Smart Communication with Space: Protocols and Mobility Management

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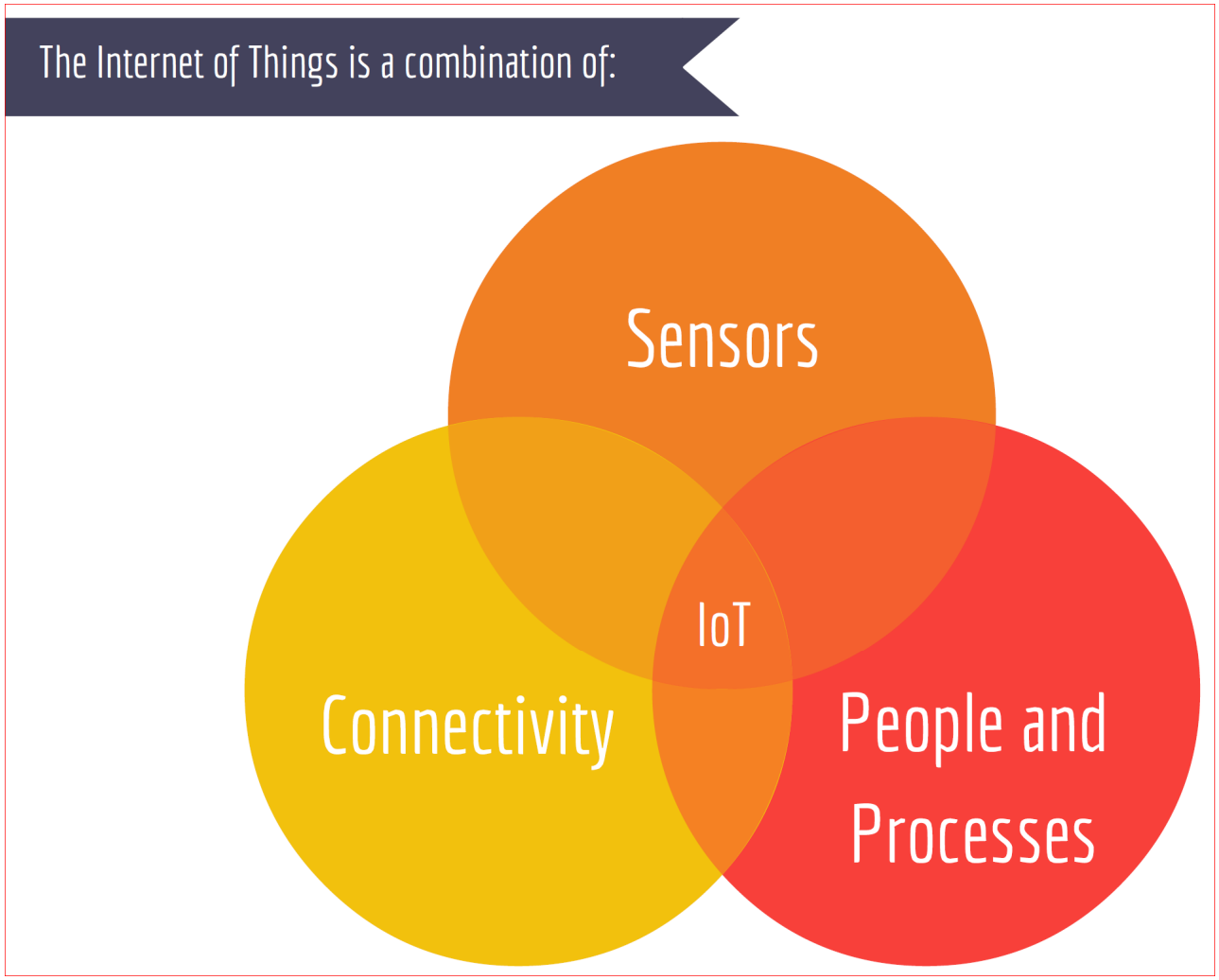
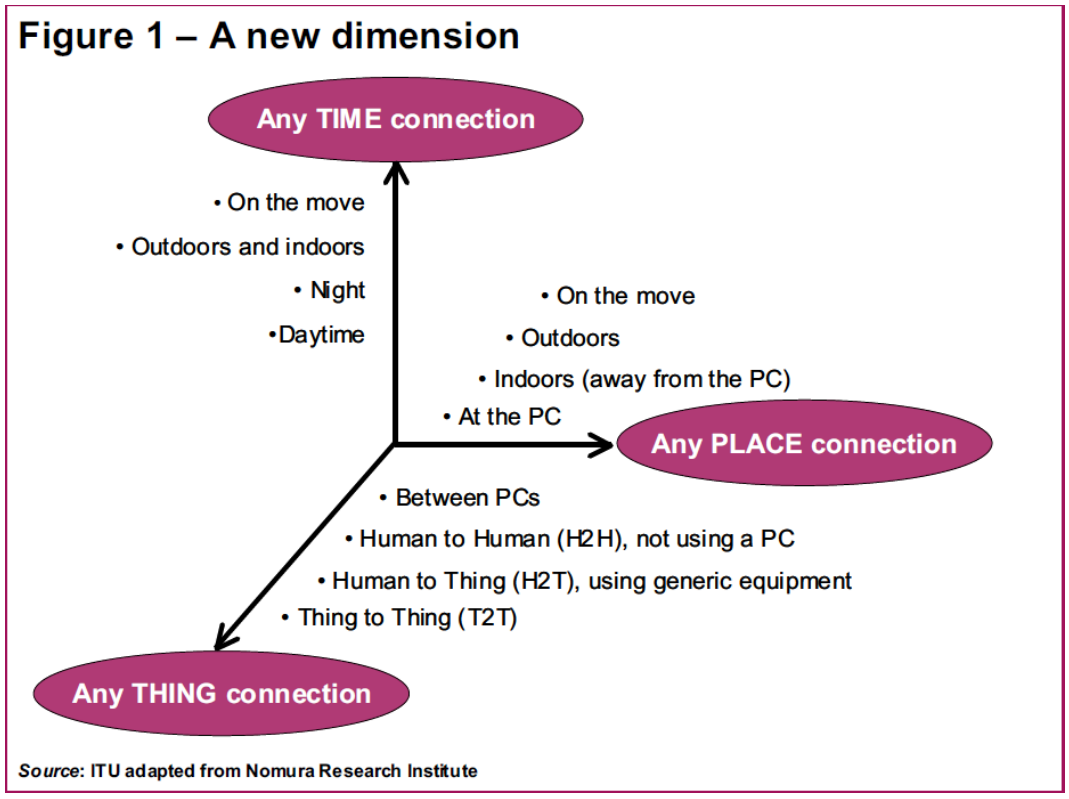
Dr. Mohammed Atiquzzaman
University of Oklahoma, Norman, OK 73019-6151, USA.
atiq@ou.edu,
www.cs.ou.edu/~atiq


The Internet of Things is a combination of:
Sensors
IoT
Connectivity
People and Processes

From any time, any place connectivity for anyone, we will now have connectivity for anything!

- WiFi
- ZigBee
- 6LOPAN
- Bluetooth
- 4G/5G
- Broadband
- WiMax
- Satellites

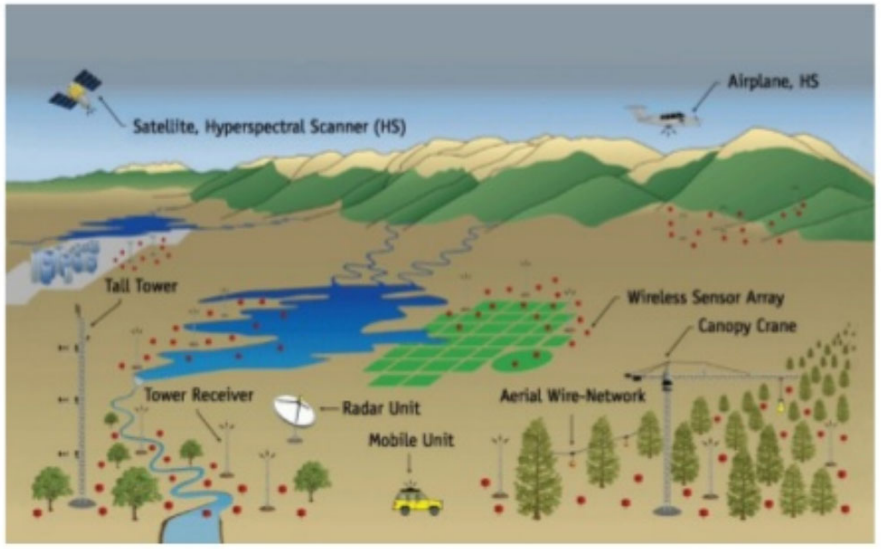


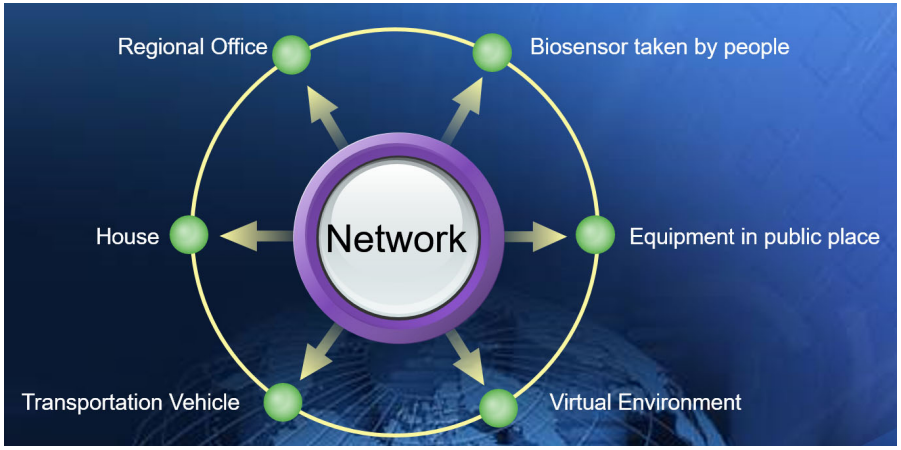
IoT/Smart World Applications

Transport and Logistics




Environmental Monitoring





Source: Pasquale Puzio, "Internet of Things and its applications"

Smart City

CONNECTED TRAFFIC SIGNALS

- Reduced congestion
- Improved emergency services response times
- Lower fuel usage

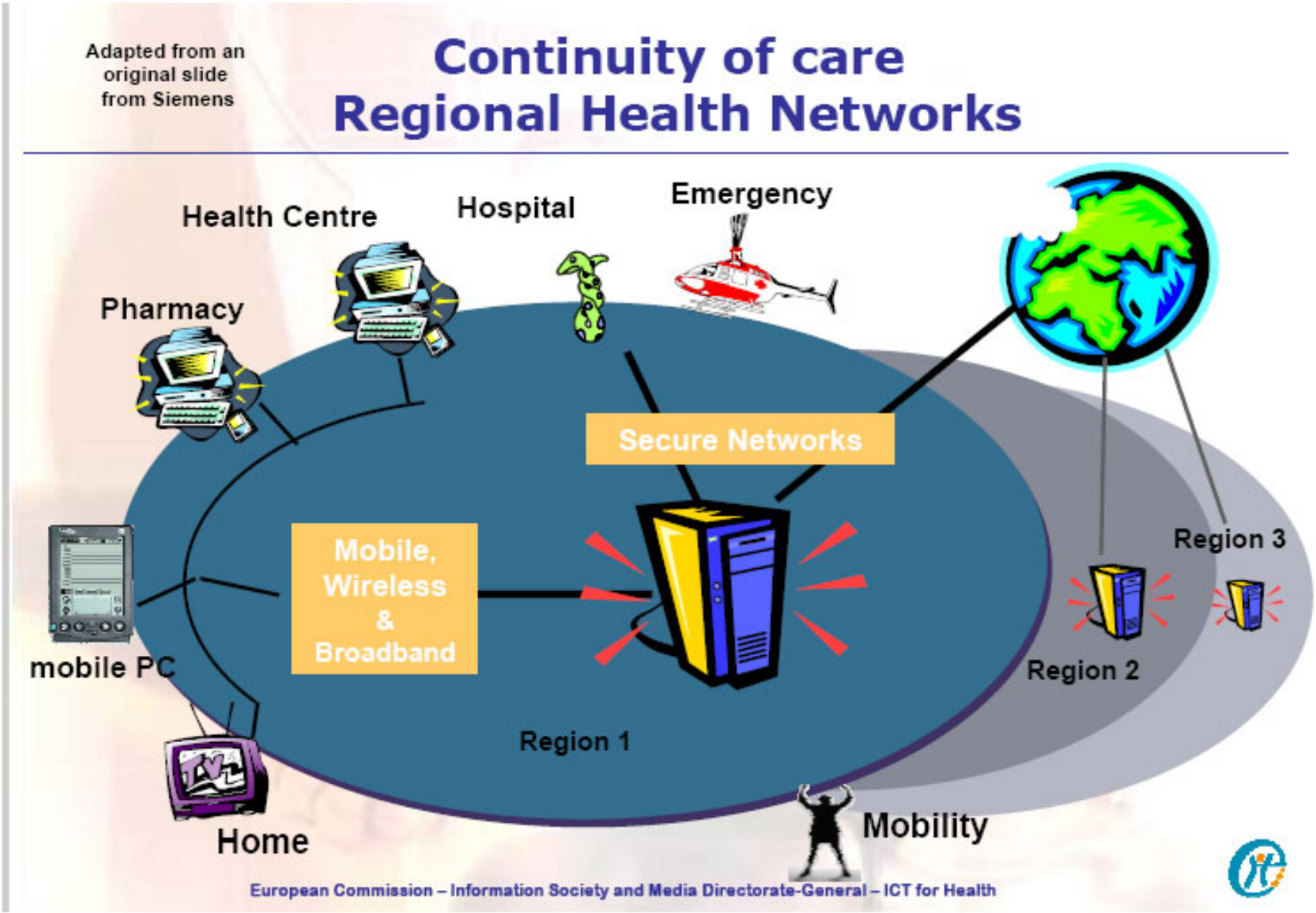
PARKING AND LIGHTING

- Increased efficiency
- Power and cost savings
- New revenue opportunities

CITY SERVICES

- Efficient service delivery
- Increased revenues
- Enhanced environmental monitoring capabilities

Source: Mikhail Kader (Cisco), IoT (Internet of Things) and Security


Adapted from an original slide from Siemens
Continuity of care
Regional Health Networks
Health Centre
Hospital
Emergency
Pharmacy
Secure Networks
Mobile, Wireless & Broadband
mobile PC
Region 3
Region 2
Region 1
Home
Mobility
European Commission – Information Society and Media Directorate-General – ICT for Health

IoT via Satellite

System View of IoT

Source: Sanctis, Cianca, Araniti, Bisio, and Prasad, "Satellite Communications Supporting Internet of Remote Things"

Advantages of Satellites over Terrestrial for IoT

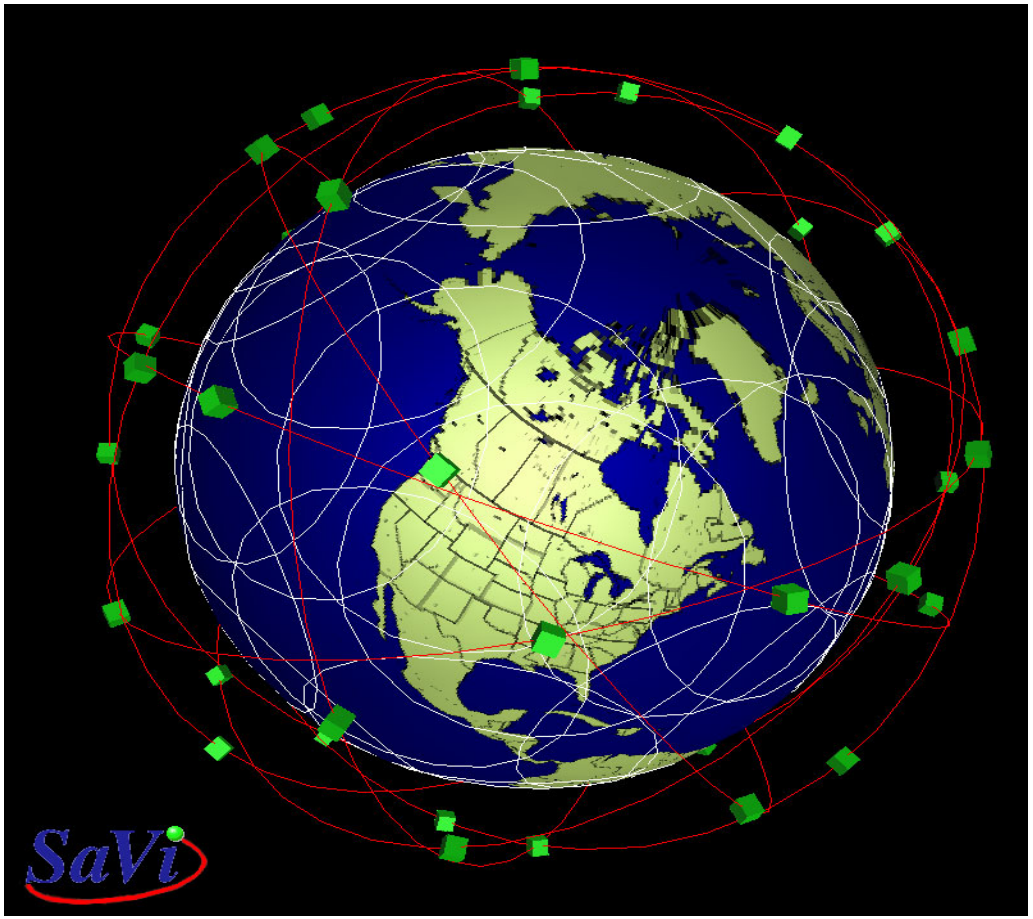
- Ubiquitous coverage and is usually more reliable, especially in remote and underserved regions.
- "Things"/Smart objects are often
  - remote
  - dispersed over a wide geographical area
  - inaccessible
- Satellite-based IoT can offer truly global coverage for many applications
  - Trans-oceanic shipping (Connected Ship), Trains, Transportation (Connected Vehicles) → Network in Motion
  - Battlefield →Mobility
  - Aeronautical → Network in Motion
  - Energy and mining companies
- IoT/M2M via satellite permits the use of a single platform, as compared to a patchwork of terrestrial networks.
  - Example: mission-critical military and transportation

IoT and Mobility

Smart Space: Connecting Space Assets

- Spacecrafts can have IP-addressable smart devices ('things')
  - Sensor
  - Radars
  - Telescopes
  - Weather observation equipment
  - Forest fire detection
- The smar space 'things' need to be connected to the Internet.
- These space 'things' are
  - Mobile
  - Connected together in a LAN on a spacecraft
- Connecting mobile space 'things' to the Internet requires mobility management.

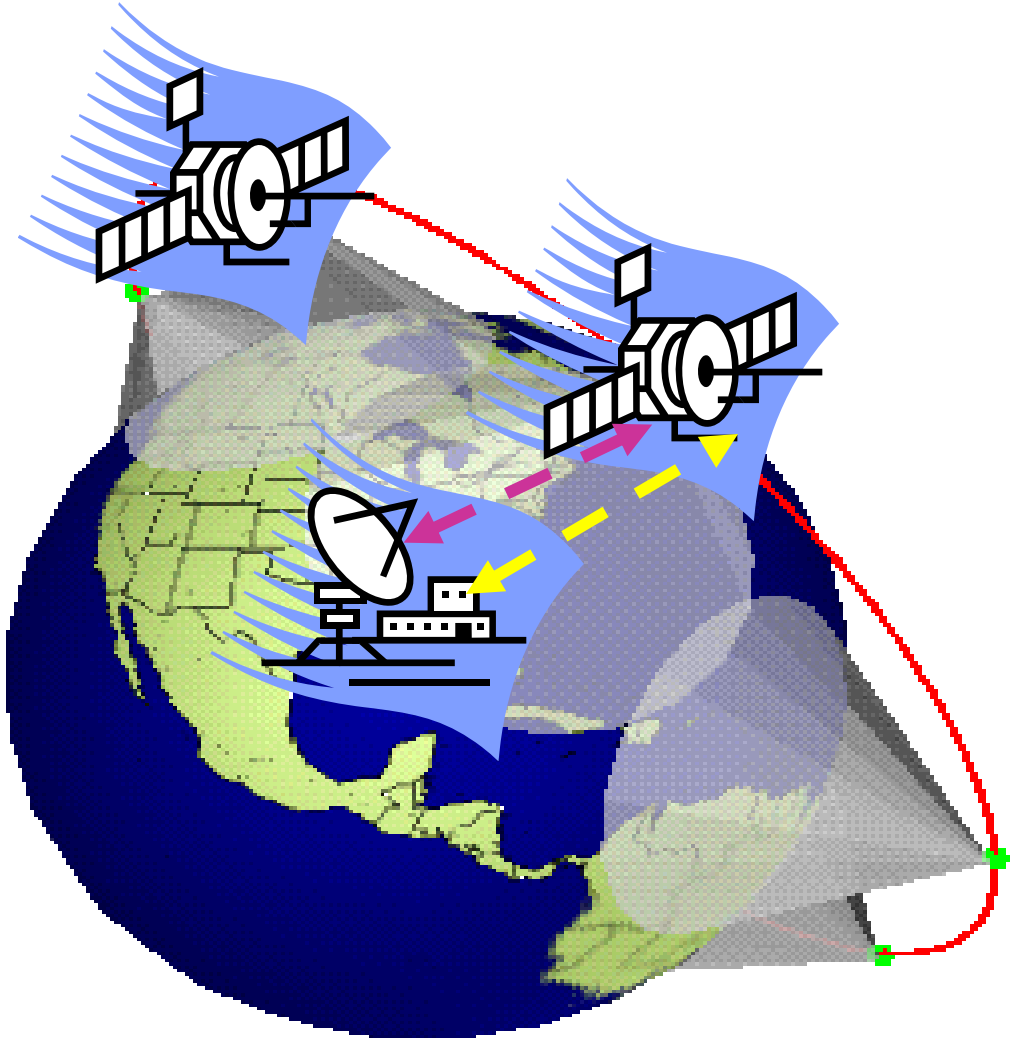
- Link Layer Handoff
  - Inter-satellite handoff
  - Link handoff
  - Spotbeam handoff
- Network Layer Handoff
  - Satellite as a router
  - Satellite as a mobile host



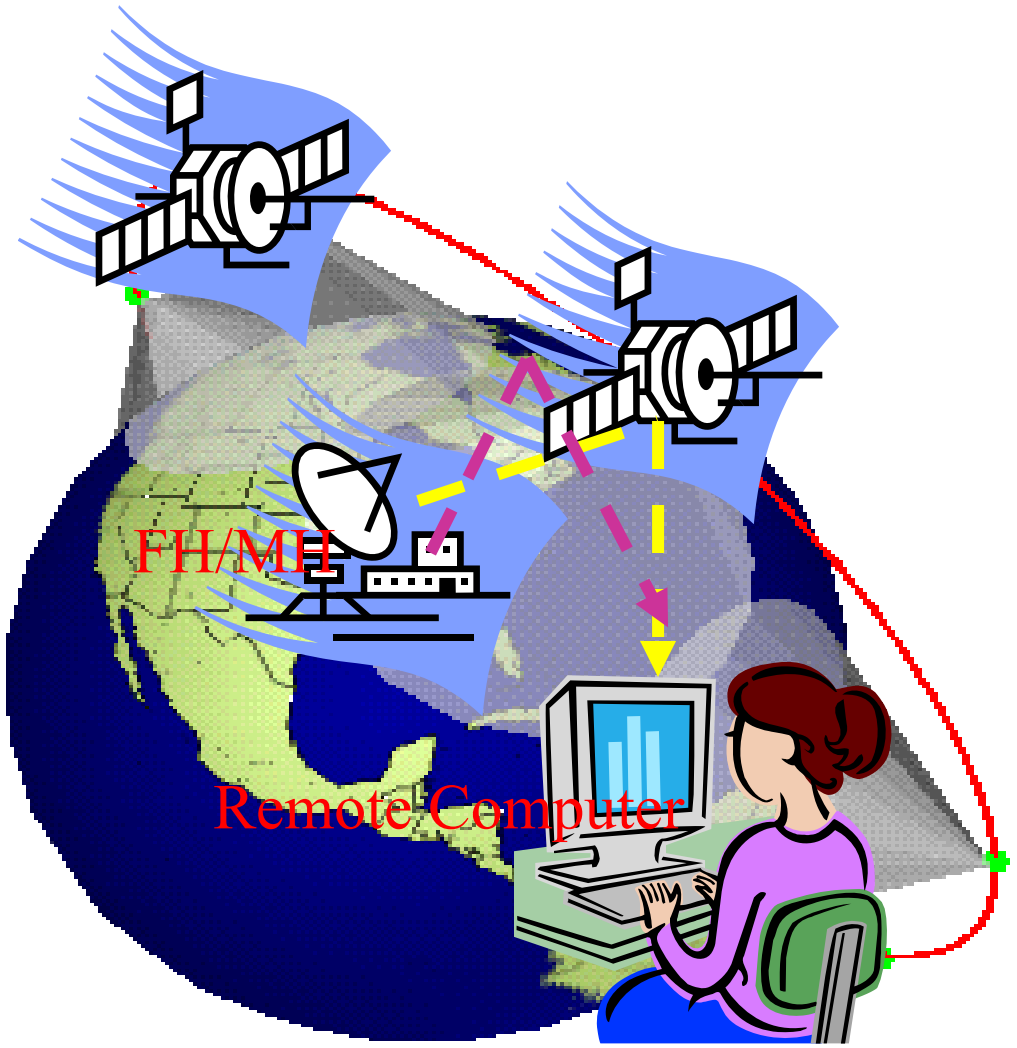
A Globalstar design, with 48 active satellites in 8 planes of 6.

Inter-satellite Handoff

- The movement of satellite causes a Ground Station being handed off from one satellite to another.
- Similar to inter-switch handoff in the case of terrestrial mobile network.

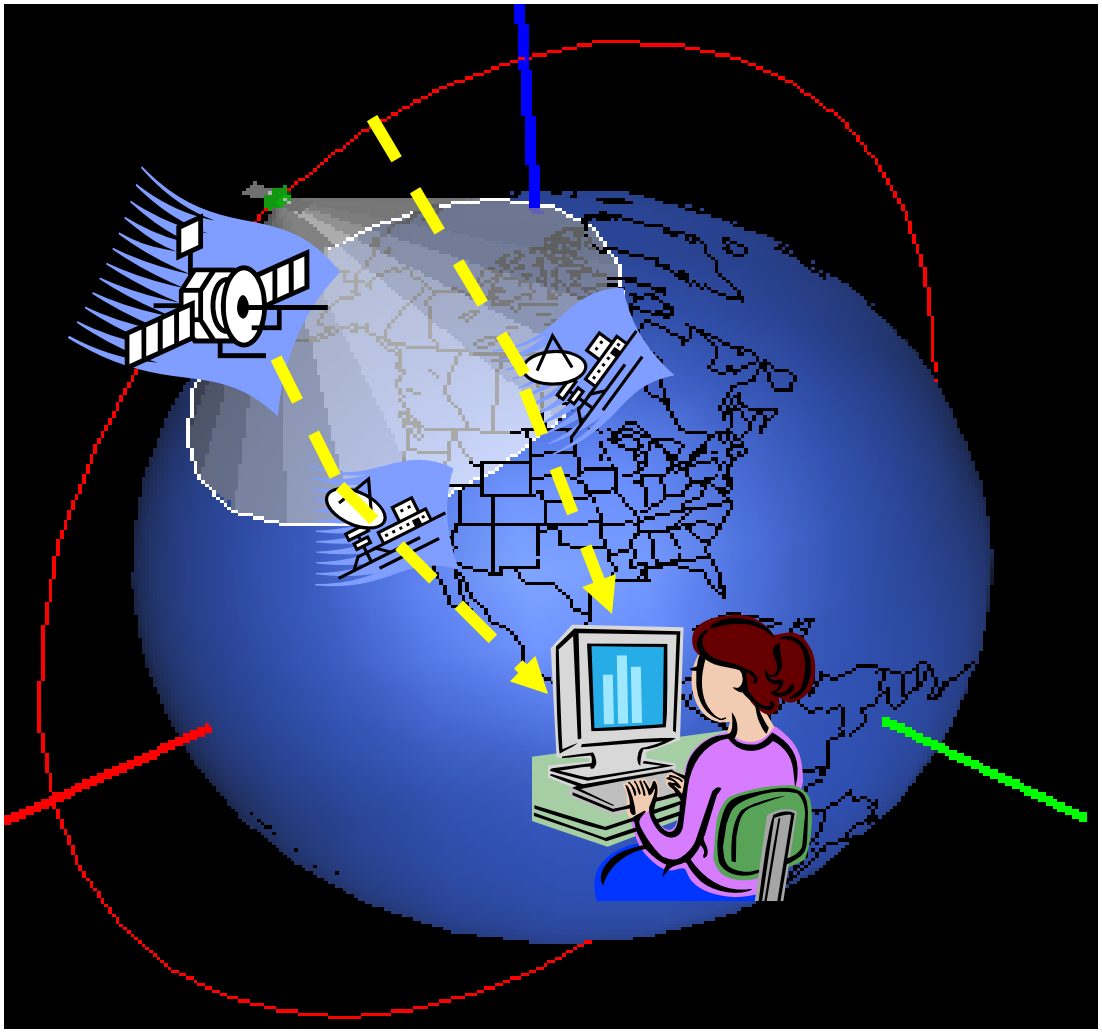


- Satellites act as IP routing devices.
  - No on-board device generating or consuming data
- Satellites are allocated with different IP prefix.
- FH/MH need to maintain continuous connection with Remote Computer.



Network Layer Handoff
Case 2: satellite as a mobile host

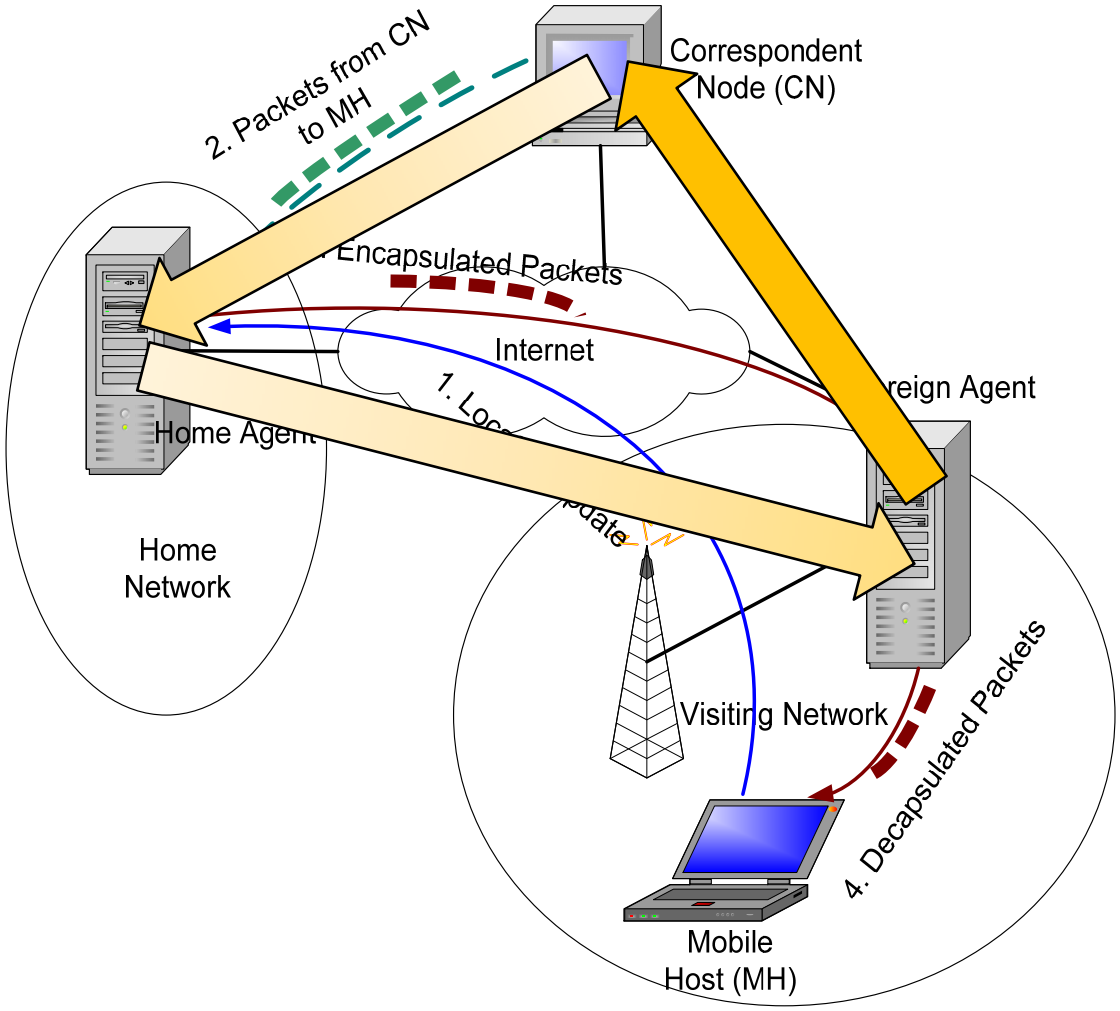
- Satellite onboard equipments act as the endpoint of the communication.
- Ground stations are allocated with different IP prefix.
- Satellite need to maintain continuous connection with remote computer.



Mobility Management

Mobile IP: Enabling IP host mobility

- When Mobile Host moves to a new domain, a location update is sent to Home Agent.
- Packets from CN to Mobile Host are encapsulated and forwarded to MH's current care-of address.
- Packets are decapsulated and delivered to upper layer protocol.



Main Drawbacks of base Mobile IP

- Need modification to Internet infrastructure.
- High handoff latency and packet loss rate.
- Inefficient routing path.
- Conflict with network security solutions such as Ingress Filtering and Firewalls.
- Home Agent must reside in MH's home network, making it hard to duplicate HA to various locations to increase survivability and manageability.

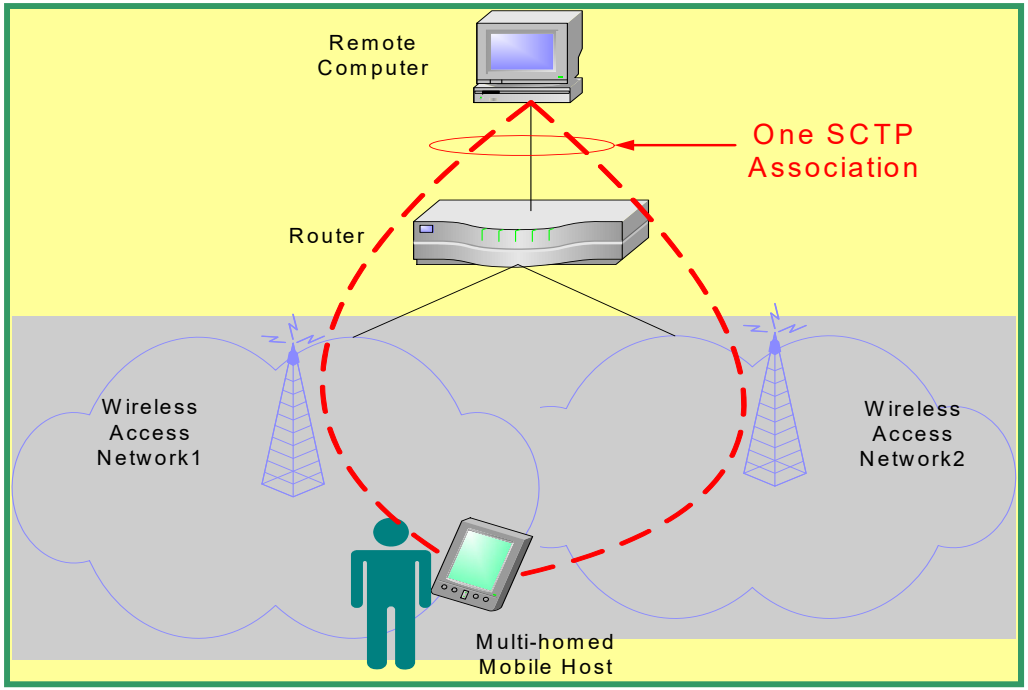
SIGMA: Seamless IP-diversity based Generalized Mobility Architecture

SIGMA: Motivation

- Several NASA projects considering IP in space and Mobile IP
  - Global Precipitations Measurement (GPM)
  - Operating Missions as Nodes on the Internet (OMNI)
  - Communication and Navigation Demonstration on Shuttle (CANDOS)
  - NASA currently working with Cisco on developing a Mobile router
- Mobile IP may play a major role in various space related NASA projects
  - Advanced Aeronautics Transportation Technology (AATT)
  - Weather Information Communication (WINCOMM)
  - Small Aircraft Transportation Systems (SATS)
- Develop an efficient, secure and seamless handoff scheme which would be applicable to both the satellite and wireless/cellular environment.

SIGMA: Basic concepts

- Mobile IP assumes the upper layer protocol use only one IP address to identify an logical connection. Some buffering or re-routing should be done at the router for seamless handover.
- SCTP support multiple IP addresses at transport layer naturally via multi-homing feature. When mobile host moving between cells, it can setup a new path to communicate with the remote computer while still maintaining the old path.



Advantages of SIGMA:

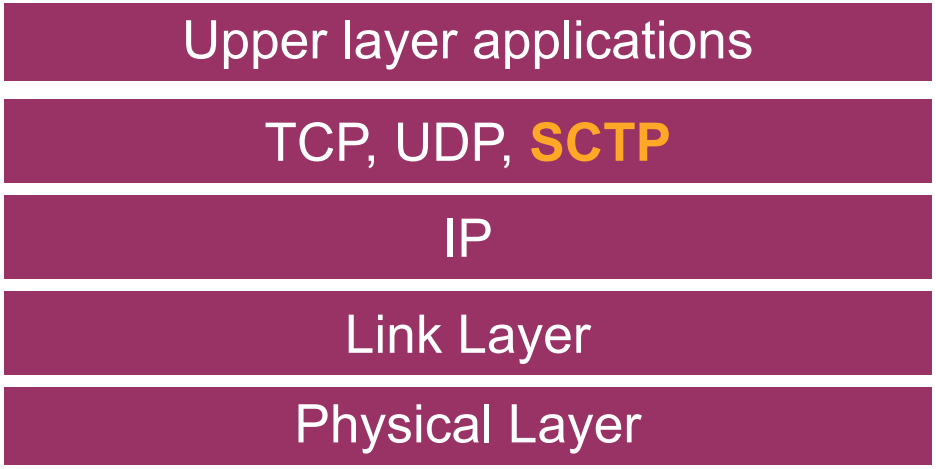
- Reduced packet loss and handover latency
- Increased throughput
- No special requirement on Router and Access networks.

What is SCTP?

- SCTP: "Stream Control Transmission Protocol"
- Originally designed to support SS7 signaling messages over IP networks. Currently supports most of the features of TCP
- Standardized by IETF RFC 2960
- Reliable transport protocol on top of IP

TCP and SCTP compared

- Both of them are reliable transport protocols;
- Similar Congestion Control algorithms (slow start, congestion avoidance);
- SCTP has two new features:
  - Multihoming
  - Multistreaming

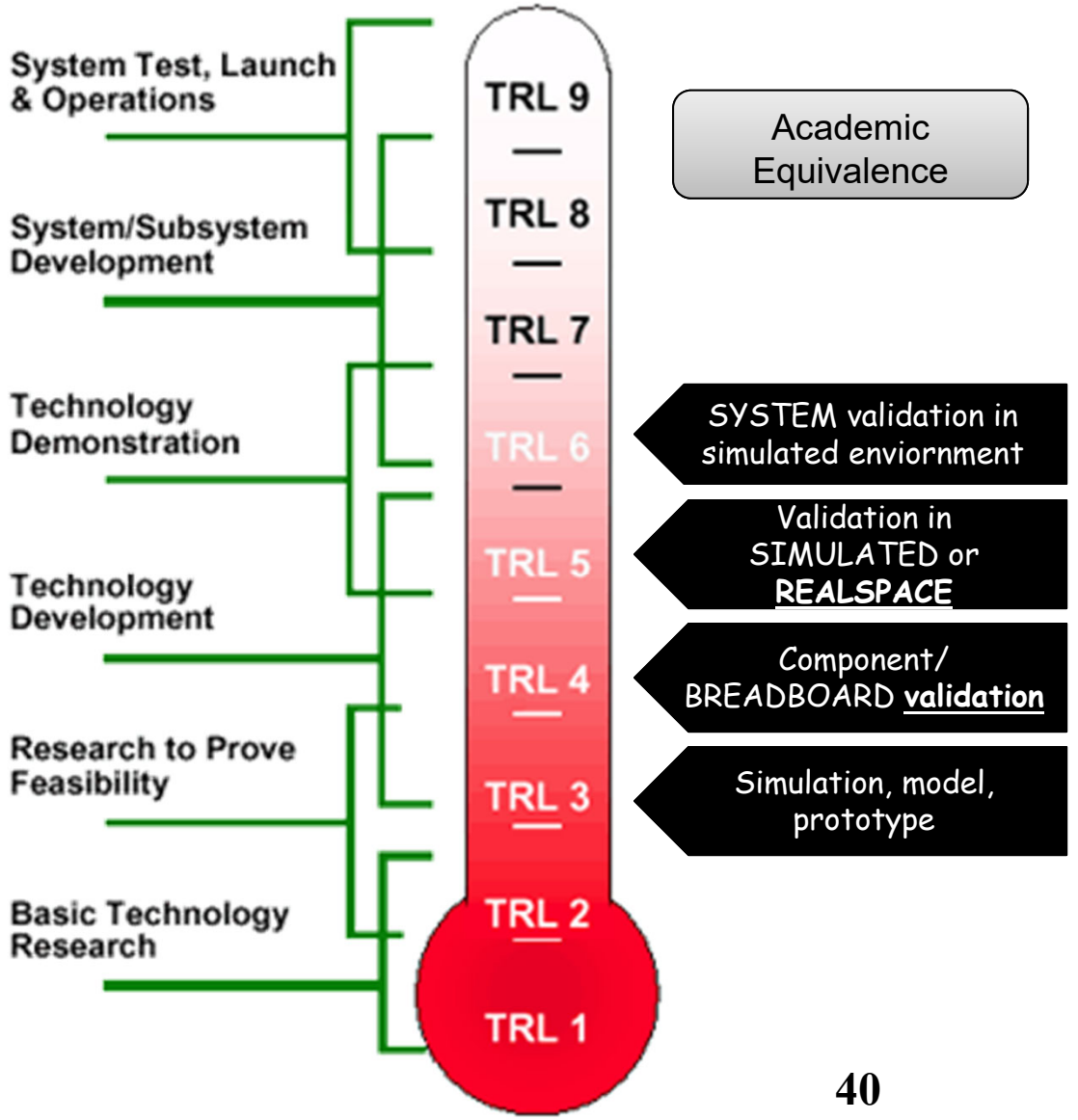


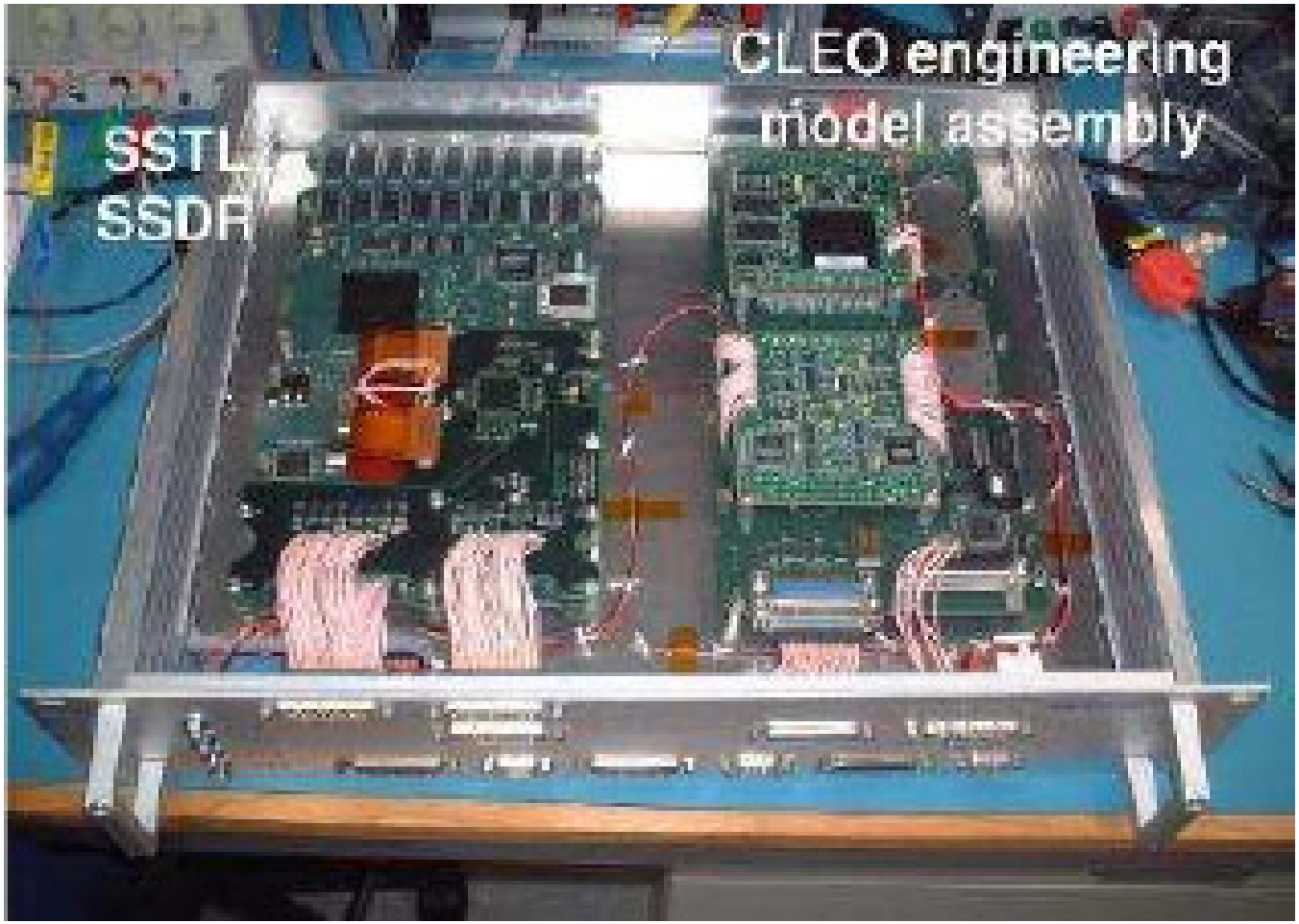
Technology Readiness Level (TRL)

TRL: a method of estimating technology maturity of Critical Technology Elements (CTE)

Examines

- program concepts,
- technology requirements, and
- demonstrated technology capabilities.





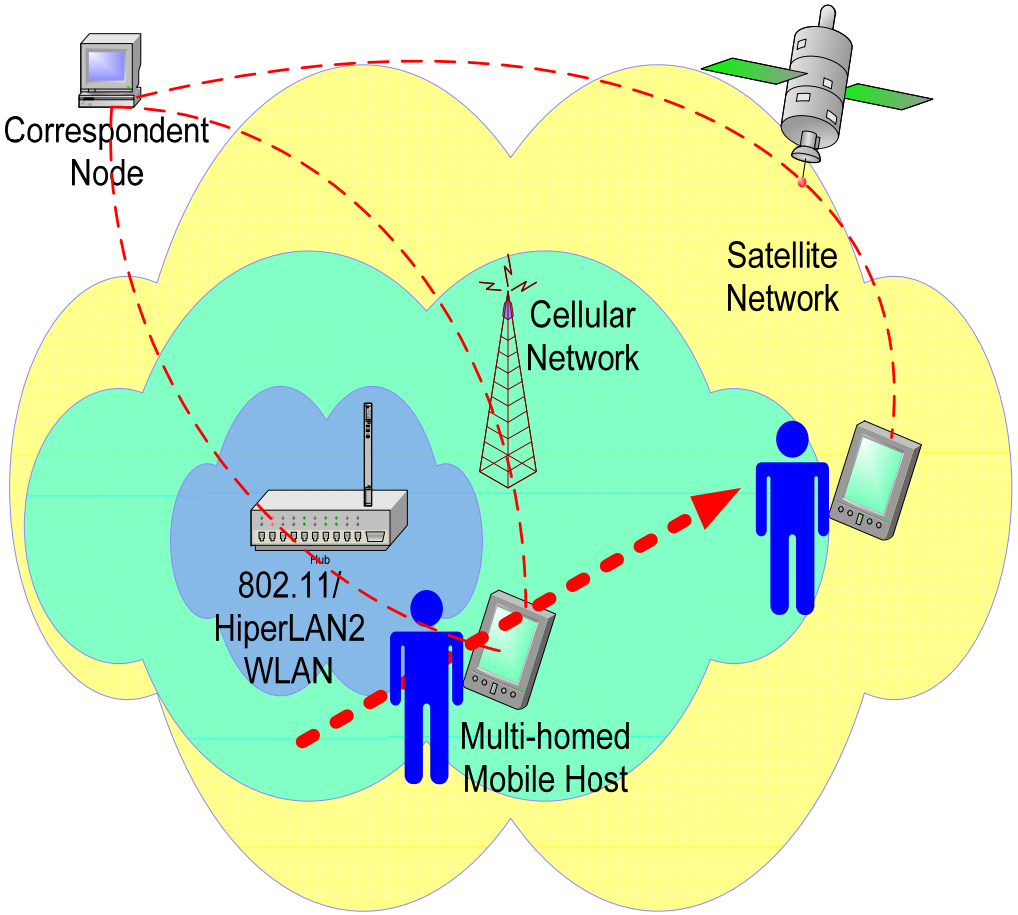
Solid State Data Recorder

- Surrey Satellite Techologies Ltd.
- Disaster Monitoring constellation
- PowerPC processor
- RTEMS operating system – very basic functionality.
- Very limited memory.

Vertical Handoff

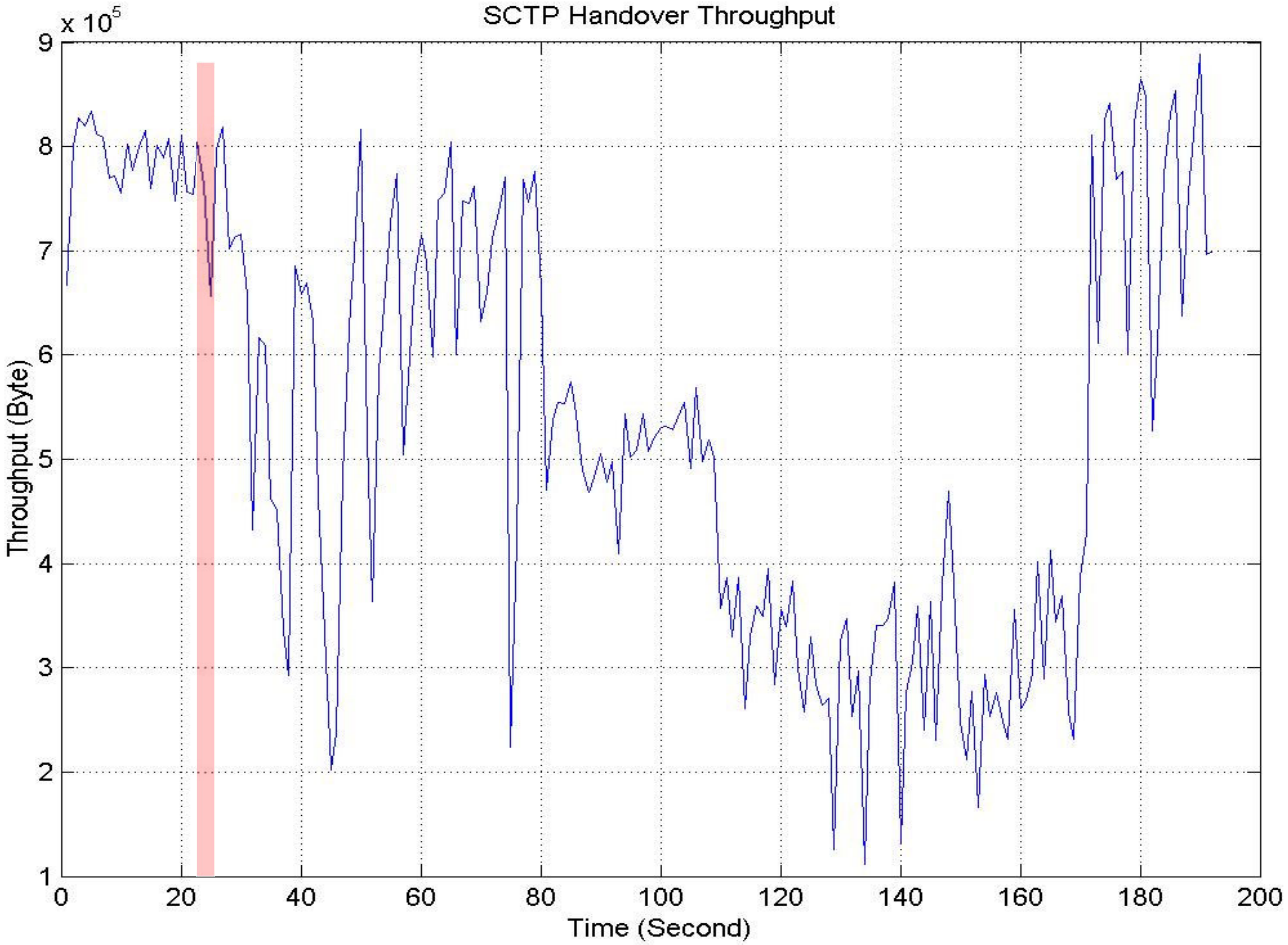
SIGMA: Application to Vertical Handoff

- Different access network technologies are integrating with each other to give mobile user a transparent view of Internet.
- Handover is no longer only limited to between two subnets in WLAN or between two cells in cellular network (horizontal handover).
- Mobile users are expecting seamless handover between different access networks (vertical handover).
- The mobility based on SCTP multi-homing is a feasible approach to meet the requirement of vertical handover.

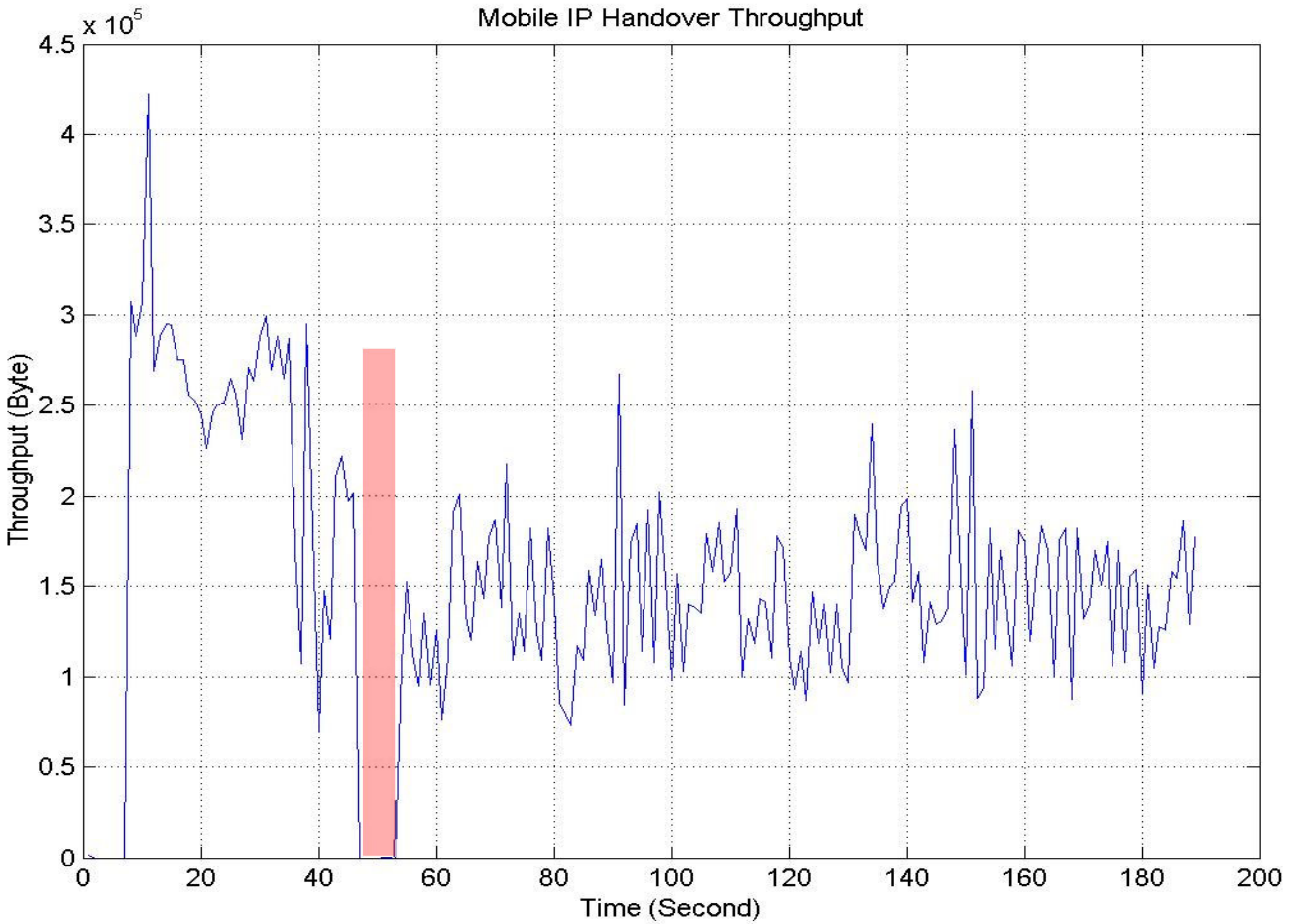


Results

SIGMA: Results



Mobile IP: Results



Criticisms of SIGMA

- Applications using TCP will not work.
- Can DNS handle location update traffic load
- DNS was not designed as location manager

Conclusions

- Satellite is a critical component of future Smart World.
- Many mobility issues arise due to movement of “things” and “satellites”.
- Efficient mobility management schemes involving satellites in IoT is an important topic for future research.
- Support of satellite services is an important component for its success in IoT.

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  - Lloyd Wood (Cisco)

Further information: atiq@ou.edu

www.cs.ou.edu/~atiq

Thank you

Contact info

Mohammed Atiquzzaman

atiq@ou.edu

(405) 325 8077

www.cs.ou.edu/~atiq