Topic 9 Notes

9.1 Introduction

VoIP, or **Voice over Internet Protocol**, is a method for taking analog audio signals, like the kind you hear when you talk on the phone, and turning them into digital data that can be transmitted over the Internet. VoIP can turn a standard Internet connection into a way to place **free phone calls**. The practical upshot of this is that by using some of the free VoIP software that is available to make Internet phone calls, you're bypassing the phone company (and its charges) entirely.

VoIP is a revolutionary technology that has the potential to completely rework the world's phone systems. Major carriers like AT&T are already setting up VoIP calling plans in several markets around the United States, and the FCC is looking seriously at the potential ramifications of VoIP service.

There are three different "flavors" of VoIP service in common use today:

i. **ATA** -- The simplest and most common way is through the use of a device called an ATA (analog telephone adaptor). The ATA allows you to connect a standard phone to your computer or your Internet connection for use with VoIP. The ATA is an analog-todigital converter. It takes the analog signal from your traditional phone and converts it into digital data for transmission over the Internet. Providers like Vonage and AT&T CallVantage are bundling ATAs free with their service. You simply crack the ATA out of the box, plug the cable from your phone that would normally go in the wall socket into the ATA, and you're ready to make VoIP calls. Some ATAs may ship with additional software that is loaded onto the host computer to configure it; but in any case, it's a very straightforward setup.

ii. **IP Phones** -- These specialized phones look just like normal phones with a handset, cradle and buttons. But instead of having the standard RJ-11 phone connectors, IP phones have an RJ-45 Ethernet connector. IP phones connect directly to your router and have all the hardware and software necessary right onboard to handle the IP call. Wi-Fi phones allow subscribing callers to make VoIP calls from any Wi-Fi hot spot.

iii. **Computer-to-computer** -- This is certainly the easiest way to use VoIP. You don't even have to pay for long-distance calls. There are several companies offering free or very low-cost software that you can use for this type of VoIP. All you need is the software, a microphone, speakers, a sound card and an Internet connection, preferably a fast one like you would get through a cable or DSL modem. Except for your normal monthly ISP fee, there is usually no charge for computer-to-computer calls, no matter the distance.

9.2 Using VoIP

Phone companies use VoIP to streamline their networks. By routing thousands of phone calls through a circuit switch and into an IP gateway, they can seriously reduce the bandwidth they're using for the long haul. Once the call is received by a gateway on the other side of the call, it's decompressed, reassembled and routed to a local circuit switch.

Although it will take some time, you can be sure that eventually all of the current circuit switched networks will be replaced with **packet-switching technology** (more on packet switching and circuit switching later). IP telephony just makes sense, in terms of both economics and infrastructure requirements. More and more businesses are installing VoIP systems, and the technology will continue to grow in popularity as it makes its way into our homes. Perhaps the biggest draws to VoIP for the home users that are making the switch are **price** and **flexibility**.

With VoIP, you can make a call from anywhere you have broadband connectivity. Since the IP phones or ATAs broadcast their info over the Internet, they can be administered by the provider

anywhere there's a connection. So business travelers can take their phones or ATAs with them on trips and always have access to their home phone. Another alternative is the **softphone**. A softphone is client software that loads the VoIP service onto your desktop or laptop. The Vonage softphone has an interface on your screen that looks like a traditional telephone. As long as you have a headset/microphone, you can place calls from your laptop anywhere in the broadband connected world.

Most VoIP companies provide the features that normal phone companies charge extra for when they are added to your service plan. VoIP includes:

i. Caller ID
ii. Call waiting
iii. Call transfer
iv. Repeat dial
v. Return call
vi. Three-way calling

There are also advanced call-filtering options available from some carriers. These features use caller ID information to allow you make a choice about how calls from a particular number are handled. You can:

i. Forward the call to a particular number
ii. Send the call directly to voice mail
iii. Give the caller a busy signal
iv. Play a "not-in-service" message
v. Send the caller to a funny rejection hotline

With many VoIP services, you can also check voice mail via the Web or attach messages to an email that is sent to your computer or handheld. Not all VoIP services offer all of the features above. Prices and services vary, so if you're interested, it's best to do a little shopping.

9.3 Circuit Switching

Existing phone systems are driven by a very reliable but somewhat inefficient method for connecting calls called circuit switching. Circuit switching is a very basic concept that has been used by telephone networks for more than 100 years. When a call is made between two parties, the connection is maintained for the duration of the call. Because you're connecting two points in both directions, the connection is called a **circuit**. This is the foundation of the **Public Switched Telephone Network** (PSTN).

Here's how a typical telephone call works:

1. You pick up the receiver and listen for a dial tone. This lets you know that you have a connection to the local office of your telephone carrier.
2. You dial the number of the party you wish to talk to.
3. The call is routed through the switch at your local carrier to the party you are calling.
4. A connection is made between your telephone and the other party's line using several interconnected switches along the way.
5. The phone at the other end rings, and someone answers the call.
6. The connection opens the circuit.
7. You talk for a period of time and then hang up the receiver.
8. When you hang up, the circuit is closed, freeing your line and all the lines in between.

Let's say you talk for 10 minutes. During this time, the circuit is continuously open between the two phones. In the early phone system, up until 1960 or so, every call had to have a dedicated wire stretching from one end of the call to the other for the duration of the call. So if you were in New York and you wanted to call Los Angeles, the switches between New York and Los Angeles would connect pieces of copper wire all the way across the United States. You would use all those pieces of wire just for your call for the full 10 minutes. You paid a lot for the call, because you actually owned a 3,000-mile-long copper wire for 10 minutes.

Telephone conversations over today's traditional phone network are somewhat more efficient and they cost a lot less. Your voice is **digitized**, and your voice along with thousands of others can be combined onto a single fiber optic cable for much of the journey (there's still a dedicated piece of copper wire going into your house, though). These calls are transmitted at a fixed rate of 64 kilobits per second (Kbps) in each direction, for a total transmission rate of 128 Kbps. Since there are 8 kilobits (Kb) in a kilobyte (KB), this translates to a transmission of 16 KB each second the circuit is open, and 960 KB every minute it's open. In a 10-minute conversation, the total transmission is 9,600 KB, which is roughly equal to 10 megabytes (check out How Bits and Bytes Work to learn about these conversions). If you look at a typical phone conversation, much of this transmitted data is wasted.

9.4 Packet Switching

A packet-switched phone network is the alternative to circuit switching. It works like this: While you're talking, the other party is listening, which means that only half of the connection is in use at any given time. Based on that, we can surmise that we could cut the file in half, down to about 4.7 MB, for efficiency. Plus, a significant amount of the time in most conversations is dead air -- for seconds at a time, neither party is talking. If we could remove these silent intervals, the file would be even smaller. Then, instead of sending a continuous stream of bytes (both silent and noisy), what if we sent just the packets of noisy bytes when you created them?

Data networks do not use circuit switching. Your Internet connection would be a lot slower if it maintained a constant connection to the Web page you were viewing at any given time. Instead, data networks simply send and retrieve data as you need it. And, instead of routing the data over a dedicated line, the data packets flow through a chaotic network along thousands of possible paths. This is called **packet switching**.

While circuit switching keeps the connection open and constant, packet switching opens a brief connection -- just long enough to send a small chunk of data, called a packet, from one system to another. It works like this:

i. The sending computer chops data into small packets, with an address on each one telling the network devices where to send them.
ii. Inside of each packet is a **payload**. The payload is a piece of the e-mail, a music file or whatever type of file is being transmitted inside the packet.
iii. The sending computer sends the packet to a nearby **router** and forgets about it. The nearby router send the packet to another router that is closer to the recipient computer. That router sends the packet along to another, even closer router, and so on.
iv. When the receiving computer finally gets the packets (which may have all taken completely different paths to get there), it uses instructions contained within the packets to reassemble the data into its original state.

Packet switching is very efficient. It lets the network route the packets along the least congested and cheapest lines. It also frees up the two computers communicating with each other so that they can accept information from other computers, as well.

9.5 Advantages of Using VoIP

VoIP technology uses the Internet's packet-switching capabilities to provide phone service. VoIP has several advantages over circuit switching. For example, packet switching allows several telephone calls to occupy the amount of space occupied by only one in a circuit-switched network. Using PSTN, that 10-minute phone call we talked about earlier consumed 10 full minutes of transmission time at a cost of 128 Kbps. With VoIP, that same call may have occupied only 3.5 minutes of transmission time at a cost of 64 Kbps, leaving another 64 Kbps free for that 3.5 minutes, plus an additional 128 Kbps for the remaining 6.5 minutes. Based on this simple estimate, another three or four calls could easily fit into the space used by a single call under the conventional system. And this example doesn't even factor in the use of data compression, which further reduces the size of each call.

Let's say that you and your friend both have service through a VoIP provider. You both have your analog phones hooked up to the service-provided ATAs. Let's take another look at that typical telephone call, but this time using VoIP over a packet-switched network:

i. You pick up the receiver, which sends a signal to the ATA.

ii. The ATA receives the signal and sends a dial tone. This lets you know that you have a connection to the Internet.

iii. You dial the phone number of the party you wish to talk to. The tones are converted by the ATA into digital data and temporarily stored.

iv. The phone number data is sent in the form of a request to your VoIP company's **call processor**. The call processor checks it to ensure that it's in a valid format.

v. The call processor determines to whom to map the phone number. In **mapping**, the phone number is translated to an IP address (more on this later). The **soft switch** connects the two devices on either end of the call. On the other end, a signal is sent to your friend's ATA, telling it to ask the connected phone to ring.

Once your friend picks up the phone, a session is established between your computer and your friend's computer. This means that each system knows to expect packets of data from the other system. In the middle, the normal Internet infrastructure handles the call as if it were e-mail or a Web page. Each system must use the same protocol to communicate. The systems implement two channels, one for each direction, as part of the session.

You talk for a period of time. During the conversation, your system and your friend's system transmit packets back and forth when there is data to be sent. The ATAs at each end translate these packets as they are received and convert them to the analog audio signal that you hear. Your ATA also keeps the circuit open between itself and your analog phone while it forwards packets to and from the IP host at the other end.

You finish talking and hang up the receiver. When you hang up, the circuit is closed between your phone and the ATA. The ATA sends a signal to the soft switch connecting the call, terminating the session.

9.6 Disadvantages of Using VoIP

The current Public Switched Telephone Network is a robust and fairly bulletproof system for delivering phone calls. Phones just work, and we've all come to depend on that. On the other hand, computers, e-mail and other related devices are still kind of flaky. Let's face it -- few people really panic when their e-mail goes down for 30 minutes. It's expected from time to time. On the other hand, a half hour of no dial tone can easily send people into a panic. So what the PSTN may lack in efficiency it more than makes up for in reliability. But the network that makes up the Internet is far more complex and therefore functions within a far greater margin of error. What this all adds up to is one of the major flaws in VoIP: **reliability**.

i. First of all, **VoIP is dependant on wall power**. Your current phone runs on phantom power that is provided over the line from the central office. Even if your power goes out, your phone (unless it is a cordless) still works. With VoIP, no power means no phone. A stable power source must be created for VoIP.
ii. Another consideration is that many **other systems in your home may be integrated into the phone line**. Digital video recorders, digital subscription TV services and home security systems all use a standard phone line to do their thing. There's currently no way to integrate these products with VoIP. The related industries are going to have to get together to make this work.
iii. **Emergency 911 calls** also become a challenge with VoIP. As stated before, VoIP uses IP-addressed phone numbers, not NANP phone numbers. There's no way to associate a geographic location with an IP address. So if the caller can't tell the 911 operator where he is located, then there's no way to know which call center to route the emergency call to and which EMS should respond. To fix this, perhaps geographical information could somehow be integrated into the packets.
iv. Because VoIP uses an Internet connection, it's susceptible to all the **hiccups normally associated with home broadband services**. All of these factors affect call quality: latency, jitter and packet loss. Phone conversations can become distorted, garbled or lost because of transmission errors. Some kind of stability in Internet data transfer needs to be guaranteed before VoIP could truly replace traditional phones
v. VoIP is susceptible to worms, viruses and hacking, although this is very rare and VoIP developers are working on VoIP encryption to counter this.
vi. Another issue associated with VoIP is having a phone system dependant on individual PCs of varying specifications and power. A call can be affected by **processor drain**. Let's say you are chatting away on your softphone, and you decide to open a program that saps your processor. Quality loss will become immediately evident. In a worst case scenario, your system could crash in the middle of an important call. In VoIP, all phone calls are subject to the limitations of normal computer issues.

Revision questions

1. How is communication effected through VoIP technology?
2. What is the relationship between VoIP and switching techniques?
3. Explain the services offered through VoIP
4. What are the benefits derived from using VoIP