

ISDN

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ABSTRACT: Described here are the basics of ISDN, including much practical information for the consumer, as well as some fairly technical descriptions of ISDN, and finally some discussion on where ISDN is going in the future.

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ISDN Overview

Motivation and History

A long time ago, the entire telephone network was analog. This was bad, because as a voice went farther down the line, and through more switches, the quality became worse and worse as noise crept in. And there was no way to eliminate the noise, no way to know what the signal was supposed to be. Digital encoding promised a way to encode the audio such that you'd know what the signal was supposed to be. As noise crept in, you could eliminate it through the phone network, assuming it wasn't worse than the variation between different digital encoding levels.

With the transistor revolution, this theory became possible, and the phone companies began converting their own networks over to digital. Today, you have to search pretty hard to find a phone company switch that isn't digital. They call their network the Integrated Digital Network, or IDN.

This solved many of the phone company's problems. However for a variety of reasons, it has been attractive to make the phone network completely digital, from end to end. For computer users, this is ideal, because we can eliminate those clumsy modems, and will hopefully benefit from higher speed. For the phone companies, they can eliminate the last of the noise and loss from the audio data. And for dreamers, this will enable a wide variety of different services to be delivered to the customer over a single interface.

What is ISDN?

ISDN stands for Integrated Services Digital Network. It is a design for a completely digital telephone/telecommunications network. It is designed to carry voice, data, images, video, everything you could ever need. It is also designed to provide a single interface (in terms of both hardware and communication protocols) for hooking up your phone, your fax machine, your computer, your videophone, your video-on-demand system (someday), and your microwave. ISDN is about what the future phone network, and information superhighway, will look like (or would have looked like).

ISDN was *originally* envisioned as a very fast service, but this was a long time ago when it was hoped to have fiber all the way to your house. It turned out that running all that fiber would be too expensive, so they designed ISDN to run on the copper wiring that you already have. Unfortunately, that slowed things down considerably - too slow for quality video, for instance.

ISDN has been very slow in coming. The standards organizations have taken their time in coming up with the standards. In fact, many people consider them to be out of date already. But on the other side of the coin, the phone companies (especially in the U.S.) have been very slow at designing products and services, or marketing them with ISDN in mind.

Things are starting to pick up, but still very slowly. ISDN is available now in many places, but it is not widely used. Further most of the products and services that people have forecast for ISDN still aren't available. For this reason many people say that ISDN also stands for "It Still Does Nothing".

B-ISDN

That brings us to B-ISDN. B-ISDN is Broadband ISDN. (The older ISDN is often called Narrowband ISDN.) This is *not* simply faster ISDN, or ISDN with the copper to your home finally upgraded to fiber. B-ISDN is a *complete* redesign. It is still capable of providing all the integrated services (voice, data, video, etc.) through a single interface just like ISDN was supposed to. But it will do it a lot faster than ISDN could. Of course, that copper to your house will still have to be replaced with fiber. But B-ISDN is still in development - it seems to be moving faster than ISDN, but it is still quite a ways off.

Fitting things together

In order to understand what ISDN is, you have to understand a bit about modern telephony. You'll invariably find lots of buzzwords, or in most cases buzz-acronyms, that seem to overlap in a terribly complex way. That's because they do overlap considerably. Nevertheless you can generalize about how certain things fit together. Hopefully I can sum it all up in a few almost correct categories.

There are two parts of a telephone network: the phone company's part, and the customer's part. The customer's part today is largely just the telephone, some house wiring, and some connectors. The phone company's part is lots more wire, fiber, switches, computers, and lots of expensive and complicated stuff.

ISDN is concerned (almost) entirely with the customer's part of the network. ISDN gets the data from you, to the phone company in a standard way. What they do with it in order to get it to its destination is entirely up to them. This is a very simple, important concept. If you understand this, then when someone says something like "[SONET](#) is the future of the modern telephone network" you'll know that they're talking (mostly) about what goes on inside the phone company, and between phone companies. They are probably right, but it is also true that "ISDN is the future of the modern telephone network" especially if you mean B-ISDN. They're just the future of different parts of the telephone network.

ISDN: The Big Picture

Let me say at this point, that B-ISDN is not ATM, nor vice-versa. ATM is Asynchronous Transfer Mode. It is a very important part of B-ISDN, arguably the most important part. But it is just one part. (Also note that ATM was not used at all in original ISDN.)

Some people refer to older ISDN as Narrowband ISDN, which is what I will do. This is sometimes abbreviated as N-ISDN, however National ISDN is also sometimes abbreviated this way and I'd rather avoid the confusion.

So to reiterate, ISDN and B-ISDN are concerned with what goes on inside of your house, and to some extent, what goes on between your house and the phone company. It defines the physical network in your house, what kind of wires can be used, what the phone jacks look like, how fast the data network is, how the phones or other phone devices communicate with each other, and how they communicate with the phone company. Again, to confuse things, ISDN defines how your phone communicates with your neighbors phone and with telephones around the world, but this only covers things like my phone telling your phone who I am. How this ISDN data gets from me to you is again, the phone company's problem,

and not defined by ISDN.

So many buzzwords, so little time

So what are all these other buzzwords? Well first, let me differentiate between *service* and *technology*. A *service* is something that is supplied to a customer. It has to carefully define things (like data rates, data encapsulation, etc.) in a standard way, so the customer can deal with it consistently.

A *technology* on the other hand is a way of getting a service to the customer. It defines hardware issues like encoding, and physical medium. Fiber optics is a technology (or collection of technologies) that the phone companies use to carry many of their services between customers (all or part of the way).

Now the really confusing part is that many of these standards define something as both a technology and a service. I'll try to explain this more after we've plowed through some buzzwords.

ATM is a really tough one. Similar in many ways to Frame Relay, it is also the core of B-ISDN. It is the fastest of all these services/technologies. In some sense, the promise of ATM is to eliminate all the confusion, in the long run. ATM may one day be the unified way in which data will get shipped everywhere, from the B-ISDN in your home, through the phone company networks, and out the other side.

Now the hard part to understand is that Frame Relay (for instance) is both a technology and a service. A customer might want to get a Frame Relay network set up with the phone company. In this sense, it is a service, and something that might compete with ISDN. But on the other hand, the phone company might choose to use Frame Relay on some internal part of their own network. The ISDN service you get from the phone company might at some point run on top of (or through) a Frame Relay network.

In this same way, SMDS can carry Frame Relay, or ATM, or X.25, or ISDN. ISDN can carry X.25. SONET can carry Frame Relay. And so on, and so on.

That brings us back to ISDN. How does all this really fit together with ISDN? X.25, Frame Relay, and SMDS all provide services to the customer. But they are not **integrated** services. Each one is different, suited to slightly different data networking solutions. But none of them is designed as a replacement for the telephone network. ISDN defines a replacement for the modern telephone, and house wiring, and FAX machines, and modems, and more. It won't necessarily replace these other services - if anything it might make access to them more streamlined or standardized.

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All about Narrowband ISDN

Access Interfaces Provided

You might be tempted to call these the "services" provided by the phone company, but you have to be careful using the word service with ISDN, because it means things like audio, video, etc. - higher level services. What you can get from the phone company in terms of service are varying data rates, and various combinations of separate channels for data and [signaling](#). These are access interfaces.

ISDN was designed around the notion of separate channels at 64Kbps. This number springs from the fact that that is essentially the data rate at which the analog lines are sampled at (8000 samples per second, 8 bits per sample) for the phone company's

[IDN](#). ISDN is essentially combinations of these channels, and also slower 16Kbps channels used only for [signaling](#). The 64Kbps channels are called B channels. The 16Kbps channels are called D channels.

The names of the channels allegedly spring from analog circuits being called A-channels (A for analog). The next type of channel to come along got labeled B, which also happily can stand for binary (some also say it is the **B**earer channel). The D channels were at one time called delta channels, because of their relationship to the B channels, but that particular greek symble being hard to type, it became D.

There are two main interfaces, Basic Rate, and Primary Rate. The Basic Rate Interface is intended for home use, and Primary Rate is intended for businesses.

The Basic Rate Interface (BRI) is designed to carry the most data you can possibly send to the home through existing copper phone lines. It turns out that they found you could reasonably squeeze about 160Kbps into those lines. With this, the phone company can provide two B channels, one D channel, and still have 16Kbps for the overhead (data framing, maintenance, and control) of communicating with your house's phone network.

In practice in the U.S, you might find the ISDN service available to you includes only a single B channel, plus a D channel, with the second B channel costing extra. One could assume this is only the quest for profit, but it also may be due to poor equipment that isn't capable of providing Basic rate ISDN without being upgraded. In addition, many locations within the U.S. Offer B channels that are only 56Kbps. This is because much of the older equipment phone companies are using assumes that there is only analog data. Under purely analog days, extra bits were pulled out from the higher frequencies of the audio in order to do out-of-band

[signaling](#). This signaling now belongs on the D channel, but it will take some time for all of the phone equipment to catch up.

The Primary Rate Interface is designed for businesses with larger data needs, or with the need to set up their own local phone system. It is generally just a much faster connection to the phone company, with several B channels. In the U.S. the most common Primary Rate Interface (PRI) is designed for 23 B channels and 1 D channel, which is the equivalent of a U.S.

[DS1 service](#). In Europe, the most common PRI is 30 B channels, and one D, which is the equivalent of

their [E1 service](#).

With a PRI, you also have the option of combining several B channels into one bigger fatter channel called an H channel. There are several different speeds of H channel. The most common, H0, is 384Kbps, or 6 B channels. H11 is 24 B channels, or the equivalent of

[DS1 service](#). H12 is 30 B channels, or European

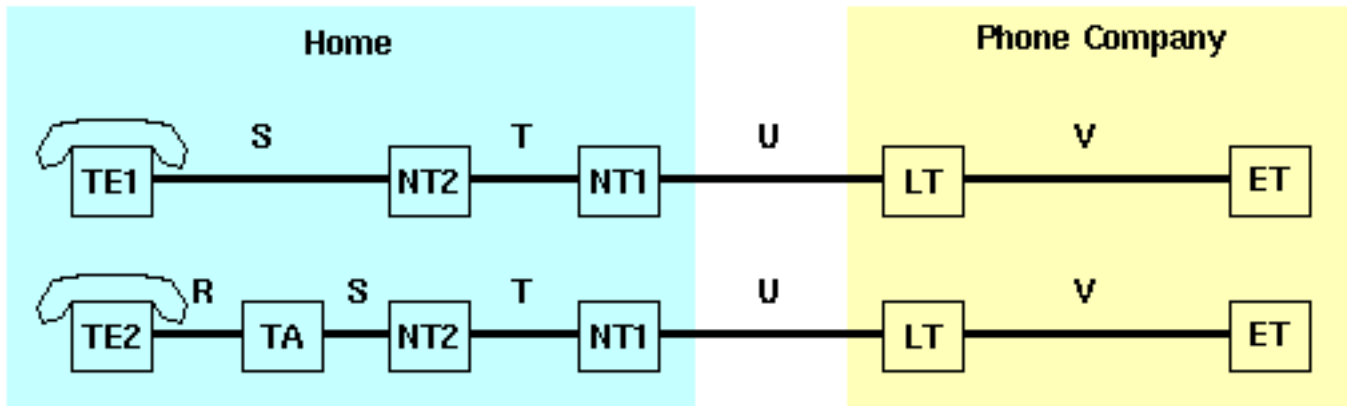
[E1 service](#). Above that, H21 provides 32Mbps (512 B channels); H22 provides 44Mbps (690 B channels); and H4 provides 135Mbps (2112 B channels), and is anticipated for use with compressed HDTV.

In practice, the phone company will probably be able to provide any combination of B, D, and H channels that it thinks it can make a buck off of.

The ISDN Reference Configurations

You can't talk about ISDN without knowing about the reference configurations. This gives you the basic vocabulary for talking about all of the pieces of ISDN. There are reference configurations for all different pieces of the ISDN network, and lots of different configurations. The following diagram shows two of the most commonly referred to configurations. The networks will actually look more complicated than this; the diagram just serves to apply standard labels to the different parts of the network you'll encounter.

Figure 1. Common reference configurations



Here's a quick glossary of some of the things shown:

- **TE1:** Terminal Equipment type 1. This is the ISDN telephone. Or computer. Or ISDN FAX machine. Or whatever it is that you've hooked up to the ISDN phone line.
- **TE2:** Terminal Equipment type 2. This is the old analog telephone. Or old-style fax machine. Or modem. Or whatever you used to hook up to the analog phone line. It can also be other communications equipment that is handled by a TA (see below).
- **TA:** Terminal Adaptor. This lets old, TE2 stuff talk to the ISDN network. It also adapts other kinds of equipment, like ethernet interfaces, to ISDN.
- **NT1:** Network Termination type 1. This is the end of the line for the local phone company, and the beginning of your house's phone network.

- **NT2**: Network Termination type 2. In most homes, this won't exist. If you were a big company with your own private telephone system, then this would be the guts of that telephone system.
- **LT**: Line Termination. This is the physical connection to the phone company.
- **ET**: Exchange Termination. This is the local phone company's logical connection from your telephones to "the phone network".

The difference between TE1 and TA is subtle but significant. If you buy an ISDN card for your computer, and device drivers that tell it how to speak ISDN, you've turned your computer into a TE1. However, if you buy an ISDN device that lets you plug your computers ethernet into an ISDN box, then you're computer is a TE2, and the box you bought is a TA. However, the difference isn't in the physical location, but more in the software. Specifically in whether there is any conversion going on anywhere.

For instance, you could conceivably buy a card that plugs into your computer and utilizes the device drivers for ethernet, and the card would convert the ethernet requests into an ISDN data stream. In this case, the card would be a TA, and your computer would be a TE2. The card has to worry about converting one protocol to another.

Note the letters, R, S, T, U, and V in the diagram. These are *reference points* that everyone uses to talk about each of these parts of the network. For instance, the R reference point is the interface between an old-style telephone and Terminal Adaptor equipment. Since most homes won't have any NT2 equipment, the S and T reference points are usually one and the same, and are called the sometimes S/T bus.

The point to all of this is that different things happen in different parts of the network. What goes on along reference point U is completely different that at the S/T reference point - different wiring requirements, different data speeds, different encoding, etc.

Notice that reference point V, and the LT and ET equipment are in the phone company's domain. I lied when I told you that ISDN defines only the customer's part of the phone network, but I only lied a little. This portion of ISDN is seldom discussed, and still largely left up to the telephone companies.

Your house's network (S/T reference points)

The phone "network" inside of your house will be somewhat more complicated with ISDN than it is today, in that it will be a true data network. This network is often called the *customer-premises installation* or CPI. This network will typically consist of telephones, computers, fax machines, videophones, and an endless list of pie-in-the-sky applications, like controlling your thermostat thru ISDN.

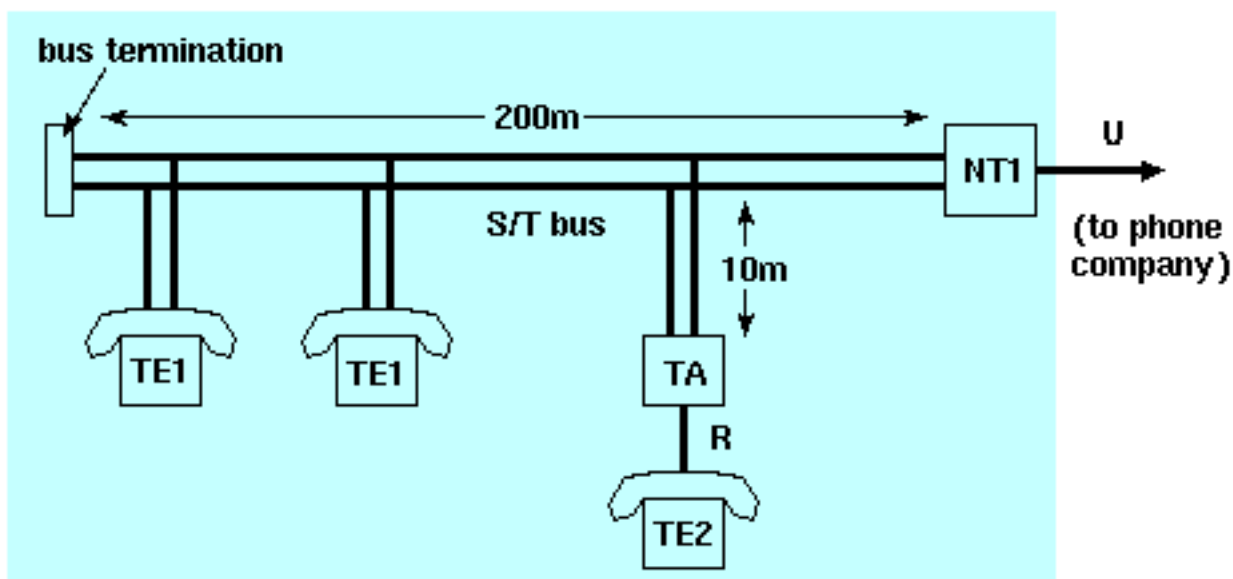
Hardware

This is layer 1 (the physical layer) of the S/T bus. This defines the physical network in your home. The most obvious things this defines, as far as a customer is concerned, are wiring, connectors, and power, so I'll talk about those first.

ISDN uses a phone jack that looks just like the standard phone jacks in use today, except that it is a bit wider. Instead of the older 4-pin jacks (which only used two wires), ISDN uses an 8-pin jack (which only uses four wires). The

[CPI](#) is based on a four wire scheme, two wires for transmitting, and two for receiving (which means you'll probably have to rewire your house). These wires are typically copper wiring of some sort, and can be longer than most users will ever need.

Figure 2. Typical CPI



(Note that each connection shown is a two-wire pair.)

If you are using ISDN with a single device (for instance, your computer is hooked up to ISDN, and your phones are still hooked up the old way), then you can have up to a kilometer (thereabouts) in your home for typical copper wiring. This is called a *point-to-point* configuration. But in most cases, you'll be using ISDN to hook up several devices, as shown in Figure 2, above. This is a *multipoint configuration*. With the standard ISDN equipment, up to eight different devices can be hooked up to the S/T bus. With this configuration the total length can be about 200 meters, and each device can be connected to the bus with up to 10 meters of wire. Devices can be placed anywhere on the bus under this setup.

This can also be modified somewhat, to extend the S/T bus up to about 500 meters. To do this, all of the devices must be connected close to the bus termination end of the bus. Further, each device on the bus must be 25-50 meters apart.

Eight devices might seem a bit low if you have an active imagination, but some of these devices could actually be brokers for other things -- for instance it is more likely that you'd have a single device that could simultaneously control your microwave, furnace, A/C, alarm clock, and house lights. Even though you can only hook up eight devices, you have an almost unlimited number of addresses (i.e. phone number extensions) for each of those devices, so it is likely that one ISDN TE1 would be used for several different purposes. On the other hand, you can't simultaneously use more devices than the available number of B-channels; for most customers this means only 2 devices can be in operation at once. In fact, with some ISDN provider's switches, you can only hook up two devices period, one assigned to each B-channel. This isn't the way things are supposed to work, but that's how a particular piece of phone company equipment works (specifically, the DMS-100 switch).

Power

One important issue of ISDN that we aren't used to worrying about is power. Currently the analog phone system provides it's own power - if the power goes out, your phone still works. However, ISDN requires more power than the phone company is in the habit of providing. Because of this, each of your ISDN devices must get it's power some other way. Under normal circumstances, what will happen is that your NT1 will be plugged in to your house's power. All the ISDN devices in your home will get power from the NT1. This is one of the reasons that ISDN uses a four wire system for the network - it allows separate lines for receiving and transmitting and at the same time allows for transmission of power.

Also, those other four unused wires in the 8-pin ISDN jack are specified in the standard to be used for alternate power supplies. Whether these will actually be used remains to be seen, but it is possible that a UPS (uninterruptible power supply) could be added to your NT1, and it could use these auxilliary lines to provide guarenteed power. Note that one of these alternate power supplies is designed to go **from** the TE **to** the NT.

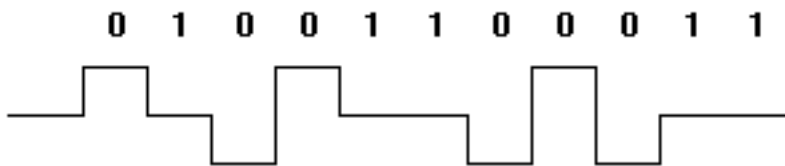
If you are outside of North America, and your power DOES go out, you are still covered though. The phone company will still provide the same power levels they used to. This should be sufficient to keep at least one TE1 device in operation. The assumption is that this would be your telephone, so that you could still call the power company and complain about your loss of power. The NT1 notifies all devices on the S/T bus of the power failure by reversing the polarity of the receive and transmit line pairs. All non-essential devices are supposed to respond by shutting themselves off. As I implied, this standard has not been used in North America - if your power goes out here, you have no phone. Don't ask me why.

Network Operation

All traffic on the S/T bus flows in 48 bit frames, at a transmission rate of 192 Kpbs. You might notice that this is higher than the 160 Kbps that I said could be sent between you and the phone company. This is because the CPI covers shorter distances, and is presumed to be more modern, and can therefore run as fast as is needed. So 144 Kbps is used for the 2B+D channels, leaving 48Kbps for overhead. Since the S/T bus has to worry about network contention in addition to other issues, it needs all of this extra bandwidth to keep things running smoothly.

The encoding on the S/T bus is a pseudoternary line code, known as *modified alternate mark invert* (MAMI). In this encoding, ones are represented by a zero voltage, and zeros are represented by a pulse, which is alternately either positive or negative:

Figure 3. MAMI encoding



Talking to the phone company (U reference point)

Outside of the U.S., the T reference point defines how the customer talks to the phone company. This is because the phone company owns and operates the NT1 equipment, even though it is located on the customer's property. Because of this, while there may be standards and recommendations regarding the setup of the U reference point, its design is largely left up to the phone companies.

In the U.S., however, it was decided that the NT1 equipment should be the customer's responsibility. This meant that what happens at the U reference point must be carefully defined in the U.S. so that the different vendor's products will all properly talk to the phone company.

Signaling

There are two different types of [signaling](#) used in ISDN. For communicating with your local phone company, ISDN uses the Digital Subscriber Signaling System #1 (DSS1). DSS1 defines what format the data goes in on the D-channel, how it is addressed, etc. It also defines message formats for a variety of messages used for establishing, maintaining, and dropping calls, for instance SETUP messages, SUSPEND and RESUME messages, and DISCONNECT messages.

Once your DSS1 signal makes it to the phone company, their own signaling system takes over to pass the call information within their system, and between other phone companies. Signaling System #7 (SS7) is supposed to be used for this. SS7 defines a communications protocol, and formats similar to DSS1, however SS7 is designed in a broader, more general way. DSS1 is specific to ISDN, however SS7 will handle the signaling needs of ISDN as well as other older signaling systems and (hopefully) will adapt well to future needs.

One important feature of SS7 is providing [CCS](#). This makes it harder for malicious users of the phone network to put one over on the phone company. It also improves the service, for instance by offering faster connection establishment. However, the phone companies haven't yet fully converted their equipment to use CCS. Older equipment still looks for the signaling information in the same channel as the voice, in the eighth bit of each piece of voice data. This is why many parts of the country only offer 56Kbps B-channels - they've lost 1/8 of their bandwidth to the older in-band signaling system.

Switching

With pure ISDN, switching shouldn't be a concern - it's basically the phone company's problem to solve as they please. So far though, they don't have it completely solved, so we need to mention it here. Traditional phone services is Circuit Switched Voice (CSV). Your voice goes through several switches before reaching its final destination. The phone company is pretty good at this. For point-to-point data connections, you need Circuit Switched Data (CSD) - the exact same thing with data instead of voice. The phone companies aren't prepared yet to dynamically provide whatever service you need right from the start, so they will want to know ahead of time what you are going to be using your ISDN channels for.

If you are using CSV, they are free to route your call through any type of switch, even the old analog

switches (there are a few left here and there). Your digital channel may also be shared with other channels, in the moments when there is silence on your phone line. And the digital parts of a CSV call can go through noisy switches that might create an undetected error here or there - it's only voice and you won't hear it.

For CSD, they can't do any of these things - your call must be routed only on pieces of equipment that will give dependable full time data channels. So even though the service in ISDN is supposed to be transparent, for the time being you have to tell the phone company how you are going to be using your B-channels. This seems to be more of a problem in the U.S. than in Europe.

Typically, each B-channel is setup for only one of these types of data. There are actually a standard set of combinations defined for setting up BRIs. These are called [National ISDN](#) Interface Groups (NIIGs), so there will be a limited menu of offerings available. Typically you can get both B-channels for data, or one for voice and the other for data, or one for voice and the other for either voice or data.

In order to facilitate this, North American phone companies use an optional part of the ISDN standard to identify each TE1 or TA you use. The phone company assigns a Service Profile IDentifier (SPID) to each of these devices, and you have to manually enter them into each device you use. The phone company then stores this data somewhere, and when you connect your machine to the network, it sends its SPID to the nearest phone company switch which identifies what type of connection the device needs and (therefore) how to route its calls. Presumably, the SPIDs have to refer to a configuratoin that matches one of the two B-channels you have.

By the way, the SPIDS are arbitrary numbers that refer to data stored by the phone company. The phone company often includes the phone number in the SPID for their own convenience, but in general you won't get anywhere trying to find significance in the patterns of SPIDs.

One older type of phone company switch, a DMS-100, was improperly designed with respect to the standards relating to SPIDs (the standards may not have been complete when the DMS-100 was designed). This switch misguidedly assigns one SPID to each B-channel that you use, rather than to each device. Therefore if your nearest switch is a DMS-100, you will only be able to hook up two devices to your [CPI](#), rather than eight.

If you are only going to be hooking up a single device to your ISDN (i.e. setting it up in a point-to-point configuration, you might not need a SPID at all, as the phone company can identify your ISDN line as one particular type, full time. This depends on what equipment they have - the old DMS-100 switch will still require you to have a SPID.

Packet Switching

Another kind of switching is also available, Packet Switched Data (PSD). With Packet switched data, each piece of data you send out might go to a different destination. This is used (or will be used) by the D-channel data. Using your D-channel, it is possible to implement various low-bandwidth services for communicating with other ISDN users.

In addition you could also use PSD on the B-channels, although this is generally only used for X.25 or something similar.

Bearer Service

The options of CSV, CSD, and PSD are broad categories of *bearer services* that the phone companies can provide. Different bearer services provide different types of guarantees about the reliability and synchronization of the data. There are currently ten different bearer services for circuit-mode, and three services for packet mode.

These bearer services are defined in terms of a number of attributes, which include mode (circuit or packet), structure (bit-stream or octet-stream), transfer rate (e.g. 64Kbps), transfer capability (basically, the content, for instance speech, 7Khz audio, video, or unrestricted), and several other attributes that specify protocols to use and other things.

The attributes of the bearer service are encoded into a Bearer Code, or BC, that is sent everytime a new connection is being set up. In theory, this allows the switches to dynamically choose from a variety of different switching paths techniques depending on requirements. In practice, as discussed before, the SPID is used to determine what services are needed for switching, as this greatly simplifies things for the telephone companies. The BC will not be completely ignored, however there are certain bearer services that will be unavailable on your B-channels, based on how they are configured

It is important to note that the BC is sent to the switch every time a connection is established. However, the SPID is only sent to the switch when you physically attach your equipment to your phone line. At this time the switch gives your device a Terminal Equipment Identifier (TEI) which is used from then on to identify all connection requests from that piece of equipment. This allows the switch to look at the TEI and BC, determine the SPID, and see if the BC and the SPID match up.

Finally, there is a feature in some TAs that allows you to use a CSV bearer service to carry data (perhaps because it is cheaper, or possibly CSV is all that is available), which is called Data Over Speech Bearer Service (DOSBS). This works by providing additional end-to-end data guarantees that can't be relied upon from the speech Bearer Service.

Rate Adaption

Terminal Adaptors are designed to facilitate equipment with data rates lower than the 64Kbps per B-channel. Because of this, standards have been developed (independent of ISDN, as they happen end-to-end) to determine how this lower rate data will be merged into the higher speed stream. There are standards for doing rate adaption with a wide variety of other communications systems, including standard serial interfaces (RS-232C), X.21, and X.25.

Because this is an end-to-end issue, it will only work if both end points can speak the same protocol. Two common rate adaption standards that are emerging as the most popular are V.110 and V.120.

V.110 is the earlier standard of the two, and is mainly concerned with synchronous transmissions. It was designed for putting low-rate (2400 or 9600 bps, for instance) synchronous data onto 56Kbps channels prior to the development of ISDN. V.110 does also support asynchronous data up to 19.2Kbps. It does not have any error correction.

V.120 is a frame-oriented protocol based on LAPD, and also supports both synchronous and

asynchronous data streams. Because of its use of LAPD, it provides error correction.

Both V.110 and V.120 support the multiplexing of several lower rate data streams onto a single channel, although this feature isn't currently found in many products. V.110 is an easier protocol to implement and is better suited to synchronous data, while V.120 is more suited to asynchronous communications, and is more complicated to implement, especially if all V.120 features are included in the implementation.

V.110 is more commonly implemented, and V.120 is gaining popularity. It is likely that for the near future vendors will try to support both protocols in their products, but eventually one will win over the other.

Inverse Multiplexing

In addition to rate adaption of lower speeds onto one B-channel, there are three common methods for combining several B-channels to get speeds greater than the 64Kbps. This is called *inverse multiplexing*.

The most common method, *BONDING* (for Bandwidth ON Demand INteroperability Group), is implemented by most vendors. The standard is still developing, and some vendors may have features that others lack, so interoperability could still be a problem. BONDING is implemented outside of the ISDN architecture, so only the end points know it is a single connection - the ISDN thinks it is just several separate phone calls. It is able to support up to 63 combined 56 or 64Kbps B-channels.

The second method, Multilink PPP, is used only when routing IP over ISDN. Under the [PPP](#) standard, it is possible to have a single logical connection multiplexed across several physical connections, and this method is widely implemented. As with BONDING, this works entirely outside of the ISDN architecture.

The third method, Multirate Service (sometimes called Nx64 service), is a more expensive service, part of the primary rate interface service. Under this service, you get a single channel, of whatever size you need (in multiples of 64Kbps), on a per-call basis. This has the advantage that only one single call is made, therefore connection setup is much faster. Multirate service is only now becoming available from the telcos.

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All about Broadband ISDN

The copper between the houses won't last forever. Eventually higher speed transmission media will be available. Narrowband ISDN was basically a stopgap measure. But its development allowed time for the design of Broadband ISDN to be even more ambitious.

Broadband ISDN (B-ISDN) is similar to Narrowband ISDN only in the most basic aspects. The reference configurations are largely the same, but every bit of the underlying design will be replaced. The S/T bus will by necessity have to be a much faster network, as will the network at the U reference point. The signaling will be changed, as will most other details. The house will most likely need to be rewired yet again, and all the physical connectors are likely to change.

B-ISDN is very strongly related to ATM. This is because ATM will provide a consistent data encapsulation scheme that can be used throughout the network, starting with your TE1 or TA equipment, and covering every piece of telecommunications equipment in use.. ATM is so important to B-ISDN that many people believe it's the same thing. It's most of what is new over Narrowband ISDN, but it isn't all of it.

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National ISDN

Most of the interesting R&D being done is in the B-ISDN world, and in the world of applications.

Surprisingly though, there is still a lot of standardization going on with Narrowband ISDN, which amounts to standardizing the standards. This is pretty dry stuff, voltage levels, ring volumes, and various things needed for vendor interoperability. The set of interoperability standards referred to is called *National ISDN*.

Applications

The standardizing of applications is really separate from the ISDN standards themselves, but these applications will be important to the future success of ISDN. Currently research is being done into ??? vidphones, low-res voice, high-res sound,

Broadband ISDN

There is still a great deal of work being done here. The biggest area of work is in the finalization of ATM.

The real world

As ISDN is deployed, few people are currently replacing their home phone system with an ISDN phone network. The trend for now seems to be providing an entire ISDN network in a single box, with the NT1, TA, and TE1 equipment all built in. An example would be the Pipeline 25, from Ascend, which provides ISDN to ethernet connections, using IP. It has an NT1 built in, and provides two phone jacks for standard [POTS](#) telephones.

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ISDN References

Books

1. **William Stallings, "ISDN and Broadband ISDN with Frame Relay and ATM, 3rd ed.", Prentice Hall, 1995.** Excellent in-depth technical descriptions of the ISDN standard
2. **Gerald L. Hopkins, "The ISDN Literacy Book", Addison Wesley, 1995.** Great for history, politics, and a light but very well done technical description of ISDN. Brings to light many of the general issues relating to the success and failure of ISDN.
3. **Hermann J. Helgert, "Integrated Services Digital Networks - Architectures/Protocols/Standards", Addison Wesley, 1991.** Good detailed technical description of ISDN, somewhat more detailed than the Stallings book in some areas. Becoming out of date.
4. **John M. Griffiths, "ISDN Explained", John Wiley & Sons, 1992.** A good technical introduction to ISDN. Becoming out of date.
5. **William Stallings, "Advances in ISDN and Broadband ISDN", IEEE Computer Society Press, 1992.** A variety of varying quality papers on various issues.
6. **William Stallings, "Data and Computer Communications, 4th ed.", Macmillan Publishing, 1994.** A good general reference for computer networking, telecommunications, etc.
7. **David Angell, "ISDN for Dummies", IDG Books Worldwide, 1995.** Completely consumer oriented, contains much information that other sources ignore, but completely glosses over most details of the ISDN architecture. Includes instructions for setting up several common ISDN devices, which is useful but will soon be out of date.

WWW References

Starting Points

1. [Dan Kegel's ISDN Page](#) - This is basically the center of the ISDN web, mentioned most commonly as a good place to start.
2. [comp.dcom.isdn Frequently Asked Questions \(FAQ\)](#) - A great bunch of information, mostly consumer-oriented.
3. [Ascend Frequently Asked Questions: Top](#) - Even though it is related to Ascend products, it still has some very good general info for consumers.
4. [ISDNbook - Table of Contents](#) A good set of info provided by PacBell.
5. [Telecom Information Resources](#) - A searchable directory of even more web sites.
6. [WWW Virtual Library Comms & Telecoms: BROADBAND](#)
7. [The World-Wide Web Virtual Library: Communications & Telecommunications](#)
8. [WWW Virtual Library Comms & Telecoms: MULTIMEDIA](#)

9. [WWW Virtual Library Comms & Telecoms: STANDARDS, TESTING AND PROTOCOLS](#)
10. [Books on ISDN](#) - Still more references.

Information on Specific Topics

11. Combinet's [ISDN Backgrounder](#)
12. [ISDN Conformance Testing](#)
13. [Cell-Relay FAQ \(part 1/2\)](#)
14. [IBM ISDN Networking Products](#)
15. [Pan-European Approvals for ISDN](#)

Organizations

16. NIST's [High Speed Networks Group Home Page](#)
17. [North American ISDN Users' Forum](#) (NIUF).
18. [ATM DOCUMENT COLLECTION 3](#)
19. [ITU \(formerly CCITT\)](#) (stingy about making recommendations available)

Service Providers, Equipment Manufacturers

20. [Basic Rate ISDN](#) from PacBell.
21. [Bellcore ISDN Home Page](#) - National ISDN
22. [Ameritech ISDN](#)
23. [Telecom Services](#) (of SwissNet)
24. [NETC Home Page](#)
25. [Cameron Communications Group](#)
26. [ISDN Product Developer's Guide](#) - List of products and development resources.
27. [Ascend Communications Home Page](#) - they make ISDN equipment.

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ISDN Glossary

BONDING Bandwidth ON Demand INteroperability Group - a method for combining multiple B-channels into a single data stream. **CCS** - Common Channel Signaling.

This means all signaling goes over a common channel, which is separate from the data channel. Using SS7, ISDN keeps the signalling separate from the B-channels, which gives both faster dialing, and the full 64Kbps. Parts of the country that haven't switched to SS7 can only offer 56Kbps. CCS also sometimes stands for Clear Channel Service, with the exact same meaning..

CPI-Customer Premises Installation - the phone network within the home or business.

CSD - Circuit Switched Data. Phone calls, with data only.

CSV - Circuit Switched Voice. This is traditional phone service.

DOSBS - Data Over Speech Bearer Service. A configuration where the phone company expects you to be using the channel for voice, but you can send data. Also called DOVBS, V for voice.

DS1 service- A standard service in the U.S. phone network, running at approximately 1.544 Mbps, capable of handling 24 standard audio phone calls.

E1 service - A standard service in the European phone network, running at approximately 2.048 Mbps, capable of handling 31 standard audio phone calls.

IDN - Integrated Digital Network, the phone company's digital network. It provides digital service within and between all phone companies, but not to the customer's door.

POTS - Plain Old Telephone System. Pre-ISDN equipment.

PPP - Point to Point Protocol. An IETF standard for transmitting IP traffic across dialup connections. PPP has been accepted as the standard for IP over ISDN.

PSD - Packet Switched Data. For using ISDN with X.25, or things like that. This won't be very common.

National ISDN A set of interoperability standards being developed in the U.S. so that all the different vendors and phone companies can make equipment that works together.

NI-1(or NI-2, NI-3) See [National ISDN](#) **N-ISDN** - More commonly stands for [National ISDN, less commonly for Narrowband ISDN](#).

SDH- is the European equivalent of SONET. They are not the same, but they are close enough that the hardware manufacturers can make equipment that conforms to both standards at the same time.

Signaling- the exchange of information for call setup and control. Sends information on the phone network regarding phone numbers, busy status, call interruptions, hangups, etc. The grating tones that a touch tone phone makes are part of signalling - they are interpreted by the local phone company as a phone number.

SONET- is a standard that defines how data flows across fiber optics. The phone companies use SONET

internally to move lots of data around. They also use SONET to provide service to customers. If you get a SONET link from the phone company, it looks like they've given you your very own dark fiber. In fact, you may be sharing a physical fiber with other people, but the way SONET is defined, you'll never know.

SPID - Service Profile ID. These identify to the phone company what types services and features are supported for a given device. SPIDs are optional in the ISDN standard, but usually required in North America.

Switching - the process of connecting a phone call by connecting lines, or logical channels to each other to form a complete end-to-end connection.

TEI - Terminal Equipment ID. These uniquely identify each TE device. This ID is dynamically allocated when the TE is attached to the network.

V.110 - A standard for rate adaption for TA equipment.

V.120 - A standard for rate adaption for TA equipment.

[Other Reports on Recent Advances in Networking 1995](#)

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