

LECTURE WK4 – NETWORKING

Workbook and Quiz

- Workbook
 - Due in WK5
 - Must hand in a hard copy to the tutor as well as an online submission
- Quiz
 - In the practical class
 - 30mins to complete the quiz
 - Short, fill in the box questions
 - 4 questions, one per week, one per topic

How do you Communicate with the Raspberry Pi?

- On your PC you send characters from the keyboard down the serial cable
- The PC also receives characters from the serial cable and writes them to the screen
- The serial cable has characters travelling both to and from the Raspberry Pi and the PC
- The serial cable represents these characters as electrical pulses - 8 on or off pulses (bits) per character
- The RPi finds the programs typed by the user and runs them
- Bash is the program running on the RPi, when you hit enter 'bash' figures out what to do
- For some commands like ls, bash knows what to do, however, for most commands, bash must search in specific places for programs with those names

What is the Internet?

- The internet and the web are different
- The internet is a communications network which links computer systems together
- The web is a particular system that runs on top of the internet for web pages

Licklider

- Ran advanced projects in the US
- Foresaw modern interfaces
- Came up with the idea of the internet
- Ran the first 'internet' the ARPANET
- Wasn't until 1995 that the internet really took off

Networking

- A lot of computer systems don't make sense by themselves
- The network connecting computers gives them more value
- To move data and communicate
- Internet is a global network of computers
- Web is HTML webpages that operate over the internet
- Can network with people, devices, ...
- **Metcalfe's Law** says the value of a telecommunications network is proportional to the square of the number of connected users of the system (n^2)

Key Terms and Concepts

- **LAN:** Local Area Networking (LAN) e.g. networking within a home, building or organisation
- **WAN:** Wide Area Network, internet between organisations – doesn't really exist, only a lot of LANs – WAN is the things outside of **our** LAN
- **Protocol:** formats and rules for exchanging digital messages – agreed (predefined) ways for things to interact e.g. all USBs work the same way
- **TCP/IP:** internet protocols for communicating on internet
- **Broadband:** high speed internet, particularly for homes, much faster than older 56Kpbs modems
- **Ethernet:** family of computer networking technologies for local area networks (LANs).
- **Voice over IP (VOIP)** – send voice sound over internet e.g. skype
- **Data communications** – the transfer of digital or analog data using digital or analog signals
- **Telecommunications** – the study of telephones and the systems that transmit telephone signals
- **Network management** – the design, installation, and support of a network, including its hardware and software
- **Switches:** LAN-LAN, connects devices to network
- **Routers:** LAN to WAN and WAN to WAN, route data between networks
- **Modem:** converts digital data to analog signals and vice versa e.g. ADSL modem for home broadband
- **(Wireless) Access Point:** connect wireless devices to a wired network using WiFi, some contain ADSL modem
- **Network card:** connects a computer to network e.g. Ethernet or WiFi

Measuring Network Performance: Bandwidth and Latency

- **Bandwidth:** data communication speed
 - Measured in bits per second bps (bit is a 0 or 1, byte = 8 bits e.g. a number in range 0-255)
 - Sometimes, confusingly bytes per second (big B or little b)
 - May be different for read vs write, download vs upload
 - e.g. what you'd need to download a movie quickly (it doesn't matter if there is a lag)
 - If you're watching a movie, it doesn't matter if you lose a few bits
- **Latency:** delay to receiving first bit of data
 - e.g. Lag in computer games
 - if you're trying to update software and you miss a few bits it could be catastrophic
- Bandwidth and latency varies between different networks, and can depend on use (congestion)
- Speeds often reduced due to software and other overheads
- Requirements of apps also varies – For streaming media bandwidth is important – For games latency is important
- Other characteristics like reliability, quality of service etc.

Varieties of Wireless Networking

- A lot of wireless networking is about trade-offs in terms of performance – power usage, bandwidth and distance
 - E.g. a smartwatch that needs to send small notifications may be energy efficient but lacks bandwidth
- Some wireless networking is for the internet e.g. 3G, WiFi or Bluetooth
- For 3G and 4G:
 - High power
 - Long range
 - Good bandwidth
 - Poor latency
- WiFi:
 - Usually LAN based networking
 - High power
 - High bandwidth
 - Good latency
- Bluetooth
 - Low energy
 - Low bandwidth

Packet Switching

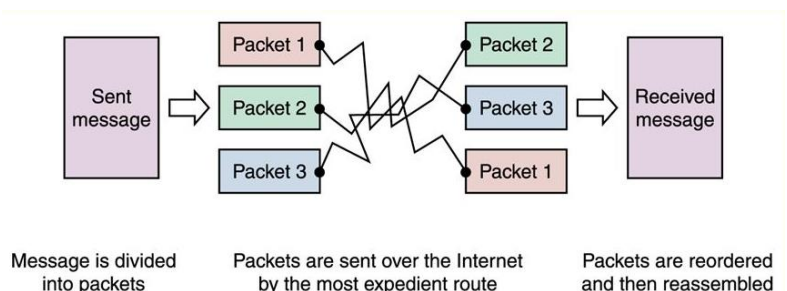
- Breaks messages into small packets of data
- Many forms of packet switching
- Connectionless ones: each packet is sent to destination and contains:
 - Destination address
 - Source address
 - Port numbers – intended program recipient of message
 - Sequence number – so packets can be sent out of order and reassembled
- Used on internet and for wireless communication
- Each packet is independent – can't be interpreted individually
- The packets find their own way to the destination (different routes means they arrive in random orders)
- **TCP** = Transmission Control Protocol
 - Breaks data into packets before they are sent over a network
 - Assembles the packets when they arrive
 - Detects errors and resends lost information
 - Flow-control, connection establishment and reliable transmission of data

- IP = Internet Protocol

- Host addressing and identification – hierarchical IP addressing system
- Packet routing

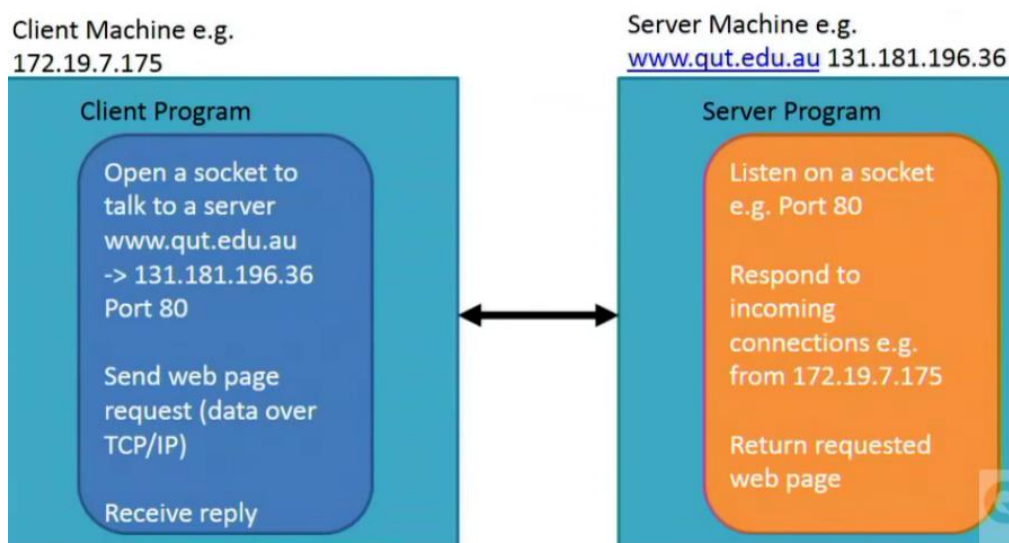
- TCP/IP Layers:

- App layer (e.g. email)
- Transport layer (TCP) – reassembles packets
- Internet layer (IP) – sending the packets
- Network access layer (e.g. physical wire)



Addresses and Identity

- **MAC address:** machine or physical address, unique number given to every network card e.g. 88-53-2E-5F-60-35, burned into hardware
- **IP address:** internet address e.g. 131.181.1.2 (IPV4 address, now moving to IPV6 e.g. 2001:db8::ff00:42:8329), can be static or dynamically allocated e.g. by DHCP server to network card
- **DNS name** (Domain Name System) name e.g. www.qut.edu.au (a DNS server looks up DNS names to IP addresses)
- **URL** (Uniform Resource Locator)
- **web address** e.g. http://www.qut.edu.au, DNS name or IP address and a protocol to access the resource e.g. HTTP
- Some IP address ranges are reserved for local use (LAN/ Internet) and don't get routed
- Local IP addresses are often dynamically allocated via a DHCP (Dynamic Host Configuration Protocol) server
- IPv4: IP version 4
 - Running out of IP addresses,
 - 32bit numeric address
- IPv6: IP version 6
 - more internet addresses (128bit address) and new features
- Ports are part of IP addresses which are used to indicate particular endpoints e.g. 208.54.245.456: **80** for the web
- There are some standard ports used for different high level protocols e.g.:
 - 21 ftp: file transfer protocol (insecure)
 - 22 ssh: secure shell: network protocol for secure communication inc command execution
 - 23 telnet: terminal protocol for command shell (insecure)
 - 25: SMTP: Simple Mail Transfer Protocol (email)
 - 80: for web HTTP: http:// ... etc
 - 443: for secure web HTTPS
- Programs listen on ports for other programs which send messages to them:



PRACTICAL WK4 – NETWORKING

- Make sure you bring your workbook to your practical
- Use STIMULATE if you need to
- The quiz is within your practical

The following commands are very useful for completing this practical:

- ifconfig
 - used to configure or view a configuration of a network interface
 - used to find your IP address
- nslookup
 - looks up a network name server
 - finds an IP address and domain name for a network server
- traceroute
 - sends a packet, showing each hop required to get to the location
- nc
 - reads and writes data across network connections using the TCP or UDP protocol
 - “nc -l 1234” and “nc -l (IP ADDRESS) 1234
- Tcpdump
 - gets a raw dump of network traffic
- Nmap – requires installation
 - a network exploration tool and security port scanner

Use these commands to investigate computer networking. The tasks outlined in the workbook will explore TCP/IP networking using the above Linux command line tools.