How Does My Connection to the Internet Cloud Really Work?

A "big picture" Guide
(with big pictures)

By Greg Barnett
www.clancys.com.au

Contents

I've looked at clouds from both sides now,
From up and down, and still somehow
It's cloud illusions I recall.
I really don't know clouds at all
Both Sides Now - Joni Mitchell

About the Author

Greg Barnett has held technical and management IT positions with University of London Computer Centre, BHP Head Office, Touche Ross & Co., KPMG Peat Marwick and Bond University. He has run his own IT businesses since 1995 including a print-design-service bureau, online problem solving services, general consulting and, most recently, training. While often at the forefront of technology, Greg formed the opinion that, while technology keeps on changing and supposedly improving, the same issues and problems keep rearing their heads … user frustration with inefficiency, wasted time and effort.

Everyone these days "uses" programs like Word and Excel, but people "don't know what they don't know" so few possess an overview of the software. Once they know what each program is good for (and what features to avoid) and the important tips and tricks, confidence improves and efficiency soars.
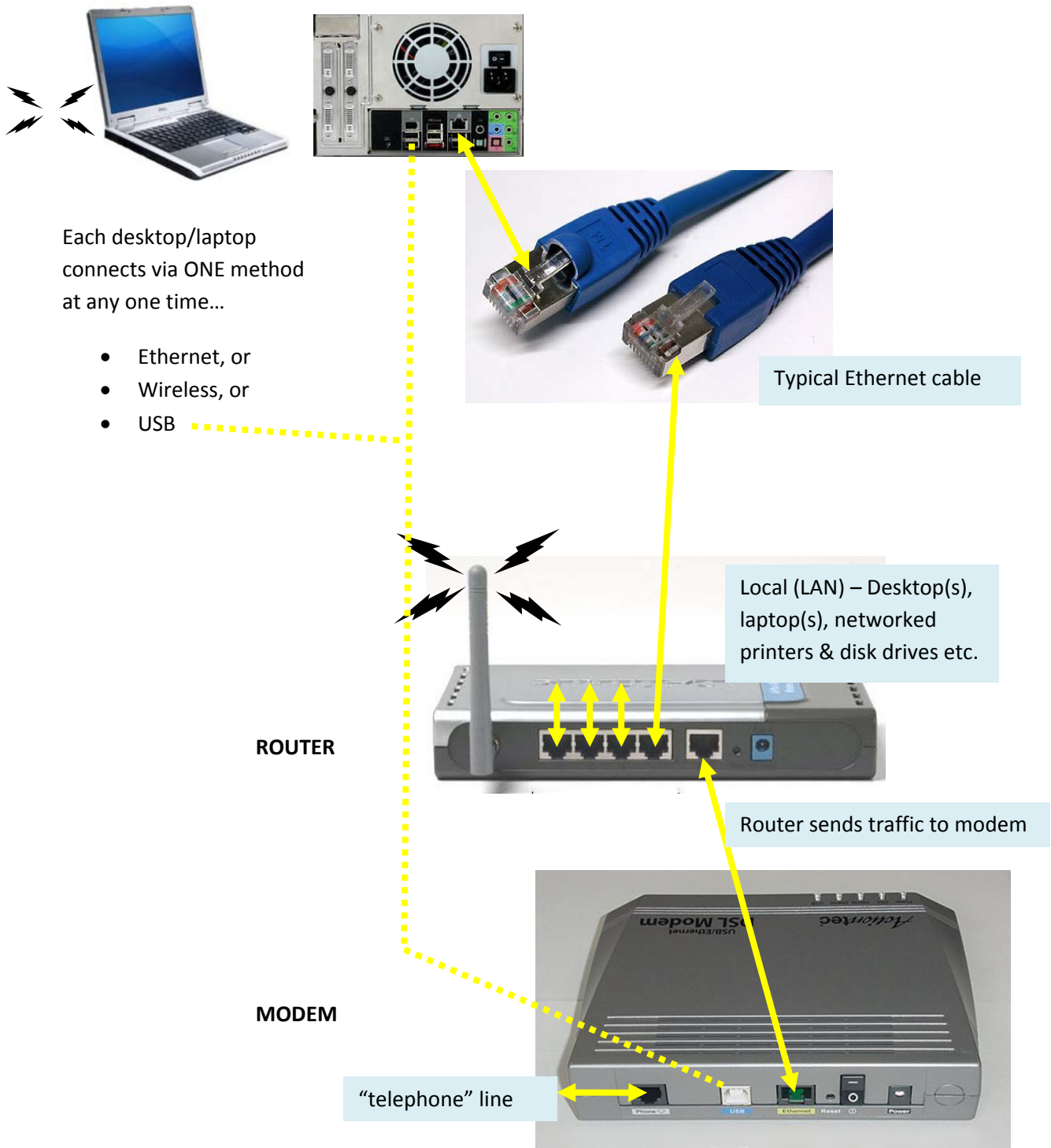
Greg is now using his considerable experience to provide half-day attractively-priced personalised workshops in the commonest computer tools … Word, Excel, Powerpoint, Photoshop, Illustrator and InDesign, and how they interact with a Windows environment. He is also available to visit you on-site if you have specific issues to discuss. He still performs work for clients and provides national & international support via Skype.
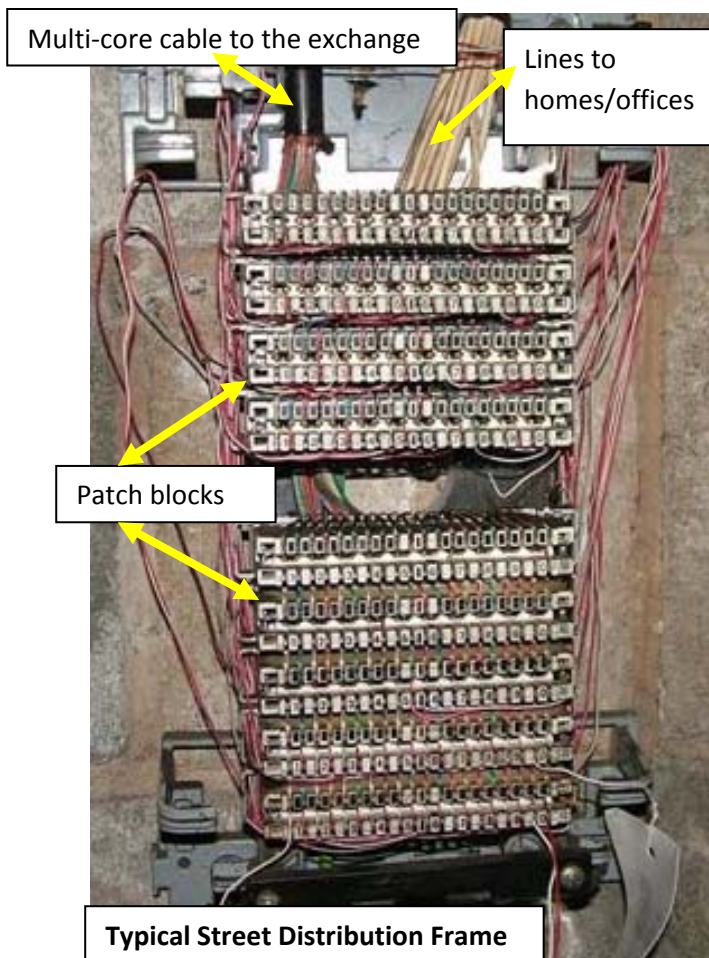

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NOTE. This simple document was laid out using standard MS Word features.

Typical Home/Office Networks

Each desktop/laptop connects via ONE method at any one time…

- Ethernet, or
- Wireless, or
- USB

Typical Ethernet cable

Local (LAN) – Desktop(s), laptop(s), networked printers & disk drives etc.

ROUTER

Router sends traffic to modem

MODEM

"telephone" line

As technology improves, modems & routers are increasingly being combined into a single unit. Such a unit can handle wireless AND wired connections within the home/office AND connect them via the "telephone" line to the internet. (This is a saving on power, power points, and installation hassles.)

The Connection beyond your home/office

Multi-core cable to the exchange

Lines to homes/offices

Patch blocks

Typical Street Distribution Frame

Telephone transmission technology standards are close to 100 years old. Fuzzy audio, clicks, echoes etc. were acceptable because the brain is superb at extracting contextual information. Data however requires 100% accuracy and telephony is simply not up to the job. Fax can be carried over telephone lines, but we'll stick with the "digital needs digital" mantra.

A telephone line is the only physical communications link to the outside world for most people. Telephones (a single pair of wires running approx 40V at very low current) are historically analogue. Some residences have 2 pairs of wires run to the house (for service backup or for an additional telephone number if later required).

Your (and all your neighbours') telephones wires run to the nearest wiring frame in the street. This is a rectangular or cylindrical hip-height box in the street, and you often see the cover off and a van + technician sitting next to them, poking at the wire-filled innards.

The picture here is an old model … new street distribution frames are more dense and compact.

Distribution points like this allows more efficient multi-core cable (e.g. 50-pr, 100-pr) to be run back to the nearest Telstra telephone exchange underground or overhead.

A handwritten book in the box and documents the house (on one side of the connection block) and the relevant matching wires in the multi-core cable they connect to. The large numbers of wires are differentiated by different colours, stripes and bands, and this is why, historically, "Telecom" engineers were tested for colour blindness.

This physical wire link from your home/office ends at the nearest Telstra telephone exchange. The development and age of your locale determines whether an exchange is close to your house (see later comment on speed vs. distance). New areas have fewer, more widely distributed exchanges. Older areas (e.g. central Melbourne, Sydney, etc.) have more, closer together.

The wire circuit from your house end up somewhere on vast main distribution frames (MDFs) at the exchange. For telephony, a physical connection (*patch*) is made from the MDF to an electronic card (in a cabinet of cards) which links you and several other houses to all the other electronic equipment at the exchange which recognise and respond to your phone going "off-hook" and dialling, and switches (routes) your call to the number you keyed. All exchanges are interconnected, just like an Internet for phones, passing control information about the call origin/destination between them. All exchanges have been using digital control and logic since the 1980's.
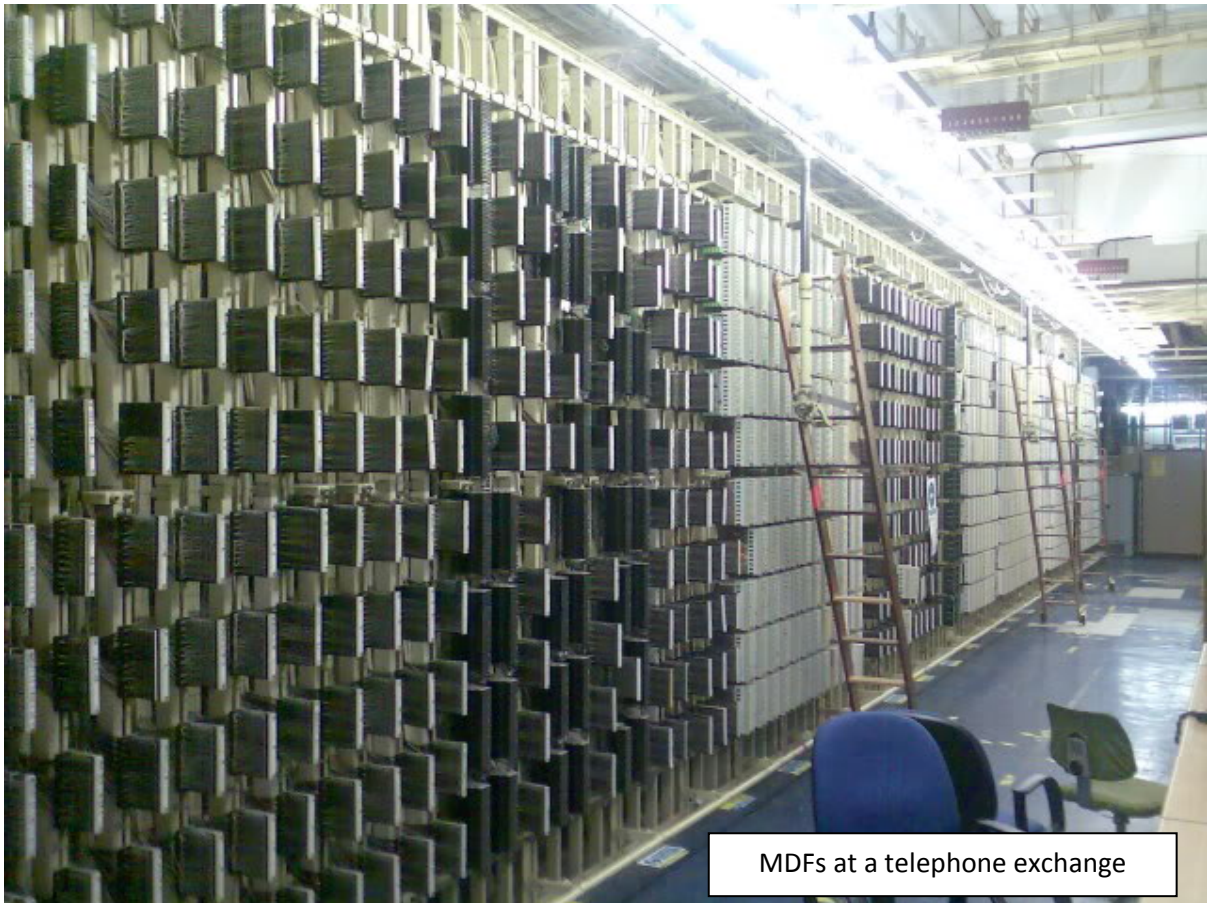
MDFs at a telephone exchange

Getting Digital Transmission onto the Analogue Telephone Line

Considering we usually only have that ONE physical connection to the local exchange, and historically it is analogue (for voice) and runs at a voltage unsuited to computers (most computer signals work at 5V), something must happen before we can use it as a line for digital transmission.

DSL, ADSL, ADSL+2

1. We opt for a particular type of service that turns the line into a Digital Subscriber Line (most of us use A-DSL …. **A**synchronous **D**igital **S**ubscriber **L**ine). Whichever service we choose, data can co-exist with the analogue voice signals by travelling at different frequencies on the same wire. *Multiplexing* is the term for sharing a link.
2. At the exchange end … your physical link is taken off the POTS (Plain Old Telephone System) and is rewired to a spare port on a DSLAM card (Digital Subscriber Line Access Multiplexer).
3. The DSLAM separates the data and telephony components.
    a. Telephony is rewired back to the POTS
    b. Your data is mingled (multiplexed) with other data from other connections on the same card and sent upstream
    c. Data from all the DSLAMs on one rack is mingled (multiplexed) and sent upstream
4. At the home/office end, the POTS part is prevented from interfering with the data stream by using cheap "line filters". One usually comes packaged with every modem, and extra units can be purchase for less than $20 at most electronics stores.

Common Line Filters

where a phone and modem need to share the same wall point

*for any phone-related device connected using the same phone number elsewhere on premises (e.g. handsets, faxed)*

All phones, faxes, answering machines, alarm systems, that have a telephone "line" cable going to a wall socket MUST have a filter installed because somewhere on your premises all these wall sockets come together to share the only line you have to the outside world. Electrical interference from unfiltered POTS equipment can seriously affect the proper functioning of your data connections.

Equipment racks these days are quite boring – no longer a galaxy of flashing lights …

… but they still have spaghetti wiring at the back.
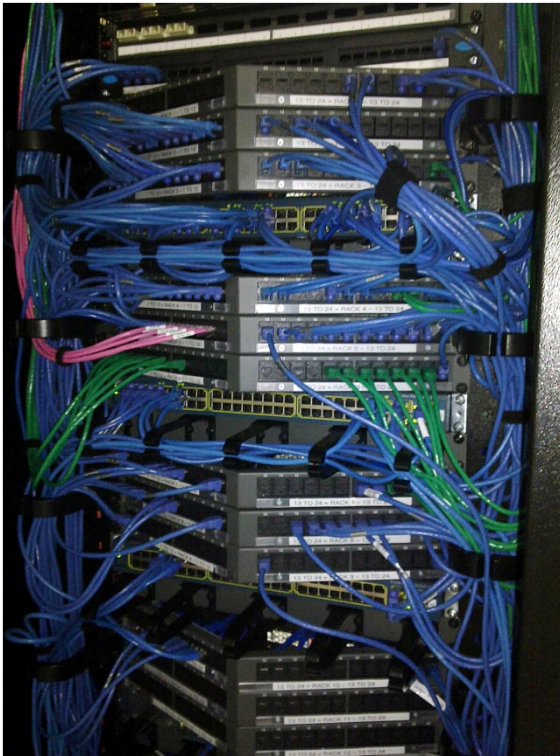
Cabinets of racks, rooms of cabinets, buildings of rooms, etc.

Photos are of OnTheNet's extensive secure data centre on Queensland's Gold Coast.

Photos by Greg Barnett

ISPs and What They Do

No one, in Australia anyway, can get "onto" the Internet without entering into an agreement with an ISP (Internet Service Provider). For example:

- you may be able to browse the internet and send email from your mobile handset
- an "internet" company has "provided" ADSL to your home
- you are using roaming wireless broadband access with Optus or Telstra so your laptop can access the network from anywhere

Usually, whoever Invoices you for your internet link is your ISP. **OnTheNet** on the Gold Coast is one. Others include Telstra, Optus, TPG, iiNet, dodo, etc..

The DSLAM at the local exchange, where your land line terminates, is installed there and owned by your ISP. This only became possible due to important deregulation in the 1990's … prior to this Telstra/Telecom had a monopoly and sole access to exchanges – services were expensive and uptake of new tech was slow, and Internet access was limited to universities and government.

Each DSLAM is internally programmed by your ISP so that your data is routed to your ISP's digital services. Every ISP is government regulated and is an authorised "gatekeeper" and point of entry to the internet. "The Matrix" really starts from here … ISPs operate multiple computers and routers which connect to major government-regulated super hubs (computers and routers) via very high speed links. Backup for power, machines and links are part of the matrix so that, if any element fails, traffic is automatically rerouted to reach the final destination.

ISPs worldwide "recognise" each other via tightly-controlled international naming conventions (IP or Internet protocol) involving the allocation of equipment addresses, and specific ways of handling data and errors. All domain names convert to IP addresses managed by ISPs. The IP addresses you use at home/office can be anything you want as they get tucked into other addressing digital envelopes by the ISP before being set free onto the internet.

Powering Up … what happens to make the internet connection

Router:
- Boots its own internal software (any digital device must have internal software to work)
- Checks its own wired and wireless ports for activity
- Shunts data back & forth between the ports (local traffic) e.g. PC-to-printer
- Diverts data destined for the internet to the uplink --- the modem

Modem:
- Boots its own internal software (any digital device must have internal software to work)
- Looks for and tests line conditions (e.g. at its simplest, that a telephone line meeting specifications is connected)
- Attempts to establish communication (handshake) with a suitable device at the other end and, if successful,l simply show a READY light and looks for data to process
- As required, passes data between the ISP and the router,

PC/Laptop
- Boots its own internal software (e.g. Windows, Mac OS, Linux) and starts up the appropriate networking software that has been installed

- Depending on what's been configured as its network method (via the Network *Control Panel)*, it will check its Ethernet port, USB or wireless connection for the network device it expects to be there
- Establishes the connection and becomes READY (an appropriate icon on the TaskBar)
- As required, transmits data upstream, or receives downstream data

ADSL – all things are NOT equal

Split Speeds
The A in ADSL means **A**synchronous – "NOT-equal time". Incoming & outgoing data are handled at different speeds. E.g. my own ADSL link is "1.5Mbps", but this is only for incoming/download data traffic. My outgoing/upload traffic is limited to 256Kbps.

This disparity was fine when all we were "sending" was mouse clicks, text emails, and small digital photos. However these days we are just as comfortable using the internet for videoconferencing, digital phone calls (VoIP), sending video files, and our photos are getting ridiculously large (consumer cameras are getting to the 20MB range, which means high quality JPGs will be 4-5MB each).

Apples and Oranges (will I get a Trademark infringement letter for saying that??)
Furthermore, FILE sizes are expressed in BYTES (**K**ilo**B**yte - thousands, **M**ega**B**yte - millions, **G**iga**B**yte - billions), whereas connection SPEEDS are always given in bits per second (e.g. 1.5**M**ega**bps**).

A byte is 8 bits, communications can never at 100% capacity, AND control information is also embedded in data communications (just like envelopes are used to send letters). **So a 1.5Mbps line speed means approx 150Kbytes per sec download … AT BEST!**

In my case, as my uplink speed is 256Kbps, the FASTEST I can *send* information is 26.4KBytes per sec … which is why videoconferencing is still jerky and is best viewed in small windows. And also why it takes much longer to send email attachments than it does to receive them.

It's Not Just You
This uplink bottleneck works *both ways*. YOU have a small pipeline for sending YOUR video. The OTHER person has a similar small pipeline to send THEIR video. **DOWNLOAD SPEEDS may therefore NOT be the limiting factor for perceived communication problems.**

End-to-end Connections in "The Matrix"
Don't forget, we have said these speeds are AT BEST. You also need to be aware that all network traffic has to traverse multiple pieces of equipment (tens of thousands of dedicated computerised boxes that run the internet) and cables, competing with other traffic (other users) for timely access to ensure the illusion of smooth activity. In reality, there are conflicts, traffic jams, late & lost data and behind-the-scenes auto-requests to repeat late/lost data. There are also equipment and cable failures, software glitches, and also nasty and pathetic people actually trying to cause chaos. These things cause minor/major traffic chaos and data is automatically (and sometimes manually) rerouted without us, the users, being aware of it. It rarely makes the news unless the effects are nationally catastrophic. This is why videoconferencing can judder to a halt, or video & audio get out sync, emails arrive late, web pages do not load, etc..
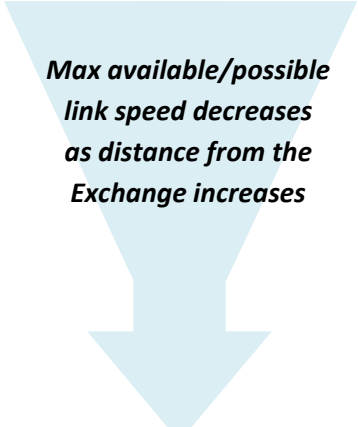
APPENDIX

Speed versus distance

The longer the wire, the slower the maximum possible data rate. The following is a rough guide to maximum data rate you can expect according to your distance form the exchange. Local conditions may vary, especially beyond 2 km:

- 25 Mbit/s at 1,000 feet (~300 m)
- 24 Mbit/s at 2,000 feet (~600 m)
- 23 Mbit/s at 3,000 feet (~900 m)
- 22 Mbit/s at 4,000 feet (~1.2 km)
- 21 Mbit/s at 5,000 feet (~1.5 km or ~.95 miles)
- 19 Mbit/s at 6,000 feet (~1.8 km or ~1.14 miles)
- 16 Mbit/s at 7,000 feet (~2.1 km or ~1.33 miles)
- 1.5 Mbit/s at 15,000 feet (4.5 km or ~2.8 miles)
- 800 Kbit/s at 17,000 feet (~5.2 km or ~3.2 miles)

Max available/possible link speed decreases as distance from the Exchange increases

Network Technology Speeds (what *is* the weakest link?)

Network Speeds within the most Home/Offices:

- USB 1   12Mbps (peak)
- USB 2   480Mbps (peak)
- 802.3   Ethernet (continually evolving). The current common ones for home/office are:
    - 100Mbps – the most used "Fast Ethernet"/100BaseT
    - 1000Mbs - Gigabit Ethernet/1000BaseT (modern wiring plus optic fibre)
- Short-distance wireless
    - 20-50Mbps - 802.11/g   (~ 100m max)
    - 100-300Mbps - 802.11/n   (~ 250m max)

Typical Internet connections:

- ADSL   1.5Mbps – most common speed
- ADSL 2+ 8Mbps +
- Broadband wireless (direct from PC to carrier e.g. NextG/3G wireless)

    1-20Mbps depending on other network traffic and signal strength. Mobile phone service quality is patchy. Sustained speed of 20Mbps is rare.

NOTE 1. These Internet Connection speeds are MUCH SLOWER than ALL the current home/office networks … your home/office network is rarely the cause of slow "internet response times"!

NOTE 2. The Australian NBN, offering optic fibre to the home/office, is touted as the solution to everything, including world peace. Policy propaganda has shown high-def video medical consultation and education. How can this succeed unless there is appropriate equipment at both ends, and at all points in-between to allow such massive data flow work seamlessly? By contrast, just **2Mbps both ways at 90% throughput** would make most people ecstatic, enable most current and near-future applications, and wouldn't cost well in excess of the "I think around" AU$40 Billion !