DSL HOWTO for Linux

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First release.		

This document examines the DSL family of high speed Internet services now being deployed in various markets worldwide. Information is included on the technology behind DSL as well as subscribing, installing, configuring, and troubleshooting, with an emphasis on how this impacts Linux users.

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1. Introduction

DSL, or Digital Subscriber Loop, is a high−speed Internet access technology that uses a standard copper telephone line (a.k.a. 'loop' in telco parlance). DSL provides a direct, dedicated connection to an ISP via the existing telco network. DSL is designed to run on up to 80% of the telephones available in the United States. By using line−adaptive modulation, DSL is capable of providing data speeds up to 8 Mbps.

DSL services are now being aggressively marketed for home and small business use. DSL is typically priced below ISDN, and well below T1 service, yet can provide potentially even greater speeds than T1 without the cost, complexity, and availability issues of T1. Since DSL is a dedicated, often 'always on' service, it avoids the delays and use charges that are common with ISDN. Making this quite a nice technology for the bandwidth starved masses.

While all this sounds exciting, DSL does have some drawbacks. The quality of the DSL signal, and thus the connection, depends on distance and various other factors. Also, there is no such thing as standard 'xDSL'. There are various flavors of DSL, and many, many ways DSL providers are implementing their networks. In typical fashion, Linux users are often left to fend for themselves, since the DSL providers are often taking the easy way out, and catering only to 'mainstream' Operating Systems.

The topics included in this HOWTO include qualification and pre−installation, installation, configuration, troubleshooting and securing a DSL connection. As well as other related topics. There are also appendices including a comprehensive DSL Overview, Frequently Asked Questions, a listing of related links, and a glossary.

Due to the fast pace of change in the telco and DSL industries, please make sure you have the latest version of this document. The current official version can always be found at http://www.linuxdoc.org/HOWTO/DSL−HOWTO.html.

1.1. Document Structure and Reading Guidelines

This document attempts to give a comprehensive discussion of DSL. All aspects are hopefully addressed to one degree or another with what can be a complex topic since it deals with networking, hardware, new fangled technologies, and various approaches taken by various vendors.

To simplify the navigation of this document, below is a suggested reading guideline. Everyone should read the Introduction. Please pay special attention to the Conventions and Terminology section, as some of this terminology may be used somewhat differently in other contexts. Also, there is a Glossary if you get lost in the world of TA (telco acronyms) ;−).

- If you don't know anything about DSL, you should probably read the entire document, with the possible exception of the 'Tuning and Troubleshooting' section. You may want to start with the DSL Overview section in the Appendix, and then the FAQ. The DSL Overview explains how the various pieces of the puzzle fit together. DSL network implementations are more complex than traditional dialup networks.
-

If you have already done some homework, but have not ordered service from anyone yet, read the Choosing Providers section, and the Linux Friendly ISPs sections. Also, you might get a head start by reading the Configuring Linux section so you know what lies ahead.

- If you have ordered service already, and are awaiting delivery, you can skip the sections on choosing a Provider. If you will be doing a self−install, you should read the pertinent parts of the Installation section, the Configuring Linux section, and the Securing Your Connection section.
- If the installation is complete, and you can't get a working connection, skip right to the Troubleshooting Section. If you are confused by what protocols are required, or what software you need to have installed, also read the Configuring Linux section. If not sure what terms like 'sync' mean in this context, then be sure to read the DSL Overview section first so you know how it all fits together.
- If trying to decide between cable and DSL, read the Cable vs DSL section, and possibly the DSL Overview section.
- There is a comprehensive Links section that has references to some topics not touched on in the main body of the Document itself.

1.2. Copyright

DSL HOWTO for Linux

1.3. Credits

Thanks to all those that contributed information to this HOWTO. I have anti−spammed their email addresses for their safety (and mine!). Remove the X's from their names.

- *B Ediger* (Xbediger@csn.net) Great Description of loop impairment.

- *C Wiesner* (Xcraig@wkmn.com) List of many ADSL URLs.
- *J Leeuw* (Xjacco2@dds.nl) Many tips on ADSL, especially in Europe
- *N Silberstein* (Xnick@tpdinc.com) Info on Netrunner and his experience with US Worst.
- Many and various posters from comp.dcom.xdsl and bellsouth.net.support.adsl, too numerous to mention individually. (HB)

1.4. Disclaimer

The authors accept no liability for the contents of this document. Use the concepts, examples and other content at your own risk. As this is a new edition, there may be errors and inaccuracies. Hopefully these are few and far between. The author(s) do not accept any responsibility for incorrect or misleading information, and would certainly appreciate any corrections. Also, this type of technology dates itself very quickly. What may be true today, is not guaranteed to be true tomorrow.

All copyrights are held by their by their respective owners, unless specifically noted otherwise. Use of a term in this document should not be regarded as affecting the validity of any trademark or service mark.

The naming of any particular product, brand, or company should not be construed as an endorsement or recommendation.

1.5. New Versions

Version .99 addresses some of the many changes that have occurred since the original ADSL mini HOWTO was published. Originally, ADSL was the primary DSL technology being deployed, but more and more some of the other DSL flavors are entering the picture −− IDSL, SDSL, G.Lite, and RADSL. Thus the renaming from 'ADSL mini HOWTO' to the 'DSL HOWTO'. There have been many other changes in DSL technology as well. PPPoE/A encapsulation has become more and more common as many ISPs are jumping on this bandwagon.

The contents have additionally been re−organized, with new sections added on security, and troubleshooting, and as well as many additions to the Links section. Various and sundry other updates and additions as well that are too numerous to mention.

Pre−release versions of this document can be found at http://feenix.eyep.net/ldp/adsl/.

1.6. Feedback

Any and all comments on this document are most welcomed. Please make sure you have the most current version before submitting corrections! These can be sent to <hal@foobox.net>

Future versions of this document may include a section devoted to FAQs and HOWTOs for specific providers. Please send in any links you may have. Also, I need more Linux Friendly ISPs! See the Linux Friendly ISPs section for what qualifies.

1.7. Conventions, Usage and Terminology

For the sake of simplicity and sanity, let's clarify some of the terminology that we will be using in this document, so that we are all on the same page. While many of the definitions below are not always 100% technically correct, they are close enough for our purposes here. In fast moving technologies like DSL, there are so many 'ifs, ands, and buts' that it is difficult to say anything with any degree of certainty and have it stick. And there are exceptions to almost every rule. And sometimes exceptions to the exceptions. We will be dealing with generalities to a large degree here, please keep that in mind.

- 'DSL' will be used to refer to the entire family of DSL technologies now available −− ADSL, SDSL, IDSL, RADSL, etc. ADSL still seems to be the most prevalent at this time, but the others are being deployed more and more. Where it is important to differentiate one type of DSL from another, the full proper name will be used: e.g. RADSL. xDSL also is also commonly used to refer to the various DSL technologies as a group, but we will be using just 'DSL' here.
- The term 'telco' here refers to any potential DSL provider. This includes the ILECs (Incumbent Local Exchange Carriers), a.k.a. the old guard phone companies. And CLECs (Competitive Local Exchange Carriers), or independent providers such as Covad and Rhythms. Both are providing DSL services over existing copper lines.
- 'CO' is the telco acronym for 'Central Office'. Traditionally this is a building where one end of your phone line physically terminates. The other end terminates at your home, office, or wherever. It will be used here to refer to the telco end termination point, regardless of whether it is a traditional Central Office building or another, smaller, remote structure or device.
- 'Loop' is telco speak for 'phone line'. Essentially, you should think of your loop as one dedicated pair of copper wires that run uninterrupted from your residence or office directly to the CO. This is perhaps an oversimplification, but will serve our purposes. DSL availability, and signal quality, is tied directly to the characteristics of your physical line −− or 'loop' as they say.
- 'POTS' is the acronym for Plain Old Telephone Service. In other words, traditional, non−digital devices like phones and answering machines.
- 'DSLAM' is the sophisticated hardware device in the telco's CO where your phone line physically terminates, and thus makes DSL happen. Increasingly, telcos are making use of smaller devices like the 'mini−RAM' in remote locations. We'll use 'DSLAM' here as a catchall for any device that

enables DSL service from a telco.

- 'Modem' will be used to refer to the end user device that enables a DSL connection. Your modem is connected to the telco's DSLAM in the CO via your loop. When they are 'talking' DSL to each other, they are in 'sync'. Without 'sync', no connection to the ISP is possible.

  'Modem' is indeed the correct terminology since there is MOdulation and DEModulation of the signal. These modems typically have other features too. Some ISPs and manufacturers may be marketing simply 'routers', 'bridges', or even 'brouters' for this purpose. These are essentially DSL modems with enhancements. A compatible 'modem' of some kind is the minimum hardware requirement at the customer's end of the connection. The most commonly supplied modem is actually a combination bridge and modem.

  Unless stated otherwise, we will also be assuming the 'modem' has an ethernet interface, and will connect to a standard Network Card (NIC). For right now, arguably the only workable configuration is an ethernet interface. And perhaps is also the only viable option based on what delivery systems and hardware are now being offered by the overwhelming number of providers. This could be changing soon however.

  It is worth noting that 'routers' as supplied by DSL providers are typically modem/router combination devices. In our context, 'router' will refer to these devices as such. There are also SOHO routers available that are only dedicated routers and lack the modem functionality.
- Previous versions of this document referred to the modem as an 'ANT' (ADSL Network Termination). While this may be technically correct terminology, it is not used by ISPs, manufacturers, telcos, or most users to any extent. The 'modem' will be just called a modem, regardless of whatever other features it may have (i.e. router, bridge, etc.).
- PPPoX will be used to refer to PPPoE (PPP over Ethernet) and PPPoA (PPP over ATM) collectively. These protocols are being used by many DSL providers now.
- The information provided in this document is based on the current state of DSL in the U.S. I would assume there are enough similarities with DSL services outside of the US that this document would still have some merit for everyone. Correct me if I am wrong by emailing <hal@foobox.net>
- A '#' will be used to denote a command that typically is run by the root user. Otherwise, a '$' will be used as the prompt for non−root users.

2. Installation

Before actually ordering service, there are several things you may want to explore.

2.1. Pre−Installation

Beyond the obvious consideration of price, there are many reasons to investigate which providers may be offering DSL services in your area. The large Telephone companies are everywhere, and may advertise the most. But increasingly smaller ISPs and independents are getting into the act. This is creating diversity in the DSL marketplace. A good thing of course, but possibly creating a little confusion too.

Not all DSL services are alike. Just because two local companies are offering 'ADSL', does not mean that necessarily there is much in common at all. In fact, there are potentially a number of factors that make one ADSL provider's service significantly different from another's. Some things to consider:

- Speed vs Price.
- What hardware is provided, i.e. modem or router. Should be external ethernet in either case.
- The ISP's Network architecture. PPPoX? Static IP? Servers allowed?
- Is it an 'always on' service, at least theorectically? Are there supplemental usage fees, or idle timeouts?
- Linux friendly, Linux hostile, or Linux agnostic?
- Quality of service. How is news, mail, etc.?

For a more lengthy discussion on some of these considerations and related issues, see the DSL Overview appendix for more on modems, qualifying for service, and choosing a provider.

Once you have chosen a provider, and ordered service, the next step is for the telco to 'qualify' your loop. This essentially means testing your line to make sure it can handle the DSL signal, and possibly what level of service may be available to you. This may take some time, especially if the telco encounters problems with the loop. If no problems are found during this phase, then possibly there will be a two to three week wait for the installation.

After the telco has qualified the loop and readied their end of the connection, the next step is installation of the necessary components at the customer's end of the connection: wiring modifications, splitter or filters, and, of course the modem and any necessary software.

2.2. Installation Options −− Self Install or Not

You may or may not have a choice on how the installation is done, or who does it. This is totally at the discretion of the provider. Many providers offer a 'self install' option where you do all the work. In this scenario, the provider will send a kit in order to save them from sending a tech, and thus reducing cost. Typically, self install kits will include microfilters for the POTS (Plain Old Telephone Service) phone jacks, the modem (and maybe a NIC), and a CDROM with drivers, etc. on it. In some cases, a splitter may be included instead of microfilters.

The other possibility is for the provider to do the installation. Obviously, the cost is higher here, but it may have the advantage of having a trained tech do any wiring. There is also a better chance of getting a splittered installation with this option (a good thing!). Another benefit is that if something is wrong with the line, or the telco has not provisioned the line properly, an on−site tech may be able to help sort out some kinds of problems quickly.

The self−install kit should come with full instructions, regardless of whether the installation will be splittered or filtered. So we won't go into much detail on this aspect.

2.3. Wiring/Installation Options

There are various wiring schemes depending on how your service is being provided, who is providing it, and which DSL service is being provided.

- *Dedicated Line*. Some DSLs require a dedicated, or 'dry', wire pair, e.g. IDSL. This means a separate line for DSL and Internet connectivity. Also, DSL services from CLECs (independent telcos like Covad or Rhythms), will use a dedicated line since the ILEC will not share one line with another company. (Instead the CLEC will actually lease a loop from the ILEC.) One your end, this simply means using one of the unused wire pairs in the telco wire bundle, and connecting it to the DSL jack.
- *Shared Line with Splitter*. For DSLs, like ADSL, that are provided over the same line as regular voice service (POTS), the signal must be filtered somehow so that voice services are not adversely effected. Installing a splitter splits the line into two pairs, and filters the DSL signal from one of them. This results in a inside wiring scheme where DSL goes to only one jack, and then POTS service to all other jacks. This is considered by many to be a better type of installation than 'splitterless'.

  Splitters are available from various manufacturers and come in various shapes and sizes. Some are small enough to fit in the NID itself (sometimes called 'SNI', this is the telco phone box on the outside of your house), while others have a housing as large as the NID itself. Typically this is mounted near the NID, on the customer's side of the demarcation point.
- *Shared Line with Filters*. Again, for DSLs that piggyback on the POTS line, the signal must be filtered or split at some point. The other way of doing this is by placing RJ11 'microfilters' in each phone jack −− *except where the DSL modem will be*. These filters are relatively small, plug−in devices and remove the higher frequencies associated with DSL. This is obviously much easier since no tools or wiring is required. This is often what is included in self−install kits, and is often referred

to as a 'splitterless' installation.

- *Shared Line, Splitterless and Filterless*. Newer DSLs, like G.Lite, have no adverse effect on regular POTS devices and thus require no filters or splitters. This would seem to be the wave of the future. Just plug and play.

Figure 1: DSL Block Diagram, POTS with Splitter (NID not shown)

```
        <−−−−−−−−Home/Office−−−−−><−−−Loop−−−><−−Central Office−−>
 POTS  X−−−−−−−+
phone,         |
fax,           |
etc,           |
               |                                 CO
               |                              −−−−−−−
               |                              |     |
               |                              |     |
               |             −−−−−            |     |
POTS  X−−−−−−−+−−−−Voice−−=| S |              |  D  |
                           | P |              |  S  |=− Voice Switch
                           | L |    2 wire    |  L  |
                           | I |=−−−−−−−−−−−−=|  A  |
                           | T |  Local Loop  |  M  |=− ISP −−> INET
          −−−−−−−−−        | T |              |     |
Linux X−−=| Modem |=−Data−=| E |              |     |
          −−−−−−−−−        | R |              |     |
                           −−−−−              |     |
                                              −−−−−−−
```

Figure 2: DSL Splitterless (a.k.a. filtered) Block Diagram

```
        <−−−−−−−−Home/Office−−−−−−−><−−−−Loop−−−><−−Central Office−−>


POTS  X−−Voice−−−[RJ11]−−−−−−+
phone,       (filter)        |
fax,                         D                  CO
etc,                         a               −−−−−−−
                             t               |     |
                             a               |     |
POTS  X−−Voice−−−[RJ11]−−−−− &               |  D  |
             (filter)        V  −−−−−        |  S  |=− Voice Switch
                             o  | N |  2 wire |  L  |
                             i−=| I |=−−−−−−−−−−−=|  A  |
                             c  | D |  Local Loop |  M  |=− ISP −−> INET
                             e  −−−−−        |     |
        −−−−−−−−−−−     |             |   |
Linux X−−=|  Modem  |=−−−−−−−|             |   |
        −−−−−−−−−−−−             −−−−−−−
```

2.4. Self Install − Wiring

If you are not doing the self−install option, then you may skip this section and move to Configuring Linux. The following procedures are meant to illustrate the wiring process. Please note that your procedures may be different at your location. Make sure you follow any warnings or safety instructions provided, that you RTFM, and that you are familiar with telco wiring procedures.

The first step will be to wire up the connections from your provider. Identify the line on which service will be installed, and the locations of your splitter and DSL jack(s). (For perhaps a better wiring scheme, see the Homerun section immediately below.)

Be aware that typical telco wire has more than one pair per bundle. Often, two pairs, but sometimes more. If you have but one phone line, the other pair(s) are unused. This makes them available for use with wiring for DSL. Wire pairs are color coded for easy identification. SDSL and IDSL require a dedicated, or 'dry', pair. If an unused pair is available, then no real re−wiring is required. It is just a matter of re−wiring an existing jack for the correct pair of wires, and attaching the modem.

2.4.1. The Homerun

"I would not use microfilters if I lived across the street from my CO. A splitter is the only way to go."

− A retired Bellsouth ADSL installer.

Perhaps a somewhat better method of wiring for the DSL modem is sometimes called a 'homerun'. It is called this because it is one, straight shot from the splitter to the modem's DSL jack. What this does is bypass the existing inside wiring altogether, and any problems that might be lurking there −− like a corroded connection somewhere on a POTS jack. Inside wiring defects can be a source of headaches, especially in older homes.

It also allows you to route the cable to avoid any potential RFI (Radio Frequency Interference) sources. RFI anywhere in the circuit can be a DSL killer. So routing the cable away from items that may have electric motors, transformers, power supplies, high intensity lighting fixtures, dimmer switches and such, is a smart way to go. And you are less likely to have a failing microfilter cause problems. You can also use a better grade of cable such as CAT 5 or shielded twisted pair wire.

If you are splitterless (i.e. using microfilters) now, this will entail purchasing a splitter, and, of course, some rewiring. Microfilters also add distance to the effective loop length −− as much as 700 ft per filter in some cases! So if you have several of these, and your sync rate or distance is marginal, eliminating the filters may result in a significant improvement.

2.5. Wire the Splitter

If you have the splitterless design or a dedicated line, you may skip this part.

The splitter will typically consist of two parts, the splitter and a small outdoor housing. Mount the splitter and accompanying housing per the telco's instructions at the Subscriber Network Interface (SNI) point (also sometimes called the NID or ONI), usually the side of your house where the phone line is located. Put it on your side of the SNI or NID. The phone company may need to access the splitter for maintenance, so its advisable to locate it on the outside where they can get at it, but outside is not absolutely necessary.

The wire bundle should have at least two separate wire pairs. The splitter takes one pair, and separates the signal onto two pairs. One pair in the bundle will then go to all POTS jacks, and the other to the modem's DSL wall jack. So connect the incoming telco line to the LINE side of the splitter. Then wire the inside pair for your telephone to the VOICE, and your inside wire pair for the modem to DATA.

Checkstep At this point, you should be able to pull dial tone off the voice side of the splitter. If this doesn't work, then you've wired it wrong. You can also plug the modem into the test jack in the SNI/NID box (most should have this). Plug in the modem's power cord, and if the line is provisioned correctly, you should 'sync' in less than a minute. This test only requires the modem. (Internal and USB modems probably will require a driver to be loaded before syncing. This means having the computer there too.)

2.6. Wire the DSL Jack

Wire the DSL wall jack (RJ11) at your computer location, which should already be connected to the DATA side of the splitter. The specifics differ for each situation, but basically you will have a wire pair that you will connect to the DSL jack. Make sure you *read the directions*, as the DSL−RJ11 wiring may be different for phones and DSL jacks. *AND* −− different modems may expect the signal on different pairs −− most on the inside pair, but some on the outside pair.

Figure 3: RJ11 Wiring options

```
    ||
    ||
    ||
   /  \
  |RJ11|
  |    |
   −−−−
   ||||

    ^^  <−− Inside     Most modems on inside pair
   ^  ^ <−− Outside    Some on outside, e.g. Alcatel 1000, SpeedTouch Home
```

2.7. Install and Test the Modem

To install, connect the modem's (or modem/router's) power cord, and connect the phone line between the DSL wall jack and the modem. This cable should be provided. If not, a regular phone cord will suffice. With the ethernet interfaced modems, you may also connect the ethernet cable between the NIC and the modem (but not really necessary at this point just to verify the modem is working).

Checkstep At this point, verify the modem syncs with the telco's DSLAM signal. Most modems have a green LED that lights up when the signal is good, and red or orange if not in sync. The modem's manual will have more details on the LEDs. If it doesn't sync, then check your wiring, or make sure that the DSL signal is being sent. Do this by calling your telco and verifying they have activated the service. Or by testing the modem at the test jack on the SNI/NID (see above). Note that having dial tone on the line does NOT confirm the presence of the DSL data signal. And vice versa −− perfectly possible to have dial tone and no DSL, or DSL and no dial tone. There should also be no static or noise on the voice line when everything is installed and functioning properly.

2.8. Install and Connect the Network Card (NIC)

If you haven't already done so, install your NIC card in your Linux machine, configure the kernel, or load modules, etc., etc. This is sometimes the biggest stumbling block −− getting the NIC recognized and working. See the various Linux references for doing this, such as the Ethernet HOWTO for more information. Also, the Troubleshooting section. This is certainly something you could conceivably do ahead of time if you already have the NIC.

Be sure the RJ45 cable between the NIC and the modem is now connected. You can hot plug this cable.

We can do a few quick tests now to see if the NIC is functioning properly:

```
13;# ifconfig eth0 10.0.0.1 up


$ ping −c 50 10.0.0.1
PING 10.0.0.1 (10.0.0.1) from 10.0.0.1: 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=0 ttl=255 time=0.2 ms
64 bytes from 10.0.0.1: icmp_seq=1 ttl=255 time=0.2 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=255 time=0.1 ms
60;snip62;

− 10.0.0.1 ping statistics −
50 packets transmitted, 50 packets received, 0% packet loss
round−trip min/avg/max = 0.1/0.1/0.2 ms


$ ifconfig eth0
eth0    Link encap:Ethernet  HWaddr 00:50:04:C2:09:AC
        inet addr:10.0.0.1  Bcast:10.255.255.255  Mask:255.0.0.0
        UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
        RX packets:428 errors:0 dropped:0 overruns:0 frame:0
        TX packets:421 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:100
        Interrupt:10 Base address:0xc800
13;
```

If 'eth0' comes up without errors, and you can **ping** it without errors, and **ifconfig** shows no errors, we should have all our hardware in working order now, and are ready to start configuring Linux. If not, see the Troubleshooting section below.

Gotcha: A few modems may already be wired as a 10baseT crossover, and require a direct Category 5 cable for a direct connection to a NIC, rather than a crossover cable. I lost around 12 hours figuring this one out, so don't make the same mistake − make sure you RTFM first.

3. Configuring Linux

After you have connected the modem and you're getting sync, and the NIC is functioning, then you're ready to configure Linux and verify your connection to your ISP. Although I will refer to a Linux System, you can conceivably connect any type of 10baseT device to the modem. This includes a router, hub, switch, PC, or any other system that you wish to use. We'll just cover the Linux PC aspect here.

Caution!Before you connect to your ISP, make sure you understand all security issues of having a direct connection to the Internet via DSL. Depending on your ISP, most outside users can access your system, and you should setup any firewalls, deactivate ports/services, and setup any passwords prior to connecting your machine to the world. See the Security section below, and the links section for more on this *very important* topic. Do not make this an afterthought! Be ready.

3.1. Bridged vs PPPoX Networks

Before we get too far into the final stages of installing and configuring our system, let's look at how various DSL ISPs set up their networks. It will be very important for you know how your ISP does this, as there is more than one possibility and the steps involved are quite different for each. This may not be the kind of thing the ISP is advertising, and since you are not using Windows, you may not have access to the setup disk that the ISP provides. If not sure, ask the ISP's tech support staff, or other users.

To muddy the waters even more, some ISPs may be offering more than one kind of service (over and above the various bit rate plans). Example: Bell Atlantic originally offered static IPs with a Bridged connection. Now all new installs use PPPoE with dynamic IPs. For installation and configuration purposes, this is very different.

The two most common DSL network implementations are Bridged/DHCP and PPPoX. Both have mechanisms for obtaining an IP address and other related networking configuration details so we shouldn't have to worry about this. Our job will be finding the right client, and doing what we have to, to get it up and running.

Important! You need to know beforehand how your ISP is setup for connecting to his network. To re−iterate, the two main possibilities are Bridged/DHCP and PPPoE. These are mutually exclusive implementations. So you will need either one or the other, and it must be the right one or you will waste a lot of time and effort. You cannot choose which one either. It is a matter of how the ISP is doing his network. Note that PPPoE can run over Bridged networks, so just knowing whether you are Bridged or not, is not necessarily good enough. PPPoA is yet another alternative. If your provider is giving you a router, there is a good chance that the router's firmware will handle all of this for you.

3.1.1. Bridged/DHCP

In the good old days of a year or two ago, 'Bridged' connections were the norm. This type of network puts you on a local subnet just like a big LAN. You are exposed to much of the local subnet traffic, especially ARP and broadcast traffic. The typical means of authenticating in this set up, is via DHCP.

DHCP is a standard, established networking protocol for obtaining an IP address and other important network parameters (e.g. nameservers). This is a very standard, well documented networking scheme and is very easy to set up from the end user's perspective. It is also a very stable connection. You can actually unplug the modem for say 10 minutes, plug it back in, let it re−sync, and the connection is still there −− same IP and everything.

3.1.2. PPPoX

The main alternative now is PPPoX, meaning either PPPoE (PPP over Ethernet) or PPPoA (PPP over ATM). Both of these related protocols are currently being deployed, but at the moment, PPPoE seems to be the more common of the two. PPPoX is a relative newcomer, and, as the name implies, is a variation of Point−to−Point Protocol that has been adapted specifically for DSL providers.

There are several PPPoE clients for Linux (see below). At this moment, PPPoA support is in beta, but should be available very soon. PPPoX simulates a dialup type environment. The user is authenticated by user id and password which is passed to a RADIUS server, just like good ol' dialup PPP. A routable IP address, and other related information, is returned to the client. Of course, no actual dialing takes place. The mechanics of how this is handled, will vary from client to client, so best to RTFM closely. Typically you will set up configuration files like `pap−secrets`, etc.

From the ISPs perspective, PPP is much easier to maintain and troubleshoot. From the end user's perspective, it is more work to set up, uses more CPU, and the connection is maybe not as stable. So anyway, this seems to be the coming trend. Many of the large telcos, especially the RBOCs (Baby Bells), have committed to PPPoX already. Setting up a PPPoX connection is completely different from setting up a bridged/DHCP connection.

3.1.3. ATM

Since the traffic on the wire from the DSLAM to the modem is ATM, a raw ATM connection would seem to make sense. While possible, this is rare, if implemented at all, in the U.S, and would require a modem in addition to a PCI ATM card, such as the Efficient Networks 3010. There is an ATM project for Linux, that is being incorporated into the 2.4 kernel. (See the Links section for more.)

This may be a viable solution at some point, but it is just not 'there' yet.

3.2. Configuring the WAN Interface

The most common configuration is a DSL modem in 'bridging' mode. Both PPPoE and DHCP can use this setup. In this scenario, the WAN interface typically means your NIC. This is where your system meets the outside world. (If you have a router see below for router specific instructions.) So essentially we will be configuring the NIC, typically 'eth0' since it is an ethernet interface.

With PPPoX, once the connection comes up, there will be a 'ppp0', or similar, interface, just like dialup. This will become the WAN interface once the connection to the PPP server is up, but for configuration purposes we will we be concerned with 'eth0' initially.

There are various ways an ISP may set up your IP connection:

- Static IP.
- Dynamic IP on Bridged Network via DHCP.
- Dynamic IP via PPPoX.
- Static IP via PPPoX.

Let's look at these individually.

3.2.1. Static IP Configuration

A 'static' IP address is an IP that is guaranteed not to change. This is the preferred way to go for those wanting to host a domain or run some type of public server, but is not available from all ISPs. Skip this section if you do not have a static IP, or if you have a router, and the router will be assigned the static IP.

Configure the IP address, subnet mask, default gateway, and DNS server information as provided by the ISP. Each Linux Distribution (Redhat, Debian, Slackware, SuSE, etc.) has a different way of doing this, so check on your distro's docs on this. Each may have their own tools for this. Redhat has **netcfg** for example. You can also do this manually using the **ifconfig** and **route** commands. See the man pages on these or the Net HOWTO for more information and specifics. A quick command line example with bogus IPs:

```
13; # ifconfig eth0 111.222.333.444 up netmask 255.255.255.0
 # route add default gw 111.222.333.1 dev eth0
```

Be sure to add the correct nameservers in `/etc/resolv.conf`.

3.2.2. Bridged/DHCP Configuration

ISPs that have Bridged networks typically use DHCP to assign an IP addresses, and authenticate the user. All distributions come with one or more DHCP clients. **dhcpcd** seems to be the most common. **pump** comes with Redhat based distributions as of Redhat 6.0. The DHCP client will obtain an IP 'lease' from the ISP's server as well as other related information: gateway address, DNS servers, and network mask. The lease will be 'renewed' at regular intervals according to the ISP's configuration.

You will want the DHCP client started on boot, so use your distribution's means of doing this. There generally is little to configure with DHCP as it is fairly straightforward and easy to use. You may need to tell it which interface to listen on if the NIC is something other than 'eth0'. You can also start it from the command line to get started. See the respective man pages for more.

Unless you have a static IP, the ISP will need some way to know who you are when you connect. There are two ways this authentication process is accomplished with DHCP. The first and most common method is via the MAC (or hardware) address of the network device. Typically this would be the NIC. The MAC address is a unique identifier and can be found among the boot messages, or with **ifconfig**, and looks something like `00:50:04:C2:19:BC`. You will need to give the ISP the MAC address before your first connection.

The other DHCP authentication method is via an assigned hostname. In this case, the ISP will have provided you with this information. Your DHCP client will need to pass this information to the server in order for you to connect. Both **dhcpcd** and **pump** accept the '−h' command line option for this purpose. See the client's man page, or your distribution's documentation, for specifics.

Caution! If your ISP uses MAC address authentication, and you change your network device (e.g. NIC), you will need to register the new address with the ISP or you won't be able to connect.

3.2.3. PPPoE Configuration

PPPoE (PPP over Ethernet) is an alternate way for ISPs to control your connection, and is becoming increasingly popular with ISPs. Setting this up is quite different, and may be a little more work than with static IPs or DHCP above. Some distros are now shipping PPPoE clients. If this is not the case for you, then you will have to download one. Check any Linux archive site like http://freshmeat.net, etc. or look below.

Some of the current GPL PPPoE clients available:

- The Roaring Penguin, http://www.roaringpenguin.com/pppoe/, by David F. Skoll. It is under very active development. Reportedly very easy to set up, and get started with. As of right now, this is probably by far and away the most popular Linux PPPoE client.
- PPPoEd: http://www.davin.ottawa.on.ca/pppoe/ by Jamal Hadi Salim. This package does require some kernel patching and other configuration related issues.
- PPPoE Redirector: http://www.ecf.toronto.edu/~stras/pppoe.html. This is a redirector which allows the use of PPPoE with pppd−2.3.7 or later. No recompiling of other system components are required. It is meant as an interim solution until the 2.4.x series, which will include kernel support of PPPoE/A. (Does not seem to be under active development at this time.)
- A purely solution can be found at http://www.math.uwaterloo.ca/~mostrows/ solution by Michal Ostrowski. This requires a 2.3/2.4 kernel. As of this writing, it is still 'experimental. Once the 2.4 kernel goes mainstream, this will be a more viable option.
- EnterNet is a non−GPL'd PPPoE client from NTS, http://www.nts.com, that is being distributed by some ISPs as the Linux client. It does come with source. This is not available for free download. (NTS was just recently purchased by Efficient Networks.)

Depending on which client you have chosen, just follow the `INSTALL` instructions and other documentation included with that package (`README`, `FAQ`, etc.).

Once a PPPoE client connects, your connection should look something like the below example from Roaring Penguin, where 'eth0' is connected to the modem:

```
13;$ route −n

Kernel IP routing table
Destination     Gateway      Genmask         Flags Metric Ref Use Iface
192.168.0.254   *            255.255.255.255 UH    0      0     0 eth1
208.61.124.1    *            255.255.255.255 UH    0      0     0 ppp0
192.168.0.0     *            255.255.255.0   U     0      0     0 eth1
127.0.0.0       *            255.0.0.0       U     0      0     0 lo
default         208.61.124.1 0.0.0.0         UG    0      0     0 ppp0


$ ifconfig

eth0     Link encap:Ethernet  HWaddr 00:A0:CC:33:74:EB
         UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
         RX packets:297581 errors:0 dropped:0 overruns:0 frame:0
         TX packets:266104 errors:1 dropped:0 overruns:0 carrier:2
         collisions:79 txqueuelen:100
         Interrupt:10 Base address:0x1300

eth1     Link encap:Ethernet  HWaddr 00:A0:CC:33:8E:84
         inet addr:192.168.0.254  Bcast:192.168.0.255  Mask:255.255.255.0
         UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
         RX packets:608075 errors:0 dropped:0 overruns:0 frame:0
         TX packets:578065 errors:0 dropped:0 overruns:0 carrier:0
         collisions:105408 txqueuelen:100
         Interrupt:9 Base address:0x1200

lo       Link encap:Local Loopback
         inet addr:127.0.0.1  Mask:255.0.0.0
         UP LOOPBACK RUNNING  MTU:3924  Metric:1
         RX packets:1855 errors:0 dropped:0 overruns:0 frame:0
         TX packets:1855 errors:0 dropped:0 overruns:0 carrier:0
         collisions:0 txqueuelen:0

ppp0     Link encap:Point−to−Point Protocol
         inet addr:208.61.124.28  P−t−P:208.61.124.1  Mask:255.255.255.255
         UP POINTOPOINT RUNNING NOARP MULTICAST  MTU:1492  Metric:1
         RX packets:297579 errors:0 dropped:0 overruns:0 frame:0
         TX packets:266102 errors:0 dropped:0 overruns:0 carrier:0
         collisions:0 txqueuelen:1013;
```

Warning! For PPPoX, the correct setting for the ppp0 interface MTU is 1492. If the MTU is set too high, it may cause failure of some web pages to load properly, and possibly other annoying problems. You may need to also set the MTU for interfaces on any masqueraded LAN connections MTU to 1452.

Actually, for PPPoE the real setting should be at least 8 bytes less than any interface between you and the ultimate destination. All routers normally would be set to 1500, thus 1492 is correct from your end. But, it may happen that somewhere a router is misconfigured at a lower setting, and this can cause problems, especially with web pages loading. The way to test this is to keep dropping the MTU until things work.

3.2.4. PPPoA

PPPoA (PPP over ATM) is a cleaner solution than PPPoE since most of the work is done in hardware, and since the raw DSL traffic is ATM. There is no client necessary to manage the connection as with PPPoE. Authentication is still the same: user id and password to connect, but the mechanics are different since no ethernet encapsulation takes place.

As of this moment, there is not really a viable, working implementation of PPPoA for Linux. There is an ATM patch for 2.2 kernels, support for ATM in the 2.4.x kernel, and a project based on the Efficient Networks 3010 [possibly out of production], as well as other ATM cards. The ATM on Linux homepage is here: http://lrcwww.epfl.ch/linux−atm/. And even more info is at http://www.sfgoth.com/~mitch/linux/atm/pppoatm/ from the kernel developer of this project. Existing PPPoA implementations are hardware/driver based, and Linux PPPoA modem drivers are scarce as hen's teeth at this time. The above modem does not seem to be available through normal retail channels. This may well be a problem, if this is the only protocol an ISP delivers. At the very least, some rather serious hoop jumping is in order.

If PPPoA is your ISP's only option, you might consider one of the router/modems that can handle PPPoA, and let the hardware handle everything.

Note: There is apparently a PPPoA beta program underway based on the Efficient Networks SpeedStream 3060/3061 (PCI, DMT). Efficient is working with kernel developers, and reportedly this program is in late beta at this time. The initial release will be binary only drivers, but open source may follow. This is a big improvement!

3.2.5. Modem/Router Configuration

Some ISPs are providing 'routers' as the connection device. Essentially these are mini routers with built in modems. These are all ethernet based devices too, so Linux should be good to go here as well. Again, a compatible NIC should be all that is required to make this work.

A 'router' has many advantages. The better ones can handle the connection management, IP encapsulation, and authentication, as well as providing a means of segregating your LAN from outside traffic, and possibly other features too. In short they can do it all. One big advantage is that they can handle whatever protocols your ISP requires in order to connect.

If the ISP is requiring PPPoX, then this makes life a little easier since you will not have to install or configure any additional software just to use their network. The modem's firmware will handle this. The downside is that most of these do not have the flexibility of a Linux router, or other software solution. Of course, you could set up a Linux router behind the router, and have the best of both worlds. The ones with more and better features are also going to cost significantly more.

While the physical installation of a router is very similar to the modem installation (see above), the router configuration itself is different since your first 'hop' will be the router's interface and not the ISP's gateway. Routers will actually have two interfaces −− one that you connect to from the LAN side, and one that connects to your ISP on the WAN side. Your point of exposure here is the WAN interface of the router.

The router will also have a pre−configured, private IP address that you will connect to from the LAN side. This will be your gateway. The public IP address will be assigned to the WAN side interface. Typically these devices also act as DHCP servers for the LAN side as well. So possibly all you have to do is to start a DHCP client such as **dhcpcd** or **pump** (Redhat based distros) to get up and running. Just make sure the modem/router is syncing first. The appropriate steps and configuration should be in the owner's manual, or available from your provider.

If you are a PPPoX customer, and the router is handling this part of the connection, then you will have to configure at least your user id and password before connecting. If a Bridged/DHCP customer, you should just have to activate DHCP on the router, and possibly register the MAC (hardware address) of the router with your provider. Some routers have 'MAC cloning' which means that they will report the MAC address of the attached NIC. If static IP, then you will have to configure this as well.

If you need to access the router directly, you will need to know the manufacturer's default setting for its IP address. See the owner's manual, or ask your provider. You will then have to set your NIC's interface to the same network as the router. For instance, if the router has an IP of 10.0.0.1, set your interface's address to 10.0.0.2 (typically eth0), and netmask to 255.0.0.0.

```
13; # ifconfig eth0 10.0.0.2 up netmask 255.0.0.0
 # route add −net 10.0.0.0
 $ ping 10.0.0.113;
```

If everything is in working order, the router should respond to pings. How to configure this permanently will vary from distro to distro. So check your distribution's documentation. Now you should be able to ping the modem/router, and, if all is well, beyond. Then use telnet or a web browser to do any further configuration of the router.

Even if the ISP is not offering any router options, there are quite a few available from third party manufacturers such as Netgear, Linksys, Cisco, Zyxel, Cayman, Alcatel and others. These will have all the features already mentioned and maybe more. Just make sure it matches your provider's DSL. This is one good way around the PPPoX bugaboo.

Warning! Some manufacturers may be marketing these as having 'firewall' capabilities. In some cases, this amounts to nothing more than basic NAT (Network Address Translation or masquerading). Not a full, true firewall by any means. Be sure to read the fine print before buying and make sure you know how much real firewalling is included.

3.3. Connect

Everything should be in place now. You probably have already tested your connection. You should be seeing ping roundtrip times of 10−40 ms to the ISP's gateway. If something has gone wrong, and you cannot connect, either retrace the above steps, or see the Troubleshooting Section below.

4. Securing Your Connection

This section is intended for those who have not previously dealt with the security implications of having a full time Internet connection. Or may not understand some of the basic concepts of security. This is meant to be just a quick overview, not a comprehensive examination of all the issues! Just enough to give you a quick push in the right direction. Please see the Links section for sites with more details. Also, your distribution surely has plenty of good information as well.

4.1. Security Quickstart

Before going on−line full−time, do not underestimate the need for securing your connection. You will have two things that mischief makers and crackers of the world are looking for: bandwidth, and a Unix−like OS. You instantly become an inviting target. And it is just a matter of time before someone comes knocking. Possibly a very short time. A quick start:

- Turn off any daemons and services that aren't absolutely essential, and can be accessed from outside. You can't get compromised through a port that isn't open. Use **ps** and **netstat** to see what services are running. (See man pages for specifics). Do you really need **named**, **sendmail**, **telnet**, **ftp** running and accessible to one and all? If not sure, then they should not be running. Then take whatever steps necessary to make sure they don't start again on the next boot. See your distribution's documentation on this.

  Many distributions start some well known services by default. You may not have done anything yourself explicitly to start these. And may not even realize these are indeed running. But it is up to you to know what is running, and how safe it is. Don't rely on a 'default' installation of any distribution to do this for you, or to be secure. Chances are it isn't.
- If you decide some services are essential, make sure you are running the most current version. Exploits are found, and then get fixed quickly. Don't get caught with your pants down. A full−time connection makes staying updated very easy −− and very important. Check with your distribution to see what new packages are available. And then stay in touch. If they have a security mailing list, get on it.
- Set up a firewall to limit access, and log connection attempts. This will be different depending on which kernel series you are using: **ipfwadm** for 2.0, **ipchains** for 2.2, and **iptables** for 2.4. See these HOWTOs for details:
-
  - Firewall HOWTO
  - Security HOWTO
  - IPCHAINS HOWTO

- IP Masquerade HOWTO

Additional references in the Links Section below.

- Take passwords seriously. Use shadow passwords. Do not allow remote root logins.
- Use **ssh**, or **OpenSSH**, instead of **telnet**.

4.2. Which Ports?

There are plenty of references around on how to setup firewalls with **ipfwadm** or **ipchains**, but a little harder to find just which ports *really need* to be open. If you are not sure of the answer to this question, then the answer is 'as few as possible'! Basic rule #1, your computer cannot be broken into through a port that is not open. And, a port can't be open if nothing is listening on that port. In other words, if no service or daemon is running that uses that port, the port is closed and inaccessible.

There are 65,536 ports available for use on Linux. These fall into several categories. The ones we are most concerned about are the 'privileged' ports, i.e. those below port 1024. This is where most public services run, like SMTP on port 25, HTTP on port 80, named on port 53, etc. These are where most vulnerabilities are on Linux. These are ports that servers accept outside connections on. If you are running the **telnetd** daemon, it will 'listen' for connections on port 23. (Actually if spawned by **inetd**, it may be **inetd** that is listening.)

But, if you want to use a telnet *client* to connect to someone else's telnet server, you do not need to be running the **telnetd** daemon on your own system. You just need to start the client program named '**telnet**' (different animal). Same is true for ftp and other services. These daemons only need to be run for excepting connections to your system from an outside source.

Unless you have a good reason for doing so, and know what you are doing, then you should not be running these services. In fact, you could probably survive quite nicely with all TCP and UDP ports below 1024 closed down. Or, at least not visible to outside connections (i.e. blocked via a firewall). A couple of exceptions:

It is relatively safe, and probably reasonably safe, to run **identd** (port 113). Many mail and irc servers aren't happy without **identd** there. This is the one, good exception to the 'nothing below 1024' rule of thumb. Newer versions are relatively secure.

Mail is a little more complicated. The only reason to have a publicly accessible SMTP (port 25) server is if you are hosting your own mail server and receiving direct incoming mail connections. If you are retrieving mail via POP3 from your ISP, this port does not need to be open to the world. Such mail does not come in via port 25. It comes in through a higher, randomly assigned port.

But −− it may still be convenient to have a mail daemon like sendmail, qmail, or postfix running to handle local mail delivery. In fact, this is a common default set up. You can get around this by firewalling off SMTP (port 25) from the outside world, or using another method to sort and deliver local mail. One way is to use procmail in conjunction with fetchmail: '`fetchmail -m /usr/bin/procmail -d hal`' will do this without having to run sendmail or other mail daemons in daemon mode. These programs are still capable of sending mail in non−daemon mode.

It is probably safe to run a web server if you want to. Most vulnerabilities there are through CGI. Just keep the web server package updated.

OK, enough exceptions. Shut down, or firewall off, *everything else* below port 1024.

Those ports above 1023 are known as 'non−privileged' ports. These are mostly used for return connections that you have initiated to someone else's server. For instance, if you telnet to someone else, you connect to their port 23. The return data comes back to you on a randomly assigned port above 1023. These are mostly safe, and in fact, should as a rule be left alone. The only exceptions are where there are indeed services running on these ports. X Windows runs on ports 6000−6009 for instance. If you are running a font server, it may be on port 7100. Any servers running on these non−privileged ports, should be firewalled too.

4.3. inetd

Let's take a quick look at **inetd**, since it starts many services. **Inetd** is a 'super' daemon. It is called this because it controls the starting of other daemons. Telnet, ftp, rsh, identd and pop3 are some of the server daemons commonly controlled by **inetd**. You may not see **telnetd** running when you use **ps** or **netstat** unless **inetd** is configured to start **telnetd**, *and* someone is actually connected to **telnetd** at the time. So it may not be so obvious which of these servers can be accessed from outside. These sub−services are controlled by the configuration file `/etc/inetd.conf`. Open this with your favorite text editor, and put a '#' character in front of any service you don't want running. A brief excerpt:

```
#ftp    stream tcp nowait root /usr/sbin/tcpd in.wuftpd −l −a −L −i −o
#telnet stream tcp nowait root /usr/sbin/tcpd in.telnetd
#
# Shell, login, exec, comsat and talk are BSD protocols.
#
#shell  stream  tcp     nowait  root    /usr/sbin/tcpd  in.rshd
#login  stream  tcp     nowait  root    /usr/sbin/tcpd  in.rlogind
#exec   stream  tcp     nowait  root    /usr/sbin/tcpd  in.rexecd
#comsat dgram   udp     wait    root    /usr/sbin/tcpd  in.comsat
#talk   dgram   udp     wait    root    /usr/sbin/tcpd  in.talkd
#ntalk  dgram   udp     wait    root    /usr/sbin/tcpd  in.ntalkd
```

This will prevent them from running. **identd** may be started from this file, and would be safe to leave uncommented. Then re−initialize: **inetd**:

```
13; # kill −HUP `pidof inetd`13;
```

Note those are 'backquotes'. For more on fine tuning inetd access via 'tcpwrappers', see the hosts_access and tcpd man pages.

5. Performance Tuning and Troubleshooting

There really are no tweaks, or performance tuning tricks that are likely to increase your performance to any significant degree −− all other things being equal. Windows 9x users often get a big boost by increasing their TCP Receive Window. But this is because it is too small to start with. This is not the case with Linux.

The only exception is if you have to routinely deal with a high latency connection. Such as maybe your provider has a satellite uplink that is consistently adding unusual latency (250ms or greater?). Then maybe a larger window will help. For the overwhelming majority of us, this is not necessary. For more on TCP Receive Window and related issues, look at http://www.psc.edu/networking/perf_tune.html.

If your connection is not performing up to what you think it should be, then possibly there is a problem somewhere. This is more worth looking into than any magical 'tweak'.

A very rough guideline on what you might reasonably expect as a maximum, based on distance from CO:

0−12 Kft − 1500 Kbps or more
12−16 Kft − 1500 Kbps −> 1000 Kbps
16−18 Kft − 1200 Kbps −> 512 Kbps
18−?? Kft − 512 Kbps −> 128 Kbps or less :(

Remember too that you will loose 10−20% of throughput to networking overhead. So a 1500 Kbps connection, is only going to realize about 1200−1300 Kbps or so of real world throughput. No tweaking is going to change this. And remember that if your service is capped at a lesser speed by your provider, then you can't get above that speed no matter what. *AND* −− that there are numerous variables that can effect your loop/signal quality, and subsequently your speed. Many of these are out of your control.

5.1. Installation Problems

Read this section, if you have no sync at all or are completely unable to connect. See your modem's owner's manual for interpreting the modem's LEDs. (Many will show a solid red (or orange) light if not in sync.)

5.1.1. No sync

The modem sync LED has never been green.

- If self−installing, the DSL jack may be wired wrong. The splitter may be wired wrong. The modem may be wired differently than standard telco POTS devices. See above.
- Is the modem Linux compatible? If ethernet interfaced, this should not be a problem. But PCI or USB modems may require drivers just to achieve sync. This could be a show stopper.
- Call your provider and make sure the line was provisioned. It is always possible someone dropped

the ball. They may even be able to run a remote test on your line just to verify. Also, a remote possibility that the DSLAM is down. They should know this as well.

- Disconnect modem power cord and disconnect from wall jack. Plug it into the test jack inside the SNI/NID (outside phone box), and run extension cord if necessary for power cord. Temporarily disconnect the wiring to the inside phone circuit. This should effectively bypass any inside wiring and environmental issues. The ethernet cable to the NIC does not need to be connected just to run this test. The modem will sync fine without it. (Easier said than done in some cases, I know.) But if possible, move enough of your system where you can view the modem's diagnostics (if available) and get the sync rate. If this works, probably something is wired incorrectly inside, or a short in a connection somewhere, or there is severe electrical interference of the DSL signal. Check splitter and wall jack. If a splitterless installation, look for bad (e.g. corroded) connections on *all* jacks, bad splices, or defective microfilters!

  If no sync on the above test, either the line was not readied, or maybe the modem is defective, or the DSLAM is down. Note that PCI and USB modems will need to load drivers before syncing, and thus make this test a little more complicated.
- If you installed microfilters, remove these temporarily and unplug *all* telco devices, such as fax machines, etc. Possibly a mircofilter is defective and shorting out the line.

5.1.2. NIC Problems

Symptoms here are: NIC is not recognized, modules won't load, or **ifconfig** shows the interface is not up or is generating lots of errors.

- Turn off PnP in BIOS. This may be labeled as 'non−Microsoft' OS. A sometimes symptom here is that the NIC is assigned IRQ 0.
- Check for IRQ conflicts with '**cat /proc/interrupts**'. If the NIC is sharing an IRQ, try moving cards around in slots, or tinker with BIOS IRQ settings. If an ISA card, you may need to get the setup utility from the manufacturer and use it to set IRQ, etc. This will require booting to DOS.
- Possibly the wrong module is being loaded. Look through the kernel source documentation in `/usr/src/linux/Documentation/*` for your card or chipset. Also, for comments and update information in `/usr/src/linux/drivers/net/*.c` for your respective chipset. It is worth noting that there are more than one module for some card types. This seems to be true of tulip and 3Com cards. Check boot messages or use '**lspci −v**' to see how the kernel is identifying your card. You can use **insmod**, **rmmod**, and **modprobe** to test different modules. See the respective man pages for more.
- Check the manufacturer's web site for Linux documentation. Or look at Donald Becker's informative site at http://www.scyld.com/network/.
- Some Linux NIC drivers reportedly work better as non−modular. In other words, compiled into the

kernel instead of as a module.

- The card is bad, or the drivers just aren't up to snuff. Try another card.

5.1.3. IP Connection Problems

Read this section if the modem is syncing, the NIC is recognized and seems to be working properly, client software is installed and running without error, but connection to the ISP fails. Verify the modem is indeed syncing by the LED(s). This may be evidenced by **ifconfig** not showing an active eth0 interface (and ppp0 for PPPoX), or **pinging** gateway and other destinations generates `network unreachable` or similar errors.

- Make sure you know which protocol your ISP is using. Are they using DHCP? PPPoX? It is critical that you have this right. You may have to ask tech support.
- If you are using DHCP, does the ISP require MAC address authentication, and if so, do they have the right address? Did they typo it?
- Look at `/var/log/messages` and see if any useful clues are there. Also, run **tcpdump** while trying to initiate the connection. **tcpdump** output is fairly cryptic, but you should certainly be able to see if there is any response at all.
- If PPPoX, is the ISP using `username` as an id, or `username@isp.com`?
- Try pinging the default gateway's address. Get this with '**route −n**'. If you can **ping** by IP address (i.e. 111.222.333.444), but not by hostname, then likely nameservers are not correctly setup in `/etc/resolv.conf`.
- If running a firewall (e.g. with ipchains), temporarily take it down. Possibly this is misconfigured, and not allowing packets through.
- If the modem was purchased from a source other than your ISP, it may the wrong kind of modem. SDSL needs an SDSL modem, for instance. Also, for ADSL there are CAP and DMT encodings, and these are incompatible with each other.

  The modem may need to be configured for your ISP's service. All modems have configurations for VCI, VPI, encapsulation, etc. Call tech support for this information.

5.2. Sync Problems

Read this section if you have had a working connection, but now have lost sync, or are intermittently losing sync, or your sync rate has dropped significantly, or are getting a 'sync/no surf' condition. (Better quality modems will have a way to report sync rate. Usually via telnet or a web browser interface. See the owner's manual.)

A loss of sync indicates a problem with the DSLAM, your line (inside or outside) or your modem. DSLAMs typically have 'shelves' with 'cards'. Alcatel DSLAM cards, just for instance, have a capacity of four connections each. If the card goes bad, at most four customers are effected. The point being that sync loss outages can be very isolated. Unlike network outages that tend to effect large numbers of users. Sync outages are also a telco problem, not an ISP problem. If your service agreement is with the ISP, you will need to contact them, who will in turn contact the telco.

Degraded sync rates, and disruption of the DSL signal, can cause various problems. Obviously, you will never get your maximum throughput under these conditions. But, the symptoms are not always obvious as to whether the problem is on your end or the provider's.

For instance, a poor inside wire connection may result in retransmissions of packets that have been lost, or dropped. This can really reduce throughput and slow a connection down. It is tempting to think of lost packets as a traditional networking problem, but with DSL it is possible to be the result of a bad line, impaired signal, or even the modem itself.

Some things to try:

- Power cycle the modem. Turn off the power button/switch, and physically unplug the cable to the wall jack for 30 seconds or so. Turn back on, and re−attach to wall jack. This will force a resync. Unfortunately, the only way to power down a PCI modem, is to reboot. This should fix a 'sync/no surf' condition that is caused by the modem, and maybe other conditions too.
- See the above section on moving the modem lock, stock and barrel to the NID/SNI and thus bypassing all inside wiring. If the situation is improved there, then the problem is inside somewhere. If not, it is a telco problem.
- RFI Bear−hunt: The DSL signal is fragile. A number of things can degrade it. RFI, or Radio Frequency Interference, from sources in and around the home/office is one common source of reduced signal strength, and/or intermittent sync loss and/or low sync rates. Our test tool here is simply a portable AM radio. Tune it to any channel where you can get clear reception −− makes no difference where. The AM radio will pick up RFI that is in the same frequency range as the DSL signal. It will sound like 'frying bacon' type static. Put against your computer's power supply. You should hear some static. Move it away and the static should fade pretty quickly. This will give you an idea of what RFI sounds like. A decent quality power supply should produce only weak RFI −− probably not enough to cause a problem. Use the radio like a Geiger counter and move it around your modem and DSL line. If you hear static, follow it to the source. Things to be suspicious of: power supplies, transformers, ballasts, electric motors, dimmer switches, high intensity lighting. Moving modem, or rerouting cables, is sometimes enough. Keeping the line between the modem and the wall jack as short as possible is a good idea too.

- Chronic sync problems are often due to a line problem somewhere. Sometimes it is something as simple as a bad splice, and easily remedied if it can be found. Most such conditions can be isolated by a good telco tech. Check with your provider, and politely harass if you have to. If you get the run−around, ask to go over their heads.
- If you are near the distance limits of DSL, and having off and on sync problems, try the 'homerun' installation. See above. This can be effective in improving marginal signal/sync conditions.
- If using a surge protector, try it without the surge protector. Some may interfere with the DSL signal.

Another possibility is a nearby AM radio station, or bandit ham radio operator that are disrupting the DSL signal since they operate in a similar frequency range. These may only cause problems at certain times of day, like when the station boosts its signal at night. A good telco DSL tech may be able to help minimize the impact of this. YMMV.

5.3. Network and Throughput Problems

Read this section if your connection is up, but are having throughput problems. In other words, your speed isn't what it should be based on your bit rate plan, and your distance from the CO. 'Network' here is the WAN −− the ISP's gateway and local subnet/backbone, etc. Remember too that a marginal line can cause a reduced sync rate, and this will impact throughput. See above.

The two factors we will be looking for are 'latency' and 'packet loss'. Both are pretty easy to track down with the standard networking tools **ping** and **traceroute**. If either of these occur in our path, they will impact performance. Latency means 'responsiveness' or 'lag time'. Actually what we are interested in is abnormally high latency, since there is always some latency. Packet loss is when a packet of data gets dropped somewhere along the way. TCP/IP will know it's been 'lost', and there will be a retransmission of the lost data. Enough of this can really slow things down. Ideally packet loss should be 0%.

Also, what we really need to be concerned about, is that part of the WAN route that we routinely traverse. If you do a traceroute to several different sites, you will probably see that the first few 'hops' tend to be the same. These are your ISP's local backbone, and your ISP's upstream provider's gateway. Any problem with any of this, and it will effect everywhere you go, and everything you do.

We can start looking for packet loss and latency by pinging two or three different sites, hopefully in at least a couple of different directions. We will be looking for packet loss and/or unusually high latency.

```
13; $ ping −c 12 −n www.linuxdoc.org
 PING www.linuxdoc.org (152.19.254.81) : 56(84) bytes of data.
 64 bytes from 152.19.254.81: icmp_seq=0 ttl=242 time=62.1 ms
 64 bytes from 152.19.254.81: icmp_seq=1 ttl=242 time=60.8 ms
 64 bytes from 152.19.254.81: icmp_seq=2 ttl=242 time=59.9 ms
 64 bytes from 152.19.254.81: icmp_seq=3 ttl=242 time=61.8 ms
 64 bytes from 152.19.254.81: icmp_seq=4 ttl=242 time=64.1 ms
 64 bytes from 152.19.254.81: icmp_seq=5 ttl=242 time=62.8 ms
 64 bytes from 152.19.254.81: icmp_seq=6 ttl=242 time=62.6 ms
 64 bytes from 152.19.254.81: icmp_seq=7 ttl=242 time=60.3 ms
 64 bytes from 152.19.254.81: icmp_seq=8 ttl=242 time=61.1 ms
 64 bytes from 152.19.254.81: icmp_seq=9 ttl=242 time=60.9 ms
 64 bytes from 152.19.254.81: icmp_seq=10 ttl=242 time=62.4 ms
 64 bytes from 152.19.254.81: icmp_seq=11 ttl=242 time=63.0 ms
 −−− www.linuxdoc.org ping statistics −−−
 12 packets transmitted, 12 packets received, 0% packet loss
 round−trip min/avg/max = 59.9/61.8/64.1 ms13;
```

The above example is pretty normal from here. (You probably have a very different route to this site, and your results may thus be quite different.) Apparently no serious underlying problems that would slow me down. The below example reveals a problem:

```
13; $ ping −c 20 −n www.debian.org

 PING www.debian.org (198.186.203.20) : 56(84) bytes of data.
 64 bytes from 198.186.203.20: icmp_seq=0 ttl=241 time=404.9 ms
 64 bytes from 198.186.203.20: icmp_seq=1 ttl=241 time=394.9 ms
 64 bytes from 198.186.203.20: icmp_seq=2 ttl=241 time=402.1 ms
 64 bytes from 198.186.203.20: icmp_seq=4 ttl=241 time=2870.3 ms
 64 bytes from 198.186.203.20: icmp_seq=7 ttl=241 time=126.9 ms
 64 bytes from 198.186.203.20: icmp_seq=12 ttl=241 time=88.3 ms
 64 bytes from 198.186.203.20: icmp_seq=13 ttl=241 time=87.9 ms
 64 bytes from 198.186.203.20: icmp_seq=14 ttl=241 time=87.7 ms
 64 bytes from 198.186.203.20: icmp_seq=15 ttl=241 time=85.0 ms
 64 bytes from 198.186.203.20: icmp_seq=16 ttl=241 time=84.5 ms
 64 bytes from 198.186.203.20: icmp_seq=17 ttl=241 time=90.7 ms
 64 bytes from 198.186.203.20: icmp_seq=18 ttl=241 time=87.3 ms
 64 bytes from 198.186.203.20: icmp_seq=19 ttl=241 time=87.6 ms

 −−− www.debian.org ping statistics −−−
 20 packets transmitted, 13 packets received, 35% packet loss
 round−trip min/avg/max = 84.5/376.7/2870.3 ms13;
```

High packet loss at 35%, and some really slow roundtrip times in there as well. A little digging on this showed that it was a backbone router 13 hops into the traceroute that was the problem. While making this site really slow from here, it would only effect those routes that happen to hit that same router. Now what would really hurt us is if something similar happens with a router that we tend to go through consistently. Like our gateway, or maybe the second hop router too. Find these with **traceroute**, by just picking a random site:

```
13; $ traceroute www.bellsouth.net

 traceroute to bellsouth.net (192.223.22.134), 30 hops max, 38 byte packets
  1  adsl−78−196−1.sdf.bellsouth.net (216.78.196.1)  14.86ms  7.96ms 12.59ms
  2  205.152.133.65 (205.152.133.65)                  7.90ms  8.12ms  7.73ms
  3  205.152.133.248 (205.152.133.248)                8.99ms  8.52ms  8.17ms
  4  Hssi4−1−0.GW1.IND1.ALTER.NET (157.130.100.153)  11.36ms 11.48ms 11.72ms
  5  125.ATM3−0.XR2.CHI4.ALTER.NET (146.188.208.106) 14.46ms 14.23ms 14.40ms
  6  194.at−1−0−0.TR2.CHI2.ALTER.NET (152.63.65.66)  16.48ms 15.69ms 16.37ms
  7  126.at−5−1−0.TR2.ATL5.ALTER.NET (152.63.0.213)  65.66ms 66.18ms 66.39ms
  8  296.ATM6−0.XR2.ATL1.ALTER.NET (152.63.81.37)    66.86ms 66.42ms 66.40ms
  9  194.ATM8−0.GW1.ATL3.ALTER.NET (146.188.233.53)  67.87ms 68.69ms 69.63ms
 10  IMVI−gw.customer.ALTER.NET (157.130.69.202)     69.88ms 69.25ms 69.35ms
 11  www.bellsouth.net (192.223.22.134)              68.74ms 69.06ms 68.05ms13;
```

The first hop is the gateway. In fact, for me the first two hops are *always* the same, and the first three or four are often the same. So a problem with any of these, may cause a problem anywhere I go. (The specifics of your own situation may be a little different than this example.) A 'normal' gateway ping (for me!):

```
 $ ping −c 12 −n 216.78.196.1

 PING 216.78.196.1 (216.78.196.1) : 56(84) bytes of data.
 64 bytes from 216.78.196.1: icmp_seq=0 ttl=64 time=14.6 ms
 64 bytes from 216.78.196.1: icmp_seq=1 ttl=64 time=15.4 ms
 64 bytes from 216.78.196.1: icmp_seq=2 ttl=64 time=15.0 ms
 64 bytes from 216.78.196.1: icmp_seq=3 ttl=64 time=15.2 ms
 64 bytes from 216.78.196.1: icmp_seq=4 ttl=64 time=14.9 ms
 64 bytes from 216.78.196.1: icmp_seq=5 ttl=64 time=15.3 ms
 64 bytes from 216.78.196.1: icmp_seq=6 ttl=64 time=15.4 ms
 64 bytes from 216.78.196.1: icmp_seq=7 ttl=64 time=15.0 ms
 64 bytes from 216.78.196.1: icmp_seq=8 ttl=64 time=14.7 ms
 64 bytes from 216.78.196.1: icmp_seq=9 ttl=64 time=14.9 ms
 64 bytes from 216.78.196.1: icmp_seq=10 ttl=64 time=16.2 ms
 64 bytes from 216.78.196.1: icmp_seq=11 ttl=64 time=14.8 ms

 --- 216.78.196.1 ping statistics ---
 12 packets transmitted, 12 packets received, 0% packet loss
 round−trip min/avg/max = 14.6/15.1/16.2 ms13;
```

And a problem with the same gateway on a different day:

```
13; $ ping  −c 12 −n 216.78.196.1

 PING 216.78.196.1 (216.78.196.1) : 56(84) bytes of data.
 64 bytes from 216.78.196.1: icmp_seq=0 ttl=64 time=20.5 ms
 64 bytes from 216.78.196.1: icmp_seq=3 ttl=64 time=22.0 ms
 64 bytes from 216.78.196.1: icmp_seq=4 ttl=64 time=21.8 ms
 64 bytes from 216.78.196.1: icmp_seq=6 ttl=64 time=32.0 ms
 64 bytes from 216.78.196.1: icmp_seq=8 ttl=64 time=21.7 ms
 64 bytes from 216.78.196.1: icmp_seq=9 ttl=64 time=42.0 ms
 64 bytes from 216.78.196.1: icmp_seq=10 ttl=64 time=26.8 ms

 --- adsl−78−196−1.sdf.bellsouth.net ping statistics ---
 12 packets transmitted, 7 packets received, 41% packet loss
 round−trip min/avg/max = 20.5/25.6/42.0 ms13;
```

41% packet loss is very high. To the point where many services, like HTTP, come to a screeching halt. Those services that were working, were working very, very slowly.

It's a little tempting on this last real−life example to think this gateway router is acting up. But, as it turned out, this was the result of a problem in the DSLAM/ATM segment of the telco's network. So any first hop problem with packet loss or high latency, may actually be the result of something occurring before the first hop. But we just don't have the tools to isolate where it is starting well enough. Packet loss can be a telco problem, just as much as an ISP/NSP problem.

It is also quite possible for the modem itself to cause packet loss. The fix here is to power cycle the modem, and resync by unplugging the DSL connection for 30 seconds or so. In fact, any part of the connection can be a source of packet loss −− modem, DSLAM, ATM network, etc.

If you do find a problem within your ISP's network, it's time to report the problem to tech support.

5.3.1. Miscellaneous Network Problems

Some odds and ends:

- *Some Web pages won't load.* For PPPoX users only, the MTU value could be too high. The correct ppp0 device setting should be 1492, but actually it needs to be 8 bytes less than any router you pass through on the way to the site. If a router somewhere is misconfigured, you could have problems. Try experimenting with lower MTU values. Any LAN hosts behind the connection, may even need to be lower −− 1452 or maybe even 1412.
- *Ping by IP address* works, but not hostname, the nameservers are not being setup correctly in `/etc/resolv.conf`. Check your client's (DHCP, PPPoX) documentation or enter these manually with a text editor.
- *PPPoX disconnects*. Unfortunately, there is a tendency for PPPoX do drop connections. PPP is apparently sensitive to any line condition which results in a temporary interruption of the connection. This may not be completely solvable, depending on what and where the problem is. You might try a different client, or check your current client's documentation on this issue. Worse comes to worse, set up a cron job to watch the connection, and re−establish if necessary.
- *Interface or route goes down for no reason*. If **ifconfig** and/or **route** show the interface and/or route has automagically disappeared, it may be due to a buggy NIC driver. This may also happen with DHCP if the server does not respond for long periods of time. (Possibly a bug in the client? I have seen this with early versions of **pump** from Redhat. HB.)
- Sub−par performance, or errors with the interface (e.g. eth0), may possibly be caused by a duplex mismatch. This would be most apparent when maxing out the connection. Most DSL modems and routers typically are set to half duplex, and your NIC should be set likewise.

5.4. Measuring Throughput

No such thing as too fast, right? One of the first things most of us do is check our speeds to make sure we aren't getting short changed, and that our system is up to snuff. Doing this accurately is easier said than done however. First, remember you are losing 10−20% right off the top due to networking overhead. Just how much is 'lost' here depends on your provider's network architecture and other considerations.

Then, any time you hit the Internet, there is some slight degradation of performance with each hop you take. Now this may not amount to much, as long as you are not taking too many hops and all the components −− your system, your ISP's network, your ISP's upstream provider, and the destination itself −− are all working like well oiled machines. But there's the rub −− how do you really know with so many variables in the mix? One flaky interface, on one router, on one hop along the path, may cause misleading results.

Your absolute max speed is going to be at your point of connection to your ISP −− the ISP's gateway. It can only go downhill from there, not up! So the ideal test is as close to home as possible. This eliminates as many unknown variables as possible. If your ISP has a local ftp server, this is an excellent place to run your own tests. (Run a traceroute though just to see how local it really is.)

If your ISP does not have this, look for an ftp site that is close −− the fewer the hops, the better. And look for one that isn't too busy, or you will get misleading results. Find a large file −− like 10 Megs −− and time the download. Try this over several days, and at different times of day. The server, and the backbone, are going to be busier at certain times of day, which can skew results and you want to eliminate these variables as much as possible. Your provider cannot compensate for heavy backbone traffic, backbone bottlenecks, slow or busy servers, etc.

There are many test sites scattered around the web. Some are better than others, but take these with a grain of salt. There are just too many variables for these tests to reliably give you an accurate snapshot of your connection and throughput. They may give you a general picture of whether you are in the ballpark of where you think you should be or not. One good speed test is http://www.dslreports.com/stest/0. Another test is http://speedtest.mybc.com/ (both are java). I find these to be better than some of the others out there.

Now keeping in mind that we are limited by the ~10−20% networking overhead rule, here is an example. My speed is capped at 1472 Kbps. Minus the ~15% is 1275 Kbps. My sync rate is known to be good and my distance to the CO is about 9000 Ft, which is close enough that I should be able to hit my real world maximum throughput of 1275 Kbps or roughly 1.2−1.3 Mbps −− all other things being equal. From dslreports.com speed test:

```
13; Test running..Downloaded 60900bytes in 5918ms
 Downloaded 696000bytes in 4914ms
 First guess is 1133kbps
 fairly fast line − now test 2mb
 Downloaded 1679100bytes in 11090ms
 Upload got ok 1 bytes uploaded
 Uploaded 1bytes in 211ms
 Upload got ok 1 bytes uploaded
 Uploaded 1bytes in 205ms
 Upload got ok 1 bytes uploaded
 Uploaded 1bytes in 207ms
 Upload got ok 50000 bytes uploaded
 Uploaded 50000bytes in 2065ms
 Upload got ok 100000 bytes uploaded
 Uploaded 100000bytes in 3911ms

 ** Speed 1211(down)/215(up) kbps **
 (At least 24 times faster than a 56k modem)
 Finish.13;
```

1.211 Mbps is probably about as good as I can realistically expect based on my service. There is no reason for me to go troubleshooting or looking for tweaks.

Big Caution: my ISP uses a caching proxy server for web pages. This is a big equalizer for these kinds of web based tests. Without that, I surely would have been significantly slower on this test. The effect of the proxy is that you are actually testing throughput from the proxy −− NOT the test site. Just FYI. Another note: at the same time I tried another test site and was consistently getting 600−700 Kbps. So YMMV with these tests. (Usually I get the same on each, more or less.) Timing a large ftp download, I calculated about 1.25 Mbps.

6. Appendix: DSL Overview

DSL is a telephone loop technology that uses existing copper phones lines, and provides a dedicated, high speed Internet connection. One of the big advantages of some DSLs (notably ADSL), are that they can co−exist on the same line with a traditional voice service or 'POTS' (Plain Old Telephone Service). This is accomplished by utilizing different frequency ranges above the voice range (voice is up to 4KHz). Essentially, this gives two lines in one: one for POTS, and one for Internet connectivity. When all is working normally, there should be no interference between the two 'lines'. This gives DSL a potentially broad consumer base, and helps minimize costs for providers.

DSL is positioned for the Home and Small Office (SOHO) market that is looking for high speed Internet access at reasonable prices. Since it also typically provides dedicated, 'always on' access, it can be used for interconnecting low to mid range bandwidth servers, and provides a great access solution for small LANs. It is also great for those Linux power users that just want a fast pipe :−).

Phone companies, and other independent telecommunications providers (CLECs), are now deploying DSL as fast as they can to stay ahead of the Cable companies −− the main consumer and SOHO competition for DSL providers. This mad rush to get 'a piece of the pie', is bringing much competition (a good thing!), much diversity, and some confusion, into the consumer market. The DSL provider (often, but not always, the phone company) will provide the DSL infrastructure. This would include your line, the DSLAM, and physical connection to the outside world. From there it is typically picked up by an ISP, who provides the traditional Internet services.

Consumer DSL plans are typically 'best effort' services. While boasting speeds approaching T1, and even surpassing that in some cases, it is not necessarily as reliable as T1 however. Business class DSL offers more reliability at a higher cost than consumer plans, and is a good compromise where both reliability and bandwidth are at a premium. All in all, the cost of DSL compared to traditional telco services, such as T1, is attractive and substantially more affordable for home and small business users.

DSL providers generally do not have service contracts for home users, while business class DSL services typically do include similar SLA (service level agreements) to that offered for a T1 line.

The downside is that DSL is not available everywhere. Availability, and available bit rate (speed), are purely a function of where you live, where the telco has installed the prerequisite hardware, how far you are from the DSLAM/CO, and the quality of your phone line (loop). Not all loops are created equal, unfortunately. The primary limitation is distance.

6.1. The DSL Family

- **ADSL**

  Asymmetric Digital Subscriber Loop. This DSL type currently supports downstream rates up to 8 Mbps, and upstream of 1024 Kbps, hence the 'asymmetric'. The most widely deployed form of DSL at this time, and was specifically developed for the home and SOHO markets. The higher downstream rates lends itself to those not running serious servers −− at least anything more than a small, personal web site. ADSL is capable of sharing data with a POTS voice line, so an additional line is not required. A big selling point. ADSL, like other DSLs, is limited by distance. 18,000 ft (5.5 km) is a typical cut−off point for telcos. ADSL does typically require either a splitter or filters to isolate the DSL signal from POTS. Sometimes referred to as 'full rate' ADSL in order to differentiate it from G.Lite DSL. There are two common line encodings for ADSL: DMT and CAP. DMT (a.k.a. Alcatel compatible) has won the standards battle and is now the more common of the two. Also, note that modems must be compatible with the encoding. In other words, a CAP modem will not work with a DMT service, and vice versa.

- **G.Lite**

  Sometimes called 'DSL Lite', 'Universal DSL' or 'splitterless ADSL', is a slower version of ADSL that require no splitters *or* filters. The isolation of voice and data signals is handled at the CO. Currently G.Lite supports speeds up to 1.5 Mbps/512 Kbps, and is expected to eventually become the dominant consumer DSL service. As of this writing, it is not as wide spread as 'full rate' ADSL however.
- **SDSL**

  Single−pair Digital Subscriber Loop, or also sometimes referred to as 'Symmetric Digital Subscriber Loop' since it is indeed symmetric with a current maximum rate of 1.5 Mbps/1.5 Mbps. SDSL requires a dedicated line, and thus true SDSL is not as readily adaptable to the consumer market as ADSL. SDSL also uses a 2B1Q encoding (same as ISDN and some T1) which is considered more robust than the DMT or CAP encoding of ADSL. True SDSL is generally considered more of a server quality DSL. It is worth noting that some providers may be marketing a 'SDSL' service that is really ADSL pinched so that upstream/downstream are the same. Wasn't all this confusing enough already?
- **IDSL**

  ISDN Digital Subscriber Loop, 144 Kbps/144 Kbps is really a new and improved ISDN from Lucent Technologies and uses the same 2B1Q line encoding as ISDN, SDSL and others. IDSL does require a dedicated line however. The benefits are that it is an 'always on' technology, like other DSLs, and provides an additional 16 Kbps over traditional ISDN. It is being marketed by some DSL providers as a low end bit rate option, where line quality is not sufficient for higher speeds such as that of ADSL.
- **RADSL**

  Rate Adaptive Digital Subscriber Loop was developed by Westell and has a potential of 2.2 Mbps downstream and 1.0 Mbps upstream. What makes RADSL more flexible is that the sync rate can be dynamically adjusted up or down as line conditions change. This makes it more of a viable alternative where line conditions are marginal. In many respects, RADSL is an enhanced ADSL to meet a more diverse set of line conditions. Like ADSL, RADSL can piggyback on the POTS line.
- **HDSL**

  High bit−rate DSL was one of earliest versions of DSL. HDSL requires multiple, dedicated wire pairs, and is symmetric at 1.5 Mbps/1.5 Mbps (actually depends on number of wire pairs used). Not a viable alternative for the consumer or SOHO markets.
- **VDSL**

  Very high rate Digital Subscriber Loop, a DSL still in development with a current downstream capacity of 52.8 Mbps, and upstream of 2.3 Mbps. At this time, VDSL is limited to very short loop lengths, and is not a viable alternative (yet). It may find application where there is fiber to the neighborhood, and thus the copper loop segment is relatively short.
-

UDSL

Unidirectional Digital Subscriber Loop is a proposal from Europe that is not yet in use.

- **G.SHDSL**

  Standards not finalized yet. Supposedly includes many enhancements.

6.2. The DSLAM

This technology is made possible by the placement of DSLAMs, or Digital Subscriber Loop Access Multiplexers, from such suppliers as Alcatel and Cisco, in the telco's Central Office. DSLAMs come in various shapes and sizes, and are the one, single complex and costly component of a DSL connection. When a qualified phone line is connected to a modem at the user's end of the loop, a high speed digital connection is established, typically over ATM, or sometimes frame relay. The DSLAM splits the signal back into separate voice and data channels. The voice channel stays within the telco network, whereas the data is picked up by an ISP.

Figure 4: A Typical DSL Connection Path

```
 Voice −+                                  +−−−> Voice
        |<−− copper loop −−> DSLAM/CO <−−{ATM cloud}−−−>|
 modem −+                      |                  +−−−> Inet
        |                      |                  |
 ether..|..... DSL/ATM here ....|.... raw ATM here .....|.. TCP/IP ..
        |                                         |
 SOHO...|............ telco (ILEC or CLEC) .............|.. ISP ..| NSP
```

6.2.1. Sync

A good, working connection to the DSLAM is referred to as 'syncing'. Without sync, nothing happens. The modem will establish a sync rate which is often throttled by the provider at a predefined limit. This limit, or 'cap', is at the provider's discretion and is part of the service that is being provided. Your modem may well sync at a higher rate than the 'cap', but your speed will be limited to whatever 'cap' the provider is enforcing. So while ADSL has an upward theoretical limit of 8 Mbps, you will not see that speed −− unless of course your provider is selling an 8 Mbps plan. Most plans are well below this.

Below is the status information from a SpeedStream 5660 modem/router via the built−in telnet interface. In this example, the customer is on a 1.5 Mbps/384 Kbps service:

```
13; Command−62; show dslstatus

 −−− Channel Info              ATU−R                    ATU−C
  Current TX Rate  −          384000                  1500000
  Previous TX Rate −               0                        0
  CRC Block Length −                −                        −
  Interleave Delay −                −                        −

 −−− Physical Layer Info        ATU−R                    ATU−C
  Current Attainable Rate −    448433                  3890243
  Current SNR Margin      −      10.5                     17.0
  Current Attenuation     −      54.5                     31.5
  Current Output Power    −       3.0                     16.0
  Current Status:
   Defects detected       −        No                       No
   Loss of Framing        −   No Loss                  No Loss
   Loss of Signal         −   No Loss                  No Loss
   Loss of Power          −   No Loss                  No Loss
   Loss of Signal Quality −   No Loss                  No Loss

 −−− ATU−R Line Status
  Line Coding − DMT
  Line Type   − Fast or Interleaved

 Command−62;13;
```

First notice the 'Current Attainable Rate' in the 'ATU−C' column. This is the downstream sync rate negotiated by the modem and DSLAM, which is over 3.5 Mbps. The actual speed is limited, however, to 1.5 Mbps/384 Kbps from the first row 'TX Rate'. This is the theoretical limit of this connection. This limit, or 'cap', can be enforced at the DSLAM, as is the case the here, or further upstream. Had the first row 'TX Rate' been lower than the provider's imposed limit, then this would indicate some kind of problem with the connection, perhaps due to distance or some kind of line impairment.

The attainable sync rate is the result of a number of factors, including wire distance to the DSLAM, quality of both inside and outside wiring, the loop wire gauge and various other factors within the loop. Actual measurable, real world throughput, on the other hand, is first of all dependent on sync rate. Low sync rate means low throughput. In the above example, had the sync rate been lower, say 500 Kbps, then that would be the maximum for that connection, even though the customer is paying for a 1.5 Mbps service.

Secondarily, throughput will depend also on the ISP's network, and then the ISP's upstream provider. You will lose approximately 10−20% of potential throughput to networking overhead. In the above example where the connection is throttled at 1.5 Mbps, the actual, real−world maximum throughput would be somewhere around 1.2−1.3 Mbps when overhead is taken into account. Moreover, once you hit the Internet proper, all bets are off as there are any number of factors that may impact throughput. A overloaded or busy server is likely to be slow no matter how fast your DSL connection is.

6.3. DSL Modems

The modem is the last piece of the connection. The modem is connected directly to the DSLAM via the copper loop on the telco end, and plugs into a wall jack on your end. When all is well, the modem 'syncs' with the DSLAM, and then makes an IP connection to the ISP. And off we go!

For Linux users, *the modem is a very important consideration*! You will need an external, ethernet interfaced modem (or modem/router combo) that connects via a standard NIC, since virtually all other modem options (PCI, USB, onboard) will not work due to a lack of drivers at this time! All ethernet based modems will work fine.

The only potential compatibility issue is the Network Card (NIC). (And really any compatible ethernet NIC should do just fine −− 100 Mbps is not necessary.) You are probably better off anyway, since PCI and USB modems are more problem prone. If your chosen provider does not offer a compatible modem as an option, then you either need to look elsewhere, or you will have to buy one outright from a third party.

As always there are exceptions. Diamond makes an internal PCI modem which has binary−only drivers, and is not in widespread use. Efficient Networks is beta testing Linux drivers for their SpeedStream 3060 and 3061 PCI modems, and is expected to be released 'any day'. At this time, this will require a 2.4.x kernel, and a patch as well for the necessary ATM support. Efficient is working with kernel developers to make their products Linux compatible. The initial version will have binary drivers only, but open sourced drivers are future possibility. It is also possible to make a direct ATM connection using a modem plus an ATM card, though this delivery system is not used in the U.S. as far as I know, and should not be considered as a viable option. This also requires a 2.4 kernel.

The most common type of modem in use today is actually a combination 'bridge' and modem device. The bridge is a simple device, typically with little configuration. Network traffic passes blindly across the bridge in either direction. Your point of exposure is the interface (typically a NIC) that is connected to the modem/bridge.

Some ISPs may also be offering 'routers'. These are basically combination modem/routers that can handle NAT, and may have other feature enhancements such as port forwarding, a built in hub, etc. These are all external, so should work too. But probably not a big deal for Linux users, since Linux can do anything these do, and more. A locked down Linux box makes a most excellent firewall/gateway/proxy!

To confuse things even more, there are also all−in−one devices: combo bridge+router+modem, sometimes called 'brouters'. In this case, the modem can be configured for either bridging or routing −− but it can't be both at the same time.

All providers should make available a 'modem' of some sort. Many ISPs will have more than one modem option. Some may give away the modem at no additional charge. Some may offer a free base model, and charge the difference for the better models with more features. Many of the modems that ISPs supply are not available through normal retail channels. Should you want to buy one yourself, this leaves used equipment outlets (e.g. ebay), or possibly buying a modem that your ISP may not support (i.e. a possibility of no tech support if you have a problem).

While some ISPs provide modems that are not readily available through normal retail channels, there are a number of manufacturers that are getting on the DSL modem bandwagon, and offering a good selection. Most have a number of enhancements. At this time Netgear, Linksys, Zyxel, Cisco, 3Com, and Cayman have products available. Depending on model and feature set, prices range from a little over $100 US to $800 and up. Many of these handle their own authentication and encapsulation (DHCP, PPPoE, etc).

Are some modems better than others? Well, fortunately for us the external, ethernet interfaced modems are the most reliable anyway. Fewer IRQ hassles, no buggy drivers, etc. So a blessing in disguise really. Are any of these better than others? Probably not. None are faster anyway. Certainly some may have more features, like the combo modem/routers. But realistically, most of this is so new there is not enough of a track record to compare brands and models with any degree of assurance. In other words, any old external, ethernet modem should do −− provided it matches your provider's DSL, and is configured for that service.

Warning! Make sure any third party modem or router you may purchase is compatible with your DSL provider. There are two major line encodings for ADSL (CAP, DMT a.k.a. Alcatel compatible), and several options for IP encapsulation. And different DSLs (SDSL, IDSL, etc) will require their own modem too. Your provider should have a list of compatible options. It may well have to be configured for your ISP's service too. Don't expect it to work right out of the box either (unless it comes from your provider). Many are accessible via telnet, or a web browser, where the configuration options are available. See the owner's manual for this.

6.4. The ISP Connection

The modem connects to the DSLAM, and then the DSLAM is connected to the telco's ATM network (or frame relay), where it is picked up by the ISP. The ISP will take over at what we 'see' as the first hop on a **traceroute**. Everything up to that point is in the hands of the telco/DSL provider. The ISP will connect to the ATM side of the DSLAM via a high−speed data connection, usually ATM over a T3 (45 Mbps) or OC−3 (155 Mbps). The important thing here is that an ISP must 'subscribe' with your telco to provide this connection. The ISP will provide traditional ISP type services: email, DNS, news, etc. It is really a two step connection −− DSL from one provider, Internet from a second −− even though these may be combined into one billing.

The Baby Bells (RBOCs) all own their own ISPs. These, of course, are connected to their DSLAMs, and are providing Internet services via the telco's ISP subsidiary. But, also many independent ISPs are availing themselves of the ILEC's DSL services, and in essence 'reselling' the DSL services of the ILEC. While the underlying infrastructure is the same in this case, having more than one ISP working out of a CO may mean a better selection of features and prices for the consumer.

Also, CLECs (independent telcos) are now installing their own DSLAMs. This makes them a direct competitor to the ILEC. In this scenario, there would be two (or more) DSL providers in the same CO, each with their own DSLAM(s), and each competing against each other. This complicates the ISP situation even further, as each DSL provider will be 'partnered' with one or more ISPs. If you are lucky here, you will have many choices of plans and pricing structures.

Typically, your service agreement is with the ISP, and not the DSL provider. This makes the actual DSL provider a 'behind the scenes' player. Though this may vary, and in some cases, you may wind up with a separate service agreement for both the DSL provider and the ISP.

See the Appendix for a list of Linux Friendly ISPs.

6.5. Availability

Who can get DSL? The first requirement is that a telco has installed the necessary hardware in your CO. You have no choice on which CO is yours −− it is wherever your loop terminates. If your CO has a DSLAM, and the necessary other components, then DSL may be available to you. This is often known as 'pre−qualifying', and is step one in getting service.

6.5.1. Ordering

Before ordering service, check to see what providers there are in your area. You may have several options, including the large phone companies, as well as smaller, local ISPs. Once an order is placed, you must wait for the qualification process before a provider will agree to provide service.

6.5.2. Qualifying

Once local availability is established, the next step is 'qualifying' your loop. The provider will run various tests to make sure that your loop can handle the DSL signal. This is to determine how suitable your line is for DSL, and maybe what level of service will be available to you. You probably will have to order service just to find this much out. It can be a fairly involved process, with a variety of different tests being run. There are a number of things that may 'disqualify' a line. The most common limitation is distance.

All DSLs have distance limitations. ADSL is limited to a loop length of roughly 18,000 ft (5.5 km), but the actual cut off point will vary from provider to provider. The further away you are, the weaker the signal, and the potential for poor connections is greater. With ADSL, if you are within approximately 12,000 ft (3.7 km), you should be able to get at least 1.5 Mbps −− all other things being equal. IDSL has even greater reach, mainly because the maximum speed for IDSL is considerably lower at 144 Kbps/144 Kbps.

Still even if close enough, there are a number of potential impediments that may disqualify a line: load coils and bridge taps are two such common impediments. These are aspects of the old telco infrastructure that once were deemed beneficial, but now are getting in the way of the newer, digital technologies. Whether you hit a snag like this, is pretty much hit or miss. Fiber anywhere in the loop is also a disqualifier. The provider may take steps to 'clean' the line. Just how far they are willing to go will vary from provider to provider, and this will likely add additional time to installation process.

Once the line is 'qualified', the next step is deciding on which plan is suitable for your situation. The provider may have differing plans available depending on how strong a signal they think your line can handle. If you are marginal, you will not be qualified for the higher speed plans. And if price is a factor, having a tiered pricing structure is good also since the lower end plans are obviously less expensive. How this is structured will also vary wildly from provider to provider. Also, DSL is a new service, and providers are trying to find the right price/feature combinations that will attract the most users and thus gain a competitive edge.

Some common data rates:

Downstream/Upstream
128 Kbps/128 Kbps
256 Kbps/256 Kbps
384 Kbps/128 Kbps
640 Kbps/90 Kbps
1.5 Mbps/384 Kbps

2.0 Mbps/512 Kbps

7.1 Mbps/1024 Kbps

and a near infinite number of other possibilities as well. Cost of different plans, of course, generally goes up with speed.

Should you be disqualified, and have other options, get a second opinion. Calculating the effective loop length is by no means an exact science. There is plenty of room for errors. Also, some providers may go to greater lengths to 'clean' the loop than others. And, if you have more than one phone line, and are disqualified, then try the other line. Just because they both terminate at your location, does not necessarily mean they are the same length! The telco network is full of surprises.

6.6. Choosing Providers

Should you have more than one choice, here are some things to keep in mind when comparing services from different providers. If you are in a populous area, chances are you do have a number of choices. There is a dizzying array of possibilities at this time. Remember too, that it is a two step connection: DSL provider and ISP. You may have choices for each.

- *A compatible modem*. For now with Linux (or any alternative OS) this essentially means an ethernet interface. 'Routers' (i.e. combo modem/routers) should be OK too since these seem to be all external, ethernet. Anything else, is a no−go! (This situation may be changing soon.)
- *Installation*. A self−install option, of course, let's anyone get up and running. And is less expensive. But if there is no self−install available, will the the provider install onto a Linux only site? Many will not! Having a Windows box (or Mac) temporarily available is a work around here. Even a laptop may be enough.
- *Static vs Dynamic IP Address*. If wanting to run servers, or hosting your own domain, static is the way to go.
- *Encapsulation*. Is the connection 'Bridged' or 'PPP'. PPPoX has the reputation of being not as stable a connection, and not 'always on'. PPPoE requires client software to manage the connection, so one more layer of code.
- *Server Policy*. Some ISPs are fairly open about this, while others forbid any servers −− even personal web sites. Others may even go so far as to block certain ports.
- *Contract*. Is there a contract, and what are the out clauses? Cancellation fees?
- *Connection Limits*. Is it 'always on' (at least theoretically :−)? Are there session limits, or idle

timeouts? Is bandwidth metered and limited to so much per month? Do they forbid a LAN behind the connection (dumb!)?

- *Linux Support*. A few ISPs may offer some degree of tech support for Linux, but most will not. This isn't so bad, as long as they don't go overboard and refuse to help with anything just because you run a non−supported OS. ('Supported' means like 'tech support'.) If they say 'we don't care', you should be good to go.
- *Free Dialup Account*. A nice thing to have if the connection is down, or you just need to check mail from another location.
- *Setup program*. A few ISPs may have a setup program you are required to run the first time you connect in order to setup your account. This will likely not have a Linux version. (BellAtlantic.net was doing this at last report.) Other than this, there is nothing proprietary about DSL, and related protocols.
- *Reliability and Quality of Service*. Ask around in your local area from those that have the same DSL provider and ISP. A local LUG is a good place to get this kind of info. How much down time (hopefully not much)? Are mail and news services good? Backbone routing? Tech support?

There are a number of other options and features that might be worth looking at too: multiple IPs, domain hosting (reverse DNS), free web space, number of email accounts, web mail, etc.

7. Appendix: FAQ

Some Frequently Asked Questions about DSL and Linux.

1. Q. Does DSL work with Linux?

   DSL is a technology, or more correctly, a group of related technologies. This is akin to asking if Linux works with telephones. The technology itself does not care. So, the short answer is 'Yes, of course!'. The long answer is that if there are any impediments, they are being imposed by the provider. There are things they may do, that can make getting Linux up and running a more of a challenge than it needs to be. Not having a compatible modem option available is one common gotcha. Also, if the telco or ISP is doing the installation, they may require a Windows or Mac system to be available. This saves them the costs of training their techs on various 'alternative' OSes. Buyer beware!

   Basically all DSL does, is facilitate a high speed Internet connection. At some point, it is all TCP/IP, and Linux, of course, handles TCP/IP quite well.
2. Q. Where can I find drivers for my PCI (or USB) modem?

   As of this moment, you probably can't, because they are not available. You need an external, ethernet interfaced modem for all intents and purposes. If your provider does not offer one, you will have to find another provider, or buy your own modem outright. Just make sure it is compatible with your provider's flavor of DSL.

   If an incompatible modem puts you in a bind, hopefully you will take the time to politely harass the manufacturer :−).

   This will likely change soon however. Efficient Networks is in late Beta stages with their SpeedStream 3060/3061 PCI drivers. Likely others will follow suit. (Make sure you are reading the latest version of this document, as I have intentions of keeping this situation updated as needed.)
3. Q. How fast or good of a network card do I need?

   Any card that is compatible with Linux should work fine. Remember even low−end cards are 10 Mbps, and no consumer class DSL is near that at this time. I would suggest a reasonably good quality card, just to help eliminate the possibility of errors and premature failure.
4. Q. How can I find out when DSL will be available in my area?

   Just where and when DSL gets deployed is totally in the hands of your friendly local telco. They obviously can't do everyone at once, so they probably are selecting areas based on competitive factors. Getting a straight answer from a telco on this question, can also be a challenge. Probably also so as not to tip their hand to competitors. But, it is a question only they can answer.
5. Q. I was disqualified because I am too far away. What can I do?

Move? Seriously, there isn't much you can do. If there are other providers, get another opinion. You never know. Determining the loop length is an inexact science, and there is room for errors. Many use databases for this, and these databases routinely have some inaccuracies. Some providers too, may be more aggressive in taking steps to help you out and clean up the line. Also, some providers offer low−end speed services that have greater reach. Maybe this will become available in your area. Or, the telco will install, at some point, remote devices for customers who are now too far away.

6. Q. What are the speed tweaks for Linux?

   There aren't any really. Linux is pre−tweaked, unlike some versions of Windows that really need some registry hacks to get optimum performance.

   Now if you are convinced you are not getting the performance you should based on your distance and line conditions, then maybe there is a problem somewhere. See the Troubleshooting section for more. What you need is a fix, more than a tweak.

7. Q. My service is limited to 640K. Can I get better speed by getting a faster modem? Any way around this?

   No, and no. The modem has little bearing on how fast your connection is for all intents and purposes. The provider has a mechanism in place for limiting your speed somewhere in the pipe before you hit the Internet. There is no way to defeat this.

8. Q. I am paying for 768 Kbps service, and the best I ever get is 640 Kbps or so. Why? Is the service oversold? I am not getting what I pay for.

   You will lose 10−20% of the rated capacity due to networking overhead. This is just a fact of life for everybody. Just how much is lost here depends on a number of factors, and may vary from provider to provider. You seem to be close to your maximum when this is taken into consideration. Also, if you read the fine print, many ISPs are advertising speeds 'up to' such and such. Check your service agreement and see if there are any guarantees. If there are, they probably are well below the advertised maximum speed.

   Also, be careful how you test this. Some of the so−called test sites can be pretty unreliable. There can be many factors between you and that site that can impact your throughput and skew results −− not the least of which is how many people might be trying that same test at the same time. The best test is via FTP download from a known good, close site.

9. Q. Why does PPPoX have such a bad rap?

   The tendency to abruptly disconnect is one of the biggest gripes. PPP is sensitive to any interruptions in the connection. Generally a disconnect means a new IP. And there are those that say PPP, by its very nature, was never meant to be an 'always on' protocol. PPP is a session management protocol at heart, that requires a user to initiate a connection and authenticate him or herself. PPPoE/A are not particularly mature protocols either. They do not have much of a history or track record. Some would say the telcos and hardware manufacturers have rushed this out the door. PPPoE also requires an additional layer of software just to maintain the connection. This is one more layer of code and one more potential point of failure. Also, more system overhead is utilized to manage the connection.

10. Q. Why PPPoX? This seems like a bad idea!

PPP gives several advantages to the provider: they can use their existing infrastructure and hardware that they now use for their (larger) dialup customer base. It is easier to control user authentication and potential abuse situations, and easier to manage their network and related issues. In fact, it most boils down to its just easier for them. Easier, means saves man hours, and therefore saves costs (at least from their perspective).

It is not a conspiracy to conserve IP addresses, or thwart heavy users. IP address costs are insignificant in the overall scheme of things.

11. Q. The only provider in my area does not support Linux. What can I do? Will I have to use Windows?

    NO! 'Support' here is support as in 'tech support'. They are just saying that they will not give you tech support when and if you have problems. This does not mean you cannot use Linux on their network. Just that you may have to fend for yourself when and if a problem does arise. Anything that is forbidden will be in their Acceptable Use Policy (AUP), or Terms of Service (TOS) agreement.

    I have heard stories where a new tech or installer has misinterpreted their own company's policy on this and told someone 'you can't use Linux here'. Same with NT server. But this is almost always a misinformed individual.

    But −− if a provider does not support Linux, they may balk at installing onto a Linux box. Hopefully, they will have a self−install option to get around this annoyance. YMMV.

12. Q. My fax software does not work with my DSL modem. Why is that?

    Faxes are normally transmitted over typical analog phone lines by dialing the fax machine on the other end. Analog modems can handle this, but DSL modems have no dialing capability. Don't throw out that 56K yet!

13. Q. How fast and powerful of a computer do I need for DSL? My ISP says I need at least a Pentium 200.

    At the most basic level, a 386 will work fine. In most situations, you are connected to what is essentially an ethernet based network. So theoretically anything that can handle a very slow ethernet connection would work. No comment on well Netscape will run on a 386 though ;−) But as far as managing the connection, a 386 is indeed workable. What else you can do with it is another matter.

    Where this gets a little more complicated is the modem, and the client that the ISP may require. Any PCI or USB modem is going to require drivers, which means more CPU and system resources. Also, PPPoE does even more processing, so again the potential CPU load is increased. Windows tends to be not so efficient with all this going on, hence the requirement for mid range Pentiums by some ISPs.

    With Linux it will depend on what you are going to do. A low end Pentium should be fine for most uses. Just remember if you are running PPPoE, you may take a performance hit on low end hardware.

14. Q. I just got my DSL installed, and my speed sucks, and/or my connection constantly drops. What is the problem?

    Not enough information to say, really. There are many, many things that can cause a lousy connection. The list is too long to mention them all.

One of DSL's weaknesses is that the signal can be fairly fragile. Many things can degrade the signal, making for poor connections, and thus speed. This can be caused by poor or substandard inside wiring, a wiring problem outside (like bad splice), RFI from any number of sources, AM radio signal interference, excessive distance from the DSLAM. Not to mention possible hardware problems with your modem, NIC, or the telco's DSLAM, etc. Not always easy to sort out.

Your provider should be able to assist you. First, make sure the problem isn't with your setup as they likely won't help solve a Linux problem. Then be persistent, and don't hesitate to go over someone's head if the help is not forthcoming. Most problems are solvable. The trick is isolating it. A good telco tech, trained for DSL, can find all kinds of obscure wiring problems.

15.
Q: Are there ADSL Standards?

A: Sort of. The U.S. Bell Operating Companies have standardized on Discrete Multi−Tone (DMT) (ANSI T1.413) in their current rollout. Most others should follow their lead in the states. There are other types of modems, most notably Carrier−less Amplitude Phase Modulation (CAP), which, of course, are incompatible with each other.

A biased comparison from an DMT−based vendor on this subject can be found at the http://www.aware.com. Still, it provides the best detail on this issue I have seen so far.

A rather expensive copy of the ANSI standard can be ordered at: American National Standards Institute ANSI Home Page

Asymmetric Digital Subscriber Loop (ADSL) Metallic Interface

ANSI TI.413−1995

Note: ANSI TI.413 Issue 2 was released September 26, 1997

16.
Q: Can I use ATM to connect to DSL?

A: Technically speaking, you can. Some DSL modems (at least the Alcatel version) has a ATM Forum 25Mbps interface, which connects to a PCI ATM card. See http://lrcwww.epfl.ch/linux−atm/ for more details.

17.
Q: Why does DSL have all these bit rates (384/1.5/7.1M/20M/etc) options?

A: The basic problem is the 100 year old design of the copper loop. It works great for analog phone, but it presents a real challenge for a digital signal. Remember that the distance of a loop is inversely proportional to the data rate that it can carry. Rate adaptive technologies are great for making a digital signal work in many situations, but it can't provide a consistent bandwidth for all applications, especially for very long (over 18,000 ft) loops. The different bandwidths that you see advertised reflect various marketing wars of vendors equipment, and the telco struggle to finalize on a 'standard' set of data rates. The bottom line is for the telco to be able to reach as broad a customer base as possible.

Also, check out the next question on the loop impairments that cause this to happen.

18.

Q: What are all these loop impairments (bridge taps, load coils, DLCs) that could disqualify my line from DSL? (thanks to Bruce Ediger)

Load coils: in−line inductances that improve voice−frequency transmission characteristics of a telephone circuit. Essentially, a "load" steals energy from high frequencies and gives it to lower frequencies. Typically only used in very long (>9,000 ft) phone lines.

By "bridges" I assume you mean "bridged taps". In older neighborhoods, the phone wiring will have been used by more than one customer. Perhaps these customers lived at different (though near−by) addresses. The unconnected "spur" of wiring is a "bridged tab" on the currently connected circuit.

DLCs, Digital Loop Carriers: there's a bunch of systems for carrying more than one voice transmission on a single pair of wires. You can shift the frequencies up or down, or you can digitize the voice transmissions and divide the telephone circuit by time or code or something. The more general term is "pair gain".

These things cause different problems for high−frequency communications.

Load coils will completely mess up things by filtering high frequencies and passing low frequencies. They probably also change the "delay envelope", allowing some frequencies to arrive before others. One byte's tones will interfere with the next byte's.

Bridged taps act as shunt capacitances if they're long in relation to the signals wavelength, and they'll actually act as band pass filters if they're about 1/4 wavelength of the signal. That is, they'll pass particular frequencies freely. Particular tones of a DMT modem might get shunted back, rather than passed along to the receiving modem, reducing bandwidth for that telephone line.

Pair gain, digital or analog, limit the bandwidth available to one transmission in order to multiplex several on one wire. High and low tones of a DMT transmission get filtered out by the apparatus.

The book "Subscriber Loop Signaling and Transmission Handbook", by Whitham D. Reeve, , IEEE Press 1992, ISBN 0−87942−274−2 covers the math of how to calculate the effect of line length, bridged tap, etc on the transmission characteristics of a telephone line. It's pretty expensive, however.

19. Q: Do you have examples of DSL Modems?

A: Short Answer: Yes. Real Answer: The evolution of this technology is moving too rapidly for anyone to keep up to date in a HOWTO. A good source of ADSL Modems is the ADSL Forum Home Page at http://www.adsl.com. Go to the Vendors pages to see what's happening. Also, check http://dslreports.com/information/equiprated/all.

However, I will provide a list of some of the current technology as of June 1998. All are ADSL 'modems' with 'DMT' encoding (a.k.a. Alcatel compatible), unless specified otherwise. [Updated Aug 2000.]

- Router/Modems with 10/100baseT Ethernet Interface:

  Examples: Flowpoint 2000 DSL(CAP), 3COM Viper−DSL (CAP), Westell

ATU−R−Flexcap (CAP), Aware x200, Zyxel P641, Efficient Networks SpeedStream 5660, Cayman 3220H, Cisco 673 (SDSL), Cisco 675 (ADSL/CAP), Cisco 677 (ADSL/DMT), Alcatel SpeedTouch Pro.

- Bridge/Modems with 10/100baseT Ethernet Interface:

  Examples: Alcatel 1000, Alcatel SpeedTouch Home [note: there are also USB and PCI versions of this one!], Westell ATU−R−Flexcap2 (CAP), Efficient Networks SpeedStream 5260, Efficient Networks SpeedStream 5251 (SDSL), Westell WireSpeed.
- Modems with ATMF Interface:

  Examples: Alcatel 1000, Alcatel SpeedTouch Home, Cisco 627 (DMT), Ariel Horizon II
- Bridge/Modems with V.35 Serial Interface (T1, Serial Router)

  Examples: Westell ATU−R
- Modems with USB Interface:

  Efficient Networks SpeedStream 4060, Intel 3100
- PCI Modems:

  Examples: Cisco 605, Efficient Networks SpeedStream 3060/3061, Intel 2100
- Dedicated Router (no built in modem) with 10/100baseT Ethernet Interface:

  Examples: Netgear RT311

This is but a very small sampling. These are NOT endorsements of the products listed, just provided for illustration. ;−).

8. Appendix: Miscellaneous

8.1. Links

- Other related documentation from the Linux Documentation Project:
    - Firewall HOWTO
    - Security HOWTO
    - IPCHAINS HOWTO
    - IP Masquerade HOWTO
    - Home Network mini HOWTO
    - Ethernet HOWTO
    - Networking Overview HOWTO
    - Net HOWTO, previously named the NET3−4−HOWTO, the definitive guide to various Linux networking topics.
    - Linux 2.4 Advanced Routing HOWTO. All the new, improved features are explained here.
    - DHCP HOWTO
- More on the 2.4 kernel packet filtering from The Netfilter Project at http://netfilter.kernelnotes.org/. Several good HOWTOs for the new features in 2.4.
- Check your security and see what ports are open at http://hackerwhacker.com/. This is one of the better sites for this. Some only test a relatively few ports.
- SuSE's Linux PPPoE page is at http://www.suse.de/~bk/PPPoE−project.html. Good information on most available Linux PPPoE implementations.
- Bob Carrick's definitive PPPoE site is at http://www.carricksolutions.com/. His Linux PPPoE page is at http://www.carricksolutions.com/linuxpppoe.htm. Some other DSL related information as well. All OSes are covered.
- The NTS EnterNet for Linux FAQ can be found at http://www.nts.com/support/FaqEnterNetLinux.html. This is a non−GPL'd PPPoE client that is distributed by some ISPs.
-

A white paper from Redback on the technology and rationale behind PPPoE can be found at http://www.redback.com/frameset.asp?page=whitepp/wp_pppoe_comparison.html. This is how the ISPs see it. (Redback is the leading manufacturer of PPPoX termination routers.)

- ATM on Linux: http://lrcwww.epfl.ch/linux−atm/. Where to find the latest info on PPPoA and raw ATM connections.
- A step by step report on getting Linux going with raw ATM is here: http://linux.com.sg/news/atm/.
- An open source project based on the Alcatel SpeedTouch Home USB modem can be found at http://kapu.name.daemon.xs4all.be:8080/Projects/. This is a beta project that requires 2.4 kernel and patches.
- FreeSwan, http://www.freeswan.org, is an IPSec & IKE VPN implementation for Linux.
- VPN and Masquerading on Linux: http://www.wolfenet.com/~jhardin/ip_masq_vpn.html
- PPTP−linux allows you to connect to a PPTP server with Linux. The home page is http://cag.lcs.mit.edu/~cananian/Projects/PPTP/.
- Justin Beech's http://dslreports.com, a great site for anything and everything related to DSL. If it's not there, then there is a link to it. (Site runs on Linux.)
- John Navas's Cable and DSL site, http://cable−dsl.home.att.net, has good general info, tweaks, troubleshooting, hardware info, etc. for all OSes.
- TCP Performance Tuning tips: http://www.psc.edu/networking/perf_tune.html. Tips on Linux, and other OSes.
- A great Linux security site is http://linux−firewall−tools.com/linux/. Lots of info from Robert L. Ziegler, author of *Linux Firewalls*. Many links to other security related sites as well.
- http://www.securityportal.com/lasg/, The Linux Administrator's Security Guide by Kurt Seifried. Good tutorials on a variety of topics −− not just firewalls, but the big picture.
- The Seattle firewall is an ipchains based firewall that can be used on a dedicated masquerading firewall machine (including LRP), a multi−function masquerade gateway/server or on a standalone Linux system. The project is located at http://seawall.sourceforge.net/
- My ipchains script is at http://personal.bellsouth.net/~hburgiss/linux/ipchains.html. This has IP Masquerading already set up, is reasonably well commented, and may make a quick starting point for your own script with only minor adjustments to suit your situation.
- Now that you have a full−time connection, want a routable hostname for your computer? Dynamic DNS services can do this, even if your IP changes from time to time. A few of the available services:
    - http://dyndns.org
    -

    - http://tzo.org
    - http://eyep.net
- ADSL Forum Home Page: http://www.adsl.com A comprehensive web site created by the ADSL vendors. Fairly complete for reference information on ADSL.
- ADSL Deployment 'round the World Claims to have a complete list − looked accurate for my area − gives providers, prices, speeds, etc.
- comp.dcom.xdsl FAQ. Actively maintained, and a great technical reference for DSL technologies.
- comp.dcom.xdsl, DSL discussions, vents, and flames on Usenet. Good place to get technical questions answered that your ISP can't.

8.2. Glossary

A dictionary of some of the jargon used in this Document, and in the telco and DSL industries.

ADSL

Asymmetric Digital Subscriber Loop. 'Asymmetric' in that the downstream potential is greater than the upstream. ADSL is capable of sharing on a single POTS wire pair. Maximum speed is 8 Mbps, though typically is limited by the provider to lesser speeds. The most popular DSL at this time.

ANT

ADSL Network Termination (a.k.a. the ADSL modem).

ARP

Address Resolution Protocol. Converts MAC addresses to IP addresses.

ASAM

Alcatel's terminology for a DSLAM.

ATM

Asynchronous Transfer Mode − provides high−speed packet switching from 155 Mbps to (currently) 2Gbps. Used to provide backbone switching for the Internet.

ATMF−25Mbps

ATM Forum Interface − 25Mbps speed, provided by a PCI NIC card.. One of the interfaces used between the ANT and PC.

brouter

A combination DSL modem that can be configured to act as either a bridge or a router.

CAP

Carrierless Amplitude Phase. A proprietary ADSL line encoding technique, that is (or was) in competition with 'DMT'. DMT has won the standards battle. CAP and DMT modems are not compatible with each other.

Central Office, or CO

Usually refers to one of two meanings −1) The local Telco building that houses telephone equipment, and where local loops terminate 2) The Telco voice switch that provides dial tone. Often referred to as just 'CO'.

CLEC

Competitive Local Exchange Carrier. 'Competitors' to the ILECs. They do not only any lines, and must lease their lines from ILEC in order to provide any service.

CPE

Customer Premises Equipment − The Telco term for customer owned equipment (i.e. the stuff you are responsible for fixing). Examples are CSU/DSU, modems, fax machines, and your phone.

DHCP

Dynamic Host Configuration Protocol − An IP protocol used to set up dynamically assigned IP addresses and other important networking parameters. The DHCP server 'leases' an IP from its pool to clients on request. The lease is renewed at regular intervals. This is a common protocol on 'bridged' DSL networks.

DMT

Discrete Multitone Technology. This is a line encoding common among ADSL deployments, and now is the standard. Sometimes referred to as 'Alcatel compatible'. Most telcos in the U.S. are in fact now standardizing on DMT. The other, less common, ADSL encoding is 'CAP'. CAP and DMT modems are not compatible with each other.

DS0

The basic digital circuit for Telcos − offered at 56 kbps or 64kbps. Can support one analog voice channel.

DSLAM

Digital Subscriber Loop Access Multiplexer − The Telco equipment installed at the CO that concentrates and multiplexes the DSL lines. One end of the copper loop connects to the DSLAM, the other to your modem. The DSLAM is essentially what makes DSL work.

DSL

Digital Subscriber Loop − A term describing a family of DSL services, including ADSL, SDSL, IDSL, RADSL, HDSL, VDSL, SHDSL, etc.

G.DMT

Synonymous with 'full rate' ADSL. Used to distinguish between full rate ADSL, and G.Lite. See DSL Family for more.

G.Lite

A lesser version of ADSL that has lower maximum speeds, and requires no splitter or filters. Not DMT compatible. See DSL Family for more.

HDSL

High bit rate DSL. See DSL Family for more.

ILEC

Incumbent Local Exchange Carrier. The Regional phone company that physically owns the lines. Examples: Bell Atlantic and U.S. West. FCC regulations are forcing the ILECs to open up their networks to independent providers. This is allowing the independents like Covad and Rhythms to offer competitive services. And is a good thing for consumers IMHO.

ISDN

Innovations Subscribers Don't Need; I Still Don't know or maybe Integrated Services Digital Network, a digital phone service that uses a single copper pair to run 2B (64k) + 1D(16k) channels that can be used for switched voice or data.

IP

Internet Protocol. Often used to simply refer to an IP address.

ISP

Internet Service Provider.

LAN

Local Area Network. A network of computers that are segregated from the WAN (Wide Area Network, i.e. the Internet). Typically using private, non−routable IP addressing, e.g. 192.168.1.1 or 10.0.0.1.

Loop

The two wire twisted pair from the telco Central Office that terminates at a customer location. For DSL, a 'clean' copper loop within the distance limitations is required.

MAC

Media Access Control. Sometimes also called 'hardware' address, it is a unique identifier of network devices and is an important aspect of some network environments.

mini−RAM

Remote Access Multiplexer, a mini DSLAM. Typically with very few connections −− eight is common. Used for remote areas too far from a CO.

MTU

Maximum Transmission Unit, the largest packet size, measured in bytes, that a network can transmit. Any packets larger than the MTU are divided into smaller packets before being transmitted.

NAT

Network Address Translation. A means of allowing computers on a LAN with private, non−routable address to access the WAN while 'masquerading' with the IP address of a host with a suitable address and configuration. With Linux this is called 'ip−masquerading'.

NID

Network Interface Device − The telco housing on the side of your house. Typically where the telco's responsibility ends, and the owner's begins. Also, called the 'SNI'.

NIC

Network Interface Card − A PC card (PCI/ISA) that supports the required network interface. Usually an Ethernet 10baseT or an ATMF−25Mbps Card..

NSP

Network Service Provider. An ISP's upstream provider or backbone provider.

OC−3

A fiber optic line capable of 155 Mbps.

POTS

Plain Old Telephone Service − The service that provides a single analog voice line (i.e. a traditional phone line).

PPPoA

Point−to−Point Protocol over ATM (RFC 2364). One of the PPP protocols being used by some ISPs. Linux support is beta at this particular moment. May be changing very soon. A hardware device, i.e. a combination modem/router, is one alternative if this is the only option available to you.

PPPoE

Point−to−Point Protocol over Ethernet (RFC 2516). Another PPP protocol in use by providers. This one is more common, and there are several Linux clients available. See the Links section for more.

PPPoX

Used to refer to PPPoE and PPPoA collectively.

RADSL

Rate Adaptive DSL. See DSL Family for more.

RBOC

Regional Bell Operating Company. The 'Baby Bells'. The U.S. phone companies that have had a state sponsored monopoly since the break up of AT&T.

RFI

Radio Frequency Interference. DSL is susceptible to RFI if in the right frequency range, and if close enough to the DSL signal.

SDSL

Single Line DSL. Also, sometimes 'Symmetric DSL'. See DSL Family for more.

SNI

Subscriber Network Interface − The Telco term for the phone wiring housing on the side of your house. It designates the point between the Telco side and the Inside Wire. This is also called the Demarcation Point. Sometimes called a 'NID' also.

Splitter

The passive device (low−bandpass filter) at or near the SNI/SNI that splits the DSL signal into separate voice and data channels. Typically installed near the demarcation point.

Splitterless

A DSL installation that does not require a splitter. For higher speeds, a RJ11 filter (sometimes called microfilters) is placed on every extension phone jack where an analog phone or other non−DSL device is used, thus filtering the DSL signal at the jack, rather than at the SNI/NID. For lower speeds, no filter is necessary. Without a filter or splitter, the DSL signal tends to cause audible interference on voice phones. G.Lite needs no splitter, nor filter, but this is the exception to the rule.

SOHO

Small Office HOme

T−DSL

German Telekom's ADSL implementation. See DSL Family for more.

T1

a.k.a DS1 − A digital dedicated line at 1.544 Mbps comprised of 24 channels, used for both voice (24 DS0s) and data.

T3

a.k.a DS3 − T1's big brother, a digital dedicated line at 44.736 Mbps, used for both voice (672 DS0s or 28 DS1s) and data.

VCI/VPI

VCI is 'Virtual Circuit Identifier' and is part of an ATM cell header. VPI is 'Virtual Path Identifier', also part of an ATM cell header which contains circuit information. These are both important configuration aspects for modems and routers. They must match what the provider is using. Frequently used VPI/VCI pairs are 0/32 or 8/35.

VDSL

Very high bit rate DSL. See DSL Family for more.

VoD

Video on Demand.

VoDSL

Voice over DSL.

WAN

Wide Area Network. For example, the Internet.

xDSL

Used to refer to the entire DSL family of related technologies: ADSL, SDSL, IDSL, etc.

8.3. Other Consumer Class High Speed Services

8.3.1. Cable Modem vs DSL

The Telcos see DSL as a competitor to the Cable Company's Cable Modem, and as such, are providing competitive pricing and configuration offerings. Although Cable Modems are advertised as having 10−30Mbps potential bandwidth, they use a shared transmission medium with many other users on the same line, and therefore performance varies, perhaps greatly, with the amount of traffic, time of day, and number of other users on the same node.

It is often heard that DSL has an advantage in that it is a private pipe to the Internet, with dedicated bandwidth. This is mostly a myth. You do have a private pipe to the DSLAM, but at that point, you enter the telco's ATM (or frame relay) network, and start sharing bandwidth. You are at the mercy of how well your DSL provider and ISP manage their networks. The consensus seems to be that DSL providers and ISPs are doing a better job of managing bandwidth than the Cable companies. It is easier for them to add and adjust bandwidth as needed to meet demand. You are less likely to have speed fluctuations due to other users being on line at the same time. But, again, this gets down to how well the network and bandwidth are managed.

DSL probably has a small security advantage too. With most Cable modem networks, it is like being on a big LAN. You are sharing your connection (and bandwidth) right at the point of connection. But if you are not doing something to filter incoming connections already, you are asking for trouble either way.

There also seems to be a better chance of having ISP alternatives with DSL than Cable. Choice is a good thing, and so is competition. It seems most Cable outfits give you just one choice for an ISP. If you don't like it, you are out of luck. The number of options with DSL probably varies greatly by geographic areas. Populous areas, like Northeast U.S., seem to have many options.

So which is better? The differences aren't as much with the technology, as they are with the implementations. If you look around, you can find plenty of horror stories on either. And plenty of happy customers too. The way to know what may be the best for you, is to do comparative shopping based on experiences of other users in your area. Don't base your choice on one person's opinion. This is statistically invalid. Likewise, don't base your choice on someone's opinion who has had a particular service for only a short time. Again, statistically not worth much. Get as many opinions from those that are using the *exact same services* that you are looking at.

8.3.2. Integrated Fiber in the Loop (IFITL or FTTC)

In some areas, newer neighborhoods are being built with fiber optic cable instead of the traditional telco copper lines. While the fiber is a definite problem for DSL services, it has it's own potential advantages. Existing fiber is potentially capable of 100 Mbps, and it looks like this could easily go up soon.

So while telco fiber customers are being shut out of the DSL market, they may have much to look forward to. Technologies are under development, and in some cases just now being deployed, to take advantage of fiber telco phone loops. Known as 'FTTC' (Fiber To The Curb), or 'IFITL' (Integrated Fiber In The Loop), this technology is another high speed service that telcos can offer. The speeds are sufficient for VoD (Video on Demand) and VoDSL (Voice over DSL), and other high bandwidth services. One nice advantage here is, that since there is no DSL signal on the wire, the only required CPE is a network card. In other words, no modem −− just connect a NIC to the wall jack and off you go!

8.4. Compatible Modems

This is an easy one right now ;−):

- *All* external, ethernet based modems, and modem combination devices, should work no problem. The only requirement is a compatible network card. (Technically speaking, there are a few, rare and very minor exceptions.)

This list is limited to those modems and delivery systems that are readily available, and should work with any current Linux distribution without having to go to extraordinary lengths. Alpha and Beta projects are not included.

8.5. Linux Friendly DSL ISPs

By 'friendly' we mean ISPs that don't put up any unnecessary impediments just because you aren't running that other guy's OS. And yes, there is some of that going around. If your choices are limited, and you are forced to deal with one of these, then having a Windows box available temporarily is one work around. Another, may be to sweet talk the installer into letting you finish the installation (NIC, etc). Of course, self installation, if available, should be completely 'Linux compatible'.

So to make this list, the ISP/provider must make available some type of workable modem (ethernet interface at this point in time). And, should not penalize you, or make things difficult, just because you are running an alternate OS. Installing directly onto Linux should be an available option, and should not cause you any undue hardship. Technical support for Linux is a nice bonus, but not necessary to make the list. Please do not take these as recommendations. Do your own homework.

To add a name to this list, mail Linux Friendly. Please included ISP's official name, URL (if not obvious), location and coverage area, modem type, server policy, and any other pertinent details.

National ISPs (U.S.):

- Speakeasy.net: Static IP and no PPPoX, servers explicitly allowed. Highly rated. National. Multiple IPs available.
- PhoenixDSL: Static IP and no PPPoX. National. Linux is supported. Servers apparently OK for non−commercial use. Tiered pricing plan.
- Telocity: Static IP, no PPPoX, liberal server policy. Reports of abysmal tech support. (Unenforced monthly bandwidth usage limit ???). National. They have their own proprietary modem, but it is ethernet based.
- Penguinista DSL, DSL with a twist. Not just Linux friendly, but Linux lovers. Sponsored by the

Benevolent Penguin Society. National. Static IP available. "Theoretical" timeouts and session limits though. Encapsulation protocol (PPP?) unknown. ???

Regional and Local ISPs (U.S.):

- qx.net, Lexington, Ky., and areas of Central and Eastern KY. Officially supports Linux. Static IP. Personal servers allowed. Tiered pricing plans. Highly rated.
- Commonwealth Technical Services, Richmond, Va. Officially, and happily support Linux. Static IP. Personal servers allowed. No bandwidth restrictions. This ISP runs on Linux!
- ExecDSL, Baltimore, MD, Washington, DC and surrounding areas. Static IP. Servers are OK. Various plans and DSL providers. Secondary MX and DNS available (nice touch!). (Apparently no official Linux support.)
- Netexpress.net, Moline, Ill. Tiered pricing. Static IP available. Apparently, no official support. Runs on Linux!
- iglou.com, Lexington, Ky., and soon in Louisville, Ky, Cincinnati, OH, and maybe Nashville, TN. Static IP available. Personal servers allowed. Tiered pricing plans with various options.
- Bluegrass.net, Lexington, Ky., and surrounding areas. Static IP. Personal servers allowed. Tiered pricing plans.
- Drizzle.com, greater Seattle, WA area. Static IP, servers OK.
- Netsync.net, Chautauqua County, NY (Fredonia, Jamestown, and surrounding areas). Static IP available, PPPoA, servers are OK. Linux is supported!
- Aracnet, greater Seattle, WA., and Portland and Salem, OR. areas. Static IP. Linux friendly! Tiered pricing. Shell access account is included (RH)!

8.6. Setting up Linux as a Router

Depending on your local setup, you should consider some other issues. These include a firewall setup, and any associated configurations. For my setup, shown in Figure 5 below, I use an old i486 machine configured as a firewall/router between the DSL connection and the rest of my home network. I use private IP addresses on my private LAN subnet, and have configured my router to provide IP Masquerading and Firewalling between the LAN and WAN connection.

See the IP Masquerade HOWTO , and Firewall HOWTO for more information. Also, for 2.4 kernels see Linux 2.4 Advanced Routing HOWTO. My experience is that Linux is more flexible and provides superior routing/firewalling performance. And it is much less expensive than a commercial router −− if you find an old 486 machine that you may be using as a doorstop somewhere.

Figure 5: A typical SOHO Network Setup

```
 <−−Private Subnet/LAN−> Linux <−−−−−ISP's Public Subnet−−−−><−−inet−−>
     192.168.1.0

  X−−+   −−−−−−−−
     |  |  |       −−−−−−−−      (eth0:0)−−−−−−−−−
     +−−=| Hub/ |       | Linux  |     +−−−−−−=|  DSL  |=−DSL−> ISP's
 X−−−−−=|Switch|=−−−−−=| System |=−−−−+       | Modem |      Gateway
     +−−=|      |  eth1 |(Router)| eth0        −−−−−−−−−
     |  −−−−−−−−    |  −−−−−−−−    |
 X−−+              |   IP_Masq    |
                   |  IP_Firewall |
                   |   Gateway    |
                   |              |
                   V              V
             192.168.1.1       Dynamic or
             LAN Gateway        Static IP
             IP Address        from ISP pool
```

What I did is setup a Linux router (Redhat Linux 5.0 on a i486) with two ethernet interfaces. One interface routes to the ISP subnet/gateway (eth0 in above example), and the other interface (eth1 above) goes to a hub (or switch) and then connects the LAN with private network addresses (e.g. 192.168.1.x). Using the private network address behind your router/firewall allows some additional security because it is not directly addressable from outside. You have to explicitly masquerade your private addresses in order to connect to the Internet from the LAN. The LAN hosts will access the Internet via the second NIC (eth1) in the Linux router. Just set their gateway to the IP address of the second NIC, and assign them addresses on the same network.

Caution Make sure your kernel is complied with IP forwarding and the IP forwarding is turned on. You can check this with '**cat /proc/sys/net/ipv4/ip_forward**'. The value is '1' for on, and '0' for off. You can change this value by echoing the desired value into this file:

```
13; # echo 1 62; /proc/sys/net/ipv4/ip_forward
```

You will also need to set up 'IP Masquerading' on the Linux router. Depending on your kernel version, this is done with **ipfwadm** (2.0), **ipchains** (2.2), or **iptables** (2.4). See the documentation for specifics on each. AND −− do not forget to have that firewall set up too!

There are also several projects that are devoted specifically to using Linux as a router, just for this type of situation. These are all−in−one solutions, that include security and various other features. Installation and configuration, is reportedly very easy. And these will run on very minimal hardware −− like a floppy drive only. The best known is http://www.linuxrouter.org. You might also want to look at http://www.freesco.org and http://www.coyotelinux.com.