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...

May 24, 2006: Deep IMPACT: Justifyin

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The Twenty Most Critical Interne

Version 6.01 Nov

Questions /

To link to the Top 20 List, use

AccessIT GROUP

-----Jump To Index of Top 20 Vulnerabilities -----

Introduction

The SANS Top 20 Internet Security Vulnerabilities

Four years ago, the SANS Institute and the Nation

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Hence, the Top-20 2005 is a co

Home >> China

China adds top-level domain names

China's Ministry of Information In

domain name system in accorda

Regulations.

After the adjustment, ".MIL" will b

"CN".

A new Internet domain name sys

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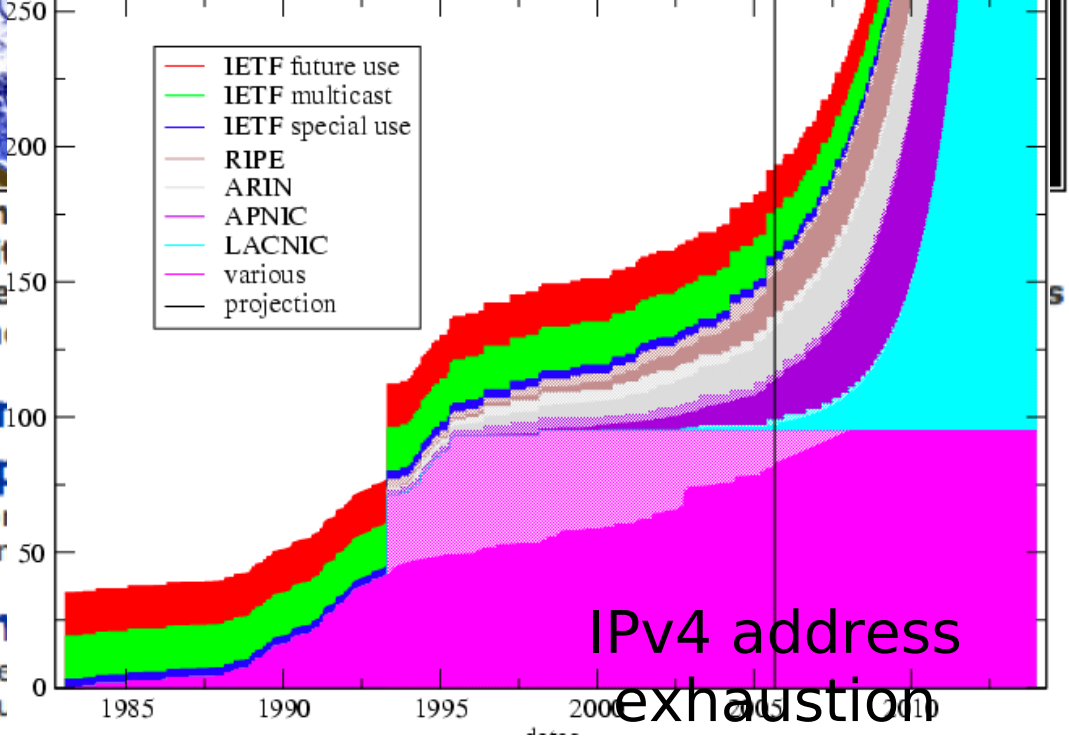


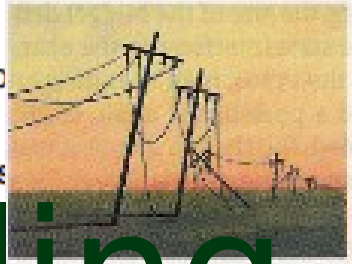
IPv4 address exhaustion

The Dark Side of the Search Engine Business

Paid search is a booming business for Google, Yahoo and Microsoft, but there's a major downside for users. A new study by McAfee's SiteAdvisor finds sponsored search results contain two to four times as many dangerous

How the internet killed the phone business

Almost-free internet phone calls herald the slow death of traditional telephony



THE term "disruptive technology" is popular, but is widely misused. It refers not simply to a clever new technology, but to one that undermines an existing technology—and which therefore makes life very difficult for the many businesses which depend on the existing way of doing things. Twenty years ago, the personal computer was a classic example. It swept aside the older mainframe-based style of computing, and eventually brought IBM, one of the world's mightiest firms at the time, to its knees. This week has been a coming-out party of sorts for another disruptive technology, "voice over

market, as the marginal price of making phone calls heads inexorably downwards.

VOIP makes possible more than just lower prices, however. It also means that, provided you have a broadband connection, you can choose from a number of providers of VOIP telephony and related add-on services, such as voicemail, conference calling or video. Many providers allow a VOIP account to be associated with a traditional telephone number or with multiple numbers. So you can associate a San Francisco number, a New York number and a London number with your computer or VOIP phone—and then be reached via a local call by anyone in any of those cities.

Furthermore, your phone (or computer) will ring wherever you are in the world, as soon as it is plugged into the interne

falling bits of sky

International Telecommunication Union

Building Partnerships for Progress

All match

More

Home : Office of the Secretary General : SPU

Next Generation Networks

Home: OECD > OECD ICCP Workshop: "The Future of the Internet", Paris, 8 March 2006

OECD ICCP Workshop: "The Future of the Internet", Paris, 8 March 2006

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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 4.3×10^9 (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 3.4×10^{38} addresses, or 5×10^{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.)

THE INTERNET.COM

Fight for Internet Freedom

the coalition f.a.q. press

THE LATEST....

Moby Speaks Out on Internet Freedom

At a press event in Washington today, Grammy-nominated musician Moby (along with

RKWORLD RESEARCH CENTER: Convergence / VoIP

IP PBX SIP VoIP Services Vendor Solutions

NetworkWorld.com > Convergence / VoIP >

What IMS promises enterprises and carriers

Internet Protocol Multimedia Subsystem called key to converged, expanded services.

By Stephen Lawson, IDG News Service, 09/26/05

where we are
[Dr. JCarl
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"where we
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gure out how b

sundry "solutions"

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>

The Future of the Internet

In a decade, the Net will dig deeper into our lives.

April 10, 2006 Issue

Credit: Dave Cutler

http://www.redherring.com

"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."

National Science Foundation
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Computer & Information Science & Engineering (CISE)

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The GENI Initiative

The Directorate for Computer and Information Science and Engineering (CISE) is planning an
Environment for Networking Innovations or GENI to explore new networking capabilities that
stimulate innovation and economic growth. The GENI Initiative responds to an urgent and imp
Century to advance significantly the capabilities provided by networking and distributed syste

The GENI Initiative envisions the creation of new networking and distributed system architectu

- Build in security and robustness;
- Enable the vision of pervasive computing and bridge the gap between the physical
  mobile, wireless and sensor networks;
- Enable control and management of other critical infrastructures;
- Include ease of operation and usability; and
- Enable new classes of societal-level services and applications.

The GENI Initiative includes:

- A research program; and
- A global experimental facility designed to explore new architectures at scale.

CISE is encouraging a broad community effort that engages other agencies, other countries, a

THE GENI RESEARCH PROGRAM

(US) NSF's hand

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?

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 ietfplenary*
- 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)

“science of the Internet”

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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