What have we done?

Geoff Huston

Around 25 Years Ago…

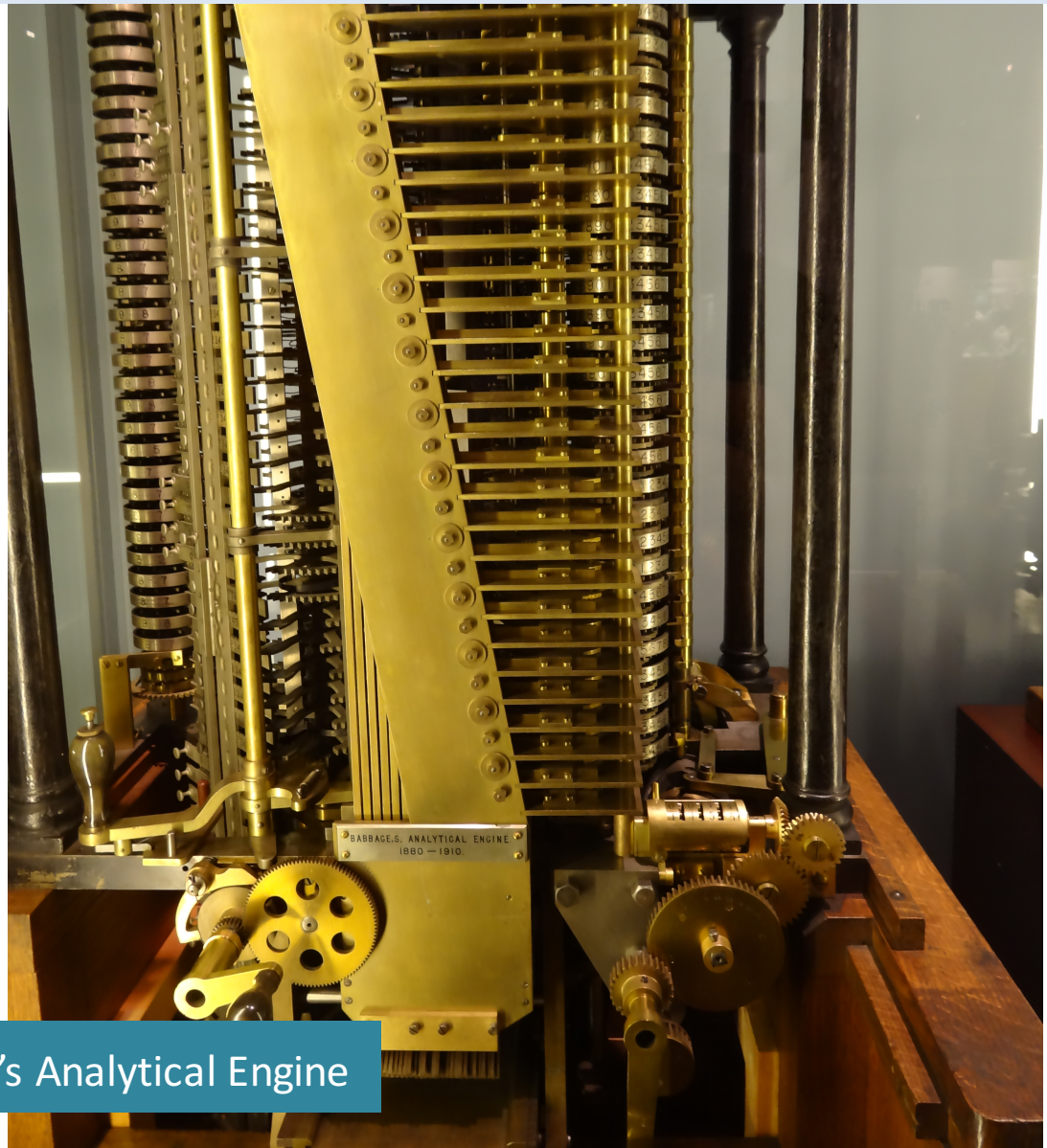
In 1990, Peter Elford and I switched on the Australian Academic and Research Network for every University and CSIRO site in Australia

The Internet had arrived for the Australian Higher Education and Research sector

So what were the issues then and how much have things changed…?

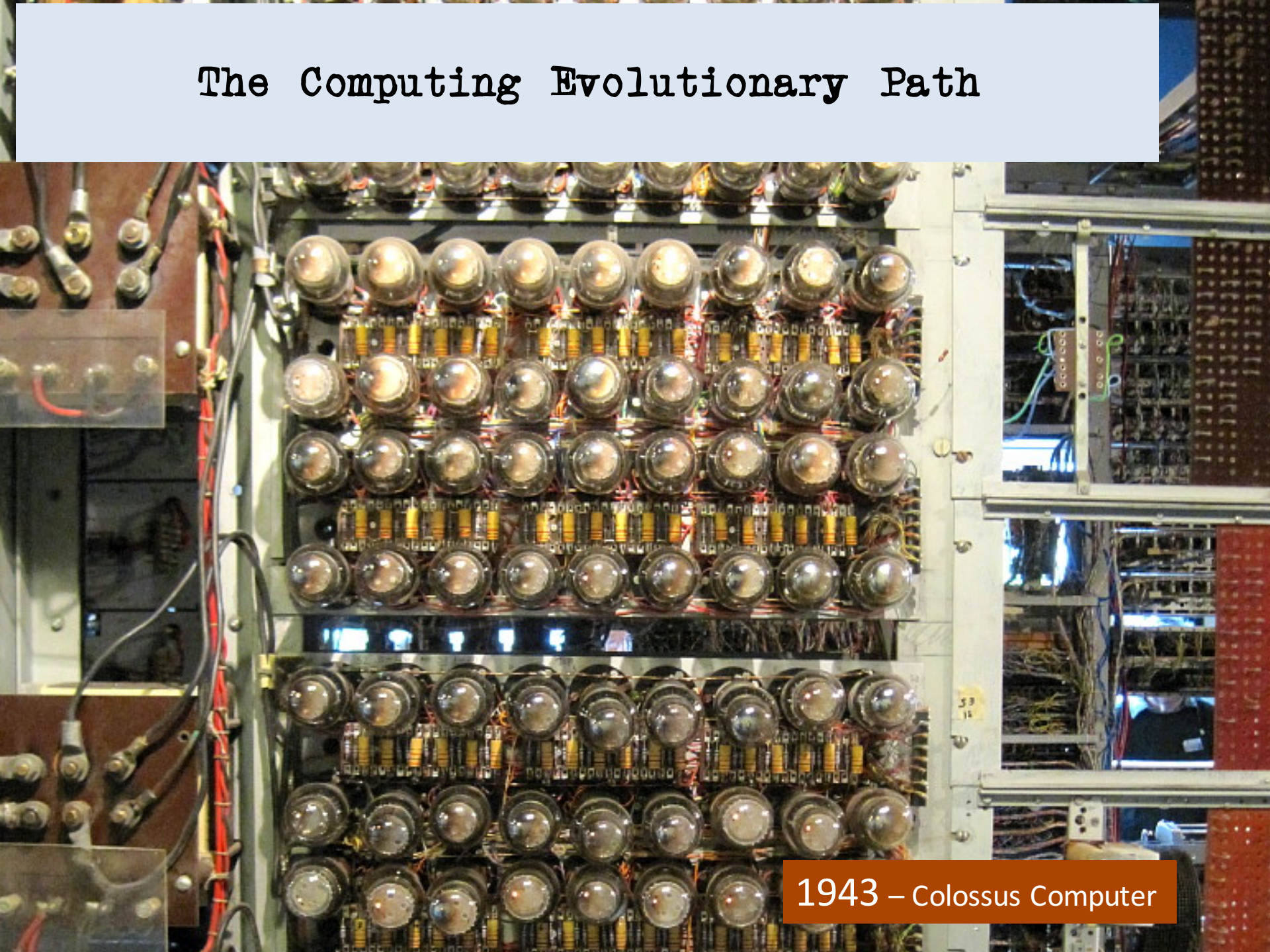

The past is a foreign land -
they do things differently
there!

The Computing Evolutionary Path



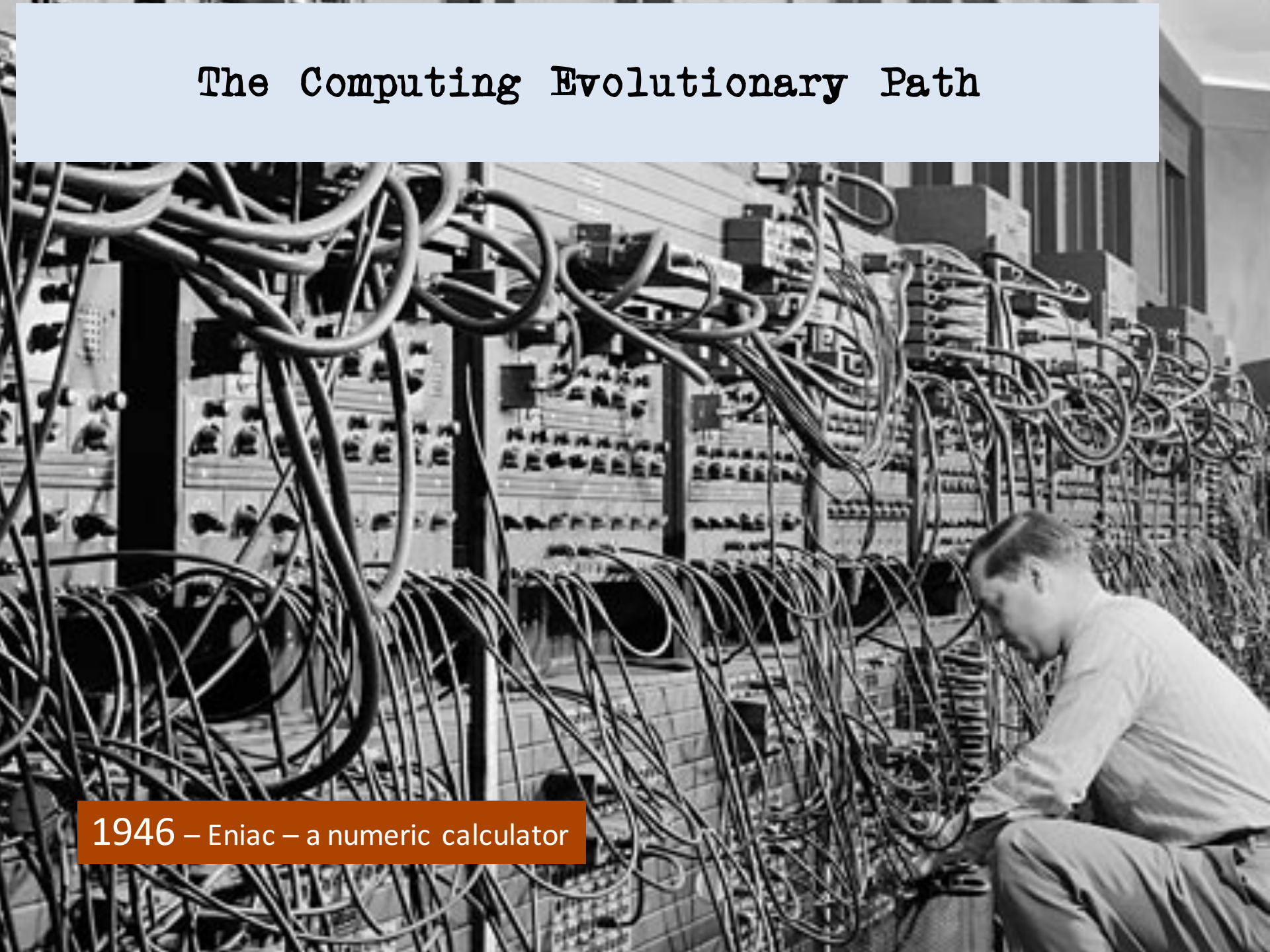
1837 – Babbage's Analytical Engine

The Computing Evolutionary Path



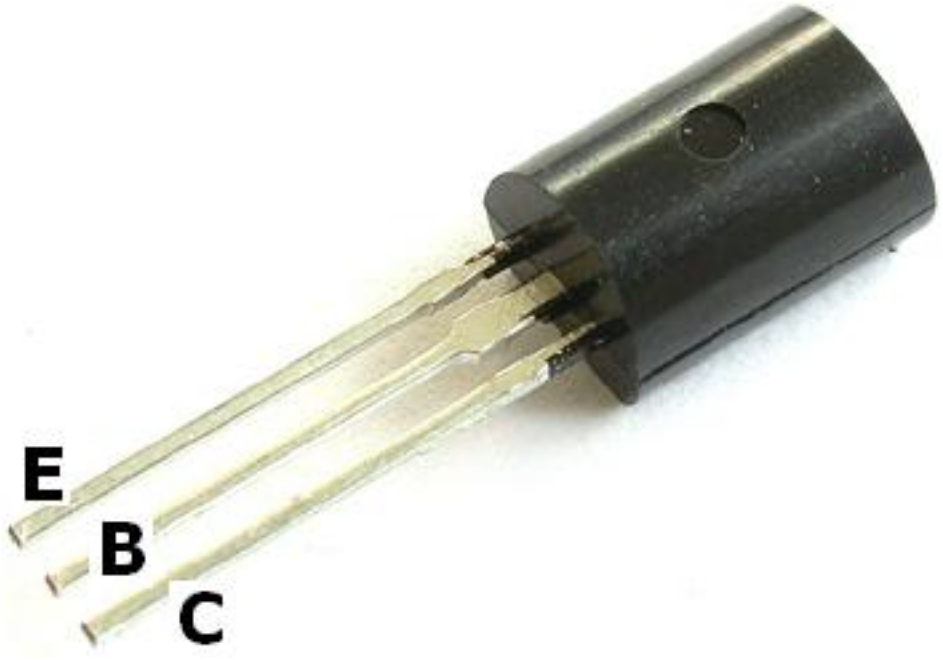
1943 – Colossus Computer

The Computing Evolutionary Path



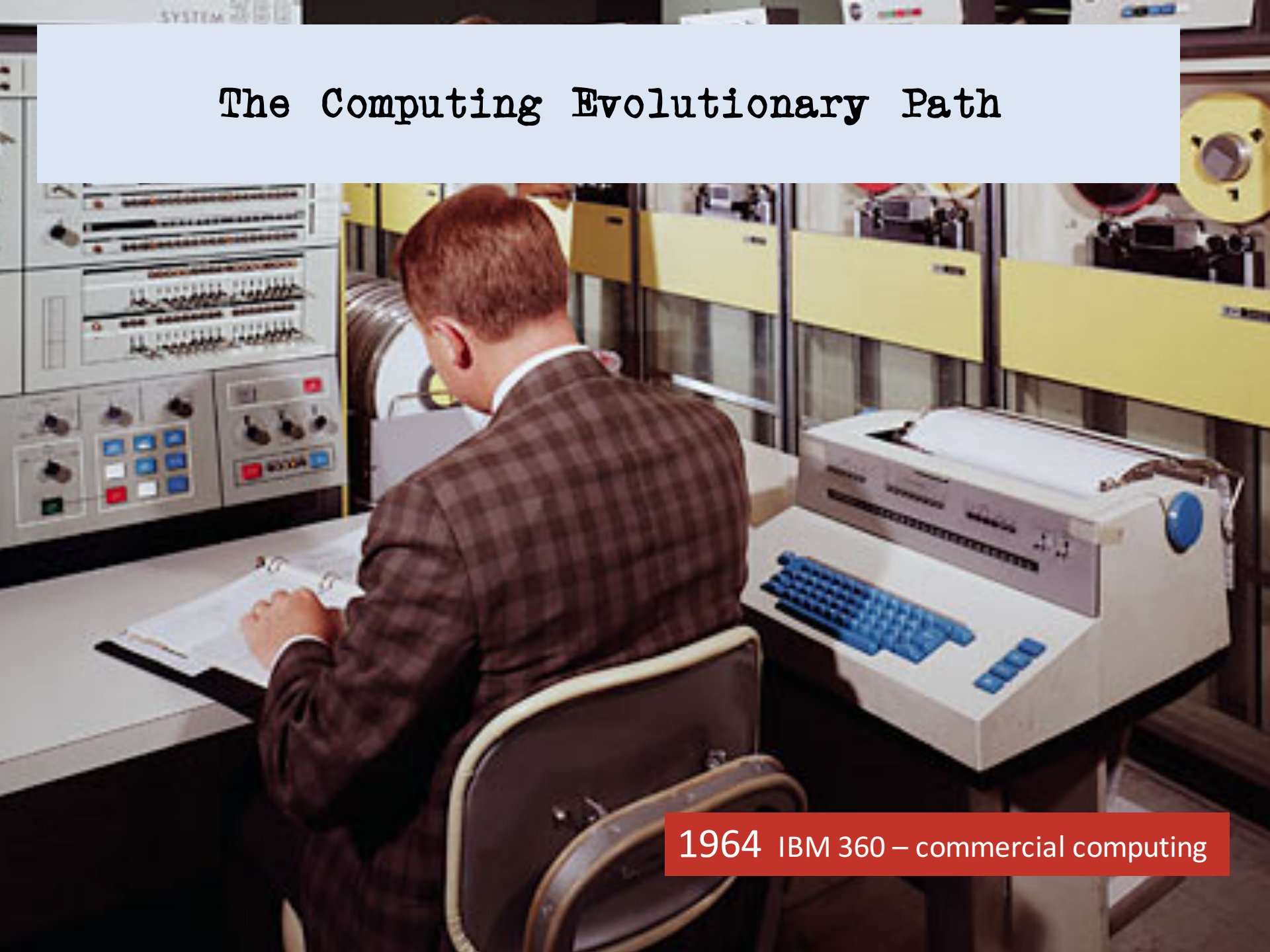
1946 – Eniac – a numeric calculator

The Computing Evolutionary Path



1947– The Transistor

The Computing Evolutionary Path

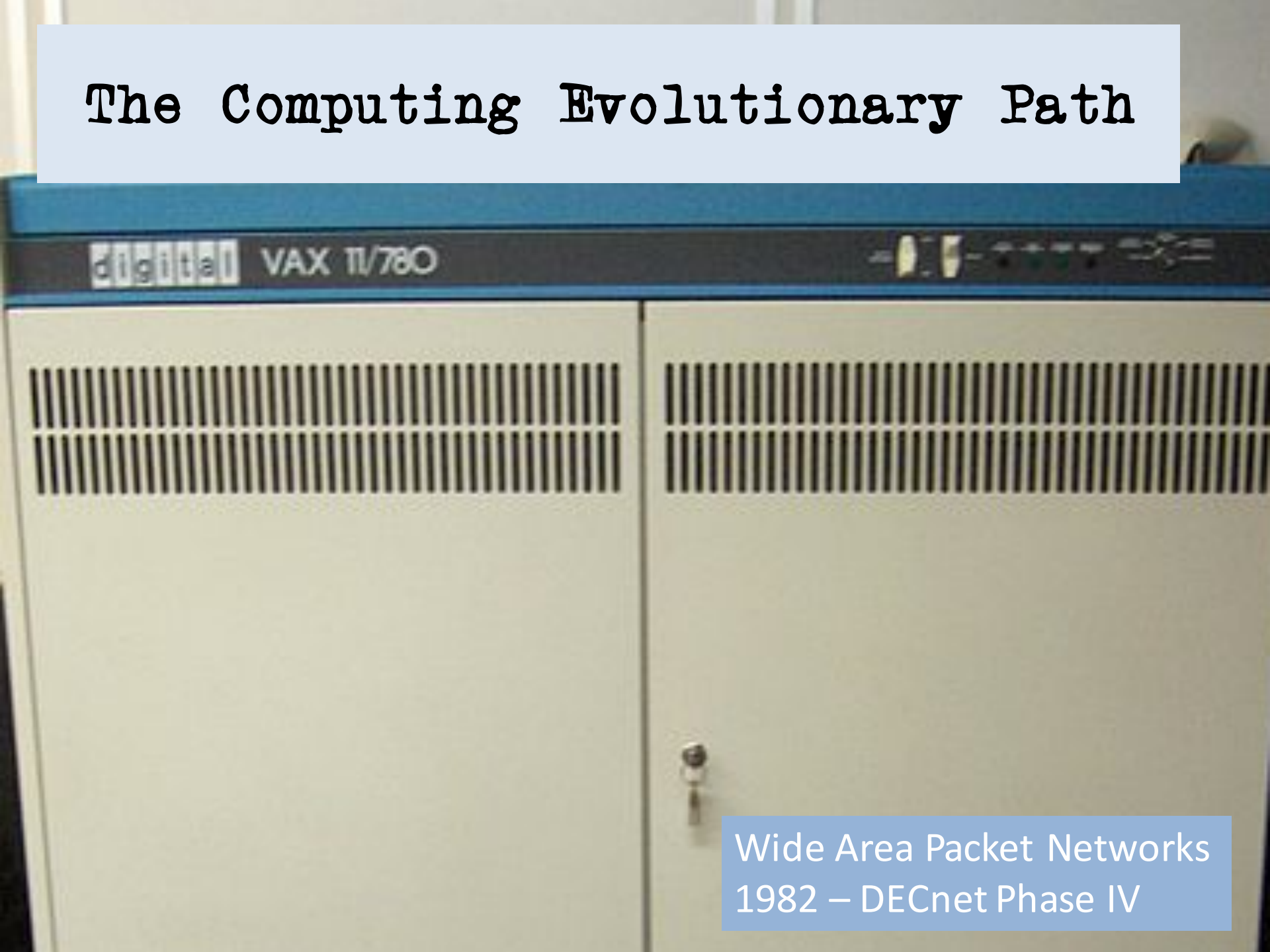


The Computing Evolutionary Path

1976 CRAY-1 – “super” computing

The Computing Evolutionary Path

The Computing Evolutionary Path

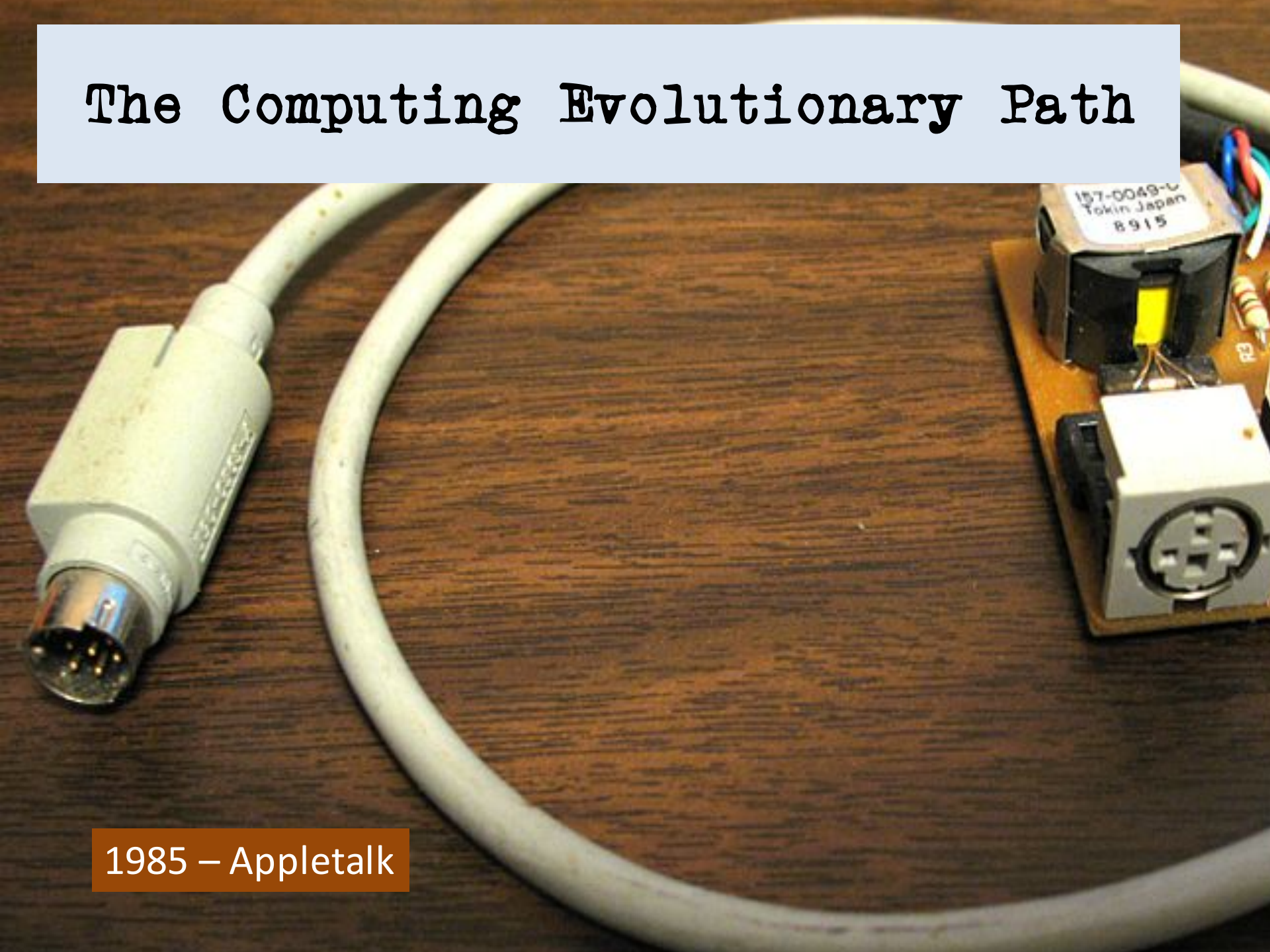


Wide Area Packet Networks
1982 – DECnet Phase IV

The Computing Evolutionary Path

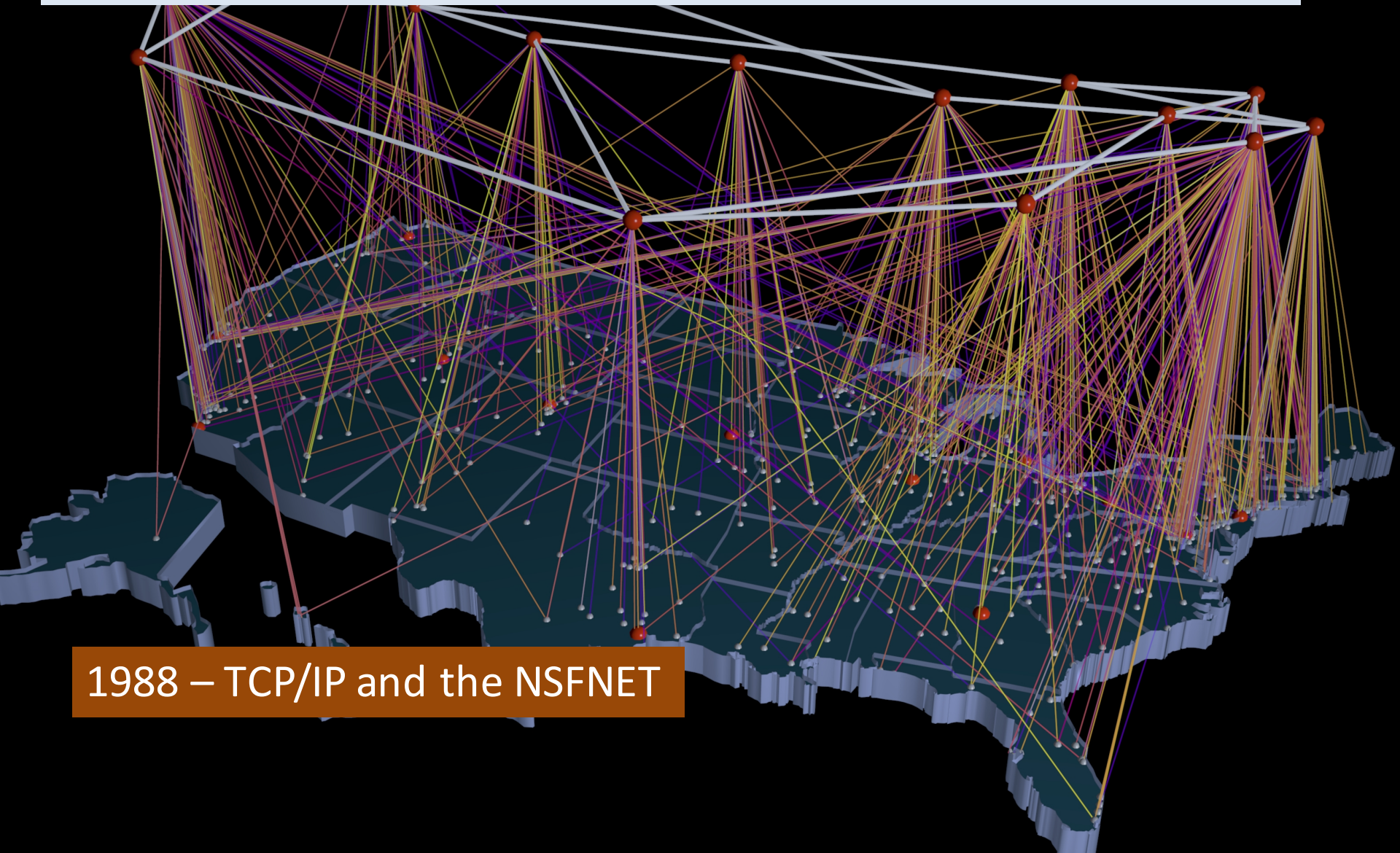
1984 – Mac - visual computing

The Computing Evolutionary Path



1985 – Appletalk

The Computing Evolutionary Path



1988 – TCP/IP and the NSFNET

Which brings us to 1990

(Or thereabouts)

What were we talking about then?

Background

- The mainframe to PC transition
- Shift away from terminal access networks
- The Local Area Network of peering hosts

The Field of Fire

- ISO/IEC OSI
- Internet IETF

OSI - the Dream

- An "open" architecture
- specified from physical to application interface
- universal signon by the industry
- The specification of a single ubiquitous technology interoperation platform for the industry as a whole

From Dreams to Nightmares

- telcos never understood the real extent of the domain
  - telcos are not no longer at the cutting edge of technology development
  - telcos are predominately billing enterprises!

- The process of standards definition was flawed when applied to technology development

And of course

- X.400 & X.500
  - working together defining the address from hell

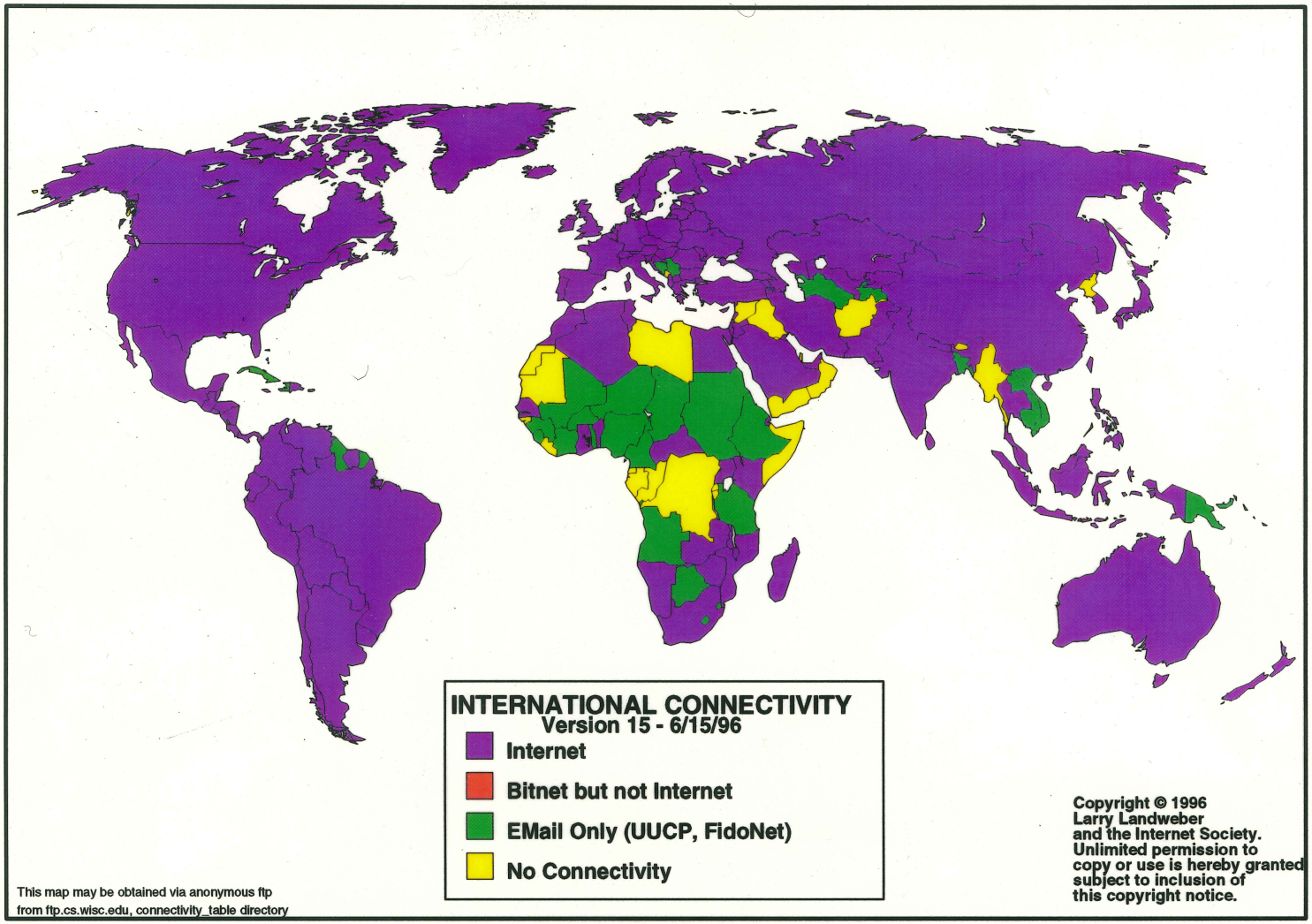
The Network Management Debacle

- One should never attribute to malice that which can be adequately explained by incompetence

The Impotence of Good Ideas

- **The OSI Standards Process...**
  - **Any Good Standards Process must be equally unfair to all participants**

We had high hopes for the Internet



But we were a lot younger then

Photo Credit: Aimee Ray https://www.flickr.com/photos/merwing/516164481

And we were the underdog

Photo Credit: https://www.flickr.com/photos/barrielynn/1817195121

Things are different now

Things are different now

We won

Things are different now

We won:

- We won the protocol wars with OSI
- We won the voice wars with telephony
- We won the content wars with television

Computers and the Internet are now everywhere…

Recording **everything**

2005

2013

Always with us

And it sure looks like…

And it sure looks like…

WE are now the subject!

Street Art: Banksy

How did we get to this unexpected point?

How did we get to this unexpected point?

What happened over the past 25 years to get us here?

What Happened?

The commercialisation of the electronic messaging Internet

- The expansion from the academic and research stable to a public venture based largely on entrepreneurial activity

What Happened?

The internal re-building of the telco industry

- Active effort to engage with the Internet and integrate it into the telco service portfolio
  - The Internet was not originally seen as a threat to voice – but it was seen as a threat to their services
- Active effort of the ISPs at the time to keep the telcos out!
- Regulatory confusion

What Happened?

- The Web World
  - De-geeking the Internet
  - Adding pictures and sound!
  - Lifting access capacity by the first orders of magnitude (Kilobits to Megabits)
  - Web content revolution
  - The rise of search
  - The emergence of VOIP as a threat to the telco core

Then what?

- Broadband Capacity meets Broadband Content – the rise of the streamers
  - Noone truly expected that the Internet would take on broadcast television at the pace and volume that it has played out
  - All of the capacity planning models for infrastructure engineering need to change
  - New business relationships between CDNs and IAPs had to be forged

Then what?

- ISP culling as volume economics places ever greater control over the access industry
  - Profitability is no longer based on aggressive market expansion, but on cost management
  - Volume wins in such a market, so the ISP industry aggregates up to a small (3 – 4) number of large providers in each national market
- The assumptions of ubiquity and the “cloud”

Then What?

The iPhone!

Then What?

The mobile ”smart device” has changed the Internet in almost every way

- the rise of social networks as a shared commentary of work and play
- the rise of the cloud as an adjunct to the terminal device
- the assumption of network as a ubiquitous unlimited resource

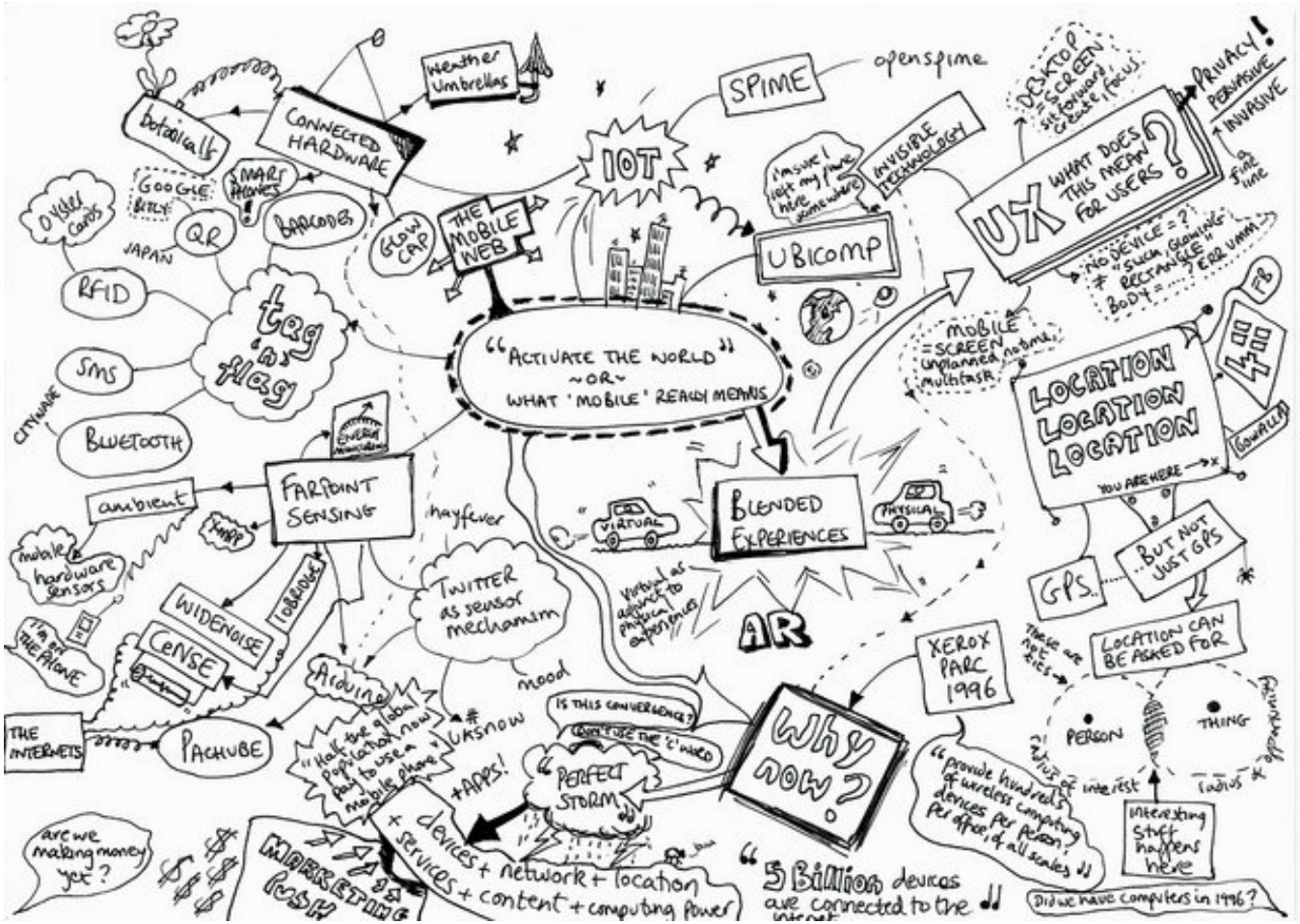
So what are the issues?

The “new” Internet is now all mobile:

- ~2 BILLION devices shipped in 2015
- 50% of all visible devices on the Internet
- 75% of all access service ARPU $ is mobiles

So mobile access networks are the focus of “new” competition in the “new Internet”– right?

So what are the issues?



http://pluseurope.over-blog.com

So what are the issues?

Our expectations about what technology can and can't achieve and reality sit on either side of an increasingly large credibility gap!

Expectations vs Reality

Terrabit was a “not in my lifetime – ever” dream

- We are now using 100Gb transmission systems
- 1Tb systems will probably appear in the coming 2 – 4 years
- Surprisingly, its still called “Ethernet”
  - And even more surprisingly we’ve been unable to figure out how to raise the packet MTU above 1,500 octets in an accepted standard manner!

Expectations vs Reality

IP was was the answer!

Yes, and No!

- We have moved back into maintained network segmentation state with MPLS foundations in most large networks
- The security issues with unmanaged endpoints and a non-segmented network were unworkable – so we addressed this by segmenting the network through “soft” circuit state overlays
- And its likely that this will continue with the work on SDN and Open Flow
- Hybrid virtual state network systems coupled with stateless packet datagrams are proving to be a resilient architecture for current networks

Expectations vs Reality

IPv6 was the answer!

Yes, and No!

- We could not conceive of a network that had run out of IP addresses – it seemed to be a contradictions in terms
- So we were all meant to switch over to IPv6 well before IPv4 collapsed
- Which we haven't
- Which means that we are in an unanticipated environment that demands we run IPv4 **and** IPv6 without a clear end in sight

Expectations vs Reality

Every device needs its own unique IP address

- Well obviously that's not the case!
- We managed to change this by changing the basic model of the network from a peer-to-peer mesh to a client/server architecture
- Clients did not need to use a dedicated address, and could share an address from a common pool using NATs
- NATs are everywhere today
- And now we are wondering just how far NATs can scale!

Expectations vs Reality

NATS are a roadbump in the evolution of IP

- It's still unclear, but we are getting really good at running a NAT-based Internet!
- Applications are now NAT agile
- We are now pushing address sharing into the server side
  The Internet's Name System is the last piece of cohesive glue
- It may be that nobody wants to rebuild the old peer IP network architecture, so we will be stuck with NATs forever!

Expectations vs Reality

NATs can scale infinitely

No they can’t

But we just don’t know if they can scale up to the same point as IPv6!

Expectations vs Reality

We can stop spam!

No we can't!

- We've tried:

  IP Black lists, DNS black lists, Grey Lists, White lists, Certification, Domain Keys, Content inspection, Data Analytics, rules, inferences, blocking, permission, regulation, legislation, industry codes of conduct, …

- It seems that no matter how high we build the wall, SPAM manages to get over it!

- And so far there is no solution in sight

Expectations vs Reality

We can “fix” Security

No we can’t!

- Does anyone even think that this is a solvable problem any more?
- The Internet is alive with malware, trojans, scanners, bots, ransomware, hackers, cyber criminals, cyber warfare,…
- And if this is a “war” then we’ve lost every battle so far!
- Complex systems appear to be vulnerable simply because they are complex
  - And we have no idea how to live in this toxic environment
- So far all of us are just “feeling lucky”

Expectations vs Reality

Encryption gives you Security

No it doesn't!

- It just changes the locus of attack
- And at the same time creates a deluded sense of security without the substance of assured robust security
- The current PKI Certificate framework used by Internet servers has been compromised many times, and will be compromised many more times
  - But we just don't want to change our behaviours

But

There is no Plan B, and no going back

We have passed the point of no return a long time ago

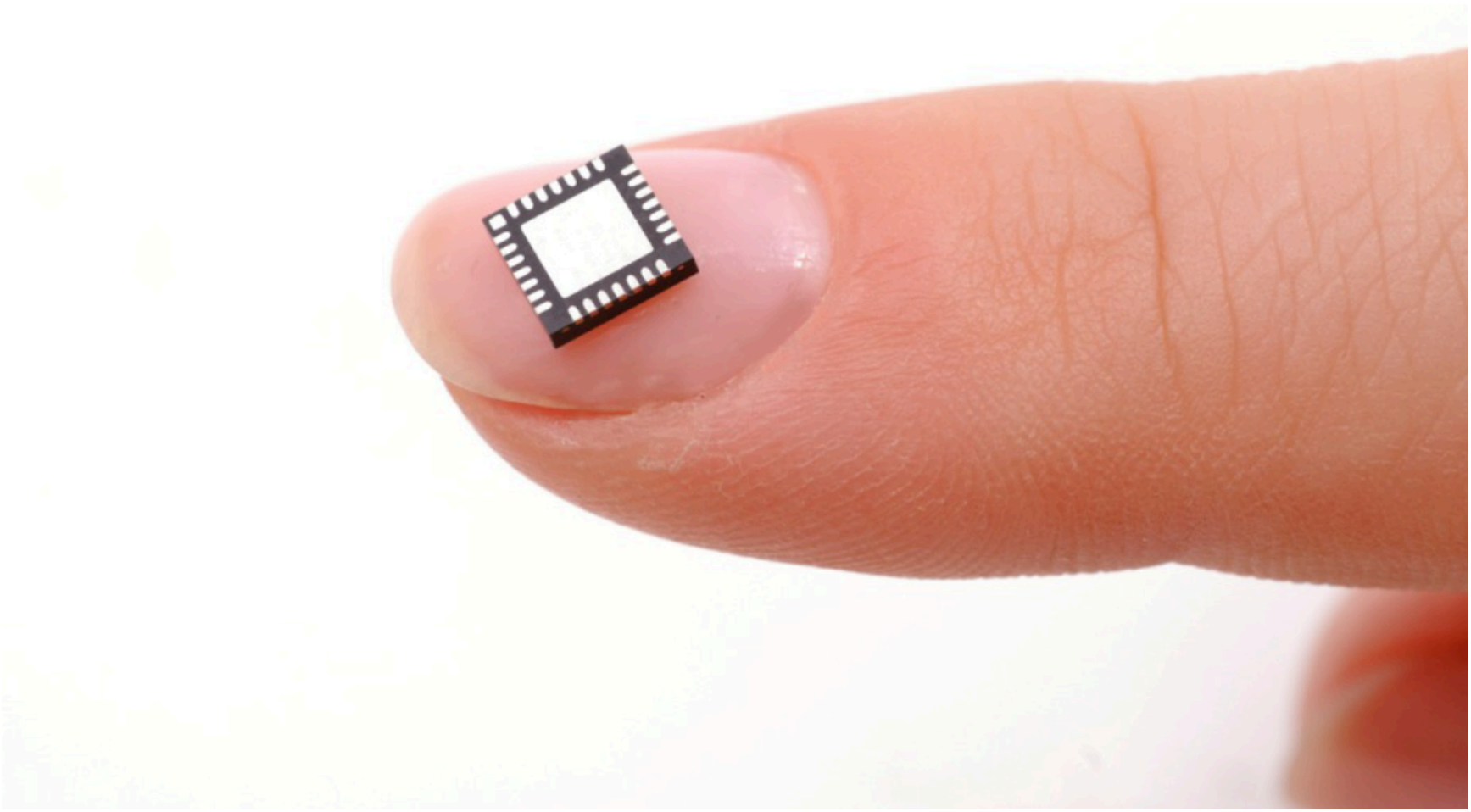
We are now completely reliant on this hyper-connected environment

We are now counting on Moore's law forever: ever faster, ever cheaper, ever smaller, everywhere.

- Even though the silicon engineers continuously declaim that the end is nigh for Moore's Law

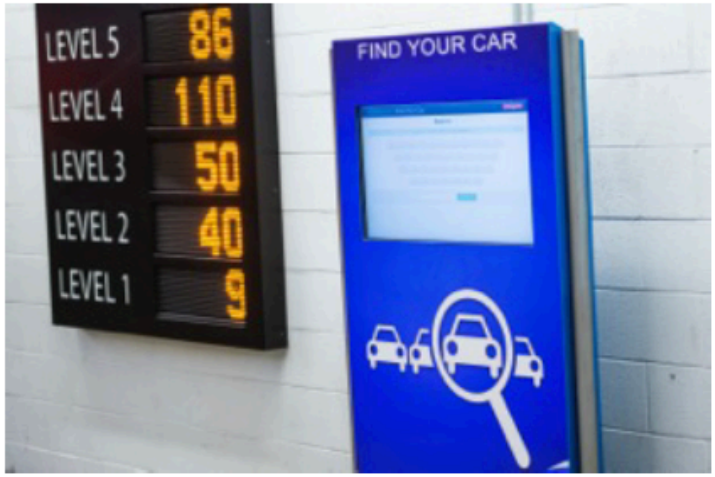
We are now being driven by change, not driving change

So what are the issues?

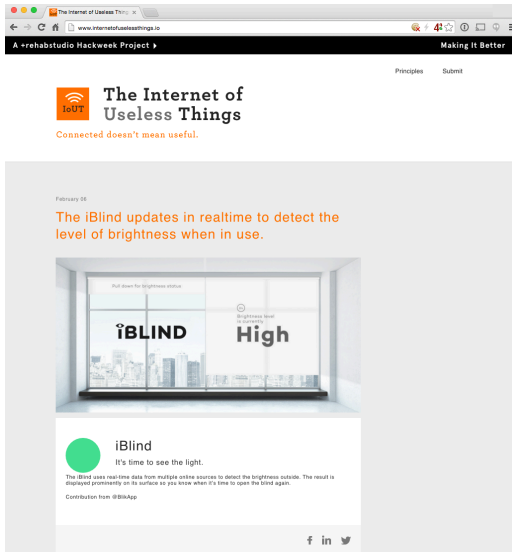


Carriage vs Content

Silicon Ubiquity



Silicon Stupidity



The Internet of Stupid Things

April 2015

Geoff Huston

In those circles where Internet prognostications abound and policy makers flock to hear grand visions of the future, we often hear about the boundless future represented by "The Internet of Things". This phrase encompasses some decades of the computing industry's transition from computers as esoteric pieces of engineering affordable only by nations, to mainframes, desktops, laptops, handhelds, and now wrist computers. Where next? In the vision of the Internet of Things we are going to expand the Internet beyond people and press on with connecting up our world using billions of these chattering devices in every aspect of our world.

It's not a new vision by any means. Already my car probably has 100 microprocessors doing everything from regulating the engine to remembering the seat position. But this grand vision connects all these processors up in one massive Internet. Gartner have projected that the world of chattering silicon will get to 25 billion devices by 2020. Cisco has upped the ante with their prediction of 50 billion such connected things by 2020, and Morgan Stanley has trumped them both by going further with a prediction of 75 billion devices connected to the Internet in that time. Other reports have placed this number as high as 100 billion. The extent of the current levels of unbounded technical euphoria in this space project economic values of this activity in units of trillions of dollars by 2020.

Internet Of Things: Limitless Dumb Possibilities

Many of the "improvements" to ordinary household objects promised by SmartThings, a software company just acquired by Samsung, are already available elsewhere or seem like overkill.

Geek's Guide To NYC Travel: Interop Preview

(Click image for larger view and slideshow.)

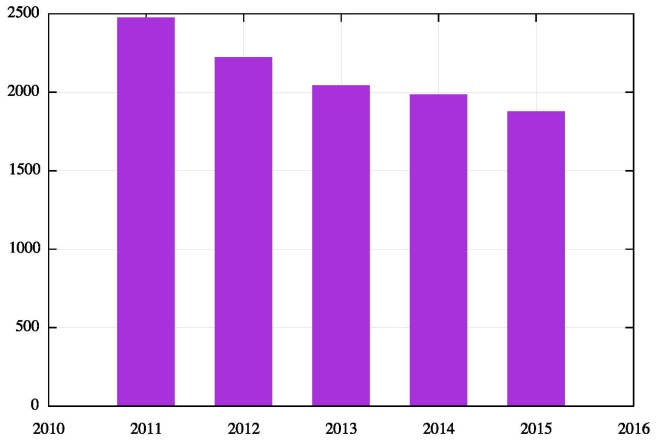
In the 2004 reboot of *Battlestar Galactica*, the starship for which the series is named escapes destruction because its computers were not networked.

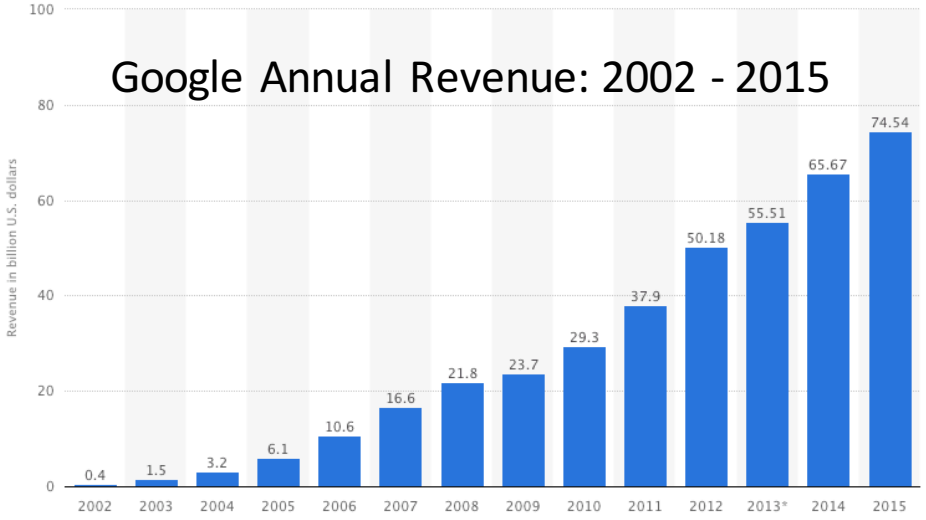
This profoundly pessimistic view of network security qualifies as realism outside the realm of science fiction. Computers and networks are full of vulnerabilities. Beyond mission-critical, heavily-overseen projects with limited scope, the security industry doesn't even contemplate bulletproof code. Instead, it measures software defects per thousand or million source code lines. There will be bugs; the only question is how many.

Out with the old and in with the new

The new product that is being marketed is now the online individual user – mass market media channels are now declining in relevance

Fairfax Media Annual Revenue: 2011 - 2015





Nowhere and Nothing to Hide Any more!

So where does it head?

In 1990, when Peter and I were connecting up campuses in Australia, our world had:

- mobile phones the size of briefcases
- “portable” computers that weren’t even luggable!
- cameras that loaded film
- “real” computers that were multi-million dollar investments with cluster of work bees to tend them
- “technology” as a skilled occupation undertaken by a small cadre of educated professional engineers
- And it may have had Microsoft and Apple, but it had no Google!

Much of that world has vanished!

So where does it head?

What has replaced it is both oddly familiar and strangely alien at the same time:

- telephones you talk to, not talk through
- cameras that take the picture you actually wanted to take
- cars that can drive you, rather than cars that you drive

And most of this took just 25 years!

So where does it head?

So what can we expect in 25 years time?

So where does it head?

So what can we expect in 25 years time?

Firstly, it’s not gong to stop here!

So where does it head?

So what can we expect in 25 years time?

Firstly, it's not gong to stop here!

But after saying that, what will happen in 25 years is far harder to predict!

"Smart" futures

There will be more machines, and more powerful machines

These automated systems will focus on human activities, and they will be driving to the point of using machinery rather than human labour for a myriad of current activities

The focus on the elements of computing and network requirements of these systems will probably shift from means to outcomes

Catalogue of fears

Probability of computerisation of different occupations, 2013
(1 = certain)

Job	Probability
Recreational therapists	0.003
Dentists	0.004
Athletic trainers	0.007
Clergy	0.008
Chemical engineers	0.02
Editors	0.06
Firefighters	0.17
Actors	0.37
Health technologists	0.40
Economists	0.43
Commercial pilots	0.55
Machinists	0.65
Word processors and typists	0.81
Real-estate sales agents	0.86
Technical writers	0.89
Retail salespeople	0.92
Accountants and auditors	0.94
Telemarketers	0.99

Source: "The Future of Employment: How Susceptible are Jobs to Computerisation?", by C. Frey and M. Osborne (2013)

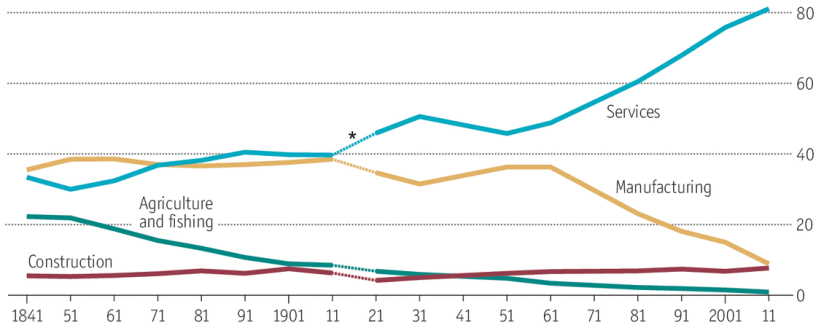
Economist.com

The debates about whether AI will destroy jobs, and whether it might destroy humanity, are really arguments about the rate of change

The Economist, June 2016

Jobs come and go

Share of employment in Britain by industry, %



Source: ONS

*England and Wales after 1911

Economist.com

Thanks!