# Living with a<br>Small Office Home Office (SOHO) Network

## 2013 Edition

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**Abstract**

*This paper discusses our experience setting up and using a small office home office (SOHO) network over more than fifteen years. It offers guidance on selecting broadband Internet Service Provider (ISP), presents Local Area Network (LAN) options, describes Internet sharing methods, and discusses typical network services.*

*We have an ADSL broadband router and 16-port Ethernet switch allowing multiple devices to share the connection. A separate 802.11n Access Point provides Wi-Fi connectivity throughout the house. LAN services include: file sharing, system backup, printing, timeserver, Syslog server, media server, greenhouse automation server and a private internal website.*

*We use a hosting service for our web server and e-mail. Hosting moves web site traffic off the broadband connection. It also significantly eases task of securing local network. A registered domain provides persistent email address reducing risk of losing contact with past colleagues and friends.*

*Big change is after many years of trying finally able to increase ADSL speed. We switched ISPs and now have 7Mbps/1Mbp ADSL. That is a vast improvement over our previous 3Mbps service. Other changes are recent addition of, WD TV live hub media server and purpose built greenhouse automation server and new 802.11n Access Point.*

# Table of Contents

# 1 Overview

In mid-1998 I set up a home network. Was starting a consulting business and wanted to learn about building and operating a Small Office Home Office (SOHO) network. My prior network experience was limited to interactions with corporate Information Technology (IT) department. Back then home networks were pretty rare and some residential ISPs even prohibited them. Today home networks are ubiquitous and the proliferation of handheld devices means residential customers often use a combination of wired and wireless networking. It has been fun documenting the change over the years.

The network has undergone significant evolution over the years. It began with dialup Internet, Wingate connection sharing software running on a Win98 laptop and a small 10 Mbps Ethernet hub. Back then Ethernet switches were expensive. Ethernet hub has long since given way to a 16-port Fast Ethernet switch. Over the years LAN has expanded beyond my home office to encompass the entire house utilizing both wired and wireless. Current Internet access is 7Mbps/1Mbps ADSL provided by CLEC G4 Communications. A ZyXel P660R-D1 ADSL2/router provides Internet sharing.

A Netgear WN802Tv2 802.11N Access Point provides high speed wireless connectivity and privacy protection.

A recycled Windows XP pro desktop serves as a poor man's server. In addition to file sharing it runs: Tardis network time service, Abyss web server Kiwi Syslog log server and Davis weather station and companion Ambient virtual weather station application. To reduce clutter I use a Belkin keyboard, video and mouse (KVM) switchbox to switch between main PC and server. A spare port on the KVM makes it easy to connect additional systems for setup and testing.

WD TV Live Hub allows us to watch Netflix and other Internet content on our living room TV and acts as a media server.

I recently added automation to our greenhouse. A programmable logic controller (PLC) automates greenhouse operation and a web interface provides remote visibility.

We have two printers; a HP OfficeJet K550 serves is the work horse printer. It has a built in Ethernet interface so is able to connect directly to the LAN. A HP PhotoSmart D7160 is used for high quality photo printing. It is connected to the server via an USB interface. Windows printer sharing allows access from any PC on the LAN. A HP 5400 USB flatbed scanner turns paper into electronic documents. The scanner is pretty old but still works fine and does double duty as the occasional copying machine.

Acronis True Image provides automatic online backup of PC data to the server. For offline backup we use several different external USB drives.

## 1.1 Goals for SOHO network:

- High speed Internet access
- Share Internet connection
- Wired and Wireless LAN
- Printer sharing
- File sharing
- Internal web server
- Multiple e-mail accounts
- Time synchronization
- Automatic PC backup
- Offline file backup
- Home weather station
- Home greenhouse automation
- Internet TV

## 1.2 Organization

This paper discusses Internet access and connection sharing options. A separate paper goes into more detail about ISPs and the tradeoffs among different type of Internet access. I recommend setting up an always-on server, even a small network benefits from having a server. This can be accomplished by repurposing a retired desktop PC. Structured wiring for telephone and Ethernet is covered in detail. Security and Troubleshooting topic provides information to maintain network and protect it from intruders.

Lastly discuss registering a domain name and running a public Internet web server. Every business ought to have an Internet presence. It does not take much effort to set up a simple web site and cost is low. Even if you do not have a business registering a domain name gives you control over email and having a web site allows you to define your presence on the Internet. For a few dollars per month it is a lot of bang for the buck.

This report is not intended as a competitive product review. Market is constantly changing; any attempt to do so quickly becomes outdated. Rather, it discusses how specific requirements were addressed. For up to date product reviews reader is directed to the many publications and articles on the subject. Products and services described in this paper represent my choice to deliver the features my family and I wanted.

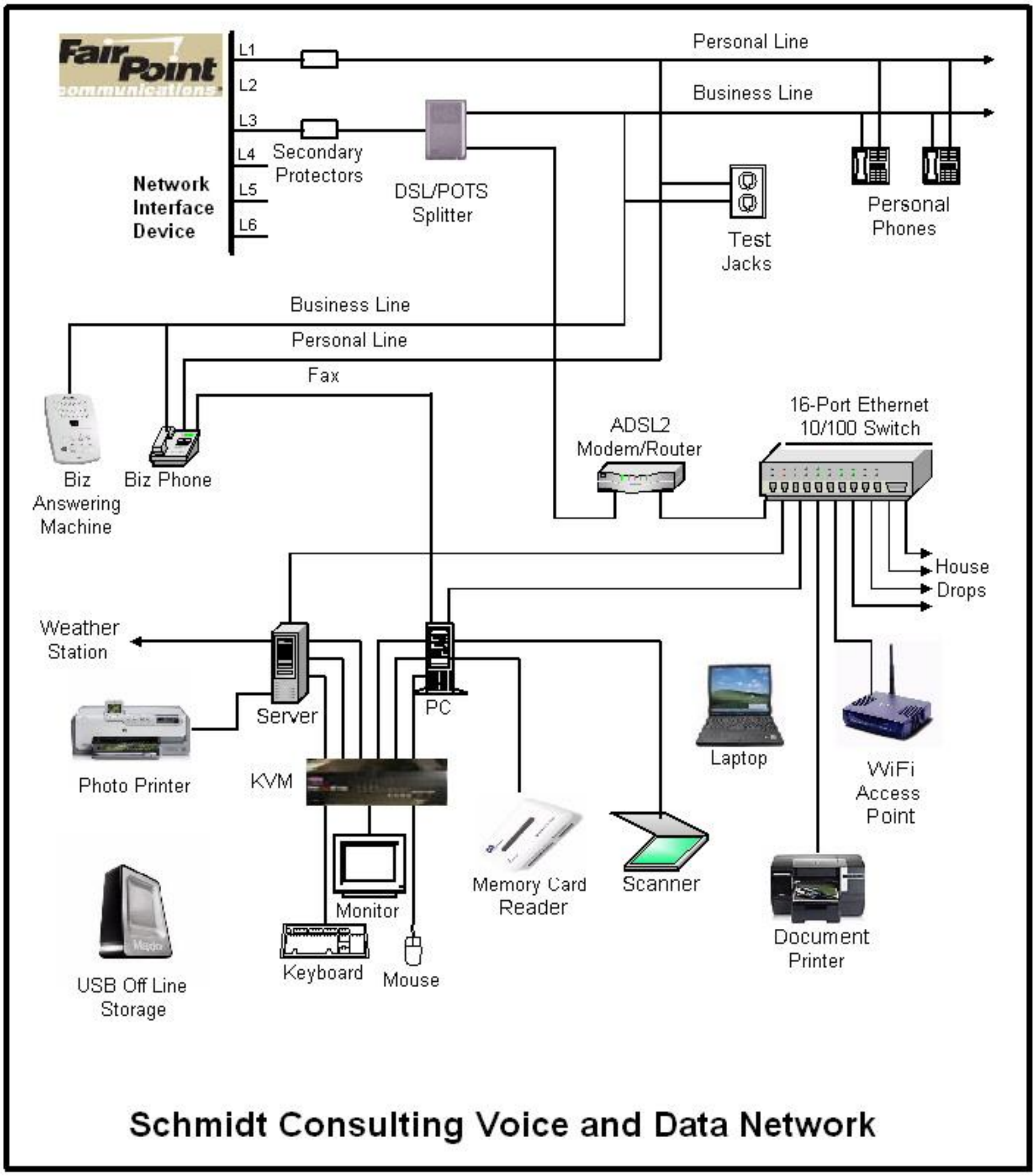


**Figure 1 SOHO Data and Voice Block Diagram**

# 2 Internet Technology – Geek Stuff

This section discusses some of the important technology involved in setting up a SOHO network. While not essential reading it is often helpful to know what is going on under the hood.

Internet was created over 40 years ago as a means for government and academics to share expensive mainframe computers. Today it is the preferred method to access all sorts of digital information: data, voice and images. Internet is a contraction of Inter Networking, literally a network of networks. Creation of the Word Wide Web (WWW) in the 1990's vastly expanded Internet popularity by providing a Graphical User Interface (GUI) on what until then had been text based. Some equate World Wide Web with the Internet. The two are not synonymous. The web is simply one, admittedly a very popular, application supported by the Internet.

The Internet is a packet network that transports data from one host to another over a network shared by many users. Internet is fundamentally different than the public switched telephone network (PSTN). The telephone network establishes a dedicated path for the duration of the call. This reservation exists whether it is needed or not. Internet on the other hand works on chunks of data called packets. Packets are presented to the Internet on an as required basis. At each hop routers examine the packet address field and determine how to forward it toward the destination.

## 2.1 ISP

Internet Service Providers (ISP) connects end users to the Internet. The incredible popularity of the Internet is driving demand for higher speed and lower cost. Connection between ISP and customer is often called the last-mile. I prefer the term first-mile, because it elevates end user's importance. Internet's value proposition is its ability to connect end points. Without end points the network is useless.

Even though we are in a fairly rural area residential broadband is available from multiple sources:

1) Comcast DOCSIS, multiple system operator (MSO)
2) FairPoint Communication ADSL, incumbent local exchange carrier (ILEC)
3) G4 Communication ADSL, competitive local exchange carrier (CLEC)

We have 7/1 Mbps ADSL from G4 bundled with phone service. This is a significant improvement from the 3000/768 kbps speed provided by FairPoint and previously 1500/384 from Verizon. Unlike FairPoint G4 does not cap the speed. Customer speed is the result of circuit characteristics. If phone loop is very short maximum speed is 24/1 Mbps. In our case we are pretty far away so speed is lower but still a very significant improvement over what we had before.

For a more detailed examination of ISPs interested reader it referred First-Mile Access paper in the writings page.

## 2.2 Latency vs Speed

Non-technical folks often confuse latency with speed. Latency is how long it takes a packet to get from location A to B. Speed is rate bits are transmitted across the network. If you are downloading a large file speed is important, latency less so. If on the other hand you are conducting a Voice over IP (VoIP) phone call latency is critical to maintaining good communication.

A useful analogy is to think of a truck full of DVDs going from Point A to B. From the time truck begins its journey latency is high – while truck travels to destination recipient can do nothing. However once it gets there speed is very high due to the tremendous capacity of the DVDs. Conversely a dialup connection has low latency since it only takes a few milliseconds for data to arrive at its destination but speed is very low – limited by telephone network performance. For a more in-depth explanation see "It's the Latency Stupid."

## 2.3 Naming Convention

Uniform Resource Locator (URL) is a human friendly handle rather than machine friendly numeric IP addresses. Translation of URL to IP address is performed by the domain name system (DNS). Domain names are hierarchal evaluated right to left. The highest-level of the tree called Root is implied. Next is the top-level domain (TLD) these are the COM, EDU, ORG, GOV, UK, TV of the world. As the Internet expanded each country was assigned a unique two-letter top-level domain. For example the TLD for the United Kingdom is UK. Within each TLD various agencies are responsible for name registration, called registrars. The role of the registrar is to insure each registered name is unique within a top-level domain. For example in our case when we were registering a domain name schmidt.com was assigned so we choose tschmidt.com.

Often an organization needs to create sub domains such as www.tschmidt.com for web access, mail.tschmidt.com for email or product.tschmidt.com for product info. Since domain name is registered and guaranteed to be unique domain owner is free to add as many sub domains as desired.

### 2.3.1 Domain Name System (DNS)

When a domain is registered the registrar database contains a list of Nameservers that provide authoritive information about the site. Authoritive Nameservers are managed by the site administrator and contain all the information necessary to access the various servers within that domain.

When a URL is entered into the browser, such as http://www.google.com/, browser first checks to see if host is on the LAN. Windows name resolution looks in the Hosts file to see if an address has been entered manually then it uses NetBIOS over IP to search local machines. This is a broadcast mechanism and works well on small LANs but does not scale well. If host name is not found locally translation request is passed to DNS Resolver.

Let’s trace what happens when we look up http://www.google.com Since Google URL is not local it is passed to the DNS system. The highest level is root. The naming hierarchy includes an implied dot (.) to the right of the TLD this is called the root. The DNS Resolver is preprogrammed with the IP address of several root Nameservers. The request goes to one of the root Nameservers that returns the address of the Nameserver for the .COM top-level domain (TLD) since Google is in the COM TLD. Then the COM Nameserver is queried for the address of Google Nameserver. The server returns the address of the authoritive Nameserver for the Google domain. It is important to note root Nameserver does not know address of any Google servers other than the Google Nameserver. Google Nameserver is then asked for the address of the desired host. Often sites create sub domains for specific servers, the process continues until the address of the desired host is determined. Once browser learns host’s IP address it is able to communicate. This is a very superficial view of how DNS works. For a more in-depth view see DNS Complexity by Paul Vixie.

Obviously going thought this multistep process each time one needs to translate a URL is rather time consuming. To speed up the process DNS resolvers’ cache recently used information. DNS records have a time to live (TTL) parameter indicating how long cached information may be used before it must be refreshed. URL name lookup is normally accomplished in a few milliseconds.

### 2.3.2 DNS Security Extensions (DNSSE)

As the Internet becomes ever more pervasive attention has been drawn to lack of DNS security. Hackers are able to easily poison cached DNS information. Doing so allows an attacker to redirect browsers to compromised site for nefarious purposes. A high priority initiative is to implement Domain Name System Security Extensions (DNSSEC) to counteract this sort of attack and increase level of confidence in DNS.

## 2.4 Routing

Internet is a routed network. This is very different then broadcast discovery scheme used locally by Ethernet or circuit switching used by telephone network. When a computer wants to communicate with a resource not available locally it forwards packet to gateway router. The gateway router is the interface between the local network (LAN) and the Internet. The router forwards packets to the proper destination or to next router in the chain. In order to learn network topology routers use a variety of techniques to communicate among themselves such as RIP and OSPF. ISP routers forward incoming packets to customers and customer originated packets to the Internet backbone. Each router in the chain forwards packets closer to the destination until the packet ultimately arrives at its destination. It is not uncommon to have ten to twenty hops between sender and destination.

The routing task for typical residential router is trivial as there is usually only one connection to the Internet. The router simply forwards all packets to the ISP's edge router.

Doing a trace route to an Internet host provides a graphic indication of how routing works. Here is a trace route from my east coast home office to my web site hosted on the west coast.

```
Tracing route to tschmidt.com [173.231.1.94] over a maximum of 30 hops:

  1    <1 ms    <1 ms    <1 ms  192.168.2.1
  2    28 ms    28 ms    27 ms  xx.milford1-1.nh.g4.net [66.211.144.97]
  3    28 ms    28 ms    28 ms  gi-3-1.nashua1-1.nh.G4.net [216.177.5.178]
  4    29 ms    29 ms    29 ms  ge-24-v108.merrimack3-1.nh.G4.net [216.177.5.150]
  5    29 ms    29 ms    29 ms  gi-21-v358.manchester3-1.nh.G4.net [216.177.30.153]
  6    29 ms    28 ms    28 ms  gi-0-0-0-0-357.manchester1-9.nh.G4.net [216.177.5.137]
  7    28 ms    28 ms    28 ms  ge-x-x-x.manchester0-8.nh.G4.net [66.211.128.9]
  8    35 ms    35 ms    36 ms  67.208.178.89.nyc.electricfiber.net [67.208.178.89]
  9    35 ms    35 ms    35 ms  xe-0-0-0.bos11.ip4.tinet.net [173.241.129.217]
 10   114 ms   114 ms   114 ms  ge-1-1-0.lax22.ip4.tinet.net [89.149.185.177]
 11   114 ms   113 ms   113 ms  ace-data-centers-gw.ip4.tinet.net [173.241.129.46]
 12   115 ms   115 ms   115 ms  69-27-173-58.acedc.net [69.27.173.58]
 13   115 ms   115 ms   115 ms  100-42-223-158.static.webnx.com [100.42.223.158]
 14   115 ms   115 ms   114 ms  100-42-223-170.static.webnx.com [100.42.223.170]
 15   115 ms   115 ms   115 ms  server54.verygoodserver.com [173.231.1.94]

Trace complete.
```

## 2.5 Unicast vs Multicast

Most Internet traffic is between one sender and one receiver (unicast). Multicast emulates traditional broadcast one-to-many model. This is a more efficient way to stream identical information to many endpoints. Unfortunately even though specification is mature not many ISPs have implemented multicast. In general if you listen to Internet radio or TV it is being transmitted as unicast.

## 2.6 TCP vs UDP

There are two principle ways to transmit information over the Internet; Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). TCP creates a session where receiver acknowledges each packet. This is ideal for file transfer type communication. Recovery from missing or corrupt packets is more important than latency. With UDP transmitter sends data without expecting feedback from receiver. UDP is commonly used with streaming audio and video transmission where latency is more important than accuracy and insufficient time exists to recover from transmission errors. If an error occurs it is up to the receiver to fake the missing data.

## 2.7 Quality of Service (QoS)

Internet is an egalitarian best effort network. This works amazing well for transferring large chunks of data from point A to point B. The network continues to operate in the presence of all sorts of impairments and failures. However: best effort does not work as well with latency sensitive applications such as telephony and streaming media. For example during a Voice over IP (VoIP) phone call round trip latency should be under 150ms, in each direction. Excessive delay makes carrying on a conversation difficult and with extreme delay virtually impossible. Streaming media is less sensitive to latency as long as average data rate exceeds playback rate. When a stream is first started an elastic buffer is filled prior to playback. The buffer fills and empties dynamically. As long as latency does not allow the buffer to completely empty the effect is hidden from the user.

QoS problems typically do not occur on the LAN where bandwidth is plentiful. The most common chokepoint is first-mile access, the ISP's edge network. Most residential broadband links are relatively slow, especially upload capacity, and they are often heavily oversubscribed to minimize capital cost. When switch or router encounters congestion it buffers incoming packets until it is able to forward them. Quality of Service (QoS) metrics allows latency critical packets go to the head of the queue. This simple strategy works well if latency critical traffic is a small percent of total so bumping its priority has little effect on other traffic. QoS marks packets with a (Diffserv) priority level. When congestion occurs higher value packets are delivered as quickly as possible. Lower value packets are delayed or discarded. QoS services allow more graceful degradation by moving high priority packets to the head of the queue. QoS is not a panacea, it does not create more capacity, it simply redefines winners and losers.

## 2.8 Flow Control - Back Pressure, TCP Slow Start, Receive Window

When a host begins transmission it has no idea how fast intervening links between it and remote host are. Switched Ethernet uses back pressure to prevent overwhelming slower links. An Ethernet receiver asks the transmitter to stop sending data by sending it a pause frame. This occurs if the outgoing switch port becomes congested.

At the IP level transmitter uses a technique called slow-start by sending a few packets then waiting for acknowledge. The faster ACKs are received the more packets transmitter sends per unit of time. TCP Receive Window (RWIN) parameter determines how many unacknowledged packets can be outstanding before transmitter must stop transmitting and wait.

## 2.9 IP Address Configuration

Each IP device (host) must have an address. Addresses may be assigned: manually, automatically by Dynamic Host Configuration Protocol (DHCP) server or by the client itself using Automatic Private IP addressing (APIPA). Traditionally a system administrator manually configured each host with a static address. This was laborious and error prone. DHCP simplifies the task by automating address allocation. When a host detects it has a network connection it transmits a DHCP discovery message. If the LAN contains a DHCP server the server responds with all the information the client needs to utilize the network. DHCP has been extended to allow automatic configuration if the client cannot find a DHCP server. In that case client assigns itself an address from the AutoIP address pool. AutoIP is convenient for small LANs that use IP and do not have access to a DHCP server. This occurs most commonly when two PC's are directly connected.

IPv4 assigns each host a 32-bit address, resulting in a maximum Internet population of about 4 billion hosts. Due to IPv4 address scarcity it is common practice for ISPs to charge for additional addresses. Address exhaustion has been a concern for a long time. Classless inter-domain routing (CIDR) and Network Address translation (NAT) are two techniques used to delay the day of reckoning. Next generation IP, version 6, expands address space to 128 bits. This is a truly gigantic number. While IPv6 holds much promise it entails wholesale overhaul of the Internet. Such change is always resisted until one has no choice to go through the pain of conversion. My ISP does not currently support IPv6 so I have limited experience with it.

### 2.9.1 IPv4 Dotted-Decimal Notation

IPv4 addresses are expressed in dotted decimal notation, four decimal numbers separated by periods, nnn.nnn.nnn.nnn. The 32-bit address is divided into four 8-bit fields called octets. Each field has a range of 0-255. The smallest address is 0.0.0.0 and largest 255.255.255.255.

### 2.9.2 Subnet

IP addresses consist of two parts a Network-Prefix and Host address. Subnetting allows IP addresses to be assigned efficiently and simplifies routing. The subnet mask defines boundary between network and host portion of address. Hosts within a subnet communicate directly with one another. Hosts on different subnets use routers to forward packets from one subnet to another.

In our network all computers are on a single subnet: 255.255.255.0 allowing up to 254 hosts (computers) also called a /24 (pronounced slash 24) subnet because the first 24-bits of address are fixed. Host addresses are allocated from the last octet (8-bits). The reason for 254 rather than 256 hosts is lowest address is reserved as network address and highest address for multicast.

### 2.9.3 Class vs Classless Inter-Domain Routing (CIDR)

When Internet was initially developed divide between network prefix and host address was embedded within the address itself, rather than set by a subnet mask. These were called address classes, lettered A – E.

**Class A** – first octet is in the range 1 – 126 (0XXXXXXXb). 8-bits reserved for network portion leaving 24 for host addresses. 24-bits provide 16,777,213 host addresses. The lowest address is reserved as the network address, highest for broadcast. 127 octet is reserved for test purposes.

**Class B** – first octet is in the range 128 – 191 (10XXXXXXb). 16-bits reserved for network portion leaving 16 for host addresses. 16-bits provide 65,533 host addresses.

**Class C** – first octet is in the range 224 – 249 (110XXXXXb). 24-bits reserved for network portion leaving 8 for host addresses. 8-bits provide 254 host addresses.

**Class D –** first octet is in the range 224 – 239 (1110XXXXb). Class D networks reserved for multicasting.

**Class E** - first octet is in the range 240 – 255 (1111XXXXb). Class E networks reserved for experimental use.

It became clear very early that allocating addresses this way was very inefficient. Class C was too small for many organizations and Class A too large. Classless Inter-Domain Routing (CIDR) was developed to allow network prefix be fixed at any bit boundary. CIDR using variable subnet mask is now universal and Class based routing of historic interest, although one still hears reference to Class A, B, and C networks.

### 2.9.4 Local host Address

127.0.0.1 is the Loopback local host address. This is useful for testing to makes sure the network stack. Sending data to the Loopback address causes it to be received without actually going out over the physical network. The entire /8 block is reserved for local loopback.

### 2.9.5 Multicast Address Block

IP sessions are typically one to one, host A communicates with host B. It is also possible for a host to broadcast to multiple hosts. IANA reserved several address blocks for multicast.

**Multicast address block**

224.000.000.000 – 239.255.255.255 (224/8 – 239/8 prefix)

### 2.9.6 Private Address Block

During work on impending IPv4 address shortage RFC 1918 reserved three blocks of private addresses. Private addresses are ideal for our purposes because they are not used on public Internet. This allows them to be used and reused without risk of colliding with Internet hosts. This eliminates need and expense to obtain a block of routable addresses from the ISP. Internal hosts are assigned an address from RFC 1918 private address pool.

**Excerpt from IETF RFC 1918 Address Allocation for Private Internets:**

> *Internet Assigned Numbers Authority (IANA) reserved the following three blocks of the IP address space for private Internets:*

```
10.0.0.0     - 10.255.255.255   (10/8 prefix)
172.16.0.0   - 172.31.255.255   (172.16/12 prefix)
192.168.0.0  - 192.168.255.255  (192.168/16 prefix)
```

> *We will refer to the first block as "24-bit block", the second as "20-bit block", and to the third as "16-bit" block. Note that (in pre-CIDR notation) the first block is nothing but a single class A network number, while the second block is a set of 16 contiguous class B network numbers, and third block is a set of 256 contiguous class C network numbers.*
>
> *An enterprise that decides to use IP addresses out of the address space defined in this document can do so without any coordination with IANA or an Internet registry. The address space can thus be used by many enterprises. Addresses within this private address space will only be unique within the enterprise, or the set of enterprises which choose to cooperate over this space so they may communicate with each other in their own private Internet.*

### 2.9.7 APIPA Address Block

A fourth block of private IP addresses is reserved for APIPA. If a host is configured to obtain a dynamic address and a DHCP server cannot be found host assigns an address to itself from this pool of reserved addresses.  Host picks an address from AutoIP address pool, and tests to see if it is already in use by trying to contact that IP address. If the address is not in use it assigns itself the address. If the address is in use it picks another at random and tries again.

**AutoIP address block:**

169.254.0.0   - 169.254.255.255 (169.254/16 prefix)

AutoIP is useful for tiny networks that do not include a DHCP server. Before AutoIP user had to manually configure address and subnet mask to set up a simple IP network.

### 2.9.8 Network Address and Port Translation

Residential ISP accounts are typically assigned a single IP address. This limits customer to connecting a single computer to the Internet. Network Address Translation (NAT) is used to convert private LAN IP addresses to/from single address assigned by the ISP. To enable multiple sessions of the same type to operate simultaneously Port numbers also need to be changed. NAT allows an unlimited number of devices, assigned private IP addresses, to share an ISP account even if ISP only provides a one IP address.

NAT is widely used on residential networks to share a connection among multiple computers.

### 2.9.9 Address Resolution Protocol (ARP)

IP addresses represent Internet global numbering scheme. Addresses used by local network are different. For example Ethernet uses a 48-bit MAC address. ARP provides a mechanism to learn MAC address associated with a particular IP address. Reverse ARP (RARP) determines if an IP address exists for a particular MAC address.

### 2.9.10 Ports

Internet host is able to carry on multiple simultaneous communications sessions. This raises the question how does the computer know how to respond to specific incoming packets? While writing this paper my mail program is checking e-mail every few minutes, I'm listening to a web based radio program and from time to time getting information from a multitude of web sites. Each TCP or UDP packet includes a port number. Port numbers are 16-bit unsigned values that range from 0-65,535. The low port numbers 0-1023 are called well-known ports; they are assigned by IANA the Internet Assigned Number Authority when a service is defined. Software uses the well-known port to make initial contact. Once connection is established high numbered ports are used during the transfer. For example: when you enter a URL to access a web site the browser automatically uses port 80. This is the well know port for web servers. Once the connection is established client and server agree on high number ports to use to actually transfer data.

## *2.10 IPv4 vs IPv6*

IPv4 is the predominant protocol used on the Internet today. A defining characteristic is its 32-bit address space. Each host on the Internet needs a unique address. The IPv4 address field is 32-bits wide able to address a maximum of 4,292,967,295 hosts. 4 billion is a pretty large number and it certainly was back in the 1980's when the Internet was limited to a few educational intuitions and the federal government.

To put 4 billion into perspective present worldwide population is approximately 7 billion. It is true that not everyone has Internet access but many do and those who have access often have multiple devices. At any given time in our home there are typically 10 devices connected to the Internet.

The address limitation of IPv4 was recognized long ago. While mechanisms such as private addresses and NAT have extended the life of IPv4 it is clear the address range needs to be expanded. A watershed event occurred February 2011 when the last IPv4 address blocks were handed out to regional registrars.

The successor to IPv4 is IPv6 with a massively expanded address range of 128-bits. IPv6 brings a host of improvements to the Internet but because it is not directly backward compatible to IPv4 adoption has been very slow. Companies and service providers are faced with a typical chicken and egg problem. There is no first mover advantage. Being the only one able to support IPv6 has no advantage.

There have been a number of well published IPv6 days to build awareness and resolve the inevitable problems. IPv6 use is increase but at a snail's pace. IPv6 support for residential gear is spotty at best and most ISPs have adopted a wait and see attitude.

The chart below shows how many IP addresses each of the five Regional Internet Registrars are issuing every day.

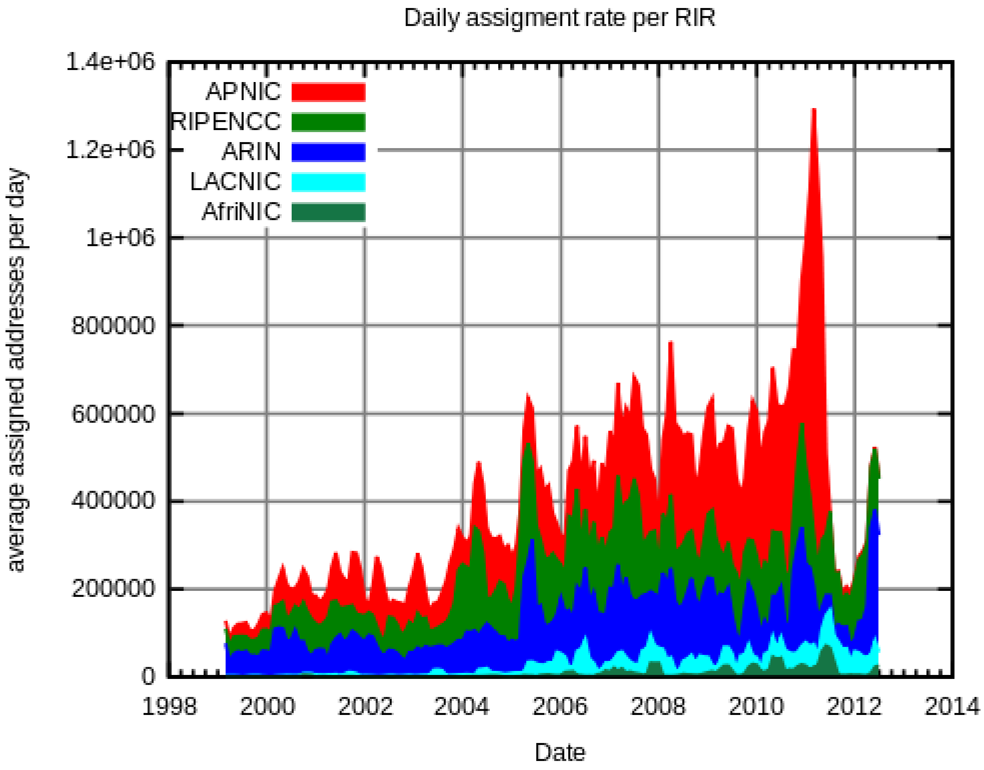


**Figure 2 IP Address Consumption per Day**

# 3 Broadband Router – One Connection Many Computers

In order to share an ISP connection a router is needed to connect the LAN to the ISP's Network. Today's residential routers combine many different functions into a single low cost device. A modem is needed to connect to the ISP's network. The job of the modem is to convert signaling used on the wide area network (WAN) to a form that can be used locally. In some instances the router incudes' a modem allowing the router to be connected directly to the ISPs network. In outer cases the router's WAN interface connects to the ISP supplied modem.

When we first set up our SOHO network back in 1998 used Wingate connections sharing software running on a laptop to share a dialup connection. Over time we have used several different routers as our ISP and connection speed changed. Our current connection is ADSL. My preference is a combo ADSL modem/router because it makes access to low level modem info easy. Having access to modem status is handy for troubleshooting.

We recently changed ISPs to get faster speed. The ISP supplied a ZyXEL P660R-D1 single port router, replacing our old Netopia 3346N.

**Figure 3 ZyXEL ADSL Router**

Using a router creates a clear distinction between LAN and WAN simplifying troubleshooting. The router market is extremely competitive. New routers can be had for less than $50 US and used high end devices go for short money on eBay.

## 3.1 ADSL Overview

ADSL takes advantage the copper circuit between phone company central office and subscriber has unused capacity. Analog voice uses only a tiny fraction of available capacity. With clever engineering that unused capacity can be used to send and receive data. A tremendous amount of engineering has gone into DSL to allow 100 year old telephone copper loop deliver multimegabit Internet service. ADSL modems use a technique called discrete multi-tone (DMT) to divide available capacity into small chunks and send a few bits over each separate tone. DMT has the advantage of being able to work around impairments by changing the number of bit bits sent in each tone.

DSL is a distance limited technology. The signal weakens as it travels down the wire and picks up noise limiting connection speed. One does not know in advance how fast the connection will be until it is turned up. ISPs often market DSL as "up to xx Mbps" causing customer frustration when actual speed is less than marketing representation. Customer must be within 18,000 feet (3.5 miles) of the central office or remote terminal to qualify at all. The closer you are the more likely to obtain high speed.

ITU ADSL specification has gone through several enhancements. ADSL2 and ADSL2+ delivers higher speed and longer range then first generation equipment. ADSL delivered up to 8 Mbps down (toward customer and 1 Mbps up. ADSL2 increased download speed to 12 Mbps, upload is unchanged. ADSL2+ doubles maximum download speed to 24 Mbps over relatively short distances.  Another standard, VDSL2 is able to deliver even higher speed but only over a few thousand feet of cable.

DSL is a complex and fascinating technology. The interested reader is invited to research the topic in depth. Allied Telesis has a White Paper that goes into much greater technical detail.

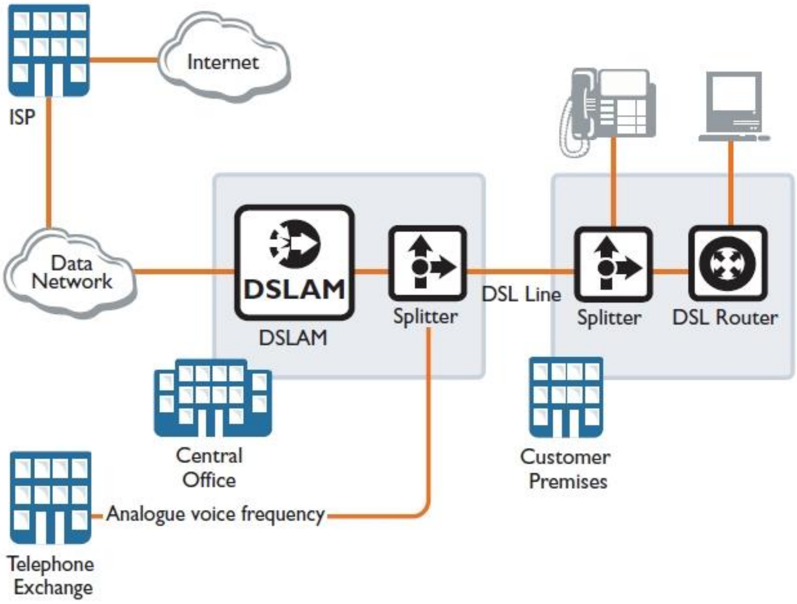


**Figure 4 DSL Central Office to Customer**

Because DSL shares the same circuit as plain old telephone system (POTS) filters are required at both ends to prevent high frequency DSL signals from interfering with telephone operation.  Customer has the option to use an in-line filter at each non-DSL device or install a whole house POTS/DSL splitter. To reduce deployment rather than sending a tech out to install a whole house splitter ISPs typically provide a self-install kit including inline filters for customer to use. I'll talk more about wiring in a later section.

### 3.1.1 Fastpath vs Interleave

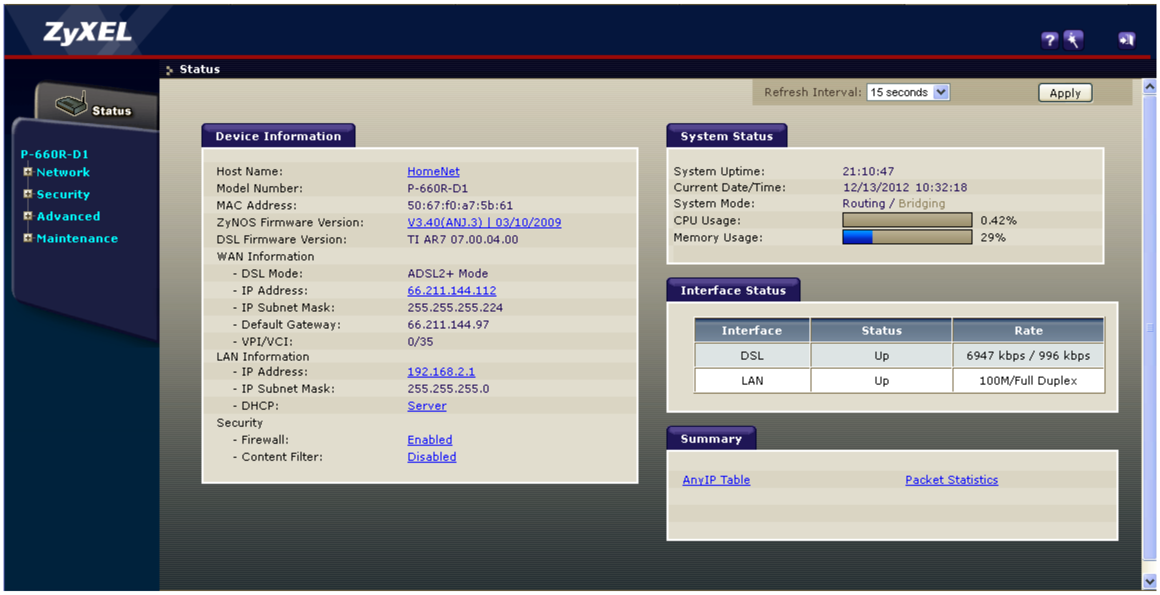
Because DSL uses copper phone lines it is sensitive to electrical impulse noise. To make the signal more resistant ADSL adds redundant bits to each frame called forward error correction (FEC). If noise corrupts some of the bits the receiver is able to correct the corrupt data as long as it is not too extensive. If too many bits are corrupt the frame cannot be recovered.  To increase noise tolerance DSL interleaves multiple frames. When the receiver deinterleaves the data noise damage is now spread over multiple frames increasing the odds receiver will be able to recover the data.

As with any engineering tradeoff there is no free lunch. Interleave increases latency because multiple frames must be queued up prior to transmission. The improved effective signal to noise ratio (SNR) is advantageous for file transfer and streaming media.  Correcting corrupt data on the fly eliminates the need for retransmission.  With streaming media there is not enough time to request retransmission so receiver needs to fake the missing data, resulting in audible or visual anomalies. How annoying that is depends on how much data has gone missing.

On the other hand latency sensitive applications benefit from fastpath, because it reduces latency at the expense of signal integrity. Fastpath reduces DSL latency by about 10ms. In most cases this savings is swamped out by other end-to-end Internet latencies. But if you are a gamer and your line stats are good may be worthwhile experimenting with fastpath.

## 3.2 ADSL Modem

FairPoint like most other ILECs markets different speed tiers. Faster speed costs more and requires a shorter loop distance. We had been capped at 3360/864 kbps sync rate for years due to distance. I recently switched landline telephone and DSL to G4 Communication. G4 is a competitive local exchange carrier (CLEC). They rent copper subscriber circuits from FairPoint, our incumbent local exchange carrier (ILEC), and collocate their equipment in FairPoint central offices. G4 markets ADSL differently as it does not impose a speed cap. Speed is based solely on what the circuit is able to handle. We were pleasantly surprised to see sync speed increase to 7 Mbps down and 1 Mbps up.



Refresh Interval: 15 seconds

Device Information

Host Name: HomeNet
Model Number: P-660R-D1
MAC Address: 50:67:f0:a7:5b:61
ZyNOS Firmware Version: V3.40(ANJ.3) | 03/10/2009
DSL Firmware Version: TI AR7 07.00.04.00
WAN Information
- DSL Mode: ADSL2+ Mode
- IP Address: 66.211.144.112
- IP Subnet Mask: 255.255.255.224
- Default Gateway: 66.211.144.97
- VPI/VCI: 0/35
LAN Information
- IP Address: 192.168.2.1
- IP Subnet Mask: 255.255.255.0
- DHCP: Server
Security
- Firewall: Enabled
- Content Filter: Disabled

System Status

System Uptime: 21:10:47
Current Date/Time: 12/13/2012 10:32:18
System Mode: Routing / Bridging
CPU Usage: 0.42%
Memory Usage: 29%

Interface Status

| Interface | Status | Rate |
|---|---|---|
| DSL | Up | 6947 kbps / 996 kbps |
| LAN | Up | 100M/Full Duplex |

Summary

AnyIP Table    Packet Statistics

**Figure 5 DSL Modem Status Page**

The ZyXEL router has a nice feature that if you do not enter a password to log in the main status screen is displayed in read only mode. This lets anyone view connection status but restricts being able to make changes.

## 3.3 ISP WAN Interface

The Wide Area Network (WAN) side of the modem is responsible for encoding and recovering bits over the phone line and extending the ISP's network to the customer. Often times the ADSL modem is combined with a residential router and in some cases a Wi-Fi access point to deliver multiple services in one inexpensive combined device.

When a router without a modem is used say with a standalone ADSL or Cable modem the physical interface between router and modem is Ethernet. In that case the WAN interface of the router acts much the same as the Ethernet interface of a normal computer. The work performed by the modem to maintain the connection is mostly hidden from the router.

The main functions of the WAN side of an ADSL router are:

- Send and recover ADSL signals over the phone line

- Data encapsulation typically using ATM between customer and ISP
- Automatically configure IP settings on customer equipment

### 3.3.1 ATM

Most DSL connections use Asynchronous Transfer Mode to transport data over the DSL link. ATM is designed to transport low latency digital telephone traffic. Data is transported in 53-byte cells of which 48 carry data the other 5 are overhead.  ATM is a legacy of circuit switched telephone network and uses virtual circuits. When setting up the modem need to specify the Virtual Path Identifier (VPI) and Virtual Channel Identifier (VCI). Unfortunately when used for data ATM adds significant overhead, the so called ATM cell tax.

There are various methods of transporting IP packets over ATM, called adaption layers. You need to use the method specified by your ISP.

### 3.3.2 IP Settings

Assuming the modem is able to successfully transport data over the DSL link the next step in the process is to configure Internet Protocol (IP) parameters so customer is able to access the Internet.

There are three methods ISPs use to configure customer equipment:

- Statically
- DHCP
- PPPoE (or PPPoA)

Most business accounts are configured statically to facilitate running servers. With a static assignment the IP address never changes.  The ISP sends customer configuration information and customer in turn manually configures equipment.

Residential accounts typically use DHCP or PPPoE. DHCP works much the same as having a PC connected to a LAN. When modem powers up it first synchronizes to the DSL line then searches for a DHCP server. The DHCP server communicates IP settings to the router. FairPoint and most other ILEC's use Point-to-Point Protocol over Ethernet. PPPoE works much the same as with dialup only much faster. PPPoE requires customer enter a user name and password. The downside of PPPoE is slightly higher overhead and the need to log in and maintain a persistent user session.

G4 Communication uses DHCP rather than PPPoE for residential accounts promising a more reliable connection. In the past we would often lose Internet access due to inability to maintain a PPPoE session even though DSL itself was working correctly.

### 3.3.3 PPPoE and MTU

The downside of PPPoE is that customer needs to login and ISP maintain an active session. Being an encapsulation protocol PPPoE reserves 8 bytes of each 1500 byte packet reducing maxim transmission unit (MTU) to 1492.

Internet packets are limited to 1500 bytes. PPPoE adds 8 bytes of overhead to each packet reducing maximum payload size to 1492. Internet packets can be fragmented and reassembled. However: many residential routers do not implement fragmentation. Even when properly implemented fragmentation incurs a significant performance penalty since an over large packet is split into two smaller ones with attendant IP overhead.

A better solution is to limit packet size so fragmentation/reassembly is not required. Windows TCP/IP protocol stack implements path discovery to automatically limit packet size so fragmentation is not needed. When PPPoE us used maximum transmission unit (MTU) is 1452 bytes: 1452 bytes data + 40 bytes

TCP/IP overhead + 8 bytes PPPoE = 1500 bytes. A good indication of packet fragmentation is if sending a little data <1452 bytes works but larger files do not.

The main downside of PPPoE is not the slight extra overhead of the 8 bytes (.6%) but the difficulty maintaining the session. If the session terminates connection is lost until the user logs in again. With a modem this happens automatically so normally hidden from the user. With both Verizon and FairPoint we would normally go days with the same PPPoE session so did not notice the momentary interruption. However on numerous occasions with both ISPs had multiple episodes where modem would log back in and almost immediately be dropped or account was not recognized at all for hours on end. I'm happy to be rid of PPPoE.

## *3.4 LAN Side Address Management*

At this point if all we wanted to do is connect a single computer we would be done. The modem is able to send digital data over the wire and the ISP has configured the customer's IP setting.

In order to connect multiple computers the router needs to perform additional tasks.

### 3.4.1 LAN IP Address Assignment

The choice for most residential networks is to configure the LAN using RFC 1918 private addresses. By using private addresses and network address translation (NAT) a virtually unlimited number of computers are able to share a single ISP IP connection. Being private the address pool can be used and reused multiple times conserving IPv4 Address space and eliminate need to request and pay for additional public addresses.

There are two ways to configure IP setting on LAN devices, statically and dynamically. Each has benefits and limitations.

### 3.4.2 Static

The pros and cons of static allocation on the LAN are much the same as on the WAN. Static assignment requires IP parameters: address, subnet mask, gateway address, and DNS address be manually configured on the device. If the LAN is using a mix of static and dynamic addresses it is important to pick a static address outside the range used by DHCP but within the subnet. If a computer is configured statically it is possible the DHCP server will assign the same address to another device. This results in an address collision which will prevent both devices from communicating. We configured the router's DHCP server to issue addresses in 192.168.2.2 - 192.168.2.100 range with a subnet mask of 255.255.255.0. Static addresses can be assigned in the range 192.168.2.101 – 192.168.2.254. This keeps all addresses within the subnet without interfering with DHCP operation.

### 3.4.3 Dynamic

This is the default behavior of most operating systems. When the computer detects it is connected to a network, either wired or wireless, it searches for a DHCP server. The DHCP server in the router responds to the request and assigns each machine an appropriate IP address. Once PC is configured it is able to communicate. The address is "leased" to the client. Prior to lease expiring the client attempts to renew it. Under normal conditions the lease never expires and client IP address remains the same. If client is off network for extended period of time lease will expire. Next time computer is attached it may receive different IP address.

### 3.4.4 MAC Reservation

For some devices, such as servers, dynamic addressing is inconvenient. For example the binding to our HP printer is by IP address. If address changes each PCs needs to be reconfigured. A solution is to create a pseudo static address. The address issued by the DHCP server is bound to the client's MAC address. As long as MAC address does not change the device is always assigned the same IP address. This is more convenient than setting addresses manually on each device but achieves the same effect.

### 3.4.5 Media Access Controller (MAC) Address

Each interface (wired or wireless) has a unique 48-bit MAC address built into hardware. This allows the device to be uniquely addressed. This address is not the same as the IP address.

**Excerpt from Assigned Ethernet numbers:**

```
Ethernet hardware addresses are 48 bits, expressed as 12
hexadecimal digits (0-9, plus A-F, capitalized).  These 12 hex
digits consist of the first/left 6 digits (which should match the
vendor of the Ethernet interface within the station) and the
last/right 6 digits which specify the interface serial number for
that interface vendor.

These high-order 3 octets (6 hex digits) are also known as the
Organizationally Unique Identifier or OUI.

These addresses are physical station addresses, not multicast nor
broadcast, so the second hex digit (reading from the left) will
be even, not odd.
```

Device manufactures obtain OUIs from IEEE. Each chip is assigned a unique value consisting of the OUI and a serial number allocated from the last three octets.  Three octets yield:  16,777,215 values, so the OUI lasts a long time. When the manufacturer exhausts the allocation they need to go back to IEEE for another OUI. Since the first three octets are assigned to the chip manufacturer it is possible to verify who made the chip by looking up the OUI on the IEEE's web site.

## *3.5 Network Address Translation (NAT)*

Most residential ISPs restrict customer to a single IP address. Limited size of IPv4 address (32-bits) space means addresses are in short supply. ISPs often charge extra if more than one address is needed. This creates a quandary; how to cost effectively connect multiple hosts to the Internet? The most common workaround is Network Address Translation (NAT) using private IP addresses. IETF RFC 1918 reserved three blocks of IP addresses guaranteed not used on the Internet. Because these addresses are not used on the public Internet they can be reused multiple times.

Combining NAT, more properly Network Address Port Translation since both address and port number are modified, and RFC 1918 private addresses allow a virtually unlimited number of computers to share an Internet connection even though ISP only provides a single IP address. NAT provides translation between private addresses on LAN side and a single address issued by the ISP on the WAN.

Internal LAN traffic proceeds normally; NAT is not required for local traffic between computers on the LAN. When a request cannot be serviced locally it is passed to the NAT router, called a gateway. Router modifies the packet by replacing private address with public address issued by the ISP and if needed changes the port number to support multiple sessions and calculates new checksum. Router sends modified packet to remote host as-if-it-originated-from-the-router. When reply is received router converts address and port number back to that of the originating device and forwards it to the LAN. NAT router tracks individual sessions so multiple hosts are able to share a single address. As far as Internet hosts are concerned the entire LAN looks like a single computer.

### 3.5.1 Performance

NAT requires a lot of bookkeeping, changing IP and port addresses, than computing new packet checksum. Routers have no trouble keeping up with WAN connections of a few megabits per second. If you are blessed with really fast broadband connection say 10 or even 100 Mbps make sure router is up to the task.

NAT translation table size limits the maximum number of simultaneous sessions router is able to maintain. This limit does not affect normal Internet usage.  However when Peer-to-Peer (P2P) protocols are used the large number of simultaneous sessions may overwhelm a low-end router.

### 3.5.2 Security

NAT blocks remotely originated traffic. It functions as a de facto incoming firewall because router does not know where to forward packets that originates outside the LAN unless specifically programmed with port forwarding rules.

### 3.5.3 Limitations of NAT

As useful as NAT is it is also controversial. It breaks the end-to-end Internet addressing paradigm. NAT maintains state information. If it fails session recovery is not possible. It interferes with server functionality and IPsec VPNs.

This is not to discourage use of NAT as it is very powerful technique. But NAT should be seen for what it is, a short-term workaround to minimize effects of IPv4 address shortage, not a permanent extension to Internet technology. For more information see RFC 2993 Architectural Implications of NAT.

## *3.6 Default Gateway*

Local devices on the LAN are able to communicate directly with one another, a router is not required. If a PC has a packet not destined for a local device it forwards the packet to the gateway. The gateway router decides how to deliver packets that travel outside the LAN. Since only a single connection exists between our network and the ISP routing is trivial. The router simply forwards all non-local packets to the ISP's edge router.

## *3.7 DNS*

The Domain Name System (DNS) allows access to Internet hosts by name rather than IP address. Name resolution for local devices is performed by NetBIOS over IP. Windows maintains a list of local computer names. It is also possible to manually define names by placing entries in the Hosts file on the computer to override other name resolution. If Windows cannot resolve a host name locally it assumes it is a remote host and makes a DNS request of the router. The router in turn forwards request to the ISP's DNS nameserver.

Router does not actually implement DNS functionality but simply relays the request to the name server provided by the ISP. When a PC connects one of the pieces of information configured by DHCP is the DNS server address. DHCP tells the PC to send DNS requests to the router. When a PC needs to look up a host address it sends the request to the router.  The router in turn figures out which DNS server to use. ISPs typically implement multiple DNS server for redundancy. If the primary DNS resolver goes down the router will attempt to use the secondary server.

Normally DNS is provided by your ISP.  However, any DNS server can be used to translate URLs to IP addresses.  If you chose not to use the DNS provided by your ISP you have two option use a public DNS server or run your own. There are a number public DNS servers of which Google is probably the most widely known.  The other option is to run your own DNS resolver.  I've used TreeWalk for many years but it appears the site no longer exists.

There is a downside of using DNS other than provided by your ISP. Many larger ISPs have special arrangements with Content Delivery Network (CDN) providers.  The role of CDN is to improve streaming performance by locating caching media servers near the respective ISP.  If you are not using DNS provided by your ISP may take a hit on multimedia performance since your DNS server is not privy to those special arrangements.

## *3.8 Firewall*

The router includes a stateful inspection firewall. This provides another layer of security by observing inbound and outbound traffic and dropping nonconforming packets.

### 3.8.1 Universal Plug and Play

UPNP is an outgrowth of PC plug and play experience designed to automatically configure local network devices. As this paper should make clear configuring a LAN can be a daunting task requiring user to be conversant with network terminology and concepts. UPNP provides automatic discovery and when needed requests firewall/router configuration changes.

Unfortunately UPNP makes no provision for security so one has no knowledge or control over malicious devices attempting to gain unauthorized access to the Internet. If you are unfamiliar with network configuration and confident PCs have not been compromised then UPNP is very convenient. On the other hand if you are comfortable configuring network devices doing so manually improves security. We leave UPnP disabled in the router.

## *3.9 QoS*

Router implements multiple QoS functions to make optimum use of limited WAN bandwidth. If packets arrive faster than they are able to be delivered QoS places high priority packets at the head of the list. It is important to keep in mind QoS does not improve capacity it simply determines winners and losers. In a bandwidth limited environment that can often improve the user experience but it does not magically create more capacity.

## *3.10 Syslog Event Logging*

Router logs significant events and forwards them to Syslog server. This overcomes one of the main limitations using a dedicated appliance for Internet sharing – limited data storage. Router emits Syslog data to the PC server. One of the services running on the server is Kiwi Syslog. Running a syslog server is convenient because it is able to aggregate logs from multiple devices – one stop shopping

Curiously I had to use Telnet to access the command line interface to set up Syslog, as there was no GUI for this feature. Syslog feature was not even mentioned in the user manual. If you are comfortable poking around with the command line interface (CLI) it makes sense to Telnet into your router to see what surprises are available.

## *3.11 Management*

Routers typically include a number of remote management features. They assist in troubleshooting but do impact security. Below are the most common management functions.

### 3.11.1 ICMP

Internet control management protocol (ICMP) is a suite of tools used to trouble network problems. For our purposes the most useful is Ping. Ping sends a small packet to the remote host and waits for a response. This is an easy way to verify remote host is up and running. It is a good idea to enable router to respond to ICMP. In addition may need to contact your ISP to have them enable ICMP within their network. Some ISPs disable support for ICMP making troubleshooting more difficult.

### 3.11.2 SNMP

Simple Network Management Protocol (SNMP) is a widely used management scheme. SNMP can be configured to provide read only access to configuration data or read/write enabling remote management. SNMP uses management information block (MIB) to interpret status and remotely manage a device. SNMP is not typically used on small networks. If SNMP is not being used disable the feature, or if device does not allow SNMP to be disabled, at least change the default read-only and read-write community strings. The community string acts as a password so device only responds to authorized queries. The default community strings are often public/private.

### 3.11.3 Broadband Forum TR-069

TR-069 is a Broadband forum spec to facilitate ISP management of end user devices. If the router is supplied or configured by your ISP this feature is probably enabled and you will not be able to turn it off. If you are managing the router yourself turn off this feature unless you have shared access password with your ISP.

## *3.12 Ethernet Switch*

Each Ethernet connection needs to connect to a port on an Ethernet switch. Many residential gateways include a built in 4-port Ethernet switch so a few wired devices can easily connect. The router provided by our ISP is a single port router, it does not have a built in Ethernet switch. This is not an issue for us as we have large number of Ethernet drops and use a 16-port Ethernet switch.

> **Performance tip** – Using a single wide switch is advantageous from a performance standpoint then cascading multiple switches. While cascaded switches are transparent doing so limits speed between switches to that of the intervening link. In a wide switch that connections occurs internal to the switch using a much faster backplane connection.

## *3.13 Public Server Behind NAT*

Running a public server behind NAT requires router forward incoming connection requests to the appropriate server. By default incoming connection requests are discarded because router does not know which host on the LAN to forward them. The router acts as de facto inbound firewall. Port forwarding configures the router to accept an inbound connection request, to say port 80, and forward to the web server. To the remote host the server looks like it is using the public IP address supplied by the ISP, when in fact web server is on a private address hidden from the Internet.

> **Operational tip** - Most Residential NAT routers do not perform WAN Loopback. This prevents access to local public server by its URL or public IP address from within the LAN. Server must be accessed by its LAN machine name or LAN IP address. When server is accessed by public IP address from within the LAN router forwards request to the Internet. It does not realize host is local. End result is packet never reaches the server.
>
> If local access by DNS name or public address is important add the name/address information to Windows Host file. The Host file performs static name translation service invoked prior to DNS. If the requested host name is found in Hosts file Windows will use that address and not query DNS.

### 3.13.1 Dynamic DNS

Remote hosts use DNS to map URL to server's IP address. DNS assumes server configuration is static and changes only rarely. This poses a problem for residential customers with dynamic address allocation since server address may change suddenly without notice. Several services have sprung up to address this issue. Dynamic DNS services either run a small application on the router or on server to detect IP address change. When that occurs Dynamic DNS service is notified of address change. This is not a perfect solution since there can be significant delay between address changes and when new address is available. However for casual residential users it works well enough.

### 3.13.2 Multiple Identical Servers

Most residential broadband ISPs allocate a single IP address per account. This causes problems running multiple servers of the same type. For example when running a web server, incoming requests are to port 80, making it impossible to run two web servers on a single IP address using well-known port number. Workaround is to use a different port number for one of the web servers. If you are the only one accessing the server this is not a concern since you are aware of the non-standard port and can easily specify it in the browser.

http://mysite.com:8080

Where this becomes a problems is with a public server. In that case users have no way to know they need to use a nonstandard port to access the server. Many DynamicDNS services have provisions to redirect requests to the alternate port.

### 3.13.3 Active vs Passive FTP

The way File Transfer Protocol (FTP) allocates ports causes problems with NAT. To NAT an outbound FTP session appears to originate from the remote server, rather than user. As a result NAT prevents transfer. Routers know about this behavior so use of default FTP ports is not a problem. It becomes a problem if you change FTP ports from default 20/21 to some other value.

To learn more read: Active FTP vs. Passive FTP, a Definitive Explanation.

### 3.13.4 Security

Great care should be taken when running public servers. If an attacker is able to exploit a weakness in the server they gain access to the entire LAN. Once in control of a compromised server they are free to attack other machines on the LAN. We use a hosting service to minimize security risk rather than run a public server locally.

## *3.14 Measuring Internet Speed*

In a SOHO network LAN performance is rarely a speed determinate. Speed is typically limited by first-mile WAN connection. It can be a challenge teasing out various components of end-to-end performance to see if ISP link is working as advertised. The first step is to determine the bit rate being delivered by the ISP. In the case of ADSL this is a matter of looking at modem status and determining download and upload bit rate.

IP transmission splits data into 1500 byte chunks called packets (1-byte = 8-bits). Some of the 1500 bytes are used for network control so are not available for user data. TCP/IP uses 40 of the 1500 bytes for control. NOTE: this analysis assumes use of maximum size packets. Since overhead is fixed using smaller packet size incurs a higher percentage overhead.  With 40-bytes reserved for control out of every 1500-bytes sent only 1460 are available for data. This represents 2.6% overhead.

Some ISPs, typically phone companies, use an additional protocol called Peer to Peer Protocol over Ethernet (PPPoE) to transport DSL data. This is an adaptation of PPP used by dialup ISPs. Telco's like PPPoE because it facilitates support of third party ISPs as mandated by FCC.  PPPoE appends 8-bytes to each packet increasing overhead to 48-bytes reducing payload to 1452. Where PPPoE is used overhead is increased to 3.2%.

Most DSL ISPs use IP over Asynchronous Transfer Mode (ATM) (AAL5). ATM was designed for low latency voice telephony. When used for data it adds significant overhead. ATM transports data in 53-byte Cells of which only 48 are data the other 5 used for ATM control. Each 1500-byte packet is split into multiple ATM cells. A 1500-byte packet requires 32 cells (32 x 48 = 1,536 bytes). The extra 36=bytes are padded, further reducing ATM efficiency. 32 ATM cells require modem transmit 1,696 bytes of which only 1452 carry payload. Where ATM/PPPoE is used overhead is increased to 14.4%.

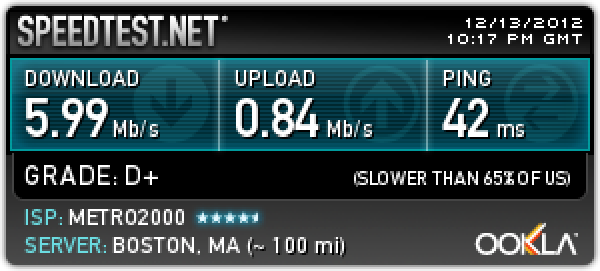
TCP/IP overhead 2.6% efficiency 97.4%
TCP/IP/PPPoE overhead 3.2% efficiency 96.8%
TCP/IP/PPPoE over ATM overhead 14.4%, efficiency 85.6%

As an example our old FairPoint 3000/768 ADSL service had a sync rate of 3360/864, 3360 kbps toward customer, 864 kbps toward Internet. FairPoint uses PPPoE and ATM yielding an overhead of 14.4%. Best-case transfer rate is 85.6% of sync rate, resulting in 2,876 kbps down 740 kbps up.

G4 DSL does not use PPPoE saving that overhead. Because speed is not capped like FairPoint sync speed varies a little. Current sync speed is about 7 Mbps down and 1 Mbps up yielding best case transfer of 6.19Mbps down and .884Mbps up.

File transfer speed reported by Broadband Reports or Speedtest.net is shown below.

NOTE: This is best-case speed based on packet overhead only. Errors, transmission delays, etc. will reduce speed from this value. The higher the speed the more impact even modest impairments have on throughput.



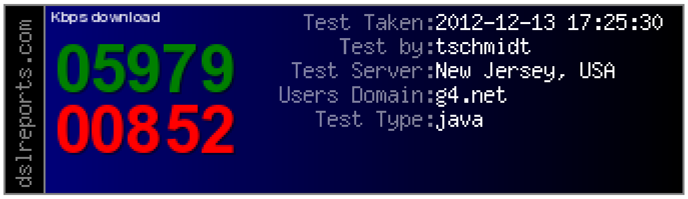
SPEEDTEST.NET
12/13/2012
10:17 PM GMT

DOWNLOAD 5.99 Mb/s
UPLOAD 0.84 Mb/s
PING 42 ms

GRADE: D+ (SLOWER THAN 65% OF US)

ISP: METRO2000 ★★★★★
SERVER: BOSTON, MA (~ 100 mi)

OOKLA



dslreports.com

Kbps download
05979
00852

```
 Test Taken:2012-12-13 17:25:30
    Test by:tschmidt
Test Server:New Jersey, USA
Users Domain:g4.net
  Test Type:java
```

**Figure 6 Speed Test Reports**

# 4 Local Area Network – Networking for Everyone

If you want to connect more than one computer to the Internet you need a Local Area Network (LAN). LANs are useful for much more than just Internet access. Having a LAN allows computers to access shared resources such as printer and files. Local resources are still available even if you lose Internet access. Unshielded Twisted Pair (UTP) Ethernet and Wi-Fi WLAN technology is ubiquitous and dominates the SOHO market.

Creating a LAN can be as simple as enabling Wi-Fi on your router to installing thousands of feet of Ethernet cable and dozens of jacks. Our network consists of an Access Point located on the second floor and 22 Ethernet jacks sprinkled throughout the house and in mine and my wife's work space.

## 4.1 Ethernet

Ethernet IEEE 802.3 using UTP cable is by far the most common local network technology in use today. Ethernet was initially based on Collision Detection Multiple Access Collision Avoidance (CDMA/CA). Think of it as a telephone party line. Before speaking one needs to listen to see if anyone else is talking. If no one is talking it is OK to begin. It is possible more than one person may start talking at the same time. That is a collision; no one is able to understand what is being said. When this occurs everyone stops talking for a while. When line is idle they try again. Each party waits a different length of time to minimize odds of colliding again. CDMA/CD imposes a number of constraints to network design. Minimum packet size must be longer than network end-to-end propagation delay. This insures transmitter is still transmitting when a collision occurs. This allows retries to be done at the data link layer hiding the collision from upper layer software. Power level and end-to-end loss budget must be set to allow reliable collision detection.

Modern Ethernet uses switches to interconnect stations eliminating the collision domain. This provides for much greater overall speed and allows full-duplex, rather than half-duplex transmission. With switched Ethernet stations are able to transmit and receive at the same time.

Ethernet has been hugely successful because it has been able to adapt to changing needs and technology while maintaining backward compatibility. Due to backward compatibility multiple generations of Ethernet gear is able to coexist.

### 4.1.1 Unshielded Twisted Pair

First generation Ethernet operated at 10 Mbps and used fat coax cable with clamp-on taps, called vampire taps. Early development focused on improving physical interconnection rather than speed. Specification evolved from fat coax, to thin coax to twisted pair. Today the most common type of Ethernet is unshielded twisted pair (UTP) copper cable consisting of 8 conductors organized as 4 pairs terminated with 8 conductor modular (8P8C) jacks similar to those used for telephone wiring. The jack is commonly, but incorrectly, referred as an RJ-45 jack.

Ethernet also supports various flavors of optical fiber but due to higher cost fiber is more appropriate where the strengths of fiber can be used to an advantage: extremely small size, incredible speed and being non-metallic fiber immune to lightning.

### 4.1.2 UTP Speed

Since its inception UTP speed has increased dramatically.

- 10 Mbp/s 10 Base-T (1990)
- 100 Mbp/s 100 Base-TX (1995)
- 1,000 Mbp/s 1000 Base-T (1999)
- 10,000 Mbp/s 10GBase-T (2006).

In general maximum Ethernet UTP cable distance is limited to 100 meters (328 feet). Range extenders can be used for longer distance or fiber. Distance is typically not a concern for residential users.

As speed and distance increases fiber becomes attractive compared to copper cable. The difficulty with fiber is not so much the cost of fiber itself but the high cost of opto-electrical converters needed to connect NICs to fiber. That being said fiber is a great choice to link out buildings as it is immune to lightning.

### 4.1.3 Automatic Link Configuration

To make Ethernet easier to use higher speeds are backward compatible.  Transceivers Auto negotiate link characteristics to determine speed and whether connection is half or full duplex. Hubs are limited to half duplex as only one device is able to transmit at a time. Switches are full duplex capable of transmitting and receiving at the same time.

NIC (computer interface) is configured as uplink port (MDI), Hub or switch as MDI-X. 10 and 100 Mbps Ethernet use one pair for transmit and one for receive, Gig and 10 Gig use all four pair in each direction. Default configuration assumes MDI port is connected to MDI-X port. Under normal circumstances devices connect using a 1:1 cable.

Problems occur when like devices are connected, say PC to PC or switch to switch. To make this easier hubs/switches typically have an uplink switch or dedicated uplink port. The uplink port reverses normal TX/RX configuration so another like device can be connected. The same effect can be obtained by using a crossover cable. Crossover cable swaps TX and RX pair at one connector.  Recently vendors have adopted Auto-MDIX to automatically determining remote port type and configure ports automatically eliminating the need for crossover cables, and uplink ports/switch on Ethernet switches.

With Auto negotiation (Speed/duplex) and Auto-MDIX (gender) Ethernet has become much more user friendly. All a user needs do is connect the cable, everything else is automatic.

### 4.1.4 Hubs vs Switches

Electrically UTP Ethernet is a point-to-point topology. Each Ethernet Interface must be connected to one and only one other Ethernet Interface. Hubs and Switches are used to regenerate Ethernet signals allowing devices to communicate with one another.  Switches used to be much more expensive than hubs but prices have come down dramatically making hubs obsolete while dramatically improving LAN performance.

CDMA/CA scheme originally used by Ethernet places a limit on the number of wire segments and how many hubs can be used in a single collision domain. At 10 Mbps the 5-4-3 rule limits maximum to 5 wire segments with 4 hubs between devices, however only 3 of those hubs can have devices attached. For Fast Ethernet the rule is more stringent. A maximum of two Class II hubs, and the distance between hubs must be less than 5 meters. Class I hubs cannot connect directly to another hub. For all intents and purposes Fast Ethernet (100 Mbps) is limited to a single hub. Ethernet switches have completely replaced hubs.

Ethernet switches operate very differently. Switch examines each arriving packet, reads destination MAC address and passes it directly to the proper output port. Switches eliminate the collision domain allowing multiple conversations to occur simultaneously as opposed to single party-line hub. This dramatically increases network performance. A 100 Mbps hub shares 100 Mbps among all devices. With a switch traffic flows between port pairs. A non-blocking 16-port 100 Mbps Ethernet switch has a maximum throughput of 1600 Mbps. This assumes 8 connections evenly divided between the 16 ports each one operating at full 100 Mbps. Port A is able to talk to port D at the same time Port F is talking to Port B and so forth. Switches enable full duplex communication. This means computers are able be transmit at the same time they are receiving. Switches offer a tremendous performance advantage compared to hubs. In a home networks switches represent a less dramatic improvement if almost all traffic is to and from the Internet. In that case the Internet connection, normally much slower than LAN, determines speed. However if there are local resources such as files and printers then switch advantages come into play.

When a switch does not know which port to use it floods incoming frame to all ports, much like a hub. When device responds the switch learns MAC address associated with the port. The switch also floods all ports with broadcast frames. Switches are transparent. Ethernet applications have no knowledge switches are being used instead of hubs.

Gig Ethernet interfaces are at price parity with Fast Ethernet. New gear delivers Gig as a baseline. Gig Ethernet is an interesting inflection point. Historically computer performance was limited by network speed. When connected to Gig Ethernet typical PCs are only able to utilize a fraction of rated speed due to internal bottlenecks. Typical PC file transfer speed when used with Gig Ethernet is limited to 300-400 Mbps due to disk speed, O/S overhead, and PCI throughput. Bottleneck is no longer communication but has shifted to computing elements.

### 4.1.5 Managed vs Unmanaged Switches

Ethernet hubs and switches come in managed or unmanaged versions. Managed devices allow the administrator control of various parameters, define VLANs and observe traffic. Managed switches are overkill in a typical SOHO network. Unmanaged devices are considerably less expensive and operate at lower power saving energy cost.

### 4.1.6 Virtual LAN (VLAN)

Virtual LANs allow a single physical LAN to interconnect multiple computers while isolating one group from another. Typical use is to create VLAN based on community of interest for example payroll, marketing and engineering. A router is used to interconnect separate groups providing a great deal of control over how data flows across VLAN boundaries.

VLANs are not common for home LANs but may become so if Internet services are delivered by multiple service providers, perhaps one for data, another for IP based TV (IPTV), and yet another offering Voice over IP (VoIP).

### 4.1.7 Topology

For maximum performance a single wide Ethernet switch should be used to serve the entire LAN. Cascading switches is transparent to traffic but limits inter switch speed to that of the link. With a single wide switch intra-LAN throughput is dictated by internal switch backbone performance.

### 4.1.8 Spanning Tree

Ethernet is designed such that one and only one path exist between any two endpoints. If multiple paths exist switches are unable to determine how to forward frames. Spanning Tree protocol was developed to address problem of multiple paths in complex networks. The protocol detects duplicate paths and turns off redundant ports.  Spanning Tree requires managed Switches – low cost unmanaged switches do not implement the protocol.  Spanning Tree is typically not an issue in simple SOHO LANs.

### 4.1.9 Power over Ethernet (PoE)

Until recently wired Ethernet delivered data but not power. Each device needed to provide its own power. For traditional “large” networked devices such as computers this was not an issue. However as more and more low power appliances such as Wi-Fi Access Points and Voice over IP (VoIP) telephones are deployed the benefit of delivering both data and power over Ethernet became obvious.

IEEE took on the challenge and in 2003 released PoE specification. PoE provides 13 watts of power per device. For 10 and 100 Mbps Ethernet PoE uses the two unused pair. Gig uses all four pair so power has to be injected into the active pairs.  Second generation PoE, called PoE plus, increases power to 25 watts

PoE has been a boom for low powered devices. It also facilitates backup power, as UPS only needs to feed PoE Switch (or power injector) rather than every device.

## 4.2 Wireless LAN

Great strides have been made creating high performance low cost wireless LANs. RF technology is at its best where mobility is of paramount importance with bandwidth less so. Wi-Fi radios operate in the unlicensed Industrial Scientific Medical (ISM) band. Wi-Fi popularity has a down side. As more devices attempt to use limited frequency allocation interference problems increase. Government regulators are addressing interference by designating more bandwidth for unlicensed use. Standards bodies are working to facilitate graceful coexistence between various devices.

IEEE 802.11 radios operate in two modes ad hoc peer-to-peer and infrastructure. Infrastructure mode requires one or more Access Points to bridge wireless network to wired network. Depending on size and type of construction a site may require multiple Access Points. Ah-hoc mode allows two or more Wi-Fi devices to communicate directly without needing an Access Point. Most Wi-Fi communication makes use of Access Points.

### 4.2.1 Wi-Fi

The success of various IEEE 802.11 wireless standards has encouraged many vendors to enter the market. The Wi-Fi Alliance works to insure interoperability between different vendors and promote use of Wireless LANs. The result is that wireless 802.11 networks are often referred to as Wi-Fi.

When security defects were discovered in the original wireless equivalent privacy (WEP) specification The Wi-Fi Alliance worked with industry to develop an interim standard called Wi-Fi protected access (WPA) that could be retrofit to existing hardware. Later IEEE developed a new much improved hardware security standard called WPA2.

### 4.2.2 WLAN Speed

As is the case with Ethernet IEEE 802.11 Wireless Local Area Network (WLAN) performance has dramatically improved over the years.

| | | |
|---|---|---|
| 2 Mbps | 2.4 GHz | 802.11 (1997) |
| 54 Mbps | 5GHz | 802.11a (1999) |
| 11 Mbps | 2.4 GHz | 802.11b (1999) |
| 54 Mbps | 2.4 GHz | 802.11g (2003) |
| 150 Mbps | 2.4/5 GHz | 802.11n (2009) |
| 500 Mbps | 5 GHz | 802.11ac (Draft) |
| 7000 Mbps | 60GHz | 801.11ad (2012) (very short range) |

Due to the way over-the-air transmission operates real world transfer speed is limited to about half raw transmission speed and often significantly lower. However advances in wireless technology make it the network technology of choice in many instances.

### 4.2.3 Security and Authentication

Wireless LANs are inherently less secure then wired. An intruder does not require a physical connection, but can eavesdrop some distance away. The original 802.11 designers were aware of this and incorporated Wireless Equivalent Privacy (WEP) into the specification. Unfortunately almost immediately security researchers found critical weakness with WEP and shortly thereafter hacking tools became readily available making WEP virtually worthless. As an interim measure the Wi-Fi alliance developed WPA that could be retrofit to existing hardware. IEEE developed a comprehensive security standard Wi-Fi Protected Access 2 (WPA2). WPA2 using AES-CCMP is the preferred privacy implementation. Only use WPA or WPA2-TKIP if equipment does not support WPA2 AES-CCMP. WEP should never be used.

In a commercial setting WPA2 if often combine with RADIUS to uniquely identify each user. That is typically not an option for home users. A simpler method is used called preshared key (PSK). With PSK the Access Point and each client have a secret password used for mutually authentication.

There are many key generation utilities available to simplify creating long security keys. Wireless keys need to be significantly stronger than a typical end user password. An attacker is able to capture wireless traffic at their leisure and then use dictionary look up or brute force methods to discover the key. This is very different then trying to login to your account since in most implementations after a few invalid attempts the account is locked.

To improve security do not used the default network name (SSID), create your own. This prevents an attacker from quickly running through a list of previously cracked passwords.

### 4.2.4 Wi-Fi Protected Setup (WPS)

WPS was designed to make it easier for home users to configure multiple Wi-Fi devices using a preshared key. Creating a long key and configuring Wi-Fi parameters can be a daunting task for the typical user. Unfortunately, as was the case with WEP, security flaws have been discovered in WPS implementation. The Wi-Fi alliance has tightened testing of WPS but to be on the safe side it is best to disable this feature and manually configure devices.

### 4.2.5 Interference

Wi-Fi radios operate in unlicensed bands so interference can be a problem, especially in congested urban areas. Interference is the result of other Wi-Fi radios, non-Wi-Fi radios operating in the same band such as Bluetooth and wireless phones and unintentional radiators such as microwave ovens. Wi-Fi operates in two bands 2.4GHz and 5GHz. The 2.4GHz band is by far the most popular but it is also the most crowded and has only three non-overlapping channels in the US. In general when operating in the 2.4 GHz band it is best to use channels 1, 6, or 11 for optimum performance.

Wi-Fi alliance has published numerous whitepapers on the subject. They are working with various standards bodies to make devices more aware of their RF environment by probing for other radios operating in the vicinity. Device use that knowledge to set operating channel and power to minimize mutual interference.

Given the tremendous popularity of this technology governments are working to increase frequency allocation for unlicensed radio use.  As radios get smarter and frequency allocation increase interference should become less of a problem.

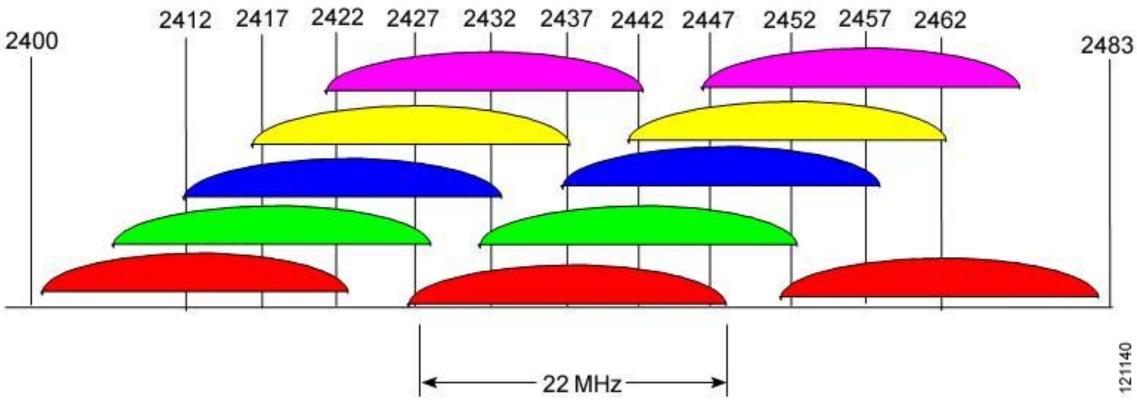


**Figure 7 2.4GHz Wi-Fi Channels**

## *4.3 Personal Area Networks*

There is another wireless technology called Bluetooth that operates in the 2.4GHz band. This wireless technology is optimized to connect peripheral to devices such as wireless headsets. Since Bluetooth operates in the crowded 2.4GHz band care needs to be taken the two technologies do not degrade one another.

## *4.4 Alternative Network Technology*

Ethernet and Wi-Fi are the dominant LAN technologies. The cost of installing network wiring is modest if done when structure is being built. The situation is more difficult for existing structures. The cost and disruption to retrofit a LAN is a significant deterrent. Various "no new wire" initiatives minimize impediments to home networking. These initiatives typically operate at lower speed than wired Ethernet but have the advantage of not requiring additional wiring.

It is a testament to Ethernet's popularity these alternatives all use modified Ethernet frames, adapted to the physical medium, making it easy to bridge to standard Ethernet equipment.

### 4.4.1 Phone Line Networking

Home Phoneline Network (HomePNA) uses telephone wiring to create bridged Ethernet LAN operating at a maximum speed of 320 Mbps. This allows computers to connect wherever a phone jack exists. The specification allows analog telephone, DSL, and LAN to coexist on a single pair of ordinary telephone wire. Like DSL HomePNA take advantage of unused capacity of copper wire to create a network.

PNA uses a slightly modified Ethernet packet. This makes HomePNA look like ordinary Ethernet to software. HomePNA equipped computers cannot connect to UTP Ethernet directly, a bridge is needed to rate match between the two networks and deal with minor signaling differences. This allows HomePNA and Ethernet devices to act as if they were connected to the same LAN.

### 4.4.2 Power line Networking

HomePlug initiative provides high-speed network device that plug into ordinary AC receptacles at speeds up to 200 Mbps. The HomePlug Powerline Alliance is the clearinghouse for power line networking products.

### 4.4.3 Ethernet over TV Coax

Multimedia over Coax Alliance (MoCA) is popularizing an interesting technology that utilizes TV coax wiring to deliver Ethernet at up to 800 Mbps. Many homes built in the last few decades have RG6 coaxial cable feeding multiple TV outlets but are not equipped with Category rated cable suitable for conventional Ethernet. Verizon is using the technology extensively to eliminate need to run both coax and UTP Ethernet when installing FIOS.

### 4.4.4 60 GHz Radio

IEEE 802.11ad operates at 60 GHz to deliver blinding fast speed of 6 Gbp/s over short distances. This technology opens the door to wireless A/V equipment dramatically simplifying installation.

# 5 Local Server – Just Like the Big Kids

A Windows PC acts as a local server providing the following network services: file sharing, print sharing, NIST clock synchronization, Syslog server, private web server and personal weather station. Current server is a recycled 2.4 GHz Compaq EVO D510 running XP Pro. Using an old PC as a server is a great way to extend the life of PC hardware. Running a server on a small network is not very demanding. Windows power management reduces energy consumption to reasonable levels.

## 5.1 KVM Switch

**Figure 8 KVM**

I did not want to add another set of user I/O when we setup the server. The solution was to use a KVM (keyboard, video, and mouse) switch. KVM's have been used in server farms for years to allow single point of control for multiple computers. I purchased a 4-port Belkin Omni View SE KVM. Port 1 is the workstation port 2 the server. A third port is used for testing. I wired up a set of I/O, network, and power cables to make it easy to temporally connect another PC for test or configuration. That has turned out to be very handy.

Switching between computers is done via a button on the KVM or a keyboard hot-key sequence. KVM creates virtual devices for each computer. When switching computers the KVM reconnects keyboard, mouse and monitor to the active computer and programs real devices to match stored virtual device configuration.

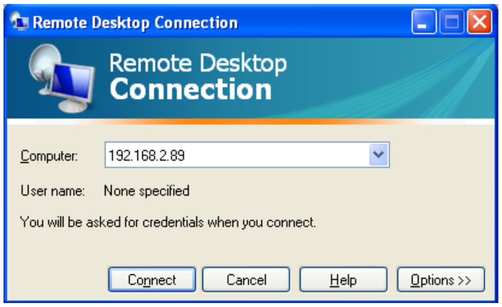
***Video Performance Tip*** -- Workstations use higher video resolution and faster refresh rate than servers resulting in very high video data rate. This is typically not a problem for KVM itself but requires high quality video cable. Coax preserves high frequency and minimizes crosstalk between signals.

***Mouse Compatibility Tip*** -- Each computer thinks it is directly connected to a keyboard, mouse and monitor. KVM memorizes commands sent to each device and restores device configuration each time a user selects a different computer. Mice cause problems because so many proprietary enhancements exist. PS/2 mice power up in compatibility mode this allows basic mouse functionally even if proprietary mouse driver is not installed. At power up mouse device driver performs a "knock" sequence to determine if a known mouse is attached. If mouse answers correctly driver switches on enhanced mode. This causes problems for KVMs. Unless KVM has priori knowledge of specific mouse it is unable to configure it properly. Depending on specifics this results in either loss of mouse control or mouse reverting to default mode. This is only a problem when switching between machines. KVM transparently passes commands from active machine to mouse.

This problem only affects PS/2 style mice since they do not support hot plug. USB KVM resets mouse whenever a different computer is selected.

***Monitor Plug and Play*** – modern CRT and LCD monitors communicate with PC using VESA Display Data Channel (DDC). This allows PC to read monitor characteristics and automatically configure video subsystem. If KVM does not emulate this feature a PC powered up on an inactive KVM port thinks it is connected to a non-Plug and Play monitor reverting to low resolution low refresh mode. A workaround for this is to disable monitor plug and play and set resolution and refresh manually. Or always make sure PC is selected by KVM before booting.

## 5.2 Remote Server Management



Computer: 192.168.2.89

User name: None specified

You will be asked for credentials when you connect.

**Figure 9 RDP**

KVM is a brute force method of server management by simply switching physical I/O devices. Its advantage is it provides access even before O/S is in control. A more elegant method is remote desktop protocol (RDP). Windows XP Pro has built in remote management capabilities and there are numerous third-party applications. Once server side is up and running remote user logs in to gain access to virtual desktop.

## 5.3 File Sharing

One of the advantages of having a LAN is to facilitate file sharing. Files can be shared directly between PCs or by using a dedicated file server. My Network Places (Called Network Neighborhood in earlier version of Windows) is organized by workgroup. In a small LAN all machines typically belong to a single workgroup, such as HomeLAN. Once configured users are able to browse network shares, as easily as if they physically resided on the local machine.

We mainly use server shares for automated backup. Software running on the workstation periodically backs up files to the server. That way if one of the workstations fail or become infected the system can be rebuilt with minimal loss of data.

Getting My Network Places to work reliably in a SOHO peer-to-peer network can be a challenge as there is no Domain controller to coordinate access and provide network browse services. As each PC is turned on it looks to see if there is already a master browser on the LAN. Note this has nothing to do with web browsing. The Master browser collects information about shared network resources, directories, files and printers and makes this information available to other computers on the LAN.

The ad hoc election process can cause problems if PC running master browser gets shutdown. It takes a while for other PCs to notice there is no longer a master browser. Until new election is held it is impossible to browse the network. Depending on power up sequences it is possible to have more than one master browser, in a workgroup at a time. Masters do not exchange information. Having multiple masters will segment the workgroup resulting in non-communicating chunks. Pchucks'n Network site has a great article about peer-to-peer browsing.

**#1 Workgroup name**
My Network Places are organized by workgroup. You can have as many workgroups as desired. In a small LAN it makes sense to use a single name, such as HomeLAN, because each workgroup requires its own Browse Master. The Browse Master is elected at boot time. If PC running Browse Master is shut down it may take a while for event to be detected and a new Master elected.

**#2 Browse Master**
Ideally Browse Master should run from an always-on computer. This is the reason to use the same workgroup name, so only a single Browse Master is required.

To force a particular machine to be the master browser turn off all PCs on the LAN. Turn on PC chosen as master browser first. As there are no other computers on the LAN it will win browser election. As other computers are turned on they will detect an active master browser and use it.

**#3 Login**
If network logon (in network properties) is set to Client for Microsoft Networks a password must be entered at boot time for the Neighborhood to be accessible. If the password is bypassed most communication functions operate normally but the neighborhood becomes inaccessible. To eliminate need to enter a password select Windows Logon. It may be necessary to delete any existing passwords. Search for *.pwd files and delete them.

**#4 Network Shares**
To enable file sharing pick the desired subdirectory to share and check sharing. That directory and all subdirectories will be shared. If desired shares can be password protected as read only or read/write.

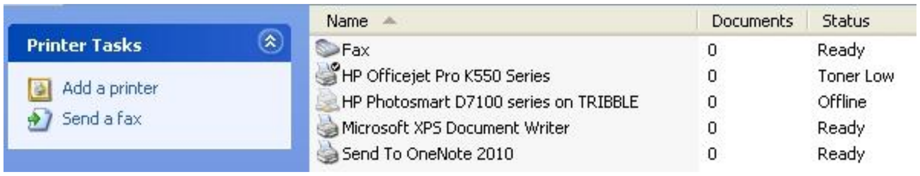
> ***Security Tip*** – Files can be shared as read only or read/write. Unless it is necessary to allow others on the LAN to modify file and/or create directories it is better to limit access to read only.
>
> ***Security Tip*** – peer to peer file sharing relies on LAN based broadcast. This presents a potential security problem if a laptop is connected to another network. Ideally public networks implement port isolation to prevent one computer from seeing another. But if not any shares will be visible to other folks on the network. To be safe do not enables shares on a laptop that might be used on another network. This will not prevent the laptop from accessing other shares but will prevent inadvertent sharing of laptop files.

**#5 Firewall**
If system uses a software firewall be sure it does not block NetBIOS and SMB ports used to discover local host names and share files. Windows built in firewall does not interfere with file sharing. Some third party firewalls have to be configured to allow the following ports.

```
TCP/UDP Port 137 NETBIOS Name Service
TCP/UDP Port 138 NETBIOS Datagram Service
TCP/UDP Port 139 NETBIOS Session Service
TCP/UDP Port 445 SMB (Server Message Block)
```

## 5.4 Printer Sharing

We have two printers. Main document printer has a built in print server and is directly connected to LAN. Photo printer has a USB connection and is connected to file server. For the photo printer I enabled printer sharing on the server to allow any PC on the network to use the printer. Depending on printer vendor and OS printer sharing can be as simple as connecting the printer and being auto discovered to needing to install and configure printer drivers on each machine.



| Name | Documents | Status |
|---|---|---|
| Fax | 0 | Ready |
| HP Officejet Pro K550 Series | 0 | Toner Low |
| HP Photosmart D7100 series on TRIBBLE | 0 | Offline |
| Microsoft XPS Document Writer | 0 | Ready |
| Send To OneNote 2010 | 0 | Ready |

**Figure 10 Shared Printers**

## 5.5 Fax

Pro version of Windows XP includes a fax capability. Being able to send and receive fax is becoming less and less important but it is nice to have the ability to send the occasional fax. This requires having a dialup modem connected to a phone line. Found my old Win98 V.90 PCI softmodem still works in XP. I doubt I'll buy a new modem if it ever dies.

If faxing is important may want to check out eFax rather than purchasing a fax machine or one of an all-in-one printer/scanner/fax machines.

## 5.6 Time Service

US National Institute Standards and Test (NIST) and other organizations maintain public timeservers. This eliminates problem of drifting and inaccurate computer real time clocks. For personal use NIST recommends using NTP Pool Time Servers. Timeservers are extremely accurate; however accessing them via the Internet adds potentially several hundred milliseconds of round trip delay. This error is not significant for our purpose and is ignored.

Current generation of Windows has a built in NTP client that is used by default to synchronize time. This means each PC on the LAN separately accesses the service. A more elegant method is to use a single time service, running on the server, and have it in turn synchronize all the PCs on the LAN.

We use Tardis 2000 running on server and K9 on each client for clock synchronization. Tardis includes a Network Time Protocol (NTP) timeserver that periodically broadcasts time info over the LAN. A companion program, K9, running on each client updates local Real Time Clock (RTC) to synchronize it to the server. This insures all computers are slaved to local server and local server in turn is synchronized to Stratum 2 timeservers.

Tardis support Syslog. This allows Syslog server to capture Tardis2000 events.

> ***Configuration Tip*** -- Windows XP/Visa/7 includes a timeserver that must be disabled when using K9 client.
>
> ***Configuration Tip*** -- The load on public timeservers is very high and getting higher, be a good net citizen set Tardis to only update every few hours and use NTP pool rather than specific server. We set this parameter to once every 2 hours. For convenience LAN broadcast occurs every 64 seconds so client clock is updated as soon as the machine boots.
>
> ***Configuration Tip*** --Tardis 2000 defaults NTP time broadcasts to all available interfaces. If Tardis is running on a computer with direct Internet access configuration should be changed to limit broadcast to LAN. IP broadcast uses the highest subnet address. Assuming a network prefix of 192.168.2/24 the broadcast address becomes 192.168.2.255. If this is not done time broadcast is sent out over all ports, including the one connected to the Internet. This may prevent dialup connection from timing out and may annoy your ISP.
>
> ***Configuration Tip*** -- Tardis monitors dialup status. This is convenient if PC running Tardis is directly attached to the Internet. Tardis will update Internet time only if the connection is active; this prevents Tardis from activating an auto dialer.

## 5.7 Private Web Server

The browser home page of each PC points to a personal web server running on local server. This allows relevant information be posted. Pages consist of both static information and dynamic weather and greenhouse data. We chose Abyss as it is free for personal use.

## 5.8 Syslog Server

BSD Syslog protocol provides a standardized method for network devices to output status information to a log server. This creates a central repository for event storage overcoming storage limitation of most network appliances. We use Kiwi free shareware program for both Syslog server and Log file viewer. The Syslog server runs as a service on the server and the data is accessible from any device on the LAN.

## 5.9 Weather Station

Davis Instruments weather station data is posted on internal web server. Weather station data is downloaded over a RS232 serial port to the server. Ambient virtual weather station software running on the server processes the data and displays it as a web page.

**Figure 11 Weather Station**

# 6 Widgets & Services – Making Life Worth Living

This section describes the various services and devices running on the LAN.

## *6.1 Computers*

We have a collection of Windows XP home, XP Pro and Win 7 PCs. Most of these were off-lease PCs purchased on eBay. If you do not need the latest and greatest hardware acquiring a 3-year old used commercial PC delivers a lot of bang for the buck.

My most recent purchase was a Lenovo T61 Thinkpad running Win7 for a couple of hundred dollars.

## *6.2 World Wide Web*

It seems browser wars are raging once again. Having multiple browsers is a useful troubleshooting tool. PCs run either Internet Explorer version 8 or 9 depending on Operating System. Firefox is my main desktop browser and just to keep life interesting I'm running Chrome on my laptop.

Key to effective use of the Internet is being able to find what one is looking for. Our preferred search engine is Google.

## *6.3 FTP*

File Transfer Protocol (FTP) is an effective way to transfer large files over the Internet. FTP predates HTTP so has kind of lost favor but is still very much alive. My main use of FTP is to make changes to my site. This paper will be uploaded using FTP.

## *6.4 Telnet, SSH, and Terminal Emulation*

While GUIs are all the rage there is a lot to be said for command line interfaces (CLI) and heaven forbid I still need to occasionally work on RS232 gear and need a terminal emulator. PuTTY is my preferred application. Being able to Telnet into the new router came in handy as that was the only way I could find to set the Syslog log server feature.

## *6.5 E-Mail*

E-mail accounts fall into three broad categories: ISP, free third party and corporate. ISPs typically provide an email account as part of the package. This is convenient but ties your e-mail address to your current ISP. Change ISP and your e-mail address changes. Free email services like Google Gmail have become extremely popular. Even though I have a domain I use my Gmail account as an alternative email account. For business purposes or to insure long lasting email identity nothing beats registering your own domain. Once registered e-mail is addressed to you@yourdomain.TLD. Even if you change hosting services you simply transfer domain registration to new provider, e-mail is unaffected.

Having multiple email accounts is a useful troubleshooting tool. If one does not work, try the other and then try to figure out the difference between the one that works and the one that does not.

### 6.5.1 Email Access

Traditionally access to email has been with an email client, such as Microsoft Outlook. Most free mail services use a browser interface eliminating need for dedicated email client. Web mail is convenient because email is accessible from any browser equipped PC. Web based email user interface is somewhat clunky but adequate for casual use.

Except for web-based mail, e-mail has a sending component, SMTP, and a receiving mailbox, POP. To send mail the client connects to a Simple Mail Transport Protocol (SMTP) mail gateway. SMTP server acts as a relay between e-mail client and POP mail server. The SMTP server verifies each recipient is accessible and returns an error message if not. SMTP server delivers mail to the appropriate Post Office Protocol

(POP) server. It works much as a physical post office mailbox. POP server stores mail temporally. When the e-mail client connects to POP server it downloads mail and typically removes it from the server. A more sophisticated alternative to SMTP/POP email is Internet Message Access Protocol (IMAP).

### 6.5.2 SPAM Mitigation

Unwanted email (SPAM) is a tremendous problem. Something like 95% of all email messages are SPAM. ISPs and third parties have been waging a losing battle of years. ISPs have adopted a number of strategies to minimize the problem.

#### 6.5.2.1 Messaging Anti-abuse Working Group (MAAWG)

Messaging Anti-abuse Working Group (MAAWG) is an industry group promulgating best-practices to reduce spam. Historically SMTP servers accepted anonymous email creating a haven for spammers. ISPs have developed a number of proprietary workarounds over the years to limit spam. Recommendation is to use SSL/TLS to securely access SMTP and POP mail server. Where SSL is not feasible use Port 587 to send email instead of Port 25. Port 587 requires authentication therefor ISPs will not block the port allowing off network access.

#### 6.5.2.2 Blacklist

Many mail services subscribe Blacklist’s such as Spamhaus. Blacklists are databases of Spammers and IP address blocks of residential ISPs. If mail arrives from a forbidden address it is rejected. MXtoolbox has a handy tool to check if the IP address of your mail server has been blacklisted. It also checks MX records and server are configured correctly.

#### 6.5.2.3 Sender Policy Framework

Sender Policy Framework (SPF) creates a mechanism to validate email return address is not forged. SPF adds DNS records indicating which servers are authorized to send email from a specific domain. Before email is accepted email server verifies it originated from an authorized server.

#### 6.5.2.4 Email Client Filter

For SPAM that makes it all the way through to email client one can set rules for handling incoming mail by the email client. This can drastically reduce the number of unwanted messages in your in box.

### 6.5.3 Email Implementation

I had been using Outlook Express but Microsoft stopped supporting it in Windows Vista. Windows Live replaced Outlook. I did not want to lose years of archived email so faced the daunting task of exporting old Outlook mail and importing it into Windows Live. After much trial and tribulation I was able to do it but it was not a pleasant experience. Personally I find the Live mail experience less satisfying then the old Outlook but mail is mail.

I configured email client to use SSL/TLS to access SMTP/POP servers. This has the added advantage of protecting privacy when using public Wi-Fi hot spots because SSL/TLS is used to send and retrieve email. Normally POP/SMTP credentials are sent in the clear making them easy to snoop when using a non-encrypted hotspot.

> ***Mail Configuration Tip*** -- Archiving mail when using multiple clients is difficult. One trick is to have your main computer remove mail from the POP server. The other machines retrieve mail but do not delete messages from the server. When you get back to the main machine it retrieves all intervening messages and removes them from the server.
>
> ***Configuration Tip*** – New mail is sent using the SMTP server defined for default account. Replying to incoming email uses the SMTP server defined for that account. This is the source of some confusion. Depending on how mail client is set up some email may be sent correctly and

some will fail.  Any SMTP server can be used to send mail, not just the one provided with the particular mail account.

***Security Tip*** -- Be careful opening e-mail attachments. This is a common method used to spread viruses and Trojans. Configure your anti-virus program to scan email and attachments prior to opening them and quarantine infected mail.

***Security Tip*** -- The aforementioned warning has been issued many times. What is less well known is that simply reading e-mail can infect your system. ActiveX controls or VB scripts can be embedded in the body of a mail messages. Reading the message activates the virus.

***Privacy Warning*** – An obnoxious privacy intrusion is the insertion a one-pixel image in HTML mail. When message is read browser has to go to the referenced URL to retrieve it. This allows the sender to monitor when and if mail is read.

## 6.6 Instant Messaging

Instant messaging (IM) has become extremely popular both full blown messaging service using a PC and short message service (SMS) via cell phone. IM requires client side software. Unfortunately there is an interoperability battle being waged among the various IM services that see proprietary and incompatible IM formats in their corporate interest.  This makes it a challenge to interconnect with users on different systems.

## 6.7 USENET

Usenet Newsgroups can be a valuable source of up to date information. Given the incredible number of users it is likely that someone will be able to provide an answer to your question. The down side of unmoderated groups is low signal to noise ratio. One needs to wade through a lot of Spam, inane posts, and flames to find the occasional gem. Many groups have an online FAQ that describes what the group is about to limit off topic posts.

Most ISPs used to include USENET access as part of the service. Due to declining interest in Usenet and legal attacks related to pornography many ISPs are taking easy way out and eliminating or scaling back support of Usenet. If your ISP does not provide Usenet access there are a number of 3rd party services.

Our ISP dropped Usenet years ago, I thought about signing up with a third party provider but no longer use it enough to justify the cost.

## 6.8 Multimedia

Adding video and audio capabilities to personal computers back in the early ’90s profoundly changed usage patterns. No longer primarily perceived as a computational tool personal computers were transformed into gateways to all sorts of digital media.

Internet multimedia was hampered by low dialup speed. Broadband eases this chokepoint opening the door to Internet delivery of telephone, radio, TV and movies.  Currently there are numerous CODECs used to compress and play audio and video. This leads to difficulty in making sure one has the correct CODEC.

Internet delivery is bringing dramatic change to long-standing business models. Prior to the Internet media distribution was an expensive proposition mastered by only a few companies. The Internet undermines traditional business model by reducing distribution cost nearly to zero. Legacy media players have had a difficult time adapting to change wrought by technology and have been primarily focused on crippling digital delivery. Over time both artists and patrons will learn how to utilize this new distribution model.

### 6.8.1 Digital Rights Management

Audio and video content owners fear lossless digital duplication of copyrighted works will undermine their business rather than open up new distribution models. Digital Rights Management (DRM) has been controversial for both philosophical and technical reasons. What is the proper balance between rights of copyright holders and patrons desire for unfettered access? Technically DRM implementations have been a disaster. DRM is easily circumvented, caused ill will on the part of consumers, broken backward compatibility, rendered investment in content library worthless and been a PR nightmare due to DRM implementation run amuck.

### 6.8.2 CD/DVD/Blu-ray evolution

Back in the early ‘90s digital versions of audio CDs were heralded as a tremendous new storage medium. CD stores about 700 Mbytes of data, compared to only 1.5 Mbytes on 3.5” floppy. At the time that seemed like an almost infinite amount of space.

Time marches on. DVDs were developed to allow digital movies be distributed in similar format as audio CDs ultimately displacing VHS videotape. DVDs store 4.7 Gbytes (single layer) of data. This is more than enough to store an entire SDTV (standard definition) movie with room for extra features.

With increased popularity of high definition Television HDTV a media format with more capacity was needed. Blu-Ray 27 GB (single layer) won the battle. HDTV dramatically improves image quality compared to NTSC standard definition TV. That being said standard definition DVDs using component video or HDMI interconnect looks pretty good on HDTV sets.

Video data is encoded and compressed using MPEG compression. Data within an image is compressed (spatially) and between frames (temporally). Audio is also compressed. Without compression files would be uneconomically large

### 6.8.3 Netflix

Netflix pioneered snail mail DVD rental. They are moving away from physical media by expanding online library. Netflix customers can use their PC to access a growing library of on-line titles or use Roku player to watch streaming media on their TV. Image quality is automatically adjusted based of broadband speed. We opted for a WD TV live hub to stream Netflix to our TV. It provides access to other streaming services and is a media server to boot. Files uploaded to the server can be watched on an ordinary TV.

### 6.8.4 ITunes

Apple’s ITunes music service has been a popular complement to the IPOD as a way to purchase and play digital music.

MPEG MP3 compression provides near CD-quality audio at 128 kbps, about a tenth the uncompressed data rate. MP3 has become a popular digital music format. We converted all CDs and some records (LP and 78 rpm) to MP3 and store music on file server. This enables any computer on the LAN equipped with an MP3 player to access music library. Near CD quality audio requires 128 kbps; this translates to about a megabyte per minute of music. This results in a large library but well within the reach of a today’s cheap hard drives.

### 6.8.5 Real Audio Player

Real Audio is a popular format for streaming audio and video as well as MP3’s.

Streaming is different than downloading in that information is rendered before it is entirely transferred to the computer. Streaming players use an elastic buffer to store incoming data before it is used. When playback is started it is delayed a short time allowing buffer to fill. Buffer isolates playback from temporary differences in transfer speed. If data flow slows down, buffer is able to feed the player. If data arrives faster than it is being used buffer expands to store it.

### 6.8.6 Windows Media Player

Microsoft developed proprietary audio and video compression formats that can only be viewed with Windows Media Player. They are also beginning to deploy provisions for secure distribution of music using Digital Rights Management (DRM). Paving the way for direct purchase or subscription based music services. So far I have not found that distribution method to be particularly convenient or advantageous.

### 6.8.7 QuickTime

Apple QuickTime is a popular movie-encoding format.

## *6.9 Radio/TV*

There are many ways to distribute Radio and Television programs. The Internet opens up fascinating opportunities for new sources not constrained by distance or even a local presence.

### 6.9.1 Internet Radio/TV

Radio and TV programs can be delivered over the air, via Cable or Satellite and more recently over the Internet. Radio programs are already commonly available over the Internet, TV less so due to limited first-mile bandwidth. This will change as bandwidth and data compression techniques improve.

Internet, unlike broadcast, is one-to-one. A user connects to a media server; server delivers information directly to user. This is both a huge advantage, compared to traditional media, and a disadvantage. An advantage because patron and source are more intimately connected, this is ideal for demand-based programming. It is a disadvantage because emulating one-to-many broadcast model over the Internet is still immature. Multicasting allows a single media stream be delivered to multiple subscribers. Multicast reduces server and bandwidth cost.

We are a Netflix subscriber and use a WD TV live Hub to watch TV. Besides Netflix it allows TV to access other Internet based content and an internal hard drives acts as a media server.

### 6.9.2 RF Radio/TV

Hauppauge TV/FM card is installed in the main workstation. It supports NTSC analog and ATSC digital TV and analog FM. I find the card very useful. ATSC standard definition TV looks surprising good on a computer screen, not as good as HD but much better than analog NTSC. NTSC resolution is about 720x480 pixels with less color depth than typical computer display. HDTV resolution is 1366x768 and 1910x1080. The card has a freeze feature to capture still images.

Titan TV is a popular on line program service.

It is also possible to implement a TV server and then distribute programs over your LAN. The Silicon Dust HDHomeRun is probably the most well-known system.

## *6.10 Telephony*

Since the telephone was invented over a hundred years ago the same basic technology has been used to connect caller to called party, circuit switching. When a call is initiated a semi-permanent path through the network is established for the duration of call. When call is over connection is torn down and network components released for use by other customers.

The Internet is causing tremendous change in all aspects of our lives not the least of which is plain old telephone service (POTS). Voice over IP (VoIP) uses packet data network to transport phone calls reducing cost and increasing functionality. Packet based networks were not designed for real time communication so making telephony work has been a challenge. As first-mile speed increases VoIP becomes more practical. The payoff is convergence – integration of all forms of communication over a single unified transport network.

Currently we use ordinary wired analog POTS telephones and Cell phones. Both live in their own silo. In the not too distant future we will be able to use a single convergence device that works at home over Wi-Fi, at Wi-Fi hot spots and when not in range the cellular network.

## 6.11 Digital Camera

Nothing beats a digital camera to quickly capture images and incorporate them into documents or a web page. Cameras typically use some form of removable Flash memory to provide virtually unlimited image storage. Images are captured and compressed in JPEG format dramatically reducing size with minimal loss in quality.

## 6.12 Document Scanning

Flatbed scanner converts documents and photographs to digital image files. These files can be faxed or incorporated into documents. Optical Character Recognition (OCR) software converts text images to format understood by word processors.

I prefer using a separate scanner rather than an all in one printer/fax/scanner because the printer is behind my desk and the flatbed scammer is conveniently positioned on the desk itself. We have an HP Scanjet 5400C flatbed scanner. It also functions as a poor man's copying machine allowing scanned images to be printed from network printer.

## 6.13 Printing

Computers were once billed as the paperless office. This has not happened. On the other hand Internet and low cost high quality printers have significantly expanded use of electronic document distribution. This White Paper is a perfect example. It was composed on a computer, uploaded to a web server and is directly viewable on the web or demand printed as needed.

### 6.13.1 Document Printing

Our main printer is an HP Deskjet K550. The K550 includes a built in print server allowing it to be directly connected to the network. This results in much richer interaction than before.

### 6.13.2 Portable Document Format (PDF)

Printing documents on different printers can be a challenge since margins and fonts differ. The Adobe PDF format has become the de facto industry standard for print document formatting.

### 6.13.3 Photo Printing

Added a HP D7160 Photo Smart printer to print high quality photographic images. On a per print basis is it not cheap compared to photo services but it is convenient. Photo Smart printer does not have a build in Print Server like the K550. It is attached to file server via USB and takes advantage of Windows print sharing.

## 6.14 Bookkeeping

Computers are ideal bookkeeping machines making them ideal for tracking home and business finances. We have been using various flavors of Quicken over the years for both personal and business.

For annual income tax we use Tax Act software.

## 6.15 Secure Remote Access - IPSEC and SSL/TLS

VPNs extend corporate network to telecommuters and business partners. There are two approaches to providing secure remote access: IPsec and SSL.

IPsec developed by the IETF has two protection mechanisms Authentication Header (AH) and Encapsulating Security Payload (ESP) AH authenticates the client's IP address. ESP encrypts data to prevent eavesdropping. Authentication is performed using Internet Key Exchange (IKE).

NAT is very hostile to VPN security because it modifies packet address and checksum. Because NAT is so ubiquitous both for employees at home and while traveling VPN software has implemented workarounds that are compatible with NAT.

Tunnel mode forces all client traffic through IPsec encrypted tunnel to the corporate LAN. This is the most secure and provides the same logging/management functions as if the employee was physically connected locally. The downside it that all traffic has to be encrypted, carried by the tunnel even if it is not directed towards the corporate LAN. An alternative configuration, split-tunnel. In split-tunnel mode tunnel only carries traffic destined for corporate network. Other traffic flows normally as if tunnel did not exist.

Having employees install IPsec client presents a management challenge. As an alternative some companies are using SSL/TLS to provide a secure connection between remote employees and corporate network. While SSL is not as powerful or secure as IPsec browsers include support for SSL eliminating the need for special client software. This is especially convenient for employees that need to connect to corporate network from multiple computers.

## 6.16 Greenhouse Automation

We have a small attached greenhouse. Designed a purpose built automation system using a simple web based programmable logic controller and some discrete logic. The PLC automatically manages greenhouse environmental systems and the web interface provides remote status.

# 7 Security -- Keeping Bad Guys Out

Internet connectivity is a double edge sword. Being connected gives one access to the vast resources of the worldwide Internet but makes your computer vulnerable to attack. Unfortunately a significant number of talented individuals take delight in wreaking havoc on others.

## 7.1 Social Engineering

Sad to say many security breaches are not the result of compromising technical security barriers. They result from individuals inadvertently giving out privileged information. An attacker typically poses as someone who would normally have legitimate access to the desired information: say a police officer or maintenance technician. If the attacker knows enough background information and lingo they are often able to fool representative into telling them information they are not authorized to access.

## 7.2 Virus & Trojans

This is probably what most people think of when discussing Internet security. This attack has been around since the days of standalone PC using floppy disks. The first line of defense is staying away from untrustworthy sites. In the past if I wanted to go to a new site I'd often guess the URL since it is often some variation of company name. This is a dangerous practice since attackers often register common misspelling of popular domain names. To prevent this sort of thing I use Google to search for site name. Does not guarantee site is safe but it reduces risk of fat-fingering a dangerous URL.

Anti-virus programs have been available for years; two of the most popular are Norton and McAfee. They check file signatures and monitor downloads. Microsoft Security Essentials is a no cost way to add anti-virus protection to Windows PCs. Anti-virus programs are powerful but often breed a sense of over confidence. Attackers and anti-virus companies are in a constant state of battle. Attackers get more resourceful and constantly introduce new viruses. There is a delay between first time attack is seen "in the wild" and a fix. This creates a window of vulnerability between virus release and antidote.

## 7.3 Phishing

Phishing email looks like it originated from a legitimate company. The email typically states recipient needs to "log in" to secure web site and review and update account information. The site it looks real but is actually controlled by the attacker. Goal of Phishing attack is to obtain user account data so attacker is able to masquerade as the user. Phishing is a classic Man-in-the-Middle attack.

## 7.4 Zombies

One of the most insidious forms of attack is using compromised computers to attack/spam other computers. Once an attacker is able to install executable code on a machine they not only have gained control of that computer but also potentially able to use that computer to attack others at will. What makes Zombie attacks devastating is often computer owner is not even aware PC is compromised. Often the first hint of a problem is a nasty email/letter from their ISP.

## 7.5 Spyware

Companies are finding ever more obnoxious ways to extract information from customers. Spyware collects application usage information and forward it back to the company. It is also used to update targeted advertising. Spyware updates the ads and in some cases selectively displays advertising based on usage.

Ad-Aware SE and SpyBot are two popular freeware programs used to remove various forms of spyware. They are updated periodically to detect and removes various forms of spyware.

## 7.6 Denial of Service (DoS)

Zombies are often used in Denial of Service attacks (DoS). A DoS attack floods victim with bogus queries. To make attack more powerful many computers are used simultaneously in a Distributed Denial of Service attack. The attack does not corrupt or deface the victim but by overloading victim's network or computers is able to takes service office line or degrade response time during the attack. DDoS attacks are common against popular sites and DNS servers.

## 7.7 DNS Cache Poisoning

Internet was designed to be robust in the face of equipment and communication failures. Unfortunately it was not designed to withstand deliberate willful attack. Domain Name System (DNS) is the vehicle used to convert user-friendly names to computer friendly IP addresses. One of the ways to minimize unnecessary load on DNS server is to cache recently used information. DNS poisoning exploits a weakness in DNS to plant bogus cached information. Once cache is corrupted computers accessing that DNS server are directed to incorrect site controlled by the attacker. A high priority initiative is to implement Domain Name System Security Extensions (DNSSEC) to counteract this sort of attack and increase level of confidence in DNS.

## 7.8 Eavesdropping

Radio communication is easy to eavesdrop. An attacker can locate a safe distance away without having to compromise physical security. An attacker can cause a Denial of Service DoS) attack and if account names and password are sent in the clear they can be harvested. During development of IEEE 802.11 Wireless Local Area Network (WLAN) this threat was recognized and provisions made for authentication and encryption called Wireless Equivalent Privacy (WEP). Unfortunately security researchers quickly discovered serious shortcomings in WEP. Weakness managing encryption key makes it relatively easy to determine the key thus breaking encryption. Current state of the art for Wi-Fi security is Wi-Fi Protected Access (WPA2) using AES encryption. There are options optimized for home networks using a preshared key and for large organization using RADIUS authentication.

> **Security Tip** –POP/SMTP email send user credential in the clear. This is not a huge concern on wired or security protected Wi-Fi networks. It is a serious when using public hotspots as over the air is sent in the clear allowing anyone with a sniffer to grab your email passwords. If at all possible use SSL/TLS to log into email to protect username and password.

Powerline and Phoneline networks leak data beyond the confines of the network. An attacker can connect to phone line or power line some distance away and gain access to network traffic. This is especially critical in multifamily housing and office buildings where multiple tenants are in close proximity.

Wired Ethernet is less susceptible to eavesdropping because signaling is contained within wiring and LAN wiring does not typically exit the building. Using Ethernet switches, rather than hubs, makes eavesdropping more difficult because only broadcast and traffic destined for the specific port is visible.

## 7.9 Man in the Middle Attack

Man in the middle is a cryptographic attack where an intruder intersperses himself between two parties. Once in position intruder is able to intercept traffic from each party and forward it to the other without either being aware of the attack. The attacker in turn is able to modify messages an observe passwords.

Until recently this sort of attack was rare because attacker needed to intercept traffic by being located within ISP or Internet backbone. With advent of Phishing and DNS Poisoning this type of attack is becoming more common. Some ruse is used to cause user to connect to attacker's site. Site is often an exact replica of a real site. Once user has been fooled into connecting to bogus site attacker is free to spoof site information and capture user's authentication credentials.

## 7.10 Passphrase storage

For a computer to recognize authorized user it needs a method to establish entered credentials are valid. This means computer must store the passphrase, or more correctly a hash of the passphrase. As long as computer remains under control of authorized user everything works fine. However if machine is stolen or lost an attacker is able to retrieve hard disk contents and run dictionary attack at his leisure. Security researchers have even found it is possible to obtain valid data from dynamic memory even after it has been powered down for a relatively long period of time.

## 7.11 Data Leaks

Computers work by receiving information, creating copies – either temporary or permanent, modifying the information as needed to accomplish desired task, make more copies of modified data and often sending it to a third party. These records are a gold mine for legitimate businesses, law enforcement, and criminals. Digital data is easy and cheap to capture and transmit. Once captured this treasure trove of information often escapes control of those who have created it winding up in unsavory hands.

## 7.12 Cookies

Cookies were introduced by Netscape to address stateless nature of the Internet. A cookie is a small block of information a web site asks browser to store on its behalf. Cookies are important because without them sites have no way to know if this is the first or thousandth visit. From this benign beginning advertisers and governments have figured out ways to use Cookies to disclose additional information about browsing activity. This occurs unbeknownst to the typical user.

The biggest problem with cookies it when sites use then to correlate user activity across multiple web locations.

## 7.13 Social Media Sites

The explosion of social media creates another avenue where personal information can be unwittingly released into the wild or harvested for nefarious purposes. Members offer unwittingly post sensitive personal information that winds up being widely distributed.

## 7.14 Countermeasures

There is no such thing as perfect security. One must take a cold hard look at how computers are used, how valuable is the information, how attractive a target and ramification of breach. Security engineering is very different than other forms of engineering. In a typical engineering problem a solution is developed and proper operation verified. Various failure modes are analyzed but there is no need to consider deliberate attack designed to pervert operation.

### 7.14.1 Security Patches

For machines running Windows the Windows update tool is a convenient way to install the latest security patches. As with anti-virus software it is important to stay current. Once vulnerability is discovered information about it is rapidly disseminated over the net.

That is also a good idea with third –party application but I have noticed a trend to incessant updates and there is always the risk an update will break something.

### 7.14.2 Configuration

To make configuration easier most programs and operating systems use default settings. Check these carefully to make sure they do not compromise system integrity.

- UPNP allows PC based application request router modify firewall rules to allow Internet access. While this is a boon for ease of use it also means a compromised machine is able to modify firewall rules. Unless user is very diligent will never know an unauthorized application has access to the Internet.
- Many devices ship with default passwords. Changing them should be a high priority.

### 7.14.3 Passphrase Management

No reputable entity will ask you for your password. If there is a problem with your password you may be issued a new one but you will never be asked to give someone your password. On line passwords are reasonable secure because most accounts will be locked out if more than a few incorrect passphrases are entered. The more significant risks are encrypted transmission and devices that can be attacked offline. In that case attacker is able to perform dictionary attack running through millions of possible passphrase until they find the right one.

- Change passwords, do not use defaults.
- Do not use a single favorite password on multiple sites. Since Internet access often uses you email address for the username if you use the same password at multiple sites and it is compromised the other accounts are at risk.
- Use long passphrases of both letters and numbers and if possible punctuation characters.
- Be wary of any email providing a link and asking you to log in – it may be a Phishing attack.
- Write down user names and passwords and store them in a secure location away from the computer so you have access when you forget them. Don't worry you will forget them.
- On your Wi-Fi network do not use the default SSID. Using the default SSID allows the attacker to precrack possible passwords. Using a unique SSID at least forces the attacker to run through the list again.
- Periodic password changes are a waste of time and tend to result in selection of trivial passwords that user is able to remember. Wherever possible forgo mandatory password but pick a robust password and one that is unique for that account.

### 7.14.4 Information Release

Limit the amount of personal information you divulge. You need to disclose just enough information to conduct the transaction. Often times you can use an alias such as in chat rooms and forums. Companies want to harvest your information to sell you stuff. It is surprising, and scary, how much information can be gathered about someone by simply following them to different sites.

### 7.14.5 Trustworthy Software

Web makes it easy to download and install software. It is hard to tell if a particular program is safe. Using antiviral software is helpful but it is not an absolute guarantee. It is possible to get infected before the antiviral program is updated.

Windows make it easier to limit unauthorized software installation by providing a pop up dialog box asking to approve installation. Much Windows software is digitally signed verifying it came from the vender it claims to come from. Note: signing says nothing about quality of the software just verifies who released it.

### 7.14.6 NAT

One of the security benefits of NAT is by default it drops incoming connection requests. If a remote host attempts to connect to public IP address NAT ignores request because it doesn't know which computer on LAN to forward it to. Only if explicit port forwarding rules are created will NAT know how to handle request. This is what gives NAT its firewall like characteristics for inbound connections.

### 7.14.7 Firewall

The first line of defense is to control data entering and leaving the LAN. Unless you are running a public server incoming security is easy, refuse all incoming connection requests. Our business web and mail server are hosted externally. This means ALL requests that originate outside the SOHO LAN can be refused

A firewall imposes policy rules on data entering and leaving the network. Software firewall running on workstation, such as Windows built in firewall is able to control access based on individual application. Many low cost Broadband routers include some form or firewall.

In some respects firewall security is overrated. A machine without active listening services is impossible to attack directly. If the host is running one or more services the firewall needs to allow incoming connection to the server. In that case the firewall is no longer part of the security scheme since it must allow data to pass. The server must be hardened to thwart malicious attack. Firewalls are great for keeping unnecessary traffic off the LAN and providing a secondary line of defense against incorrectly configured machines – but firewalls are not the magic bullet many people think they are.

### 7.14.8 Data Backup

Having duplicate copies of important data is critical to recovering from data loss, either accidental or deliberate.  With available of large low cost drives both internal and external backup has never been easier.

## *7.15 Internet Paranoia*

When reading about various threats it is easy to become overwhelmed. Assuming you are using either a NAT router or firewall the first thing you notice when examining security logs is a tremendous number of "bad" packets. Very little of this traffic is actually an attack. Most is the result of incomplete sessions and mistyped or misprogrammed addresses. Before sending off an irate e-mail to your ISP complaining about being attacked may want to take a gander at this tongue in cheek posting called: You pinged me you dog, Internet Paranoia. Security is a balance, taking reasonable precautions go a long way to keeping oneself safe in the digital world.

# 8 Backup – Oops Protection

Having an always-on server makes it possible to use automatic backup. On line backup is convenient insuring backup actually happens. However it is not as secure as offline offsite backup. With online backup a software attack or power anomaly may destroy all copies of the data. If both copies are in the same location they may be destroyed in a fire. Optimum backup strategy should consist of on and off line backup.

## 8.1 On Line Backup

One of the purposes of having a server was to provide a backup location so each person is able to backup data to the server. We chose Acronis True Image backup utility. It has the capability to backup data or create a disk image that can be used to do a system restore if HDD becomes corrupted.

Backups are scheduled to occur automatically insuring data is safely duplicated. Use of incremental backup saves changes since last backup reducing amount of disk space needed to roll back files.

## 8.2 External Drive

**Figure 12 External HDD**

External hard drives are an ideal way to provide backup. They can be disconnected when not in use protecting them from lightning strikes and hardware failures.

The Maxtor One Touch USB 500 GB we had been using for several years reached capacity. Repurposed that drive to store the initial disk image of each PC we placed in service. That way if needed we can easily go back in time to reimage a computer. I had done that before as part of other back up media but on more than one occasion deleted this first backup image because I forgot what it was. The prevented being able to restore system to pristine condition.

To keep up with every increasing storage requirements bought a Seagate Backup Plus 1 TB external drive. Perhaps it is just me but I found the user interface much less institutive the Maxtor.

## 8.3 CD/DVD/Blu-ray

There is no substitute for off line backup. It is the best ways to recover from virus or physical damage, such as fire assuming copies are stored in a different location. CDs and DVD are cheap high capacity means to create off line storage. There is some concern about long-term stability of writeable media. It is unclear how long writable media lasts before data is unrecoverable. However it is likely to be at least tens of years so will not to cause problems as off line backup medium.

## 8.4 USB Flash Drive

**Figure 13 Flash Drive**

Multi Gigabyte USB Flash Drives  have become extremely popular over the last few years. They offer advantage of large, low cost rewriteable removable storage. Once data is copied and stick removed hardware/software problems on computer will not affect data. I like Cruzer Flash drives because they have a retractable USB plug rather than end cap.

# 9 Troubleshooting -- When Things Go Wrong

Networks occasionally fail. Good troubleshooting skills are necessary to determine root cause. For a small SOHO network good use can be made of the diagnostic tools built into Windows and indicators on most Ethernet devices. Hardware, software, and service vendors are also a good diagnostic source. Consumer products are very competitively priced, that limits how much one-on-one support a vendor is willing to provide. There are many Internet resources, besides product vendor, able to help resolve end user issues. My favorite is Broadband Reports.

Windows includes a number of command line utilities to help debug network issues. To run the desired utility press the Windows key and the R key simultaneously. Type “cmd,” press OK. This opens the command prompt, also called the DOS box.

There are lots of ways to troubleshoot problems. The most comprehensive is to start at the bottom and work your way up.

1. Does device think it is connected to a wired or wireless network?
2. Does the PC have the appropriate IP address for the specific network?
3. Can you access the router’s web GUI or Ping it?
4. Is Router able to establish an ISP link?
5. Are you able to Ping remote host?
6. Is a remote site able to Ping the router?

## *9.1 Ethernet Indicators*

Ethernet cards, hubs and switches typically include a number of indicators that are very helpful troubleshooting aids.

| Indicator | Purpose |
|---:|---|
| Link | Active connection between card and hub/switch |
| 10/100/1000 Mbps | Indicates link speed |
| Full Duplex/Half duplex | Half duplex when used with a hub and full duplex with switch |
| Activity | Flashes during transmission or reception |
| Collision | Flashes when hub detects collision |

If Link indicator is off link is inactive. This is most likely a cable fault or Ethernet hardware failure.

Ethernet cards automatically select optimum speed. For 100 and 1,000 Mbps operation both sides must be capable of the same speed and wiring meet Cat5e or Cat 6 requirements. When connected to a hub Ethernet runs in half duplex (HDX). Ethernet switches allow simultaneous send and receive - Full Duplex (FDX). When using hub collisions get worse as utilization increases. Occasional collisions are nothing to worry about. Hubs are obsolete so rarely used on residential network.

In Windows go to the Network Connections page and click on the interface you are using. If the word Status is not in bold the PC does not think that interface is connected to a network. If you prefer command line troubleshooting type the command: GETMAC –v. It will display each interface and whether or not Windows thinks it has an active connection.

If the desired device does not show up at all that means Windows does not think it exists. Sometimes an interface may lock up. Unplug the PC from power; do not just turn it off. This makes sure power is removed from everything except the RTC. Leave it off for a few seconds and try to reboot.

> ***Debug tip*** – If cable is not terminated correctly end-to-end continuity may exist but pairs miswired, causing a condition known as a split-pair. A split pair cable will often operate at 10 Mbps but fail at higher speed.

***Debug tip*** – Normally a computer is connected to a Hub or Switch using a straight through patch cable. When connecting PC-to-PC or Switch-to-Switch a crossover cable or uplink port is needed. Newer devices implement Auto-MDIX eliminating the need for crossover cables. If ports are mismatched the link will not work.

## 9.2 Modem Statistics

The modem connects to the ISP network: ADSL, Cable, satellite, or if you are very unlucky dialup. Modem stats provide a powerful diagnostic aid since reports condition of the physical interface rather than end-to-end performance.

The Status page of our ADSL2 router shows DSL link speed and IP settings. There is a diagnostic submenu to display low level ATM and ADSL stats.

## 9.3 PING

PING is a Windows command line utility to determine if a remote machine is reachable. The host is specified by either IP address or domain name. PING uses Internet Control Message Protocol (ICMP) to determine round trip time to the remote host. Not all hosts respond to Ping some administrators disable it.

In the first example we ping a local PC its IP address. In the second case we ping a public web server on the Internet by its domain name. When Pinging by name first step is to translate host name to IP address. This quickly determines if DNS is working correctly. The third example shows a typical report when the host ignores ping requests.

**Tip** – Ping is extremely useful but not all routers and hosts respond. If a device does not respond need to determine if that is because of a problem or it is configured to ignore Ping.

**Example 1: Ping local computer IP address.**

```
Pinging 192.168.2.2 with 32 bytes of data:
      Reply from 192.168.2.2: bytes=32 time=2ms TTL=128
      Reply from 192.168.2.2: bytes=32 time=1ms TTL=128
      Reply from 192.168.2.2: bytes=32 time=1ms TTL=128
      Reply from 192.168.2.2: bytes=32 time=1ms TTL=128
```

**Example 2: Ping remote host by DNS Name.**

```
Pinging broadbandreports.com [209.123.109.175] with 32 bytes of data:
      Reply from 209.123.109.175: bytes=32 time=26ms TTL=242
      Reply from 209.123.109.175: bytes=32 time=21ms TTL=242
      Reply from 209.123.109.175: bytes=32 time=23ms TTL=242
      Reply from 209.123.109.175: bytes=32 time=20ms TTL=242

      Ping statistics for 209.123.109.175:
          Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
      Approximate round trip times in milli-seconds:
          Minimum = 20ms, Maximum =  26ms, Average =  22ms
```

**Example 2: Ping remote host by DNS Name, ICMP response disabled.**

```
Pinging www.cnn.com [64.236.16.84] with 32 bytes of data:
      Request timed out.
      Request timed out.
      Request timed out.
      Request timed out.
```

## 9.4 Trace Route

Trace route (Tracert in Windows) determines round trip time to each hop between user and remote host. This information is useful to determine underlying cause of slow Internet response or unavailable hosts. Trace route uses Time To Live (TTL) parameter to control at which hop the packet expires. When a router receives a packet with an expired TTL it discards the packet and informs sender TTL expired. Trace route uses this information to build a path map and response time list to each hop between source and destination.

Round trip time increases with distance and hop count. A sudden unexplained increase typically means that hop or previous one is congested. PING is given a low priority so it is not uncommon for a router or server to ignore it. In that case Trace route responds with an “*” indicating nothing was returned.

Windows includes a command line Trace route utility, TRACERT. VisualRoute provides a graphical format.

**Typical TRACERT report:**

```
Tracing route to broadbandreports.com [209.123.109.175] over a maximum
of 30 hops:

 1 <1 ms <1 ms <1 ms 192.168.2.1
 2 23 ms 23 ms 23 ms 10.20.12.1
 3 25 ms 23 ms 23 ms pool-64-222-165-50.man.east.myfairpoint.net
                     [64.222.165.50]
 4 32 ms 33 ms 32 ms POS5-0.GW1.NYC9.ALTER.NET [208.192.176.109]
 5 33 ms 33 ms 33 ms 0.so-1-0-1.XT1.NYC9.ALTER.NET [152.63.99.178]
 6 33 ms 34 ms 33 ms 0.so-6-0-0.XL1.EWR6.ALTER.NET [152.63.16.53]
 7 33 ms 32 ms 32 ms POS6-0-0.GW4.EWR6.ALTER.NET [152.63.2.205]
 8 34 ms 34 ms 35 ms telecomeitalilia.alter.net [157.130.67.178]
 9 33 ms 34 ms 34 ms customer-side-netaccess-1-new3.new.seabone.net
                     [195.22.216.214]
10 34 ms 34 ms 34 ms 0.e1-4.tbr1.oct.nac.net [209.123.10.122]
11 34 ms 34 ms 34 ms vlan804.esd1.oct.nac.net [209.123.10.2]
12 34 ms 35 ms 35 ms www.dslreports.com [209.123.109.175]

Trace complete.
```

## 9.5 IPCONFIG

IPconfig is a Windows command line utility that displays IP settings for each network interface. If Point-to-Point Protocol (PPP) or VPN is used they are also shown. With the advent of IPv6 the IPCONFIG /ALL command gets pretty verbose with all the tunnel adapters. Tunnel adapters are software that allows data to move between IPv4 and IPv6 networks.

Adapter Address is the hardware address assigned to the physical network interface. For Ethernet this is a 48-bit Media Access Controller (MAC) address. Dialup PPP assigns a dummy MAC to the adapter. Default Gateway is the address packets are sent to connect to foreign hosts. DHCP server is the address of the dynamic host controller protocol server. At power up client emits a DHCP discovery message to find active DHCP servers. DNS server is the address of the name server. In a simple network DNS, Gateway and DHCP address will be that of the broadband router. The last two lines show when lease was obtained and when it expires.

```
Windows IP Configuration
 Host Name . . . . . . . . . . . . : Tom-Desktop
 Primary Dns Suffix  . . . . . . . :
 Node Type . . . . . . . . . . . . : Hybrid
 IP Routing Enabled. . . . . . . . : No
 WINS Proxy Enabled. . . . . . . . : No
```

```
Ethernet adapter Local Area Connection:
 Connection-specific DNS Suffix :
 Description . . . . . . . . .  : Intel(R) PRO/100 VM
 Physical Address. . . . . . .  : 00-08-02-C9-3B-5E
 Dhcp Enabled. . . . . . . . .  : Yes
 Autoconfiguration Enabled . .  : Yes
 IP Address. . . . . . . . . .  : 192.168.2.13
 Subnet Mask . . . . . . . . .  : 255.255.255.0
 Default Gateway . . . . . . .  : 192.168.2.1
 DHCP Server . . . . . . . . .  : 192.168.2.1
 DNS Servers . . . . . . . . .  : 192.168.2.5
 Lease Obtained. . . . . . . .  : Thursday, December 27, 2012:11:05AM
 Lease Expires . . . . . . . .  : Saturday, December 29, 2012:11:05AM
```

Useful IPCONFIG options are:
/flushdns – clears DNS cache
/release – releases DHCP lease
/renew – attempts to obtain new DHCP lease (Note) if computer has more than one adapter will get error message cannot renew lease on disconnected interfaces.

## 9.6 NETSH

Netsh is a Windows command line scripting utility to modify network setting useful for resetting TCP/IP stack.

In Vista and later operating systems it is a handy way to troubleshoot wireless issues. Typing the command: “netsh wlan show interfaces” displays the wireless network name (SSID), the MAC address of the access point as well as the MAC address of the computer.

## 9.7 Browstat

Browstat is a Microsoft utility that displays which PC is acting as Master Browser and other stats about network browsing. Browstat is not installed by default. In a Peer-to-Peer LAN each workgroup elects a machine to act as Browse Master. The Browse Master collects and distributes information about file and printer shares. Browstat does not come bundled with XP it must be downloaded.   The computer with an active Master Browser is the one collecting information about other computers on the LAN.

This is the status report from our LAN. It was obtained from a client PC. Tribble is a desktop (XP) acting as file server.

```
Status for domain HOMELAN on transport \Device\NetBT_Tcpip_{8927E1F6-
3E61-445B-822F-DF018AC0B1EF}
    Browsing is active on domain.
    Master browser name is: TRIBBLE
Could not connect to registry, error = 53
Unable to determine build of browser master: 53
    \\\\TRIBBLE      .  Version:05.01  Flags: 51003 NT POTENTIAL MASTER
    1 backup servers retrieved from master TRIBBLE
        \\TRIBBLE
    There are 2 servers in domain HOMELAN on transport
\Device\NetBT_Tcpip_{8927E1F6-3E61-445B-822F-DF018AC0B1EF}
    Unable to retrieve server list from TRIBBLE: 64
```

## 9.8 DNS Performance Testing

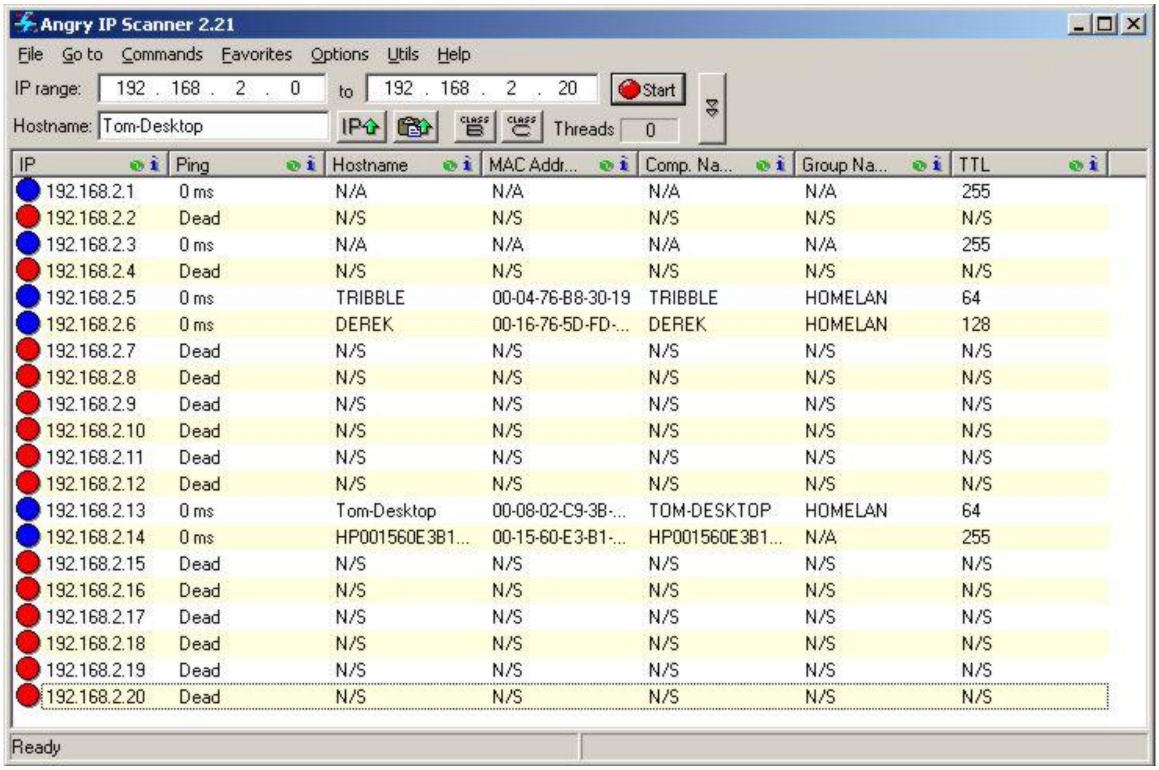
DNS servers operate behind the scene largely unnoticed until something goes wrong. Normally an ISP provides the address of two DNS server so if the primary goes down the backup is able to resolve queries. When that occur will likely notice browsing problem that looks like slow Internet access. Most web pages consist of many parts each with a unique URL. If the primary DNS server fails system waits for a response when it times out it tries the backup server. This is manifest as very slow browsing.

Gibson Research has a handy DNS benchmarking tool to evaluate DNS performance.

## 9.9 Angry IP

AngryIP is a useful utility to view information about which devices are connected to the LAN. Also facilitates finding unauthorized devices.

> **Security tip** – Microsoft Security Essential flags Angry IP as a potential threat. Need to click "Allow" so it does not complain.



IP range: 192 . 168 . 2 . 0 to 192 . 168 . 2 . 20

Hostname: Tom-Desktop

Threads 0

| IP | Ping | Hostname | MAC Addr... | Comp. Na... | Group Na... | TTL |
|---|---|---|---|---|---|---|
| ● 192.168.2.1 | 0 ms | N/A | N/A | N/A | N/A | 255 |
| ● 192.168.2.2 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.3 | 0 ms | N/A | N/A | N/A | N/A | 255 |
| ● 192.168.2.4 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.5 | 0 ms | TRIBBLE | 00-04-76-B8-30-19 | TRIBBLE | HOMELAN | 64 |
| ● 192.168.2.6 | 0 ms | DEREK | 00-16-76-5D-FD-... | DEREK | HOMELAN | 128 |
| ● 192.168.2.7 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.8 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.9 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.10 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.11 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.12 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.13 | 0 ms | Tom-Desktop | 00-08-02-C9-3B-... | TOM-DESKTOP | HOMELAN | 64 |
| ● 192.168.2.14 | 0 ms | HP001560E3B1... | 00-15-60-E3-B1-... | HP001560E3B1... | N/A | 255 |
| ● 192.168.2.15 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.16 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.17 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.18 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.19 | Dead | N/S | N/S | N/S | N/S | N/S |
| ● 192.168.2.20 | Dead | N/S | N/S | N/S | N/S | N/S |

Ready

**Figure 14 Angry IP LAN Scan**

## 9.10 WireShark

When you need to get down and dirty to see exactly what is going on over the wire nothing beats a packet sniffer. Sniffers observe and display incoming and outgoing packets. If you have a network with managed switches switch can be configured to pass packets of interest to the test PC. When used with unmanaged switch need to run WireShark on the PC of interest. This is one of the downsides of using switches vs hubs since switches limit most traffic to selected endpoints. Ethereal is a very popular open source diagnostic program recently renamed WireShark.

## 9.11 inSSIDer

inSSIDER is a handy troubleshooting tool for wireless problems. It scans all 2.4 and 5 GHz channels (assuming radio supports both) and display signal level, network name and encryption type. If you are in an urban area it is truly amazing how many wireless networks there are. Even though there is often more than one network on a given channel Wi-Fi radios are able to cut through the clutter and deliver fast Internet access.

## 9.12 Belarc Advisor

Belarc Advisor is a freeware (for personal use) application that displays hardware and software configuration information.

## 9.13 Internet Speed Testing

Speed testing measures end-to-end file transfer speed. For most SOHO networks ISP first-mile link will be the principal determinate of speed. However it is possible congestion elsewhere in network is degrading performance. There are numerous speed test utilities. The two I use are Broadband Reports and Speedtest.net.

## 9.14 LAN Speed Testing

If you need to test file transfer performance between PCs on your LAN use IPERF

## 9.15 Debugging Techniques

The key to effective debugging is to break complex systems into bite size chunks and build on what you know works. One of the nice things about using a router is it provides a clear demarcation point between LAN and Internet. First step is determining if the problem is the LAN or Internet.

**LAN Debug**

- Are all PCs connected to the LAN? LAN transfers should work even if Internet access is down. If you can get to your router's web configuration/status screen that is a good indication locally everything is working correctly.
- Is the Ethernet link indicator on? If so it means the physical connection is good.
- Do all machines have the proper IP address? When set for DHCP if the machine cannot find a DHCP server it will self-assign an APIPA address. If PC has an APIPA address 254.169.x.x there is probably something wrong with your gateway's DHCP server.
- Ping the default gateway address. This is the address of your router.
- Ping machines on the LAN by Network name and IP address. This verifies internal Windows NetBIOS name resolution is working correctly.
- If networking looks really broken try pinging local Loopback address 127.0.0.1. This tests PC's IP stack, and works even if the machine is not connected to a LAN. If this does not work try deleting and reloading TCP/IP stack.
- If some PCs do not show up in My Network Places refer to file sharing section.

**WAN Debug**

- If your DSL or Cable modem has a ready light make sure it is on. This indicates modem is communication properly over DSL or Cable network.
- If modem is able to report status use that information to verify physical connection is working correctly.
- If your ISP uses PPPoE make sure it accepted your authentication credentials. If account uses DHCP try to disconnect and renew the address.
- Ping a stable site like Broadbandreports.com that does not block ICMP Echo (Ping). If Ping cannot resolve host name you may be experiencing a temporary DNS problem. Try Pinging the site by IP address. As of December 2012 Broadbandreports.com address is: 209.123.109.175. If you can ping site by IP address but not URL you have identified a DNS problem. If site is not accessible by address there is a bigger problem.

- Perform a Trace route (tracert in Windows) to stable sites. This will give you an idea if your ISP is experiencing congestion (high ping), or is unable to route to the remote host. It is not uncommon to have sites “disappear” after a major fiber cut as routers try to route around failure.
- If you have DSL or dialup and are experiencing slowness, temporally connect modem directly to Telephone Company NID test jack. This disconnects inside wiring. If speed improves inside wiring or equipment is interfering with DSL or dialup.
- Sites like Broadband Reports have tools to continuously monitor connection quality.

Internet access problems can be caused by many things: 1) your computer, 2) other computers on your LAN, 3) LAN, 4) router or ICS, 5) first-mile WAN connection, 6) internal ISP routing, 7) Internet backbone, 8) ISP used by remote host, 9) remote LAN and lastly, 10) remote host. The trick is to quickly determine which link in the chain is causing the problem.

# 10 Wiring – Cables and Connectors

Many improvements in wiring technology were developed by the Telephone industry to deal with massive number of circuits they install and manage.  Of particular significance for our purposes are modular jacks and type 66 and 110 punch down blocks.

Modular jacks were developed by the old US Bell Telephone System to reduce cost of installing and maintaining customer equipment. Until the 1970s phones were hardwired. This required a craftsperson to come on site for even the simplest task. Deployment of modular jacks meant that in many instances customers could: repair, move, or install their own equipment.  Within the old Bell system they were known as registered jacks. A uniform service ordering code (USOC) defined the physical jack, type of mounting, and how the jack was connected to the telephone network.

About the same time as modular jacks became popular Type 66 punch down termination was introduced. It is called punch down because each conductor is terminated with a spring-loaded tool that pushes a wire into an insulation displacement contact and automatically cuts it to length. 66 style blocks are still widely used for phone systems. LAN wiring uses second-generation termination Type 110.  110 terminals are smaller allowing more circuits to be terminated in a given area. Due to its smaller size 110 provides better high frequency performance than type 66. There are other types of insulation displacement technology but these two are the most relevant for our purposes.

Prior to Telecommunication Industry Association EIA/TIA 568 Commercial Building Telecommunications Cabling Standard and EIA/TIA 570 Residential Telecommunication Cabling Standard wiring requirements were developed by various industry groups or in many cases equipment vendors themselves. TIA recognized cable infrastructure has a long life expectancy. It is typically used with multiple generations of electronic equipment. TIA devised a performance based wiring scheme independent of usage and equipment. This was a breakthrough; almost all communication systems now use structured wiring. TIA Structured wiring implements a home-run wiring method between a centralized wiring closet and terminal devices. Horizontal wiring originates at a patch panel in an equipment room and runs to jacks near the network device. Short patch cables connect devices to jack and patch panel to network infrastructure equipment.

When US telephone network was deregulated FCC took over responsibility for end user equipment and inside wiring standards, called Customer Premise Equipment (CPE). Phone company practice for the previous 100 years was to wire phone jacks as a daisy chain. Outside wiring, called customer drop, terminated at a lightning protector. Inside wire originated at the protector and ran to the first outlet, from there to the next, and so on. As customers began using more sophisticated services limitation of this method became apparent. FCC mandated telephone inside wiring confirm to TIA structured wiring guidelines. Adoption of TIA structured wiring means identical wiring methods are used for both voice and data.

## *10.1 Modular Connectors – Registered Jack*

When the old Bell system moved to connectorized customer premise equipment (CPE) it created a family of modular connectors.  Modular connectors come in 4, 6 and 8 position versions. A center locking key prevents the plug from being accidentally ejected from the receptacle.

As US telephone industry was migrating to modular connectors it was also in early stage of divesture and FCC mandated CPE interconnect. For the first time Customers Premise Equipment (CPE) could directly connect to the telephone network. This resulted of many tariff offerings defining various interconnect arrangements. Each tariff not only defined the type of jack, but whether it was flush or surface mount and how it connected to the telephone network. The system was called Uniform Service Ordering Code (USOC) Registered Jack (RJ) designation. Most Registered Jacks are only of historical interest today. The RJ nomenclature has passed into popular usage only loosely coupled to its original intent. The more precise way to refer to modular jacks is in term of positions and contacts. For example the single line phone jack commonly referred to as RJ11 is a 6P2C; it is a 6-position modular connector of which only 2 contacts are used. The so called RJ45 jack used in networking is more properly called an 8P8C.

The 4-position connector is used to connect telephone handset to phone. It is not assigned a RJ designation as is was never intended as an interface point for customer premise equipment.

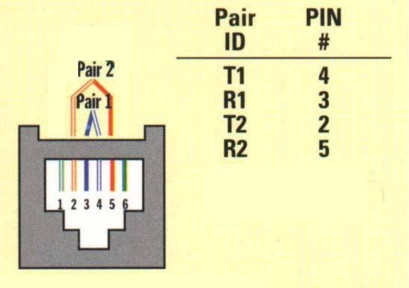
The most popular 6-position jack is referred to as RJ11. It connects single line voice grade telephone equipment to the public switched telephone network (PSTN). A two-line version using the 6-position jack is the RJ14. Analog phones are often called POTS for Plain Old Telephone Service.

8-position RJ31 and RJ38 jacks connect alarm systems to the PSTN.

The 8-position RJ48C and RJ48X jacks are used for Business Class T-1 carrier.

TIA choose 8-position jack for structured wiring. This jack is often erroneously called RJ45. USOC RJ45 connects analog data equipment to the PSTN. A resistor in the Jack is used to set transmit power level.

## 10.2 Telco Uniform Service Ordering Code (USOC) Pin out



| Pair ID | PIN # |
|---|---|
| T1 | 4 |
| R1 | 3 |
| T2 | 2 |
| R2 | 5 |

**Figure 15 RJ11 & RJ14 POTS**

RJ11 6-position jack connects a single-line phone to the telephone network using pins 3 and 4. RJ14, also 6-position, is used with two-line phone using pins 3 and 4 for line 1, and pins 2 and 5 for line 2. An infrequently used three line version RJ25 uses pins 1 and 6 for the third line.

RJ31 and RJ38 are 8-position jacks used with alarm dialers. The jack is placed in series with the phone line close to the Telephone Company Network Interface Device (NID). Phones are wired downstream of the jack. Shorting bars within the jack establish continuity when the alarm is not plugged in. Connecting alarm opens the circuit placing the alarm in series with CPE devices. This allows the alarm dialer to disconnect downstream CPE devices so it is able to seize line and dial out even if line was being used. RJ38 is identical to RJ31 except it has a strap between positions 2 and 7. This allows dialer to determine if it is plugged into a jack.

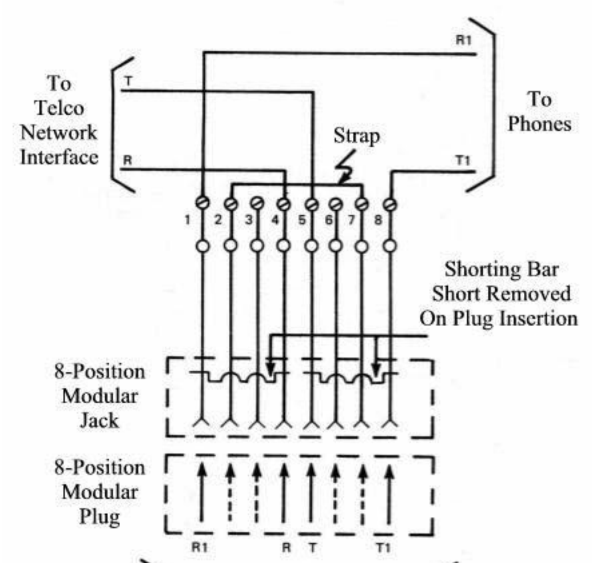


**Figure 16 RJ31 & RJ38 Alarm Jack**

Uncommon in residential use RJ48C and RJ48X are 8-position jacks used to terminate 1.544 Mbps T-1 digital service. Receive pair use pins 1-2 transmit 4-5. RJ48X provides automatic Loopback when plug is removed. Unlike other 8-position USOC jacks pairing arrangement is compatible with TIA 568 so LAN patch cables can be used.

## 10.3 Type 66 Punch Down Block

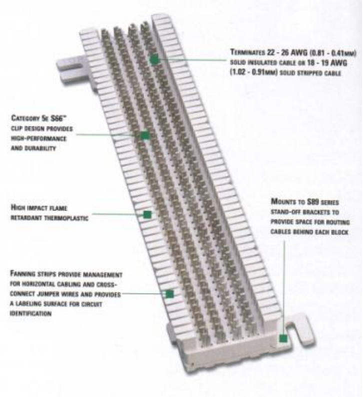

Terminates 22 - 26 AWG (0.81 - 0.41mm) solid insulated cable or 18 - 19 AWG (1.02 - 0.91mm) solid stripped cable
Category 5e S66™ clip design provides high-performance and durability
High impact flame retardant thermoplastic
Mounts to S89 series stand-off brackets to provide space for routing cables behind each block
Fanning strips provide management for horizontal cabling and cross-connect jumper wires and provides a labeling surface for circuit identification

**Figure 17 66-Block**

The first type of insulation displacement terminal was the 66 block. These continue to be used extensively. An advantage of the 66 family is it accepts larger gauge wire than newer 110. Type 66 blocks are typically attached to a standoff bracket screwed to the wall or backer board. The bracket allows building wiring to be run underneath the block making for a neat installation.

Building wiring is terminated on one set of 66 blocks and equipment on another. Interconnect is accomplished with cross connect wire. This allows a great deal of flexibility in adding and changing equipment over time.

To save space split blocks can be used. In a split block each row of four terminals is divided in half. If needed, a bridging clip can be used to connect the terminal on left to the right side. Use of bridging clips facilitates troubleshooting allowing circuits to be easily isolated.

## 10.4 Type 110 Punch Down Block

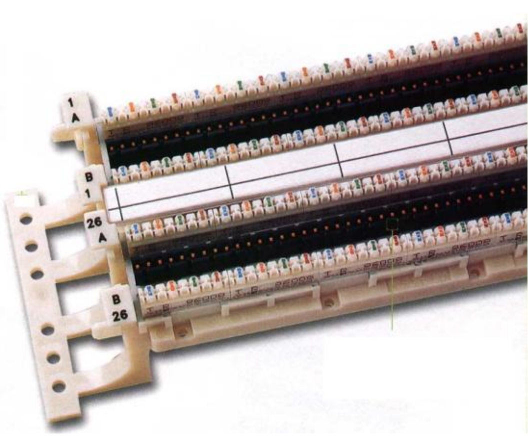


**Figure 18 110-Block**

Type 110 terminals allow higher density wiring than Type 66. 110 termination is preferred for LAN use. Typical 110 module includes a standoff. Building wiring is routed through the standoff and fanned out to the appropriate location. Multiple position 110 blocks are inserted over the base. Cross-connect wire is punched down to the upper terminals of the block. Cross-connect blocks are mainly used with telephone wiring.

When a LAN is installed the cable from each drop is connected to patch panel consisting of a large number of 8-position modular jacks. Short cables, called patch cable, are used to connect the drop to network electronics. This improves transmission characteristics compared to using punch down blocks for cross-connect.

## 10.5 Structured Wiring

**Figure 19 8P8C Receptacles**

The key to EIA/TIA 568 & 570 is notion of structured point-to-point wiring. A cable from each receptacle runs directly to a central wiring closet. Cable cannot be spliced or connected to other outlets. At the wiring closet each cable is terminated at a patch panel. To provide service a short cable, called a patch cable, is connected between patch panel and equipment used to service the room receptacle. At the other end another patch cable connects receptacle to network device.

Structured wiring specification defines multiple wiring types: unshielded twisted pair (UTP) shielded twisted pair (STP) and fiber optic (FO). UTP is the overwhelming choice for home and commercial local area network (LAN) and telephone.

UTP cable is rated by Category; higher numeric designation indicates higher performance. TIA created Category 3, 4, 5, 5e 6, 6a. UTP structured cabling is designed for a maximum end-to-end distance of 100 meters (328 ft.). This distance includes a patch cord from device to wall jack, 90 meters of building wiring (in TIA parlance called horizontal wiring), and another patch cord in the wiring closet to connect facility cabling to network electronics.

### 10.5.1 Patch Panel

Receptacles use type 110 punch down termination. This allows rapid termination with a punch down tool. In the wiring closet each cable is terminated at a jack on a patch panel. Using a patch panel allows short jumpers called a patch cable to connect individual drop to network gear. Patch panels are designed to mount on equipment racks. It is also possible to mount then directly on a will using a hinged bracket. Panel projects several inches from the wall in normal use but by unscrewing one side of the panel it swings out providing access to rear terminations.

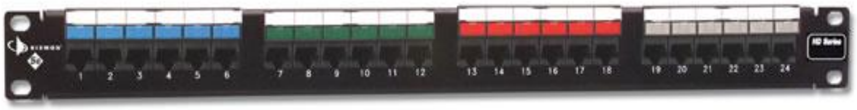


**Figure 20 24-Port Patch Panel**

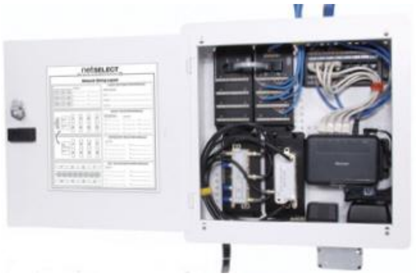


**Figure 21 Wiring Cabinet**

In office environments patch panels and active electronics are usually mounted on 19” racks. For residential use special wiring cabinets are often used to terminate phone, TV and LAN wiring and provide power for network devices.

The downside of residential wiring cabinets is space and power dissipation. My preference is to mount patch panel, punch down blocks and active equipment to a plywood backboard. This provides maximum flexibility.

### 10.5.2 Category Rating

Cat 5e supports Ethernet (10 Mbps), Fast Ethernet (100 Mbps), Gigabit Ethernet (1000 Mbps), as well as ordinary phone service. Cat 3 can be used for phone service but cost is comparable to Cat 5e which provides greater flexibility. Cat 4 is obsolete. When Gigabit Ethernet was developed it was designed to operate on installed base of Cat 5. However, real world experience showed that not all installations were up to the task, hence the minor revision Cat 5e to guarantee worst case compliance with Gig Ethernet. In reality well installed Cat 5 cable will probably work just fine on Gig Ethernet, especially the relatively short runs and low cable density typical of the home.

The highest level is Cat 6. Cat 6 doubles bandwidth from 100 MHz for Cat 5e to 250 MHz IEEE recently released specification for 10G over UTP. As happened with Gig Ethernet during spec development it was found necessary to tweak the cabling spec. Due to the higher frequencies involved at 10 G crosstalk from other nearby cables, called alien crosstalk, is a problem. Cat 6a (augmented) addresses this. Cat 6a cable has a larger outside diameter then Cat 6 to reduce alien crosstalk. As with Cat 5 vs 5e using lower rated cable may work but it does not meet worst-case parameters.

EIA/TIA just started work on the Category 8 standard to support 40 G Ethernet. It will be a long time before residential networks come anywhere near requiring that speed.

EIA/TIA is a US standards organization. Europe and rest of the world use similar standard defined by ISO/IEC 11801. Performance is grouped by Class rather than category. Class C is equivalent to Cat 3, Class D to Cat 5, and Class E to Cat 6. There is a higher rated spec commonly called Category 7. However there is no version of Ethernet that requires it.

The various UTP category grades are outwardly similar. The differences are in the number of twists per inch and mechanical tolerances. The higher the Category rating the more tightly pairs are twisted and mechanical specifications are held to tighter tolerances. It is important not to mix components of different Category grades, doing so reduces overall rating to the lowest grade used.

### 10.5.3 Cable Types

The most common type of Category cable is UTP PVC. It can be used in most habitable spaces. The larger diameter of Cat 6a used with 10G Ethernet is increasing interest in screened cable. Screened cable has an outer foil shield. Screened cable is more difficult to work with but its smaller diameter is attractive when used with high density wiring such as data centers. It will be a long time, if ever, that SOHO networks need 10G Ethernet.

Where cable is installed in air handling space such as under a raised floor or within a suspended ceiling it must be Plenum rated. Plenum cable is insulated with Teflon rather than PVC. It is a common misperception Plenum rated cable is fire proof, which is not correct.  Teflon is fire resistant not fire proof. The goal of Plenum cable is to delay onset of combustion until the fire is so advanced to make the space incompatible with life.

Outdoor wiring is subject to UV radiation and moisture. Outdoor cable is gel filled (icky-pic) to prevent moisture intrusion and has a UV resistant outer jacket, usually black. Direct burial cable includes a corrugated metal rodent shield to protect against burrowing animals.

For long runs especially between buildings fiber is ideal. Being nonmetallic it is not susceptible to lightning damage. The downside of fiber is termination cost and cost of electro/optical converters.

### 10.5.4 Patch Cables

Patch cables connect equipment to wall jack, and patch panel to network electronics. T568A and T568B pin out options can be ignored in patch cable since both ends are terminated by the manufacture.

Patch cables come in two versions, straight through and crossover. Straight through are used in most circumstances. UTP Ethernet uses a point-to-point wiring scheme. The transmit port of the computer connects to the receive port of the hub/switch and vice versa. If this arrangement cannot be used, for example two computers in direct connection or connecting a switch to another switch a crossover cable is used. Crossover cable swaps transmit and receive pair at one end so like devices can be interconnected. The function of Crossover cable is identical to using an Uplink port on an Ethernet Hub or Switch.  10 and 100 Mbps Ethernet use two of the four pair, Gig and 10G use all four.

Newer Ethernet devices implement Auto-MDIX that automatically determines which pair is used for transmit and receive. Auto sensing eliminates need for crossover cables and uplink ports.

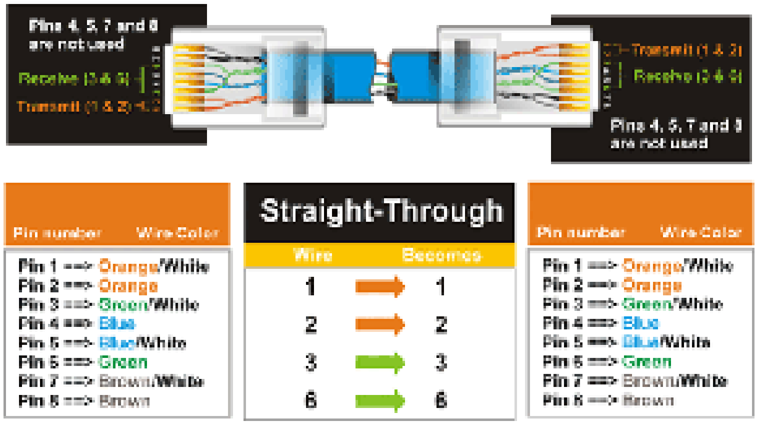


**Figure 22 UTP Straight-through Patch Cable**

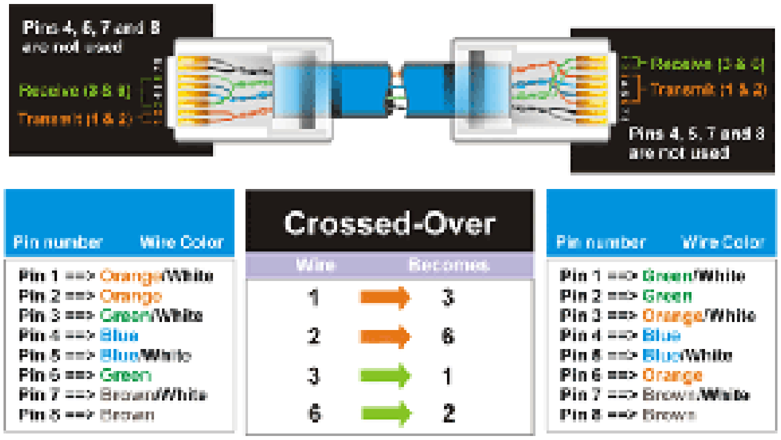


**Figure 23 UTP Crossover Cable**

## 10.5.5 TIA T568A and T568B Structured Wiring Pin out

A cause of much confusion when implementing EIA/TIA 568 structured wiring is the fact two different connector pin outs are defined: T568A and T568B. They are nearly identical except pairs 2 and 3 are swapped. Electrically this is of no consequence as long as both ends use the same pin out.

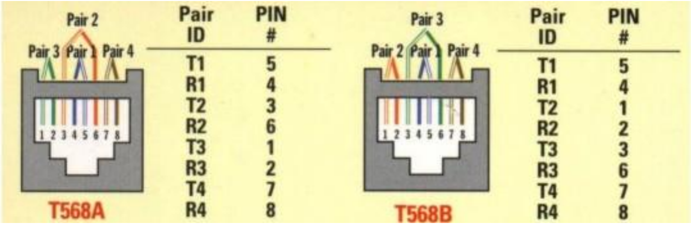


**Figure 24 TIA Structured Wiring Jacks**

Pairing arrangement of TIA differs from that used on USOC voice jacks. Inner two pairs are the same but outer two differ. This was done to improve high frequency transmission characteristics. It is important to use the correct type of patch cable. Use of 8-position USOC style patch cable in a Category rated network will cause problems due to split-pair.

The inner two-pair of TIA-568 8-postion jack mates with inner two pair of RJ11 and RJ14 USOC 6-position plug. This eliminates need for adapters when connecting RJ11 and RJ14 equipment to 8-pos structured wiring. EIA/TIA 568 commercial and EIA/TIA 570 residential structured wiring specifications require use of T568A unless building is already wired with B. T568A is preferred because inner two pair map directly to pair 1 and 2 on USOC punch down blocks, making cross connection easier. T568B is popular in the United States because it uses the same pin out as AT&T key systems in common use prior to the development of structured wiring standard.

## 10.6 Color Code

Legacy Telco USOC RJ11 and RJ14 jacks use green, red, black and yellow conductors. TIA Category rated cable consist of 8-conductors, arraigned as 4-twisted pairs. Each pair is a different color, to identify conductors within each pair one wire is solid color (Ring) the other has a White stripe (Tip). The term Tip and Ring refer to old style manual switch boards where operator had to physically insert a phone jack to make the connection.

Standard Telephone practice has Tip conductor positive with respect to Ring. Early touchtone phones were polarity sensitive. Today most telephone equipment includes a diode bridge so polarity is unimportant. However it is good practice to maintain proper polarity. Low cost phone line testers are available to quickly determine polarity.

| TIA Color Code | T568A 8-pos (preferred) | T568B 8-pos | Telco Color Code | Telco Designation | RJ11/14 6-pos |
|---|---|---|---|---|---|
| Blue/White | Pair 1 pin 5 | Pair 1 pin 5 | Green | Tip + Line 1 | Pair 1 pin 4 |
| Blue | Pair 1 pin 4 | Pair 1 pin 4 | Red | Ring - | Pair 1 pin 3 |
| Orange/White | Pair 2 pin 3 | Pair 2 pin 1 | Black | Tip + Line 2 | Pair 2 pin 2 |
| Orange | Pair 2 pin 6 | Pair 2 pin 2 | Yellow | Ring - | Pair 2 pin 5 |
| Green/White | Pair 3 pin 1 | Pair 3 pin 3 | | | |
| Green | Pair 3 pin 2 | Pair 3 pin 6 | | | |
| Brown/White | Pair 4 pin 7 | Pair 4 pin 7 | | | |
| Brown | Pair 4 pin 8 | Pair 4 pin 8 | | | |

**Figure 17 Wiring Color Codes**

## 10.7 Telephone

We have two wired phone lines, one for personal use and one for business.  Lines are configured as a hunt group, also called transfer on busy. If line 1 is busy incoming calls are redirected to line 2. Hunting is unidirectional; if someone calls the second line and it is busy switch will not ring the first line. Residential telephone service reps may not be familiar with Hunting because it is a "business feature." You may have to press the rep a little to get it. Surprisingly there was no extra charge for this feature, probably because it results in more completed calls.

Before the advent of broadband Internet we made extensive use of dialup. Dialup uses the public telephone network to provide Internet access. Unlike ADSL a dialup connection actually places a phone call to the ISP and ties up the line for the duration of the session.  If someone picks up a phone it will disconnect the session and if the phone is in use when the modem attempts to initiate the call it will interfere with the voice call. For readers still stuck on dialup I designed a device to minimize interference between dialup and phone lines.  More information about the Modem Access Adapter (MAA) is available on the writings page.

For some years I after we were able to get ADSL maintained dialup as a backup. We no longer do so. DSL service has been very reliable. With web sites increasing being optimized for broadband dialup browsing is painful.

## *10.8 Telephone Network Interface Device (NID)*

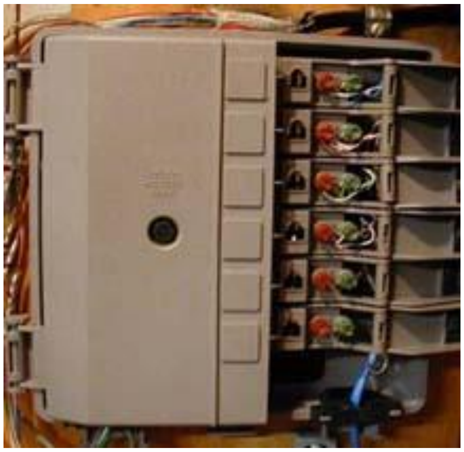


**Figure 18 Network Interface Device**

In the bad old days before US telecom divestiture (1880 to early 1980's) Phone Company delivered phone service, wired customer's premise and leased all telephone equipment. With divestiture Phone Company's regulated responsibility was limited to delivering service to customer's premise. Inside wiring and equipment became customer responsibility. This created a dilemma for the Phone Company, how to determine if a problem was their responsibility or the customer?

Enter the Network Interface Device (NID). NID is the demarcation point, between Phone Company and customer. It incorporates lightning protection and a method to easily disconnect customer premise equipment (CPE) from the telephone network. Over time NIDs evolved into a single integrated package.

The specific embodiment of the Network Interface Device (NID) has changed over the years but purpose remains the same: Terminate outside wiring; provide lightning protection and disconnect inside wiring for testing. Some NIDs include a half-ringer test circuit. The half-ringer creates a unique signature to allow test equipment to determine if fault is on Telco or customer side. Modern NIDs use gas tube protectors rather than old style carbon block. Gas tube provides tighter control of overvoltage and being hermetically sealed minimizes added noise.

Picture above shows a typical multiline NID installed indoors, as opposed to more common location outside. Telephone Company wiring terminates under the protective cover on the left. The Telco side contains protection circuits that divert lightning surges to earth ground. The right hand side has provisions to connect CPE wiring and a test jack for each line. Opening the line module cover exposes a RJ11 test jack. Plugging a phone into the test jack automatically disconnects inside wiring. If phone works when plugged into the test jack problem is due to customer wiring or equipment, if not problem is with Telco.

### 10.8.1 POTS/DSL Splitter

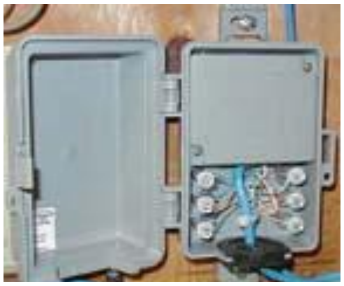


**Figure 19 Splitter**

ADSL rides on the same phone line used to voice. Filters are required to prevent high frequency DSL signaling from interfering with voice.  To reduce cost ISPs often send customer a self-install kit. The kit includes in-line filters that must be used by each non-DSL device connected to phone line.

Rather than using a microfilter at each non-DSL device I installed a POTS/DSL splitter. Splitter provides a low pass filter isolating voice from high frequency DSL. Splitter has two outputs; "Data" connected directly to the DSL modem and "Voice" connected to inside phone wiring.  The splitter contains a half-ringer test circuit after the low pass POTS filter allowing the one in the NID to be removed. ADSL was designed to operate in the presence of half-ringer but it represents a small additional load.

In some cases the local phone company will install a splitter directly in the NID eliminating the need for customer installed external splitter or in-line filters.

***Home Alarm Tip*** – If a phone is connected to splitter "Data" port it will work normally. This creates a potential safety hazard with a home alarm system. If a phone is inadvertently connected to data port and is in use when alarm needs to seize phone line it will be unable to do so. Care should be taken when using a splitter so only DSL modem is connected to "data" jack. The other option is to install splitter after alarm jack and filter alarm separately.

## 10.9 Secondary Lightning Protection

The key to minimizing lightning damage is bonding all services together with a low impedance path to each other and Earth ground. All conductors entering the building should be bonded together and equipped with surge protection. This minimizes potential differences during transient conditions. IEEE has a nice white paper about lightning and surge protection. A good analogy is to think of your home as a bank vault. The goal of protection equipment is to prevent dangerous voltages from passing through the perimeter and to insure everything metallic is at the same potential.

### 10.9.1 Electrical

**Figure 20 Mains Surge Protector**

Whole house surge protector should be used to protect electrical system. Goal is to direct transient energy into low impedance ground and to provide low impedance bonding of all metallic conductors. We use a GE THQLSURGE protector. Installation is easy. Device plugs into breaker panel much like an ordinary two-pole breaker.

Lightning protectors do not absorb energy they divert it. If diversion path is not low impedance a substantial voltage difference is created. This is what kills electronic gear.

### 10.9.2 Telephone

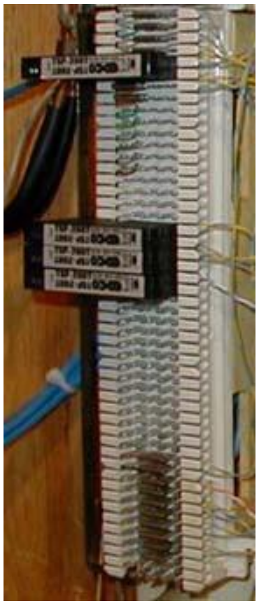


**Figure 21 Telephone Surge Protector**

Telephone Company provides lighting protection as part of the NID. NID is connected to building ground system. Electronic devices are more fragile than electromechanical phones. This is especially the case with computer equipment because it has multiple connections: power, phone, DSL and Ethernet. This makes equipment susceptible to transient surges. Adding secondary protection minimizes risk of equipment damage. Best location for secondary protection is at building entry point. This allows protector to use same Earth ground as AC mains to minimize voltage difference between services.

EDCO TSP-200 series protectors add very little capacitance to phone line. This is critical so protector does not interfere with high frequency DSL. Protector clips to 66 style split block. Surge protector acts like a bridging clip between the left side (Telco) and right side (Phone). When protector is removed inside wiring is completely isolated from external circuit. A grounding bar runs down the left side of the block. This is connected to a high quality earth ground, the same used by NID and power mains. When protector fires fault current is shunted to ground.

One protector is used for each incoming telephone line. Additional protectors should be used on any lines connected outbuildings.

### 10.9.3 CATV or Over The Air (OTA) Antenna

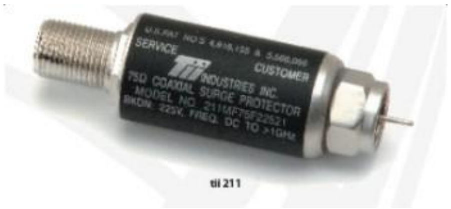


**Figure 30 Coax Surge Protector**

Cable provider must ground coaxial cable where it enters residence to building ground system. This insures cable sheath is as at same potential as building Earth ground. As with Telephone it is advisable to add secondary CATV protection to limit transient voltage on inner coax conductor.

Over the Air (OTA) antenna needs to be grounded where it enters the dwelling. We have roof mounted TV and FM antennas. Surge protector on each cable protects AV equipment.

## 10.10 Power Distribution

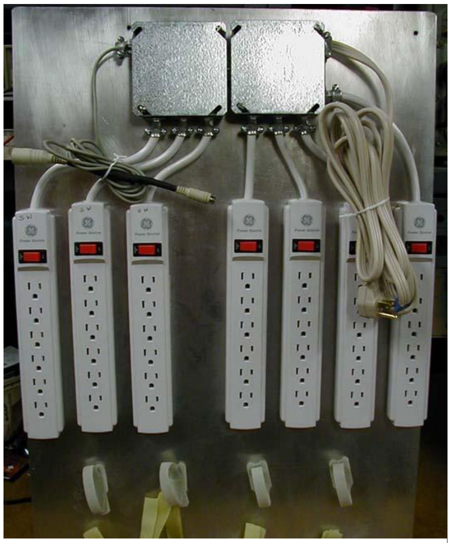


**Figure 31 Power Panel**

Electronic devices create a jumble of cables, both data cables and power cords. Low power devices tend to use external power supplies, called wall warts, which take up a fair amount of space. After struggling with the clutter of multiple power strips I decided to try an organize power distribution.

**Power Panel requirements**

- Multiple always on receptacles
- Multiple switched receptacles controlled by workstation
- Wire routing provisions
- Mounting provisions for "wall wart" power supplies.

To minimize power consumption devices that do not have to be on continuously are automatically switched on/off with workstation. Power bricks take up a lot of space, so the number of outlets is generous. Panel has four always on strips with six receptacles each and three strips controlled by workstation. A cable plugs into PS/2 keyboard or mouse port sensing 5 Volts. That signal is used to control a solid-state relay to turn power on/off.

> ***Power Tip*** -- some PCs leave PS/2 ports powered all the time to allow keyboard controlled wake-up. In that case power panel needs to sense power directly from PC main power supply. Many newer PCs no longer have PS/2 ports. Assuming USB 5 volt power is turned on/off that can also be used to switch external power.

Two rows of Velcro are used to organize power wiring. Upper level consists of Cat 5 Velcro cable wraps. This holds excess power cable. The bottom row uses longer pieces of regular Velcro to mount larger inline supplies.

## 10.11 Tools

Proper tooling is essential to install a reliable network. Jacket ripper uses a sharp blade to cut through outer jacked without deforming twisted pair or cutting through insulation. Punch down tool with interchangeable blades for 66 and 110 termination is needed for both LAN and telephone work. I found a handy palm rest at local big box home center to hold Jack during termination. This makes terminating jack easier. Use Rino hand labeler to mark cable ends. This is a handy little device that dispenses and cuts cable labels.

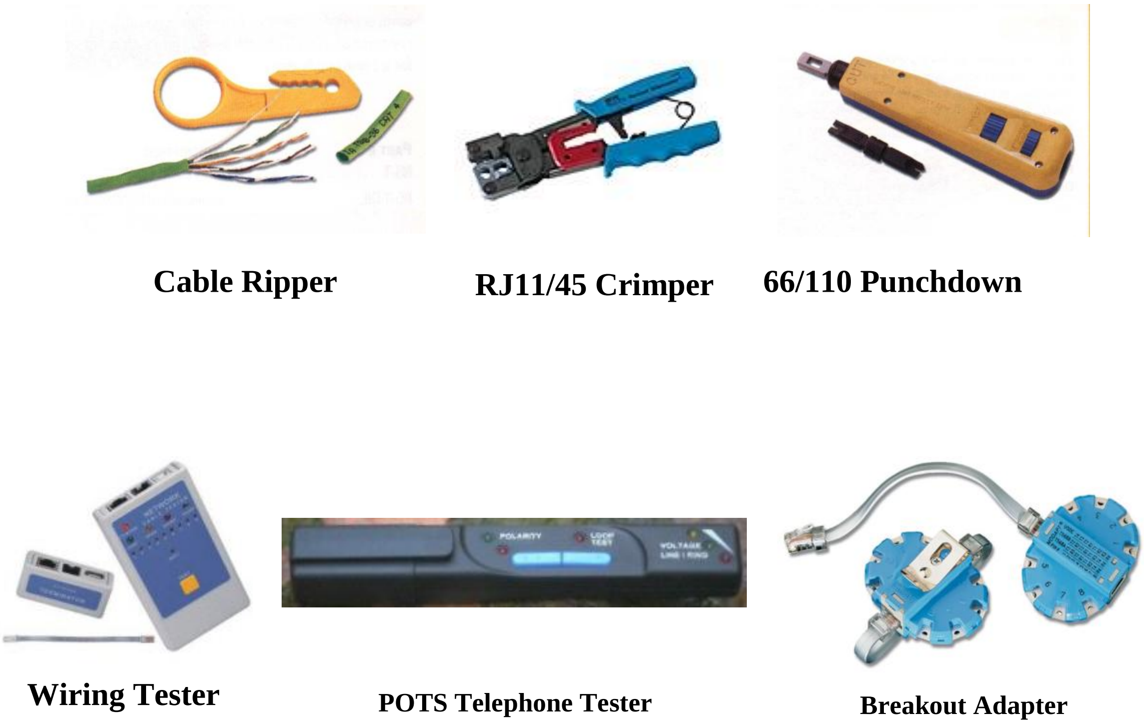
Once cabling is installed commercial installations perform full parametric testing to verify system meets applicable performance standards. That test equipment is very expensive and not practical for the casual installer. There are numerous continuity testers in to $20-$50 range. These low cost tester are only able to verify continuity and shorts, will not detect excessive untwist, split-pair etc. Still for the price is a great time saver to verify cable is property terminated.

Phone line tester is handy for checking active telephone lines. Verifies line polarity, voltage, loop current and ringing voltage.  If you do a lot of telephone work a buttset is handy to have. A buttset is modified telephone used for testing.

If you are faced with the task of identifying unknown cables a toner is invaluable. Toner consists of two parts a tone generator and sensor.  The generator places a signal on the wire. When the sensor is brought near it emits a tone due to capacitive coupling.

Lastly found breakout tester that came in handy doing nonstandard wiring. I used Category rated cable to connect weather station. Breakout provided access to individual conductors to verify I wired it up correctly.

| Tool | Purpose |
|---|---|
| Wire Cutters | Cut cable to length |
| Jacket Ripper | Removes outer cable jacket |
| Punch down Tool | Terminate Punch down terminals |
| 110 Blade | Terminate 110 blocks |
| 66 blade | Terminate 66 blocks |
| Palm Rest | Holds Jacks being terminated |
| Crimper | Crimps cable into modular plug |
| Fish tape | Snake wire through walls |
| Labeler | Identifies Cable ends |
| Phone line Tester | Indicates polarity and loop current of phone circuit |
| Cable Tester | Verifies proper installation of Category rated wiring |
| Toner | Identifies cable ends |
| Buttset | Portable Telephone to test phone line |
| Breakout adapter | Electrical access to each wire |



Cable Ripper

RJ11/45 Crimper

66/110 Punchdown

Wiring Tester

POTS Telephone Tester

Breakout Adapter

**Figure 32 Telephone and Network Tools**

## *10.12 Putting it all Together*

Drawing shows overall connection of phone and DSL wiring. NID, secondary lightning protection, POTS/DSL splitter, test jacks, test phone and Type 66 punch down blocks. Wiring terminates in two different locations, one for phone and alarm wiring another for networking.

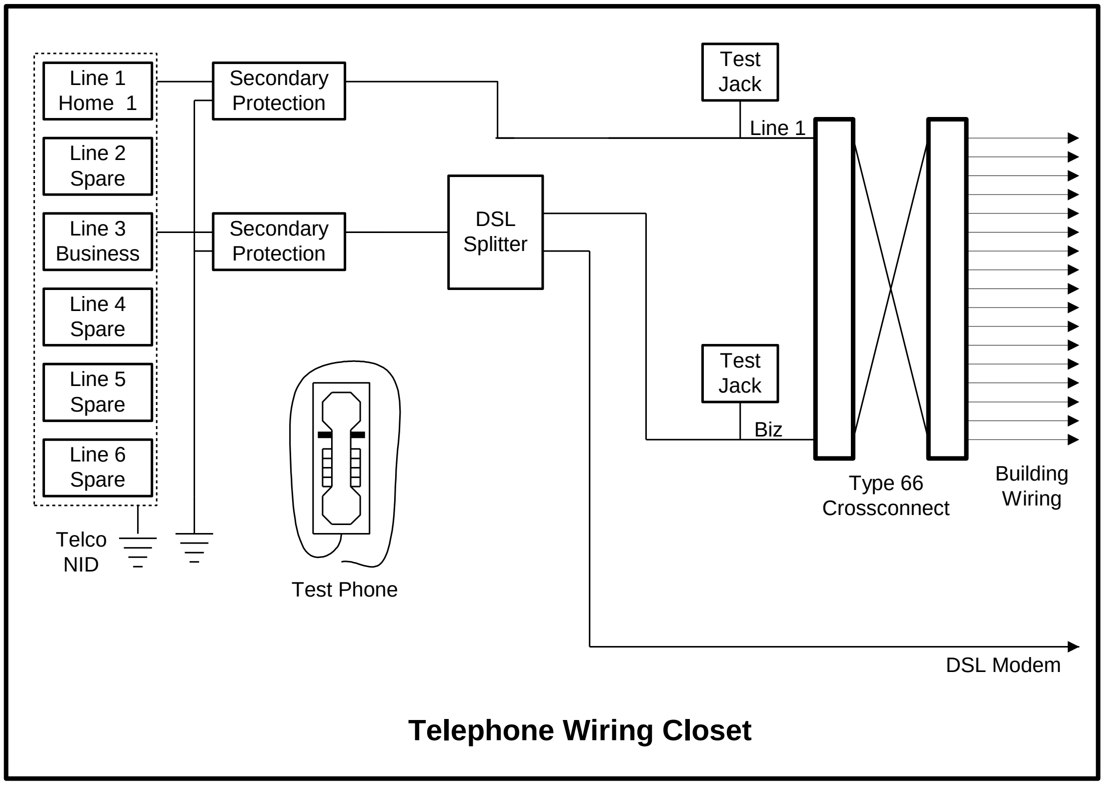


**Figure 33 Telephone Wiring Closet**

### 10.12.1 Telephone wiring

Telco NID is located in basement. From NID each line goes to a secondary protector. A POTS/DSL splitter is connected to business line. Splitter “Data” port runs directly to DSL modem. “Voice” port terminates at 66-block to be connected to multiple phones.

To make changes easier all building wiring is terminated on punch down blocks. Cross-connect wire is a single twisted pair used to interconnect building wiring. This makes it easy to rearrange wiring by adding and removing cross-connects. Test jacks connected to each line allow a test phone to be conveniently plugged in during troubleshooting. The test jacks are different than the ones in the NID in that connecting a phone does not disconnect downstream wiring.

A wall phone is permanently mounted in wiring closet, with a RJ11 corded plug. This allows test phone to be plugged into the CPE test jacks or directly into the NID. Having phone permanently located in wiring closet insures it is available when needed.

### 10.12.2 LAN Wiring

House was built in 1982 predating SOHO networking. LAN wiring closet is in center of basement rather than at outer edge with phone wiring to optimize cable runs. LAN wiring has been expanded over the years. When first installed wired a few drops in the basement. Several years later added drops in bedrooms. Most recent upgrade added wiring to support media server in living room and greenhouse controller.

When I initially installed LAN did not use patch panel. Instead terminated each cable with a modular plug and plugged cable directly into an Ethernet switch. Modular plugs are more difficult to install than receptacles so this is not for the faint of heart. Over time some of the drops failed due to connector problems. Upgraded system with a 24-port 1 U rack mount Patch Panel. Like most other networking items Patch Panels have gotten dramatically cheaper over the years. We are using 22 of 24 ports leaving a couple of spares for future expansion. Purchased a 1U hinged bracket to mount panel to wall.

> **Tip** – if you decide to terminate cable with plugs make sure the plug is compatible with the type of wire you are using. Plugs are normally used on patch cords with stranded conductors. The internal contact for stranded and solid conductor wires is different.

### 10.12.3 Ethernet Switch

I wanted to locate the Ethernet switch directly above the patch panel but the switch does not have option of rack mounting ears. I bent a piece of thin gauge aluminum stock to act as a shelf above patch panel. This provides a convenient place for the Ethernet switch. Switch connects to patch panel with 1-foot patch cables.

**Figure 34 16-Port Ethernet**

LAN began life back in 1998 with a small 8-port 10 Base-T Ethernet Hub. Hubs have been replaced by higher performance switches. Current switch is a Netgear FS116 16-port unmanaged 10/100BaseT switch. Switch is convection cooled – eliminating need for fan.

> ***Tip*** When purchasing a switch or patch panel get one with more ports than required, networks tend to grow.
>
> **Tip** Switch is always on so energy consumption is an issue. Convection cooled devices are silent. Unless you need the features get an unmanaged switch. They are much cheaper and consume less power,

### 10.12.4 Wi-Fi Access Point

**Figure 22 AP**

The IEEE 802.11n standard represents a significant advantage over previous b and g generations.  I replaced our preN AP with a Netgear wn802tv2.

Setup was pretty straightforward. AP defaults to static IP address 192.168.0.233. To configure AP connected it to wired port on my laptop and configured the port statically to match the settings of the AP. Logged into the AP and changed AP network settings to obtain IP address automatically. To prevent the address from changing configured router to use MAC reservation. That way the DHCP server always issues the same IP address.

Debugged connection without security then configured WPA2 AES. We do not have a RADIUS authentication server so selected WPA2 pre-shared key mode. With a pre shared key each device must be configured with a passphrase. This eliminates need for RADIUS authentication but requires the passphrase be entered into each device. This is labor intensive, on a large network but not a big deal for a small one. An important downside of shared key is if a device is lost/stolen passphrase needs to be changed or intruder will have easy access to LAN.

Ideally passphrase should be random and very long to defeat dictionary lookup attack. Good passphrases are difficult to generate manually. Luckily Internet once again comes to the rescue with an online passphrase generation site.

WPA2 has several encryption options, for maxim security and performance use AES not TKIP. Temporal Key Integrity Protocol was developed as an intern improvement to address serious weaknesses discovered in the original encryption scheme Wireless Equivalent Privacy (WEP). TKIP is in essence a wrapper around the flawed WEP, as such is it more computationally intensive and not quite as secure as AES. Unless you need backward compatibility with old Wi-Fi clients use AES.

## *Future Proofing*

During any discussion about wiring the topic of future proofing is bound to come up. The problem is wiring and buildings have very long life expectancies. It is very difficult to anticipate network requirement 10 – 50 years down the road.

Some folks are proponents of the “kitchen sink” approach, wire up every possible location with every sort of physical connection that may be needed. The down side is excessive upfront cost and it is rather brittle in the face of changing needs, say a new type of cabling or the need of network access at an unanticipated location.

Try to anticipate near term needs but don’t go overboard. No matter how carefully you plan down the road you will find yourself in a situation where you need to add wiring for something completely unanticipated. To deal with the unanticipated try to include pathways that makes it easy to add wiring. Install empty conduits; build wiring chases etcetera to make modifications as easy as possible. I’ve been lucky. When we built the house there is ventilation duct used to blow air from the cathedral ceiling on the second floor down into the basement. That has turned out to be a lifesaving cable chase when I’ve needed to add wiring.

**My Top 10 Predictions**

1. POTS phone service will be largely replaced by VoIP and network convergence, eliminating need for analog POTS wiring but increasing the need for Ethernet ports that supply power (PoE) to make deploying wired phones easy. Not everyone wants a wireless phone on their desk.

2. Improvements in Wi-Fi and increased use of hand held devices will place a premium on wireless access. The upcoming 801.11ac specification delivers truly blazing speed. Using PoE eliminates the need for AC power at the access point and make emergency backup easier.

3. Wired connection is the technology of choice for demanding application and core network devices such as servers and routers.

4. There is a long term trend to Video over IP (VoIP) but it will be a long time before RF based coaxial TV distribution fades to insignificant. MoCa is a good way to bridge the two technologies allowing IP based devices to utilize coax for both RF and Internet.

5. Security cameras continue the inexorable march to IP. They also benefit from PoE.

6. Smart white good evolving in concert with a smart grid allows network management via web protocols. ZigBee or something similar is likely to dominate that space.

7. Security systems are also migrating to wireless with ultra-low power devices that harvest energy eliminating the need for batteries.

8. Deployment of 60 GHz wireless should be a boon to eliminate the rat’s nest of wires needed in a typical home theater system. This is a short range wireless network limited to a few feet but blazing speed ideal to for A/V equipment.

9. Converged cellular and Wi-Fi networks. As demand for wireless bandwidth explodes carriers will increasing look at offloading traffic to Wi-Fi networks.

10. 1 Gbp/s data rate per device will be more than adequate for years to come.

# 11 Laptops & Tablets – Internet on the Road

We use a laptop at our home office, in the office and while traveling. This means it needs to connect to multiple networks.

## 11.1 Location Dependent Settings

Network settings are sprinkled all over Windows and within various applications. This makes it hard to move computer between locations. Even though we minimized differences between locations we still wound up with several site-specific settings. The solution is a program called NetSwitcher. NetSwitcher works by modifying Windows Registry. It is able to change most network settings and select default printer. During Windows shut down NetSwitcher dialog box pops up. This allows correct configuration to be selected for next boot cycle. This problem has become less of an issue with newer versions of Windows.

## 11.2 Security

A large number of laptops/phones/tablets are lost or stolen daily. Minimize the amount of sensitive information loaded on the laptop and think about using encryption to protect sensitive files. Once you have lost possession of your computer an attacker has unlimited time to crack whatever security you have used. If laptop has sensitive information consider using some sort of encryption to protect files, or better yet leave the sensitive files in the office and use remote desktop or Citrix to provide access without the need to save the data locally.

Wi-Fi hotspots normally do not provide over the air security like WPA2. This means non-encrypted traffic is easy to eavesdrop. The worst offender is SMTP/POP protocols since they send login credentials in the clear. If your ISP supports using SSL access to mail use that to protect you privacy when accessing email. If not consider restricting access to over a VPN to protect privacy.

Windows finds other network resources locally by broadcasting info over the LAN. Normally when connecting to public networks these broadcasts are blocked (port isolation). However if the public network is not configured correctly others may be able to see shared directories/files/printers. It is good practice to disable sharing on mobile devices. This does not impact being able to access shares on other computers just does not share files on this particular PC.

Flash drives are often used to move files around between PCs at meetings. There is always a risk of plugging in an infected drive. Maintain up to date anti-virus software and make sure it is configured to verify removable media.

# 12 Hosting -- Your Presence on the Net

Every business should have at least a minimal Internet presence. Creating a simple web site is neither difficult nor expensive. The web server can be located in-house or operated by a hosting service. Registering a domain name creates a permanent Internet presence regardless of how business connects to the Internet or where the servers are located.

Even if you are not a business having your own domain is still advantageous. It gives you a personalized email address for as long as you want it. That makes it easy for folks to stay in touch. Having your own site gives you a great deal of freedom to use it as you please. This paper is a good example. I enjoy writing about what I am doing and the solutions to various problems I've worked out. My site provides a vehicle to post those articles. Lastly if you are in a technical field can't hurt your resume that you have your own site.

For most small to midsized businesses using a virtual server managed by a hosting service is the optimum solution. Server is located in a data center with virtually unlimited access to bandwidth. A single computer is able to host many sites resulting in very low cost. The server used for my site hosts several hundred other web sites in addition to mine.

The hosting service takes care of most of the technical details: setting up the various servers, registering a domain name and creating DNS records. This allows customer to focus on the creative aspects of building a web site.

Creating the site itself requires a combination of artistic and technical skills. There are many software packages available to help create a web site. In some cases site development tools are provided by the hosting service as part of your contract. If you don't want to develop the site yourself there are many companies that specialize in web site development.

## *12.1 Registering a Domain Name*

The first decision is which Top-level domain (TLD) is most appropriate. The same name can be registered in multiple TLDs. This is commonly done when the company's name is trademarked. Large companies often register variations on their name to prevent cybersquatters from registering confusing or derogatory domains. The COM and BIZ TLDs are for commercial use. Networking companies commonly use the NET TLD. Some TLDs are country specific such as .UK or .US. If you want to identify your company with a specific region they are a good choice. Many hosting services provide automated tools to register and setup a domain. Registrars coordinate with ICANN or other registration agencies to insure each domain is unique within its respective TLD.

The registration process involves providing information on domain name ownership and creating records that point to the Nameservers used to tell remote users the IP address of your site. When you submit a proposed domain name the registrar database is examined to insure the request does not conflict with an existing name within the TLD. The new name is assigned provisionally in case another registrar has recently recorded the same name. After a little while the registration is made permanent or if name is already in use will need to choose a different name. If you really want a name that is already registered all is not lost. You can try to purchase it from the owner. When I registered my domain wanted schmidt.com but that was already registered by a printer in Minnesota so I picked tschmidt.com

### 12.1.1 Email

With a registered domain name email is addressed to the domain, not a third party. This personalizes your businesses persona. Email is structured as username@yourdomain.TLD. Most hosting services allow multiple mailboxes. This enables employees or family members to have individual accounts without the need to run an internal mail server.

## *12.2 Internet Server*

There are many ways to operate a public web server: hosting service virtual server, locate your equipment at a data center, or run the server locally.

### 12.2.1 Virtual Server

Easiest way to set up a web site is with a hosting service. Use of a hosting service maintains 24/7/365 service and keeps site traffic off first-mile Internet connection. Even companies with only dialup Internet can have a web site. Virtual hosting is appropriate for low traffic sites. The hosting service runs multiple virtual web servers on a single physical server. We use a local hosting service Hollis Hosting at a cost of $40 per year plus another $15 for annual domain registration. Most hosting services have business relationships with a domain registrar. This allows one stop shopping for domain registration/renewal and Internet hosting. Our domain name is registered with eNom, a popular registrar used by many hosting services. The hosting service also runs virtual SMTP and POP servers to send and receive email.

Transferring account from one hosting service to another is pretty easy. DNS registrar needs to be notified of new Nameservers and web site contents transferred from old to new server.

Normally one has to register a domain name to allow public access to a server. Some hosting services allow customers to set up a web site without a domain name. The virtual site is assigned a name that looks something like http://www.hosting.net/~yourbiz. This uses the domain name of the service as the starting point to access your site.

### 12.2.2 Dedicated Server Collocation

Most hosting services offer collocation where customer is able install their own equipment in a secure area. Collocation services typically provide redundant high-speed access and emergency backup power.

This allows complete flexibility as to equipment and software used to support the site and restricts access to sensitive company data to in-house IT personnel.

### 12.2.3 On Site Hosting

Large companies often host their own sites since they have the necessary expertise and already run extensive data centers.

On site hosting is also an option for casual personal sites. To accomplish this one needs to set up a web server. Running the server on a dedicated PC is more secure than sharing the PC between web server and other functions because it is easier to constrain what the attacker is able to access if they compromise the computer. Abyss web server is free for personal use and runs on Windows PCs. I use it for an internal non-public web server on our network.

Most residential broadband services are asymmetric; upload is much slower than download. This limits site performance. Heavy site traffic will interfere with other Internet usage.

Most residential broadband uses dynamic address assignment making it difficult to host a server as the address can change unpredictably. Dynamic DNS services such as DYN provide a workaround. The DNS service is updated each time the server’s address changes. This works well for personal sites but be aware the site becomes temporarily inaccessible during the address update making it inappropriate for serious commercial use. Software running on the customer side detects when the IP address is changed and updates the dynamic DNS service.

Most residential ISPs prohibit customers from operating servers. Some enforce this restriction aggressively other turn a blind eye unless there is a problem. Some ISPs block access to Port 80 used to access web sites forcing the use of a nonstandard port. This is not an issue if you are using the site it for personal access simply append the port number to the URL so the web browser knows which port to use. For example: http://mysite.com:8080

Residential accounts are normally limited to a single IP address. This is a problem if more than one web server is needed. A workaround is to use a non-standard port, such as 8080, for one of the servers.

## *12.3 WHOIS Record*

Information for each registered domain is maintained in the WHOIS databases are maintained by Regional Internet Registries (RIR). The database maintains administrative and technical contact information about the site.  The Whois database does not maintain information about the site itself. To find the IP address of a site one needs to query one of the nameservers associated with the site.

### 12.3.1 Administrative

Administrative information records data about site ownership and contact.

### 12.3.2 Technical

Technical information records data about network operation center contact.

### 12.3.3 Nameservers

Nameservers' listed in the Whois database are the authoritative servers for your domain. These are the servers used by DNS to convert a domain name to IP address. The registrar does not maintain information about the site itself, simply an address pointer to the Nameserver that does. Registrars require two Nameservers, primary and backup. Ideally DNS servers are in widely separate locations served by different providers. This minimizes risk the authoritive Nameserver ever becoming inaccessible.

**WHOIS record for tschmidt.com**

```
Registration Service Provided By: Hollis Hosting
Contact: admin@tschmidt.com
Visit: http://HollisHosting.com

Domain name: tschmidt.com

Registrant Contact:
  Schmidt Consulting
  Tom Schmidt admin@tschmidt.com
  +1.6036732463
  Fax:
  95 Melendy Rd
  Milford, NH 03055-3417
  US

Administrative Contact:
  Schmidt Consulting
  Tom Schmidt  admin@tschmidt.com
  +1.6036732463
  Fax:
  95 Melendy Rd
  Milford, NH 03055-3417
  US

Technical Contact:
  Schmidt Consulting
  Tom Schmidt admin@tschmidt.com
  +1.6036732463
  Fax:
   95 Melendy Rd
   Milford, NH 03055-3417
   US

Status: Locked

Name Servers:
   ns1.hollishosting.com
   ns2.hollishosting.com

Creation date: 04 Nov 1998 05:00:00
Expiration date: 03 Nov 2013 05:00:00
```

## *12.4 DNS Record*

Once domain is registered Nameserver records must be created. These records provide translation between URL and IP address.  If you use a hosting service they will most likely setup the Nameserver for you. Still it is a good idea to understand basic concepts. A DNS record lookup utility is available to view DNS records. The site View DNS has a nice tool to check DNS entries for errors.

The name server maintains a number of different records. Below are commonly used record types.

### 12.4.1 Address Records (A)

Address records map host name to IP address.

### 12.4.2 Canonical Name Records (CNAME)

Canonical records allow a specific host to be known by more than one name. For example tschmidt.com and www.tschmidt.com resolves to the same IP address.

### 12.4.3 Mail Exchange Records (MX)

Mail Exchange records provide the address of mail servers. The preference field allows more than one host to be used. This provides backup in case a mail server goes down.

### 12.4.4 Pointer Records (PTR)

Pointer Record translates host IP address to machine name. This performs reverse lookup based on address rather than name.

### 12.4.5 Nameserver Records (NS)

The Nameserver record provides the name of authoritive Nameservers for the domain. Authoritive servers are the primary repositories of domain information. Other servers called secondary name servers cache this information to speed up access. The information cached on secondary servers must be periodically refreshed.

### 12.4.6 Start of Authority Records (SOA)

The SOA denotes entry as the official source of information for the domain.

> **Serial number** records revisions to the record. This allows other Nameservers to determine if the record has been revised and local copy needs to be updated. Preferred format for the serial number is YYYYMMDDNN. NN is an incrementing number that allows the record to be revised more than once per day.

**Refresh** indicate how often secondary servers should check authoritative server for changes.

**Retry** indicates how long secondary server should wait to reconnect if connection was refused.

**Expire** is how long secondary server should use the current entry if it is unable to contact the authoritive server.

**Minimum** indicates how long secondary servers should cache domain information.

### 12.4.7 Sender Policy Framework (SPF)

Sender Policy Framework (SPF) adds DNS record to allow mail servers to verify incoming email was sent from domain and not spoofed by spammer.

**DNS Record for Tschmidt.com**

**Answer records**

| NAME | CLASS | TYPE | DATA | TTL |
|---|---|---|---|---|
| tschmidt.com | IN | A | 72.37.245.142 | 14400s (4h) |
| www.tschmidt.com | IN | CNAME | tschmidt.com | 14400s (4h) |
| tschmidt.com | IN | MX | preference: 10<br>exchange: tschmidt.com | 14400s (4h) |
| tschmidt.com | IN | NS | ns2.hollishosting.com | 86400s (24h) |
| tschmidt.com | IN | NS | ns1.hollishosting.com | 86400s (24h) |
| tschmidt.com | IN | SOA | server: ns1.hollishosting.com<br>email: hbidad@gmail.com<br>serial: 2007122701<br>refresh: 86400<br>retry: 7200<br>expire: 3600000<br>minimum ttl: 86400 | 86400s (24h) |

**Authority records**

| NAME | CLASS | TYPE | DATA | TTL |
|---|---|---|---|---|
| tschmidt.com | IN | NS | ns2.hollishosting.com | 86400s (24h) |
| tschmidt.com | IN | NS | ns1.hollishosting.com | 86400s (24h) |

**Additional records**

| NAME | CLASS | TYPE | DATA | TTL |
|---|---|---|---|---|
| tschmidt.com | IN | A | 72.37.245.142 | 14400s (4h) |

## 12.5 Creating a Web Site

Creating a web site requires a combination of artistic and technical skills. Sites range from simple static web pages to complex database driven e-commerce sites able to perform credit card transactions. A word processor can be used to create a simple site. Often the hosting service provides a development toolkit to assist customers designing a web site. For more complex sites specialized design tools such as WordPress can be used to good advantage. If you want to outsource the design there are numerous companies that specialize in web site development.

### 12.5.1 Uploading Web Pages

Once created the various pages must be uploaded to the web server. The most popular method is File Transfer Protocol (FTP). Files are uploaded and managed used a FTP program such as CuteFTP.

## 12.6 Robots File

Search engines make it easy to find information on the Internet by indexing and cataloging information. Search engines perform this task by using search bots, called spiders, to traverse Web hypertext structure. Spiders periodically visit millions of sites to maintain an up to date index of billions of web pages.

An informal Internet standard has been developed to control the actions of these search engine spiders. When the spider first connects to a site it looks in the root directory for the file robots.txt. The purpose of robots.txt it to tell well behaved spiders, which web pages they are not supposed to index. Even if the site does not intend to prevent spiders from indexing pages it is a good idea to place a null robots.txt file in the root directory. This eliminates numerous entries in the server's error log about access to a non-existent file.

**Robots.txt file for Tschmidt.com**

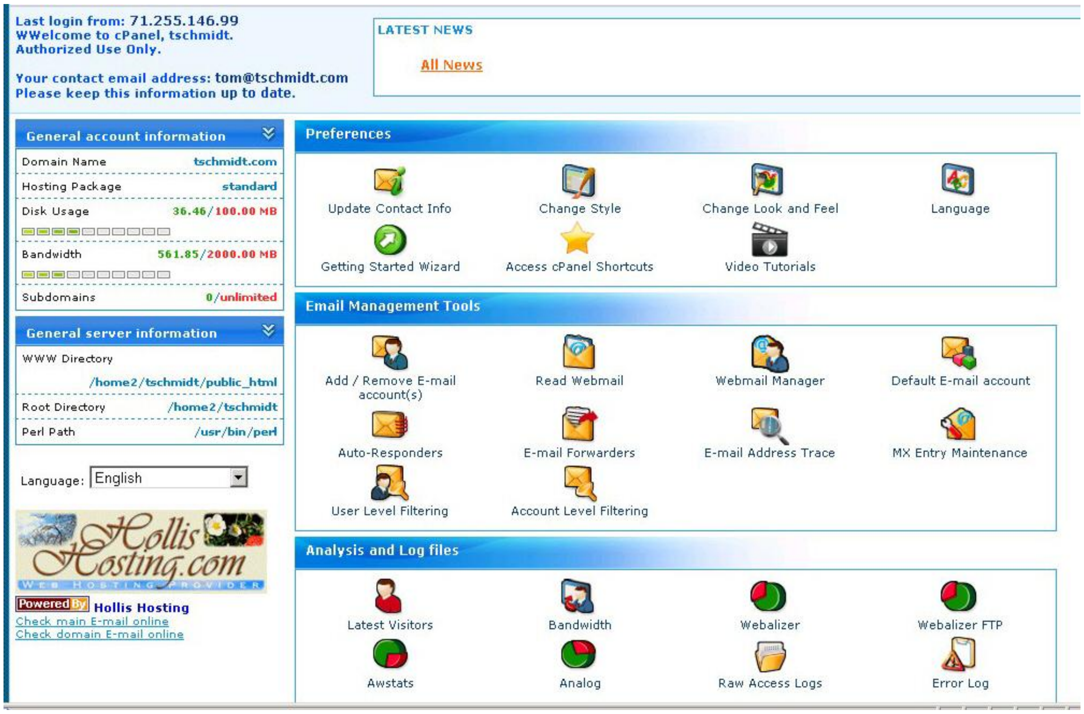
```
# www.tschmidt.com
# Created 2/25/2006

# All robots can spider domain
User-agent: *
Disallow:
```

## 12.7 Site Management

cPanel is a popular application used by both customers and hosting services to manage web, FTP, and email accounts. It also generates statistics to analyze who visits the site, what pages they view and how long they stay. Prior to the popularization of cPanel separate applications were used to manage customer account, create email accounts and generate usage statistics.

For example creating a new email account is as simple as entering an account name and password for that account.



Last login from: 71.255.146.99
WWelcome to cPanel, tschmidt.
Authorized Use Only.

Your contact email address: tom@tschmidt.com
Please keep this information up to date.

LATEST NEWS

All News

General account information

| | |
|---|---|
| Domain Name | tschmidt.com |
| Hosting Package | standard |
| Disk Usage | 36.46/100.00 MB |
| Bandwidth | 561.85/2000.00 MB |
| Subdomains | 0/unlimited |

General server information

| | |
|---|---|
| WWW Directory | /home2/tschmidt/public_html |
| Root Directory | /home2/tschmidt |
| Perl Path | /usr/bin/perl |

Language: English

**Figure 236 cPanel Home Page**

# Conclusion

Setting up a SOHO network has been an interesting and rewarding experience. The network meets our business and personal requirements. It is a pleasure having high speed Internet access and being able to share network resources.

Significant technical expertise is required to setup a network. The necessary components are readily available but assembling the knowledge needed to create and troubleshoot can be rather intimating. Each year more residential and SOHO networks are installed. Manufactures are getting better at designing customer friendly equipment. In general failures are pretty straightforward to identify and fix once root cause is determined. However, determining cause is not always easy. Help is available from many sources. Manufacturer-sponsored forums and specialized home network interest groups provide problem isolation and resolution help.

Networking today is similar to the early days of the automobile. When it worked it was exhilarating, but one needed a riding mechanic to keep the machine operational. As networking expands beyond the province of corporate IT departments it will become even easier to install and maintain.

# Happy Networking