1.264 Lecture 20

Telecom fundamentals

Telecom/CEE/MLog future

By the year 2025 the entire world will be encased in a communications skin, according to experts at Lucent Technologies' Bell Labs. "We are already building the first layer of a mega network that will cover the entire planet like a skin," says Arun Netravali, president of Bell Labs. "As communication continues to become faster, smaller, cheaper and smarter in the next millennium, this skin, fed by a constant stream of information, will grow larger and more useful." This skin will consist of millions of electronic measuring devices-- thermostats, pressure gauges, pollution detectors, cameras, microphones -- monitoring cities, roadways and the environment. All of these will transmit data directly into the network, just as our skin transmits a constant stream of sensory data to our brains," said Netravali. Such systems might be used for anything from constantly monitoring the traffic on a local road, water level in a river to the temperature at the beach or the supply of food in a refrigerator. These sensors will be just one source of an increasing amount of machine-to-machine and object-to-object communication in the future. In fact by 2010, Netravali predicts that the volume of this "infrachatter" will actually surpass communication between humans. "At home, your dishwasher will be able to call its manufacturer when it is malfunctioning and the manufacturer will run diagnostics remotely, he explains. "Or your lawn sprinkler could check the Web site of the National Weather Service before turning itself on, to make sure the forecast doesn't call for rain." Bell Labs experts also predict that as the millennium unfolds communications advances will make waiting by the phone, surfing the Internet, and traveling for business as antiquated as using carbon paper is today. [November, 1999]

Telecom future: an example

CriticalDevices offers X-node hardware from X-tra Web, a subsidiary of World Wireless Communications. X-node, a 1-inch-square Web server, can be attached to a restaurant's walk-in cooler, for example. The hardware might be programmed to track temperature fluctuations, alerting the owners to a rapid temperature drop. X-node then would send a wireless warning to a CriticalDevices network center, setting off a chain of communications ending with a message to the restaurant manager via pager, E-mail, fax, the Internet, or a personal digital assistant.

The companies plan to target corporate, industrial, manufacturing, home-automation, and fast-food restaurant markets. Kevin Gallagher, Newport Group's VP of research and reporting, says manufacturing and fast-food restaurants will benefit from the technology. "Manufacturing companies have a need to monitor status and performance of those machines in the field.“ [November, 2000]

Telecom future: another example

Connect One Ltd., a maker of embedded chips, has introduced an off-the-shelf processor that lets companies quickly add Internet connectivity to previously unconnected remote and mobile devices. The new chip makes it possible to achieve real-time, two-way communication with devices such as vending machines, utility meters, or even video-game consoles without having to redesign the hardware in question.

Connect One VP Alan Singer says the chip is an after-market add-on that makes a serial connection between the device and its host processor, enabling Net connectivity through any Internet service provider. So far, Singer says, the chip is mostly being sold to customers in the industrial and medical worlds, but the company is also in talks with consumer electronics companies regarding the chip's incorporation into devices such as DVD players, MP3 players, and cordless telephones. [November, 2000]

Telecom future: last example

- http://www.mediaeater.com/cameras/locations.html shows the locations of surveillance cameras monitoring public spaces in New York City.
  - A red dot shows a camera; many streets in Manhattan are solid red
  - These cameras are generally not connected to the Internet now, but Web cams are easy to set up.
- So, the “Bell Labs vision” is not that far away
  - 1 inch square Web servers have existed for years
  - Chips to interface with existing devices and communicate via wireless modems have existed for years
  - Arlington MEng project on wireless water monitoring could implement the water sprinkler option. Some sprinkler sense rain now.
  - MIT I-Campus project looking at remote accelerometers, strain guages, anemometers, thermocouples

Telecom future motivation

- **This is why we cover telecom in this class: it's vitally important to supply chain and engineering in the future**
  - **Supply chain, environmental, structural, geotechnical, construction applications will have machine-machine or object-object communications via HTTP, XML and HTML**
  - **Data will be stored in relational databases, which will become more complex over time**
  - **Wireless and wireline communications, using a variety of technologies will tie the 'communications skin' together**
  - **Software technologies will be integrated into the daily activities of engineers and analysts**
- **You will need to configure wireless and wireline networks to access data, sensors and applications**
  - **A basic understanding of telecom principles is needed now; there is no single telecom integrator like the former AT&T**

Central issue: network access (“dial tone”)

- Who can use the network, and how easy is it?
- Voice:
  - Voice <u>dial tone</u> is universal access to network
  - Reliable, universal, standard (though poor) user interface
  - Supports many advanced services, will be model for data services in some ways
- Data:
  - World Wide Web, browsers are the first version of <u>data dial tone,</u> after many years of research and experimentation
  - Not truly reliable, becoming widely available (especially wireless), standard and good user interface
  - Few advanced services (e.g. bandwidth management, security, etc.), but these will be available within a few years (PKI, quality of service [QoS], etc.)
  - Issues: PCs need to be always on, net needs to always be connected, device needs to be easier to use and manage than a PC
- Video:
  - <u>Video dial tone</u> still remains to be worked out
  - Interactive video not workable; streaming video problematic
  - Awaits fiber optic networks or broadband wireless to end users

Major technological issue: switching

- Switching is core to telecom today
  - Perhaps unnecessary in future
- Switching needed only if bandwidth is scarce
  - Otherwise we can have point-point connections everywhere
- Switching currently a bottleneck, has much less capacity than telecom transmission gear (because it's electronic and not photonic)
  - Fundamental physics favors fiber over electronics (bosons vs mesons)
- Can broadcast all voice, data and video on a gigantic wide area network
  - Each terminal can just pick off packets addressed to it
  - Each terminal can send packets to other terminals with their address
- Idea is not so wild
  - Being considered for local number portability (LNP) [lifetime phone number]

Major classes of telecom equipment

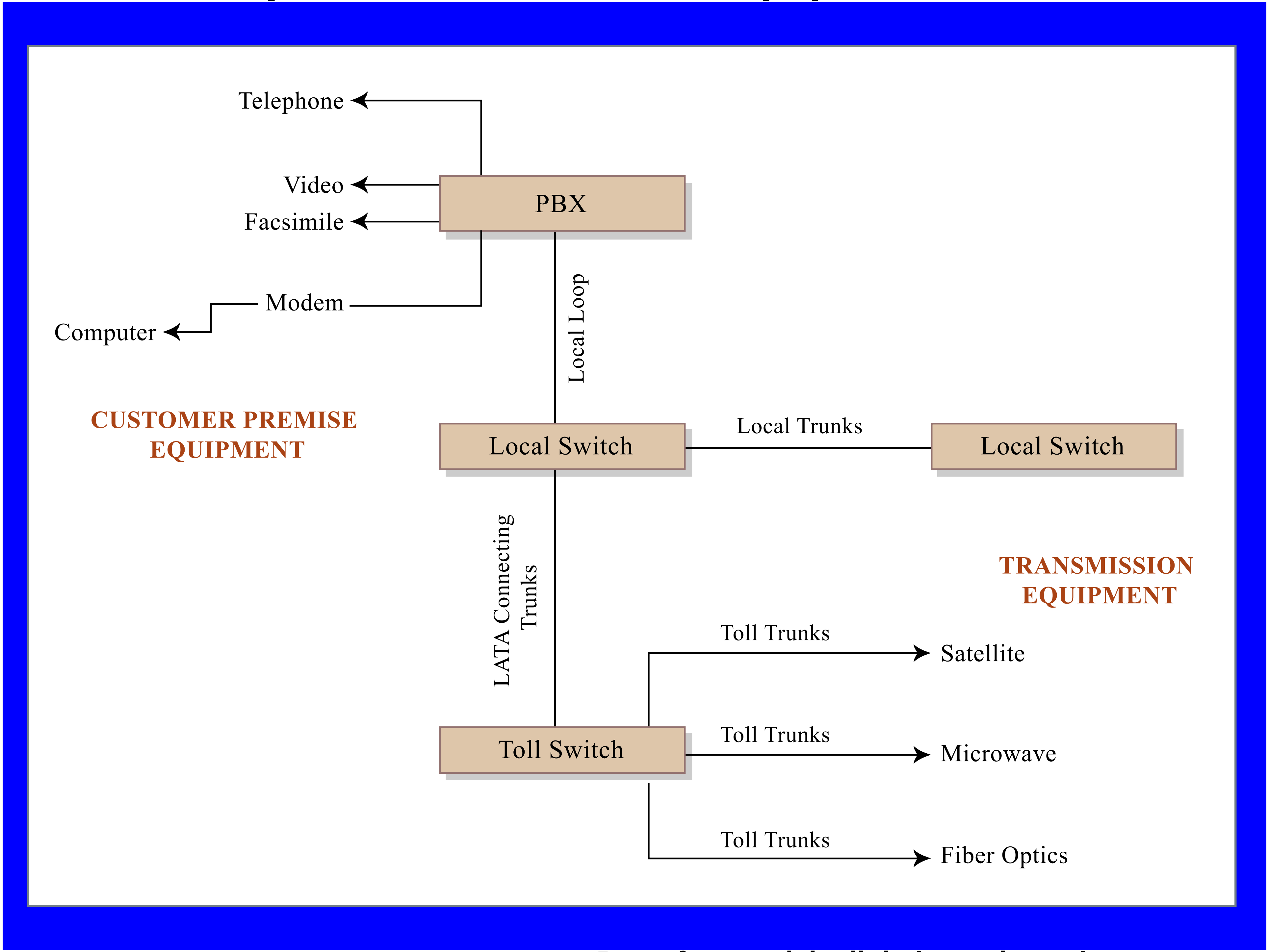
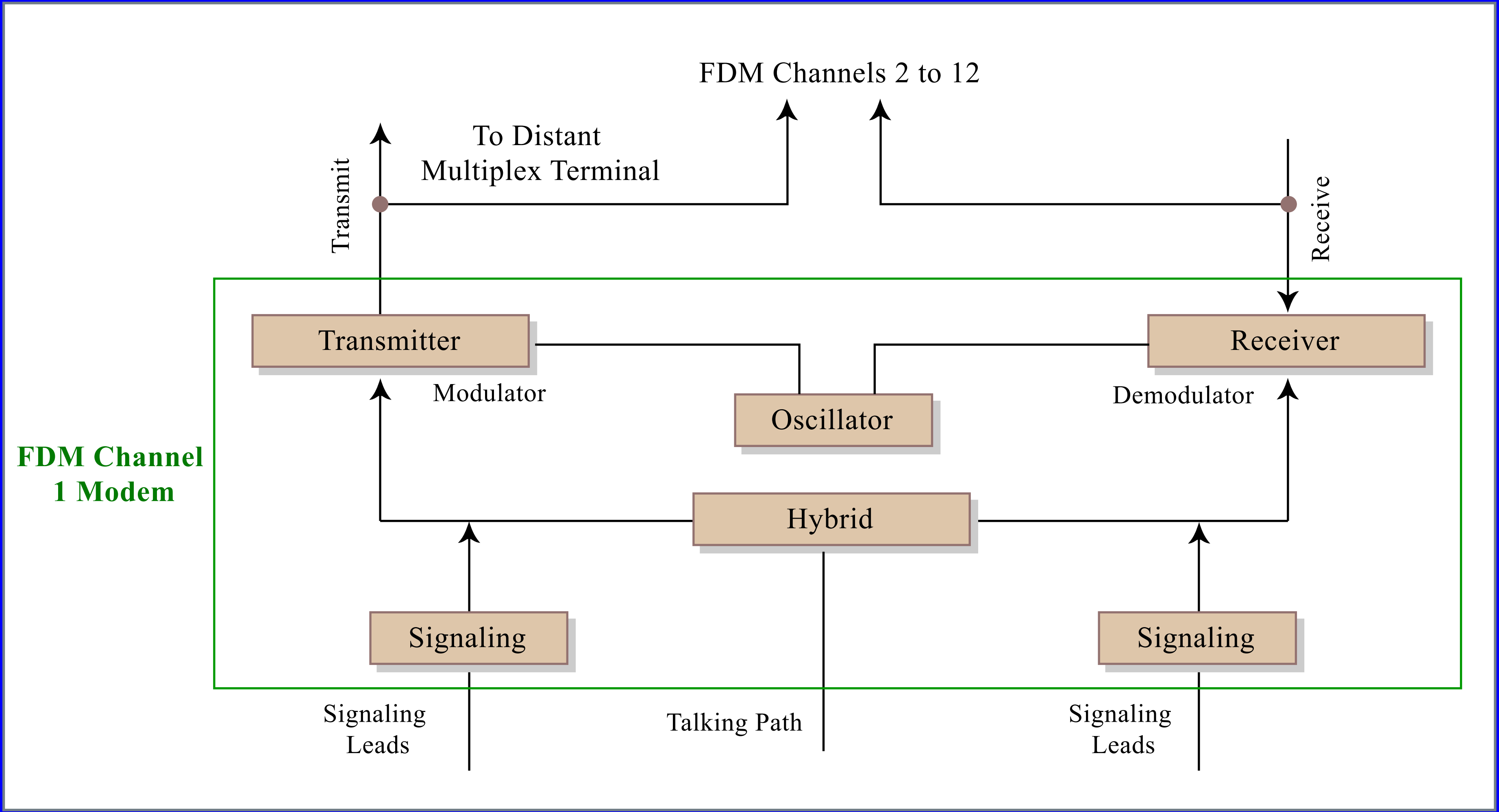


Figure by MIT OCW.

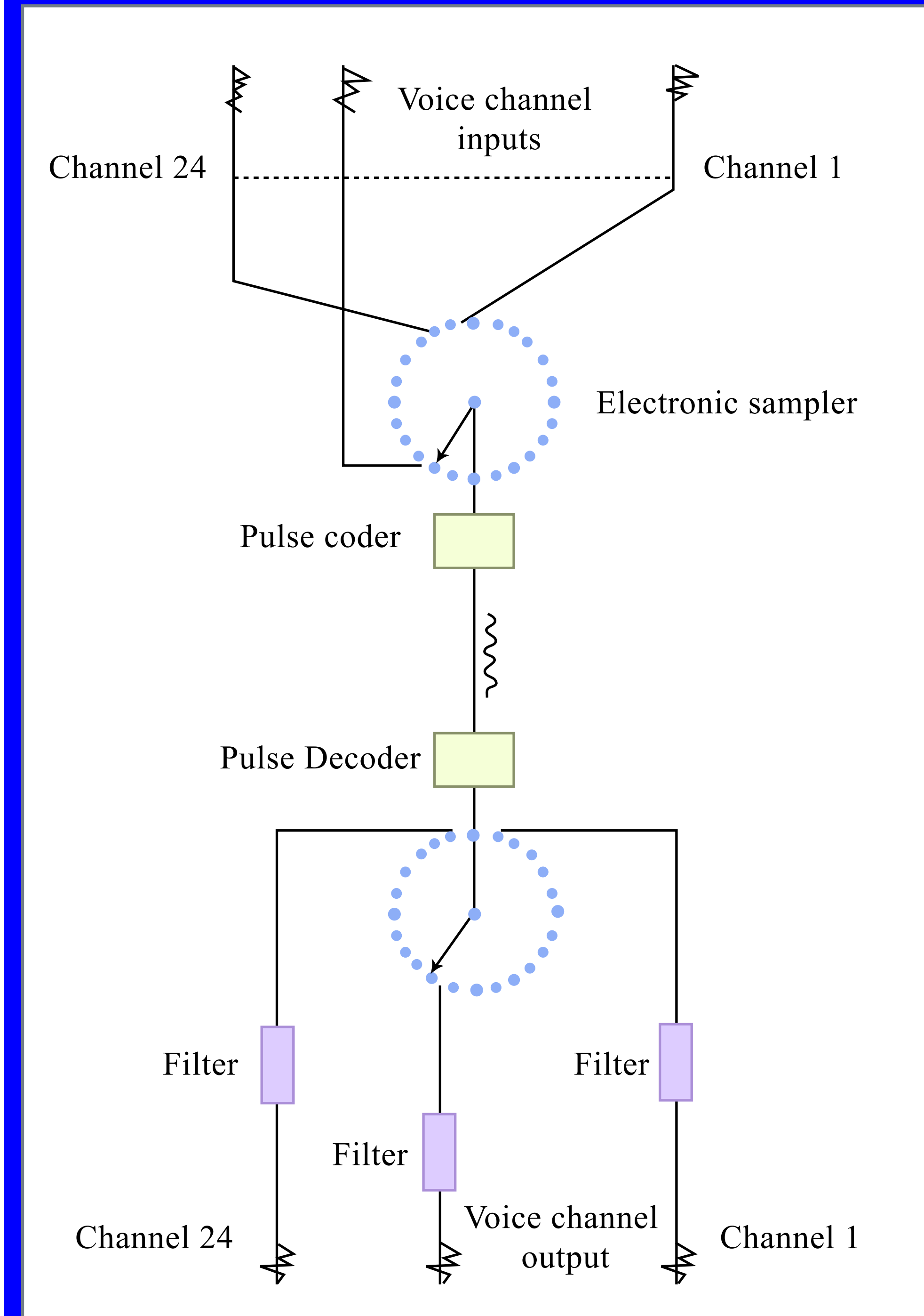
Part of network is digital, part is analog
Circuits can be switched or fixed (nailed up)

Frequency division multiplexing



- Traditional method of carrying multiple channels on a cable
- Similar to radio broadcasting with stations at different frequencies
- Being used again in ADSL, CATV, satellite, …
- Basic frequency is 4kHz band, based on voice needs
- Voice hears from 20 to 20,000 Hz, but mostly 300 to 3500 Hz

Figure by MIT OCW.



Time division multiplexing

Time division samples each 4kHz channel
Shannon/Nyquist: Sample at twice the bandwidth to code and decode all possible information
So, sample 8000 times/second at 8 bits per second (or 256 levels) Yields 64kb/sec channel, which is the basic rate of voice and data comm

24 64kb/sec channels is a T-1 (32 in Europe form an E-1) US channels are often only 56kb/sec because of bit robbing TDM used in fiber optic technologies; lasers can do both TDM and FDM (colors)

Figure by MIT OCW.

PCM Framing in T-1 circuits

8,000	samples per second
x 8	bits per sample
64,000	bits per channel
x 24	channels
1,536,000	bits per second
+ 8,000	framing bits per second (not enough!)
1,544,000	bits per second total in T-1 circuit

Framing used to keep sync between ends of circuit. If all 24 circuits are quiet, only framing bits keep the clocks at both ends of the circuit in sync

Convergence: use of same networks, protocols, equipment to carry both data and voice. T-1 is the backbone for both!

T-1s operate over both copper and fiber. Higher bandwidth is fiber only.

SONET

SONET & SDH LINE RATES

SONET	SDH	SPEED (Mb/s)
STS-1		51.840
STS-3	STM-1	155.520
STS-9	STM-3	466.560
STS-12	STM-4	622.080
STS-18	STM-6	933.120
STS-24	STM-8	1,244.160
STS-48	STM-16	2,488.370
STS-192	STM-64	9,953.280

Figure by MIT OCW.

Fiber bandwidth, beyond T-1

STS-1, or OC-1, is same as T-3, or 28 T-1s

SONET can be divided into channels as small as 64kbps

- **Voice carried at 64kbps**
- **Data carried at many rates**
- **Video carried at MPEG-1 (1.5Mb/sec) or MPEG-2 (6Mb/sec); these are highly compressed**
  - **Can’t compress Hollywood video! Uncompressed video can be 200Mb/sec or more**

SONET Rings

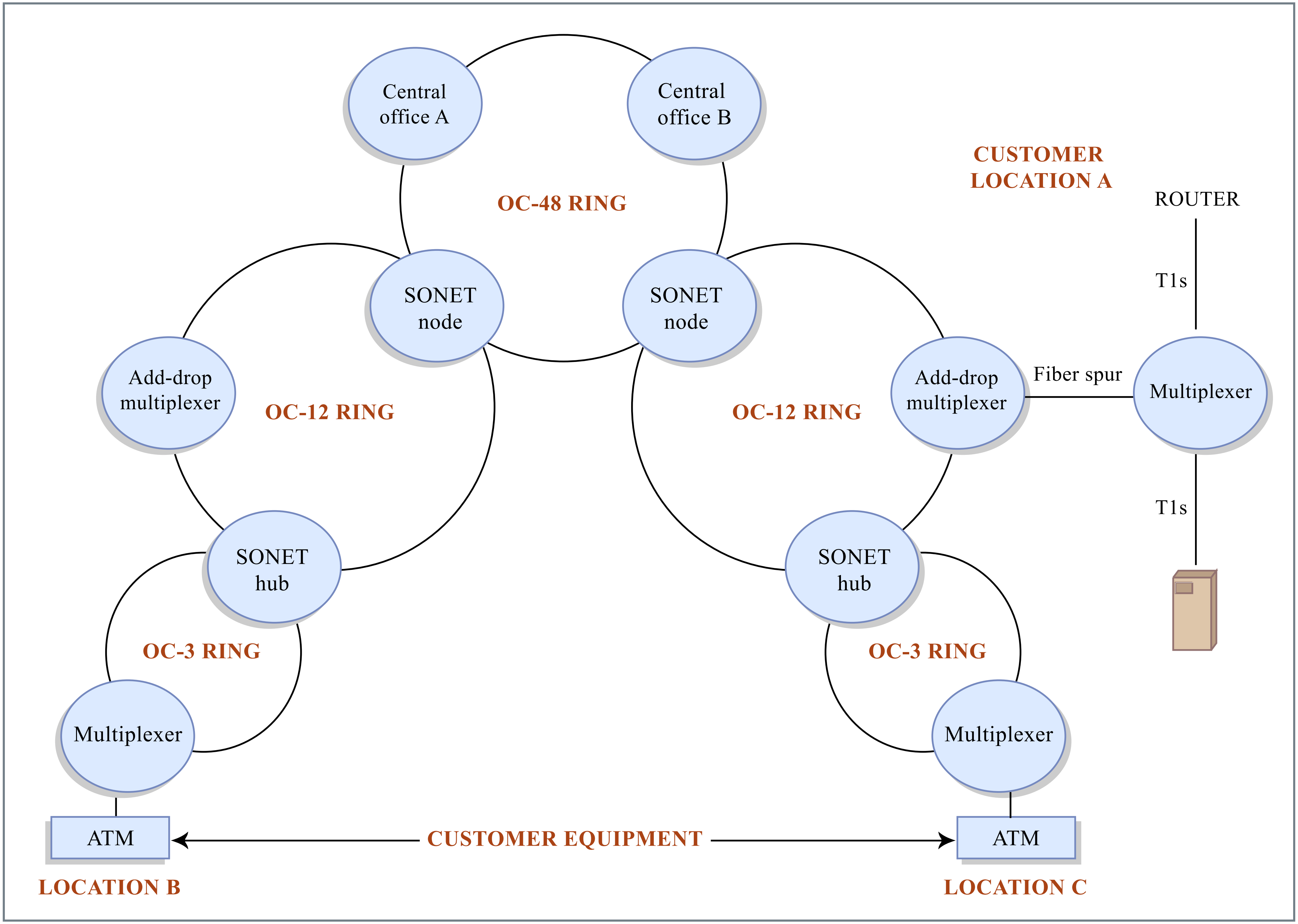


Figure by MIT OCW.

Outside plant

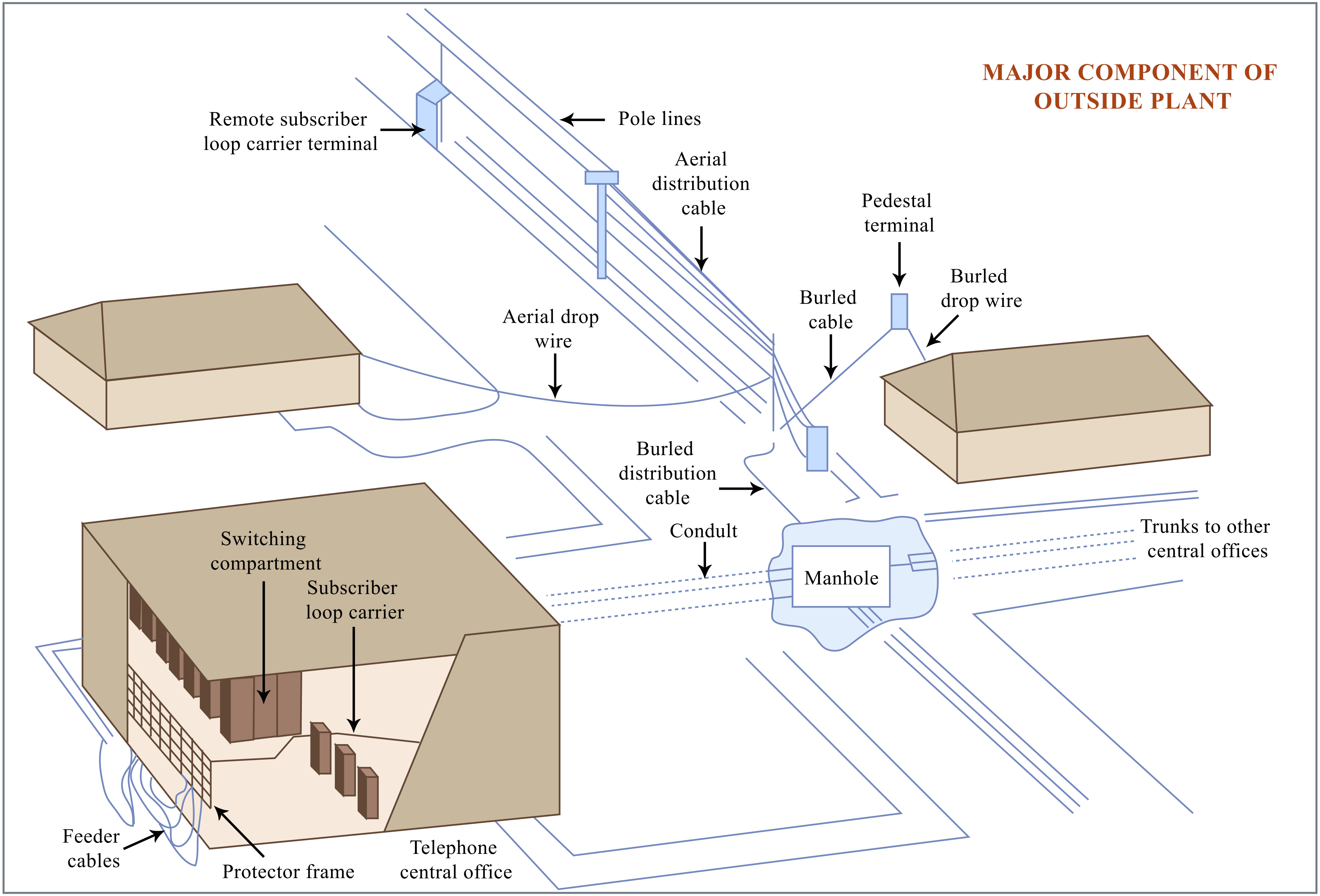


Figure by MIT OCW.

Feeder and distribution cable

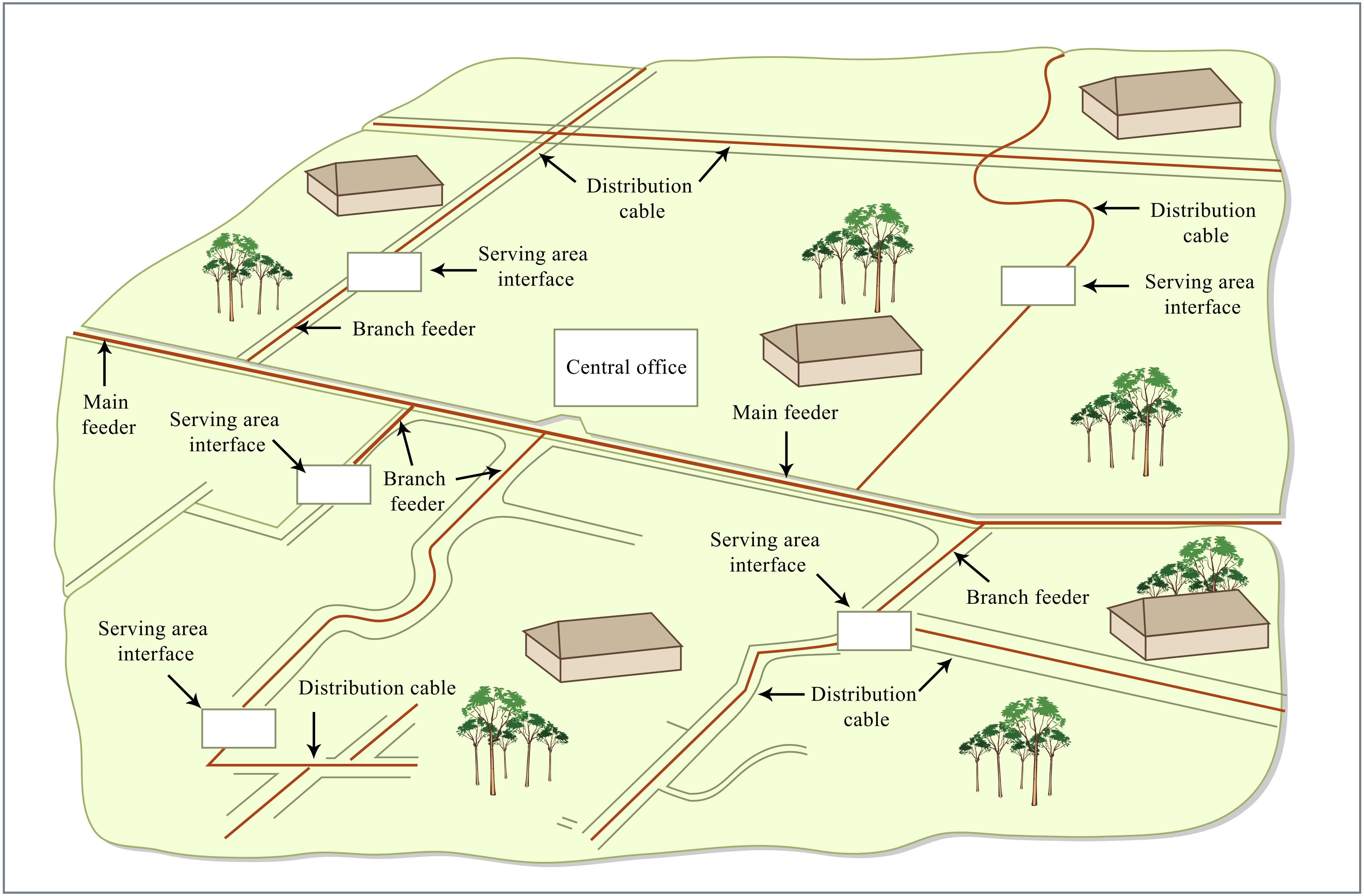


Figure by MIT OCW.

Feeder cable becoming all-fiber. Some distribution is fiber, more planned

Convergence

- The telecom network supports data (Internet) and voice communications in a fairly integrated fashion now.
  - It didn't even as little as three years ago
  - Video still has minor usage and support
  - T-1, SONET, copper local loop (DSL, dialup modems, T-1), various switch components are used heavily by data and voice
  - T-1s can be used for data and/or voice services interchangeably
    - Some companies dynamically allocate to voice and data
  - Next lecture will cover data protocols and how data and voice coexist in the network
    - Data is now well over 90% of all traffic
    - It was less than 5% in 1994.
    - Data is fitting into the 'traditional' voice telecom network very well!
    - Within data traffic, much more than half is machine-machine