Week 2 Online Session

Welcome to new students!

- I keep a spare week for, well, spare. A lot of courses finish teaching before the end of term, but I used to pack content into the last week. Now I keep a week spare for contingencies.
- **Welcome to our new friends from Cyber Security!**
- That’s why I am using up the spare week this week: we have a lot of late starters, and as I dropped a load of content last week I am delaying this week’s material until the end of the week to give Cyber students a chance to catch up.

Reliability

- This week I am going to talk about reliability, and how it means different things to different people.
- This is timely: I know that Facebook is joining email in *things for old people* land, but presumably you noticed that Instagram and WhatsApp were out on Monday, approximately 1550–2100 UTC.
- Let’s talk about network reliability design, and how it affected the choices made back in the day.

Telephones

- Peter Jarratt (“PJ”) was professor of Computer Science at Birmingham in the 1980s.
  - He isn’t the Jarratt of Jarratt Hall: that’s Alex Jarratt, the then vice-chancellor, so far as I know not related.
- Although a computer scientist, he was of the opinion that the telephone was the single most important technological development of the 20th century, in terms of its effect on society. It’s an arguable case, but it’s certainly affecting modern networking in deep ways.

Telephones

- First real-time, or remotely close to real-time, means of communication available to individuals and small businesses.
  - Telegrapm, telex, semaphore relay are one or both of “not real time” or “not widely available”.
- Very rapid adoption
- Government operated (local, then national) in Europe, effectively government operated in USA (“AT&T”, “Bell”, etc the sort of companies which only function with massive government help).

Telephones

- Once a call is connected, it tends to stay connected.
- The resources required to connect it are in short supply, both “control plane” (decoding pulses/tones) and “data plane” (long-haul circuits).
  - Hence charging, and when I started work Birmingham to London was £6/hour, 0800-1300.
- Local calls (within one exchange) are only limited in call set up, as the local loops are always there.
- You can therefore prioritise…

Telephone Reliability
20th Century Style

- Works with the power off at the subscriber: phone is entirely powered over the exchange circuit.
- Works with the power off at the exchange, hopefully: big batteries, diesel generators, everything powered by 48V DC supplies.
- Works-ish under overload, with call-gapping
- Crucially 999 works even under overload (although people didn't realise this, and didn't know you could dial into no dial tone).
- "Government Preference Working" for national emergencies.
- The crucial metric is BHCA: Busy Hour Call Attempts.

Consequences

- It becomes reasonable to rely on phones for medical emergencies, alarm monitoring, etc. Most people would never experience a phone outage, other than their local loop failing, in their lives.
- Collapses incredibly rare (DJ offers Concorde tickets to first caller, DJ offers tickets to Oasis' gig at Maine Road, that sort of thing).
- Even then, 999 works.

Consequences

- Traditional telephone systems (“POTS” — Plain Old Telephone Service), both in network design and in equipment design, are wildly, wildly over-engineered.
- They are therefore expensive, use few commodity parts, and sell in small numbers.
- In effect, the stuff only governments and government-backed organisations can develop and maintain.

Market Failure

- No one is willing to pay what the service really costs to deliver: Post Office Telephones lost money most years.
- No one is willing to develop new switches. System X was developed by a consortium of UK suppliers managed by the GPO in the 1970s. There were similar national equivalents, mostly government funded or backed (AXE10, 5ESS). That's it: there are no replacements.
- A separate lecture I might give later charts the troubled story of trying to get System X out. Current plan: out by December 2025.
  - We have heard this before: the equipment will be in some cases fifty years old.

Do we need this reliability?

- Well, do we? We have lots of communication paths, and (for example) home broadband with 4/5G backup is now commodity.
- Common core networks (cf. Facebook killing Instagram) but the edges are genuinely disjoint.
  - Don’t even share trenches, mostly
- Most people are not using their phone to dial in the status of their home dialysis machine, and won’t pay to subsidise the people who are.

Telephone Reliability
21st Century Style

- Works most of the time
- Speech quality is fine, most of the time
- If it doesn’t work, meh
- There’s always Zoom/Insta/Whats/Twit/Face/SMS/iMessage/BBM…
- 7/7 was a learning
  - Mobile overload control is hopeless, the battery/generators don’t work, but we survive.

So how does this affect what we use today?

- The telephone service evolved to be as reliable as possible: you should always be able to set up a call, and that call should always work.
- If that was expensive, so be it: it was a social good.
- That mentality dies hard, particularly with data.
- Early data services were designed to be like this: “utilities”.

X.25

- I am going to mention X.25 at several points, although I will not set questions on it.
- One example would be “PSS” in the UK in the late 20th and early 21st century.
- Packet switching with virtual circuits.
- Each end point has an address. You submit a call setup request with the address of the other end, and a call is set up. Once you have it, packets flow between the two endpoints.

X.25, ATM, Frame Relay

- This idea comes up repeatedly in telco-inspired data networking. “We will give you a data service like a phone call: set it up via a reliable control plane, and the data will flow via a reliable data plane. It just works. Trust us. ~~Pay us.~~”
- My hypothesis is that this was the result of voice mentality: we didn’t expect your grandmother to manage her risk appetite, we just wanted her to be able to phone 999, even at 00:01 01-Jan-2000. So the same for your email.
- The result was **staggeringly** expensive, and still largely loss-making.

Data is more tolerant

- Data is far more tolerant of delay, loss and failure. We will be talking about how TCP deals with this, but the same is true of other appropriate protocols.
- If you have serious availability needs, it is cheap (relative to the presumed value of what you are doing) to have two paths out of your building, either active/passive (4G backup) or active/active (literally two Internet connections, over different bearers to different ISPs)
  - This wasn't possible for traditional voice: lack of copper, no "out of area" copper.
- Back to voice, 4G backup is a thing, right?

Unreliable Networks

- So the basic premise is that we have networks, plural, which are less than 100% reliable, but have strategies to deal with short-term problems (packet loss) and longer-term problems (circuit loss).
- 1 hour per year outage is 99.99% (“four nines”)
- 1 hour per year outage on two independent systems is better than 99.999997% (“seven nines”): 41 seconds per year.
- Which is easier/cheaper:
  - engineering 1 hour a year downtime, doubling up where needed,
  - or engineering 41 seconds per year?

It turns out that voice is hard

- It turns out that replicating the precise properties of voice networks, such that you can plug a phone into a box and do phone-y things the way you use a phone, is very hard.
  - “MSAN” projects in the noughties mostly failed on things like overload control and 999 prioritisation.
- But if you just want to ship data, it’s much easier. Instead of “call a number to report your dialysis machine is failing”, “send some data”.
- And that’s where we are today.

The 21CN Debacle

- BT’s original proposal to take out System X and attendant systems was “21CN”, announced in 2005.
- It did not end well.

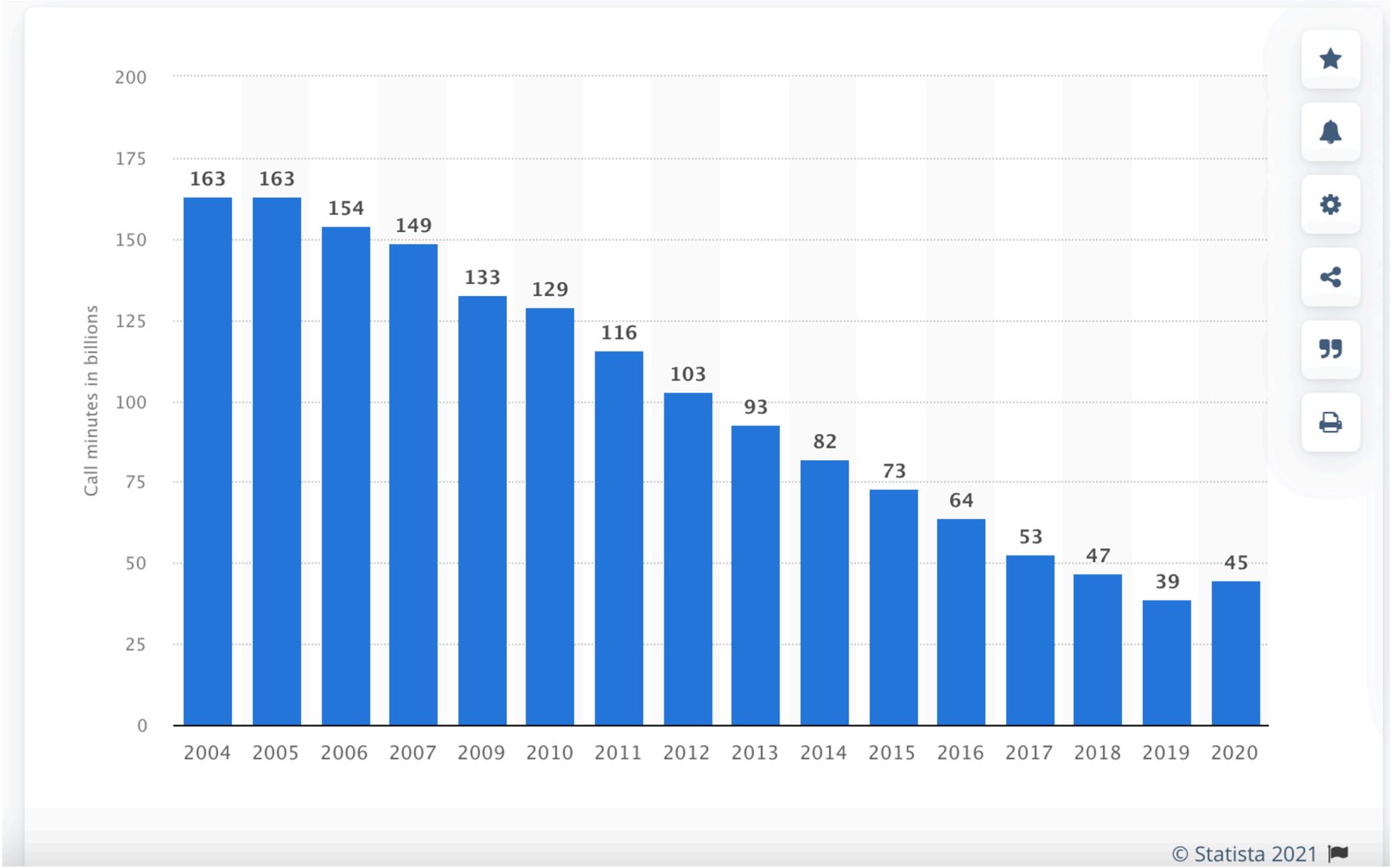
As a result, DKW reckons Marconi will pick up a sizeable portion of the business, and that its share price is set to leap when the 21CN deals are announced. Marconi's current share price is 486.5 pence ($9.28), its 12-month low, compared with a high of 648 pence ($12.37). DKW rates Marconi a Buy, with a target price of £7 ($13.36).

The analysts believe Marconi will pick up about 40 percent of the access equipment deals, with Alcatel (NYSE: ALA; Paris: CGEP:PA) and Fujitsu Telecommunications Europe Ltd. picking up the rest. If DKW is correct, that would leave Huawei Technologies Co. Ltd. without a piece of the access pie.

21CN

- 21CN assumed you could “double up” commodity equipment and get reliability easily. The idea was to drive price down, “no BT specials” and engineer reliability by duplication and smart management plane services.
- I was too close to the trenches to be objective, but my suspicion now is that:
  - The “young Americans” were just a little ahead of themselves
  - Voice was still the main priority, and is hard, and they didn’t know what was coming (*vide supra* and *infra*).

Fixed-Line Voice: Who Cares?



What we should do in 2021?

- Networks are reliable, ish. Most of the packets get to where we want them to, most of the time.
- Occasionally it goes wrong.
- We are **never going to have** 100% available networks, and we are **never going to be willing to pay for** six-nines networks.
- When we design network applications, we need to engineer for this: if the data matters, what should we do?

Lessons from Monday

- Separate “Operations and Management” networks
- “Out of Band” management
- Avoidance of cascading failures
- Avoidance of assuming independence
- Well tested disaster plans: bring-up is hard.