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THE COMPUTER CORNER

MODEMS

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Modems are pretty much standard equipment on today's computers. They are amazing devices. Computers, of course, are digital devices and understand only zeros and ones. When they send digital data to your modem for subsequent transmission over the phone lines, the modem converts the digital data to analog tones, much like the conversion done by a sound card when you play music recorded digitally on a CD. After conversion is complete, the tones are sent out over the phone line, received at the other end by another modem, and converted back to digital data so the receiving computer can understand the data. The process of converting digital data to analog by the modem at your end is called *modulation*, and the process of converting it back to digital stuff at the other end is called *demodulation*. Hence the name MODEM for the device: MOdulateDEModulate.

When two modems first connect with each other over the phone lines, it is a little bit like two people from different countries trying to establish communications. A Frenchman might say "Parlez vous Francais?" and the other person might reply "Nein, Ich sprechen das Deutsch". Then the Frenchman says "I can also speak English; can you speak it?" The German then replies "Yes, I can speak and understand English". The two humans have been negotiating the rules of communication between them. When modems do this it is called "handshaking", or "training". When modems handshake, they are deciding on several different issues:

1. How fast to transmit and receive data between each other.
2. What protocols to use, including:
   a. How to handle data compression
   b. How to handle error checking.
3. What signaling method to use to pass the data between each other (flow control).

That's a lot to agree on! But they generally agree on everything in just a couple of seconds. You can hear them start negotiating these different items when your modem first connects with the remote modem, but the handshaking continues for a few seconds even after your speaker turns off.

SPEED: The first item, speed, is something most of us care about dearly. Today's modems are rated in bits per second (BPS), and higher is better. Most modems you purchase today are rated at 56.6 KBPS, the current theoretical upper limit for data transmission over ordinary phone lines. However, you will not quite achieve that rate of data transfer. Why? For several reasons, which are grounded in the basic fact that everything going over your phone line, including your voice during a standard telephone call, is fake!

When you talk into the phone with a friend, the person at the other end is not hearing your voice. "Of course", you say, "they are hearing the analog squiggly sine wave reproduction that the speaker element in my phone makes". Nope. They are hearing a signal that has been converted from analog to digital and back at least a couple of times.

Just the way a sound card can change music from your tape recorder to digital data for storage on your hard drive and later playback, the phone company changes your beautiful analog voice tones into digital data, somewhere along the line. Then it transmits the digital data over the long haul distance to somewhere near your friend's house. Then it is converted back into an analog signal and sent to your friend's phone. This conversion from analog to digital may even occur several times, depending on the particular path your signal takes, and it can occur even if your friend lives next door. All this conversion takes time, and reduces the effective communication rate even more. But now lets see the numbers.

When the phone company changes your analog voice to digital, they use a sampling rate of 64 KBPS (64,000 kilobits per second). Take off a few thousand bits per second for overhead - a

conversion or two or three. Also take off some bits for noisy lines (moisture, storms), which are not uncommon. Also take off some time for multiplexing – the sharing of several logical phone connections on a single physical twisted pair. All of these factors eat up time, so it is easy to drop down to the 56.6 KBPS rating of your modem. The upshot is, using today's technology, a 56.6 KBPS modem will let you send and receive stuff at an upper limit of just about 53 KBPS under ideal conditions when ordinary phone lines are used. The latest standard, V.90, may bump the rate up a little bit when one end is using a digital connection, as is probably the case with your Internet provider. The digital end feeds digital data directly to the phone companies lines, so it doesn't need to be converted first.

Now let us see what the other handshaking protocols do. The most widely used protocol today is CCITT (or ITU) V.42bis, which sets standards for both data compression and error correction. We'll consider them separately.

Data compression is good because it reduces the size of what is being transmitted. Your modem compresses chunks data into packets using an algorithm very much like PKZIP. Textual material may be compressed as much as 4:1 – a 100-byte chunk reduces to only 25 bytes. That means that 75 bytes don't need to be transmitted over the phone lines. At the other end, since the receiving modem has already agreed to use V.42bis also, it simply decompresses the file using the same algorithm, and the 75 bytes are restored.

Error correction is another neat feature that insures virtually 100% accuracy of the data being transmitted. Your modem breaks up the data into packets known as frames and calculates a checksum for the frame. A checksum is just a summary calculation that is based on the data in that frame, for example adding up a simple numerical total of all the binary values in the frame. When the modem at the other end receives the frame, it goes through exactly the same calculation, then compares it's results with the results your modem sent. If they are exactly the same, it knows the data was accurately transmitted. If there are differences in the two checksums, the receiving modem asks for the frame to be sent again. Sound familiar at all? You bet! We use the same type of technology in our TNCs for packet radio.

Flow control is a way for the two modems and their computers to start and stop the flow of data in case the receiving end is not ready for more. Most setups today use **hardware flow control**. When a receiving modem gets a message from its PC to wait a little bit so it can catch up with stuff; the modem just deactivates the line between it and the sending modem. That forces the sending modem to wait, which it dutifully does until the line is reactivated. The older, **software flow control** was used back when mostly ASCII was sent between computers. It doesn't work so well with today's data and today's speeds.

Other stuff. The two modems also have to decide on a few more things. Back when modem to modem communication was in pure ASCII format, all the characters in use could be represented by only 7 bits, and the 8^{th} was used for parity checking – an older method to detect errors. . Now that we send more than just ASCII characters, 8 bits is the standard and we leave error correction up to the modem as described above. One last item. When a modem is going to send a character out, it first sends a single bit that tells the receiving modem that a character is starting. Modems also usually send a single stop bit, which signals that the character is complete. The two modems need to agree on all this stuff, too, before they actually begin the sending/receiving process.

So there you have it. Those two modems are really talking fast at the beginning of a connection, to decide on all these parameters between them. Think about that next time you dial up your Internet connection for an evening of web surfing! Happy computing.