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

cooperative association for internet data analysis

12 October 2006
Quilt workshop
kc@caida.org
outline of talk

what is critical infrastructure

top problems of Internet

historical context (incongruity)

what have we learned and how can we apply it?

[ case study: scalability (separate talk) ]

what we (all) can do to help
critical infrastructure

what is it? how does it get that way?

what are common characteristics?

is the Internet one? or will it be soon?

what are the implications for public and private sectors?

underlying goals: innovation, economic strength, democracy, freedom, health, science, arts, society.

it really is about living in a better world...
The Dark Side of the Search Engine Business

IPv4 address exhaustion

The SANS Top 20 Internet Security Vulnerabilities

The Twenty Most Critical Internet Security Questions

The SANS Institute and the National Business Center

How the internet killed the phone business
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."
public sector starting 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
NSA: topology data for information assurance
GAO: cost of Internet katrina

entire muni and community wireless networking movement...
<insert graph i wish we had available>
“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.”
motivation

e.g. NSF’s GENI initiative

- US NSF responding to network research community frustration
- difficulty with technology transfer, not to mention science
- persistent problems leaking into unready world
- attempt to redesign components ‘in the light’
- what did we learn from measuring this one?
top Internet problems

16 operational internet 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)
why we’re not making progress

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

• even the most theoretical computer scientists are convinced.

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

1986: NSFNET backbone, 56Kbps. NSF-funded regionals. IETF, IRTF. MX records (NAT for mail)

1991: CIX, NSFNET upgrades to T3, allows .com. web. PGP.

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

and this decade, free markets go up against free speech
what have we learned?

• most important thing we’ve learn so far: society has decided IP is like water.
  • “our best success was not computing, but hooking people together”   --david clark, 1992 ietf plenary

• strong implications for an industry structuring itself to sell wine. but that’s what the data shows.

• when you want to move water, you care about 4 things: safe, scalable, sustainable, stewardship.
the 4 S’s

- **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 of these are purely technical issues, but they all require deep technical (among other) 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. e.g., not only don’t we understand the economics, but we don’t understand that 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 (free markets vs free speech)
The wonderful thing about science is that eventually nature tells you when you are fooling yourself. Real objects can be measured again and measured by somebody else -- false signals will eventually be weeded out.

Robert Kirshner, *The Extravagant Universe*

but if what you need to measure is economics.

Knowing what to measure and how to measure it makes a complicated world less so. If you learn how to look at data the right way, you can explain riddles that otherwise might have seemed impossible.

Steven Levitt, *Freakonomics*
network economics: dismal science(s)

known: economics of current architecture need study

  can we rearchitect to increase the value of the network?

'wealth of networks' [tvest] analyses, as yet undocumented

  [how] does it make sense to pool buying power?

  offload transit & increase settlement-free peering?

need to extract insights from conversations

  rest of the world (esp communities) needs them “yesterday”

not just economics: also technology, policy, education, social
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.
understanding and enlightened evolution of the Internet

(1) sound measurement and analysis methodologies were, are, and will always be the key to enlightened policy.

(2) the free market has failed thus far to achieve these goals on its own.

(3) QUILT is in unique position to help
fostering enlightened evolution of the Internet

(1) facilitate business models competing on fair playing field. “freedom from” as well as “freedom to”

(2) leverage strengths: transparency, peer review, analysis

(3) QUILT is (again) in unique position to help
proposed COMMONS project

problems:
(1) no incentive even for public sector to provide access to data on operational infrastructure.
(2) emerging community networks lack resources and experience to make good provisioning decisions

solutions:
(1) provide economic and other incentives to share data
(2) engage in public conversation about provisioning and operational decisions
Cooperative Measurement and Modeling of Open Networked Systems (COMMONS)

(1) Offer cooperative backbone in exchange for mutual, privacy-respecting, community-defined transparency across network

(2) experiment with different architectures: not just technical, but economic and policy

(3) use strengths of Internet to overcome its weaknesses
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