What have we done?

Geoff Huston
Around 25 Years Ago...

The Internet jumped across from a small scale US research program into a mainstream role in computer networking

By 1990 it sure looked like the Internet had arrived, but its future was still unclear

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
1964: IBM 360 – commercial computing

The Computing Evolutionary Path
The Computing Evolutionary Path

1976 CRAY-1 – “super” computing
The Computing Evolutionary Path

1976 Ethernet
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
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
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*
Always with us
And it sure looks like...
And it sure looks like...

WE are now the subject!
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?
Email replaced the Fax

The commercialisation of the electronic messaging Internet

– The expansion from the academic and research stable to a public service

– The once booming Fax market limped on for another decade, but email simply won over in convenience and price
Telco Deregulation

The internal re-building of the telco industry

– Deregulation in many markets meant not just more telephone service providers, but it also permitted entrance of data service providers (ISPs)

– 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 service monopoly
  • Active effort of the ISPs at the time to keep the telcos out!

– Regulatory confusion
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
Streaming Video

Broadband Capacity meets Broadband Content
– the rise of the streamers
  – No one 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
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
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?
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, it’s still called “Ethernet”
Expectations vs Reality

IP was was THE answer!

Yes, and No!

– 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.

– We have moved back into maintained network segmentation state with MPLS virtual circuit foundations in most large networks.

– And its likely that this will continue with the current 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.
Expected vs Reality

IPv6 is 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
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, and we might 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
We can “fix” Security

No we can’t!

– If this is a “war” then we’ve lost every battle so far!

– The Internet is alive with malware, trojans, scanners, bots, ransomware, hackers, cyber criminals, cyber warfare,…

• Does anyone even think that this is a solvable problem any more?

– Complex systems appear to be vulnerable simply because they are complex
  And we have no idea how to live in this toxic environment

– Today its just a case of “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 and tech enthusiasts talk of the Internet of Things, it is often with a sense of awe and wonder. This phrase encompasses the many devices and objects that are connected to the Internet. Computers, smartphones, refrigerators, ovens, cars, and even medical equipment are all examples of connected devices. The Internet of Things promises to revolutionize the way we live and work, enabling us to connect with the world and each other in new and innovative ways.

But for every promise of the Internet of Things, there are also concerns and challenges. The integration of these devices into our daily lives raises questions about privacy, security, and the potential for misuse. There are also concerns about the impact on our environment and the sustainability of the technologies used.

One of the biggest challenges facing the Internet of Things is the issue of security. The sheer number of connected devices makes it difficult to ensure that all of them are secure against potential threats. Hackers and cybercriminals are always looking for new ways to exploit vulnerabilities in these devices, and the potential for damage is significant.

Despite these challenges, the Internet of Things continues to grow and evolve. As more devices are connected to the Internet, the potential for new innovations and applications increases. However, it is important to remember that with great power comes great responsibility, and as we move towards a more connected world, we must ensure that the benefits of the Internet of Things are balanced with the precautions needed to keep our devices and our data safe.

The Million Plus Open Resolver Challenge

The Problem

Could you withstand a 2G Gigabit per second packet flood without it adversely affect your business? In 2009 one provider was on the receiving end of a DNS amplification and reflection attack that peaked upwards to 30 Gb/s in aggregate. In 2013 attacks have risen ten times that size, to 300 Gb/s and larger. They are sure to climb higher as long as there remains a substantial number of public open resolvers and the ability to spoof source IP addresses

Over one million open DNS resolvers were used to disrupt their business and take them offline. Not nearly zero compromised machines participated. How? It is very similar to the ICMP Smart attacks of the past. With the ability to spoof packets on the Internet and route traffic through improperly configured DNS recursive resolvers, this attack used the amplification power of DNS queries to build a highly effective flood. Studies have shown that this may actually be only a fraction of the actual number of open recursive servers out there on the Internet today.

You may have been an unwitting participant in a DNS amplification attack, or worse, what if you had been the victim?
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

Google Annual Revenue: 2002 - 2015
Nowhere and Nothing to Hide Any more!
So where does it head?

In 1990 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 going to stop here!
So where does it head?

So what can we expect in 25 years time?

Firstly, it’s not going 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

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

<table>
<thead>
<tr>
<th>Job</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational therapists</td>
<td>0.003</td>
</tr>
<tr>
<td>Dentists</td>
<td>0.004</td>
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<tr>
<td>Athletic trainers</td>
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<tr>
<td>Clergy</td>
<td>0.008</td>
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<tr>
<td>Chemical engineers</td>
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<tr>
<td>Editors</td>
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<tr>
<td>Firefighters</td>
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<tr>
<td>Actors</td>
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<td>Health technologists</td>
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<tr>
<td>Economists</td>
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<tr>
<td>Commercial pilots</td>
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<tr>
<td>Machinists</td>
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<tr>
<td>Word processors and typists</td>
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<tr>
<td>Real-estate sales agents</td>
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<td>Technical writers</td>
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<tr>
<td>Retail salespeople</td>
<td>0.92</td>
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<tr>
<td>Accountants and auditors</td>
<td>0.94</td>
</tr>
<tr>
<td>Telemarketers</td>
<td>0.99</td>
</tr>
</tbody>
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Jobs come and go
Share of employment in Britain by industry, %

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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
Thanks!