Living with a
Small Office Home Office (SOHO) Network

2009 Edition

Tom Schmidt
Schmidt Consulting
28 February 2009
tom@tschmidtdotcom
http://www.tschmidt.com

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

Local Telephone Company 3000/768 Digital Subscriber Line (DSL) provides Internet access. A broadband router allows multiple computers to share connection. Fast Ethernet (100 Mbps) LAN provides high-speed internal communication. LAN services include: file sharing, backup, network printing, timeserver, DNS server, Syslog server and local private web server.

We use a hosting service for business web server and e-mail. Use of a Hosting service moves web site traffic off 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.

Recent changes are: faster DSL, upgraded LAN wiring, photo printer and off-line backup.

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 networking experience was limited to interactions with corporate Information Technology (IT) department.

LAN and Internet access has undergone significant evolution over the years. Began with Dialup Internet and a few Ethernet drops. Over the years LAN expanded beyond my home office to encompass the entire house utilizing both wired and wireless Ethernet. 3000/768 DSL replaced dialup. Currently using a Netopia (now part of Motorola) 3346N DSL modem/router for Internet sharing.

A recycled desktop serves as a poor man's server. In addition to file sharing it runs: TreeWalk DNS Resolver, Tardis network time service, Abyss web server Kiwi Syslog log server and Davis weather station. Each computer normally requires its own keyboard, video and mouse (KVM). Rather then use separate I/O devices for server and desktop use a combination of Belkin KVM switchbox and RealVNC remote control software. Having a KVM makes it easy to temporally connect additional systems for setup and testing.

HP OfficeJet K550 document and PhotoSmart D7160 photo printers are networked and accessible from any PC on the LAN. HP 5400 flatbed scanner turns paper into electronic documents.

Traveling with a Laptop can be a challenge: as network configuration differs at each location. NetSwitcher automates this task providing one click switching between locations.

We use Acronis True Image for automatic on line back up and a Maxtor One Touch USB drive for off line.

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 interested 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.

Goals for SOHO network:

- High-speed Internet access
- Share Internet connection
- Wired and Wireless LAN
- Print sharing
- File sharing
- Private web server
- Secure remote access to corporate network
- Access multiple e-mail accounts
- USENET newsgroups
- Fax without a fax machine
- Time synchronization
- Automatic file backup
- Offline backup
- Display home weather station data
- Learn networking

This paper discusses Internet access and connection sharing options. Recommends setting up an always-on server, even a small network benefits from having a server. Structured wiring for telephone and Ethernet is covered in detail. Security and Troubleshooting topic provide 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.

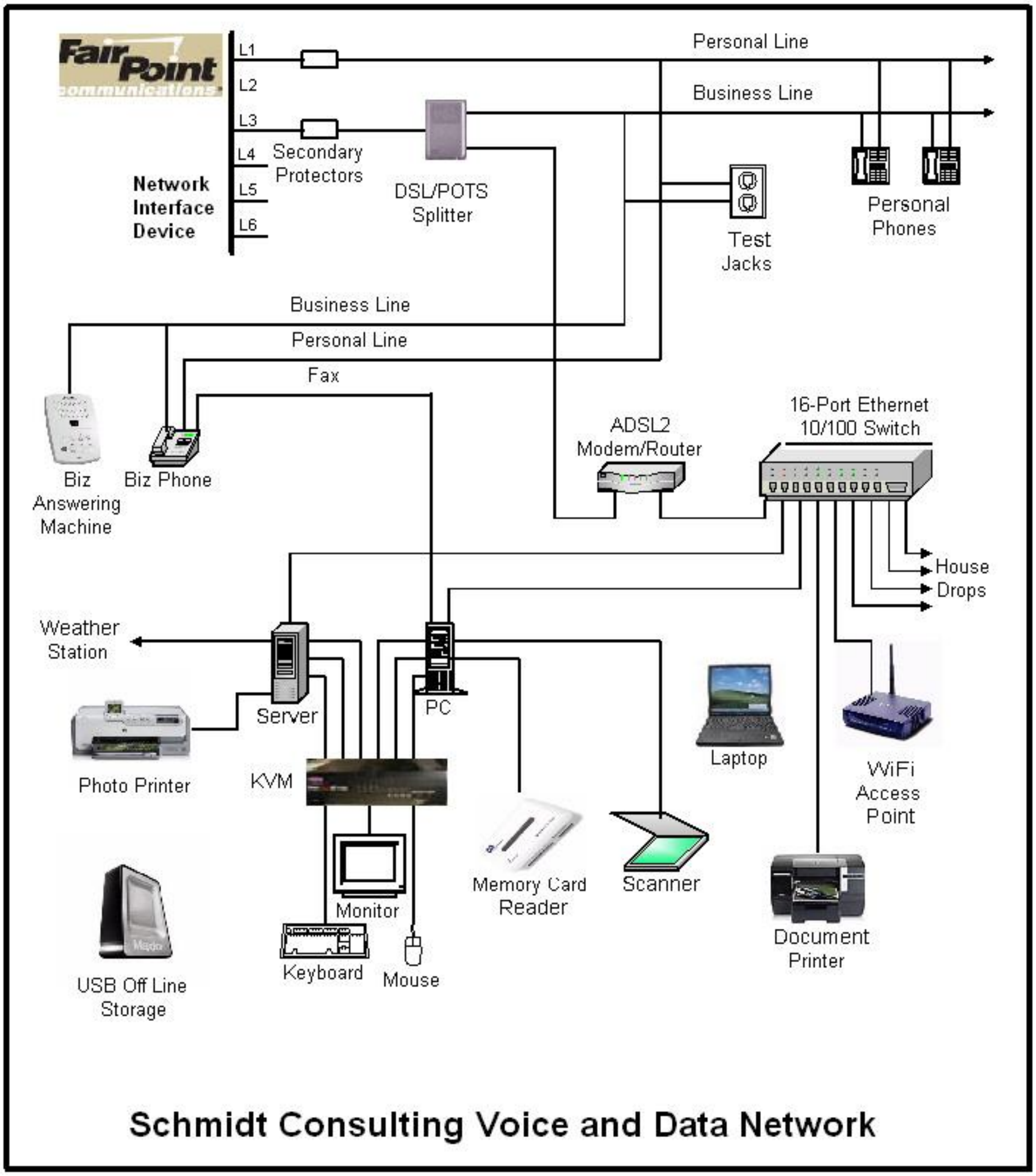


Figure 1 SOHO Data and Voice Block Diagram

2 Internet – Much More Than World Wide Web

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 types of digital media: data, voice and images. Internet is a contraction of Inter Network, literally a network of networks. Creation of 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.

Internet is a packet network that transports data from one host to another over a network shared by many users. Internet is fundamentally different then 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 packet address field and determine how to forward it toward the destination.

2.1 *ISP*

Internet Service Provider (ISP) connects end user to Internet. Internet popularity is driving demand for high-speed low cost service. High-speed Internet access is becoming widely available. Even though we are in a fairly rural area broadband is available from multiple sources:

1) Comcast Cable DOCSIS
2) FairPoint communication ADSL
3) DSL competition from G4Communication that collocate DSLAMs at Central Offices
4) NH has numerous Wireless ISPs (WISP) but none currently service our area.

Currently have 3000/768 kbps ADSL service provided by local phone company, FairPoint Communication, as the result of Verizon's sale of VT/NH/ME territory. Previously had 1500/384 DSL. Tried for years to upgrade but were told we were too far away. When FairPoint took over tried again. Was told we were over the limit but representative agreed to enter the upgrade. That was middle of 2008 and have been happy with faster speed ever since.

Connection between ISP and customer is often called the last-mile. I prefer term first-mile because it denotes importance of end user. Internet's value proposition is its ability to connect end points. Without end points the network is useless.

For a more detailed examination of ISPs interested reader it referred First-Mile Access paper on 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. 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 data arrives milliseconds after it is requested. Speed on the other hand is very low – limited by switched 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 person friendly handle rather than machine friendly numeric IP addresses. Translation of URL to IP address is performed by 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, MIL and GOV 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 schmidt.com domain was already assigned so we picked 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 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.

Lets trace what happens when we look up www.google.com. Since Google URLis 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 then 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 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 Internet becomes ever more pervasive attention has been drawn to lack of DNS security. Hackers are able to 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. Router forwards packets to 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.

Network Address Translation (NAT) router allow residential customer to connect an unlimited number of computers to a single ISP account. Forwarding function for residential router is trivial since it typically has only a single WAN connection although there are load balancing routers that support multiple connections.

2.5 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 then 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 then accuracy and insufficient time exists to recover from transmission errors. If an errors occur it is up to the receiver to “fake it.”

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 critical applications such as telephony and streaming media. For example during a Voice over IP (VoIP) phone call round trip latency should be under 150ms. Excessive delay makes carrying on a conversation difficult and with extreme delay virtually impossible. On the other hand if a print job is delayed a little no one is likely to notice as long as it completes successfully.

Residential LANs result in few QoS problems on wired segments. Wireless LANs are slower and subject to radio interference benefit from QoS. Where QoS is most important is uploading/downloading over the Internet. Most consumer broadband links are relatively slow especially upload capability. This disparity makes it easy to saturated upload path. For example TCP/IP, the protocol used for file transfer, constantly transmits acknowledgements (ACKs) back to sender letting it know data is arriving correctly. If ACKs are delayed sender will stop sending and wait for receiver to “catch up” or in extreme cases resend data assuming it was lost. If file is being uploaded at the same time a VoIP call is in progress voice packets are given priority over file transfer packets.

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 head of the line. 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. If congestion occurs higher value packets are delivered as quickly as possible. Lower value packets are delayed during congestion or discarded during periods of extreme congestion. QoS services allow more graceful congestion 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.

At the IP level transmitter uses a technique called slow-start by sending a few packets then waiting for acknowledge. The faster ACKs arrive 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 Addressing

Each IP device (host) must have an address. Addresses may be assigned, statically, automatically by Dynamic Host Configuration Protocol (DHCP) or automatically by the client itself, AutoIP. 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. The down side is need for a DHCP server. DHCP has been extended to allow automatic configuration if client cannot find a DHCP server. In that case client assigns itself an address from 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.

2.9.1 Dotted-Decimal Notation

Internet 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 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 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 then 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 provides 16,777,213 host addresses. The lowest address is reserved as the network address, highest for broadcast. NOTE: first octet of 127 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 provides 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 provides 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 submask 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 Port Number

Internet host is able to carry on multiple simultaneous communications sessions. This raises the question how does the computer know how to respond to 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.

2.9.5 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.*

2.9.6 AutoIP Address Block

A fourth block of private IP addresses is reserved for AutoIP also called zero configuration. If a host is configured to obtain a dynamic address and 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.

2.9.7 Localhost Address

127.0.0.1 is the Loopback localhost address. This is useful for testing to makes sure the network interface is working. Sending data to the Loopback address causes it to be received without actually going out over the physical network.

2.9.8 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)

2.9.9 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 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.

3 Broadband Router – One Connection So Many Computers

When we first set up our SOHO network back in 1998 used Wingate connections sharing software to share dialup. That was replaced with a MultiTech RF500S router used with Vitts Net-to-Net SDSL modem then later with a Westell B90 modem when we switched to Verizon, now FairPoint, ADSL. Main reason for choosing particular router was ability to fallback to dialup if DSL failed. At the time it was one of the few broadband routers that included automatic dialup fallback. This came in handy when our first broadband SDSL ISP went bankrupt. ADSL service has been very stable so several years ago we dropped dialup account.

Currently using a Netopia 3346N that combines ADSL2 modem, NAT router, Firewall, and 4-port Ethernet switch in a single device. This makes access to modem stats more convenient. Before we had to temporally connect DSL modem directly to PC, bypassing router, to access stats. Now stats are a web page accessible from any PC on the LAN.

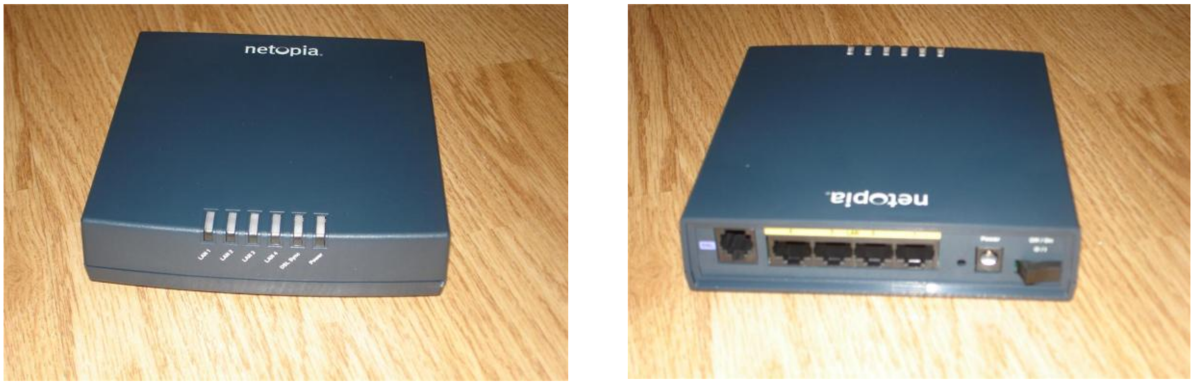


Figure 2 Netopia ADSL Router

The other reason was to experiment with newer modem that supports ADSL2 and ADSL2+. ITU created enhanced versions of ADSL that deliver higher speed and longer range. Verizon, now FairPoint Communication, does not advertise ADSL2. However as new generation DSLAM cards are placed into service they support ADSL2 and ADSL2+. If both DSLAM and customer modem support enhanced feature they will be activated, if not connection falls back to original ADSL functionality. Had nothing to loose by getting a newer modem, as it is backward compatible with previous generation ADSL.

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 then $50 US and used high end devices for similar price on eBay, where we purchased used Netopia router.

3.1 ADSL modem

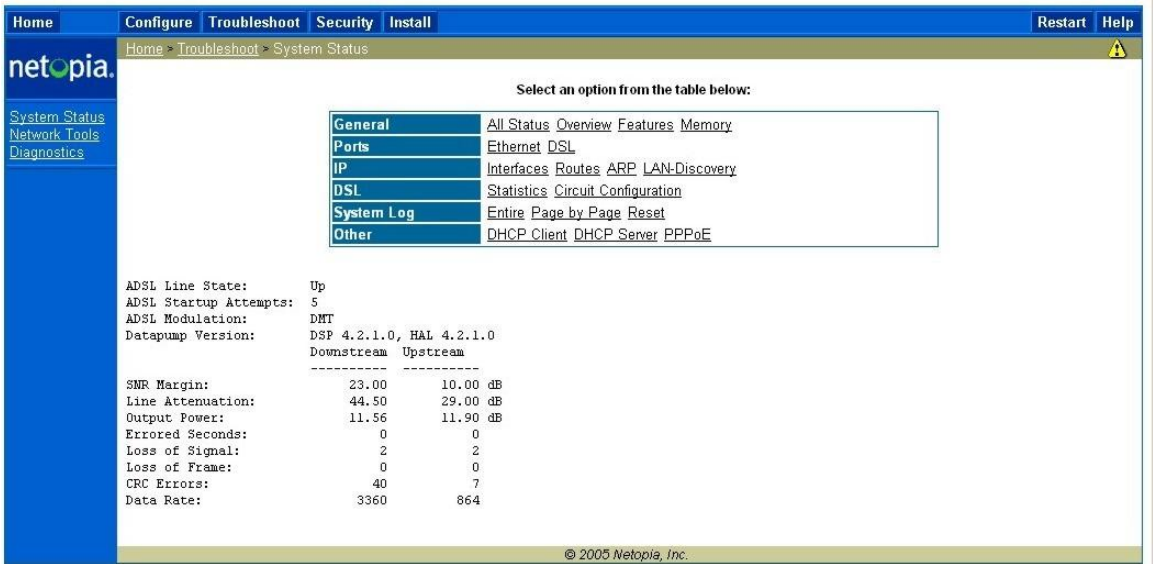
Netopia 3346N router has a built in ADSL and ADSL2+ compatible modem. Turns out our DSLAM only supports ADSL. Given low cost of the unit it was worth a try. Plus we are ready for ADSL2 if FairPoint ever swaps out DSLAM line card.

There are three ways ADSL modem connects to ISP: Statically, DHCP, and PPPoE. Most business accounts are static to facilitate running servers. With static customer manually enters IP settings into the router. Residential accounts typically use DHCP or PPPoE. DHCP works much the same as having a PC connected to LAN. When modem powers up it searches for a DHCP server. The server automatically loads IP settings into router. FairPoint uses Point-to-Point Protocol over Ethernet in our area. PPPoE works much the same as with dialup only much faster. PPPoE requires customer enter a user name and password.

Behind the scenes most Telco's use Asynchronous Transfer Mode (ATM) to transport IP packets. ATM normally requires configuring virtual circuit parameters. Verizon and FairPoint use VPI/VCI of 0/35 The Netopia modem automatically discovers these setting so all user needs to do is enter user name and password.

Router maintains WAN connection even if it is unused for a long time making the connection instantaneously available. If connection is lost for any reason router automatically reestablishes it.

We have 3000/768 ADSL residential package at about 13,000 feet from the Central Office. Exact distance is different each time we call. One of the benefits of transition from Verizon to FairPoint we were finally able to upgrade from 1500/384 to 3000/768. We are slightly too far to qualify for 3000 speed. Verizon strictly enforced distance limit. FairPoint acknowledged distance but was willing to increase speed. As expected margins were reduced due to faster speed but connection has been reliable.



Select an option from the table below:

General	All Status Overview Features Memory
Ports	Ethernet DSL
IP	Interfaces Routes ARP LAN-Discovery
DSL	Statistics Circuit Configuration
System Log	Entire Page by Page Reset
Other	DHCP Client DHCP Server PPPoE

```
ADSL Line State:         Up
ADSL Startup Attempts:   5
ADSL Modulation:         DMT
Datapump Version:        DSP 4.2.1.0, HAL 4.2.1.0
                         Downstream  Upstream
                         ----------  ----------
SNR Margin:                   23.00       10.00 dB
Line Attenuation:             44.50       29.00 dB
Output Power:                 11.56       11.90 dB
Errored Seconds:                  0           0
Loss of Signal:                   2           2
Loss of Frame:                    0           0
CRC Errors:                      40           7
Data Rate:                     3360         864
```

Figure 3 DSL Modem Status Page

3.2 PPPoE and MTU

Point-to-Point Protocol over Ethernet (PPPoE) is an encapsulation protocol. PPPoE works much like dialup PPP to connect a computer over a point-to-point link to ISP. PPPoE uses high-speed Ethernet rather then low speed RS232 Serial.

Normally Ethernet packets are limited to 1500 bytes. This is also the typical maximum size transmitted over the Internet. 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 stack implements path discovery mechanism to automatically limit packet size so fragmentation is not required. Typical maximum transmission unit (MTU) is 1452 bytes: 1452 bytes data + 40 bytes TCP/IP overhead + 8 bytes PPPoE = 1500 bytes. A good indication of overly large packet problem is if sending a little data <1500 bytes works but larger files do not.

3.3 Network Address Translation (NAT)

Most residential broadband 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 then one address is needed. This creates a quandary; how to cost effectively connect multiple hosts to the Internet? The most common solution 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 an unlimited number of computers to share an Internet connection even though ISP only provides a single IP address. Private addresses are prohibited on the Internet allowing them to be used and reused indiscriminately. NAT provides translation between private addresses on one side and single public address issued by the ISP. NAT offers the advantage of a proxy server while being transparent to most applications. Proxy services were used extensively prior to deployment of NAT.

Internal LAN traffic proceeds normally; NAT is not required for local traffic. When a request cannot be serviced locally it is passed to NAT router, called a gateway. Router modifies packet by replacing private address with public address issued by the ISP and if needed modifies 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.

3.3.1 Performance

NAT requires a lot of bookkeeping, changing IP and port addresses, then 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 5 or 10 or even 100 Mbps make sure router is up to the task.

Internal NAT translation tables limit the number of simultaneous sessions router is able to maintain. This limit does not affect normal Internet usage. However when Peer-to-Peer (P2P) is used the very large number of sessions may overwhelm a low-end router.

3.3.2 Security

NAT blocks remotely originated traffic. It functions as a de facto incoming firewall because router does not know where to forward packets that originate outside the LAN unless specifically programmed to do so.

3.3.3 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.

When NAT was first developed it was assumed private address pool was truly private and no one but the local administrator cared about local address usage. Today in the age of VPNs these internal addresses **ARE** being exposed to other networks. If a telecommuter's residential LAN and office network both use private addresses they may overlap. In a simple case this is not major problem, the user simply moves the LAN to a different address block. But what happens if home LAN must support multiple telecommuters? This requires coordination of multiple corporate LANs and SOHO LAN. In this case it may be impossible to resolve address collisions if multiple networks use identical address blocks.

This is not to discourage use of NAT 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.

3.4 LAN IP Address Assignment

Each device on the network requires a unique IP address. These addresses are not used on the Internet therefore they are not coordinated by IANA. However they must be coordinated within the LAN. The router has the flexibility to use static, dynamic address allocation.

3.4.1 Static

When static allocation is used IP parameters: address, subnet mask, gateway address, and DNS address need be manually assigned to the computer. The router's DHCP server issues 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 in the same subnet without interfering with DHCP operation.

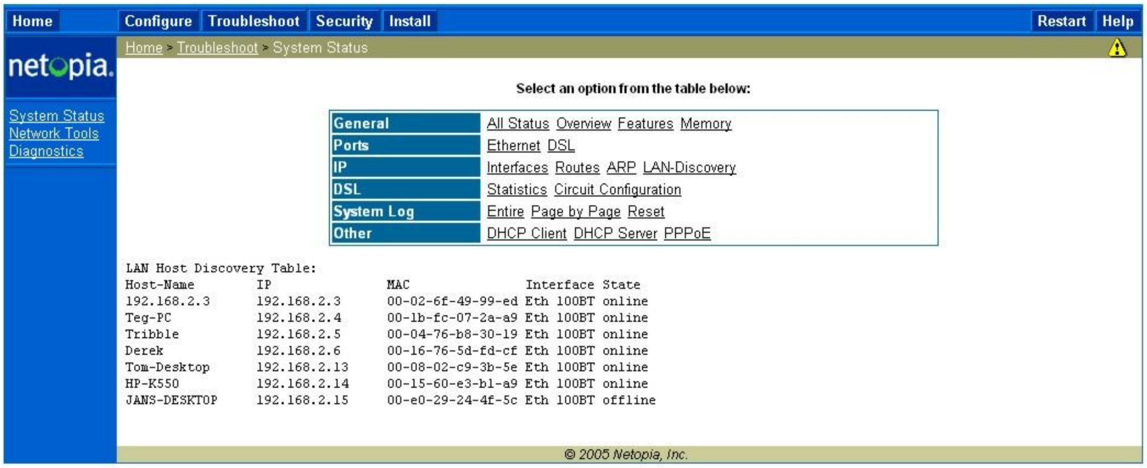
3.4.2 Dynamic

This is the default Windows IP configuration, at power up PC searches for a DHCP server. The DHCP server in the router assigns each machine's IP parameters. Once PC is configured it is able to communicate. The address is "leased" to the client. Prior to lease expiration 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 will likely receive different IP address.

3.4.3 MAC Reservation

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

All machines, except guests, are issued reserved addresses. This makes it much easier to interpret Syslog entries that record events based on IP address.



Select an option from the table below:

General	All Status Overview Features Memory
Ports	Ethernet DSL
IP	Interfaces Routes ARP LAN-Discovery
DSL	Statistics Circuit Configuration
System Log	Entire Page by Page Reset
Other	DHCP Client DHCP Server PPPoE

```
LAN Host Discovery Table:
Host-Name        IP               MAC               Interface State
192.168.2.3      192.168.2.3      00-02-6f-49-99-ed Eth 100BT online
Teg-PC           192.168.2.4      00-1b-fc-07-2a-a9 Eth 100BT online
Tribble          192.168.2.5      00-04-76-b8-30-19 Eth 100BT online
Derek            192.168.2.6      00-16-76-5d-fd-cf Eth 100BT online
Tom-Desktop      192.168.2.13     00-08-02-c9-3b-5e Eth 100BT online
HP-K550          192.168.2.14     00-15-60-e3-b1-a9 Eth 100BT online
JANS-DESKTOP     192.168.2.15     00-e0-29-24-4f-5c Eth 100BT offline
```

Figure 4 LAN Status Page

3.5 10/100 Ethernet Switch

LAN wiring upgrade allowed moving router near 16-Port Ethernet Switch. One port of the Router is connected to Switch leaving 15 Switch ports available plus three unused on the router.

Most modern Ethernet switches implement Auto-MDIX. Switch checks link configuration and automatically selects the correct port type depending if switch is connected to a PC or another switch. This eliminates hassle of using crossover cable or up-link ports to interconnect multiple switches.

3.6 DNS

Host name resolution for local devices is performed by NetBIOS over IP. If Windows cannot resolve a host name it assumes it is a remote host and forwards request to router. Router forwards request to FairPoint DNS Nameserver. To devices on the LAN router looks like a DNS server.

We run a local DNS Nameserver that requires overriding settings provided by FairPoint. Unfortunately router does not include a mechanism to point to an internal Nameserver. Workaround was to manually configure DNS Nameserver address in each client's TCP/IP configuration. The primary DNS address is the internal DNS server, secondary points to ISP DNS server in case local server is down.

3.7 Gateway

Each PC forwards packets that cannot be delivered locally to the gateway. The gateway router decides how to deliver packets that travel outside the LAN. Only a single connection exists between our network and the ISP so routing is trivial. The router simply forwards all packets to the gateway address assigned by the ISP.

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.

3.9 QoS

Router implements multiple QoS functions to make optimum use of limited WAN bandwidth.

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. Syslog server stores data from both Router and Tardis Time server for later review.

3.11 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 an 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, when in fact it is on a private address block.

> **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.

3.11.1 Active vs Passive FTP

The way File Transfer Protocol (FTP) allocates ports causes problems with NAT. To NAT connection appears to originate from the server, rather then user. This causes NAT to prevent transfer. This can be a problem if you change FTP ports from default 20/21 to some other value. NAT routers only know how to handle FTP on the default port.

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

3.11.2 Multiple Identical Servers

Most residential broadband ISPs only allocate a single IP address per account. This causes problems running multiple servers of the same type. For example when running a web server, all incoming requests are to port 80, this makes it impossible to run two web servers on a single IP address using well-known port. Work around is to use a different port for one of the web servers. This can cause problems since the remote user has no way to know server is using a non standard port. Many DynamicDNS sites have provisions to redirect request to the alternate port.

3.11.3 Dynamic DNS

Remote hosts use DNS to translate 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 happens Dynamic DNS service database is notified of new address. This is not a perfect solution since there can be significant delay between address changes and when new address is available. However for most casual residential users it works well enough.

3.11.4 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 then run public server locally.

3.12 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.

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 incurs higher 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 an additional 8-bytes to each packet increasing overhead to 48-bytes reducing payload to 1452. Where PPPoE is used overhead is increased to 3.2%.

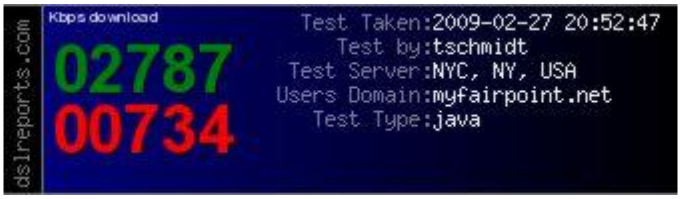
Many phone companies use IP over Asynchronous Transfer Mode (ATM) (AAL5) to carry DSL traffic. ATM was designed for low latency voice telephony. When used for data it adds significant overhead. ATM transports data in 53-byte Cells of which only 48 are data the other 5 used for ATM control. Each 1500-byte 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%

It is easy to determine best-case file transfer rate if modem data rate is known. Broadband marketing rate may not the same as modem transfer rate. This may be done to simplify marketing by presenting a nice round number. Some Telco's set transfer rate higher then marketing speed. When customer performs speed test they receive value close to marketed speed. Most broadband modems have status page allowing user to observe true transfer rate. Keep in mind this is rate modem connects to ISP not speed computer connects to modem or router with is typically 10 or 100 Mbps.

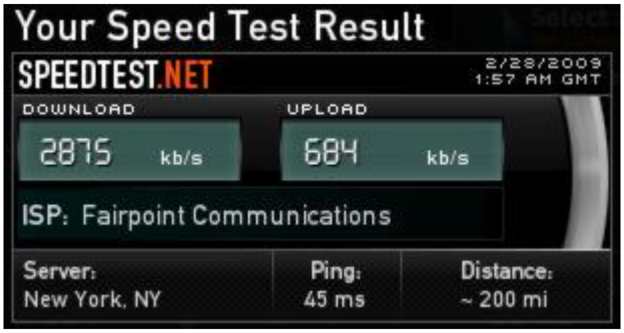
As an example our FairPoint 3000/768 ADSL service has a sync rate of 3360/864, 3360 kbps toward customer, 864 kbps toward Internet. FairPoint uses PPPoE and ATM yielding an overhead of 14.4%. Best-case transfer rate is 85.6% of sync rate, resulting in 2,876 kbps down 740 kbps up. Typical file transfer speed reported by Broadband Reports or Speedtest.net is shown below.

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



Kbps download
02787
00734

Test Taken:2009-02-27 20:52:47
Test by:tschmidt
Test Server:NYC, NY, USA
Users Domain:myfairpoint.net
Test Type:java



Your Speed Test Result
SPEEDTEST.NET
2/28/2009
1:57 AM GMT

DOWNLOAD
2875 kb/s

UPLOAD
684 kb/s

ISP: Fairpoint Communications

Server: New York, NY
Ping: 45 ms
Distance: ~ 200 mi

Figure 5 Speed Test Report

4 Local Area Network – Networking for Everyone

Local Area Network (LAN) allows computers to access shared resources such as printer, files, and the Internet. Ethernet, both wired and wireless, dominates SOHO network market.

4.1 Ethernet

Wired Ethernet IEEE 802.3 is the most common local network technology in use today. It was initially based on Collision Detection Multiple Access Collision Avoidance (CDMA/CA). Think of original Ethernet as a telephone party line. Before speaking listen to see if anyone else is talking. If no one is talking it is OK to start. It is possible more then 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 then network end-to-end propagation delay. This insures transmitter is still transmitting when collision occurs allowing retries to be done at the data link layer. Power level and end-to-end loss budget must be set to allow reliable collision detection.

When Ethernet was originally developed it operated at 10 Mbps and used fat coax cable with clamp on taps, called vampire taps. Early development focused on improving physical interconnection rather then speed. Specification evolved from Fat coax, to thin coax to twisted pair. Today 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 jacks similar to those used for telephone wiring. Since its inception speed has dramatically increased from 10 Mbps (1980) to 100 (1995) to 1G (1,000 Mbps) (1998), 10G (2002) work is under way on 40G and 100G Ethernet.

Switching has replaced Hubs, dramatically improving performance, and enabling full duplex operation by eliminating Collision domain.

As speed or distance increases fiber becomes attractive compared to copper cable. The difficulty with fiber is not so much fiber cost but high cost of opto-electrical converters needed to connect NICs to fiber cable.

4.1.1 Media Access Controller (MAC) Address

Each Ethernet interface (wired or wireless) has a unique 48-bit MAC address. This allows each interface to be uniquely addressed. This is not the same as the IP address. IEEE assigns MAC vendor ID.

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.

4.1.2 Virtual LAN (VLAN)

Virtual LAN technology allows the same physical LAN to connect 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 yet 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).

4.1.3 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 discovered and when needed request firewall/router to adjust configuration to allow the particular service Internet access.

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

4.2 Wired Ethernet

Modern digital networks are packet based. Ethernet "packets" are called frames. Data is divided into chunks called frames. Ethernet frame can be up to 1518 bytes long of which 1500 bytes are available for payload. 18 bytes are used for Ethernet addressing and frame management. When Gig Ethernet was developed specification was modified to allow larger frames, called Jumbo Frames, but that need not concern us here. Each packet includes network specific information providing necessary information to deliver the packet. This consists of sender and destination address, packet length, and error detection to verify errors did not corrupt the packet in transit.

4.2.1 10 – 100 – 1,000 – 10,000 – 100,000 Mbps

Initially UTP Ethernet operated at 10 million bits per second (10 Mbps) over Category 3 UTP wiring. Ethernet development has been in 10X increments. Fast Ethernet increased speed to 100 Mbps over Category 5 wiring. Gigabit Ethernet increased speed another 10 times to 1,000 Mbps. During Gigabit Ethernet development the Cat 5 specification was tightened resulting in Cat5e. The fastest version of Ethernet, 10 Gigabit (10,000 Mbps), has recently been modified to work over Cat 6a. Prior to that 10G required fiber. Work is under way on 100G. Given the high speed it is unlikely to operate over UTP, most likely some form of short distance coax.

4.2.2 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.

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 work very differently then hubs. Switch examines each arriving packet, reads destination MAC address and passes it directly to the proper output port. Switch eliminates 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 betweens 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. Switches enables full duplex communication. This means individual computers can be transmitting at the same time they are receiving. In actual use the speed improvement will be less but switches offer a tremendous performance advantage compared to hubs.

When a switch does not know which port to use it floods incoming packet to all ports, much like a hub. When device responds switch learns MAC address associated with particular 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. Switches used to be much more expensive then hubs. In recent years prices have come down dramatically making hubs obsolete while dramatically improving LAN performance.

Gig Ethernet NICs and Switches are almost at price parity with Fast Ethernet. Gig Ethernet LANs are an interesting inflection point. Historically computer performance was limited by network communication. 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 has shifted to computing elements.

4.2.3 Managed vs Unmanaged Switches

Ethernet hubs and switches come in managed or unmanaged versions. Managed devices allow the administrator control of various parameters and observe traffic. Managed switches are overkill in a typical SOHO network. Unmanaged devices are considerably less expensive.

4.2.4 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 can be transmitting 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. Having NICs wired as MDI and hub/switch as MDI-X means that in most cases interconnect is a simple 1:1 cable.

Problems occur when like devices are connected, say NIC to NIC or hub/switch to another hub/switch. To make this easier hubs/switches typically have an uplink switch or 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. Cross over cable swap TX and RX pair at one connector. Recently vendors have adopted Auto-MDIX to automatically determining remote port type and configure ports automatically. With Auto negotiation (Speed) and Auto-MDIX (gender) Ethernet has become more user friendly. All user need do is connect the cable everything else is automatic.

4.2.5 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 throughput is dictated by internal switch backbone performance.

4.2.6 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 paths. 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.

4.2.7 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 Internet appliances such as WiFi Access Points and Voice over IP (VoIP) telephones are deployed benefit of delivering both data and power over Ethernet cable became obvious.

IEEE took on the challenge and in 2005 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. IEEE 802.3at is currently working on a higher power version of PoE to increase power to about 30 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 then every device.

4.3 Wireless Ethernet (WiFi)

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. WiFi radios operate in the unlicensed Industrial Scientific Medical (ISM) band. WiFi 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 managed. Managed 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 WiFi devices to communicate directly without needing an Access Point. Most WiFi communication make use of Access Points.

The success of various IEEE 802.11 Wireless standards has encouraged many vendors to enter the market. The WiFi Alliance works to insure interoperability between different vendors and promote use of Wireless LANs.

4.3.1 2 – 11 – 54 - 250 Mbps

Initial version of IEEE 802.11 delivered 2 Mbps in 2.4 GHz ISM band. 802.11b increased speed to 11 Mbps, 802.11g increased speed to 54 Mbps. 802.11a operates at 54 Mbps in the 5 GHz band. The much hyped 802.11n operates at 250 Mbps. 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.

4.3.2 Security

Wireless LANs are inherently less secure then wired. An intruder does not require a physical connection, but can eavesdrop while some distance away. The original 802.11 designers were aware of this risk 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. IEEE developed a comprehensive security standard and several enhanced implementations are available. WiFi Protected Access (WPA2) is current state of the art for wireless security. There are different versions optimized for residential and commercial customers. Netstumbler is a useful tool to help secure WiFi LANS.

4.3.3 Interference

WiFi radios operate in unlicensed bands so interference is a problem, especially in congested urban areas. Interference is the result of other WiFi radios, non-WiFi radios operating in the same band such as Bluetooth and wireless phones and unintentional radiators such a microwave ovens.

WiFi 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.

4.4 Alternatives

Ethernet, wired and wireless, is the dominant LAN technology. 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.

4.4.1 Phone Line Networking

Home Phoneline Network (HomePNA) uses existing phone 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.

Phone Line LAN uses slightly modified Ethernet packets. 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 175 Mbps. Many homes built in the last few decades have RJ6 coaxial cable feeding multiple TV outlets but are not equipped with Category rated cable suitable for conventional Ethernet. Verizon is using the technology to eliminate need to run both coax and UTP Ethernet when installing FIOS.

4.4.4 Ultra Wideband Radio

A number of emerging wireless technologies are targeting so-called last-foot problem. One only has to look at the rear of typical residential TV/stereo/home theater installation to understand problem. The mass of cabling needed to interconnect individual components and the inability of components to talk to one another hinders adoption and is at odds with ease of use. This limitation has dogged consumer electronics industry for years. The goal of Ultra Wideband and WirelessHD technology is to deliver incredibly fast data rates over a few meters eliminating need for A/V cabling.

5 Local Server – Just Like The Big Kids

Local server provides several network services: file sharing, DNS Nameserver, NIST clock synchronization, Syslog server, private web server and personal weather station. At first we used a laptop server. This was convenient because it was self-contained but had limited disk storage capacity. It was replaced with a 200Mz Pentium desktop with a 45GB hard drive. Most recently server has been replaced with a recycled 1 GHz Pentium desktop with 320 Gig drive running XP.

5.1 KVM Switch

Figure 6 KVM

We did not want to add another set of user I/O when we setup server. The solution was to use a KVM (keyboard, video, mouse) switch. KVM's have been used in server farms for years to allow single point of control for multiple computers. We purchased a 4-port Belkin Omni View SE KVM. Port 1 is the workstation port 2 the server leaving 2 ports for future use.

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 coaxial 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 a 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

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 access software. Windows XP Pro has built in remote management capabilities and there are numerous third-party applications. A popular remote access program is Real VNC. Real VNC provides encrypted access to prevent eavesdropping and can be used from anywhere with an Internet connection. 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 between machines. Files can be shared directly between PCs or by using a dedicated file server. My Network Places (Called Network Neighborhood in some version of Windows) are 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 were on the local machine.

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.

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 then 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 File and Print Sharing Service
Make sure Microsoft "File and Print sharing service" is installed on each machine (Win98/ME). Nothing need be shared but the service must be running for the machine to show up in the Neighborhood. In XP Simple File sharing is defaulted on except when XP pro is joined to a domain.

#2 Bindings (Win98/ME)
File and print sharing must be bound to a communication protocol typically TCP/IP. Before the popularity of the Internet NetBEUI or IPX were commonly used on the LAN. They are considered obsolete protocols and no longer build into Windows. NetBIOS/SMB is the programming API used by Microsoft to exchange information over the network.

#3 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.

> ***Windows Configuration Tip*** – There is a compatibility problem between Win2000/XP/Vista and older versions of Windows and Win98/ME. We had trouble getting a Win 98 laptop to show up in a corporate network of Win 2000/XP machines. Our workaround was to place laptop in its own workgroup.

#4 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. In older versions of Windows is was possible to force a machine to always be the browse master. That is no longer an option with XP/Vista. Browsing performance is much improved in newer versions Windows.

To force, which machine will be the master browser shutdown 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.

#5 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.

#6 Enabling Shares
To enable file sharing pick the desired subdirectory to share and check sharing. That directory and all subdirectories will be shared.

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.

#7 User Account
Some versions of Windows need user or guest account to share files, this limits shares to authorized users.

#8 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. XP SP2 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.

5.5 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.

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 -- XP/Visa 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 then 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.

5.6 Local DNS Resolver

Normally ISP provides DNS. However, any DNS server can be used to translate URLs to IP addresses. ADSL services has been very reliable, but have had numerous DNS problems. At first I used DNS server from my dialup ISP but decided to run my own DNS server. TreeWalk was installed on the server. Running my own DNS server has solved chronic DNS problems. For typical home LAN running local DNS is not very demanding and does not interfere with other programs running on the server.

Running TreeWalk DNS is straightforward. Install the software, and then modify TCP/IP settings. On the PC running TreeWalk set DNS IP address to Loopback address 127.0.0.1. On other PCs primary DNS address is set to TreeWalk server. ISP DNS is set as secondary in case local server goes down.

Running your own DNS Resolver is also a convenient way to block ads, more info about ad blocking here.

5.7 Private Web Server

The browser home page of each PC points to web server running on local server. This allows relevant information be posted on local site. Pages consist of both static information and dynamic weather data. XP pro includes built in IIS server but not XP home. The server is running XP home so we needed to use a third party web server. We chose Abyss as it is free for personal use. Abyss replaced Xitami server running on the previous server under Win 98.

5.8 Weather Station

Davis Instruments weather station data is posted on internal web server. Davis software is configured to update historical data file and create real time and historic GIF images. GIFs are posted automatically to local web server allowing anyone on the LAN to retrieve weather data.

5.9 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. Currently the only devices originating Syslog entries are broadband router and Tardis Time service.

We use Kiwi shareware program for both Syslog server and Log file viewer.

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 menagerie of Windows XP home, XP Pro, Vista and even one ancient Win98 box as a spare. For demanding application opted to purchase new PCs for others bought used boxes.

A local computer dealer had a bunch of HP/Compaq Evo 530 towers come off lease. Bought a couple to replace Dell XPS T500 and Toshiba V3100 for my wife and myself. We also purchased a used Dell Latitude C600 laptop locally from another dealer. These are nice solid boxes at very attractive prices. Unless one needs latest and greatest PC hardware buying used PCs off lease is worth looking into.

We acquired new HP M8000e tower. This replaced my daughter's HP Pavilion 6735. This is the first AMD PC I've owned. AMD represents a lot of bang for the buck.

My son had a Dell Dimension 4100 1 Gigahertz PC deemed inadequate for gaming. Replaced it with an eMachine W3502. Dell is now acting as home server replacing an aging IBM 300GL P200 by installing a 320 Gig hard drive for file sharing.

6.2 World Wide Web

All PCs use Microsoft Internet Explorer and some use FireFox. It seem seems browser wars are raging once again. Having multiple browsers is a useful troubleshooting tool. Internet Explorer version 7 seems to break compatibility with some web sites so after trying it for a while reverted back to version 6.

Key to effective use of the Internet is being able to find what one is looking for. Our preferred search engine is Google. They have a nifty IE and FireFox search toolbar add-on. The toolbar allows Google queries be made directly from browser toolbar.

6.3 FTP

File Transfer Protocol (FTP) is a very effective way to transfer large files over the Internet. FTP predates HTTP.

6.4 Instant Messaging

Instant messaging (IM) is becoming 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.

6.5 E-Mail

E-mail accounts fall into three broad categories: ISP accounts, free third party services and business email. ISPs typically provide email service as part of the total package. This is convenient but ties your e-mail address to current ISP. Change ISP and your e-mail address changes. We are in the process of going though ISP transition due to sale of Verizon's New England territory to FairPoint. Free mail services like Yahoo are advertising supported. Google Gmail has become a very popular free email service. I use it as an alternative to business email. Third party email decouples e-mail address from ISP. Free accounts make sense for personal use and as throwaways if they attract too much spam. For business purposes or to insure long lasting email identity nothing beats registering your own domain name. Once registered e-mail is addressed to you@yourdomain.TLD. If you change hosting service you simply transfer domain registration to new provider, e-mail is unaffected.

6.5.1 Email Access

Traditionally access to mail 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 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 e-mail client connects to POP server it downloads mail. An alternative to SMTP/POP email is Internet Message Access Protocol (IMAP).

Telecommuters and road warriors need access to corporate mail when out of the office. Depending on where mail server is located this may be easy or difficult. If access is not restricted user can log in like any other email account. If email server is not publicly accessible the employee needs to connect using the corporate VPN. Some companies are implementing web-based email making life easier for road warriors and telecommuters. Corporate web based e-mail is convenient because it does not require a specialized email client – any machine with a web browser is able to access mail.

6.5.2 SPAM Mitigation

Unwanted email (SPAM) us a tremendous problem. Something like 95% of all email messages are SPAM. ISPs and third parties have been waging a loosing battle of years. ISPs have adopted a number of strategies to minimize the problem. It can be a challenge choosing optimum email configuration when using multiple mail accounts and multiple ISPs.

6.5.2.1 Messaging Anti-abuse Working Group (MAAWG)

Messaging Anti-abuse Working Group (MAAWG) is and industry group promulgating best-practices to reduce spam. Recommendation is to use SSL/TLS to securely access SMTP and POP mail server and not use Port 25 for outgoing email.

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.

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 that domain. Before email is accepted email server verifies it originated from 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

Our broadband ISP’s does not currently block outgoing port 25. However based on MAAWG recommendations they may chose to do so. In preparation reconfigured email client to use SSL/TLS to access SMTP/POP servers. This has the added advantage of protecting privacy when using public WiFi hot spots because SSL/TLS is used to send and retrieve email.

> ***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.
>
> ***Outlook Configuration Tip*** – New mail is sent using the SMTP server defined for default account. Replying to incoming email uses 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. Outlook preview has to read the first few lines so it is possible to become infected even it the message has not been read. Outlook has been patched to fix this but one never knows what clever dodge virus writers will come up with.
>
> ***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 USENET

Usenet Newsgroups are 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 provide access to USENET. 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. Usenet access is also available from a number of specialized companies.

We use Outlook Express as the newsreader. News server authentication can occur automatically when connecting to the ISP or require explicit authentication or in FairPoint's case they require both. Off network access is not allowed.

> ***Security Tip*** -- Spammers commonly harvest email addresses from Usenet posts. It is common practice to use a fake mail address on Usenet. Do no simply make up an email address – it may turn out to be someone else's real address, instead use an invalid Top Level Domain. My Usenet mail address is tomnews@tschmidt.invalid.

6.7 Multimedia

Internet multimedia was hampered by low dialup speed. Broadband eases this chokepoint opening the door to Internet delivery of phone, 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.

Digital 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. Digital deliver undermines existing business models 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 creators and patrons will learn how to utilize this new distribution model.

6.7.1 Audio and Video

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

6.7.2 Digital Rights Management

Audio and video content owners fear lossless digital duplication of copyrighted works will undermine their business rather then 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.

6.7.3 CD/DVD/Blu-ray evolution

Back in the early ‘90s digital versions of audio CDs were heralded as a tremendous new storage medium. Typical CD stores about 700 Mbytes of data. Compared to only 1.5 Mbytes on 3.5” floppy. This seemed like and infinite amount of space. Back then hard drives were not much larger then a single CD.

Time marches on. DVDs were developed to allow digital movies be distributed in similar format as audio CDs ultimately displacing VHS videotape. Current mass-market DVD technology stores 4.7 Gbytes (single Layer) of data. This is more then enough to store an entire SDTV (standard definition) movie with room for other features.

With increased popularity of high definition Television HDTV a media format with more capacity was needed. Blu-Ray 25 GB (single layer) won the battle. Current price points of Blu-Ray players and media remain high. HDTV represents a tremendous improvement over NTSC. That being said Conventional NTSC DVDs using component video or HDMI interconnect looks very 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

6.7.4 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 innovative Roku player to watch streaming media on their TV. Image quality is automatically adjusted based of broadband speed.

6.7.5 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 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.

6.7.6 Real Audio Player

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

Streaming is different then 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 then it is being used buffer expands to store it.

6.7.7 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.

6.7.8 QuickTime

Apple QuickTime is a popular movie-encoding format.

6.8 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.

6.8.1 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 not mature. Multicasting allows a single media stream be delivered to multiple subscribers. Multicast reduces server and bandwidth cost.

6.8.2 RF Radio/TV

Hauppauge TV/FM card is installed in the main workstation and HP M8000. It supports both NTSC analog TV and ATSC digital TV and analog FM. I find that combination very useful. TV looks surprising good on a computer screen. The card has a freeze feature to capture still images. Image quality illustrates just how poor over the air NTSC TV is compared to typical computer resolution. NTSC resolution is about 720x480 pixels with less color depth than typical computer display. HDTV resolution is 1366x768 and 1910x1080. TitanTV is a popular on line program service.

6.8.2.1 Over the air (OTA) reception

We live in a TV fringe area. With June 12 2009 (postponed from Feb 17, 2009) looming as the deadline to end of analog over-the-air (OTA) transmission wanted to see if we were able to receive OTA digital TV programming. We were able to receive some DTV stations but not all we were interested in. Over the summer upgraded 20-year old outdoor antenna in preparation for transition to digital TV (DTV). That helped some but still unable to receive some of the weaker stations consistently. New Hampshire is difficult topography for broadcasters. I've documented my experience setting up an outdoor TV antenna on my site.

6.9 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 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. 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 wireless Cell phones. Both live in their own silo. In the not to distant future will be able to use a single convergence device that works at home over WiFi, at WiFi hot spots and when not in range the cellular network.

6.10 Fax

Originally we did not want to use fax at all, preferring to interact with clients via e-mail or telephone. We found it difficult to get away from fax entirely so sought a solution that did not require a "real" fax machine or dedicated fax phone line. As time went on fax has become less and less important. However: it is nice to be able to send and receive the occasional fax.

Initially we used Fax application called BVRP Phone Tools application bundled with Dell Win98 system and free eFax account. On migrating to XP use Fax application built into XP and an onboard dialup modem salvaged from another PC. This works well for the limited number of faxes we send and receive.

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.

The popularity of solid-state media cards has spawned a wide assortment of media reader/writers. The HP M8000e PC came with a built in media reader. On other PCs use CP Technologies 10-in-1 USB memory card reader/writer.

6.12 Document Scanning

Flat bed 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.

Use an HP ScanJet 5400C flat bed scanner. It also functions as a poor mans copying machine allowing scanned images be printed from network printer.

6.13 Document 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 hard copy as needed.

We had been using a HP 2000 professional Inkjet printer and a HP JetDirect 300X print server for a number of years. It quit working in the middle of my wife finalizing her Masters thesis. It was replaced with and HP K550. The new printer is much faster and cheaper then the 2000 while still retaining individual ink supply. The K550 is network ready, print server is built in rather then external. This results in much richer interaction with printer then before. Curiously one of the reasons for choosing this particular printer was that it still supported Win98. As fate would have it upgrading printer triggered a flurry of system upgrades so we no longer need Win98 support.

6.13.1 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. I use CutePDF Writer to convert MS Word documents to PDF format.

6.14 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.

6.15 Accounting

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 TaxAct software.

6.16 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 and cannot be used with NAT because NAT modifies the address. ESP encrypts data to prevent eavesdropping. Authentication is performed using Internet Key Exchange (IKE).

Depending on the type of VPN broadband router may have to support IPsec pass through. IPsec has a similar problem as FTP. Even though request originates from local user, session appears to originate from remote server. NAT needs to be able to learn the active port or session will fail. This requires router to function as an Application Lavel Gateway (ALG). It has to recognize IPsec, just as it needs to recognize FTP.

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, addresses that problem.

In split-tunnel mode tunnel only carries traffic destined for corporate network. Other traffic flows normally as if tunnel did not exist. Split-tunnel creates a potential security concern. Client is able to access Internet and corporate network simultaneously. If an attacker compromises client he is able to use client to relay traffic directly between client and corporate LAN. As a minimum each client should be running the latest antiviral software. User training should stress safe computing practices.

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 all browsers support SSL, eliminating the need for special client software. This is especially convenient for employees that need to connect to corporate network from multiple computers.

7 Security -- Keeping Bad People Out

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

7.1 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 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. 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.

7.2 Zombies

One of the most insidious form 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 aware PC is compromised. Often the first hint of a problem is a nasty email/letter from their ISP.

7.3 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.

7.4 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.

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 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. 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 WiFi security is WiFi Protected Access (WPA2). There are versions optimized for home networks and large corporate sites.

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 wiring does not typically exit building. Using Ethernet switches, rather than hubs, makes eavesdropping more difficult because only broadcast and traffic destined for the specific port is visible.

7.7 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.

7.8 Phishing

Phishing email looks like it originated from a legitimate company. 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.

7.9 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.

7.10 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 common. Some ruse is used to cause user to connect to attacker's site. Site is often an exact duplicate of 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.

7.11 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 Passphase storage

For a computer to recognize authorized user it needs a method to establish entered credentials are valid. This means computer must store the passphase, or more correctly a hash of the passphase. 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.

7.13 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 then other forms of engineering. In a typical engineering problem a solution is developed and proper operation verified. There is no need to consider deliberate attack designed to pervert operation.

7.13.1 Security Patches

For Machines running Windows Microsoft 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.

7.13.2 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.

7.13.3 Passphase Management

No reputable entity will ever 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 lock out if more then a few incorrect passphases are entered. Real 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 passphase until they find the right one.

- Change passwords and account names, do not use defaults.
- Use long passphass of both letters and numbers and if possible punctuation characters.
- Be weary 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.

7.13.4 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.

7.13.5 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.

7.13.6 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.

7.13.7 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 XP's 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 firewalls are 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. When that happens firewall is no longer part of the security scheme. 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.

7.13.8 Data Backup

Having duplicate copies of important data is key 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.

7.14 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 backups actually occur. 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 backup location so each person is able to backup data on the server. We chose Acronis True Image backup utility. It has the capability to backup data or create a complete 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 USB External Drive

Figure 7 External HDD

Recent addition is Maxtor One Touch USB 500 GB external hard disk. We use it exclusively to provide off line backup. Device is connected to each PC to back up selected files. Being an external HDD I keep it disconnected to reduce risk that Virus or Lightning will corrupt backups. Being off line protects back up copies but is only useful if backup process is followed.

Drive support USB 2, if it is connected to older computer that only support USB 1.1 backup will be very slow. That was the case with 1GHz PC used as a server, added USB 2 card to speed up transfer.

8.3 CD/DVD

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 8 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 then end cap.

9 Debug -- 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 go to START menu open the RUN dialog box, enter “command,” press OK. This opens the command prompt, also called the DOS box.

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.

> ***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 like devices say PC-to-PC or Switch-to-Switch a crossover cable or uplink port is used. Some newer devices include auto-sensing ports eliminating the need for crossover cables. If ports are mismatched the link will not work.

9.2 *Modem Statistics*

Device directly connected to first-mile network often has ability to report low-level connection statistics. This is a powerful diagnostic aid since it measures condition of physical interface rather then end-to-end performance.

Netopia 3346N DSL modem/router displays two pages of modem data. Display shows line attenuation, sync speed and noise margin. 6 dB is the minimum acceptable ADSL noise margin. Error count should be low relative to amount of data transferred. Startup attempts record number of times router had to reinitialize PPPoE sessions since last power up.

```
ADSL Line State:        Up
ADSL Startup Attempts:  5
ADSL Modulation:        DMT
Datapump Version:       DSP 4.2.1.0, HAL 4.2.1.0
                        Downstream  Upstream
                        ----------  ----------
SNR Margin:                  23.00       10.00 dB
Line Attenuation:            44.50       29.00 dB
Output Power:                11.56       11.90 dB
Errored Seconds:                 0           0
Loss of Signal:                  3           3
Loss of Frame:                   0           0
CRC Errors:                   3870         455
Data Rate:                    3360         864
```

```
ATM port status    : Up
Version: CPAAL5: 01.07.2b    SAR: 52

Rx data rate (bps) : 3360
Tx data rate (bps) : 864
ATM Virtual Circuits:

VCC #  Type  VPI   VCI   Encapsulation
-----  ----  ---  -----  --------------------------
  1     PVC    0     35  PPP over Ethernet (LLC/SNAP encapsulation)

ATM Circuit Statistics: VCC-1

  Rx Frames     :    36400460          Tx Frames     :    28239495
  Rx Octets     :   979218661          Tx Octets     :   776100270
  Rx Errors     :           0          Tx Errors     :           0
  Rx Discards   :           0          Tx Discards   :        3044
```

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 host 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.

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 Traceroute

Traceroute (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. Traceroute uses Time To Live (TTL) field causing packets to expire at each hop. To reach the next hop TTL is increased. When a router receives a packet with an expired TTL it discards the packet and informs sender TTL expired. Traceroute 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 Traceroute responds with an "*" indicating nothing was returned.

Windows includes a command line Traceroute 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 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. Two I use are Broadband Reports and Speedtest.net.

9.6 IPCONFIG

IPconfig is a Windows command line utility to display IP settings for each network adapter. If Point-to-Point Protocol (PPP) adapters are present IPconfig will also display the virtual adapter entries that emulate physical interfaces.

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, February 26, 2009:11:05AM
 Lease Expires . . . . . . . . . . : Saturday, February 28, 2009:11:05AM
```

9.7 Route

Route is a Windows command line utility to display and manipulate network routing tables.

Network Address	Netmask	Gateway Address	Interface	Metric
0.0.0.0	0.0.0.0	192.168.2.1	192.168.2.13	20
127.0.0.0	255.0.0.0	127.0.0.1	127.0.0.1	1
192.168.2.0	255.255.255.0	192.168.2.13	192.168.2.13	20
192.168.2.13	255.255.255.255	127.0.0.1	127.0.0.1	20
192.168.2.255	255.255.255.255	192.168.2.13	192.168.2.13	20
224.0.0.0	224.0.0.0	192.168.2.13	192.168.2.13	20
255.255.255.255	255.255.255.255	192.168.2.13	192.168.2.13	1

9.8 NETSTAT

NETSTAT is a Windows command line utility to display protocol statistics and current TCP/IP network connections.

```
  -a            Displays all connections and listening ports.
  -b            Displays the executable involved in creating each
                connection or listening port. In some cases well-known
                executables host multiple independent components, and in
                these cases the sequence of components involved in creating
                the connection or listening port is displayed. In this case
                the executable name is in [] at the bottom, on top is the
                component it called, and so forth until TCP/IP was reached.
                Note that this option can be time-consuming and will fail
                unless you have sufficient permissions.
  -e            Displays Ethernet statistics. May be combined with –s.
  -n            Displays addresses and port numbers in numerical form.
  -o            Displays owning process ID associated with each connection.
  -p proto      Shows connections for the protocol specified by proto;
                proto may be any of: TCP, UDP, TCPv6, or UDPv6.  If used
                with the –s option to display per-protocol statistics,
                proto may be any of: IP, IPv6, ICMP, ICMPv6, TCP, TCPv6,
                UDP, or UDPv6.
  -r            Displays the routing table.
  -s            Displays per-protocol statistics. By default, statistics
                shown for IP, IPv6, ICMP, ICMPv6, TCP, TCPv6, UDP, UDPv6.
                -p option may be used to specify a subset of the default.
  -v            When used in conjunction with -b, will display sequence of
                components involved in creating the connection or listening
                port for all executables.
  interval      Redisplays selected statistics, pausing interval seconds
                between each display.  Press CTRL+C to stop redisplaying
```

9.9 NBTSTAT

NBTSTAT is a Windows command line utility to display protocol statistics and current TCP/IP connections using NBT(NetBIOS over TCP/IP).

```
-a (adapter status)   Lists remote machine's name table given its name.
-A (Adapter status)   Lists remote machine's name table given its
                      IP address.
-c (cache)            Lists NBT's cache of remote [machine] names and
                      their I addresses.
-n (names)            Lists local NetBIOS names.
-r (resolved)         Lists names resolved by broadcast and via WINS.
-R  (Reload)          Purges and reloads the remote cache name table.
-S (Sessions)         Lists sessions table with the destination IP
                      addresses.
-s (sessions)         Lists sessions table converting destination IP
                      addresses to computer NETBIOS names.
-RR ReleaseRefresh)   Sends Name Release packets to WINS and then,
                      starts Refresh.
RemoteName            Remote host machine name.
IP address            Dotted decimal representation of the IP address.
interval              Redisplays selected statistics, pausing interval
                      seconds between each display. Press Ctrl+C to stop
                      redisplaying statistics.
```

9.10 NETSH

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

9.11 NET

NET is a Windows command line utility to display information about Windows networking and workgroup

9.12 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.

This is the status report from our LAN. It was obtained from a client PC. Tribble is a desktop (XP) acting as file server. Because Tribble is running desktop, rather then server O/S, Browstat has limited ability to retrieve information. However in most cases what is important is simply being able to determine which PC is acting as master browser.

```
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
```

9.13 Ethereal/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.

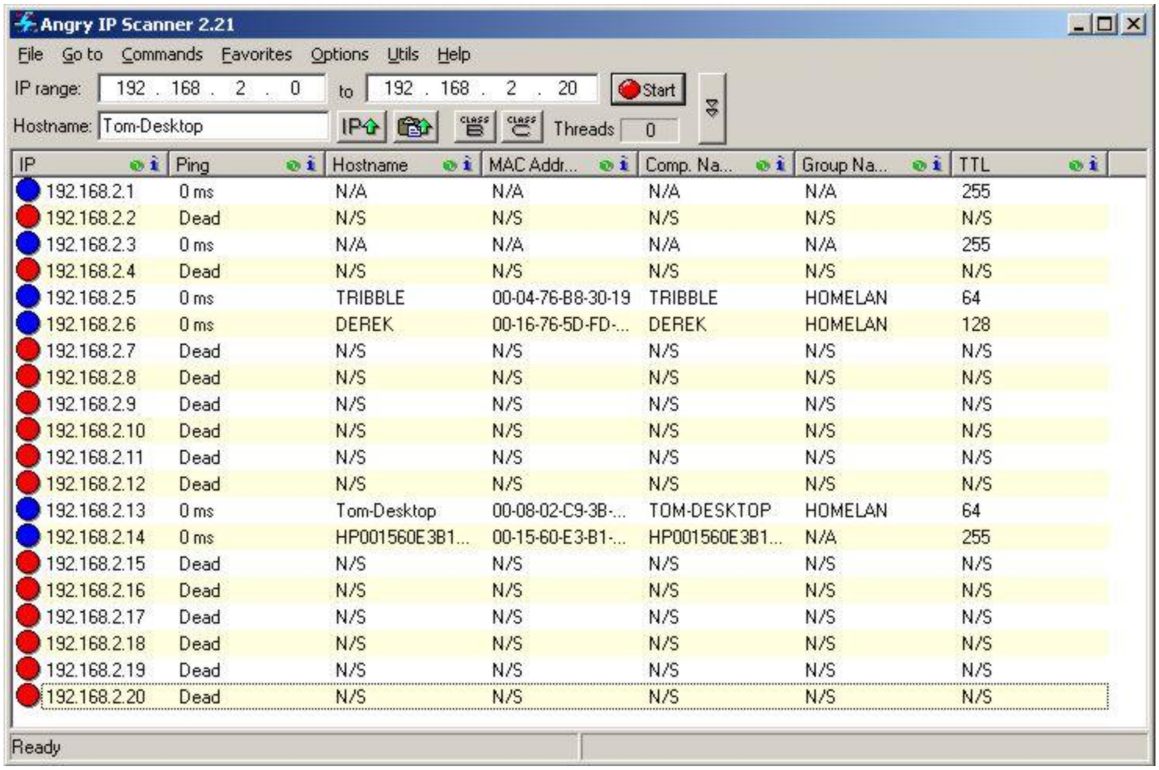
Ethereal is a very popular open source diagnostic program recently renamed WireShark.

9.14 Belarc Advisor

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

9.15 Angry IP

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



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

9.16 NetStumbler

Netstumbler is a popular utility to debug and analyze WiFi problems.

9.17 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?
- 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 AutoIP address. AutoIP address is in a different subnet than private addresses preventing intercommunication.
- Ping machines on the LAN by Network name and IP address. This verifies internal Windows name resolution and the TCP/IP stack is working correctly.
- Attempt to access router configuration page or the PC running connection sharing. If it does not respond but other machines do the problem is likely the router.
- If networking looks really broken try pinging local Loopback address 127.0.0.1. This tests PC’s IP stack, and works even it the machine is not connected to a LAN. If this does not work make sure the NIC is bound to TCP/IP. If configuration is correct try deleting and reloading TCP/IP stack.
- If some PCs do not show up in Network Neighborhood 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 the 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 February 2009 Broadbandreports.com address is: 209.123.109.175. If that works you have identified a DNS problem. If site is not accessible by address there is a bigger problem.
- Perform a Traceroute (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 Techniques – 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.

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 it 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.

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, typically being used with multiple generations of electronic equipment. They 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 centralized wiring closet and terminal devices.

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 originating at 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 Structured Wiring

Figure 9 8-Pos 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. Only Category 5e and 6 are current, other ratings are obsolete. 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.

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 patch panel.

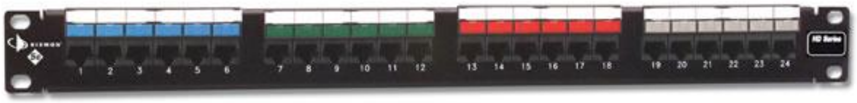


Figure 10 24-Port Patch Panel

Cat 5e allows a single wiring scheme for Ethernet (10 Mbps), Fast Ethernet (100 Mbps), Gigabit Ethernet (1000 Mbps), 10 G Ethernet (10,000 Mbps) as well as ordinary phone service.

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.

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 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 then category. Class C is equivalent to Cat 3, Class D to Cat 5, and Class E to Cat 6.

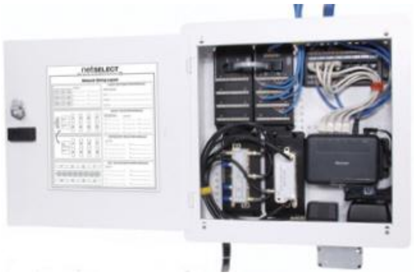


Figure 11 Wiring Cabinet

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.

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.

10.2 Modular Connectors

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 y 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.

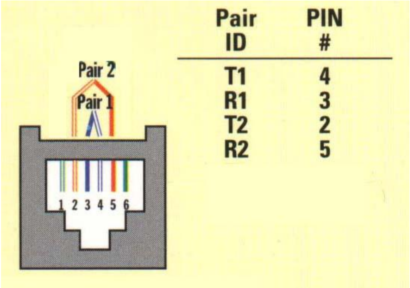
4-position connector is used to connect telephone handset to phone. It is not assigned a RJ designation and need not concern us here.

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.

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.

10.2.1 Telco Uniform Service Ordering Code (USOC) Pinout



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

Figure 12 RJ11 & RJ 14 POTS

RJ11 6-position jack connects a single-line phone to telephone network. RJ14, also 6-position, is used with two-line phone.

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. When an event occurs alarm dialer is able to disconnect downstream CPE devices so it is able to seize line and dial out even if line was previously in use. 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 the 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.

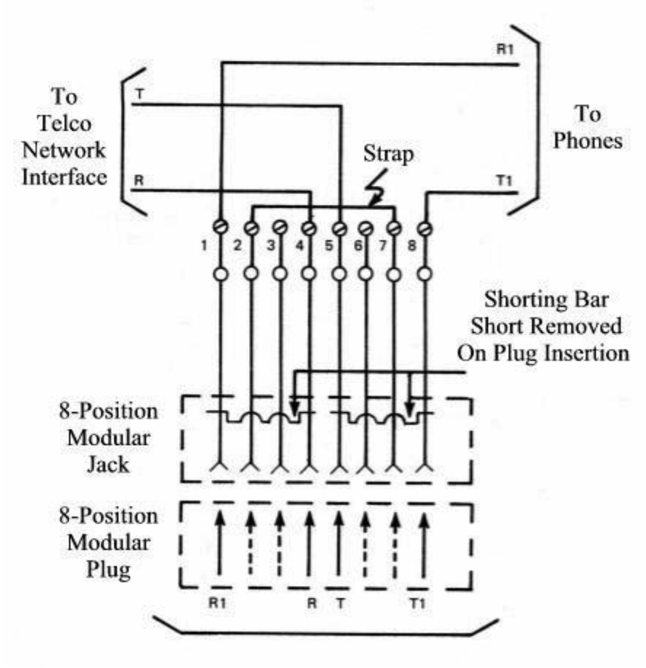
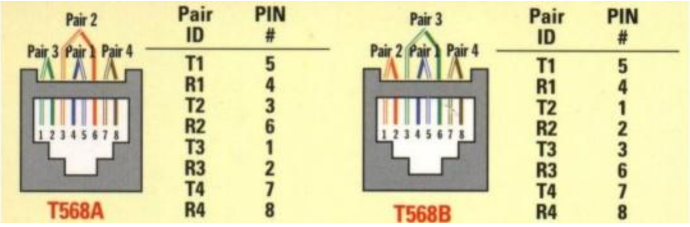


Figure 13 RJ31 & RJ38 Alarm Jack

10.2.2 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 were 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.



Pair ID	PIN #
T1	5
R1	4
T2	3
R2	6
T3	1
R3	2
T4	7
R4	8

Pair ID	PIN #
T1	5
R1	4
T2	1
R2	2
T3	3
R3	6
T4	7
R4	8

Figure 14 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.

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 prior to development of structured wiring techniques.

10.3 Wiring Color Code

Telco USOC RJ11 and RJ14 jacks use Red, Green, Yellow and Black conductors.

TIA Category rated cable consist of 8-conductors, arraigned as 4-pairs. Each pair is a different color, to identify conductors within a pair one wire is solid color the other has a White stripe.

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 considered good practice to maintain proper polarity. Low cost phone line testers are available to quickly determine polarity.

TIA Color Code	T568A 8-pos Pinout (Preferred)	T568B 8-pos Pinout	Telco Color Code	Telco Designation	RJ11/14 6-pos Pinout
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			

10.4 Type 66 Punch down Block

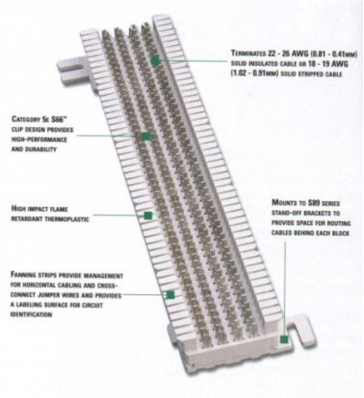

TERMINATES 22 - 26 AWG (0.81 - 0.41MM) SOLID INSULATED CABLE OR 18 - 19 AWG (1.02 - 0.91MM) SOLID STRIPPED CABLE
CATEGORY 5E S66™ CLIP DESIGN PROVIDES HIGH-PERFORMANCE AND DURABILITY
HIGH IMPACT FLAME RETARDANT THERMOPLASTIC
MOUNTS TO S89 SERIES STAND-OFF BRACKETS TO PROVIDE SPACE FOR ROUTING CABLES BEHIND EACH BLOCK
FANNING STRIPS PROVIDE MANAGEMENT FOR HORIZONTAL CABLING AND CROSS-CONNECT JUMPER WIRES AND PROVIDES A LABELING SURFACE FOR CIRCUIT IDENTIFICATION

Figure 15 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 device called a bridging clip can be used to connect the left terminals to the right set. Use of bridging clips facilitates troubleshooting allowing circuits to be easily isolated.

10.5 Type 110 Punch down Block

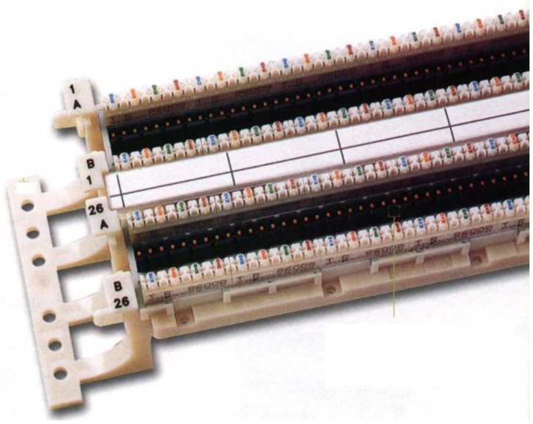


Figure 16 110-Block

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. The 110 block is 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 results in better transmission characteristics than using punch down blocks for cross-connect.

10.6 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 very 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.

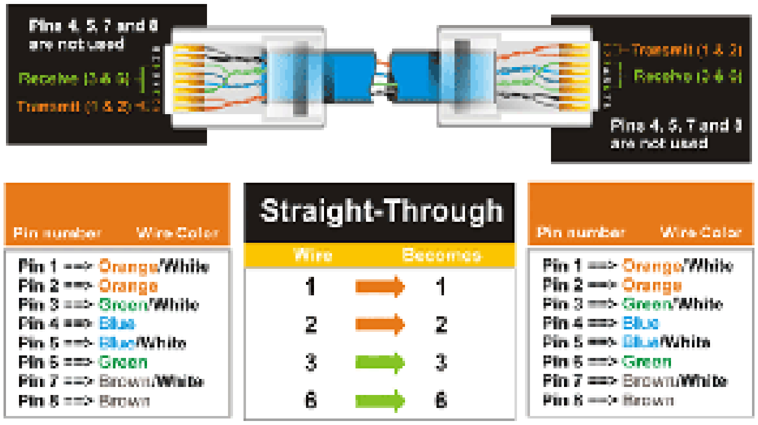
Outdoor wiring is subject to UV radiation and moisture. Outdoor cable is gel filled to prevent moisture intrusion and has a UV resistant outer jacket, usually black. Direct burial cable includes a corrugated metal rodent shield to protect against burrowing animals. Fiber is ideal for outdoor runs. Being nonmetallic it is not susceptible to lightning damage.

10.7 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.

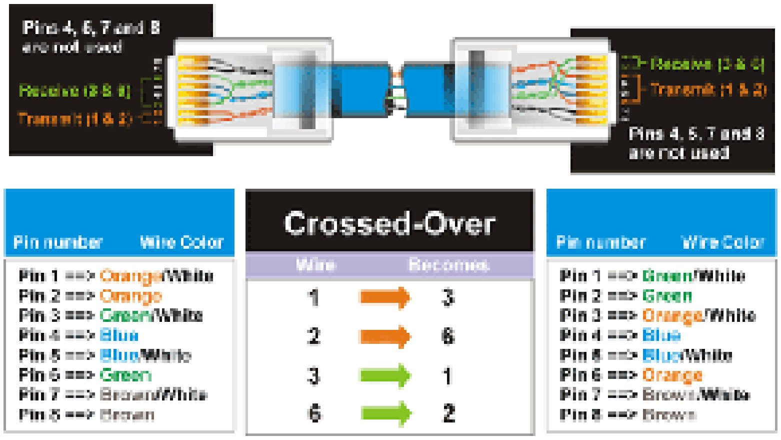


Pin number	Wire Color
Pin 1 ==>	Orange/White
Pin 2 ==>	Orange
Pin 3 ==>	Green/White
Pin 4 ==>	Blue
Pin 5 ==>	Blue/White
Pin 6 ==>	Green
Pin 7 ==>	Brown/White
Pin 8 ==>	Brown

Wire	Becomes
1	1
2	2
3	3
6	6

Pin number	Wire Color
Pin 1 ==>	Orange/White
Pin 2 ==>	Orange
Pin 3 ==>	Green/White
Pin 4 ==>	Blue
Pin 5 ==>	Blue/White
Pin 6 ==>	Green
Pin 7 ==>	Brown/White
Pin 8 ==>	Brown

Figure 17 UTP Straight-through Patch Cable



Pin number	Wire Color
Pin 1 ==>	Orange/White
Pin 2 ==>	Orange
Pin 3 ==>	Green/White
Pin 4 ==>	Blue
Pin 5 ==>	Blue/White
Pin 6 ==>	Green
Pin 7 ==>	Brown/White
Pin 8 ==>	Brown

Wire	Becomes
1	3
2	6
3	1
6	2

Pin number	Wire Color
Pin 1 ==>	Green/White
Pin 2 ==>	Green
Pin 3 ==>	Orange/White
Pin 4 ==>	Blue
Pin 5 ==>	Blue/White
Pin 6 ==>	Orange
Pin 7 ==>	Brown/White
Pin 8 ==>	Brown

Figure 18 UTP Crossover Cable

10.8 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.

Initially we used dialup as backup if DSL failed. We no longer do so. DSL service has been very reliable. With web sites increasing being optimized for broadband dialup browsing is painful. I designed a custom built device to minimize interference between dialup and phone lines. More information about the Modem Access Adapter (MAA) is available on the writings page.

10.8.1 Telephone Network Interface Device (NID)

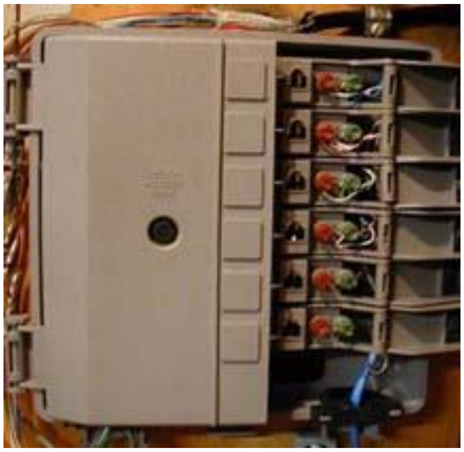


Figure 19 Network Interface Device

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 premise. Inside wiring and equipment became customer's responsibility. This created a dilemma for the Phone Company, how to determine if a problem was their responsibility or that of 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. Early NIDs used modular jack connected to old style carbon block lightning protector. 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 means to disconnect inside wiring. Some NIDs include a half-ringer test circuit. Half-ringer creates a unique signature to allow test equipment to determine if fault is on Telco or customer side.

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 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.

10.8.2 POTS/DSL Splitter

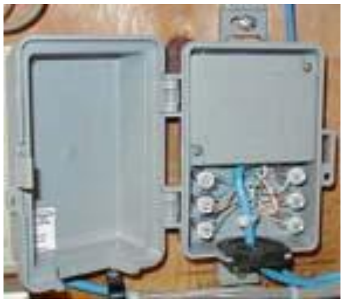


Figure 20 Splitter

ADSL uses a single phone line to deliver both voice and data service. Filters are required to prevent high frequency signaling used by DSL from interfering with voice. To reduce cost ADSL service uses customer-installed filters. All non-DSL equipment must be behind a filter.

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. This allows removal of half-ringer in NID, minimizing DSL signal loading.

> ***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 Earth ground. All conductors entering the building must be bonded together and equipped with lightning protection. This minimizes potential differences during transient conditions.

10.9.1 Electrical

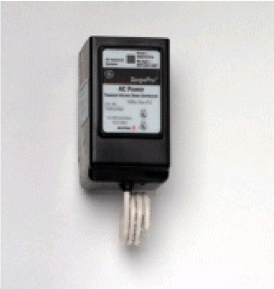


Figure 21 Mains Surge Protector

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

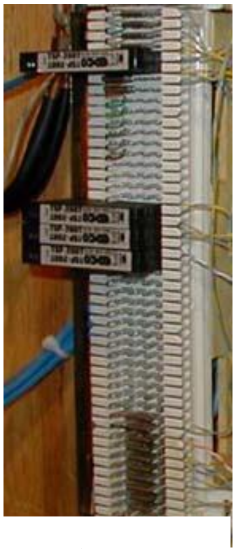


Figure 22 Telephone Surge Protector

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. Protectors clip 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 23 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 also needs to be properly grounded where it enters the dwelling.

10.10 Power Distribution

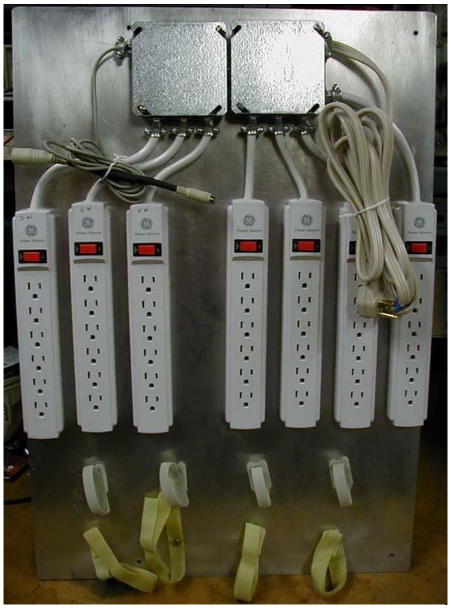


Figure 24 Power Panel

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.

<u>Power Panel requirements</u>

- 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 constant on strips with six receptacles each and three strips controlled by workstation. An adapter cable plugs into PS/2 keyboard or mouse port sensing 5 Volts to solid-state relay that controls switched outlets.

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.

<u>Power Tip</u> -- some power managed PCs leave PS/2 ports powered all the time to allow keyboard controlled wake-up. In that case panel needs to sense power directly from PC main power supply.

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. Punch down tool with interchangeable blades for 66 and 110 termination is needed for both LAN and telephone work. Found a handy palm rest at local big box home center to hold Jack during termination. Makes termination easier in confined places. 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.

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
Breakout adapter	Electrical access to each wire

Cable Ripper

RJ11/45 Crimper

66/110 Punchdown

Wiring Tester

POTS Telephone Tester

Breakout Adapter

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 wiring closets, one for phone and alarm wiring another for networking.

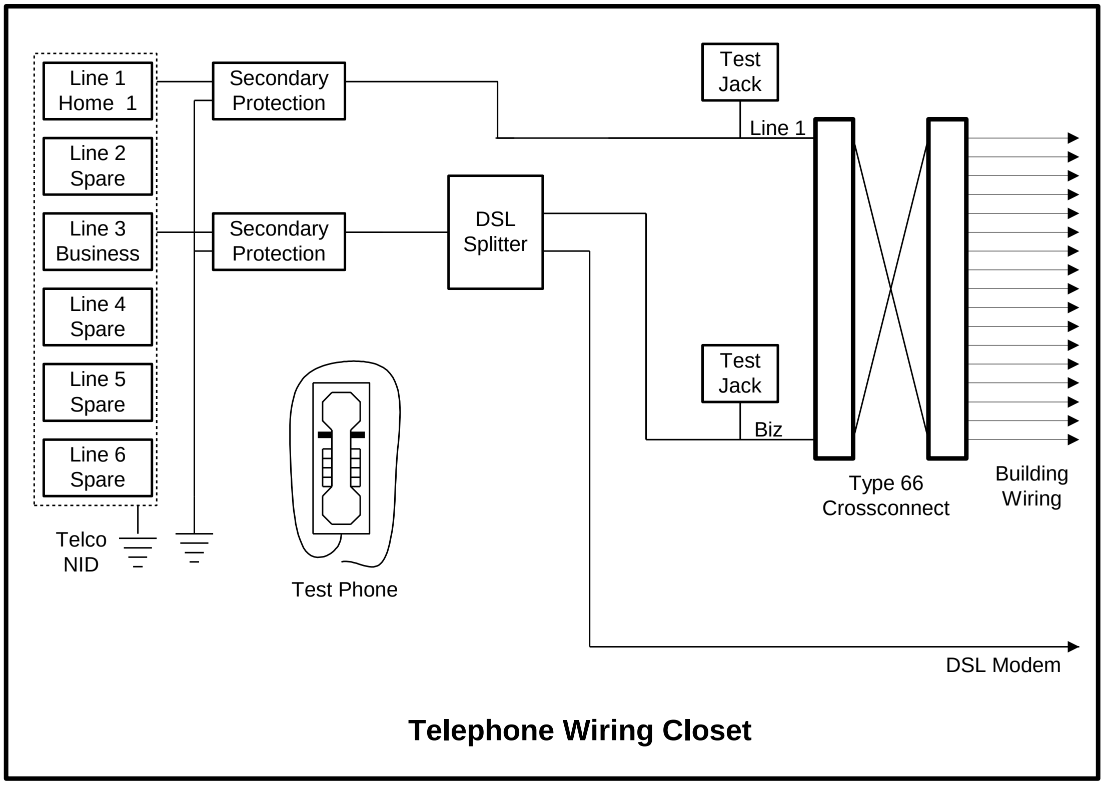


Figure 25 Telephone Wiring Closet

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 changeover easier all building wiring is terminated on punch down blocks. Short twisted pair wire, called cross-connect wire, is used to interconnect various circuits. 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.

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 then 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 between LAN patch panel and telephone wiring closed, added drops in cubbyhole above bedroom closet for WiFi Access Point and increased number of drops in my office from four to six. Most rooms are equipped with two Ethernet drops.

When I initially installed LAN did not use patch panel. Chose to reduce wiring cost by terminating each horizontal LAN cable directly with a modular plug. 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. As part of the most recent upgrade reconfigured system with 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 18 of 24 ports leaving 6 spares for future expansion. Purchased a 1U hinged bracket to mount panel to wall. Bent a piece of thin gauge aluminum stock to act as a shelf above patch panel. This provides convenient place for Ethernet switch. Switch connects to patch panel with 1-foot patch cables.

Figure 26 16-Port Ethernet Switch

LAN began life back in 1998 with an 8-port 10 Base-T Ethernet Hub, later replaced with 16-port 10/100 Base-T Fast Ethernet Hub. With falling semiconductor prices Hubs are obsolete replaced by Ethernet Switches. Switches eliminate Ethernet Collision domain and each connection operates in Full Duplex (send and receive at same time) dramatically improving performance. Currently using 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.

10.12.3 WiFi Access Point

Figure 27 Access Point

With adoption of WPA2 finally felt confident enough to install WiFi on our SOHO LAN. Chose EnGenius ECB-3220 Access Point. The AP is located in a second floor utility closet providing coverage throughout the building and limited coverage outdoors. To increase range purchased a higher gain rubber ducky antenna.

A feature of this AP is support for Power over Ethernet (PoE). I am not currently using it but it makes providing backup power easy as a single UPS can be used rather then needing AC at every location.
Setup was pretty straightforward. AP defaults to static IP address 192.168.1.1. To configure AP connected it to a spare PC and changed to DHCP client mode. Configured router to use MAC reservation and always issue AP same IP address. AP. Like many other devices it uses Web based configuration.

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

Ideally passphase should be random and very long to defeat dictionary lookup attack. Good passphases are very difficult to generate manually. Luckily Internet once again comes to the rescue with an online passphase generation site. SSID should also be changed to something unique rather then left as default.

Encryption is computer intensive so turning on WPA2 negatively impacts throughput. I find that a small prices to pay for increased security. So far WiFi has worked well – enjoy untethered network access.

11 Laptop – 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. During meetings we often set up an ad hoc isolated network to exchange files among participants.

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.

Windows XP handles Wired and Wireless networking automatically. If both wired and wireless networks are detected wired will be used and wireless ignored. For home use WPA2 and strong password is used. While in the road security or lack of it is dependant on how local Access Point is configured. One needs to exercise caution when using WiFi hot spots, as over the air transmission is easy to eavesdrop potentially compromising sensitive information.

12 Internet 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 and where servers are located. Hosting service charges are low enough to meet any budget requirement.

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 company's name is trademarked. COM TLD is for commercial use, so is the new BIZ TLD. 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 registered domain is unique within its TLD.

The registration process provides information on domain name ownership and creates 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.

Business site requires a static IP address. This provides long-term DNS stability. Primary DNS Nameserver can be moved on site or remain with the ISP. Secondary Nameserver should be located at a different location for maximum reliability.

12.1.1 Email

With a registered domain email is addressed to the domain, not some third party. This personalizes your businesses persona. Hosting services typically provide one or more e-mail accounts. Email is structured as username@domain.TLD. Most hosting services are able to sort incoming mail to multiple mailboxes. This enables employees' to access individual accounts without the need to run an internal mail server.

12.2 WHOIS Record

Information for each registered domain is maintained in the WHOIS database. The database maintains administrative and technical information about the site.

12.2.1 Administrative

Administrative information records data about site ownership and contact.

12.2.2 Technical

Technical information records data about network operation center contact.

12.2.3 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 servers are in separate locations served by different providers. This minimizes risk authoritive Nameserver become 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: +1.9282234815
   95 Melendy Rd
   Milford, NH 03055-3417
   US

Administrative Contact:
   Schmidt Consulting
   Tom Schmidt  admin@tschmidt.com
   +1.6036732463
   Fax: +1.9282234815
   95 Melendy Rd
   Milford, NH 03055-3417
   US

Technical Contact:
   Schmidt Consulting
   Tom Schmidt admin@tschmidt.com
   +1.6036732463
   Fax: +1.9282234815
   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 2009 05:00:00
```

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

12.3.1 Address Records (A)

Address records map host name to IP address.

12.3.2 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 resolve to the same IP address.

12.3.3 Mail Exchange Records (MX)

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

12.3.4 Pointer Records (PTR)

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

12.3.5 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.

12.3.6 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.

12.3.7 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 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 email: hbidad@gmail.com serial: 2007122701 refresh: 86400 retry: 7200 expire: 3600000 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	72.37245.142	14400s (4h)

12.4 Internet Server

There are many ways to operate a publicly accessible server, using a virtual server as part of a hosting service, collocate your equipment at a data center, or run the server locally.

12.4.1 Hosting Service

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 simple site. 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 $30 per year plus another $10 for annual domain registration. Most hosting services have business relationships with a domain registrar. This allows one stop shopping for domain registration/renewal and hosting service. 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 hosting service.

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.

12.4.2 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 limits access to sensitive company data to in-house IT personnel.

12.4.3 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. 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.

Residential broadband services often use dynamic addresses making it difficult to host a server as the address can change without notice. Dynamic DNS services such as DynDNS minimizes this problem. The DNS service is updated each time the server's address change. This works well for personal sites but the site will be temporally inaccessible during address update making it inappropriate for serious commercial use.

Most residential ISPs prohibit customers from operating servers. Some enforce this restriction aggressively other turn a blind eye unless there is a problem. My ISP, FairPont, does not allow servers on residential connections, but not enforce the restriction unless there is a problem. They block incoming access to TCP Port 80, the initial port used to connect to Web server. This restriction requires the use of alternate port.

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, coding HTML manually. For more complex sites specialized tools such as Dreamweaver can be used to good advantage. Numerous companies specialize in web site design if you decide to outsource this task.

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.

12.5.2 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

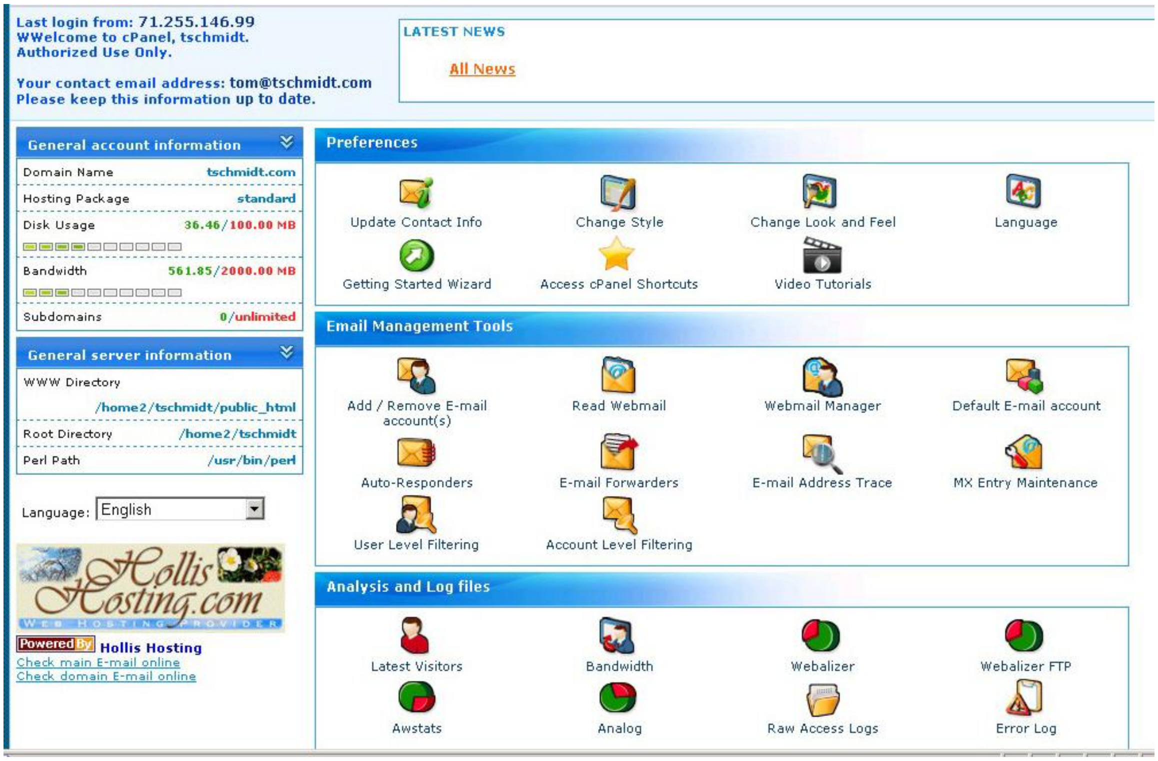
```
# www.tschmidt.com
# Created 2/25/2006

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

12.6 *Managing site*

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

Powered By Hollis Hosting
Check main E-mail online
Check domain E-mail online

Figure 28 cPanel Home Page

Conclusion

Setting up a SOHO network has been an interesting and rewarding experience. 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 the network. The necessary components are readily available but assembling the knowledge needed to create and troubleshoot it 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