ISDN

The New Legal Limit

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ABSTRACT

Amateur radio operators have always embraced new technology, and in many cases, have been the developers. The new frontier today is the World Wide Web which is affecting the way we communicate and get information. A limitation to the information superhighway is the connection speed. This article describes the Integrated Services Data Network (ISDN), an all digital connection to the Public Switched Telephone Network (PSTN). The paper focuses on ISDN connections to the Internet which provide significantly improved connection speeds over standard analog modems. Included are the author's experiences with special attention given to the costs that one should consider. In addition, a discussion of hardware required, an overview of what ISDN is, and references are provided for further investigation.

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A SOLUTION WAITING FOR A PROBLEM

I suppose if you ask the QRP amateur radio operator why he uses low power, he will tell you it is the thrill and the challenge. Ask the ham running a "Texas Gallon" why he doesn't use low power, and he will tell you that life is too short to be wasted with hit and miss attempts at communication. However, if you ask them about connect speeds to the Internet, I doubt you will get disagreement; **the faster, the better!**

For most of the 1970s, 300 baud was the de-facto standard for those telecommuting, although the word *telecommuting* did not exist at the time. Advances in technology and a larger market fueled the jump to 1200 baud, and then to 2400, which at the time was considered the limit to telephone data rates. Before jumping to 9600 we had to shed the practice of interchangeably using the terms *baud* and *bit*, since 9600 bps, still uses a baud rate of 2400. The life expectancy of 9600 bps modems was short-lived, as almost overnight came the 14.4 Kbps modems. Additional standards were developed and again the speed limit was pushed to the present 28.8 Kbps standard. There are some modems that push the envelop a little further at 33 Kbps and some claim faster rates, but that is *throughput* rate from compression schemes rather than real physical layer data rates.

For those wondering what the next step is, it is already here, it is called Integrated Services Data Network (ISDN). Like many other technologies, ISDN, has been around a long time, over a decade to be more precise. ISDN was a solution waiting for a problem. Without a doubt, the Internet, and more importantly, the World Wide Web with copious text and color graphics, has created the problem that ISDN was waiting to solve, albeit, not the problem that Ma Bell had envisioned solving so many years ago.

This article hopes to provide the ham radio operator with the real life experiences that I found in implementing ISDN. Secondly, I hope to provide numerous references for future exploration. And lastly, if nothing else, it is my hope to dispel much of the stigma and aura that has plagued widespread use of the technology. **ISDN is here now, and it works!**

28.8 KBPS, IT'S THE LAW

One might be tempted to trivialize the ISDN solution. After all, in a relatively short time, we have gone from 300 baud to 28.8 Kbps. Ingenuity and know how will provide 56 Kbps and even faster speeds very soon. Not so! Granted, we have developed new technologies that continue to amaze us, but they all obeyed the speed limit, the law. That law, or limit, is referred to as the **Shannon-Hartley Law** and is shown as:

$$C = B \log_2 (1 + S/N) \text{ bps}$$

C is the information rate in bps, B is the bandwidth of the line in Hz, S is the signal power in watts, and N is the random noise power in watts. If you assume the bandwidth of the PSTN (Public Switched Telephone Network) is 3 KHz, and a typical signal-to-noise ratio of 20 db, then C is 19.9 Kbps, slower than the present 28.8 Kbps standard. To get higher speeds you need either higher bandwidth, which is not a real option, or higher signal to noise ratios, also a difficult barrier to break. If you want to go faster, you need to leave the analog world and go 100% digital, which is exactly what ISDN does.

I STILL DON'T KNOW

The standard joke about what ISDN stands for unfortunately still persists, I Still Don't Know. But nothing could be further from the truth. I have been reading for many years about ISDN applications. The readings all too often include a few nightmare stories about experiences that the authors had while implementing ISDN. Most of the stories start with, "when I called the phone company and asked for ISDN service, they said, "What's that?" These stories prevented my further exploration until recently. Having made the decision to throw caution to the wind and try ISDN for myself, I was prepared to spend a morning and afternoon, if necessary, finding the right phone number and person to speak to. I was also

prepared to give a mini-lecture on the benefits of ISDN and the significance of the Shannon-Hartley law. In my case, and I think in most cases now, the widespread use of ISDN throughout the country makes getting service pretty easy. I was pleasantly surprised to find that Pacific Bell (my local telephone company) had a phone number set up specifically for ISDN orders with a staff of knowledgeable people.

Ordering the service went quickly. The operator spent a good deal of time explaining rates and installation charges, and possible changes in rates that were impending. About the only technical question was, "What type of router or terminal adapter was I going to use?"

Shortly after ordering the service, it was installed. No access to the home was required nor was additional wiring necessary. It is pretty incredible to think that ISDN can use plain old twisted pair wires to send 128 Kbps, the maximum ISDN rate. Since I was home at the time, the installer was good enough to make sure the connection was good right up to the wall socket, rather than just up to the side of the house. He did a quick BER (Bit Error Rate) test, gave me the new phone numbers for the service, the type of electronic switch at the local central office, (this information is referred to as the SPIDs), and I was ready to hit the information superhighway at the new legal limit.

TERMINAL ADAPTER

A terminal adapter (TA) is the name of the device that replaces your modem in ISDN implementations. As the name ISDN implies, it is digital ... all digital. There is no modulation or demodulation. The data is 100% digital from your computer, through the TA, to the local central office, throughout the vastness of the PSTN to its final destination (presumably another computer). The return path is also digital; at no point is there any modulation or demodulation. Realizing that much of the world is still analog however, manufacturers also make ISDN modems. These devices offer the best of both worlds. The ISDN modem can act as a 100% digital terminal adapter, and a traditional analog modem to provide the user the ability to connect to services that do not offer ISDN connections.

A TA can be either an external stand-alone unit or a card that fits inside your computer, just as your present modem can be external or internal. The external style has the advantage of allowing you to see the LEDs which provide useful troubleshooting information and a warm fuzzy feeling that all is working well. Figure 1 shows the present standard analog modem connection. The same system is shown in Figure 2 using a TA. Note that they are virtually identical.

The maximum allowable speed of your serial port needs to be considered when deciding between an internal and external TA. ISDN is fast, 128 Kbps to be exact. If your serial communications port cannot support these high speeds, your computer will be the bottleneck and you won't get the full advantage of ISDN. If you have a 486 or higher speed computer with a 16650 serial communications chip, you should have no trouble. On the other hand, an internal TA card bypasses the serial port which should obviate the concern over the limitations of the serial port.

ROUTERS

Most families own two cars, two televisions, and now two computers. For those with more than one computer, you must purchase an additional TA for each computer, just as you must purchase a separate analog modem for each computer. In addition, you must acquire additional phones lines for each modem assuming you wish to use the computers simultaneously. Clearly, this is not cost effective. The solution is a router.

A router is a more complex device and thus requires a little more work and knowledge to set up. When going the router route (no pun intended), it is first best to setup your computers on a local network. This requires additional hardware besides the router.

Figure 3 shows a block diagram of a network connected to the Internet via a router. The computers are connected on a network using ethernet Network Interface Cards (NIC) rather than a serial communication's port. The router then serves as the interface between the local network and the rest of

the Internet. Note also that in this arrangement, each of the computers can communicate with each other even when there is no connection to the Internet. This is not automatic, additional software, such as telnet and ftp daemons, must be installed to support this feature.

You will also have to get IP (Internet Protocol) addresses for each of the machines, most likely an additional expense that your local ISP (Internet Service Provider) will charge. If you have enough machines, you may even be given a small block of numbers to make a subnet requiring you to become a system administrator. It is a lot of work and requires a fair amount of expertise, but is a great way to learn about networks.

The router solution is significantly more expensive for several reasons. The router is $1,000 to $1,500, the network interface cards required to implement the network are an additional cost, and lastly, the ISP will charge more due to the additional IP addresses required. However, having said that, it is an excellent solution if you have the need.

SO WHAT IS ISDN?

I recently went to an amateur radio club meeting that discussed the GPS (Global Positioning System). After the meeting a fellow ham said, “GPS is simple”. From the user’s standpoint, it is true that GPS is simple, technically however, GPS uses very advanced technology. There are numerous erudite books written exclusively on the subject that discuss everything from the mathematics and physics used, the RF spectrum allocation, the spread spectrum spreading technique, the atomic clocks in the satellites, the ground control system, reliability and available factors, selective availability, encryption, security issues, the satellite constellation, and more. There is nothing simple about the GPS.

ISDN is also complex, but so is a television and we don’t think twice about using it. From the user level, there is not too much you need to know about it. ISDN consists of two B channels and one D channel. This 2B+D is called the Basic Rate Interface (BRI). Each B channel can carry information at 64 Kbps, giving a total throughput of 128 Kbps when the channels are strapped together. The D channel, when used, transmits data at up to 16 Kbps. It carries control and signaling information to set up and tear down the voice and data calls. When the D channel is used, the B channels revert to 56 Kbps to keep the total bandwidth to the 128 Kbps limit. It is interesting to note that when the B channels are used simultaneously for communication, if a call occurs, one of the B channels will be released to allow the call to be made. The speed drops in half during this period, but returns to the higher rate when both of the B channels are available. The significance of the separate “D” channel needs to be emphasized. The “D” channel handles the control of the call (e.g., call setup, call forwarding, call waiting, etc.) and provides enormous improvements in bandwidth available for voice since the control function need not ride along with the voice packets. ISDN is an out-of-band signaling system since the control function is separate from the voice channel. In analog systems, the signaling rides along with the voice, and is called an in-band signaling system.

There are three basic ISDN configurations. The “U” interface is the most common interface and uses a single pair of wires. An “S” (also sometimes called a “T”) configuration uses 2 pairs of wires. The third ISDN option is the Primary Rate Interface (PRI), referred to as a 23B+D or 30+D interface. The 23B+D is a standard T-1 line in the US and can carry 23 simultaneous calls. The 30B+D is a European standard, called E-1 and carries up to 30 calls. There are distance and data rate limitations to each of these which also differentiate the configurations.

From the user’s standpoint, ISDN is simple, but don’t let that fool you into thinking you can take the TA apart and see what makes it tick, although it would be an instructive, if not humbling, experience.

SIDE BENEFITS

It should be clear what the benefits of the faster connect speed are: no more long waits for megabyte files to download, and no more waiting for graphics to appear on the web. However, there are a few fringe benefits that come with ISDN that may not be so obvious.

First, some terminal adapters have two ports allocated for POTS (Plain Old Telephone Service) analog phones, answering and/or fax machines. This means when the TA is not being used, your single ISDN line can be used as two separate phone lines. Try to forget that it is a single twisted pair cable. Even though you may pay a slight premium for an ISDN line, you are essentially getting two phone lines with two separate phone numbers. This is a big plus since it may even save you money by allowing you to drop service of one line that you may presently use. Remember when you are surfing the net, when a phone call is made (inbound or outbound) one of the two channels is released for the voice channel. Your throughput drops from 128 Kbps to 64 Kbps (approx.), but that is still higher than the present 28.8 Kbps standard.

For those who are planing on using the single ISDN line exclusively for all telephone communication, remember that the TA or router requires conventional power. Therefore, in the event of a power outage you will lose use of your phones. Considering the high reliability of electric power and the fact that most hams are prepared for emergency communication, this may not be factor, but something to consider nevertheless.

Secondly, the speed at which connects and disconnects are made with the central office (CO) is very fast. When a normal analog modem makes a call, it picks up the phone, waits a few seconds for the dial tone, listens, and then uses tones to specify the phone number. The modem at the other end has to synchronize to the tones and many other magical things occur during the call setup (e.g., the quality of the phone line is checked). This is why, the observant user will notice that even when a 28.8 Kbps modem is used, the connect rate will vary slightly. For example, even though you may have a 28.8 Kbps modem, you will often see connect speeds of 26.4 Kbps or lower. When all of the handshaking is complete, 20 to 30 seconds have passed. Connections using ISDN take approximately 12 seconds. Some users report connections as quick as 3 seconds. The disconnect is also much faster, typically 3-4 seconds. For those who think the difference is only a few seconds, I would not argue. But I do find that the connect time has been reduced to a level that I find checking mail or running to the computer to do a quick search more palatable.

WHERE DO I SIGN UP

It would be a mistake to provide exact costs for an ISDN implementation without noting that costs vary widely across the country, and they are continuing to undergo changes. My personal example working with Pacific Bell Telephone may aid in giving the reader an idea as to what to expect, but use it only as a starting point.

Telephone costs:

- Monthly Service Fee $24.50
- Installation Fee $125.00 waved if 2 year contract is accepted
- New Line Fee $34.50 to install an additional line
- Usage $.01 per minute during business hours, free otherwise

ISP and hardware costs:

- ISP $30 to $50/month (varies greatly)
- TA $300-600

For me, the monthly fee is virtually the same as the normal analog phone line, so there was no increase in cost there. I accepted a 2 year contract so the installation fee was waved. Since I had been using a telephone line dedicated to an Internet connection already, there was no new line fee, I merely

switched the line from analog to ISDN. Therefore, **there was virtually no increase in cost for ISDN service**. In fact, there could be a decrease in cost if I used the single ISDN line to obtain two phone lines and drop service of the analog line. The only significant cost is the initial one-time cost of a TA and the recurring monthly premium that your service provider will charge for an ISDN line.

The web is the best place to get up-to-date information. There is a plethora of pages to choose from, but if you have time for only one, go to **http://www.icus.com/kegel/.** There you will find most of what you need to know, and numerous informative links. When you finally make the decision to break the speed limit, try to get the phone number of the ISDN department for your carrier and tell them you want a ISDN Basic Rate Interface. If you want to impress them, tell them you want the 2B+D "U" configuration to enable you to bypass Shannon-Hartley limitations.

CONCLUSION

The intent of this article was to provide the reader with a background to ISDN technology and further sources of information. A secondary goal was to de-mystify and dispel inaccurate tales of ISDN implementation today, versus that of a few years ago. Remember, while an ISDN TA is different than a standard 14.4 or 28.8 Kbps analog modem, the concept is the same.

You can never have enough computer memory, disk space, power, or speed. As these increase, so does the variety and demand of the applications. Multimedia, high fidelity audio, real-time video conferencing are only now possible due to leaps in computer power. But these are not yet in your home and ISDN is only a partial solution. To get connect speeds higher than BRI ISDN can offer, there are not too many options. If you stick with the phone company, the next step is a PRI ISDN, a T1 line (1.544 Mbps) with a price tag to match. More reasonable and hopeful, in the near future at least, is the use of cable modems. The idea is that the local cable company will provide service using the existing high bandwidth CATV infrastructure. Cable modems are now enjoying some use in Canada. Only time will tell if this is the real answer to increased speed and the ultimate goal of having the information superhighway running through your living room. I dare not venture any further guesses. I think we all will agree these are exciting times and the future will no doubt continue to amaze us, and more often than not, prove us wrong in our prognostications.

REFERENCES

1. Angell, David, *"The Ins and Outs Of ISDN,"* Internet World, March 1996, pp. 78-82.
2. Savetz, Kevin M., "*My ISDN Experience*," Internet World, March 1996, pp. 84-85.
3. Key ISDN Web page URLs for information on ISDN products, ISPs, and Telcos. If your time is limited, visit the first one.
   `http://www.icus.com/kegel/`

   `http://www.pacbell.com/products/business/fastrak/networking/isdn/home-isdn/index.html`

   `http://www.alpha-tele.com/`

   `http://www.halcyon.com/tcs/`

   `http://isdntek.com/`

   `http://www.psi.net/`

   `http://www.cisco.com/`

   `http://www.mot.com/MIMS/ISG`

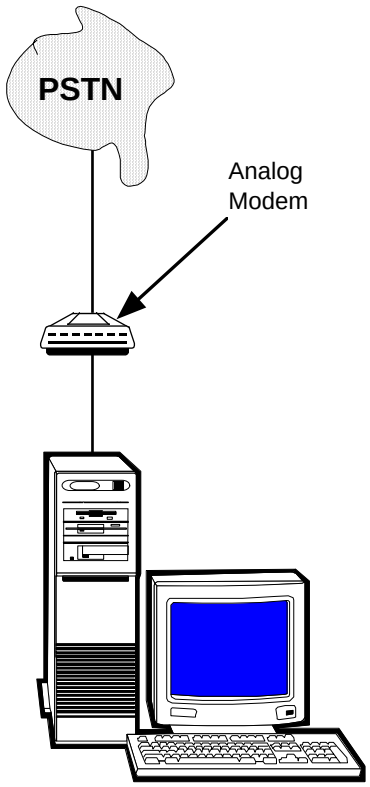

FIGURE 1

Here we see the traditional connection to the telephone company central office. A standard analog modem provides the interface to change digital signals to audio signals.

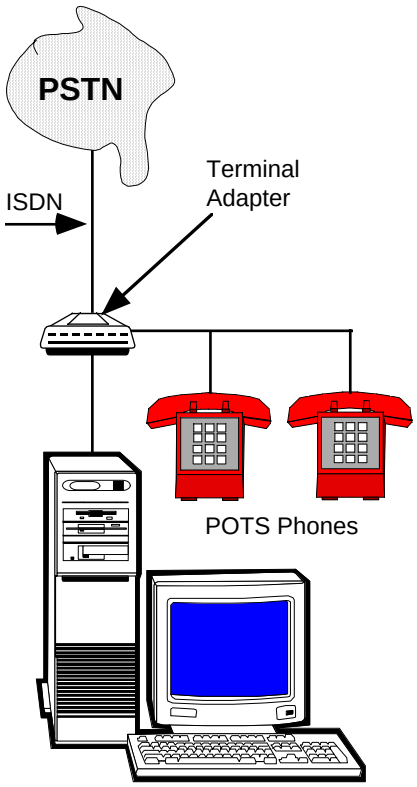

FIGURE 2

In this configuration the terminal adapter (TA) takes the place of the modem and very little else changes except the connect speed jumps to 128 Kbps. Terminal adapters, and some routers provide the ability to connect additional POTS phones.

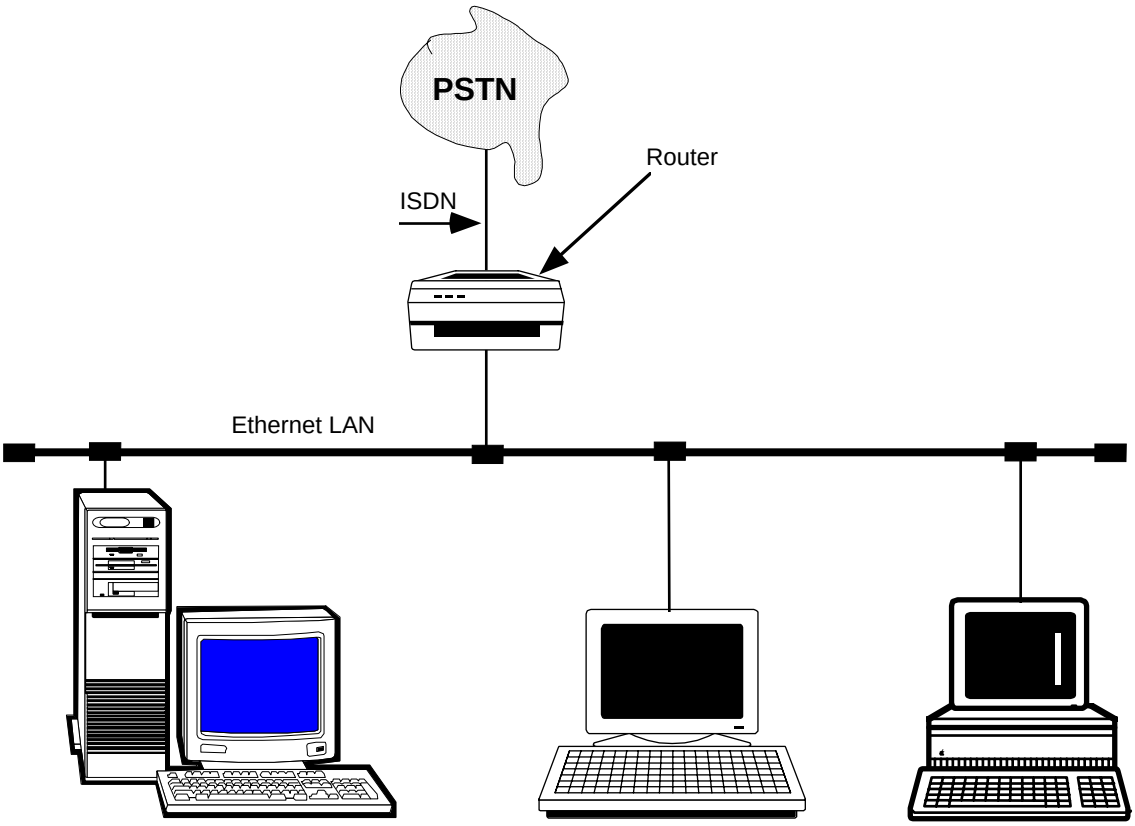

FIGURE 3

A router provides the interface between a small network of computers. This last solution, albeit a good solution for connecting multiple computers, requires significant additional costs and system administration expertise.