Next Generation Internet and Wireless Networking Research at Washington University in Saint Louis

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

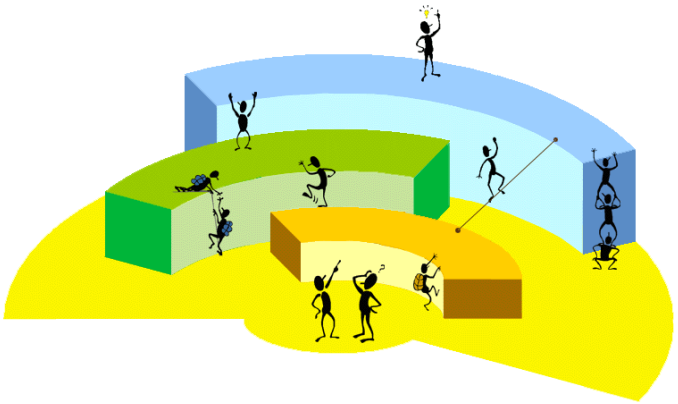
Washington University in St. Louis

Overview

- Internet 3.0: Next Generation Internet
  - Cloud Computing: Network as a Service (Naas)
- Resource Allocation in WiMAX and Future Wireless Networks
- Mobile Video Modeling
- Aeronautical Datalinks: Challenges

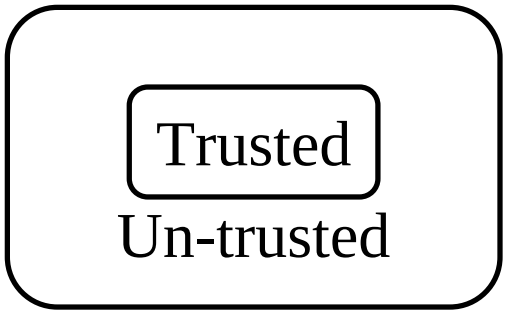
Internet 3.0: Next Generation Internet

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



Problems Addressed by Internet 3.0

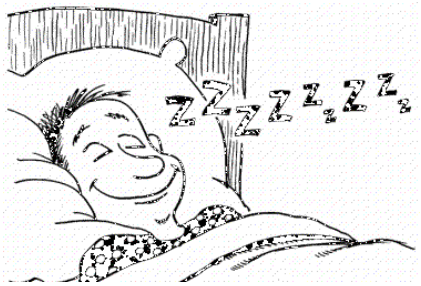
1. Designed for research
   ⇒ Trusted systems
   Used for Commerce
   ⇒ Untrusted systems
2. Difficult to represent organizational, administrative hierarchies and relationships. Perimeter based.
   ⇒ Difficult to enforce organizational policies



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.

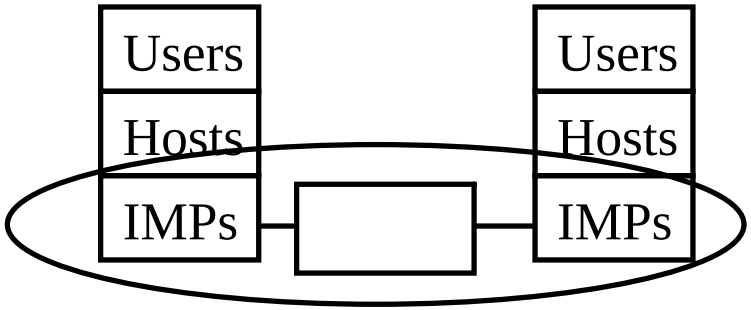


5. No representation for real end system: the human.

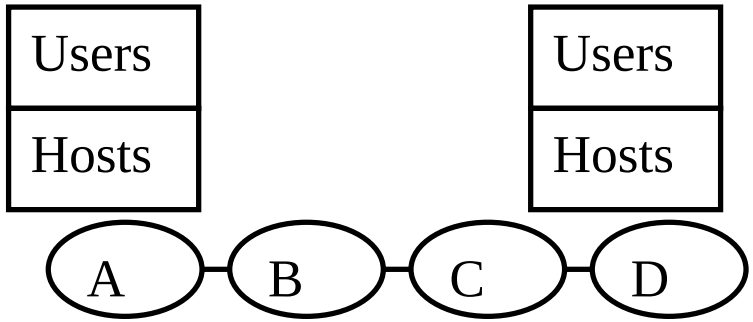
Ref: http://www.cse.wustl.edu/~jain/papers/gina.htm

Internet Generations

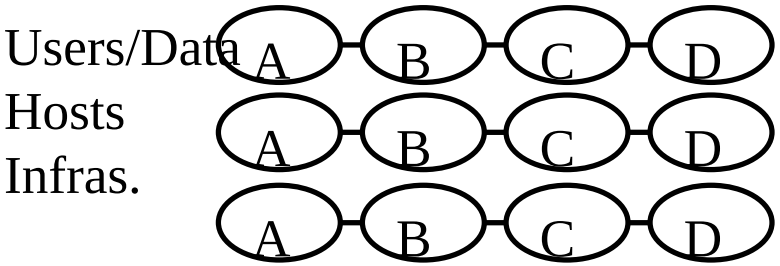
- **Internet 1.0** (1969 – 1989)
  - Single ownership ⇒ Trust
  - complete knowledge
  - Algorithmic optimality ⇒ RIP



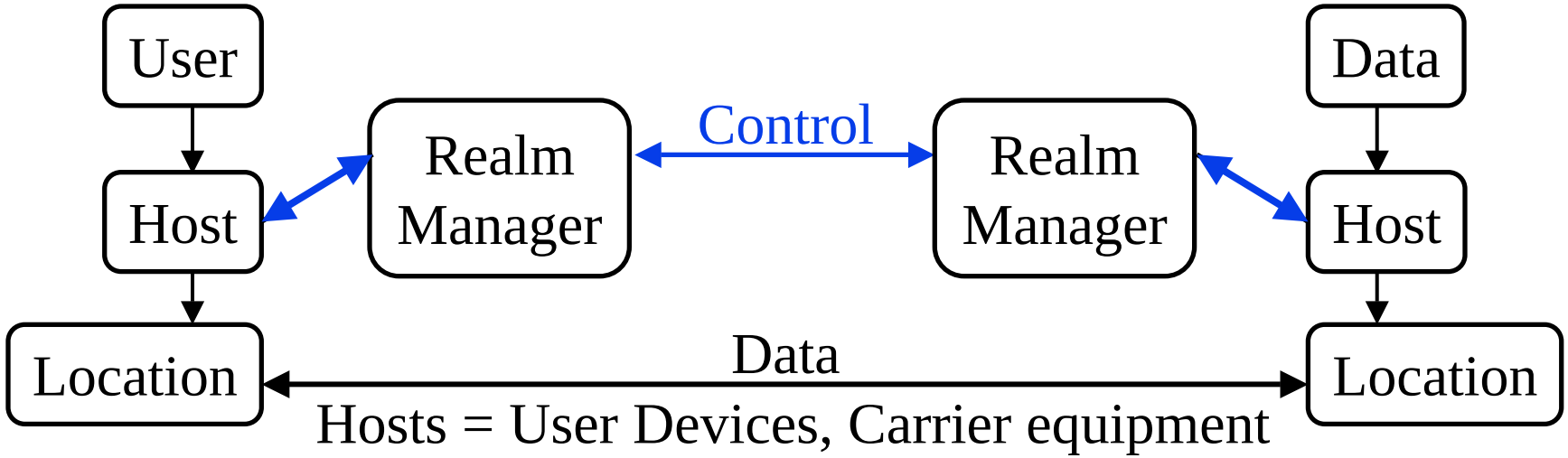
- **Internet 2.0**(1989–2009) Commerce
  - Multiple ownership of infrastructure ⇒ Distrust, **Security**
  - No knowledge of internal topology and resources
  - ***Policy based*** routing ⇒ BGP



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



Policy Based Networking Architecture



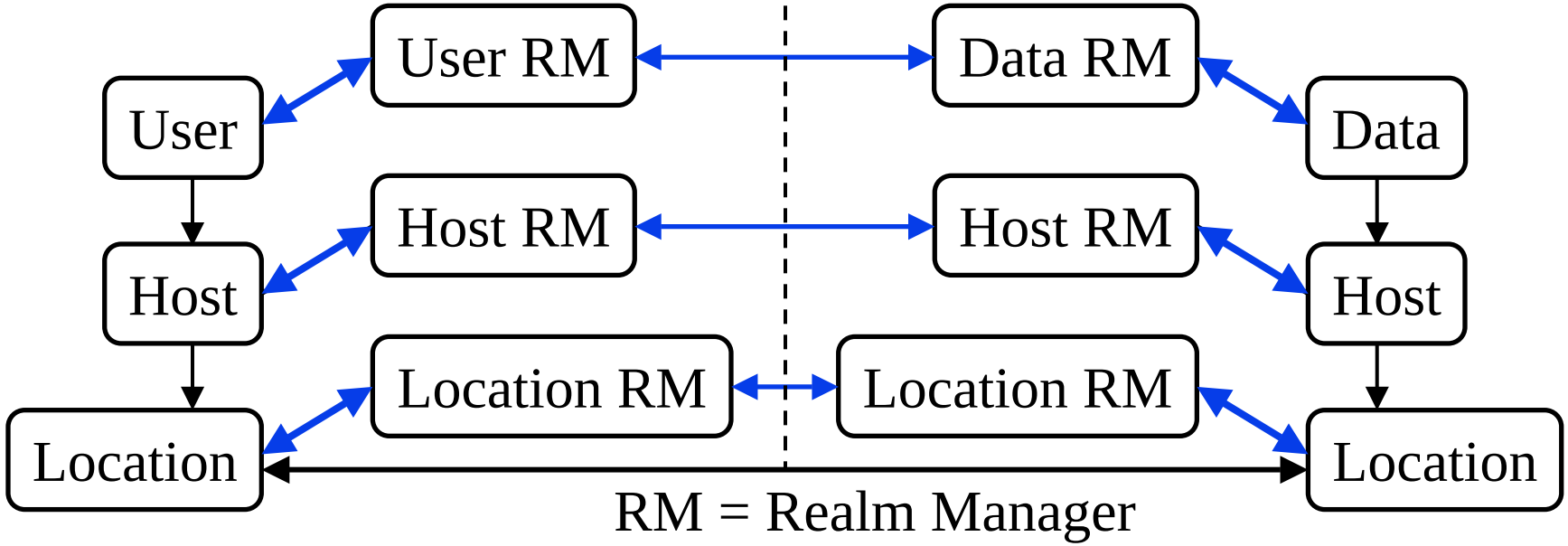
Realm managers (RM): Many organizational functions

- 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

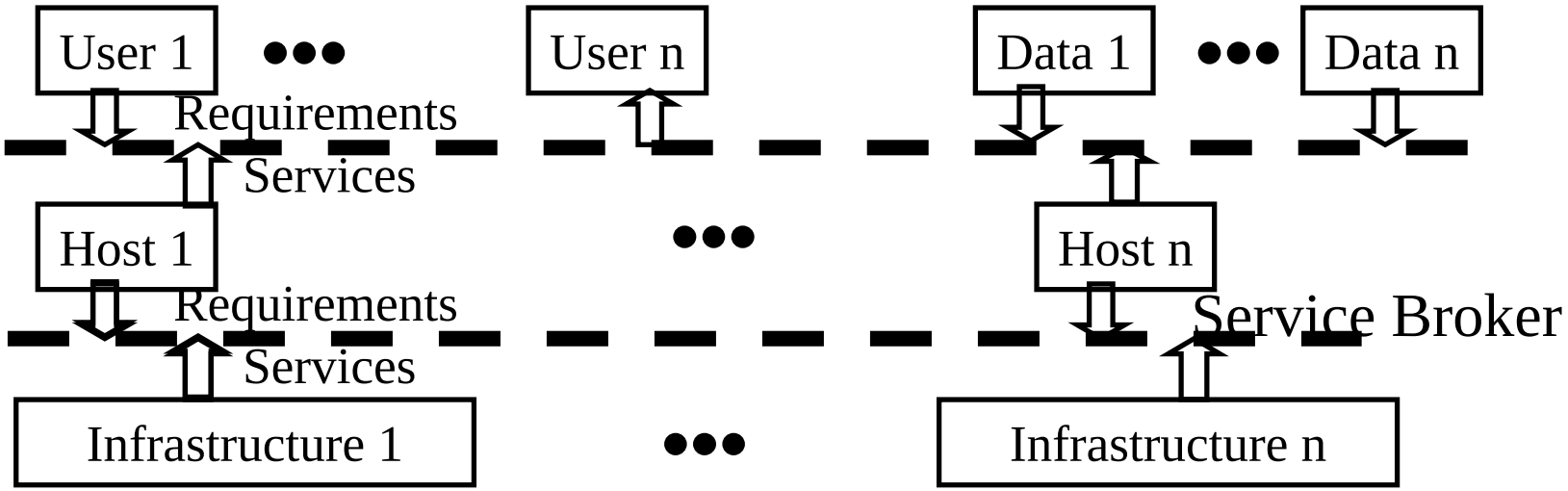
- Ref: http://www.cse.wustl.edu/~jain/papers/milsa.htm

3-Tier Model of Internet 3.0



- 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.
- Ref: http://www.cse.wustl.edu/~jain/papers/bcs08.htm

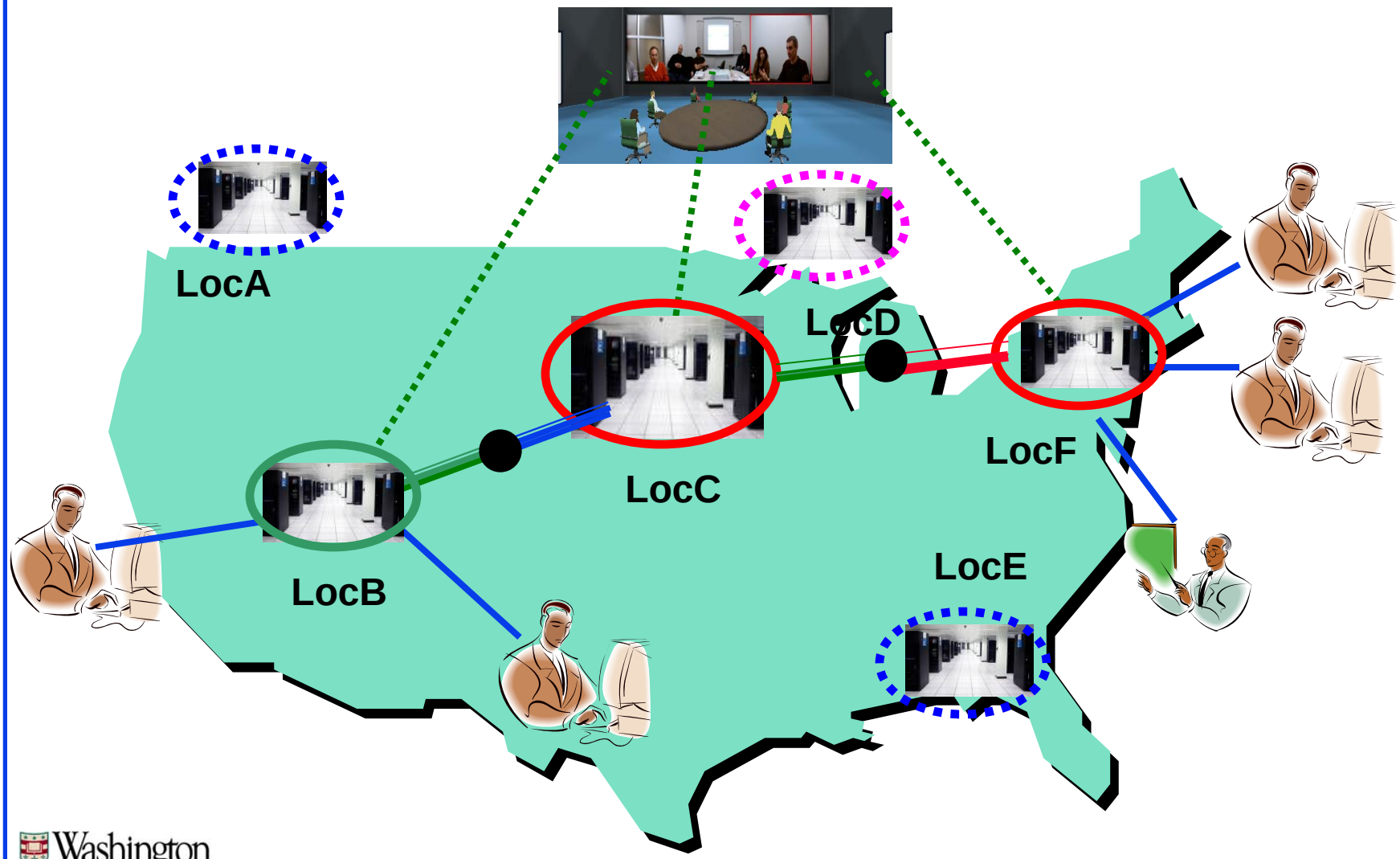
Object-Oriented View



- 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

Cloud Computing: Network as a Service (Naas)



Washington University in St. Louis

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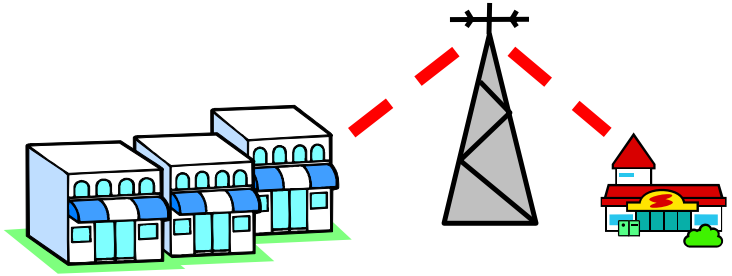
Key Distinction of Our Research

- Research topic of current interest to Industry
- Funded by industry partners: Intel, WiMAX Forum, Boeing, …
- Impact real-world by participating in standards organizations and industry forums:
  ATM Forum, IEEE Standards, American National Standards Institute (ANSI), International Telecommunications Union (ITU), Internet Engineering Task Force (IETF), Internet Research Task Force (IRTF), WiMAX Forum
- Work on long term as well as short term research

Resource Allocation in WiMAX and Future Wireless Networks



- Editor of WiMAX System Evaluation Methodology
  - Agreed upon by members of WiMAX Forum
  - Can be used by anyone to develop their own simulation
  - Allows comparison of performance results from different vendors
- Schedulers for WiMAX like systems
  - Optimal scheduling for various classes of service

Ref: Our paper in IEEE Wireless Magazine, October 2008 issue

Mobile Video Modeling

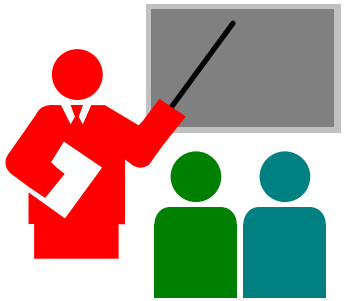
- Developed a general model for MPEG4 compressed video frame sizes can be modeled as a time series
- SAM = Simplified Seasonal ARIMA model for Mobile Video
- One model that seems to fit many movies
- Only 5 parameters
- Can be used as a workload for analysis and performance of mobile video
- All the traces and the model are available on-line.

Ref: http://www.cse.wustl.edu/~jain/papers/vid_jsac.htm

Aeronautical Datalinks: Challenges

- Very long distances:
  - WiFi covers 100m. WiMAX covers 5km
  - L-DACS (L-Band Digital Aeronautical Communication System) needs to cover 200 nautical miles (360 km)
    - Limited Power ⇒ High bit error rate or very low data rate ⇒ Low Spectral efficiency (2 bps/Hz is a challenge)
    - Long turn-around times ⇒ Large guard times (360km = 1.2 ms one-way at speed of light)
- Very High Mobility:
  - WiFi isn't designed for mobility (200m at 60km/hr = 12s between handovers)
  - WiMAX is designed for 60 km/hr
  - L-DACS needs to cover 600 nm/hr (1080 km/hr)

Summary



1. Both short term and long-term research.
   Of interest to industry.
2. Active participation industry forums and standards
3. Internet 3.0 is the architecture for the next generation.
   $\Rightarrow$ Networking as a Service (NaaS) for Cloud Computing
4. Wireless performance modeling and resource scheducing
5. Mobile video characterization
6. Aeronautical Networks: High mobility and long distances

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