Module Nine

CSG1105 Applied Communications

May 3, 2020

Wide Area Networks (WANs)

- LANs
  - So far, we have mostly been considering LANs and their implementation
  - LANs are usually considered to be a single site a room, building or group of buildings
  - LANs are implemented with technologies that generally have short distance limits
- WANs
  - The primary purpose of WANs is to connect LANs
  - WANs may span a city, country or the entire planet (Even the ISS!)
  - WANs are implemented with technologies that can span long distances
  - WANs are generally implemented using **Common Carrier Services**
  - Common carriers are Telecommunications companies like Telstra, Optus, Amcom

WAN Issues

- WAN links are (generally) lower bandwidth than LAN links
- Latency in WANs is higher than LANs
- The WAN network access layer is (generally) different to the LAN layer
- WAN links (generally) incur a recurrent cost
- WAN maintenance and repair is (generally) not under the control of the organisation
- Some WAN technologies share capacity with other users, resulting in unpredictable throughput

Common Carriers

- In most jurisdictions, operating a communications service beyond the boundaries of a single site requires licences from the government
- The original WAN links were voice links with the computer signals converted from digital to analogue (ref: Module Two)
- The phone links were **circuit switched** with a end to end connection
- With the rise of computers, carriers started to provide copper **Leased Lines**, a dedicated point to point connection that didn't involve having to dial a number to establish a connection
- To link Computers or LANs on different sites, interface equipment (MODEMs, routers etc) and leased lines would be procured and built using an appropriate **topology**. (ref: Module 7)

Simple Leased-Line WAN

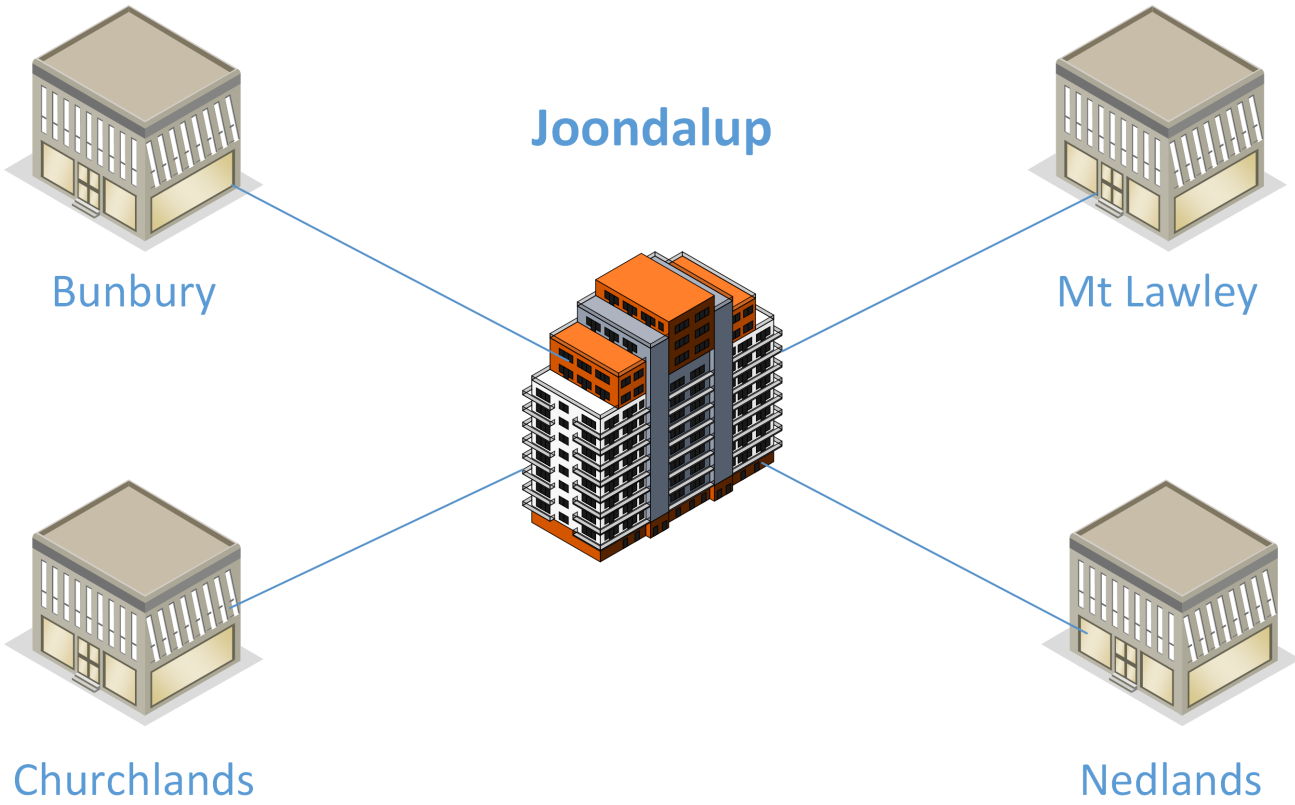

Figure 1: WAN

Private WAN Services

- Over time, standards bodies and carriers developed protocols for the implementation of WAN connections that were separate to voice services
- Companies linked sites using services provided by common carriers
- Earlier private WANs were to link sites **not** to the Internet, generally to mainframe computers
- Links to central sites may still occur if all Internet access is to be filtered through a single point for security purposes

Private WAN Technologies

- X.25
- ISDN
- Frame Relay
- ATM
- MPLS
- Carrier Ethernet

*Mostly Obsolete

X.25

- X.25 is a **packet switching** WAN technology, designed in the mid-1970's
- Connecting to an X.25 network required a dial-up or leased line connection to an X.25 PoP
- The addresses in X.25 networks were very similar to phone numbers
- The internals of the network were opaque to the end users
- Connections, once established, acted like circuit-switched connections
- Ad-Hoc connections could be done using **Virtual Calls**
- Permanent connections cold be done using **Permanent Virtual Circuits (PVCs)**
- Costs consisted of a fixed connection fee and a fee for total traffic per billing period
- X.25 had the reputation of being very fault-tolerant, even running over fencing wire (temporary connection when phone cable was severed)

ISDN

- ISDN - Integrated Services Digital Network
- Technology was designed in the late 1980's
- It was an approach to integrate both voice and data services
- It consisted of aggregations of 64kb channels, a single 64kb channel supported a single voice channel
- Two primary services were 1) **Basic Rate** 2x64kb B channels and a 16kb D management channel and 2) **Primary Rate** 30x64kb B channels and two 64kb D channels
- For data transmission purposes, the B channels were often aggregated giving a 128kb connection for Basic rate and a 2 Mb connection for Primary rate
- Required specialised interface equipment for the customer end points

Frame Relay

- X.25 included substantial provision for operation over error-prone analogue media designed for voice
- The error checking restricted the performance of X.25 links
- Frame relay was based on X.25, but designed to run over reliable digital media like ISDN
- The digital media has lower error rates and frame relay does not perform error correction as did X.25, it simply drops bad frames, leaving the higher layers to recover
- Frame Rely, with the reduced error recovery, is far faster than X.25
- Like X.25, Frame Relay provides virtual circuits
- Frame Relay is in decline as a WAN protocol as new services provide superior links

ATM

- ATM (Asynchronous Transfer Mode)
- ATM is a packet switching protocol developed to provide links for B-ISDN (Broadband ISDN)
- Unlike IP, all ATM "cells" are the same size, 53 bytes (48 payload + header)
- A path through an ATM network is established at connection setup and all cells are switched through the same path, allowing rapid transfer
- ATM, like Frame Relay, is in decline as newer services emerge and dominate
- ATM has survived as the lower-layer service of ADSL and is also used in WiMAX

MPLS

- MPLS (Multiprotocol Label Switching)
- MPLS can operate over many lower-layer protocols and is independent from them
- MPLS was designed with IP compatibility in mind, unlike Frame Relay and ATM
- MPLS as the name *Multiple Protocol* implies, can carry any payload (IPv4, IPv6, **Ethernet**, ATM, DSL and Frame Relay)
- Labels are applied to incoming traffic which identify where and how the traffic is to be directed.
- Other protocols are often **tunnelled** over MPLS to provide legacy support or network **bridging**.
- MPLS is often used by Common Carriers for service provision.

Carrier Ethernet

- Ethernet technologies originally distance limited by signalling on copper for CSMA/CD
- Optic Fibre extended range available
- High speed WAN technologies permit Ethernet to be used over WAN connections
- Often tunnel through other services such as MPLS
- Module Six: VLANs - Double Tagging

Carrier Ethernet Example

- A **traceroute** on Telstra Bigpond shows internal use of ethernet by a common carrier
- They offer a national ethernet service, **National Ethernet**

```
tracert google.com

Tracing route to google.com [216.58.196.142]
over a maximum of 30 hops:

  1     6 ms     4 ms     3 ms  mygateway [10.0.0.138]
  2    36 ms    53 ms    28 ms  gateway.wb05.perth.asp.telstra.net [58.162.26.133]
  3    27 ms    27 ms    26 ms  203.50.25.32
  4    56 ms    73 ms    69 ms  bundle-ether3.fli-core10.adelaide.telstra.net [203.50.6.232]
  5    65 ms    63 ms    65 ms  bundle-ether16.win-core10.melbourne.telstra.net [203.50.6.229]
  6   114 ms    78 ms    82 ms  bundle-ether12.ken-core10.sydney.telstra.net [203.50.11.122]
  7    76 ms    76 ms    76 ms  bundle-ether1.ken-edge903.sydney.telstra.net [203.50.11.173]
  8   109 ms    81 ms   118 ms  goo2503144.lnk.telstra.net [58.163.91.202]
  9   119 ms    76 ms    82 ms  108.170.247.81
 10    78 ms    77 ms    77 ms  209.85.142.137
 11   117 ms    80 ms   113 ms  syd15s04-in-f14.1e100.net [216.58.196.142]

Trace complete.
```

Figure 2: Bigpond traceroute to google.com

Public WAN Connections

- The previous technologies are generally used to construct **Private** WANs
- Technology specific connection and interface equipment need to be procured
- Configuration of connections and traffic under the control of the company
- ISPs (**Internet Service Providers**) provide access to a **Public** WAN, the Internet
- There are ISPs who provide consumer access and ISPs who are **backbone** providers, linking small ISPs and enterprise customers

Dial-up (obsolete)

- The original consumer internet access used dial-up MODEMs
- Land-line phone connection was analogue, converting sound to electrical signal
- Voice connection unavailable when data connection was in use
- The maximum data rate was 56 **kbps** (*not Mbps*) and was often much slower depending on distance from exchange and quality of copper cabling
- Still available (surprisingly :-))

ADSL/VDSL

- ADSL (Asynchronous Digital Subscriber Line)
- Split speed - High download, slow upload
- Most common technology to provide Internet connections for home and SOHO (Small Office Home Office) use
- May utilise existing fixed phone copper connection (one of two pairs)
- Speed is very dependant on a) distance from exchange b) quality of cable
- Speeds of up to 8/1 (ADSL), 24/1(ADSL2+), 24/2.5 (ADSL2+ Annex M) Mbps
- VDSL (Very high speed DSL)
- Speeds of up to 55/1 (VDSL), 200/100 (VDSL2), 300/100 (VDSL Annex Q) Mbps

Cable

- Internet access over Coax/HFC connection used for cable TV access
- Requires a specific *cable modem*
- Not broadly deployed in Australia
- Unlike DSL where ISP may be chosen, usually single ISP - CTV provider

Wireless

- Internet access provided via EM spectrum, requires external antennas
- WiMax (ref Module 8) LoS to ISP tower, Speeds up to 350 Mbps
  - Perth ISP PentaNet uses AirMAX, a similar last mile protocol
  - Comparable speeds to cabled connection
- Satellite (ref Module 8) Speed typically 25 Mbps down, 5 up

Cellular

- Access to Internet via Cell phone towers
- Use 3G/4G/5G technology
- Speeds very variable, distance from tower, number of users, technology used
- Expensive, $AU 8-10 / Gb
- Mobile, accessible anywhere cellular access available
- Often used by field workers
- NBN Fixed Wireless
  - NBN uses 4G/LTE for it's Fixed Wireless Internet service
  - Fixed wireless currently offers speeds of up to 12Mbps
  - Requires an external antenna

VPN

- Virtual Private Networks
- This will be covered next week

Infrastructure

- Connecting a LAN to a WAN requires
  - A router - performs routing and security functions as well as link layer protocol conversion
  - MODEM (Modulator/Demodulator) or NTU (Network Terminating Unit) to convert LAN digital signals into a format suitable for WAN.
  - Domestic routers combine Router, MODEM, NAT gateway, Firewall, Switch and Wi-Fi Access Pont