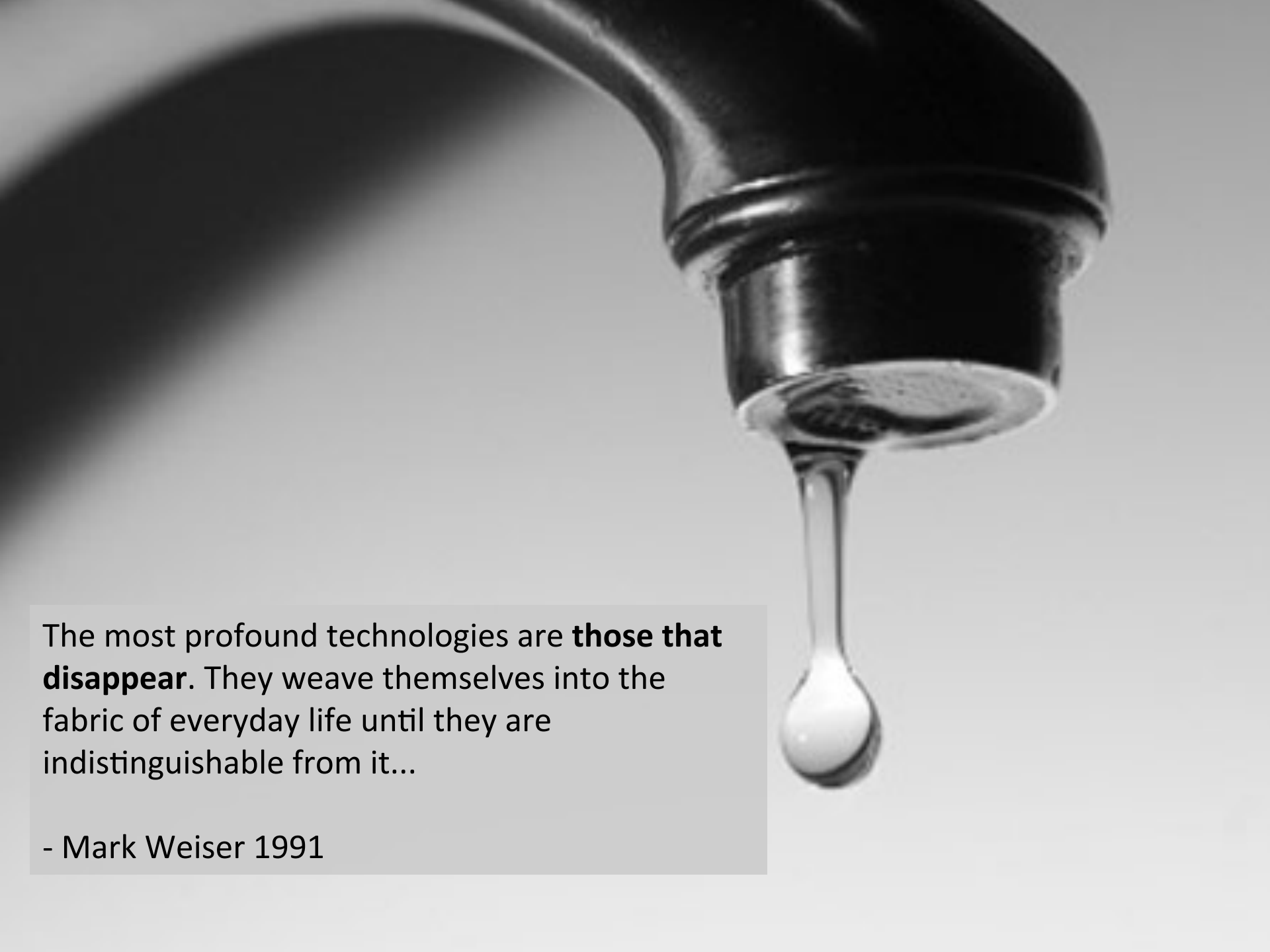
Tomorrow's Internet

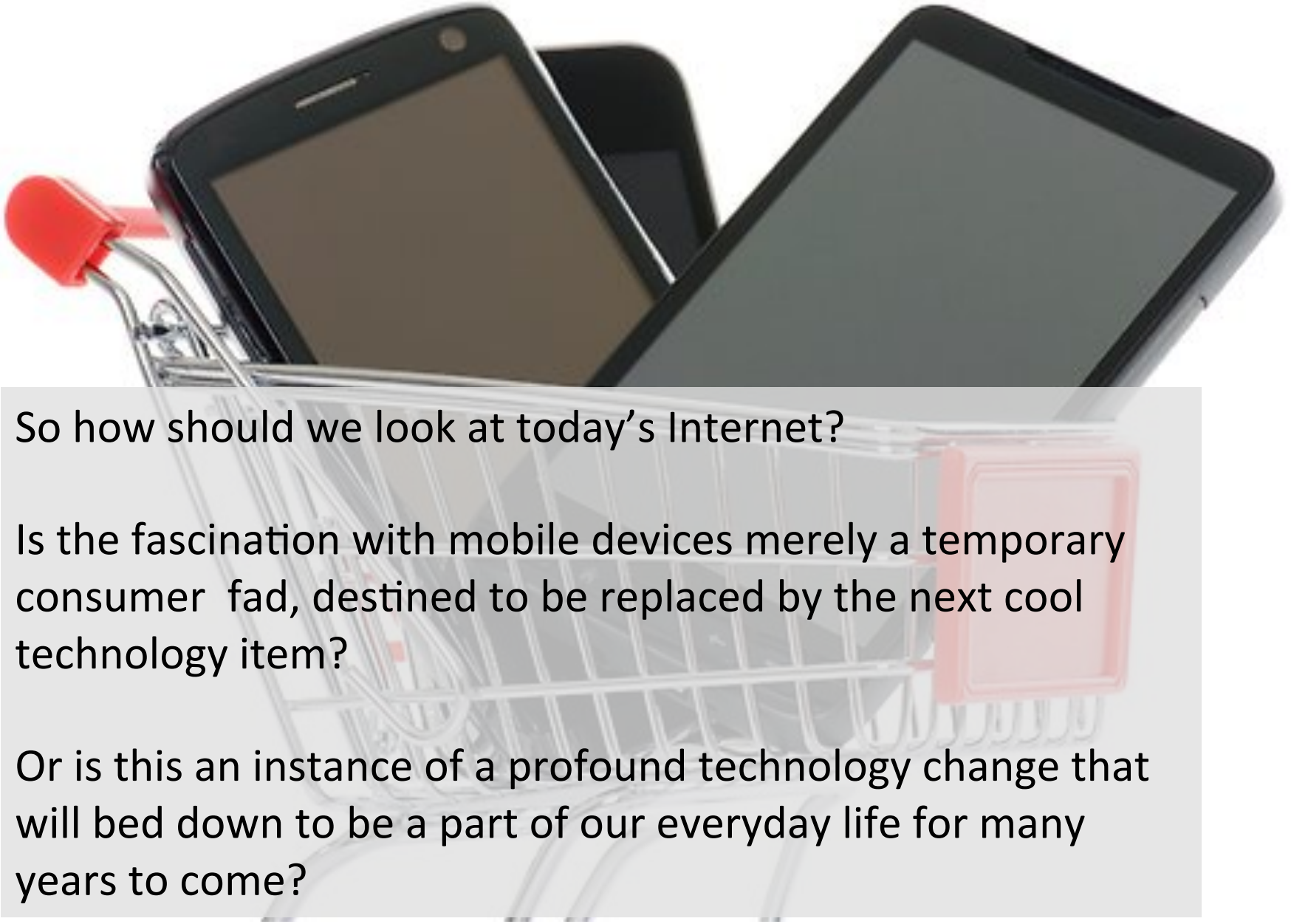
A highly personal (and somewhat opinionated) view by

Geoff Huston,
APNIC



The most profound technologies are **those that disappear**. They weave themselves into the fabric of everyday life until they are indistinguishable from it...

- Mark Weiser 1991



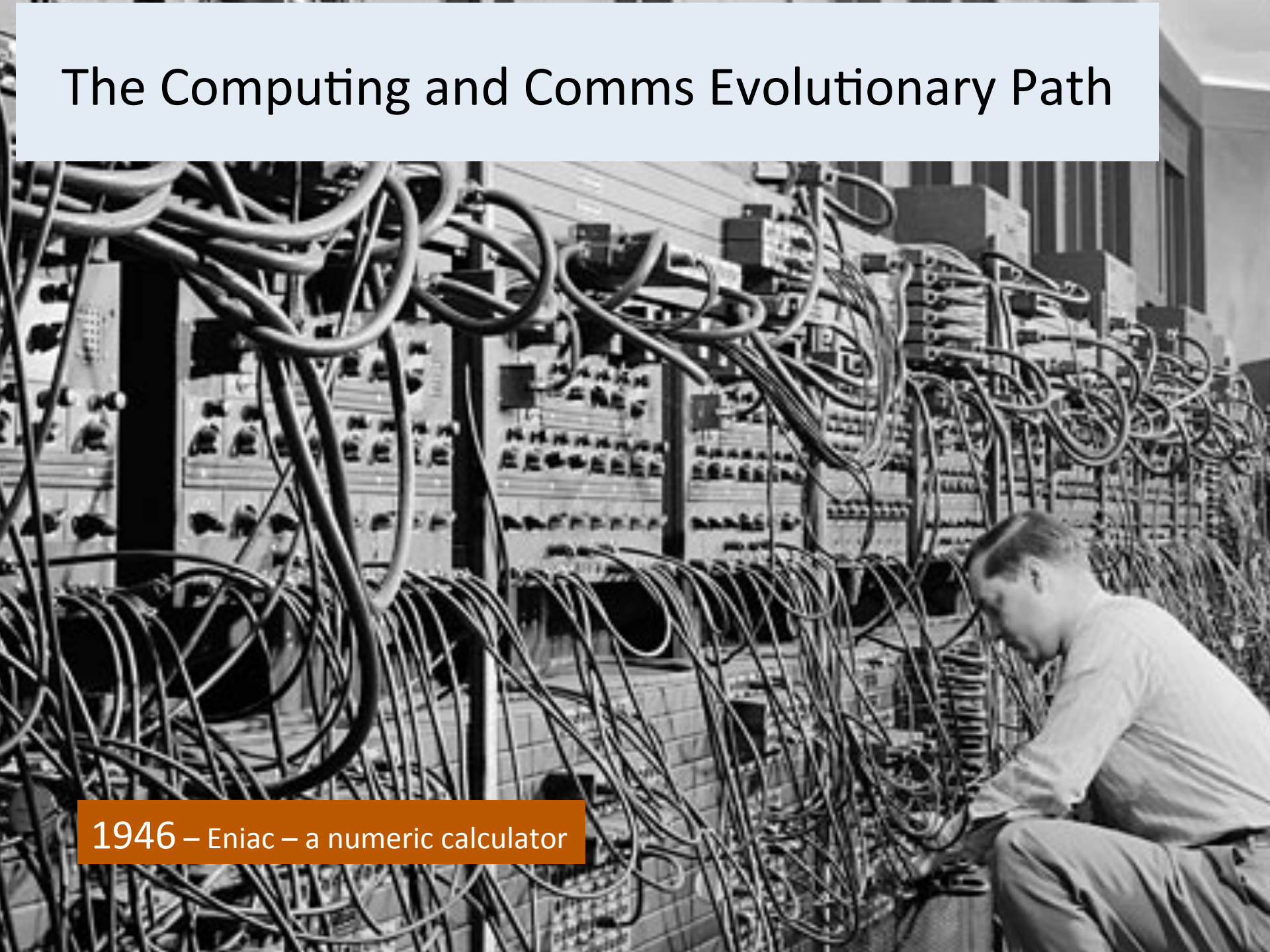
So how should we look at today's Internet?

Is the fascination with mobile devices merely a temporary consumer fad, destined to be replaced by the next cool technology item?

Or is this an instance of a profound technology change that will bed down to be a part of our everyday life for many years to come?

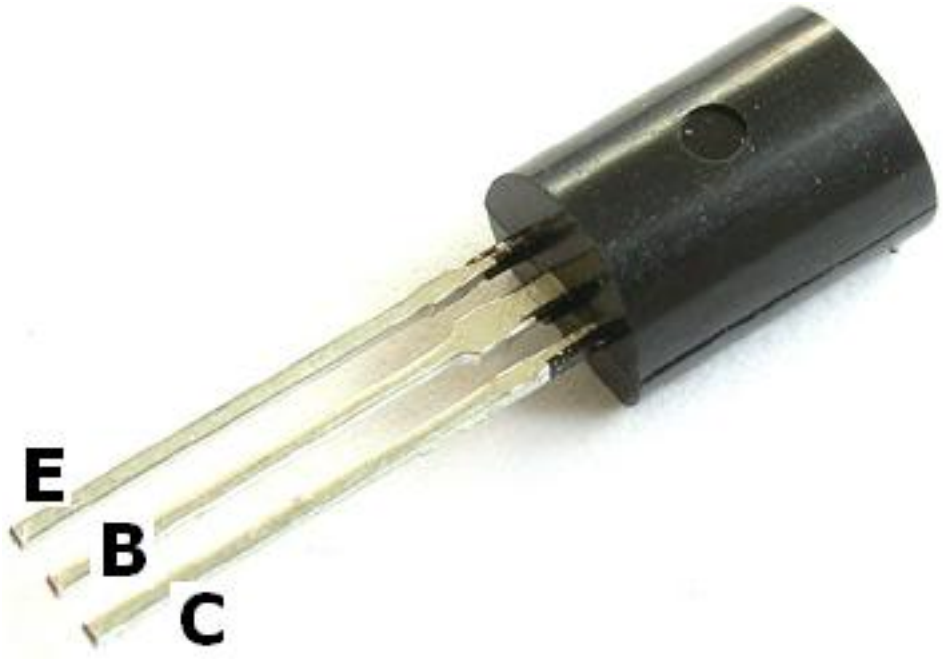
To try and answer this, lets try and put this question into some broader context of the evolution the computer and communications enterprise

The Computing and Comms Evolutionary Path



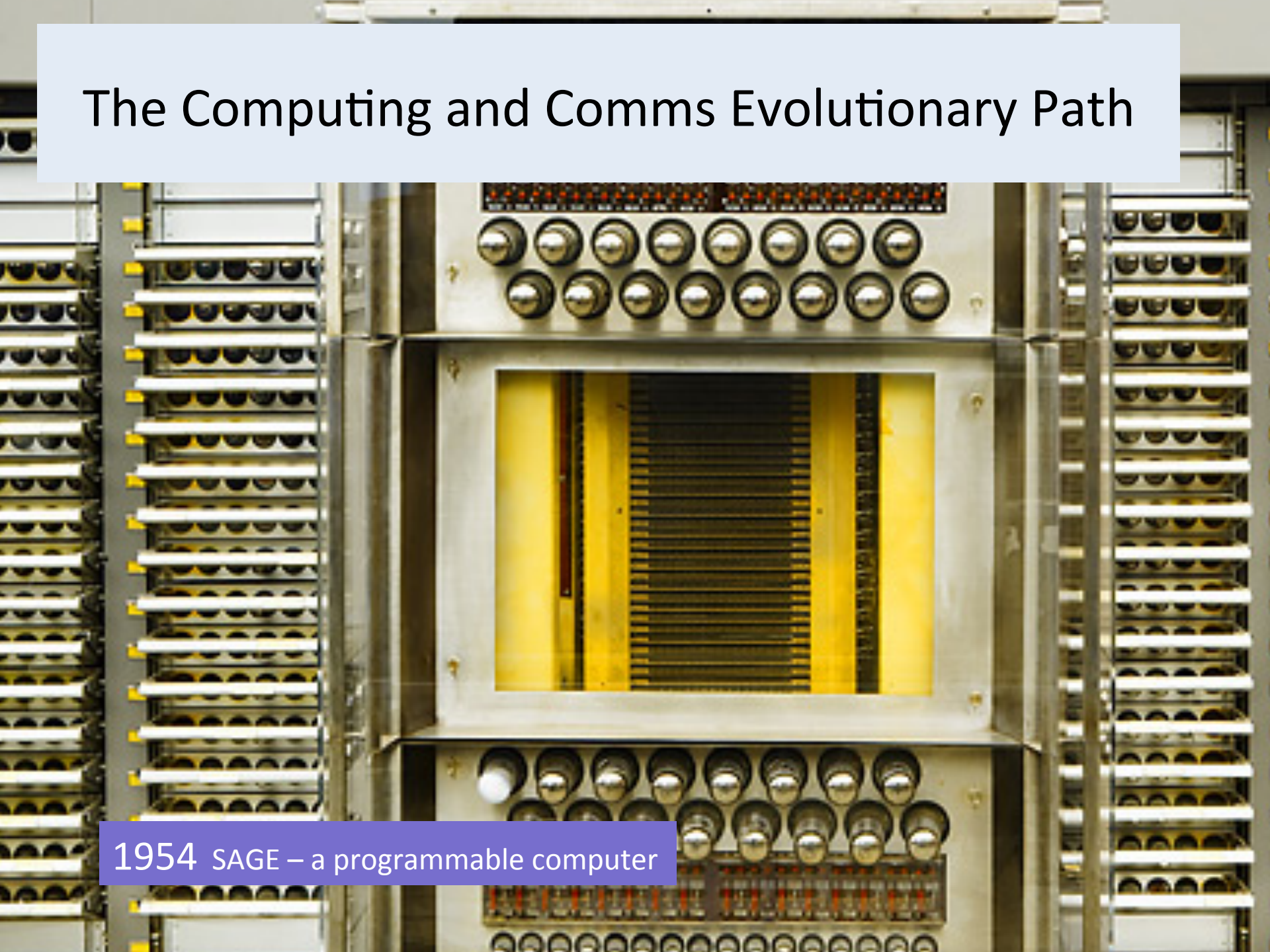
1946 – Eniac – a numeric calculator

The Computing and Comms Evolutionary Path



1947– The Transistor

The Computing and Comms Evolutionary Path



1954 SAGE – a programmable computer

The Computing and Comms Evolutionary Path

1964 IBM 360 – commercial computing

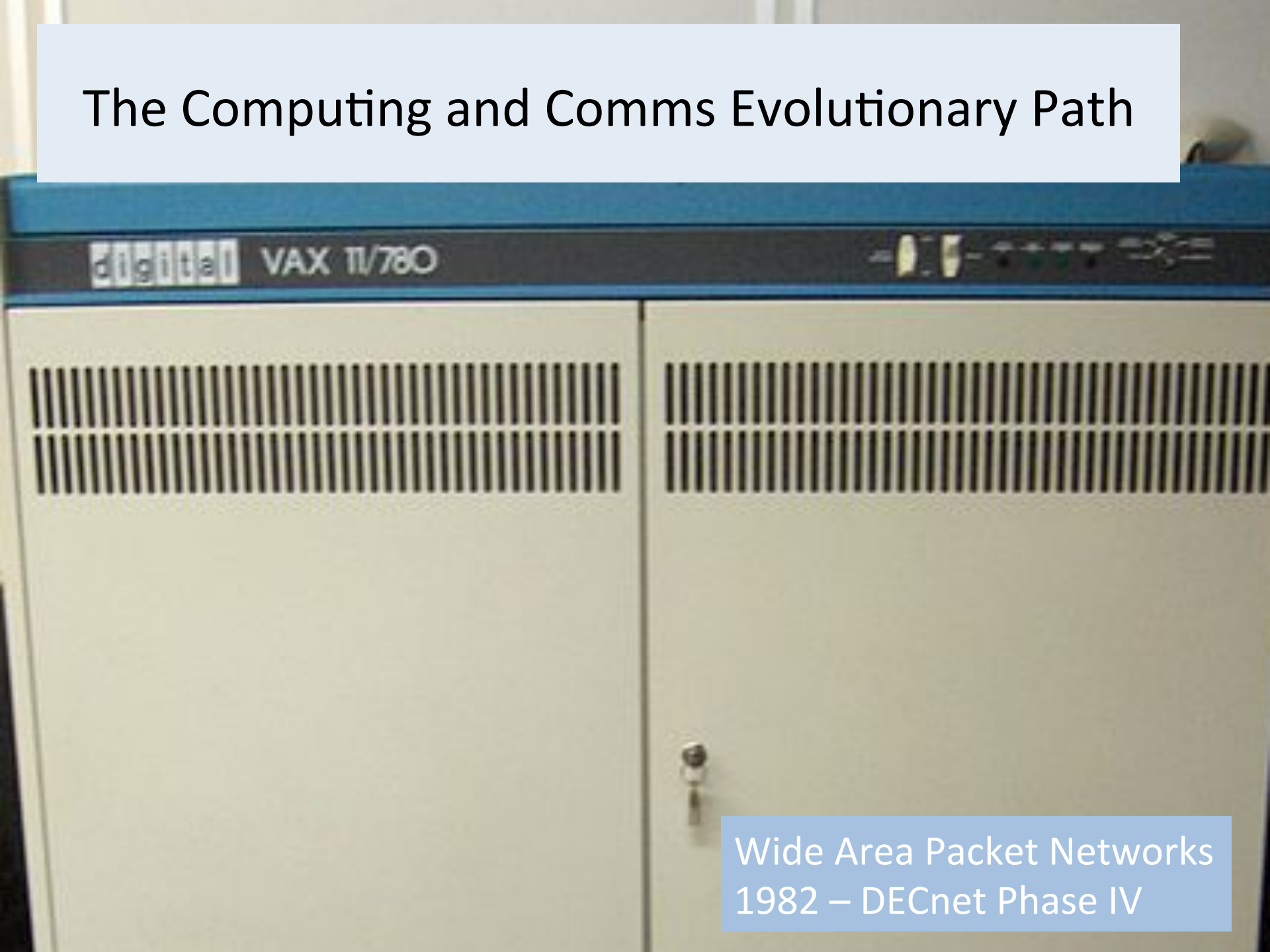
The Computing and Comms Evolutionary Path

The Computing and Comms Evolutionary Path

The Computing and Comms Evolutionary Path

A fork in the road:
1976 – Apple-1 “personal” computing

The Computing and Comms Evolutionary Path

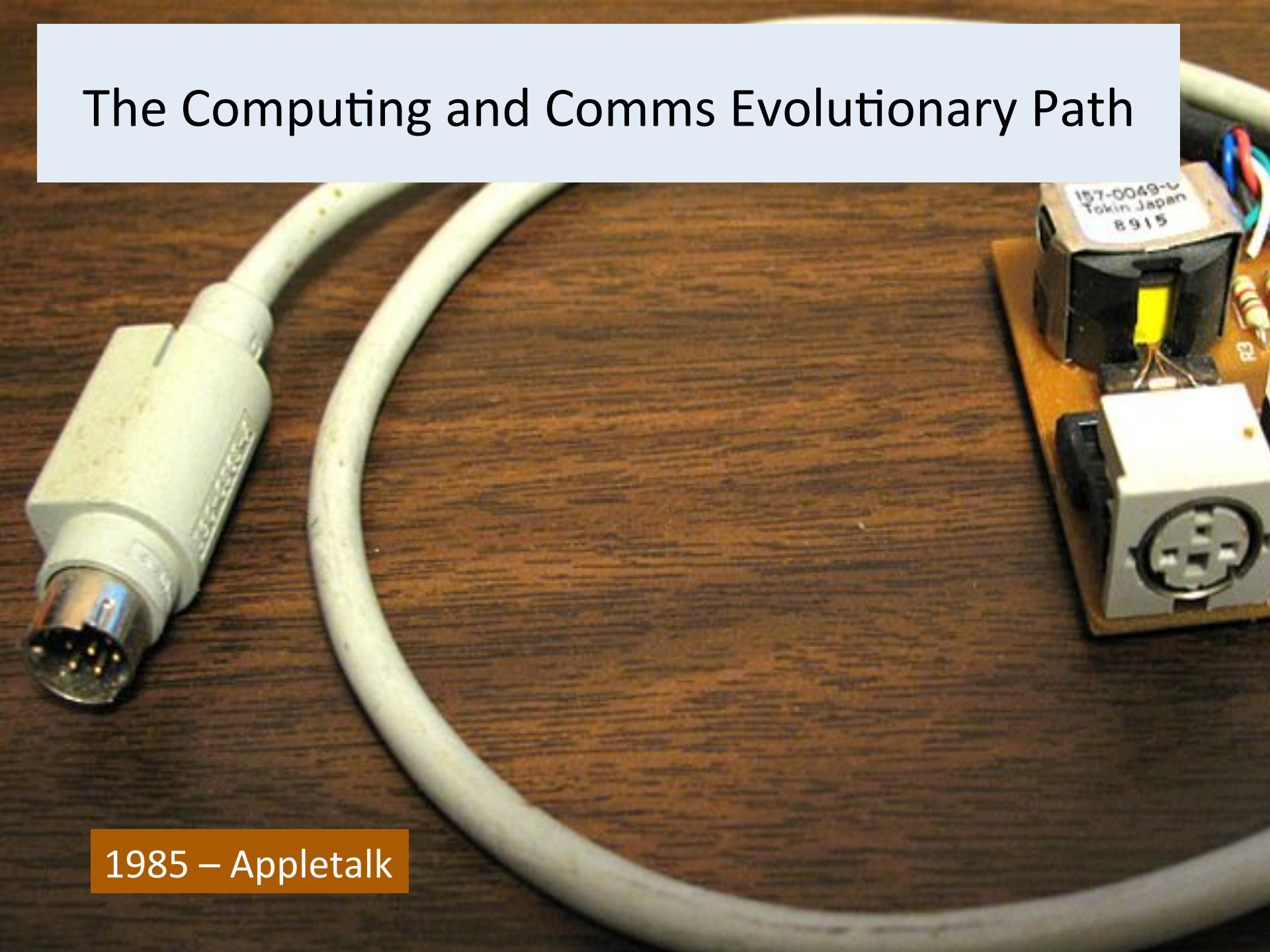


Wide Area Packet Networks
1982 – DECnet Phase IV

The Computing and Comms Evolutionary Path

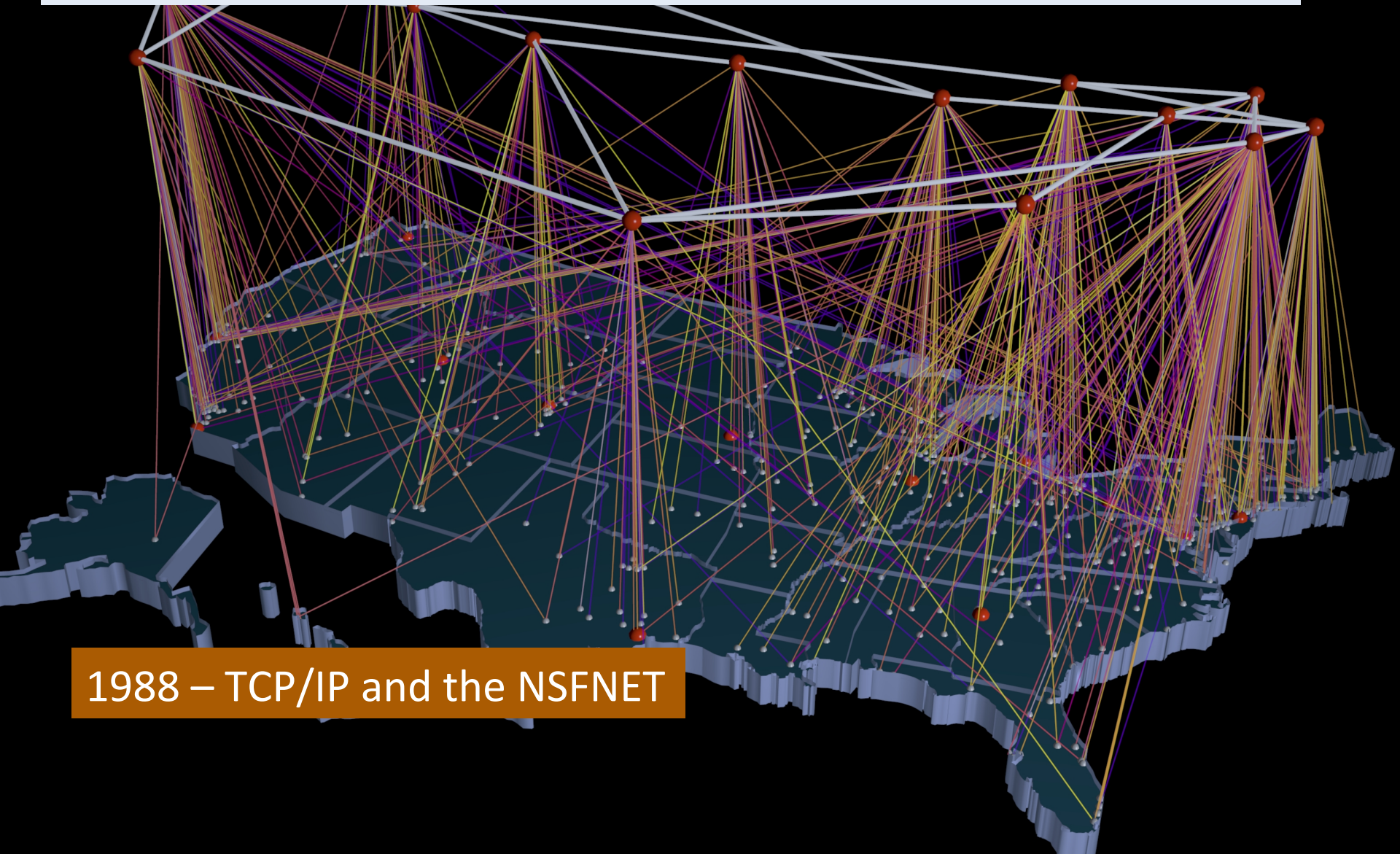
1984 – Mac - visual computing

The Computing and Comms Evolutionary Path



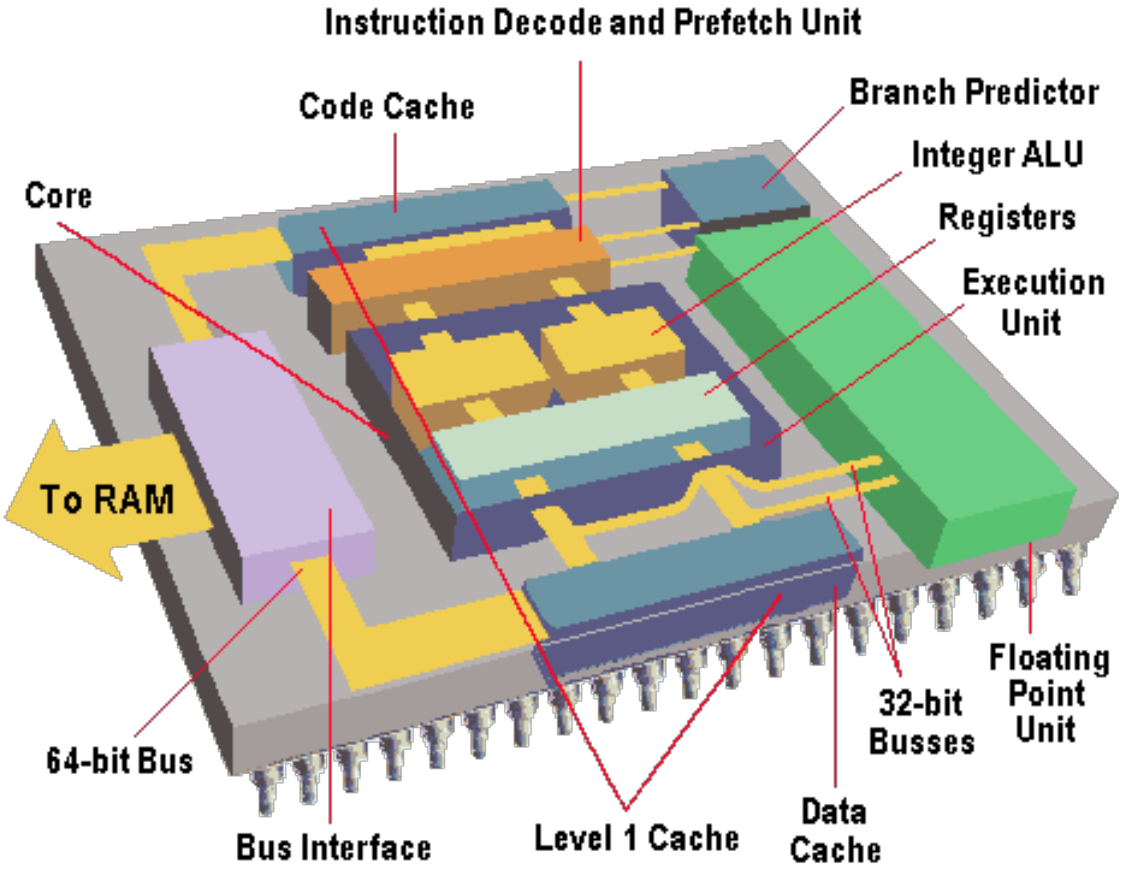
1985 – Appletalk

The Computing and Comms Evolutionary Path



1988 – TCP/IP and the NSFNET

The Computing and Comms Evolutionary Path



1993 – Intel - Pentium processor

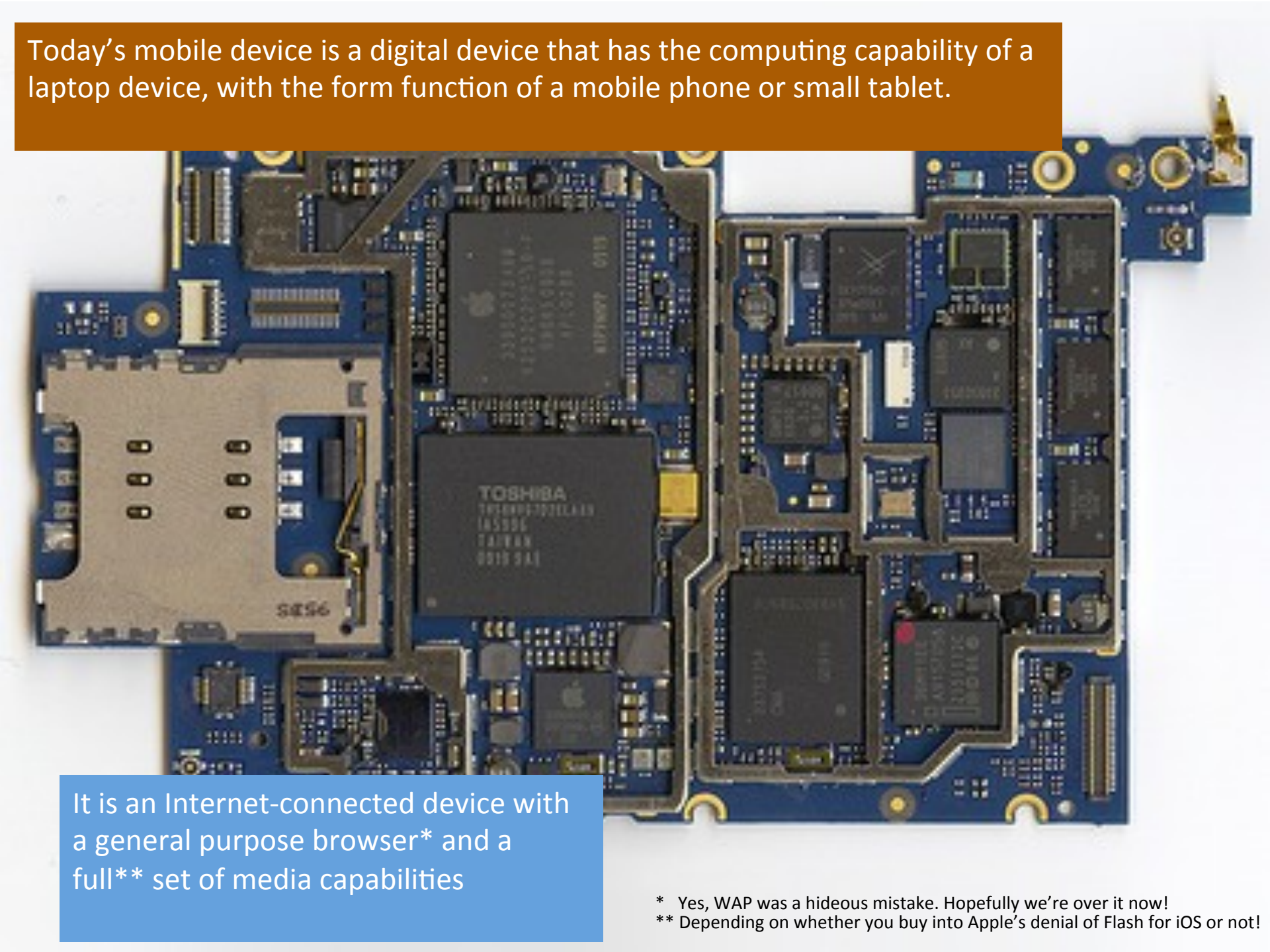
The Computing and Comms Evolutionary Path

1993 – GSM

The Computing and Comms Evolutionary Path

2007 – Apple's iPhone

Today's mobile device is a digital device that has the computing capability of a laptop device, with the form function of a mobile phone or small tablet.



It is an Internet-connected device with a general purpose browser* and a full** set of media capabilities

* Yes, WAP was a hideous mistake. Hopefully we're over it now!
** Depending on whether you buy into Apple's denial of Flash for iOS or not!

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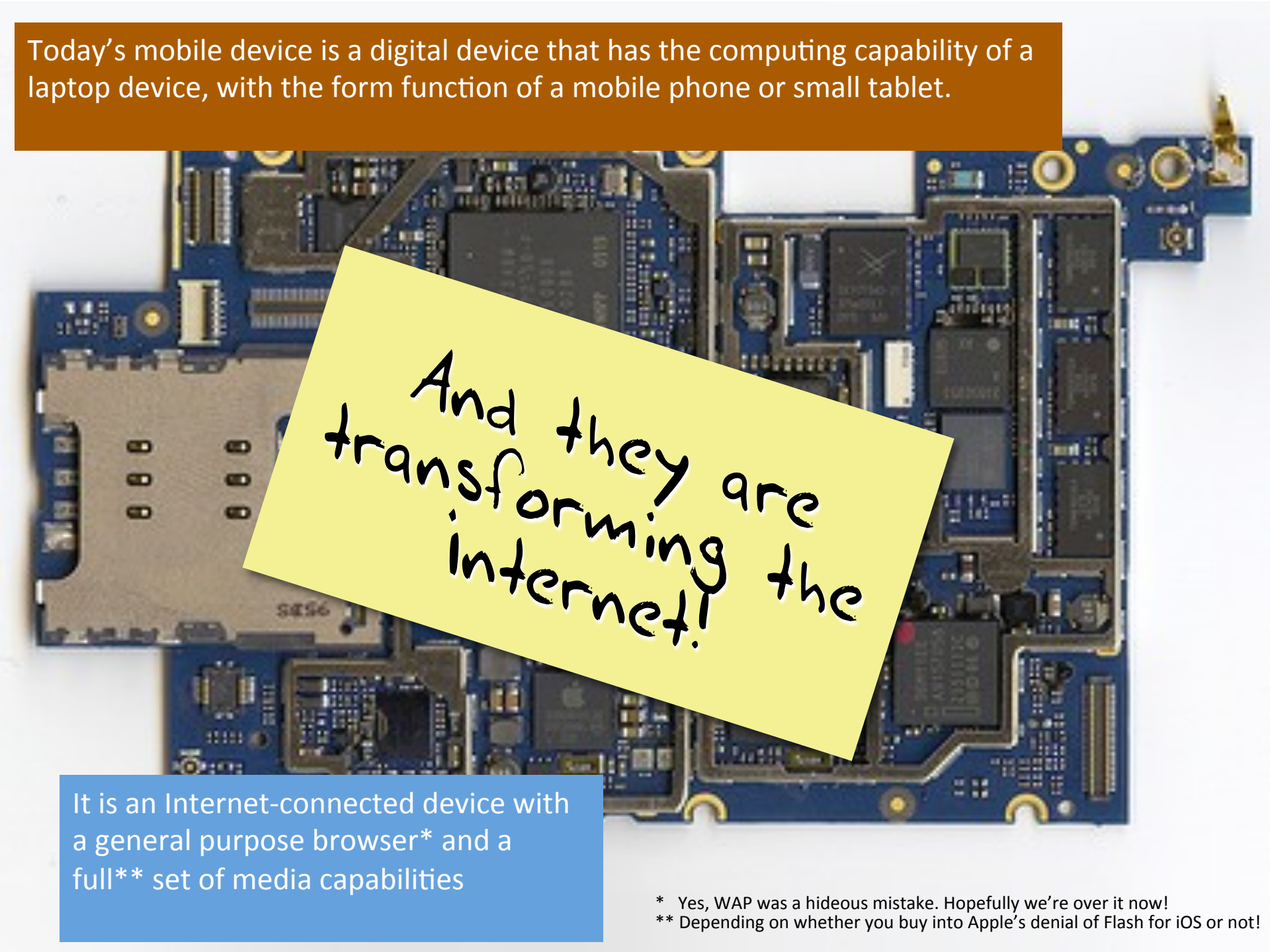

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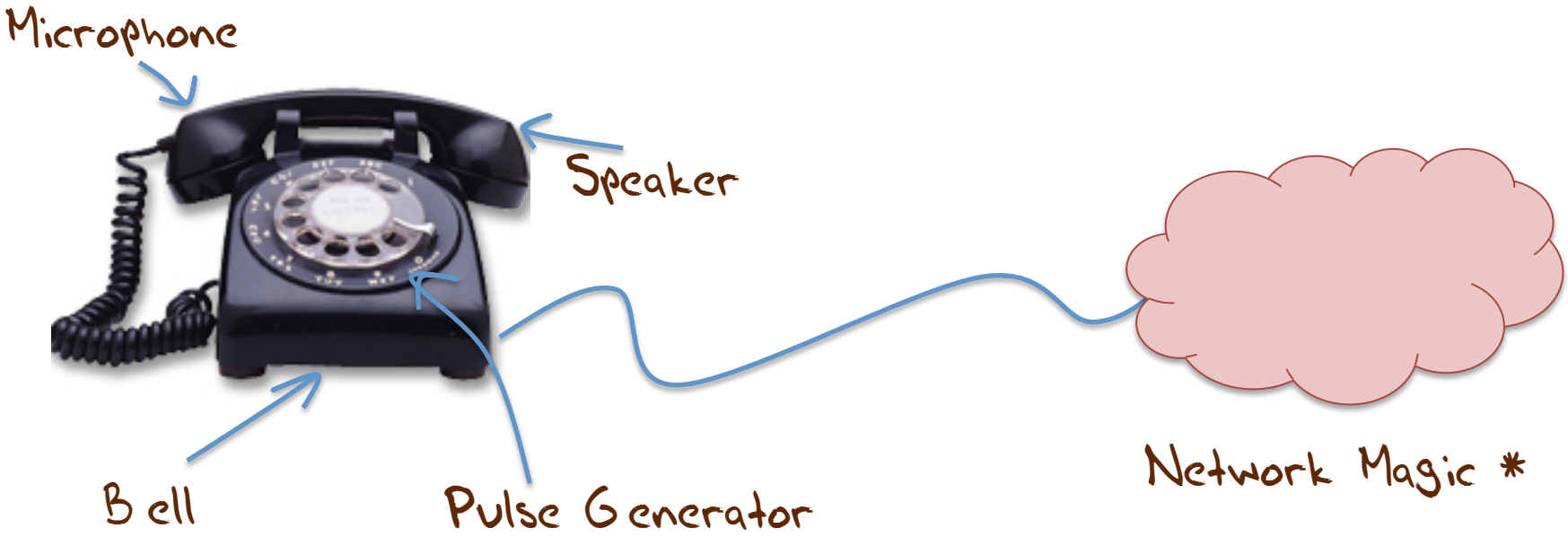
PLACED UPON THE HORIZON (CASTING SHADOWS)
MASSIVE CHANGE
The Future of Global Design
WORLD PREMIERE
October 2, 2004 to January 3, 2005

With desktop devices the Internet was a dedicated activity


The Internet is now anywhere and everywhere
radio connectivity
Thumb operated
hand sized
battery power
Its trivial, commonplace and blends into all our activities

Telephony Networking

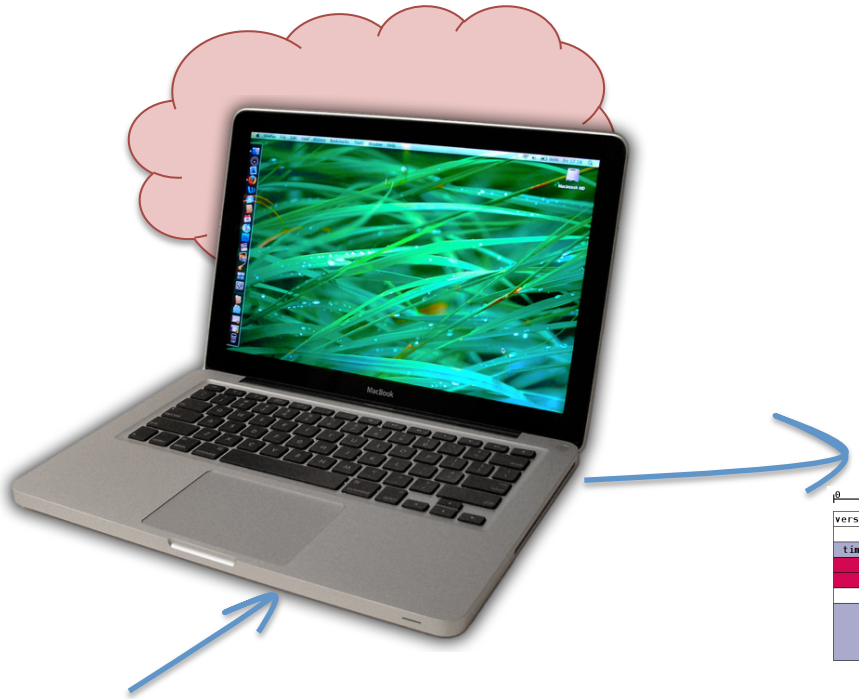
Telephony Networking



The Network defines the Service

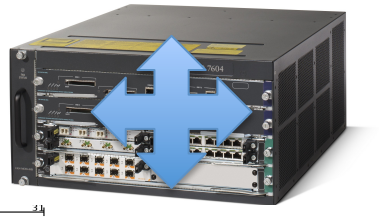
IP Networking

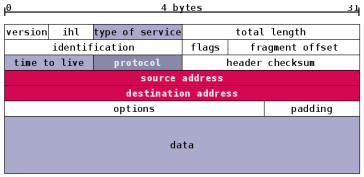
IP Networking



Application Magic *

Packet Switch





iP Packet

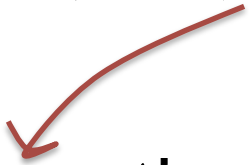
The Applications define the Services

IP: Occam's Razor applied to Networking

Why has IP been so effective?

IP: Occam's Razor applied to Networking

Why has IP been so effective?



Because it's cheap!

IP: Occam's Razor applied to Networking

Why has IP been so effective?

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Why is IP cheap?

IP: Occam's Razor applied to Networking

Why has IP been so effective?

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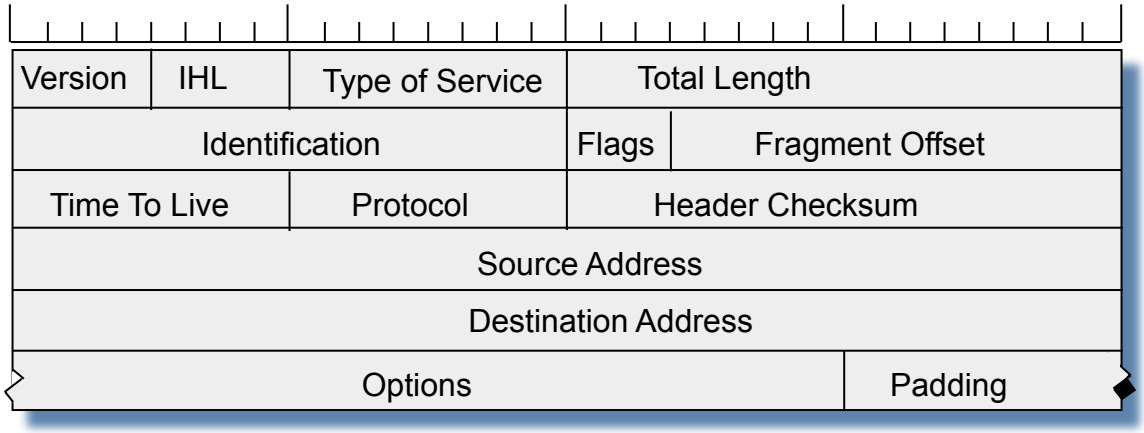
Why is IP cheap?

Because its minimal in what it does!



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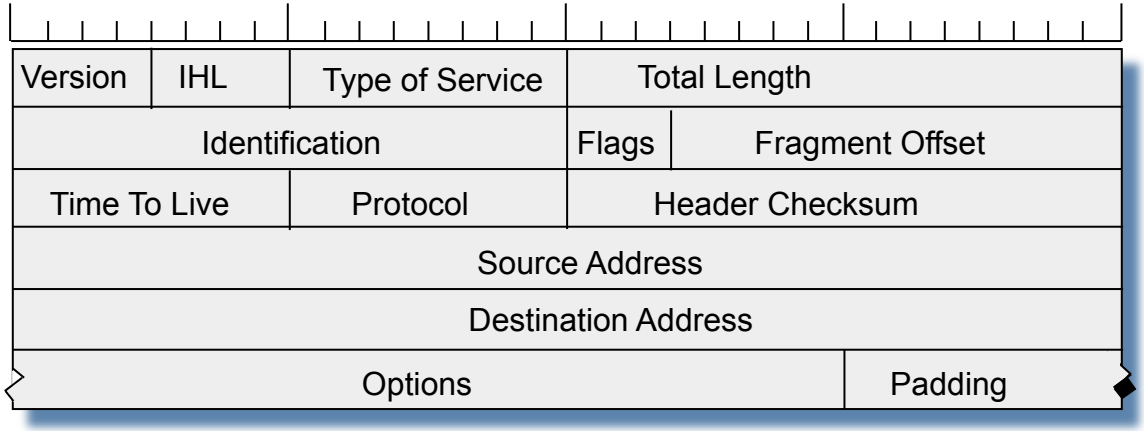

What about all the other "network" functions?

IP: Occam's Razor applied to Networking

Why has IP been so effective?

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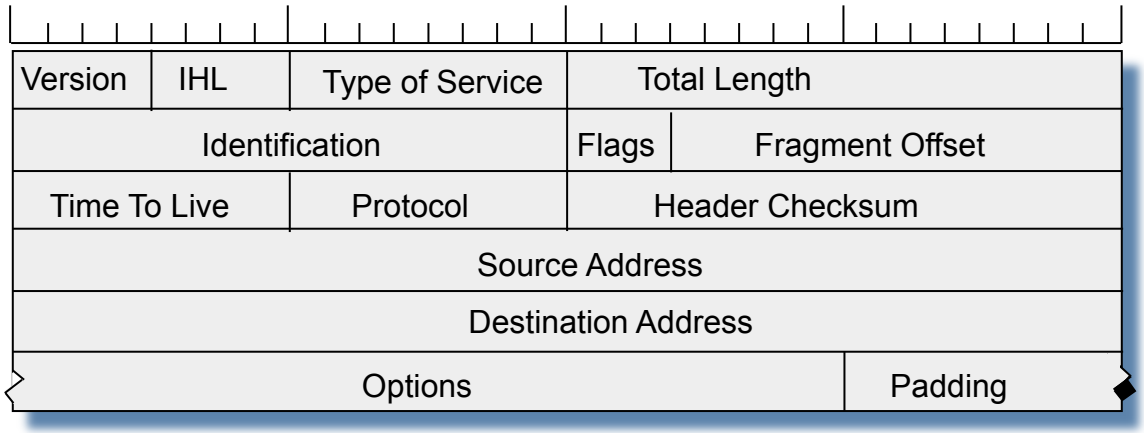

What about all the other "network" functions?

They are now part of the upper levels at edge, not part of the network!

But - is minimalism sustainable?

Drilling down…

So far this is all rather abstract

Drilling down...

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Lets take a more detailed look at some specific technologies

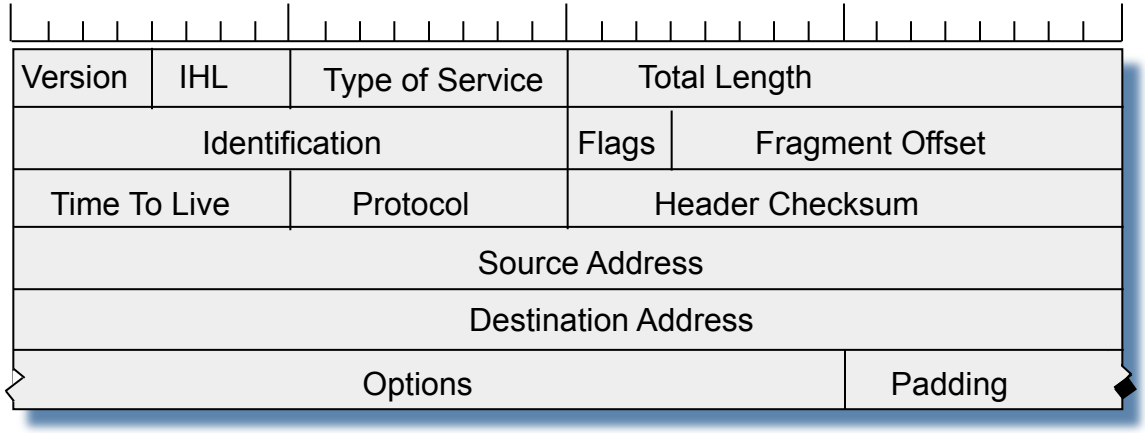
Drilling down...

This is all rather abstract

Lets take a more detailed look at some specific technologies

And bear in mind that the shape of the future can often be found in the mistakes of the past!

IP was just so simple…



Hop-by-Hop stateless forwarding

Datagram transmission

End-To-End data integrity

Decoupled resource management, topology management

What could possibly go wrong?

What's not working…

What's not working…

Multicast

What's not working...

Multicast

MPLS

What's not working...

Multicast

MPLS

Congestion Control

What's not working...

Multicast

Buffering and Queues

MPLS

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Routing

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Load Management

What really needs to work...

Where to from here?

Today!

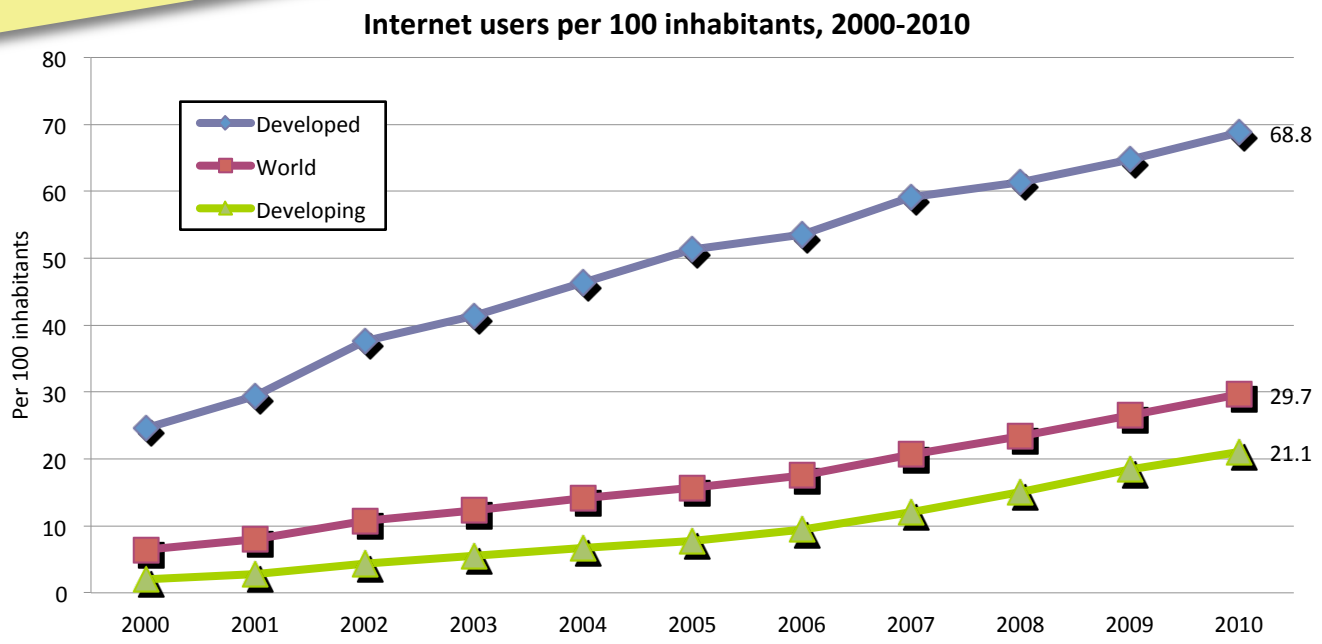
"We are now living in a post-PC world"

Apple's Tim Cook, March 2012

The metrics of success

Counting Users...

There are 2.5 billion internet users today

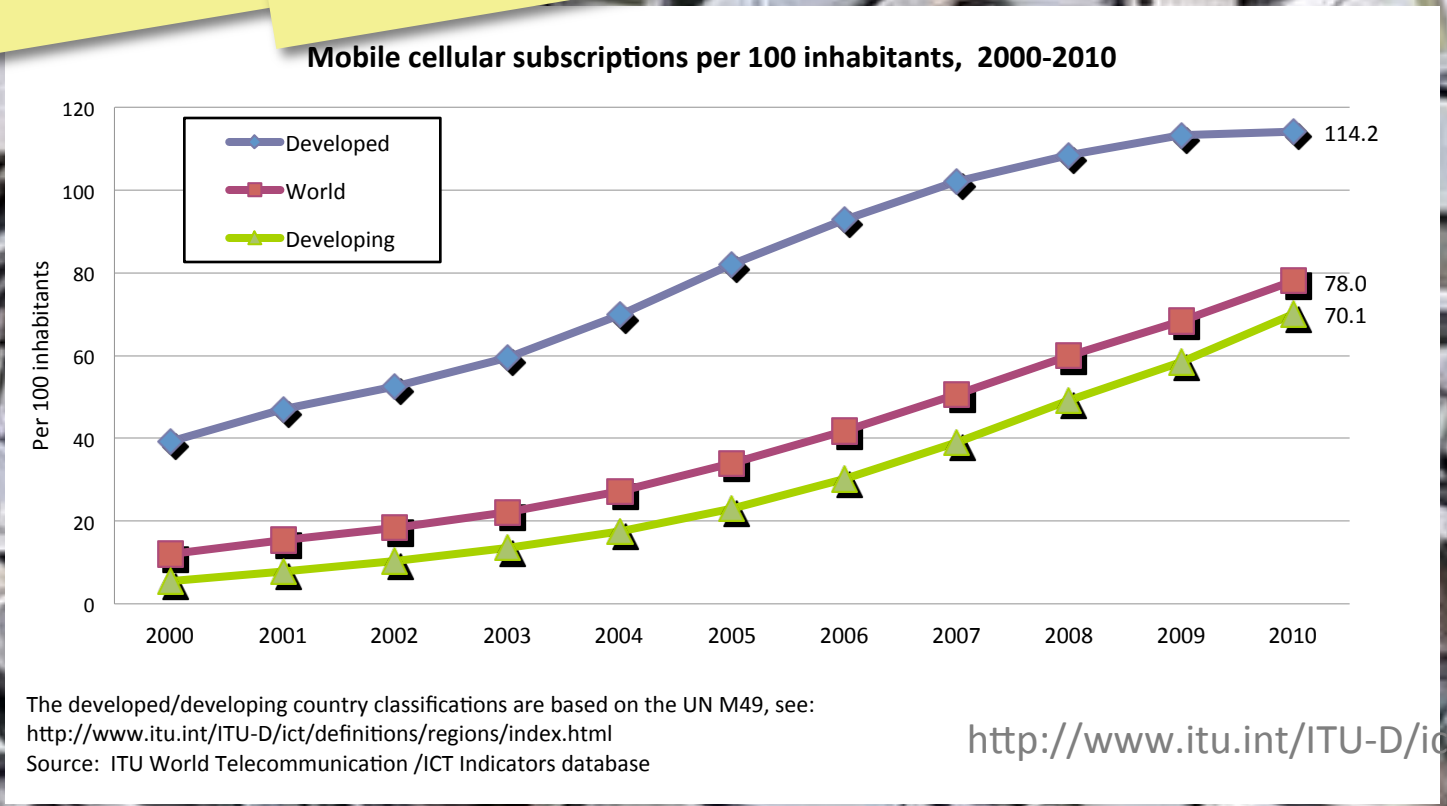


http://www.itu.int/ITU-D/ict/statistics/

Counting Users...

There are internet use

And 5 billion mobile phone users!



The developed/developing country classifications are based on the UN M49, see:
http://www.itu.int/ITU-D/ict/definitions/regions/index.html
Source: ITU World Telecommunication /ICT Indicators database

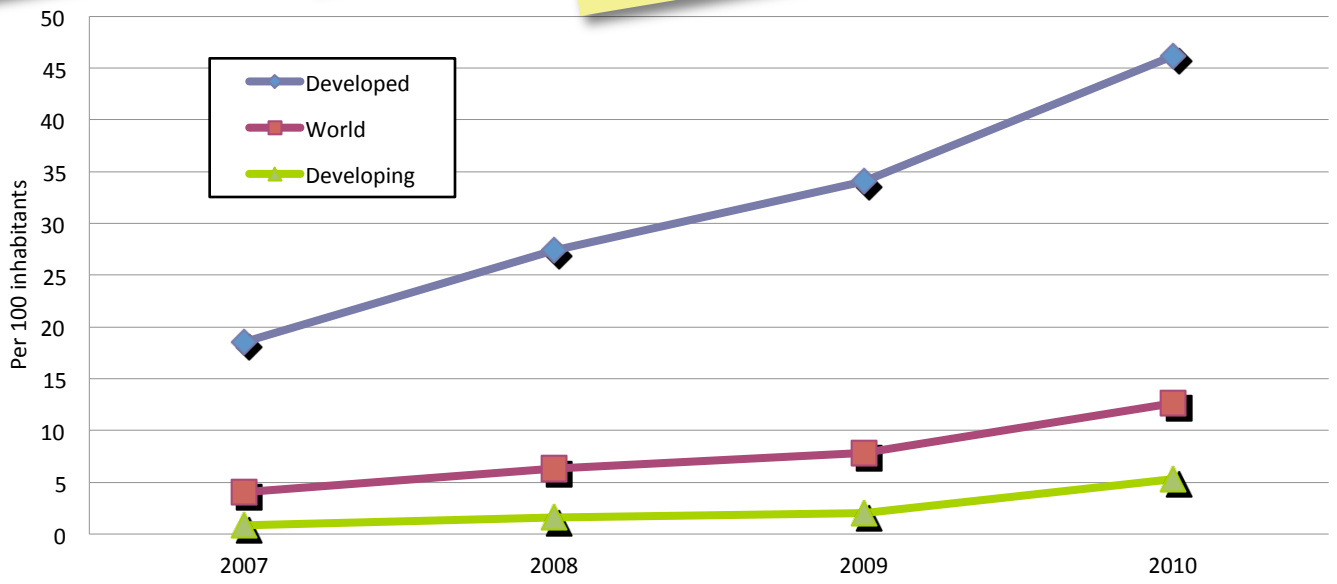
http://www.itu.int/ITU-D/ict/statistics/

Counting Users...

There are
internet us

And 5

And 750 million
mobile internet
users!



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Source: ITU World Telecommunication /ICT Indicators database

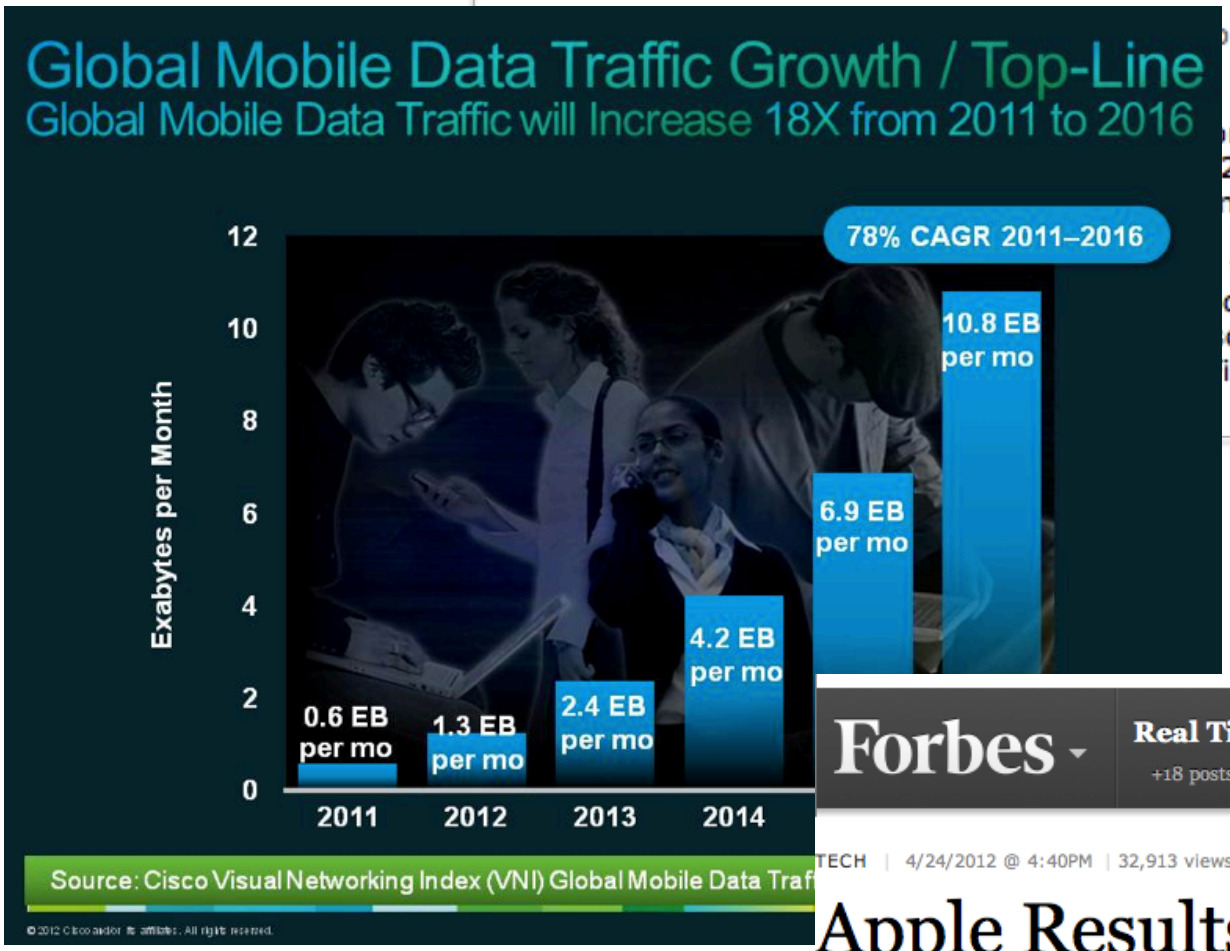
Tomorrow's Users and Usage

Gartner Says Worldwide Media Tablets Sales to Reach 119 Million Units in 2012

...or Approximately 35 Percent of Sales

...rldwide media tablet sales to end ...2012, a 98 percent increase from ...ner, Inc.

... tablet operating system (OS), as it is ...de media tablet sales to end users in ...oft-based devices to this market, and ...ire, Apple will continue to be the



Forbes | Real Time +18 posts this hour | Popular 89 Cliches For MBAs | Lists The World's Billionaire | Vide... Sell Yo...

TECH | 4/24/2012 @ 4:40PM | 32,913 views

Apple Results Top Estimates as iPhone Sales Soar

Where to from here?

5 Years Out

it's a mobile world!

2011: 270 million mobile units shipped

Factors:

- **Production volumes are bringing down component unit cost**
- **Android is bringing down software unit cost**
- **No need for new content - leverage off the the existing web universe of content**
- **Shift away from the desktop and the laptop by the production industry seeking new markets for their production capability**
- **Assumes an abundant minimal common network substrate**

Apple's Numbers

iPhones:

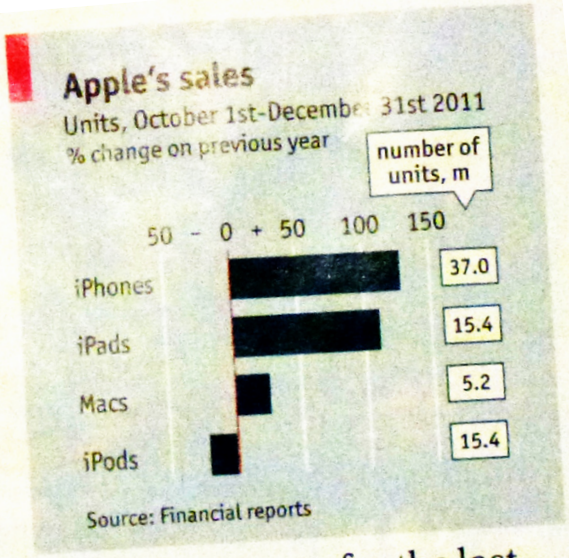
- Q3 2010 : Apple shipped 8.4M iPhones
- Q3 2011 : Apple shipped 20.3M iPhones
  - Added 42 carriers and 15 countries in the quarter!

iPads:

- Q3 2010 : Apple shipped 3.3M iPads
- Q3 2011 : Apple shipped 9.2M iPads
  - “every iPad we could make has been sold”

Q3 2011 profit: $US 7.3B

.e's Numbers



Apple's earnings for the last three months of 2011 surpassed all expectations. It racked up a record $46.3 billion in sales for the quarter and more than doubled its net profit, to $13.1 billion. Apple's share price jumped on the news, vaulting it once again over Exxon Mobil to become (briefly) the world's most valuable listed company.

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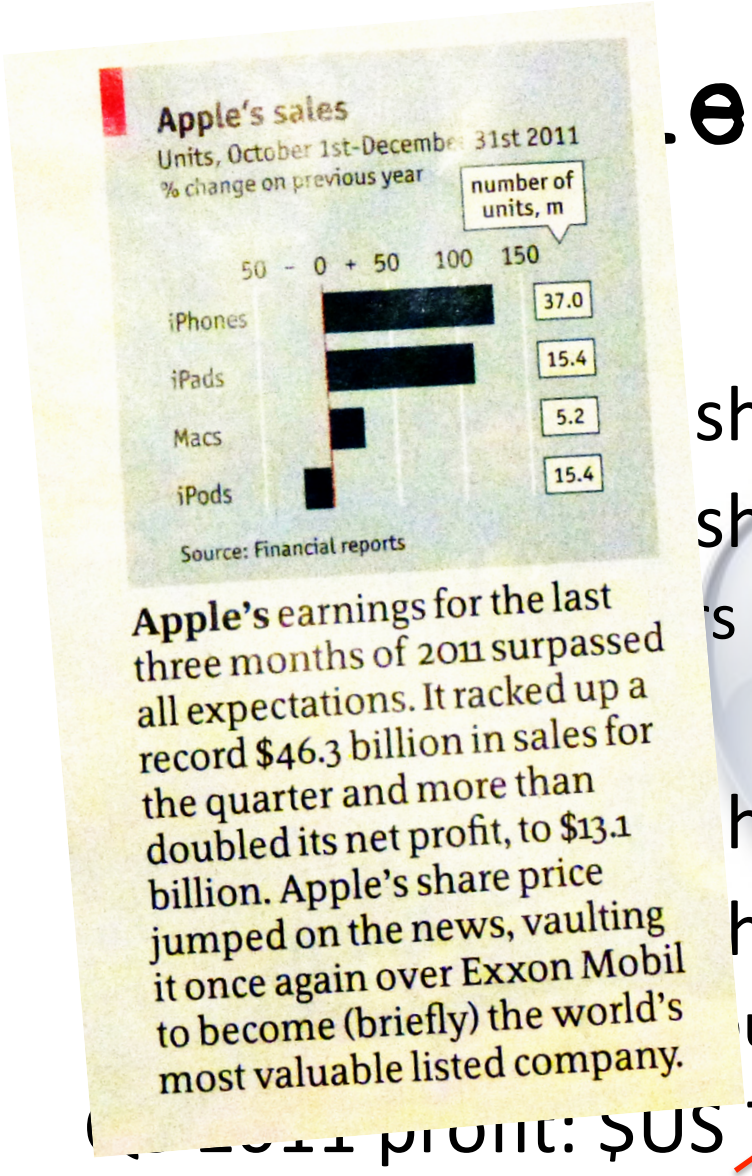
And Q4 2011 was even bigger!

.e's Numbers



37M iPhones

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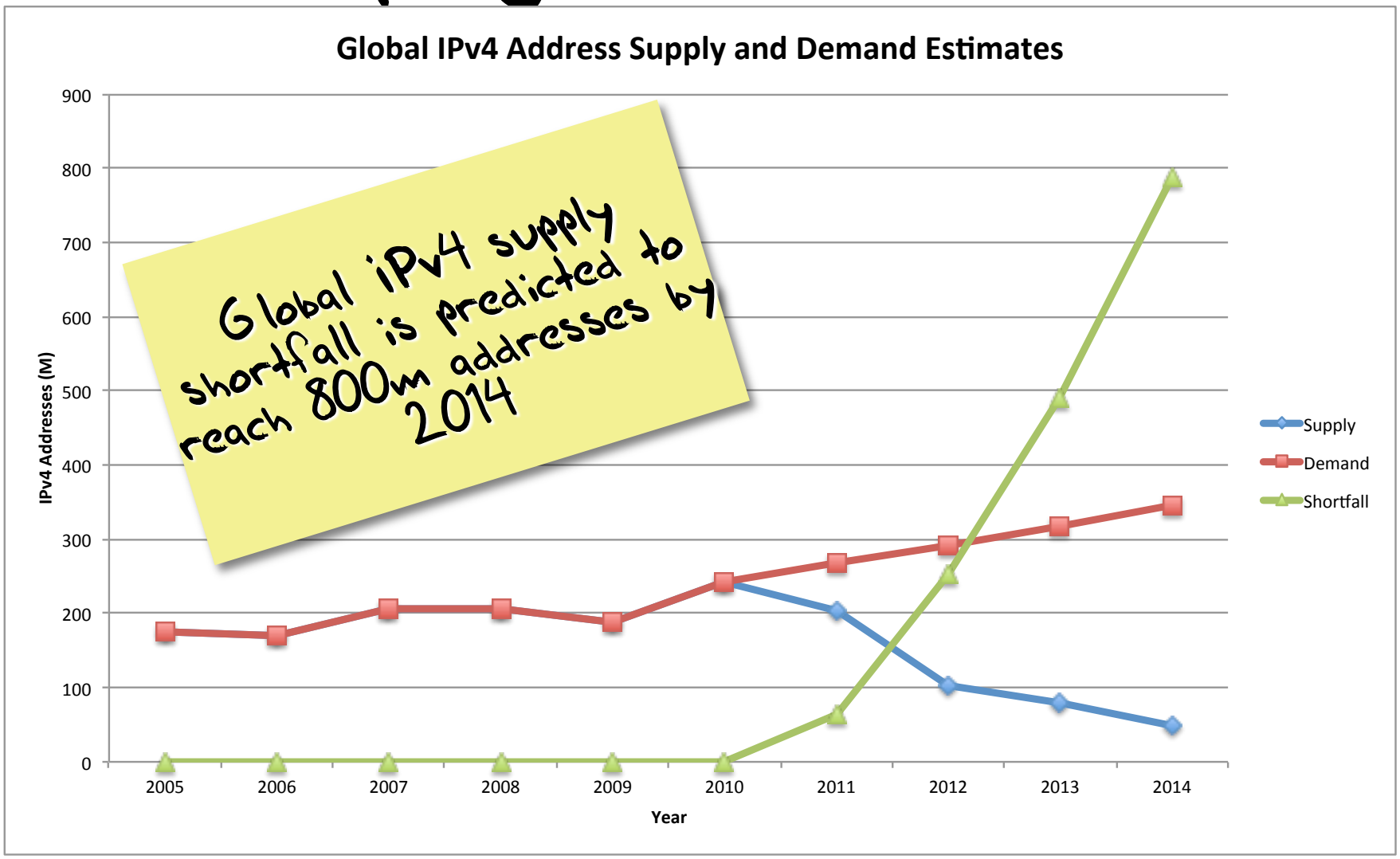
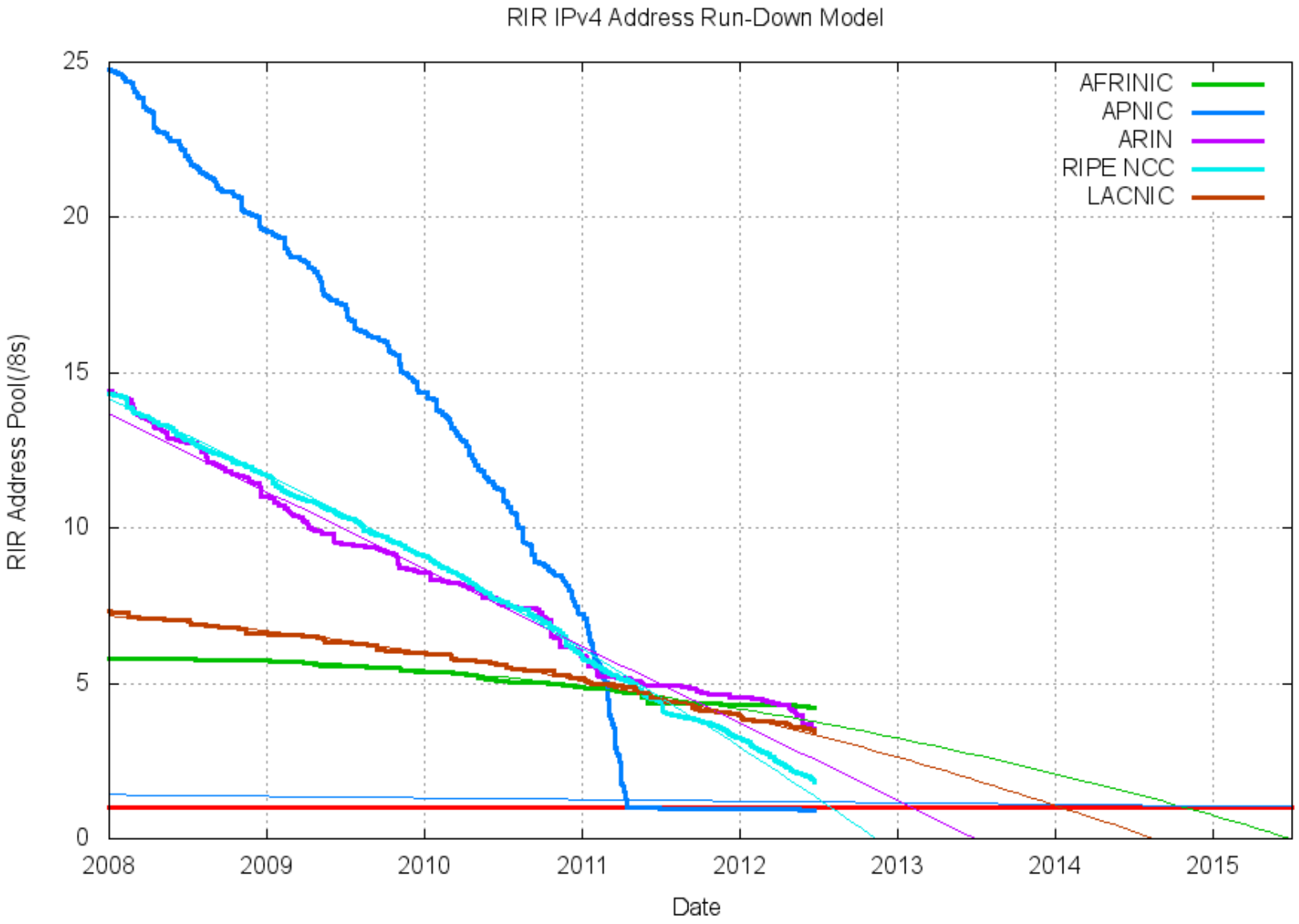
Coping with Demand



Coping with IPv4 Address Exhaustion



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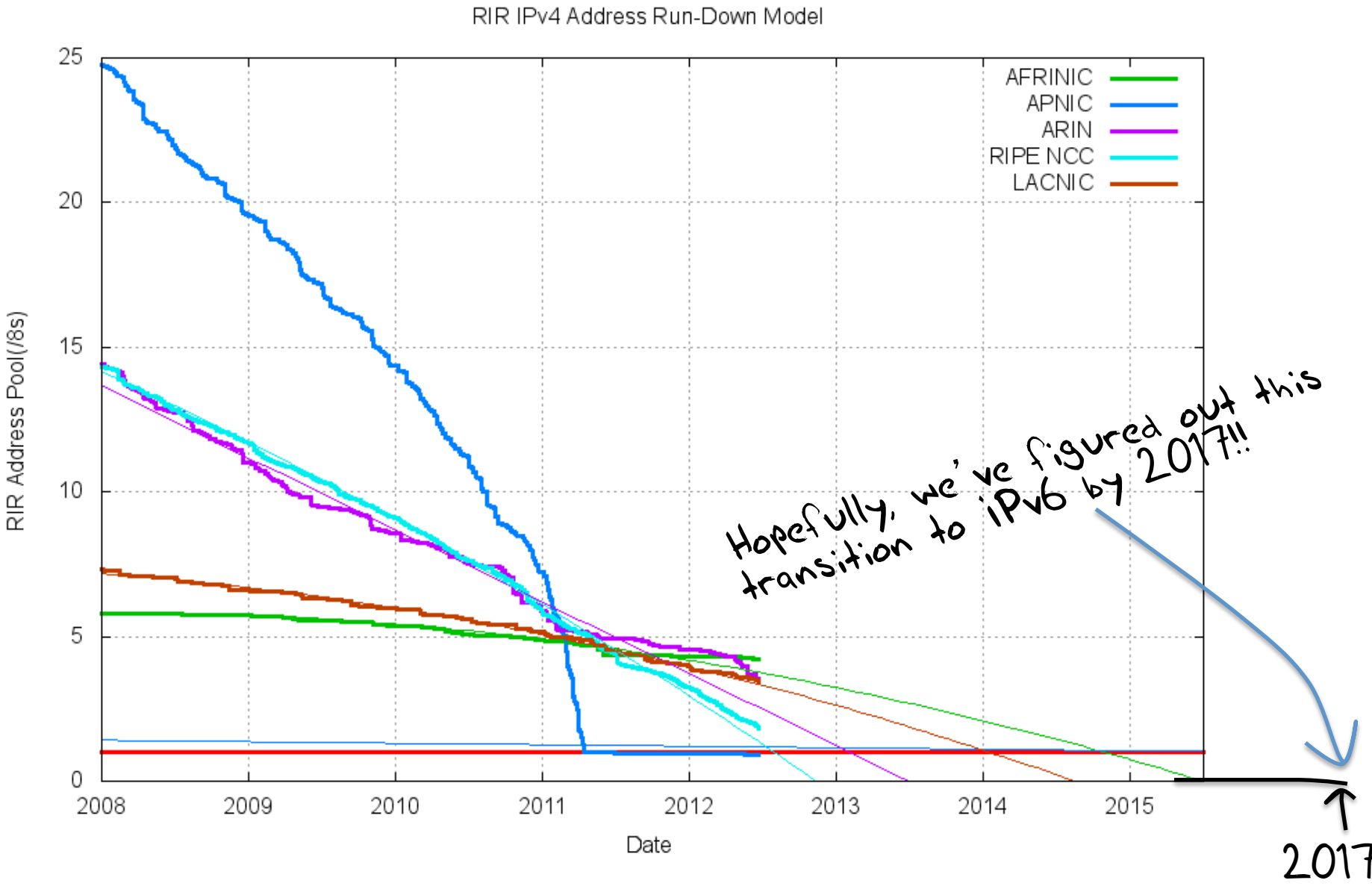


in the next five years...

in the next five years...

And its not yet clear which path the internet will take!

And its not yet clear which path ~~the internet~~ will take!

market forces

Can we look further out?

10 Years Out?

My personal view...by 2022

The Internet will be all IPv6 by 2022!

- There is no extended afterlife in store for IPv4
  - CGNs also have near term limits under intense scaling pressure and ALGs break just about everything!
  - There is no room for more than one protocol - Look at what happened to DECnet, SNA, Appletalk, X.25,...
- There is no afterlife for MPLS, VPNs, QoS, NGNs, Multicast or SDNs either
  - IP is a minimal value add to raw bandwidth:

    Packet quantization of the bandwidth resource

    Routing to maintain simple shortest path topology
  - Everything else is an overhead

My personal view...by 2022

Or there will be no more Internet by then

- because all the CGNs, ALGs, CDNs in the world will not hold the Internet together for 10 years of intense growth pressure
- And because one common protocol platform, one common address space, one common name space is a brittle state, it will fracture and splinter under adornment pressure from both vendors and operators

My personal view...by 2022

If we still have one Internet, radio spectrum will become even more of a scarce and highly valuable asset

- well it is already, but the competition for spectrum in highly populous areas will continue
- Fewer wide area services - more cellular / femtocell services backed by fibre backhaul to improve spectrum efficiency

My personal view…by 2022

Cloud / Data Centre services may well be at or after their peak by 2022

- Innovative competitive pressure at this time may well come from highly distributed systems that do not rely on intense concentrations of computation and information storage

20 Years Out?

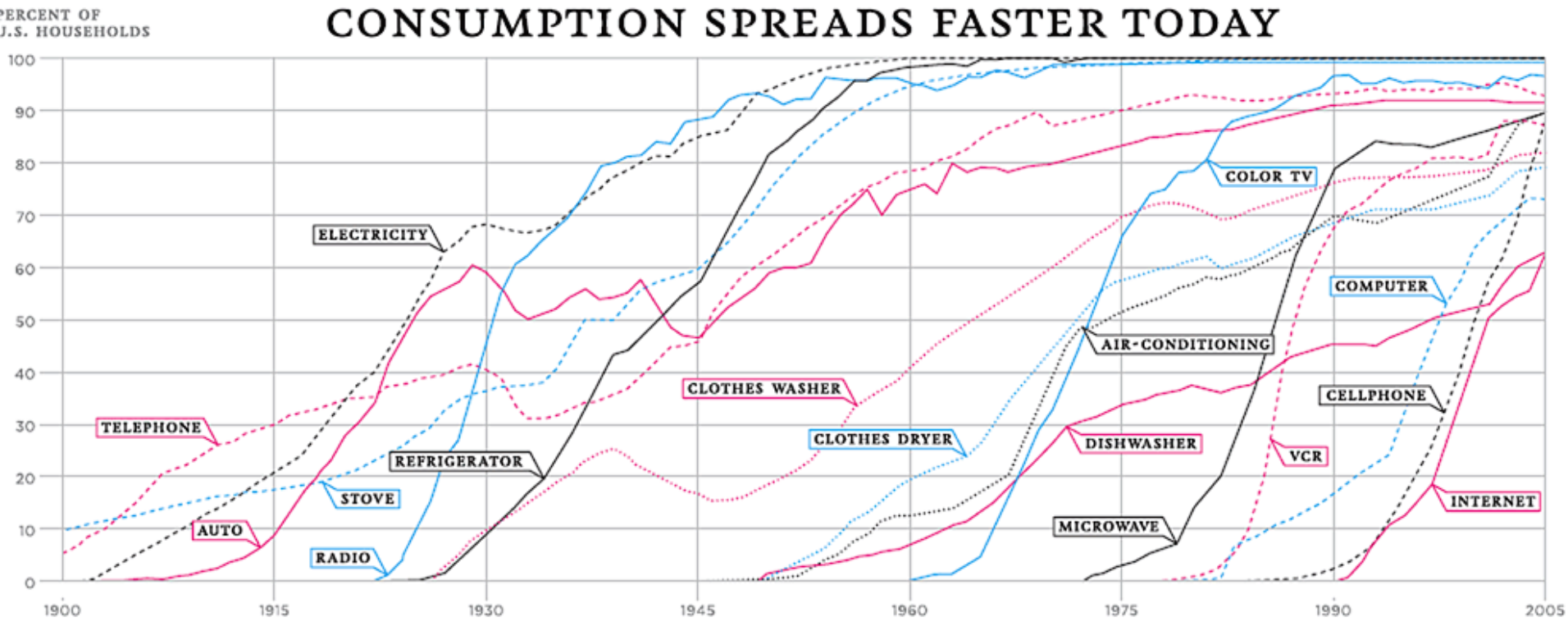
My personal view…by 2032

This is extremely tough!

- very little from the world of 1992 is still with us today
- very little of today's environment will be persistent for the next two decades

Why?

As the pace of technology adoption gets faster we cycle through successive generations of technologies at ever faster rates



http://visualecon.wpengine.netdna-cdn.com/wp-content/uploads/2008/02/history-of-products.gif

What's shaping our future?

We need to think about a post-PC world where computation, storage and communications are all abundant commodities. It's innovative services and applications that will shape much of the Internet's future. And the most effective innovative force in such an environment is open technologies, and open software in particular. This allows innovators to assume the entirety of the current state of the art and build from there. This is truly a powerful model!

In thinking about a future Internet

There's no need to clean the slate

There's no need to clean the slate

Nor to forget everything we've learned about packet networks so far

There's no need to clean the slate

Nor to forget everything we've learned about packet networks so far

But we need to think about a future that is way beyond today's Internet

And as we look at the evolution of the technology there are probably two important design principles to bear in mind ...

Focus

Simplicity

Thank You!

Questions?