type set to 1, 2, 3, 4, or 5.

Example: Call Signaling at Home

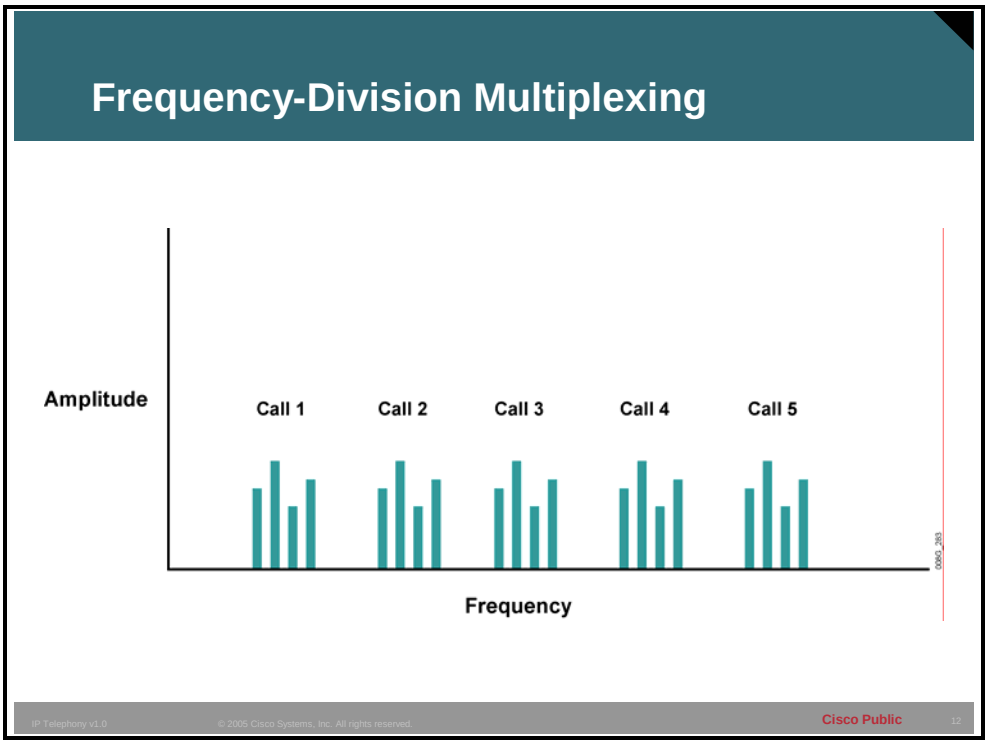
A call placed from your residential telephone uses all three types of call signaling. When you lift the handset, a switch in your telephone closes to start current flow and notifies the telephone company that you want to make a call (supervisory signaling). The telephone company then sends dial tone to indicate that it is ready to receive your dialed digits (informational signaling). You then dial your digits by pressing the number on the keypad (address signaling).

Multiplexing Techniques

A two-wire analog local loop typically carries one call at a time. To make better use of wiring facilities, different multiplexing techniques have been implemented to enable two-wire or four-wire connections to carry multiple conversations at the same time. This topic discusses two of these multiplexing techniques.



Time-division multiplexing (TDM) is used extensively in telephony networks to carry multiple conversations concurrently across a four-wire path. TDM involves simultaneously transmitting multiple separate voice signals over one communications medium by quickly interleaving pieces of each signal, one after another. Information from each data channel is allocated bandwidth based on preassigned timeslots, regardless of whether there is data to transmit.



Frequency-division multiplexing (FDM) involves carrying multiple voice signals by allocating an individual frequency range to each call. FDM is typically used in analog connections, although its functionality is similar to that of TDM in digital connections. FDM is used in cable or digital subscriber line (DSL) connections to allow the simultaneous use of multiple channels over the same wire.

Example: Multiplexing Television Channels

If you have cable television service at your home, the television channels are all carried (and multiplexed) over a single pair of wires. This includes both the audio signals and the video signals. Your set-top cable tuner then determines which channel is sent to your television by way of selecting the channel you want to watch. All of the channels are present on the cable wires all of the time, but you tune your selected channel using the set-top tuner.