Systems and Devices 2 (Network)
Lec 1: Introduction

Course information

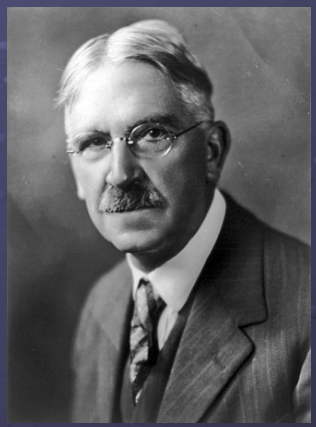
- Lecturer: Michael Freeman
- Office : CSE131, Email : mjf@cs.york.ac.uk
- Home page : http://www.cs.york.ac.uk/~mjf
  - My timetable and links other stuff ...
- Teaching Material : http://vle.york.ac.uk
  - Slides, Laboratory scripts, Exercises ...
    - Lecture slides, teaching material containing supporting background material, examples to help illustrate important points.
      - IMPORTANT: you do not need to memorise specific RFCs or protocols, but you will need to remember a lot of acronyms :)
- Q&A : if you have any questions do pop in.

Module aims

- Module descriptor
  - https://www.york.ac.uk/students/studying/manage/programmes/module-catalogue/module
- What the department says for SYS2(NET):
  - “This module introduces students to the core concepts of computer networking. It starts by covering the layered network model and discusses the utility and motivation for such an approach. Services that are layered on this model (such as UNIX sockets, DNS, TCP, IP) are detailed and students will develop software to experiment with these features. After taking this module, students will have an understanding of how all kinds of computer networks, including the Internet, are created.”

How this module will be taught

- Learning by doing
  - “a hands-on approach to learning, meaning students must interact with their environment in order to adapt and learn”
  - Therefore, you shall :
    - Build different networks: hosts, switches, routers ...
    - Configure hosts and application software to run on these networks.
    - Examine data packets sent over these networks.



John Dewey

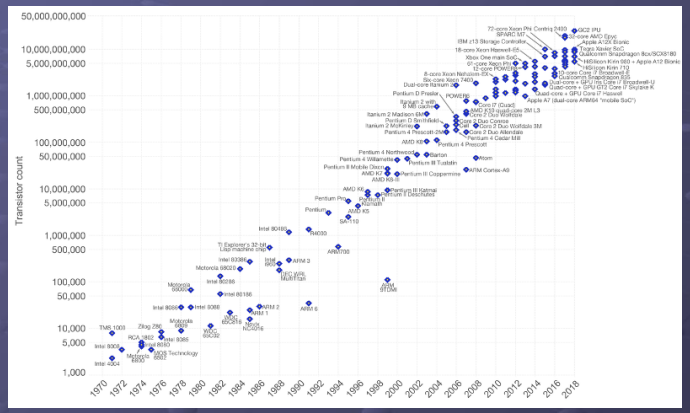
Timetable

Semester one (September 2024 to January 2025)

	SEPTEMBER			OCTOBER				NOVEMBER				DECEMBER					JANUARY			
Week commencing	16	23	30	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27
Week number	S1/0	S1/1	S1/2	S1/3	S1/4	S1/5	S1/C	S1/6	S1/7	S1/8	S1/9	S1/10	S1/11	V	V	V	S1/12	S1/13	S1/14	S1/15
Undergraduate	F	1	2	3	4	5	C	6	7	8	9	10	11	V	V	V	RV	RA	RA	RA
	Freshers		Teaching				Consolidation	Teaching						Vacation			Assessments			
Lecture (recorded)		L1, L2a	L2b	L3a	L3b1	L3b2		L4a	L4b	L5a	L5b	L6								
Practical		P1	P2	P3	PT1	P4	PT2	P5	P6	P7	P8	P9								
Lecture review		R1	R2	R3	R4	R5		R6	R7	R8	R9	R10	RV							

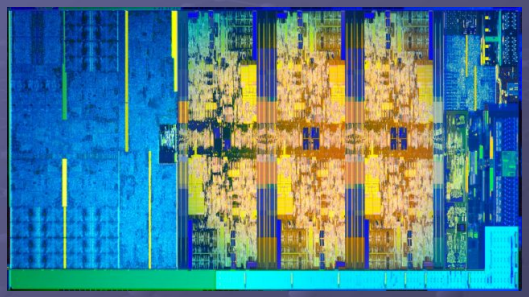
- SYS2(NET) 10 credit “module” = 100 hours
  - Lectures (recorded) (1-6) : 10 hours
  - Lecture review classes (1-9) : 9-11 hours, RV = Revision
  - Practicals (1-9) : 22 hours, PT = Programming Task
- Reflection, research and revision : 22
- Open Assessment : 35 hour
  - Assessed lab questions to be handed in after Week 12

Why is networking important?



- Connectivity becomes more important given the “end” of Moore’s law, the single-atom transistor.

Why is networking important?

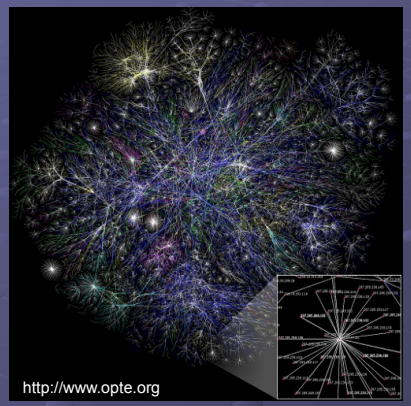


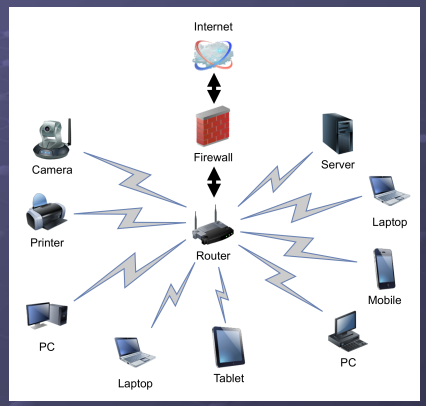
- Improvements to silicon technologies continues to increase processor performance. However, one of the most important developments in processing architectures that should not be overlooked is connectivity i.e. the simple ability to connect two computers together.

Why is networking important?

- Modern modular supercomputers linking together multiple processors, containing multiple cores. NASA's Aitken architecture.
  - 4 HPE Cascade Lake E-Cells, using 100 Gbps links
  - 1,150 nodes, 46,080 cores, and 221 TB of memory
  - 3.69 petaflops theoretical peak performance
  - Web: https://www.nas.nasa.gov/hecc/resources/aitken.html

Why is networking important?



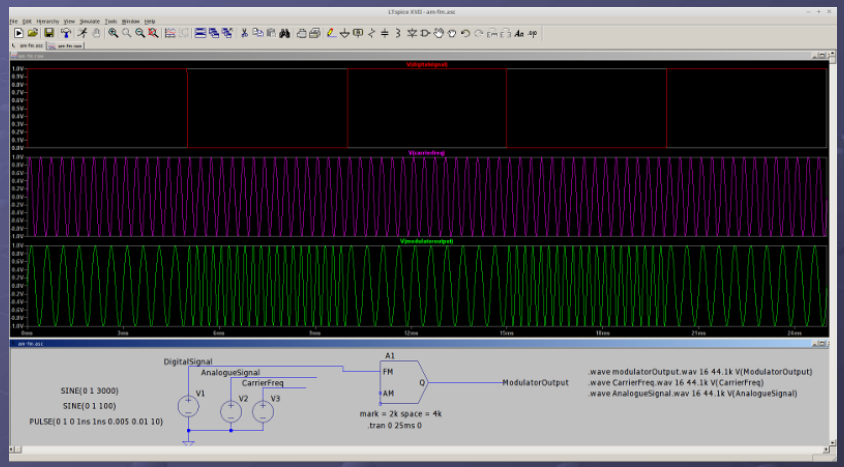


- Finally, we live in a connected world, ubiquitous computing, everything is connected to everything.

When did it all start?

- For me, dial-up modems (1980s)
  - MOdulator-DEModulator
  - Public Switched Telephone Network
  - Limited to 4KHz bandwidth (audio)
  - Copper cables
  - Speed : 300bps - 56Kbps

Demo

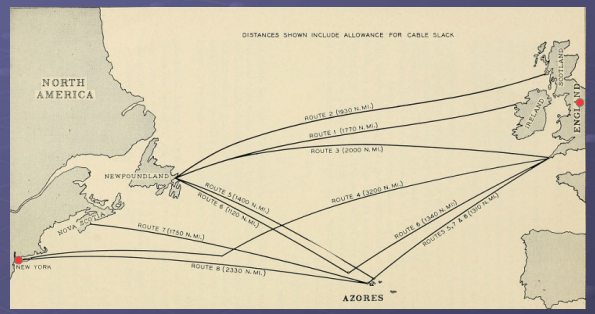


- Q: what are those sounds?

When did it all start?

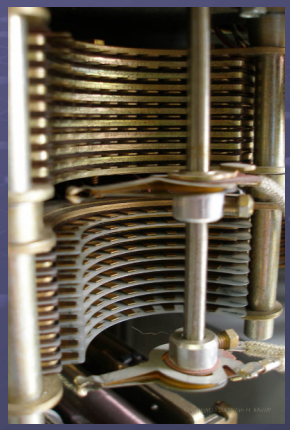
- For you :
  - ADSL : asymmetric digital subscriber line (DSL) modem.
    - Copper cable, connects to Digital Subscriber Line Access Multiplexer (DSLAM) in local exchange.
    - Frequencies 25KHz to 1MHz
    - Speed : ~10Mbps down, ~1Mbps up
  - FTTH : fibre to the home
    - Fibre optic cable
    - Speed: ~100Mbps down, ~10Mbps up
  - FTTP : fibre to the premises ...

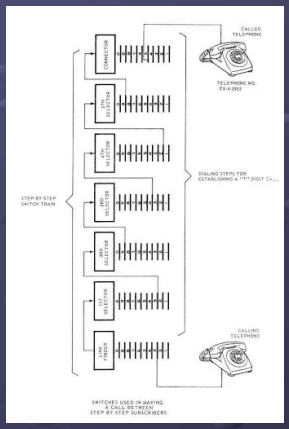
Telephone networks



- TAT-1 (1956 – 1978)
  - Two cables laid, one cable for each direction
  - Underwater valve based repeater to boost signals.
  - 35 speech channels
- Q : how do you connect a telephone in York to New York?

Circuit switching





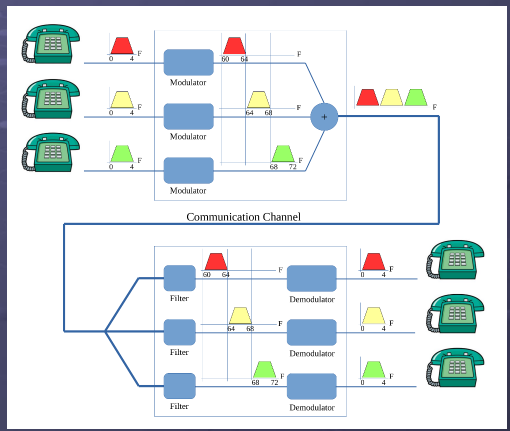
- A : lots of switches, automatic telephone exchange
  - Strowger switch (electro-mechanical / relay based switches)

Circuit switching

- A “classic” telephone network is an example of a circuit switched network. When a call is made specific communication channels (circuits) are reserved for that call.
  - Establishes an end-to-end connection, remains connected for duration of call and guarantees full circuit bandwidth.
- Q : if 100 people wanted to phone New York do we need 200 cables?
- A : no, using some electronics we can share a cable (communication channel) between circuits using:
  - FDM : Frequency division multiplexing
  - TDM : Time division multiplexing

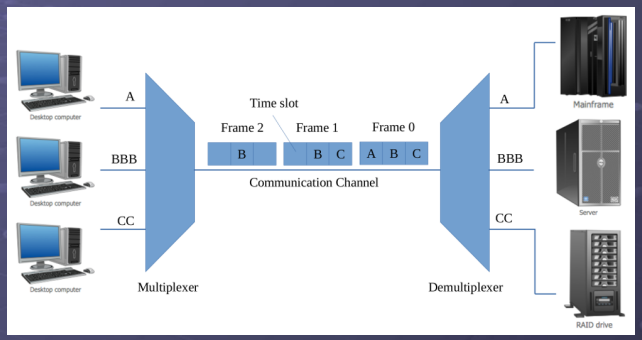
Frequency division multiplexing

- All signals transmitted at the same time
  - In different parts of the frequency spectrum
  - No synchronization needed
- Communication channel’s bandwidth significantly greater than signal’s
  - $BW_c >> BW_s$
- Need guard bands to stop interference (crosstalk)
  - Limits the number of signals



Time division multiplexing

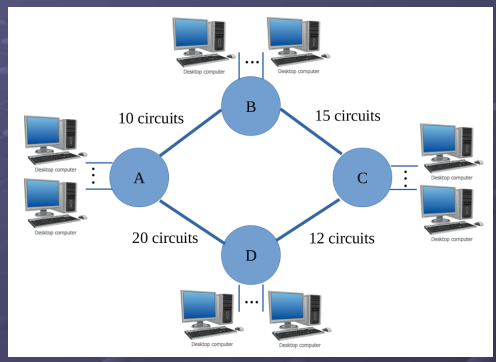
- A signal can use the full channel bandwidth, but only in specific time slots.
  - Synchronised switches



- Available transmission time divided between users : frame
  - Synchronous TDM : time slot in frame allocated to user even if data does not need to be transferred, reducing data transferred rate.
  - Asynchronous TDM : use different techniques to reallocate unused slots.

Quick Quizzz

- What is the maximum number of parallel connections that can occur in this network?
- If each connection requires two hops, connected clockwise, how many connections can be established?

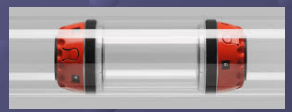


- If each communication channel has a bandwidth of 1.5Mbps, how long will it take to transfer a 1KB of data from A to C?

Problems ...

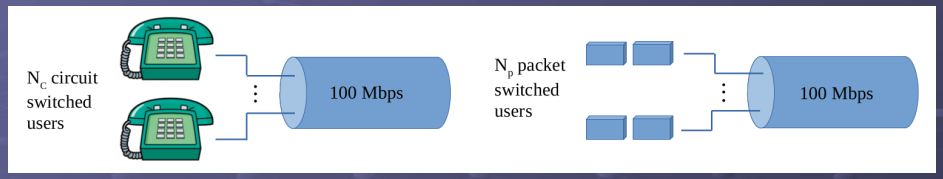
- Connection orientated networks such as circuit switching are great for real time application where we need guaranteed bandwidth, but can result in inefficient utilisation e.g. when no data is being transmitted. Therefore, an alternative approach is packet switching:
  - Transfer and routing of data by means of addressed packets
  - Channel is occupied (“reserved”) during the transmission of these packets. However, on completion the channel is now available to transfer other packets from different sources.
  - Move the intelligence into the switches, let the data find its own path, maximising bandwidth usage.

Packet switching



- The classic mail analogy :)
  - Circuit switching: pneumatic tube carrier
    - A connection orientation network.
  - Packet switching: postal service
    - The exact path taken by a letter from house to house not know e.g. plane, van, bike ...
    - A connectionless orientation network.
    - Store-and-Forward Transmission
    - Full bandwidth available to packets, but we can now loose “packets”

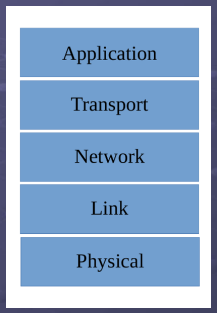
Quick Quizzz

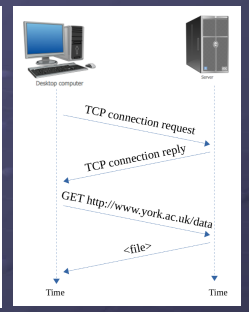


- Each user requires a 10Mbps data link
  - Using circuit switching
    - How many users can connect?
    - What are the maximum and minimum transfer speeds?
  - Using packet switching
    - How many users can connect?
    - What are the maximum and minimum transfer speeds?
- Hint, you may need to make assumptions for some questions.

Packet switching

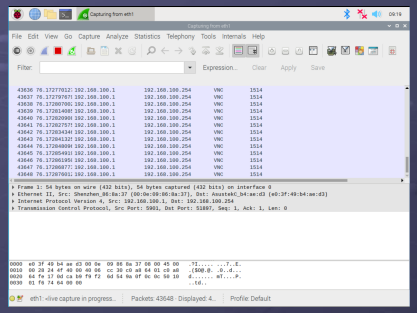
- More suited for “bursty” types of communications
- To route a packet from one computer to another we need to define how they are addressed and how they will communicate

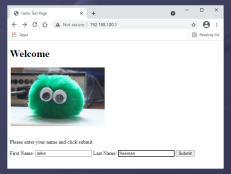


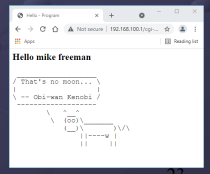


- To mange complexity this is normal structured using a number of different protocols (layers), a protocol stack
  - The Internet protocol stack is shown above, we will be examining this in greater detail through this module, from HTTP to RJ45.

Demo

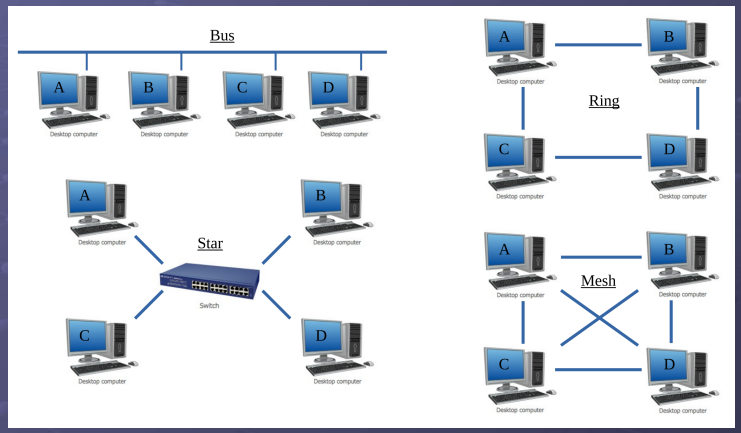






- Clients, servers, switches, routers, python, command line tools and Wireshark

Network topologies



- Bus, Star, Ring, Mesh, Hybrid …
  - Collision and Broadcast domains

Exam

- At the end of each week's lab sheet there are a set of assessed questions. These are submitted as a single report at the end of the semester.
  - Mix of paper work questions and practical experiments.
  - These questions MUST be answered from your assigned desk e.g. machine specific answers, screen shots etc.
  - Lab sheets are a mix of information and tasks, therefore, I strongly recommend that you read through the lab sheet BEFORE the lab to save time.
  - Make sure you complete each week's lab. If needed you can use the lab Mon-Fri, 9:30-17:30. Closed evenings and weekends.
  - Don't leave it to the end of term!

Summary

- At the end of this module a student will be able to:

Learning Outcome	Description
SYS2(NET) 1	Be able to articulate the motivation behind the layered network model.
SYS2(NET) 2	Develop software using OS-level networking concepts (i.e. sockets) to communicate with other systems.
SYS2(NET) 3	Demonstrate understanding of networked architectures, how they are integrated into an operating system, and develop simple applications using this knowledge.

- Confess, not very descriptive. For me at the end of this module you will have learned basic network engineering skills: how to build and test networks.