Chapter 7. selection

Telephony

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The Telephone Industry Structure

The telephone industry reaches nearly 96 percent of all U.S. homes and touches virtually all phases of U.S. consumer and business activity.[1] The term *common carrier* is used to describe those companies engaged in the business of message delivery on a point-to-point or point-to-multipoint basis. Common carriers offer their service on a nondiscriminatory basis to anyone who is willing to pay for it. In principle, they do not interfere with the content of the message. Common carriers are regulated by appropriate state or federal agencies.

Prior to 1984, approximately 80 percent of the public switched telephone network in the U.S. was part of AT&T (or the Bell system of communication). As a monopoly, AT&T was a full service provider and handled all aspects of the telephone call. As a result of the divestiture agreement, there were essentially two types of wireline carriers in the U.S.: incumbent local exchange carriers (ILECs) and interexchange carriers (IXCs) or long-distance carriers. Today, there is no longer the formal distinction between local and long-distance telephone service providers. The combination of changing market conditions (i.e., mergers and acquisitions and cross-media ownership) coupled with advancement in telephone communication technology (cellular telephony, the Internet, Voice Over Internet Protocol and Over-the-Top Videostreaming services) has eroded the once formal distinction.

Local Exchange Carrier

The local exchange carrier (LEC) is the telephone company that provides local and long-distance telephone communication. The ILEC is typically assumed to be the former Bell system or independent telephone companies responsible for providing local telephone service in a specified geographic area. The LEC is responsible for telephone service provision, network management, customer service and billing.

In addition, the LEC provides the basic gateway to the national and international systems of telephone communication. The LEC also provides enhanced information services such as caller identification (caller I.D.), high-speed Internet access (DSL), Internet protocol television (IPTV) as well as high-speed data lines and SONET fiber optic carriage. Several of the more notable U.S. ILECs include: Verizon, AT&T, CenturyLink and Frontier Communications.

Competitive Local Exchange Carrier

The local exchange market also consists of competitive local exchange carriers (CLECs, pronounced *see-leks*). CLECs are telephone companies that directly compete with the traditional ILECs. CLECs will sometimes operate their own network, but are often resellers of a telephone service: that is, they purchase traditional telephone service at wholesale levels and then turn around and resell them to the public at discounted rates. Being a reseller saves the CLEC from having to invest in telephone networking equipment, including switches, fiber optic cable, pole attachments, etc. Examples of CLECs include companies like TC3, Covad Communications and TelNet Worldwide. One important factor that distinguishes the relative success of the CLECs is their scale of operation. CLECs tend to focus on smaller niche markets. They keep their marketing and customer service costs at a minimum.

Telephony: System Overview

Telephony (or telephone communication) is the science of converting voice, data and video information into electrical signals which can be transmitted over physical wire or through the air on a point-to-point or point-to-multipoint basis. Telephony is a system of communication that consists of two basic parts, including the telephone handset and box (or terminal equipment) and the physical network.

Telephone Switching and Routing

Telephone switching and routing refers to the combined activities of connecting and routing phone calls. The traditional telephone system of communication is designed as a circuit-switched (or line-switched) network. The phone call goes from the subscriber's telephone over telephone

lines to a central office (CO) switch maintained by the LEC. When a telephone call is placed, the CO master switch automatically locates a circuit before putting the call through. The speaking parties stay connected on that line until the phone call is complete.

Telephone Lines to the Home

The phone lines coming into a house typically consist of a twisted pair of copper wires; one for incoming, the other for outgoing communication. The twist is to reduce crosstalk (or induction) between adjacent lines. The more twists per foot, the better the reduction in crosstalk. As a narrowband medium, twisted copper pair is the most technically limited in terms of information-carrying capacity. It is sufficient to carry acceptable voice conversations and computer data over a short distance of a few miles.

Star Network Design

When engineers discuss the topology of a network, they are describing how the physical parts of the network are configured. Telephony utilizes what is called a star network configuration. Every terminal in the star can be connected to every other terminal through a central switch. Each terminal can transmit and receive information.[6] (See Figure 7.4.)

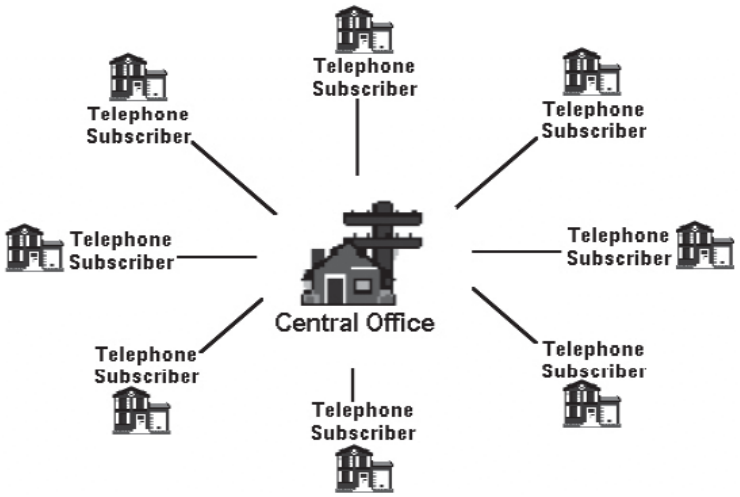

Figure 7.4 The LEC and Star Network Configuration (illustration by Chan, Chin Bong)

The public switched telephone network (PSTN) represents the complex web of national and international common carriers, switching facilities and electronic pathways that makes voice and data communication possible for business and residential users. The original telephone system of communication was designed as a circuit-switched network. In practice, the phone call goes from the subscriber's telephone over telephone lines to the Class 5 telephone switch located at the LEC's CO (or end office). When a telephone call is placed, the master switch automatically coordinates a temporary circuit before putting the call through. The speaking parties stay connected on that line until the phone call is complete.

Digital Switching Technology

In the years following the AT&T divestiture, several major developments have altered the basic design and operation of the modern telephone network, including advancements in digital switching, improvements in modern signaling systems and the introduction of fiber optic technology.[10] While the basic architecture of the PSTN remains largely circuit-switched, the network is controlled digitally, thus permitting voice and data signals to be transferred digitally within the network.[11] Over time, the digitization of the network has evolved to a more general-purpose computing platform (including out-of-band signaling) which provides the basis for packet switching and Internet data transport.

Telephone Management and Service Provision

The telephone has become so ubiquitous in our everyday lives that we take it for granted. We don't pay much attention until it doesn't work. Owning a telephone has become a right. People expect good telephone service and it's the phone company's job to give it to them. Rarely do people think about their telephone service when it works correctly, but they feel very inconvenienced when it does not work. ILEC telephone service requests fall into five general categories, as shown in Table 7.4.

Basic Telephone Service

Today, basic telephone service includes both local and long-distance telephone communications. All of the major ILECs offer combined local and long-distance telephone service packages for a flat rate. Basic telephone service is also offered by competitive local exchange carriers (CLECs) who may operate a private network and/or function as resellers of basic telephone service at a discounted rate.

Table 7.4 General Categories of Telephone Service Requests

- Basic Telephone Service
  - Local and Distance
- Enhanced Information Services
  - High-Speed Internet Access
  - Voice Over Internet Protocol (VOIP)
  - Internet Protocol Television (IPTV)
  - Desk Top Video
  - Smart Homes
- Information about Billing
- Telephone Maintenance and Repair
- Request for Small Business Consulting.

Mobile Telephony: Design Characteristics

A mobile telephone system is designed to service customers within a specified geographical area, known as a cellular geographic service area (CGSA). The CGSA generally corresponds to a metropolitan area, including a central city, its suburbs and some portion of its rural fringe. The CGSA can also encompass two or more cities located relatively close together. Cellular systems are designed to interface with the public switched telephone network, thereby enabling the user to make both local and long-distance telephone calls.

A cellular telephone system consists of four major parts. They include:

1 Cell site
2 Base station (BS)
3 Mobile telephone switching office (MTSO)
4 Cellular telephone.

Cell Site

The cellular geographic service area is designed as an interlocking grid of cell sites (or coverage areas). The CGSA is often visually depicted as a series of hexagonal zones or circles. Each cell has its own base station and a dedicated set of over-the-air frequencies. Areas of coverage overlap at the outer boundaries. (See Figure 8.1.)

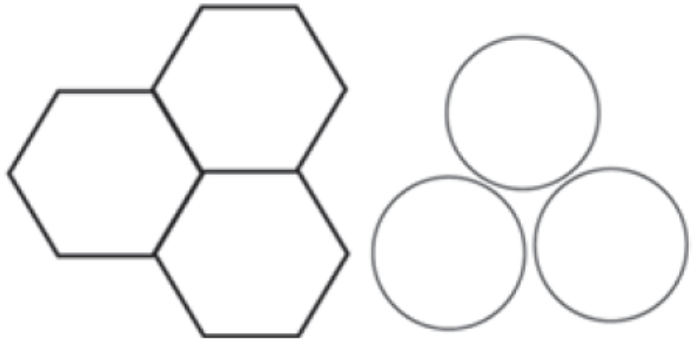

Figure 8.1 Cell Site Coverage Areas

In reality, cell sites are seldom perfect hexagons or circles. There are obvious gaps between and among cell sites. The cell size depends on population density (including expected number of users), physical terrain and traffic. Cell sites will vary in size, ranging from 500 ft (major urban centers) in what are called microcells, to 5–8 miles (suburbs and rural fringe areas). In contrast, highly rural areas can have cell sizes closer to 15–20 miles due to the lack of population density.

The Principle of Frequency Reuse

Cellular telephone systems are organized into cell clusters. A cluster is a group of cells, the clusters are then repeated over and over again to form the entire CGSA. The number of cell clusters will vary according to the system design. Cell site cluster configurations are typically

designed in one of four variations, including four, seven, ten and twenty-one cells. Figure 8.3. provides an illustration of a seven-cell cluster configuration.

Cellular telephony operates on the principle of frequency reuse in nonadjacent cells: that is, users can operate on the same set of frequencies in nonadjacent cells without causing interference. Each of the seven numeric cells is assigned a bloc of frequencies that can only be used within that designated cell. The beauty of cellular telephony is the ability to reuse the same set of frequencies over and over again (in nonadjacent cells), thus optimizing spectrum efficiency and avoiding co-channel interference.[6] Cellular telephone capacity is measured in the number of calls per cell site.

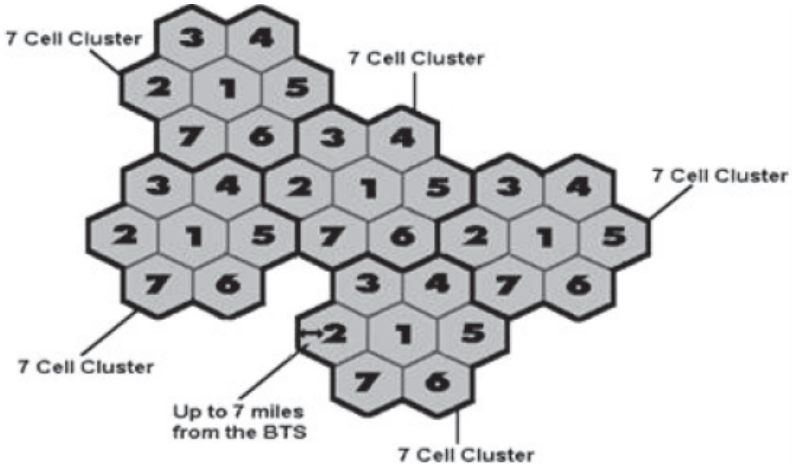

Figure 8.3 Seven-Cell Cluster Configuration (illustration by Chan, Chin Bong)

Base Station (BS)

Each cell has its own low-power transmitter. The low-power transmitter is part of a base station (BS), which is located towards the corner (or contiguous points) of each cell. The transmitters in a cellular system are tailored to the size and shape of the cell.[7] The height of the transmitting antenna depends on the topology of the area it covers. They are low in power so that their signal does not spill over to an adjacent cell. This, in turn, allows for greater efficiency by dynamically allocating the same set of frequencies for reuse in nonadjacent cell sites.[8] (See Figure 8.5.)

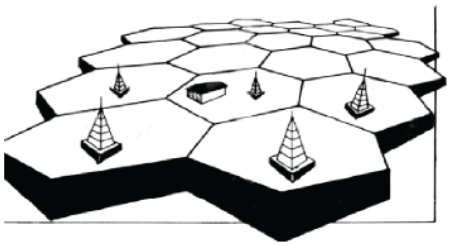

Figure 8.5 Cellular Telephone Base Tower and Transmitter

Locating and Handing Off

As a car (or moving vehicle) passes from one cell to another, the system must be able to determine the location of the moving vehicle and automatically switch to an available frequency as it enters the new cell. The changeover must be smooth and without disruption to the telephone call. In order to accomplish this, the BS monitors the calls in progress and can sense the signal strength of the mobile units in their own areas (and in the overlap areas of adjoining cells). The results are sent on to the MTSO, which determines when the telephone call should be handed off upon entering a new cell site. The control data communicates to the mobile unit the new frequency assignment. The mobile unit automatically switches frequencies and the call continues. The handoff should be fast with no detectable interruption.[9] (See Figure 8.7.)

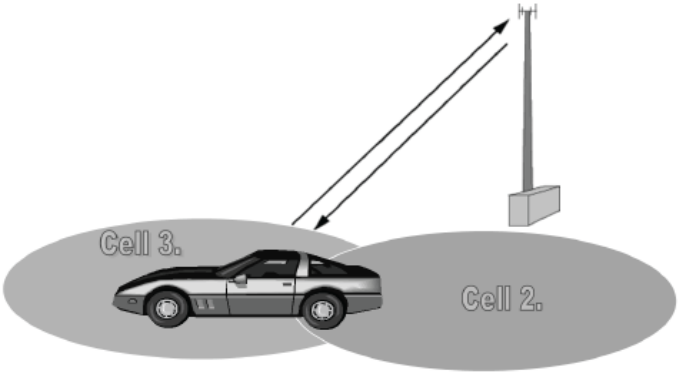

Figure 8.7 Frequency Channel Handoff
Source: Richard A. Gershon, Western Michigan University.

Digital Phones

Digital mobile phones use the same radio technology as analog phones, but they use it in a different way. Digital communication offers several important advantages when compared to analog communication, including: (1) better quality, less noise, (2) more efficient use of bandwidth, (3) better throughput and speed, (4) increased capacity and security, and (5) convergence and multimedia displays. The latter point becomes especially important when it comes to smart phones and providing enhanced services features, such as caller I.D., text messaging, high-speed Internet access, video streaming, GPS and MP3 music downloading and playback. A second consideration has to do with available bandwidth.

As more and more consumers utilize smart phone features, the issue of bandwidth becomes a major consideration. Digital cellular can accommodate more users per cell site than was true with the traditional analog systems. Digital cellular converts the user's voice (and specialized applications) into binary format and then compresses it. This compression allows between three and ten digital cellphone calls to occupy the space of a single analog call.[11]

Smart Phones

During the past five years, many industry watchers and device-makers have coined the term *smart phone* as a way to describe a new generation of cellular telephones that is highly personalized and features a variety of enhanced information services. The real introduction into smart phone design began in 2006 with the introduction of the Apple iPhone. Since then, there have been multiple iterations of the Apple iPhone. The iPhone is a multimedia Internet-enabled mobile phone that uses a multi-touch screen with a virtual keyboard and buttons. The iPhone emphasizes the personal aspect of wireless technology by advancing a number of enhanced feature elements, including:

1 Email
2 Personal planner
3 Text messaging
4 Camera and video camera
5 Internet access
6 MP3 music player
7 Photo storage
8 GPS locator.

Today's smart phones have built-in functionality that is programmable.

The iPhone is managed and synced by the Apple iTunes media software store. iTunes serves as the basic platform for downloading music, photos and other software applications onto the mobile device unit. Since the introduction of the Apple iPhone, other companies have introduced alternative versions to the iPhone's basic design. Companies like Samsung, Verizon and others have introduced their own version of smart phone design. Unlike Apple's IOS proprietary operating software, most other companies have adopted the Android "open source" operating software developed by Google.