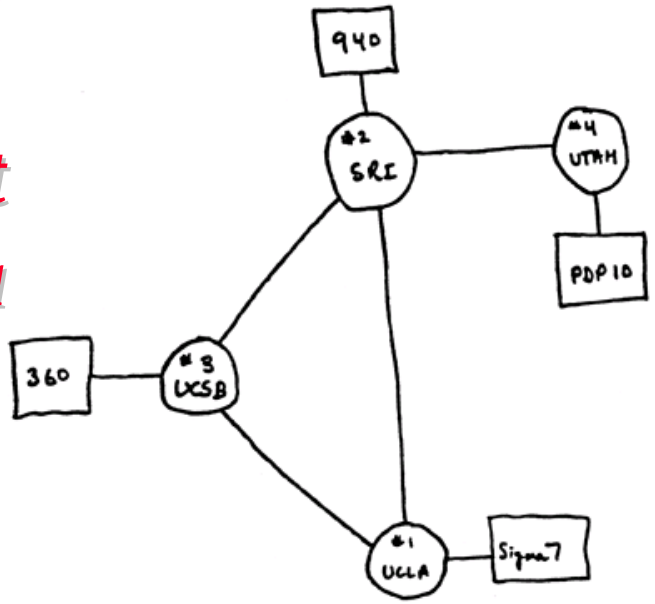
Internet 3.0:

Ten Problems with Current Internet Architecture and a Proposal for the Next Generation



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Presentation at Huawei, Beijing, September 26, 2008

These slides and Audio/Video recordings of this talk are at:
http://www.cse.wustl.edu/~jain/talks/in3_hu.htm

Overview

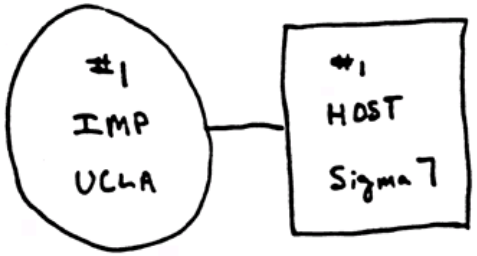
1. What is Internet 3.0?
2. Why should you keep on the top of Internet 3.0?
3. What are we missing in the current Internet?
4. Policy Oriented Naming Architecture (PONA)
5. Benefits of PONA

Internet 3.0

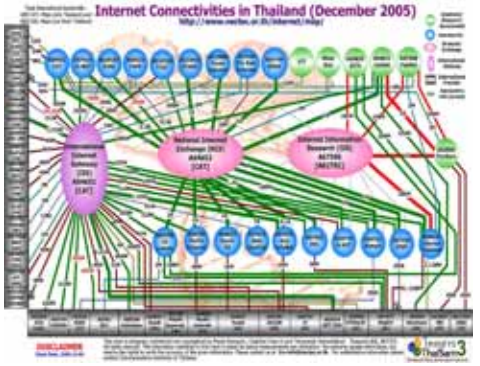
- US National Science Foundation is planning a $300M+ research and infrastructure program on next generation Internet
  - Testbed: "Global Environment for Networking Innovations" (GENI)
  - Architecture: "Future Internet Design" (FIND).
- Q: How would you design Internet today? Clean slate design.
- Ref: http://www.nsf.gov/cise/cns/geni/
- Most of the networking researchers will be working on GENI/FIND for the coming years
- Internet 3.0 is the name of the Washington University project on the next generation Internet
- Named by me along the lines of "Web 2.0"
- Internet 3.0 is more intuitive then GENI/FIND

Internet Generations

- **Internet 1.0** (1969 – 1989) – Research project
  - RFC1 is dated April 1969.
  - ARPA project started a few years earlier
  - IP, TCP, UDP
  - Mostly researchers
  - Industry was busy with proprietary protocols: SNA, DECnet, AppleTalk, XNS

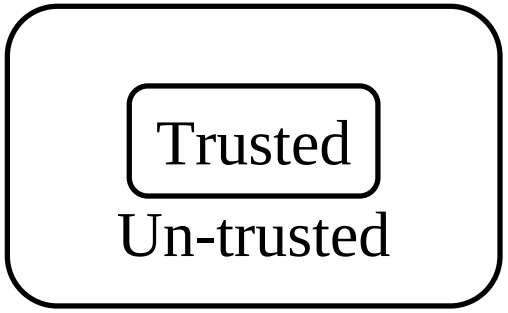


- **Internet 2.0** (1989 – Present) – Commerce ⇒ new requirements
  - Security RFC1108 in 1989
  - NSFnet became commercial
  - Inter-domain routing: OSPF, BGP,
  - IP Multicasting
  - Address Shortage IPv6
  - Congestion Control, Quality of Service,…



Ten Problems with Current Internet

1. Designed for research
   ⇒ Trusted systems
   Used for Commerce
   ⇒ Untrusted systems
2. Control, management, and Data path are intermixed ⇒ security issues
3. Difficult to represent organizational, administrative hierarchies and relationships. Perimeter based.



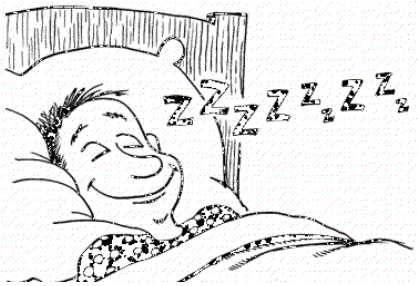
Problems (cont)

4. Identity and location in one (IP Address)
   Makes mobility complex.

5. Location independent addressing
   ⇒ Most services require nearest server.
   ⇒ Also, Mobility requires location

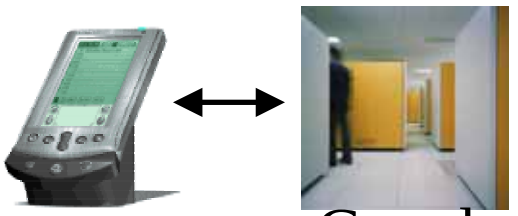
6. No representation for real end system: the human.

Problems (cont)



7. Assumes live and awake end-systems
   Does not allow communication while sleeping.
   Many energy conscious systems today sleep.
8. Single-Computer to single-computer communication ⇒ Numerous patches needed for communication with globally distributed systems and services.

9. Symmetric Protocols
   ⇒ No difference between a PDA and a Google server.



Google

Problems (Cont)

10. Stateless ⇒ Can't remember a flow
    ⇒ QoS difficult.
    QoS is generally for a flow and not for one packet

Physical vs Logical Connectivity

- Physically and logically connected:
  All computers in my lab
  = Private Network,
  Firewalled Network

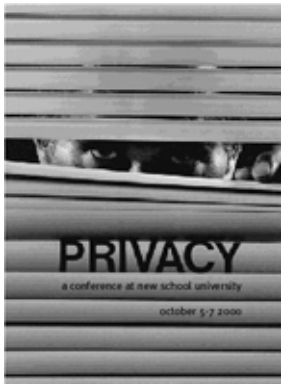
- Physically disconnected but logically connected:
  My home and office computers

- Physically connected but logically disconnected: Passengers on a plane, Neighbors, Conference attendees sharing a wireless network, A visitor

Physical connectivity ≠ Trust

More Problems with IP Addressing

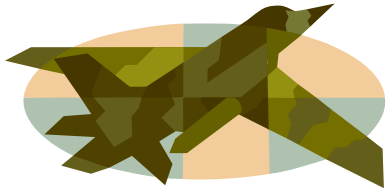
- Multihoming is not properly represented
  - TCP is bound to an IP address. If one port fails, TCP gets disconnected.
- Private IP addresses behind NAT boxes are not reachable from outside
- Mobile IP can provide either location privacy by triangulation or route optimization with no location privacy



Our Proposed Solution: Internet 3.0

- Take the best of what is already known
  - Wireless Networks, Optical networks, …
  - Transport systems: Airplane, automobile, …
  - Communication: Wired Phone, Cellular nets,…
- Develop a consistent general purpose, evolvable architecture that can be customized by implementers, service providers, and users



Names, IDs, Addresses

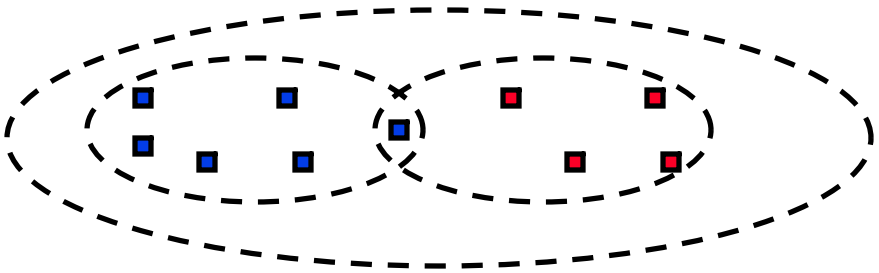
Name: John Smith

ID: 012-34-5678

Address:
1234 Main Street
Big City, MO 12345
USA

- Address changes as you move, ID and Names remain the same.
- **Examples**:
  - Names: Company names, DNS names (microsoft.com)
  - IDs: Cell phone numbers, 800-numbers, Ethernet addresses, Skype ID, VOIP Phone number
  - Addresses: Wired phone numbers, IP addresses

Realms



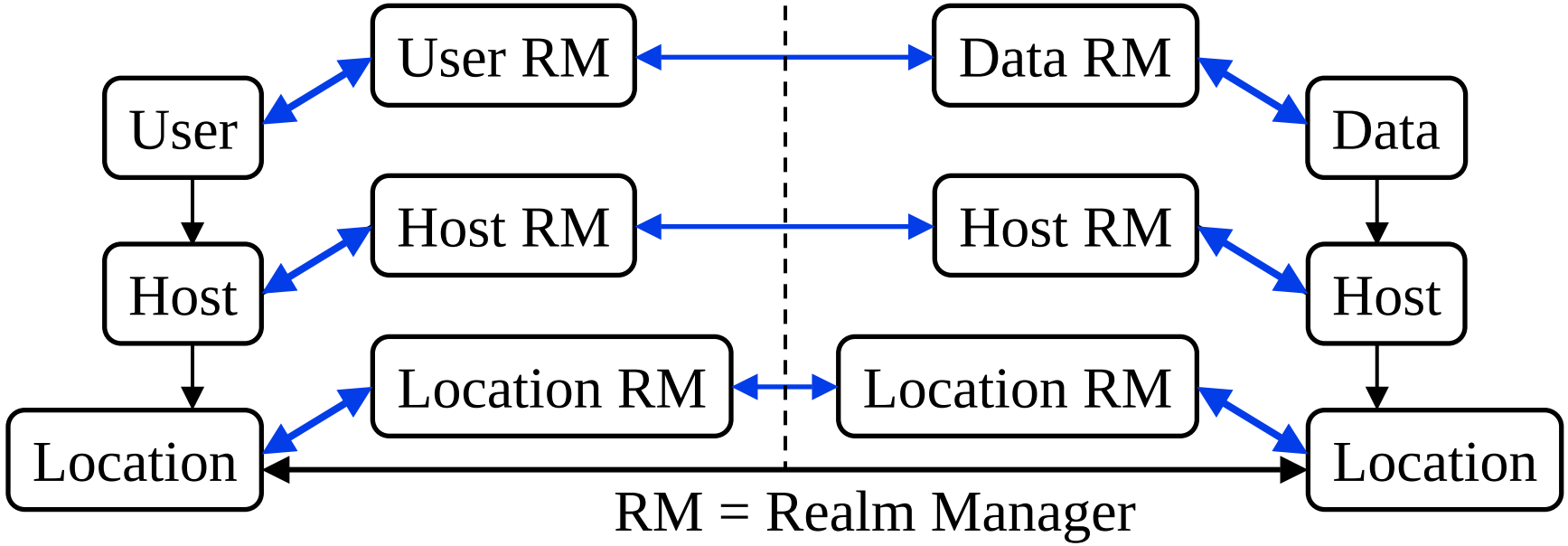
- Object names and Ids are defined within a realm
- A realm is a **logical** grouping of objects under an administrative domain
- The Administrative domain may be based on Trust Relationships
- A realm represents an organization
  - Realm managers set policies for communications
  - Realm members can share services.
  - Objects are generally members of multiple realms
- Realm Boundaries: Organizational, Governmental, ISP, P2P,…

Realm = Administrative Group

User- Host- and Data Centric Models

- All discussion so far assumed host-centric communication
  - Host mobility and multihoming
  - Policies, services, and trust are related to hosts
- User Centric View:
  - Bob wants to watch a movie
  - Starts it on his media server
  - Continues on his iPod during commute to work
  - Movie exists on many servers
  - Bob may get it from different servers at different times or multiple servers at the same time
- Can we just give addresses to users and treat them as hosts? No! ⇒ Policy Oriented Naming Architecture (PONA)

Policy Oriented Naming Architecture

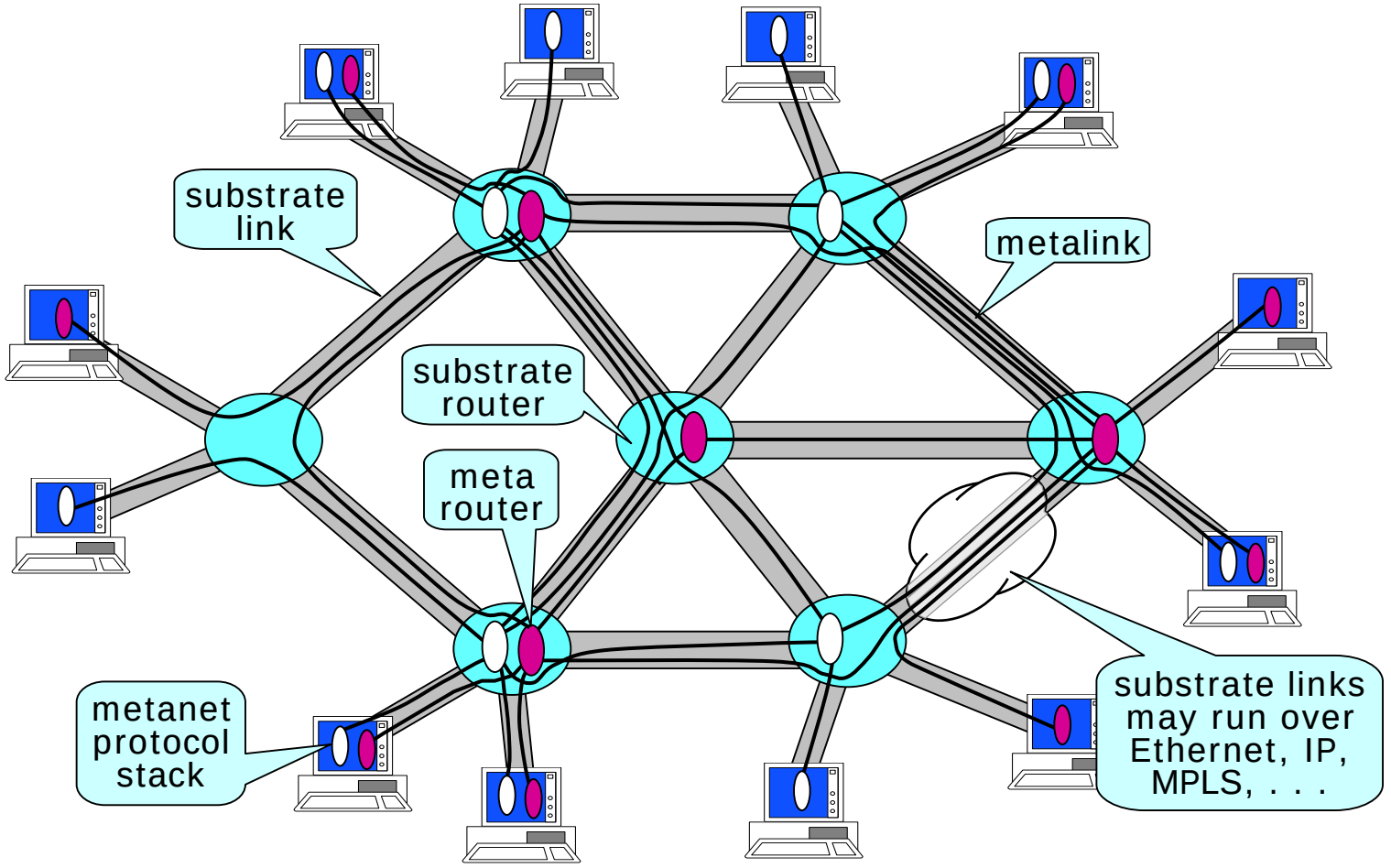


- Both Users and data need hosts for communication
- Data is easily replicable. All copies are equally good.
- Users, Hosts, Infrastructure, Data belong to different realms (organizations).
- Each object has to follow its organizational policies.

PONA (Cont)

- User and data realms are higher level than host realms
- Most communication is user-data communication
- User, Host, and Data can move independently
  - Hosts move from one location to next
  - Users and data can move from one host to the next
- User ID ⇒ Host ID ⇒ Host Location = Address
- User realm managers provide User ID to Host ID translation
- Realm managers enforce organizational policies
- Realm managers setup trust relationships between organizations

Virtualizable Network Concept

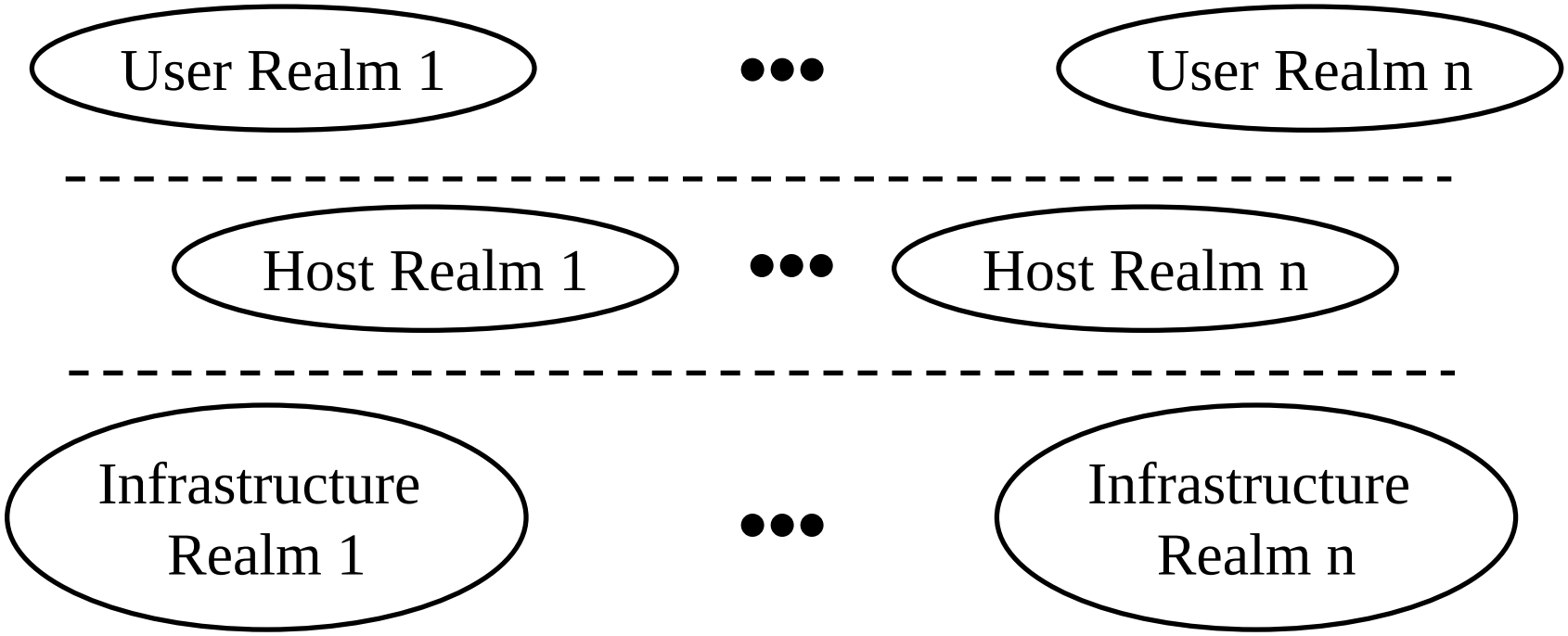


Ref: T. Anderson, L. Peterson, S. Shenker, J. Turner, "Overcoming the Internet Impasse through Virtualization," Computer, April 2005, pp. 34 – 41.

Slide taken from Jon Turner's presentation at Cisco Routing Research Symposium

http://www.cse.wustl.edu/~jain/

Realm Virtualization

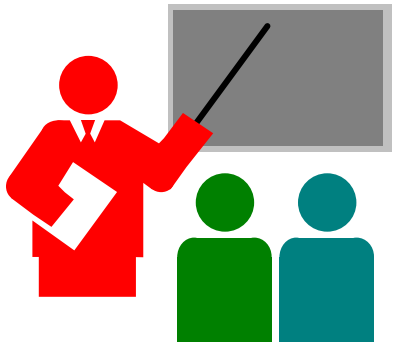


- Old: Virtual networks on a common infrastructure
- New: Virtual user realms on virtual host realms on a group of infrastructure realms. 3-level hierarchy not 2-level. Multiple organizations at each level.

Benefits of PONA Architecture

- Enforcement of Organizational structure and Policies
  - Hosts/Users/Data/Network Infrastructure may belong to different organizations (realms)
  - Each organization can enforce its policies on its members
- Security: Policies for realm boundaries and between objects
- Mobility: Hosts/Users/Data can move indendently
- Representation of non-electronic end systems: Users and Data
- Multi-Layer virtualization

Summary



1. The next generation of Internet must be secure, allow mobility, and be energy efficient.
2. Must be designed for commerce
   $\Rightarrow$ Must represent multi-organizational structure and policies
3. Moving from host centric view to user-data centric view
   $\Rightarrow$ Important to represent users and data objects
4. Users, Hosts, and infrastructures belong to different realms (organizations). Users/data/hosts should be able to move freely without interrupting a network connection.

References

1. Jain, R., "Internet 3.0: Ten Problems with Current Internet Architecture and Solutions for the Next Generation," in Proceedings of Military Communications Conference (MILCOM 2006), Washington, DC, October 23-25, 2006, http://www.cse.wustl.edu/~jain/papers/gina.htm

References: Coming Soon

2. Jianli Pan, Subharthi Paul, Raj Jain, and Mic Bowman, "MILSA: A Mobility and Multihoming Supporting Identifier-Locator Split Architecture for Naming in the Next Generation Internet,," Globecom 2008, Nov 2008.
3. Subharthi Paul, Jianli Pan, Raj Jain and Mic Bowman, "A Survey of Naming Systems: Classification and Analysis of the Current Schemes Using a New Naming Reference Model," to be submitted for publication, 2008.
4. Subharthi Paul, Raj Jain, Jianli Pan, and Mic Bowman, "A Vision of the Next Generation Internet: A Policy Oriented View," British Computer Society Conference on Visions of Computer Science, Sep 2008.