TEU00311
What is the Internet doing to me?
(witidtm 2023/2024)

Stephen Farrell
stephen.farrell@cs.tcd.ie

https://github.com/sftcd/witidtm
https://down.dsg.cs.tcd.ie/witidtm

URLs accessed 20230829 (not all content from URLs updated)

What’re we here for?

- We all use the Internet all the time
- You may or may not know what’s happening under the hood, and shouldn’t need to know all the nitty-gritty detail
- But, to make better decisions as to what you do, it’s good to know something about some of those details
- This module aims to help you learn enough to make better decisions about what you want, and how to get it, as you interact with the Internet
- I hope: you’ll apply those lessons, tell others about it all and maybe agitate for a better Internet for a better society (but you won’t fail the module if you don’t agitate:-)

Administrivia

TCD Personnel/Contacts

- Lecturers:
  - Dr. Stephen Farrell, stephen.farrell@cs.tcd.ie
  - Dr. Dave Lewis, dave.lewis@cs.tcd.ie
    - You'll see Dave mostly after reading week
  - Dr. Eoin O'Dell, eoin.odell@tcd.ie
    - You'll see more of Eoin in a couple of weeks
- For generic stuff, email Stephen – try include "witidtm" in the subject line

about:me

- SCSS research fellow
- Research topics: Internet security & privacy and delay-tolerant networking
- Pronouns: he/him
  - Feel free to let us know if/when we get yours wrong
- Other courses taught, pubs, CVish stuff etc:
  - https://www.scss.tcd.ie/Stephen.Farrell/

about:us

- 1 Bioengineering
- 3 Business and Economics
- 1 Chemical Sciences Single Pathway
- 3 Computer Engineering
- 2 Computer Science AND Business Joint Pathway
- 18 Computer Science Single Pathway
- 1 Deaf Studies Single Pathway
- 2 Electronic and Computer Engineering
- 1 English Literature and History
- 1 English Literature Single Honours
- 1 Film Single Pathway
- 1 Genetics
- 1 Global Business
- 1 History Single Pathway
- 1 Human Genetics
- 1 Law Single Honours
- 3 Law Single Pathway
- 1 Management Science and Information Systems Studies Single Pathway
- 1 Neuroscience
- 1 Physics Single Pathway
- 1 Semester Start Up AHSS Michaelmas Term
- 2 Semester Start Up AHSS One Year
- 1 Semester Start-up EMS + HS Michaelmas Term Single Pathway
- 2 Theoretical Physics Single Pathway
- 10 UG Visiting AHSS Michaelmas Term
- 1 UG Visiting Students AHSS
- 1 Under Graduate Visiting EMS + HS 1YR Single Pathway

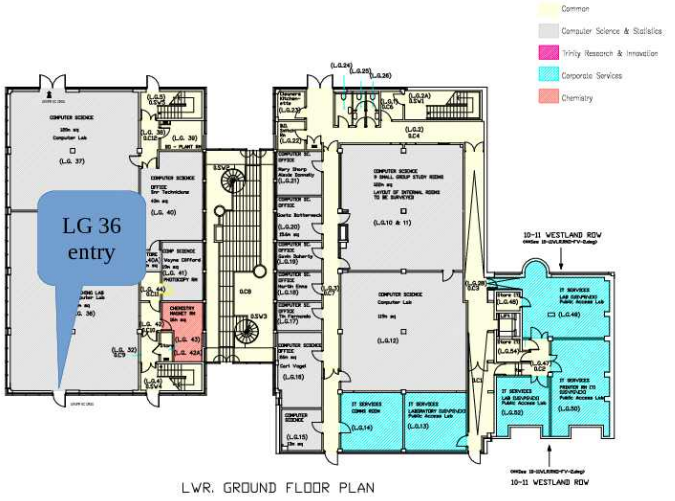
SITS as of 2023-09-08

Schedule

- Two lab sessions on Thursday Sep 21st and 28th (location: next slide +1)
- Otherwise, lecture slots are:
  - Tuesday 1000-1050, Lloyd 1.07
  - Thursday 1600-1750, M20 Museum building
- “Office hours”:
  - Monday 1100-1130+ via BB collaborate “ultra”
  - Lecturer(s) will hang out there/then, any of you welcome to join & chat
  - Might swap that time after reading week depending on conflicts with other schedules
- Reading week: October 23rd

Labs Location

- Labs on Thursday 2[1st] and 28[th] September in ORI **LG36** from 1600-1750
- Bring a laptop and phone if you can
- You should be able to use lab PCs anyway (if necessary, you should have gotten a mail wrt scss account this week, if not, don't worry)



Assessment

- 3 Assignments, submit via Blackboard
- AS1: GDPR request and anonymised report – 25 %
- AS2: Individual report on device & app tracking – 25 %
- AS3: “Ethics canvas” – 25 %
  - Deadlines for all: we’ll talk about those in a week or two
- In-person attendance over full semester – 25%
  - Because attendance is good:-)
  - If you have a valid reason for absence then then please send mail etc. to Stephen and we’ll factor that in
  - We’ll have sign-in sheets at the front of the room, make sure you fill that in every time
- Re-assessment (if needed) will be an in-person, sit-down, exam, sample on web site

Background Survey

- There’s a quick 5 question survey on blackboard
- Please complete that before the end of Wednesday 13th
- I may modify the topics-covered based on the answers
- I will use the answers to level-set
- So please fill that in

Module Materials

- There is no book – feel free to recommend some if you like
- Materials will be linked to from, or on, the module web page:
  - https://down.dsg.cs.tcd.ie/witidtm
- Content of module web page is also in Github at:
  - https://github.com/sftcd/witidtm
- Clone that repo and/or visit that page often, as it will change during the runtime of the module!
  - Who knows what “clone that repo” means?
  - I’ll be happy to take PRs, if offered – if **very** good I might even give some marks

Style

- **This module is fully in-person with no recording and no streaming**
- **Don’t sit there and say nothing!**
- It is entirely ok to ask what might appear to be less-than-clever questions, e.g. “Who makes money from YouTube?” - supposedly naive questions can be good and the answers might be quite subtle
- It is entirely ok to comment on what we tell you, e.g. “That’s nonsense – I use <foo> all the time and it’s fine afaics” - this is about you after all, so (dis)agreeing with us and one another is desirable (but don’t be an ass, and do listen)
- If you don’t comment or ask questions, we’ll all be more bored and I’ll get cranky!

Do self-organise a chat medium

- If (subsets of) the class have their own external chat room(s)... I don’t care:-)
- Actually, I’d prefer you do, so who’ll organise that?
- If you’d like me to broadcast the co-ordinates for that (an invite, a web page or whatever) please let me know and I’ll send mail to the group
- I won’t be spying on whatever you get up to there:-)

So, with administrivia out of the way,
let’s start...

Here’re some questions we’ll come back to at the end of the slide-deck (today or next day, whenever) but please start to ponder them...

I think the Internet is great
(and have for 30+ years)
but
are the 3-4 billion people connected
all your friend?

How do you interact with the Internet?

Do you care about your, my, or all of our, security on the Internet?

If so, what do you care about most?

Do you care about your, my, or all of our privacy?

That’s all for now, we’ll be returning to those questions as we go.

But… what other questions should we be considering?

What else?

- Your topic here... what’d you like to cover?
-
-
-

(we can revisit this multiple times)

Meanwhile… let’s start with…

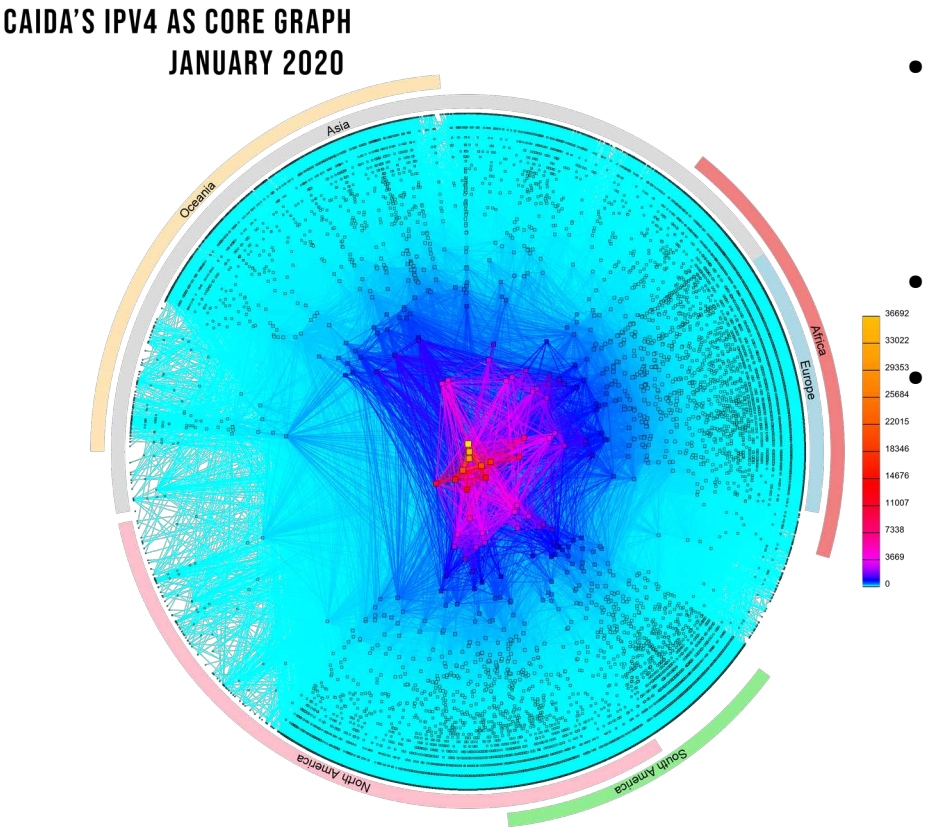
Is the Internet a network?

Is the Internet a network?
(hint: the answer is “no”:-)

A network of networks

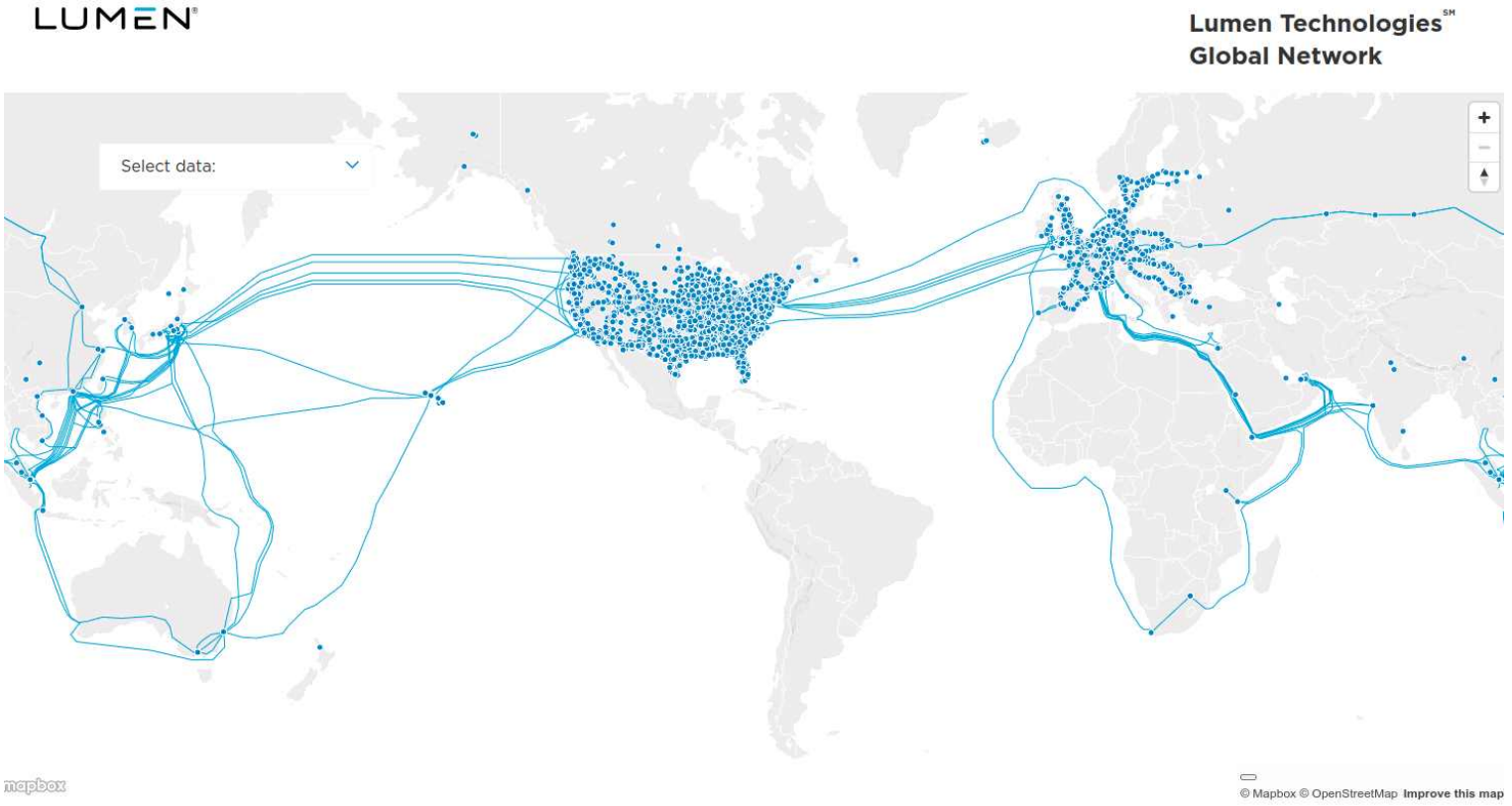
- The Internet is made up of tens of thousands of Autonomous Systems (ASes)
  - https://en.wikipedia.org/wiki/Autonomous_system_%28Internet%29
  - 74903 ASes as of 20230829, (https://www.cidr-report.org/as2.0/)
    - Was: 73797 ASes as of 20220817
    - Was: 72173 on 20210907
    - Was: 65,428 in Aug 2019
- Think of these as the set of Internet Service Providers (ISPs, like Eircom, Vodafone, Virgin), other networks (e.g. HEANET which is TCD's "ISP"), big companies (e.g. Alphabet/Google, Meta/FB) and oddities like Internet eXchange Points (IXPs, like INEX)
- Each is (in principle and often in practice) an independent network (or set of networks) and their operators can do whatever they want
  - They're essentially defined by sets of numbers: Static: AS number (ASN); Dynamic: sets of IP address prefixes
- They interact using Internet protocols (like IP, TCP, BGP)
  - IP: Internet Protocol; TCP: Transmission Control Protocol; BGP: Border Gateway Protocol
- We'll delve more into all that later, but first… some pretty pictures

CAIDA Map of ASes



- CAIDA (Center for Applied Internet Data Analysis) is a UC San Diego Internet measurement organisation
  - You can measure **a lot** of what happens on the Internet as it happens!
- This is a 2020 map of the ASes as they were then https://www.caida.org/projects/cartography/as-core/2020/
- More central => more connected, serving more people
  - In the middle, are the highly connected ASes such as level3 and cogent

Lumen (was Level3 etc.) is one of those (a BIG one)



https://www.lumen.com/en-us/resources/network-maps.html

Cogent similarly

Capacity

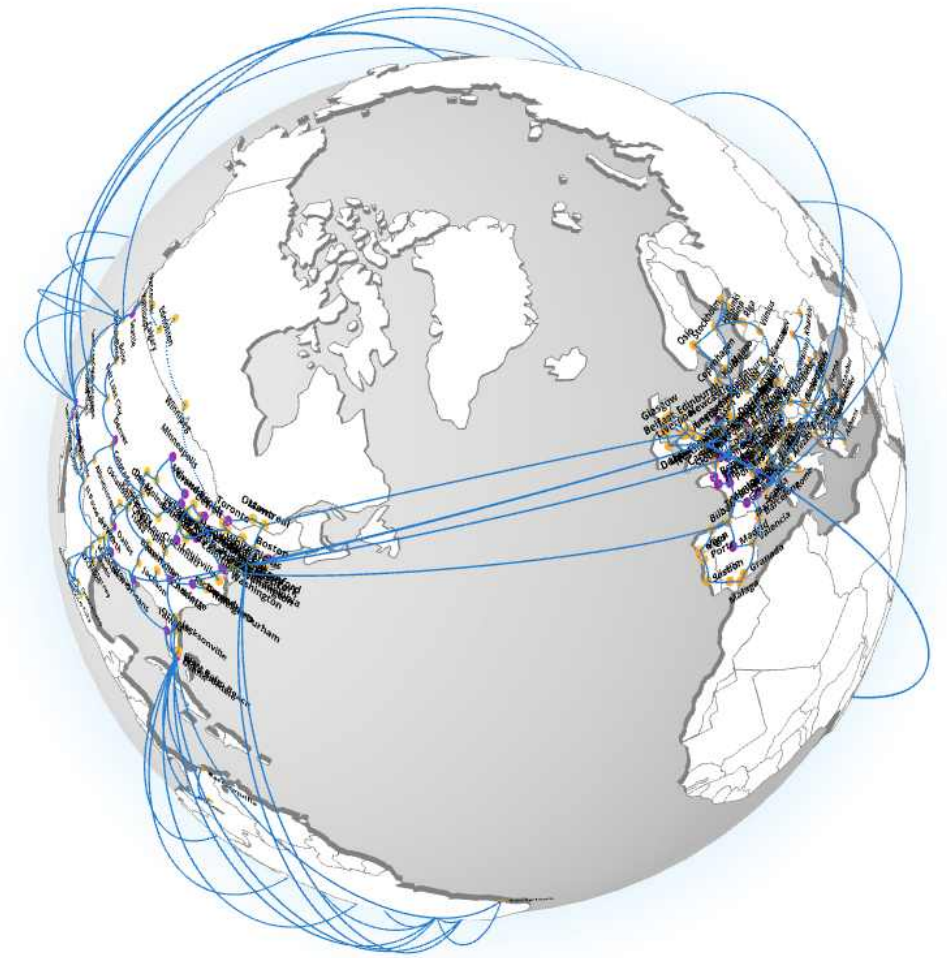
Link capacity up to:
6.0 Tbps intercity
5.6 Tbps metro
3.7 Tbps transoceanic

Connectivity

7,891 AS networks
542 Tbps internetworking capacity

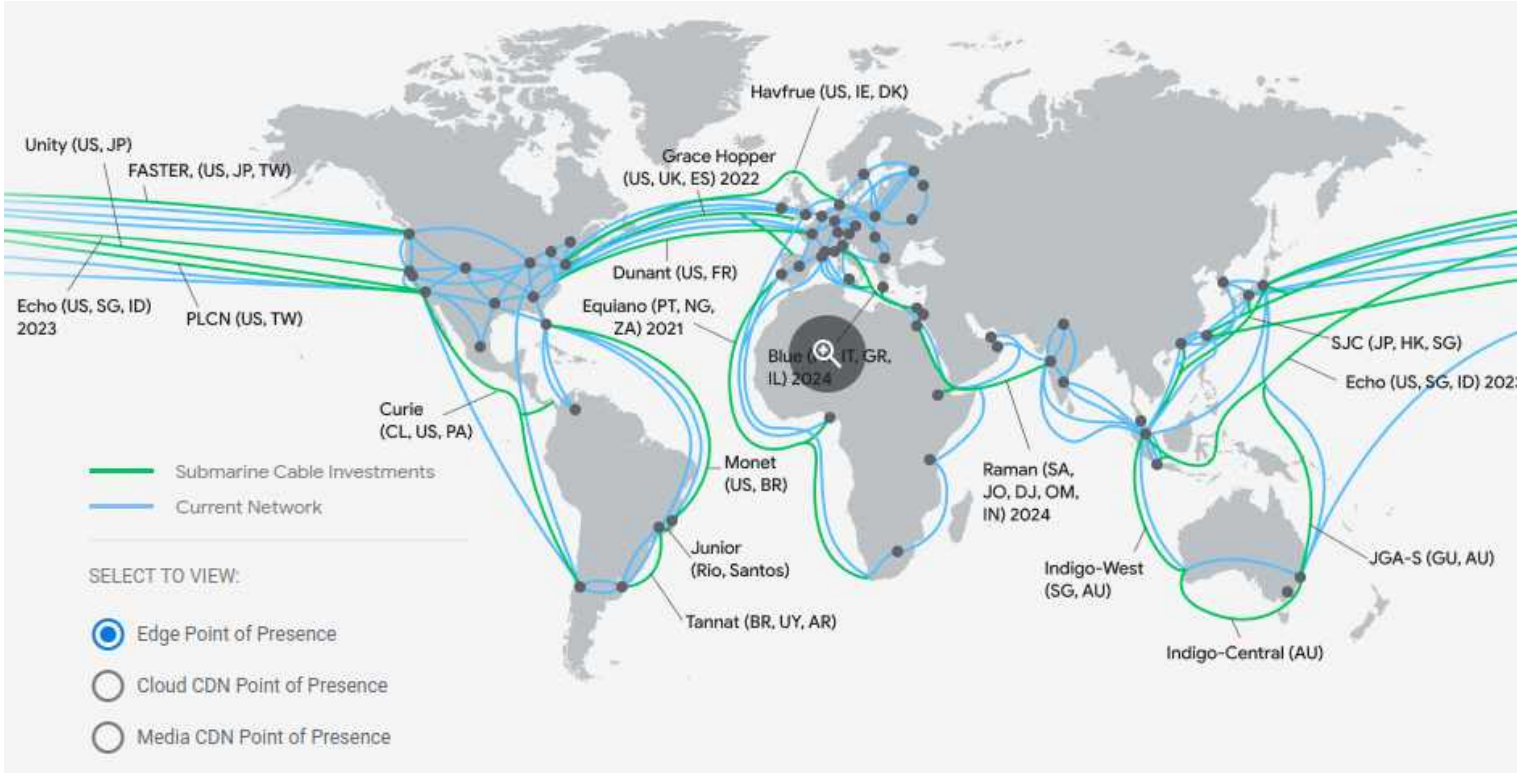
Footprint

227 markets in 54 countries
Long-haul Fiber: 61,300 route miles
Metro Fiber: 1153 rings on 43,200 miles



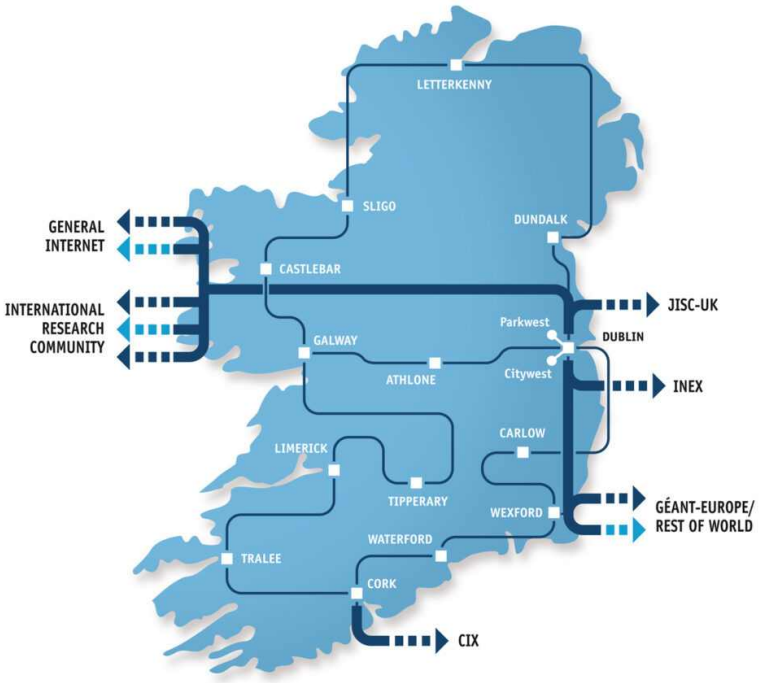
https://www.cogentco.com/en/network/network-map

Google cloud



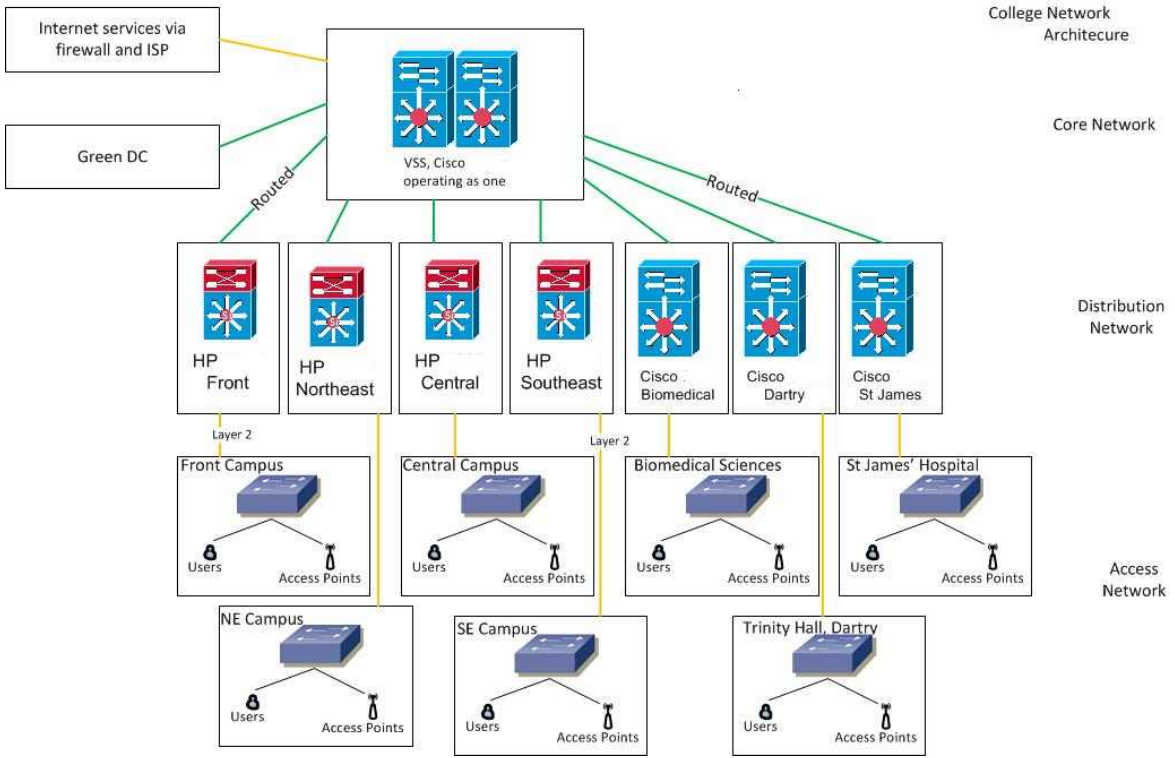
https://cloud.google.com/about/locations/#network note this is just google cloud, not all their stuff

Heanet national n/w



https://www.heanet.ie/network-maps

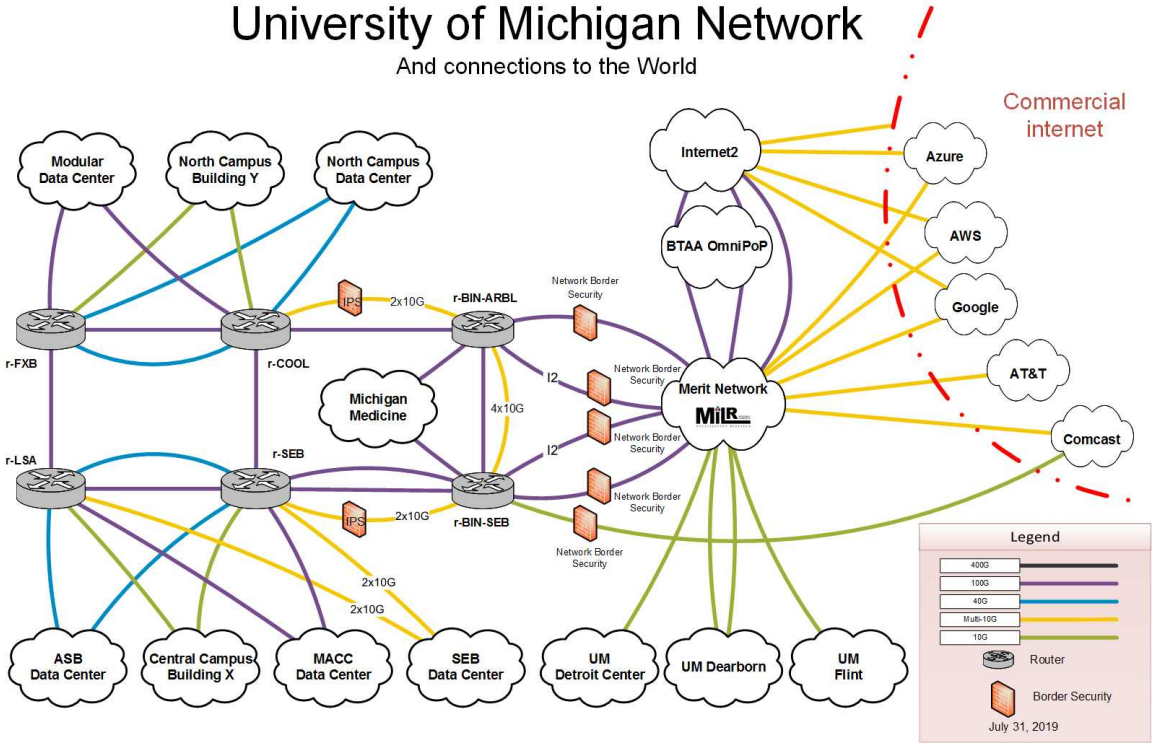
The TCD network (circa 2019)



- Network Core - Routers (High-availability pair)
- Distribution Layer - routed Layer 3 switches serving x7 campus zones
- Access Layer - Layer 2 Ethernet switches in building comms rooms and wireless Access Points
- External internet connectivity via L3 WAN block to ISP - Border Routers and Firewalls, DMZ hosting web services
- Data Centre network connectivity - central server and application hosting

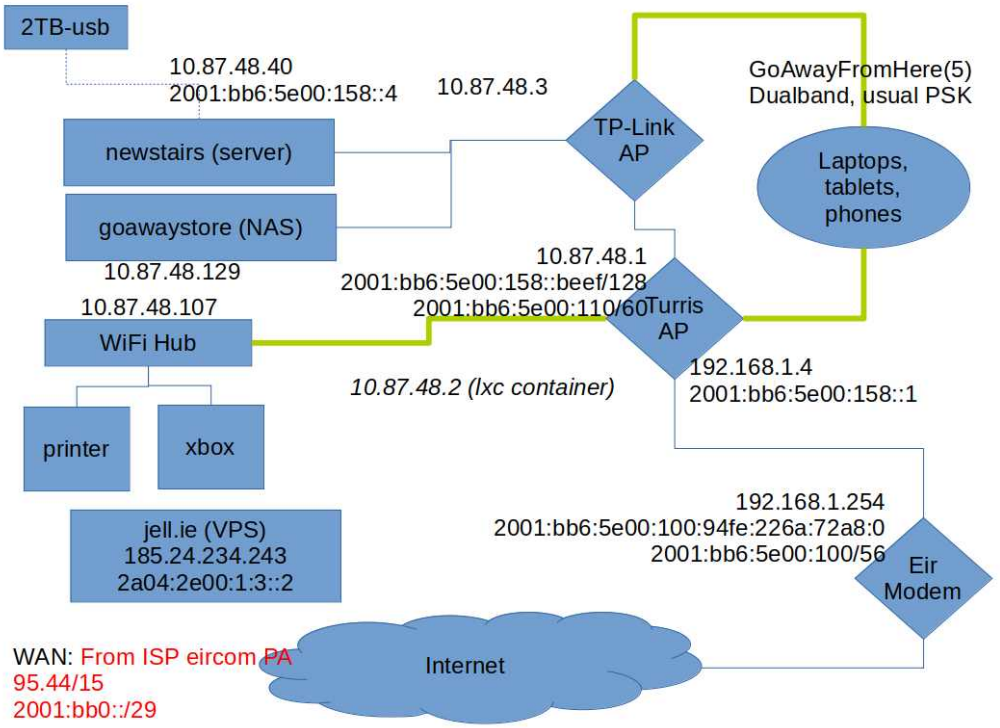
Thanks to TCD IT for providing this anonymised diagram – doing that's not a no-brainer btw!

A 2nd campus example



https://its.umich.edu/enterprise/wifi-networks/campus-network-diagram-description

My home network

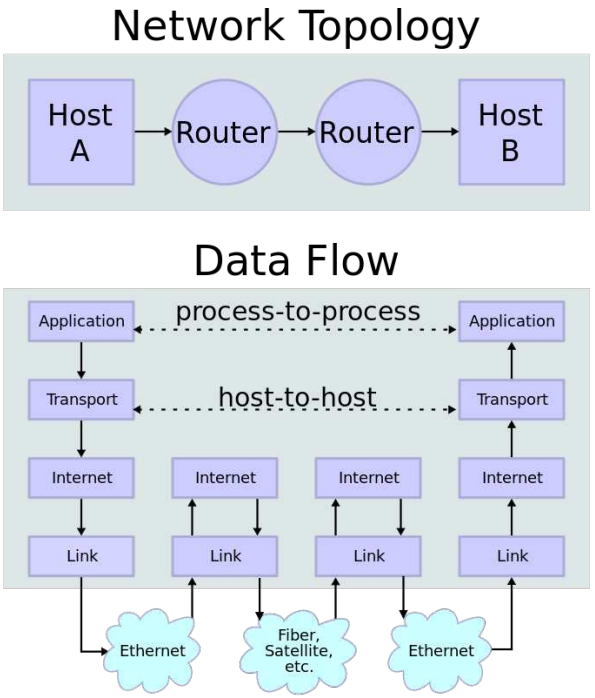


That's from a few years ago – so is somewhat out of date:-)

Interoperability

- To make the Internet work, with all those networks at different scales, we need to agree on how to **interoperate** for some basic/minimal set of things
  - That means defining/agreeing on Internet Protocols
  - Where we need to agree on how to interoperate, a lot of that is done by the Internet Engineering Task Force (IETF) and other Internet standards bodies (IEEE SA, W3C)
    - I'm quite involved with IETF stuff, so consider me biased there:-)
- But we do not aim to agree about everything in everyone's network
  - So an awful lot happens at the "application layer" in code written by people and organisations, e.g. FB, Google, banks, Netflix, ...
  - Those services are **not the Internet** – they depend on the Internet!
- And yet more happens when people configure services that use generic code

What’s a network protocol?



https://en.wikipedia.org/wiki/File:IP_stack_connections.svg

“Permissionless innovation”

- One important point is: in principle each network operator can do whatever it wants so long as it interoperates “nicely” with others (and even when it doesn’t act particularly nicely;-)
  - That also applies to your home network (if you want and are able)
  - There are no protocol police (yet!)
- This is one of the main reasons why the Internet has been so successful
- Related: the classic “End-to-end argument” paper
  - Salzer, Reed. Clark,“End-to-end arguments in system design” ACM ToCS (1984).
    - https://web.mit.edu/Saltzer/www/publications/endtoend/endtoend.pdf
  - I recommend a read of that!
  - Don’t consider it as gospel though – it’s the end-to-end **argument** and not really the end-to-end **principle** even though it gets called the latter a lot

“Tussles”

- Repeating: we do not aim to agree about everything in everyone’s network...
  - So an awful lot happens at the “application layer” in code written by people and organisations
  - And yet more happens when people configure services that use that code
- When the “policies” reflected in those collide then “fun” follows;-)
  - If protocols or application code constrains what operators can do then people complain
  - If what n/w operators are doing breaks (esp changes to) applications then people complain
  - In both cases people often complain at the wrong place;-)
- Another paper:
  - Clark, David D., et al. "Tussle in cyberspace: defining tomorrow's Internet." ACM SIGCOMM Computer Communication Review. Vol. 32. No. 4. ACM, 2002.
    - https://www2.cs.duke.edu/courses/compsci514/cps214/spring09/papers/p347-clark.pdf
  - Same “Clark”, but older:-) Interestingly, the 2002 paper is IMO far more dated (and wrong!) than the 1984 paper!
- We’ll consider a “topical” example later (Search for “DNS over HTTPS” if you want to check it out); don’t worry if this issue seems a bit too hard to grok at this point

Aside: Cyber<blah>

- Be wary of anyone who uses a term like “Cyber<blah>”
- ~90% of the time, that’s a strong indicator that they don’t really know what they’re talking about (if they did, they’d use a more precise and well-defined term)
- Sadly, about 10% of the time (and increasing) such terms are used because “industry” keeps on doing it and people just repeat stuff thoughtlessly
- Don’t be afraid to ask someone to define “Cyber<blah>” if they use such a term, and don’t be surprised if they find that hard!
  - E.g. “Does cyberspace include a person driving a car that’s had it’s license plate automatically scanned?” or “What’s not included in cybersecurity?”

The Internet is not the web

- Another important point!
- The web is (roughly) the set of computers that speak the HTTP protocol
  - HTTP == HyperText Transfer Protocol (http://example.com)
  - HTTPS == HTTP/Transport Layer Security (https://example.com)
- Email doesn’t use HTTP, but rather (mostly) the Simple Mail Transfer Protocol (SMTP) which is a couple of decades older than HTTP
- Mobile network internals (3G, 4G, 5G...) mostly run over IP using a bunch of protocols you’d prefer to never have to know about
- But lots of our interactions with the Internet are via the web

Some of the things we'll do later...

- Understand what happens under the hood when your browser loads a web site
- Learn how to watch network traffic
- Get an overview of advertising networks
- Talk a bit about spam and phishing (email badness)
- We'll look more at the web soon, meanwhile back to you...

How do you interact with the Internet?

Do you care about your, my, or all of our, security on the Internet?

If so, what do you care about most?

Do you care about your, my, or all of our privacy?

That’s all for now, we’ll be returning to those questions as we go.

But… what other questions should we be considering?

What else interests you?

- List:
  - ...
-

(we can revisit this multiple times)