Internet 3.0: The Next Generation Internet

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http://www.cse.wustl.edu/~jain/talks/in3_mics.htm

Overview

1. What is Internet 3.0?
2. What are we missing in the current Internet?
3. Our Proposed Architecture for Internet 3.0

Next Generation Internet

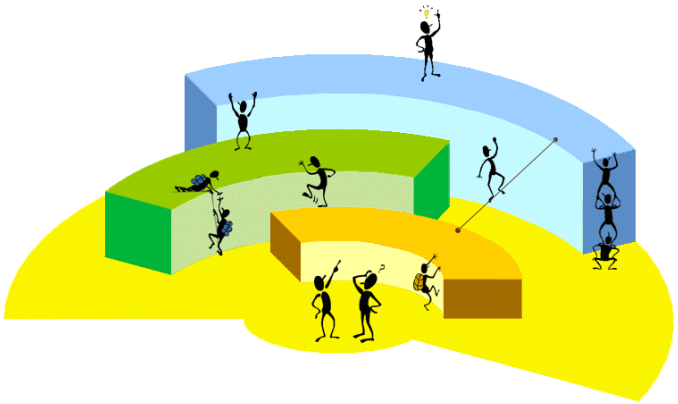
- In 2005 US National Science Foundation started a large research and infrastructure program on next generation Internet
- Q: How would you design Internet today? Clean slate design.
- "Future Internet Design" (FIND
- "Global Environment for Networking Innovations" (GENI): European Union: 7th Framework program
- Japan: AKARI (A small light in the dark pointing to the future)
- China, Korea, Australia, …20+ countries
- **Ref**: See our survey report, WUSTL-2009-69, Oct 2, 2009

Why to worry about NGI?

Billion dollar question!

Internet 3.0

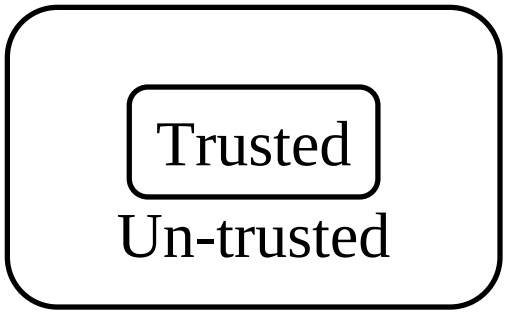
- Internet 3.0 is the name of the Washington University project on the next generation Internet
- Internet 3.0 is more intuitive then GENI/FIND
- Goal 1: Develop a *clean slate architecture* to overcome limitations of the current internet
- Goal 2: Develop an *incremental approach* to implement the architecture



Key Problems with Internet

1. Designed for research
   ⇒ Trusted systems
   Used for Commerce
   ⇒ Untrusted systems

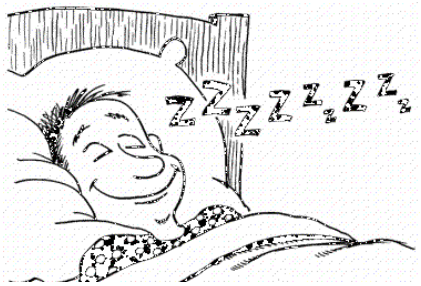
2. Difficult to represent organizational, administrative hierarchies and relationships.
   Perimeter based.
   ⇒ Difficult to enforce organizational policies



Problems (cont)

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

4. Assumes live and awake end-systems
   Does not allow communication while sleeping.
   Many energy conscious systems today sleep.
5. No representation for real end system: the human.



Ref: Our Milcom 2006 paper

Names, IDs, Locators

Name: John Smith

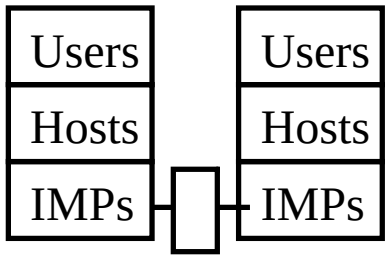
ID: 012-34-5678

Locator:
1234 Main Street
Big City, MO 12345
USA

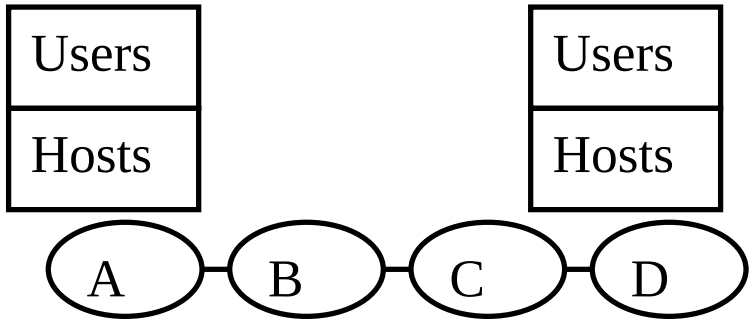
- Locator changes as you move, ID and Names remain the same.
- **Examples**:
  - Names: Company names, DNS names (microsoft.com)
  - IDs: Cell phone numbers, 800-numbers, Ethernet addresses, Skype ID, VOIP Phone number
  - Locators: Wired phone numbers, IP addresses

Internet Generations

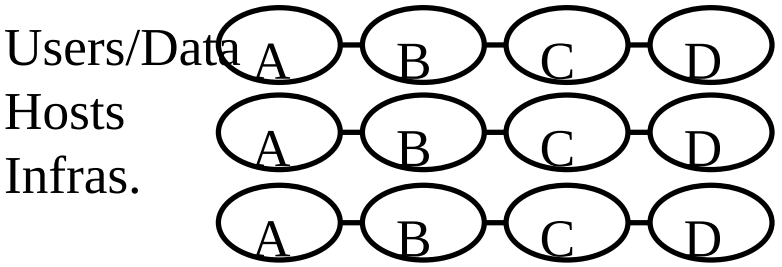
- **Internet 1.0** (1969 – 1989)
  - Single ownership ⇒ Trust
  - complete knowledge
  - Algorithmic optimality ⇒ RIP



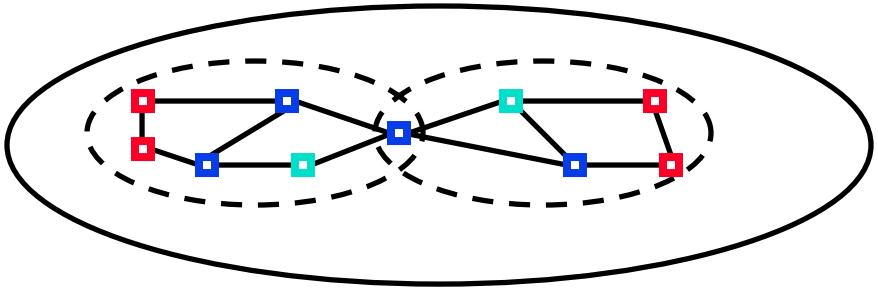
- **Internet 2.0**(1989–2009) Commerce
  - Multiple ownership of infrastructure ⇒ Distrust, **Security**
  - No knowledge of internal topology and resources
  - ***Policy based*** routing ⇒ BGP



- **Internet 3.0**(2009–2029) Commerce
  - Users, Content, Host ownership
  - Requirements, Service Negotiation
  - Mobility of users and distributed data



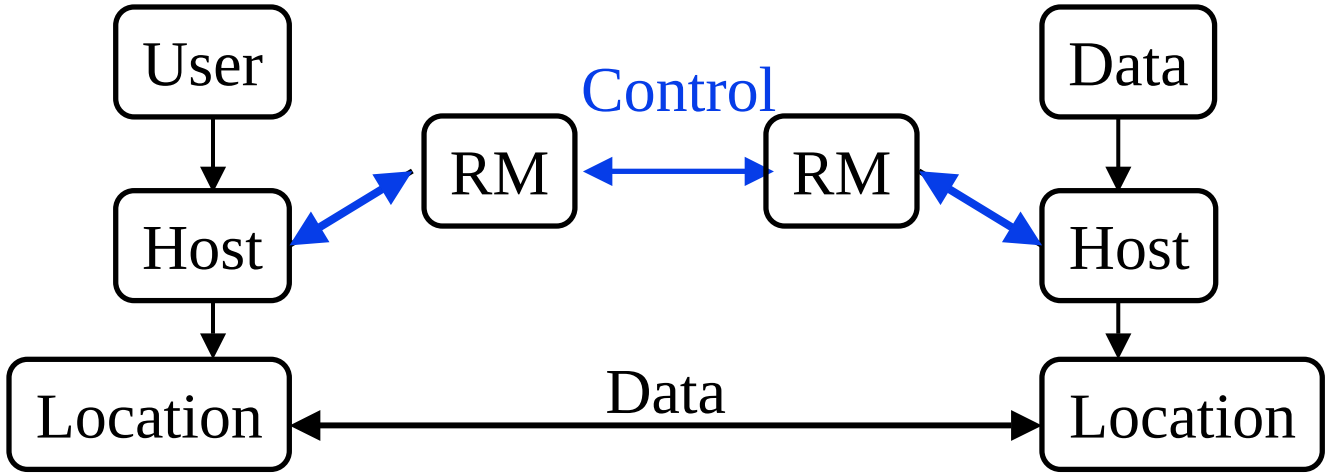
Realms



- 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

Policy Based Networking



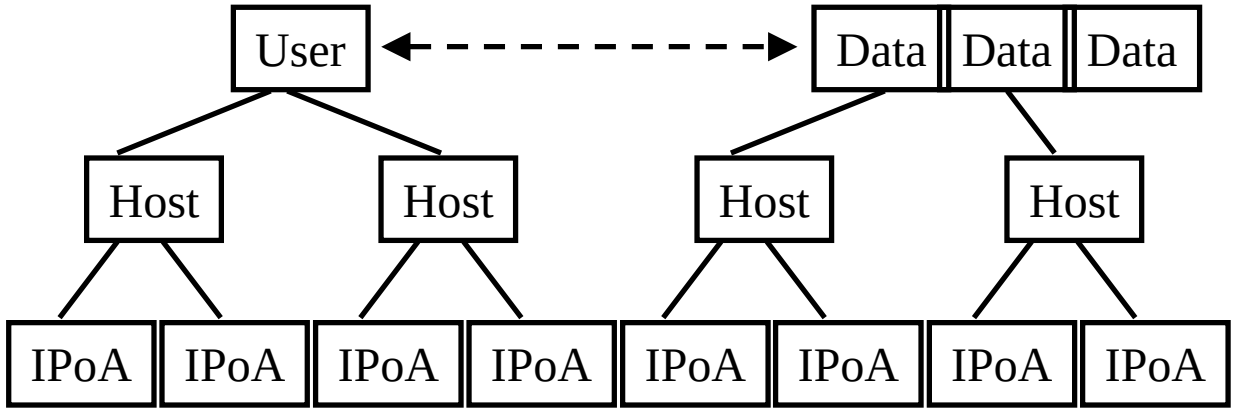
Realm managers (RM): Many organizational functions

- Allow **mobility**, multi-homing, location privacy
- **ID-Locator**: Resolve current location for a given host-ID
- Policy Monitoring. Conformance to Contracts. Troubleshooting.
- Enforce policies related to authentication, authorization, privacy
- Proxy services enabling hosts to sleep ⇒ Energy-aware networking

2. Intelligence in the network ⇒ Suitable for the masses

- Ref: Our Globecom 2008 paper [2]

User-Data Connections



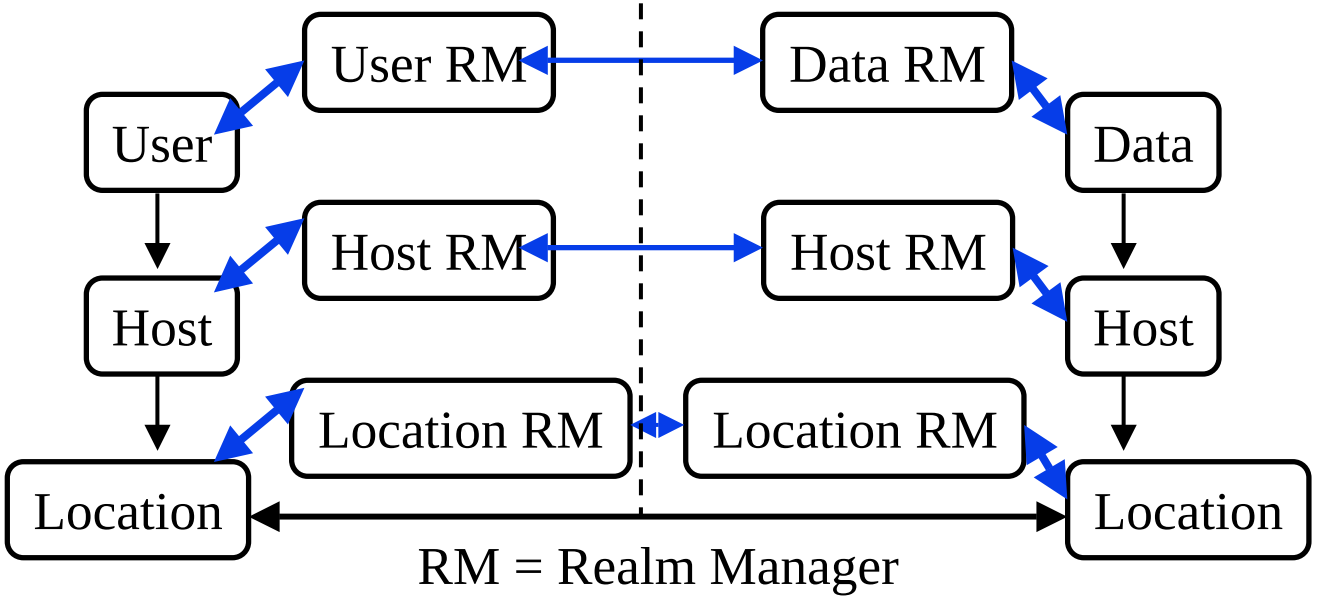
- Currently the connections are between hosts and so users are disconnected when the data or user change hosts
- The fact that data is divisible and replicable is completely ignored

User- Host- and Data Centric

- So far only host-centric communication
  - Host mobility and multihoming
  - Policies, services, and trust related to hosts
- User Centric View:
  - Bob wants to watch a movie
  - Starts it on his media server
  - Continues on his iPhone 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

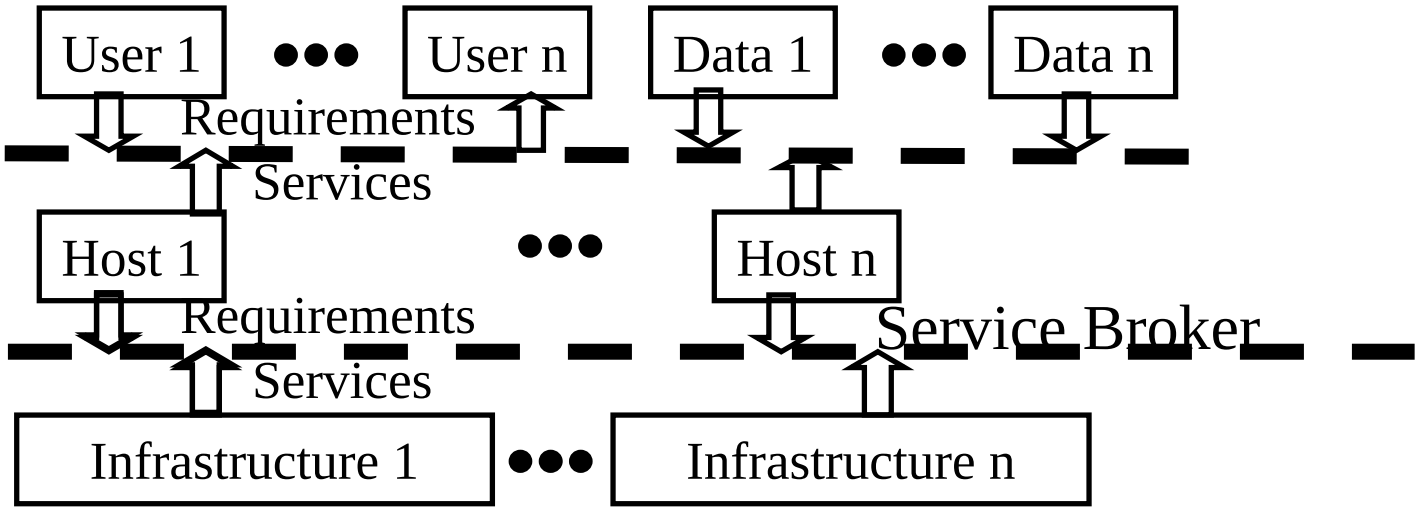
- Can we just give IDs/locators to users and treat them as hosts? No! ⇒ Policy Oriented Naming Architecture (PONA)

Policy Oriented Naming



- 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.

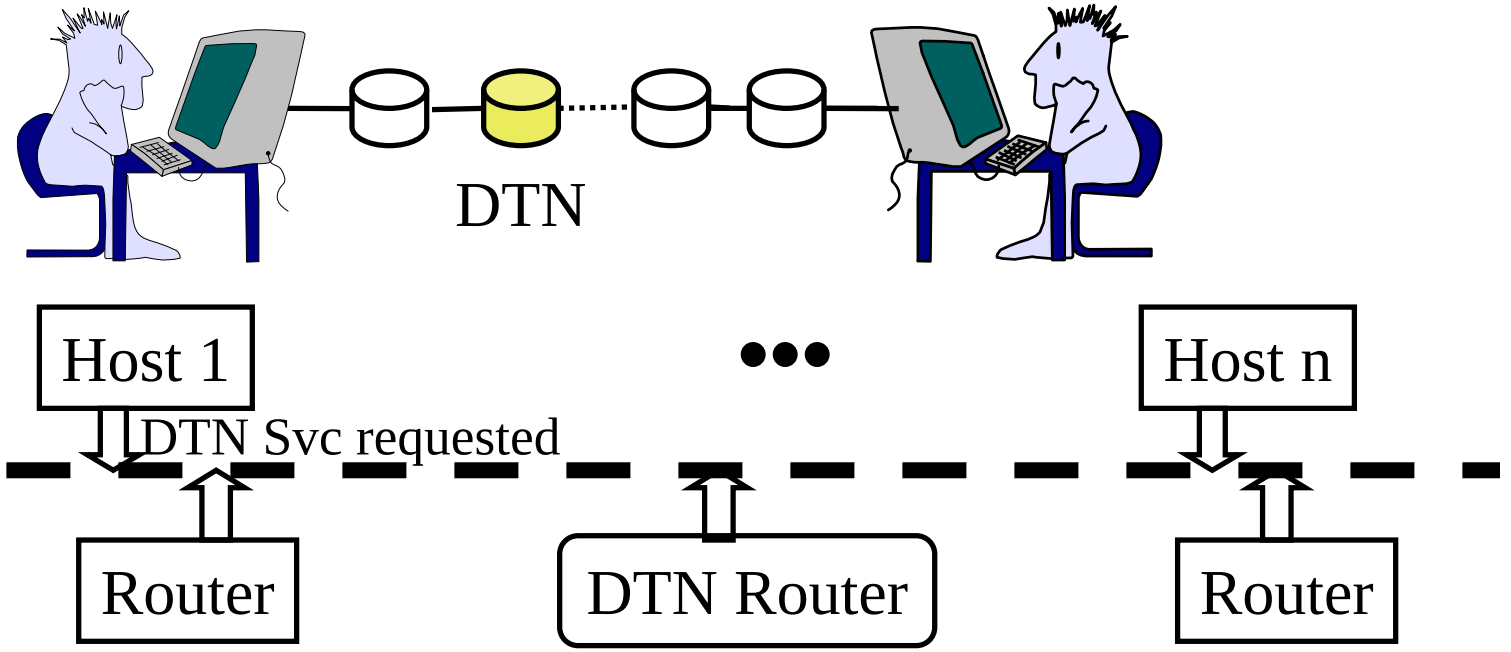
Object-Oriented View



- Objects provide services. Higher tiers specify the requirements
- Tier service broker (shown by dotted line) composes a service
  – can negotiate with multiple realms in that tier
  -Can monitor and provide independent verification
- Higher tier may not/need not find details of lower tiers

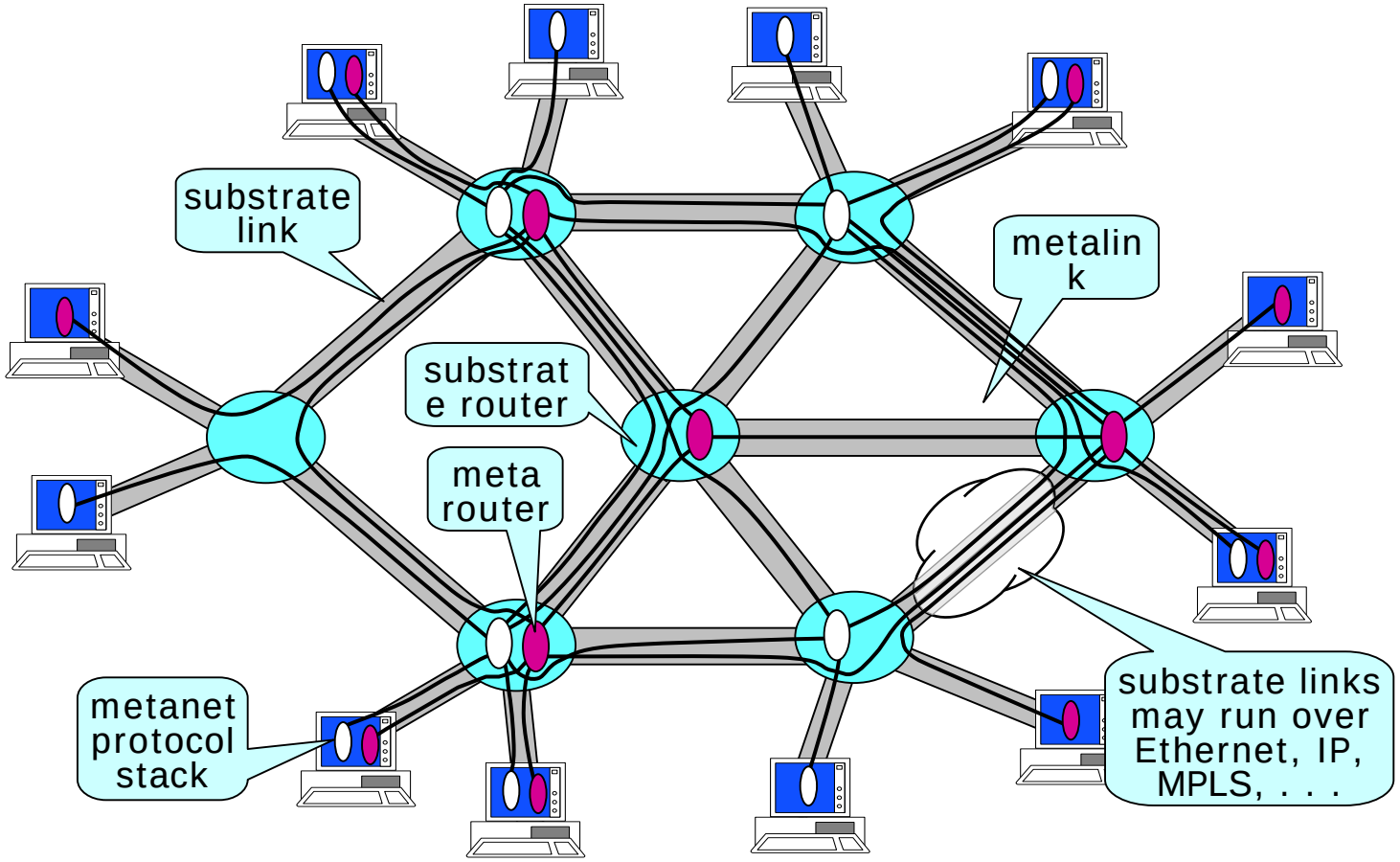
Allows creating requirement specific networking context

Disruption Tolerant Network



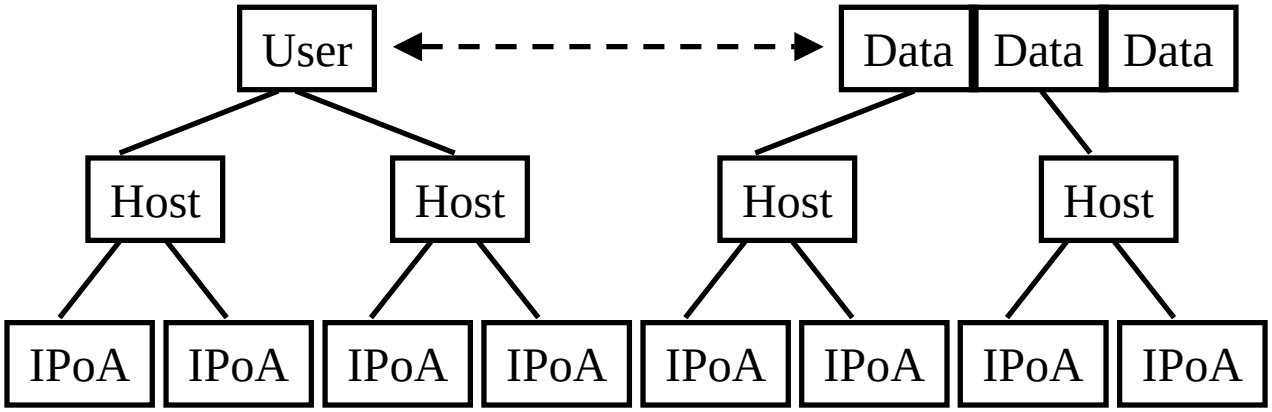
- Normally all routers on the end-to-end path should be up
- DTN-aware routers store data until it can be forwarded
- In Internet 3.0, DTN service can be advertised by DTN routers and negotiated by the service broker

Virtual Network Concept



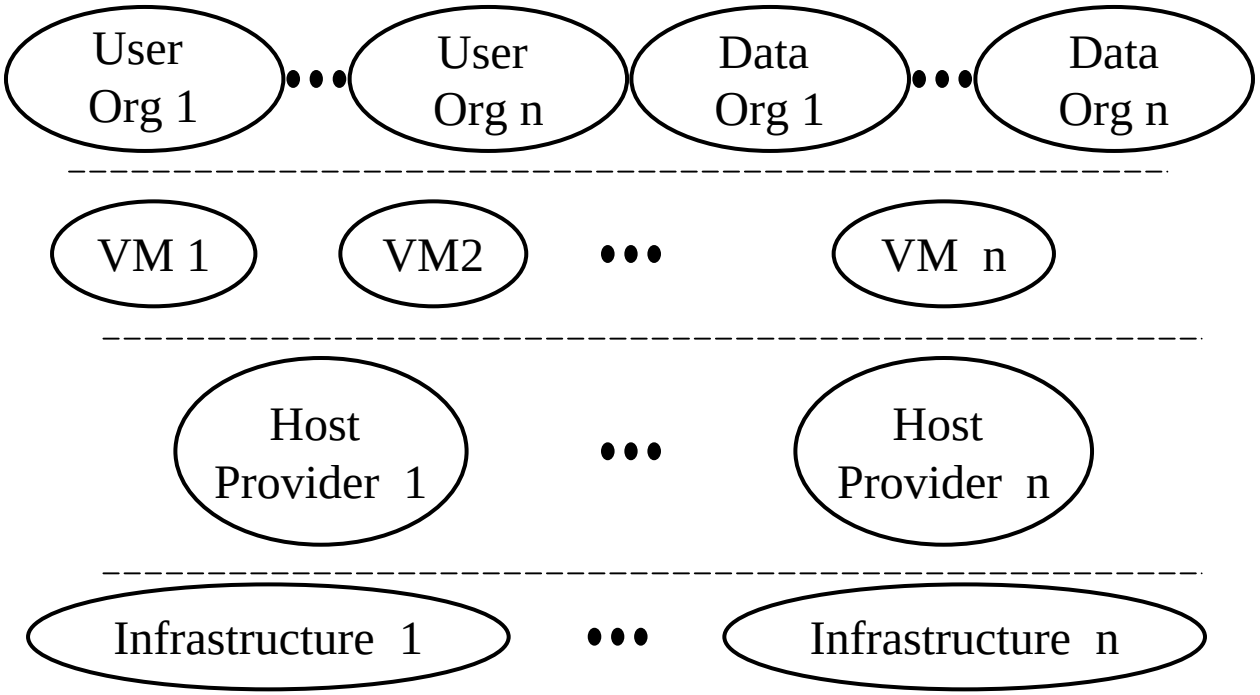
Ref: T. Anderson, L. Peterson, S. Shenker, J. Turner, "Overcoming the Internet Impasse through Virtualization," Computer, April 2005, pp. 34 – 41.

Multi-Tier Issues



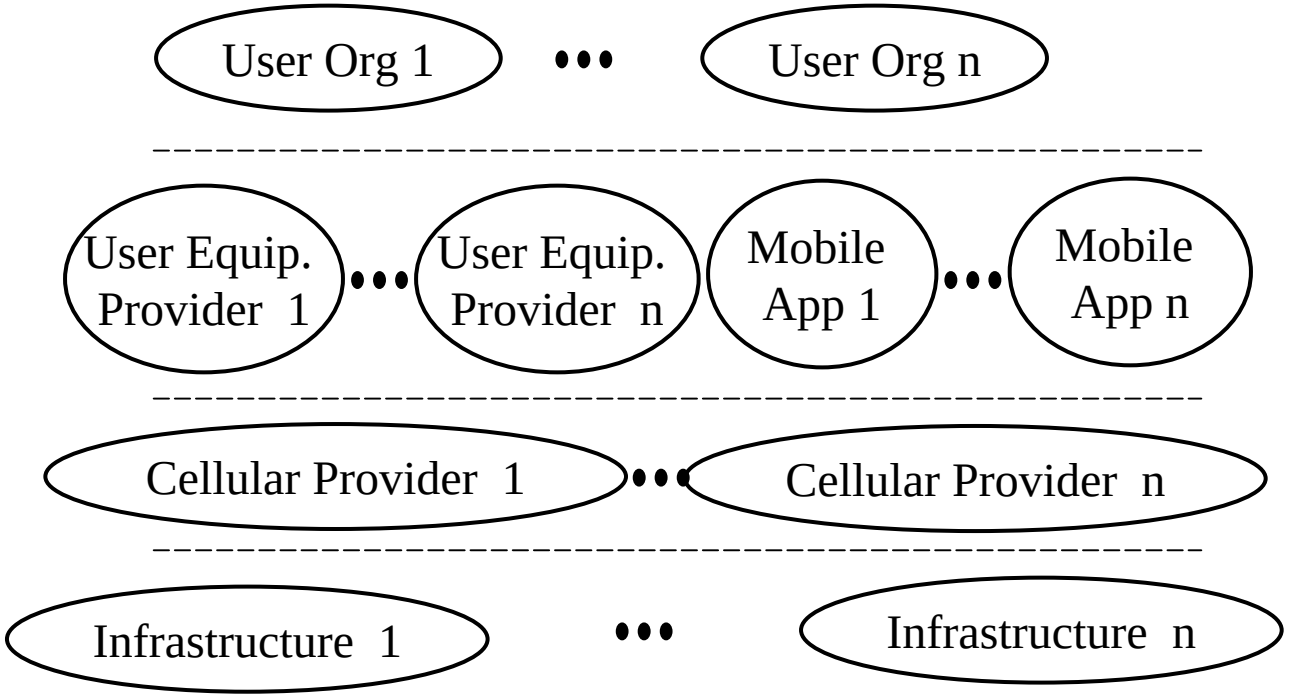
- **Multi-Tier Multi-homing**: Users are accessible via multiple hosts. Each host has multiple Infrastructure Point of Attachments (IPoAs)
- **Multi-Tier Mobility**: Users are constantly changing hosts. Hosts are changing their IPoAs.
- **Multi-Tier Virtualization**

Cloud Computing: 4-Tier



- Authenticate/authorize data using data/user policies
- Lease hosts that meet user/data policies
- Connect hosts using host policies
- Transfer data in infrastructure while meeting host requirements

Future Cellular Networks



- **Other Examples**:
  - P2P: File sharing groups over hosts over infrastructure
  - Distributed Services: Services over multi-homed hosts
  - National Security: Infrastructure vs. national boundaries

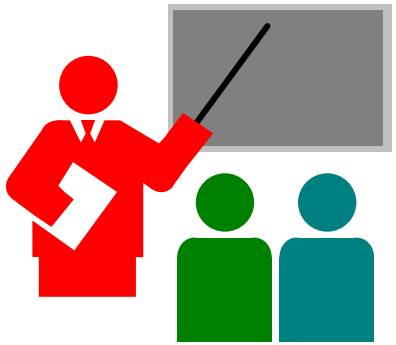
Internet 1.0 vs. Internet 3.0:

	Feature	Internet 1.0	Internet 3.0
1.	Energy Efficiency	Always-on	Green ⇒ Mostly Off
2.	Mobility	Mostly stationary computers	Mostly mobile *objects*
3.	Computer-Human Relationship	Multi-user systems ⇒ Machine to machine comm	Multi-systems user ⇒ Personal comm systems
4.	End Systems	Single computers	User/Data/Distributed systems
5.	Design Goal	Research ⇒ Trusted Systems	Commerce ⇒ No Trust Map to organizational structure
6.	Ownership	No concept of ownership	Hierarchy of ownerships

Internet 1.0 vs. Internet 3.0

	Design Issue	Internet 1.0 Solution	Internet 3.0 Solution
1	Connections	Host-Host	User-Data (Hosts are intermediate systems)
2	Information	Complete knowledge of all tiers	Only service API's are disclosed
3	Resource allocation	Algorithmic Optimization	Policy based
4	Multi-homing	Host multihoming	Multi-tier multihoming (User/Data/Host)
5	Mobility	Host mobility	Multi-tier mobility (User/data/host)

Summary



1. Internet 3.0 is the next generation of Internet.
2. It must be secure, allow mobility, and be energy efficient.
3. Must be designed for commerce
   ⇒ Must represent multi-organizational structure and policies
4. Different ownership/policies of users, hosts, infrastructure
   ⇒ Multi-tier, object oriented, service broker architecture
5. Object-oriented architecture allows services to be composed that meet upper tier's requirements while not requiring disclosure of lower tier's mechanisms and details

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Thank You!

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Hvala

Grazie

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Bedankt

Teşekkürler

Díky

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Ευχαριστώ

Merci

Gracias

Obrigado!

Vielen Dank

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