the Internet as emerging critical infrastructure: what needs to be measured?

cooporative association for internet data analysis

10 sept 07
kc@caida.org
outline of talk

the Internet becomes critical infrastructure...

top problems of Internet

historical context (incongruity)

what have we learned and how do we apply it?

[asking: dhs, ncs, nist, doe, fcc, ftc, nsa, gao, nsf ]

what we (all) can do to help
IPv4 address exhaustion

Hence, the Internet domain name system (DNS) and its underlying infrastructure need to be upgraded to support more flexible and efficient name resolution systems.

This is where China steps in. China has made significant progress in this area, implementing reforms and regulations to support the transition to a more efficient DNS system.

The SANS Top 20 Internet Security Vulnerabilities

Four years ago, the SANS Institute and the National Internet Security Center (NIPC) released a document that included thousands of vulnerabilities. The latest version of the SANS Top 20 Vulnerabilities lists that followed one, two, and three times as many dangerous vulnerabilities as the previous versions.

Adobe Plugs Dreamweaver SQL Injection Flaw

How the Internet killed the phone business

Despite the widespread use of smartphones, landline telephones still have a place in today's world. However, the increasing adoption of mobile devices has led to a decline in the use of traditional telephones.

The Internet has made it possible for anyone to place a call anywhere in the world, as long as they have access to the Internet. This has made traditional phone systems obsolete, as they are no longer as convenient or cost-effective as mobile devices.

The Twenty Most Critical Internet Security Vulnerabilities

To link to the Top 20 List, use the Access IT Group banner. The people that can help with your needs.

The International Telecommunication Union (ITU) reports that there are over 7.5 billion active mobile phone users worldwide, representing a growth of 10% from the previous year. This trend is expected to continue, with the ITU predicting that the number of mobile phone users will reach 8.5 billion by 2020.

In conclusion, the transition from traditional telephones to mobile devices has had a significant impact on the telecommunications industry. As we move further into the digital age, it is clear that the need for reliable and efficient communication systems will only grow.
We don't presently have a roadmap of where we are trying to go with the Internet," says MIT's [Dr.] Clark. Instead of worrying about backward compatibility and migration issues, the focus has shifted to "where we would like to be in 10 to 15 years," he explains. "If the story is compelling enough, people will figure out how to get there."

IPv6

From Wikipedia, the free encyclopedia

Internet Protocol version 6 (IPv6) is a network layer standard used by electronic devices to exchange data across a packet-switched internetwork. It follows IPv4 as the second version of the Internet Protocol to be formally adopted for general use.

IPv6 is intended to provide more addresses for networked devices, allowing, for example, each cell phone and mobile electronic device to have its own address. IPv4 supports $4.3 \times 10^9$ (4.3 billion) addresses, which is inadequate to give one (or more if they possess more than one device) to every living person. IPv6 supports $3.4 \times 10^{38}$ addresses, or $5 \times 10^{28}$ ($50$ octillion) for each of the roughly 6.5 billion people alive today.

Invented by Steve Deering and Craig Mudge at Xerox PARC, IPv6 was adopted by the Internet Engineering Task Force in 1994, when it was called "IP Next Generation" (IPng). (Incidentally, IPv5 was not a successor to IPv4, but an experimental flow-oriented streaming protocol intended to support video and audio.)

sundry “solutions”
public sector resuming inquiry

DHS: data to validate security tools, SBGP, DNS
NIST: ways to measure DNSSEC penetration
DOE: way to estimate available bandwidth
FCC: way to measure outage
FTC: how to inform network neutrality debate
NCS/NSA: topology data for information assurance
GAO: cost of Internet katrina
NSF: can’t we just start over and do it right?

entire muni & community wireless networking movement....
“While the business case for the carriers may be disappearing, a host of new business and investment opportunities is being created with far greater economic wealth creation,” Mr. Arnaud writes in his blog. “Our biggest concern is that governments will be distracted by the complaints of the old industry such as carriers and penalize the new economy industries of the Internet.”

“We don’t presently have a roadmap of where we are trying to go with the Internet,” says MIT’s Mr. Clark. Instead of worrying about backward compatibility and migration issues, the focus has shifted to “where we would like to be in 10 to 15 years,” he explains. “If the story is compelling enough, people will figure out how to get there.”
top Internet operational problems

• security
• authentication
• spam
• **scalable configuration management**
• robust scalability of routing system
• compromise of e2e principle
• dumb network
• measurement
• patch management
• “normal accidents”
• growth trends in traffic and user expectations
• time management and prioritization of tasks
• **stewardship vs governance**
• intellectual property and digital rights
• interdomain qos/emergency services
• inter-provider vendor/business coordination

persistently unsolved problems for 10+ years
(see presentations at www.caida.org)
top Internet problems

why we’re not making progress

• if providers are broke, they can’t invest in long-term health of infrastructure.

• so add to list of problems: sustainability

• top unsolved problems in internet operations and engineering are rooted in economics, ownership, and trust (EOT).

does not mean there aren’t useful technical problems to study. but there will be no technical solutions to these problems that don’t solve the EOT issues.
historical context

1966: Larry Roberts, “Towards a Cooperative Network of Time-Shared Computers” (first ARPANET plan)

(we are still using the same stuff)

1969: ARPANET commissioned by DoD for research

1977: Kleinrock’s paper “Hierarchical Routing for large networks; performance evaluation and optimization”

(we are still using the same stuff)

1980: ARPANET grinds to complete halt due to (statusmsg) virus


IETF, IRTF. MX records (NAT for mail)

1991: CIX, NSFNET upgrades to T3, allows .com. web. PGP. kc gives first talk on net to ATT.

1995: under pressure from USG, NSF transitions backbone to competitive market. no consideration of economics or security. kc proposes caida.org

2005: The Economist’s cover story: “How the Internet killed the phone business” (September)
what have we done?

we replaced a critical infrastructure with something not designed to be critical infrastructure

historical context explains it but does not address incongruities

result: free markets up against free speech
network economics: dismal science(s)

known: economics of current architecture need study have never been a priority.
conversations for last 15 years have been private enlightened policy impossible

our misunderstanding the economic architecture threatens an architecture we hold much more dear..

[how] can the academic community help?
cataloguing lessons

• although the Internet has over-achieved on plenty, it has underachieved on: security, scalability, sustainability, and stewardship. substantial oversights.

• our ability to measure is surprisingly abysmal, although policy history explains

• cooperative, data-sharing approaches to sound measurement and analysis are key to enlightened policy

we have learned more from our failures than from our successes...
the 4 S’s of critical infrastructure

- safety: is the data toxic upon arrival?
- scalable: can we route/name/address earth’s needs?
- sustainable: is it economically viable?
- stewardship: will the provisioning and legal frameworks we choose leave our children -- and democracies -- better or worse off?

none are purely technical, but all require technical understanding to get right. and they’re all connected.
how have we done?

how safe is the Internet?  data doesn’t look good
how scalable is the Internet?  data doesn’t look good
how sustainable is the Internet?  data doesn’t look good
how did we do on stewardship?  data doesn’t look good
failure (to measure progress) on 4S’s poses risks to economies & democracies:

• that we won’t learn from our own history, won’t admit we don’t understand the economics, and thus must set policy based on unvalidated assumptions

• that we will design another architecture with no actual plan for economic sustainability (much less incenting further innovation in a competitive market!)

• that other forces will “code” innovation into the architecture
not that we haven’t been trying
e.g., all caida projects are on the 4 S’s:

1) safety: security, DNS, PREDICT, telescope
2) scalability: routing and topology research
3) sustainability: EOT, DNS, COMMONS
4) stewardship: address consumption, trends, all measurement & data activities

measurable progress on real Internet eludes us
NAS report on ‘network science’

1) networks are everywhere and thus important

2) we don't yet have any predictive power over complex networks

3) funding situation backwards: domain-specific (splintered) rather than fundamental
NAS report on ‘network science’

identifies as top three challenges:

1) characterization of dynamics and information flow in networked systems

2) modeling, analysis, and acquisition of experimental data for extremely large networks

3) rigorous tools for the design and synthesis of robust, large-scale networks

http://fermat.nap.edu/books/0309100267/html
there is good news

• we made something so great, everyone wants it.
• in fact many of us want it more than once! (um..)
• the current industry is a historical artifact of technical and (science & regulatory) policy ‘innovations’ in the 60s, 70s, 80s, 90s, and 00s
• people are starting to study interplay, but they’re undercapitalized
• in the meantime, it became global critical infrastructure. oops.
measurement accuracy is the only fail-safe means of distinguishing what is true from what one imagines, and even of defining what true means.

..this simple idea captures the essence of the physicist's mind and explains why they are always so obsessed with mathematics and numbers: through precision, one exposes falsehood.

a subtle but inevitable consequence of this attitude is that truth and measurement technology are inextricably linked.

-- robert b laughlin, a different universe,