Telecommunication Service Providers

This lecture provides an overview of the technologies used by telecommunication service providers. These technologies are the focus of this course.
After this lecture you should be able to: explain the role of access, switching and trunk technologies and give examples for each. You should be able to explain the purpose of a codec and the three goals of communication security. You should also be able to define the terms and acronyms defined in this lecture.

Telecommunication Service Providers

Telecommunication service providers (public "carriers") include companies that started as telephone companies (Telus, AT&T), as cable television companies (Shaw, Comcast), as providers of internet services (Google) and as providers of data links between cities and continents (Level3).

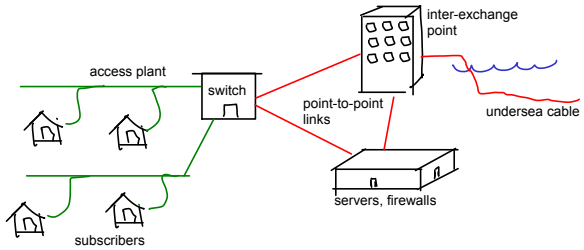
You may be familiar with LANs (Local Area Networks) that provide service for the network's owners and provide service inside one building (e.g. a WiFi network within your home). Public service providers' networks, often called WANs (Wide Area Networks), differ from LANs in that:

- the geographic scope of the networks is much larger. These networks usually provide worldwide connectivity, often through agreements to exchange data or connect calls with other service providers.
- aggregate (combined) data rates are much higher than on a LAN.
- the number of users is much larger. Many service providers have tens of millions of subscribers and addressable devices.
- usage must usually be tracked for billing purposes
- large amounts of remotely-located equipment must be monitored and redundant equipment activated when problems are detected
- government regulations often constrain the types of services that can be provided and often the pricing
- equipment is often installed in locations where vandalism and environmental extremes are an issue
- subscribers usually have expectations of communication privacy and data security

Exercise 1: Make a (very) approximate estimate of the revenue generated by telecommunication service providers in Canada based on an estimate of the population and your estimate of the average revenue per person. Compare your answer with other student's estimates. Make a similar estimate for another service industry or utility and compare them.

Network Architecture

Service provider's telecommunication networks are organized hierarchically as in the example below:



- A local access technology connects subscribers to a location owned by the service provider over the access plant (equipment). This can be twisted pair, co-axial cable, or fiber optic cables, either buried in conduits or aerial (wires strung between poles).
- A switching function at the service provider's premises connects the subscriber to one or more higher-capacity point-to-point links. The service provider's location is sometimes a large nondescript, often windowless, building but

sometimes the equipment is located in cabinets (pedestals) on the street (curb) or in an office building.

- High-capacity point-to-point links interconnect switching locations, typically in a hierarchy of switching centers.

The first part of the course is divided into three parts, each covering one of the above aspects. Each of these parts is described in more detail below.

With the exception of POTS service, modern networks are digital. In addition to data, they also carry digitized speech or video signals. In the second part of the course we will study how speech and video signals are digitized, compressed and secured for transmission over digital networks.

Access Technologies

The purpose of an access technology is to connect a subscriber to the service provider. The most common access technologies include:

- plain old telephone service (POTS). These carry analog voice-band signals over twisted-pair cable for distances of up to a few km. We will study basic POTS call signalling.
- Asymmetric Digital Subscriber Line (ADSL). These carry data signals at frequencies above the audible range. The subscriber uses an ADSL modem to connect to a DSL access multiplexer (DSLAM) at a telephone company's "central office". We will study some of the ITU ADSL standards.
- Cable Modems (CM). These use the co-axial cable infrastructure originally installed to distribute community antenna television (CATV or "cable TV"). These networks are now typically a hybrid of optical fiber and co-axial cable links (HFC). The subscriber uses a cable modem to connect to a cable modem termination system (CMTS) at the cable company's "head end". We will study the Data Over Cable Service Interface Specification (DOCSIS) cable modem standards.
- Passive Optical Networks (PON). These use fiber optic cables and optical splitters to create a high-speed access network. Although PON provides the highest data rates, it requires installing new cabling to subscribers and the costs have limited the rate of deployment.

There are also wireless access technologies including terrestrial cellular and satellite-based data systems. Wireless access technologies are important for mobile users but propagation and mobility aspects make these systems significantly different than wired ones. They are covered in other courses.

Switching and Routing

At the service provider's site (CO or Head End), equipment is installed to support the other side of the access link and to aggregate data into a smaller number of lines that connect to the service provider's other locations.

For the PSTN (Public Switched Telephone Network) the service provider's equipment is called a telephone switch and the point-to-point links between COs are called trunks. Digital trunks carry multiplexed digitized speech signals.

For digital subscriber access services the DSLAM or CMTS is connected to an Internet Protocol (IP) router which in turn is connected to high-speed fiber-optic (FO) point-to-point links carrying multiplexed data streams.

Service providers have migrated from circuit switching to store-and-forward packet-switching using IP protocols. We will study the various algorithms and protocols used by service providers to maintain IP routing tables.

The functions of switching and routing equipment can be divided into signalling and switching. Signalling is the communication of information that helps manage communication such as the start and end of a call, the identity of the parties involved and information about network congestion. Switching is the transfer of information between users.

Today, most networks operate on small (under 1500 byte) packets of data each of which carries it's own addressing information and which traverse the network independently of each other in a "store and forward" manner. This is called "packet switching" in contrast to the earlier "circuit switching" where a set of access lines and trunks was allocated for the duration of a phone call.

Core Network

The core of the network consists of high-speed (multi-Gb/s) fiber-optic links carrying multiple logical data streams in a time-multiplexed manner between service provider premises. Undersea cables are used for intercontinental links.

The most common standards for these links are SONET (Synchronous Optical Networking) and SDH (Synchronous Digital Hierarchy). We will study how different types of data streams are multiplexed into these formats.

Exercise 2: Highlight or underline the acronym definitions and any unfamiliar terms introduced in this lecture.

Digitization of Audio and Video

Modern networks only carry digital information. Transmission of audio and visual information requires that the time variations of sound pressure (audio) and light intensity (video) be converted to and from digital form. This conversion is done by digitizing the signals (sampling at discrete times and quantizing into discrete levels) and then encoding these digitized values using techniques that are appropriate for each type of signal ("source" coding). Codecs (short for "COder" "DECoder") are the hardware and software that do this.

We will briefly study different types of codecs. For example, PCM (Pulse Code Modulation) can be used to encode any waveform. However, codecs for specific types of signals can reduce the required bit rate by making use of redundancy in the signal.

For example, characteristics of human perception of sound can be used to compress audio signals. An example is the popular MP3 encoding. If the audio is speech, characteristics of the human vocal tract can be used to reduce the bit rate even further. An example is the AMR (Adaptive Multi-Rate) codec used by many cellular telephone systems.

The response of the human eye can similarly be used to compress still images. An example of an image codec is JPEG. Compression of moving images can take advantage of similarities between successive frames, including motion of objects. An example is the x.264 video codec.

Security

We will also briefly cover security for communication systems. Data communication security has the following goals:

secrecy ensures that the contents and sometimes information about the communication ("metadata") are not disclosed

authentication identifies the originator

integrity ensures that the message has not been modified by the communication system

These goals are typically achieved using a combination of symmetric and asymmetric ("public key") encryption together with protocols that allow secure communication sessions to be set up. Examples of encryption algorithms include AES (Advanced Encryption Standard) and RSA while examples of secure protocols include TLS (Transport Layer Security) and SSH (Secure SHell).