Internet Technologies for Space Applications

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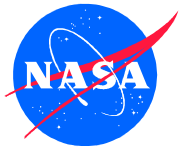
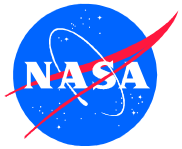


Agenda

- Why IP
- CLEO/VMOC overview
- Participating Organizations
- Mobility
- The Network
- Mobile IP / Mobile Network Data Flow
- New Capabilities

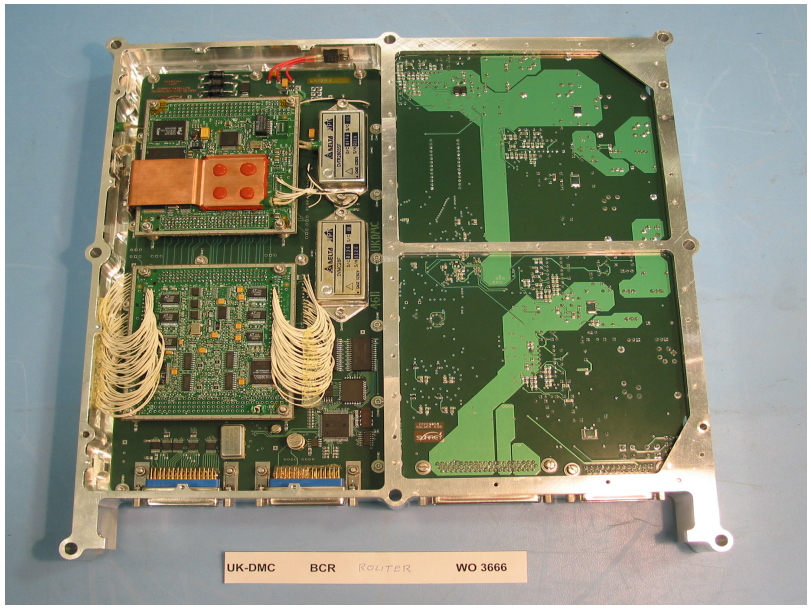


Why IP?

- Shared Network Infrastructure (Mobile-IP)
  - $$$ Savings
    - Ground Station ISP
      - $400- $500 per satellite pass
      - No salaries
      - No heath benefits
      - No infrastructure costs
  - System Flexibility
  - Greater Connectivity
  - Relatively easy to secure
- TCP/IP suite
  - COTS Standard
  - Free tools
  - Skilled professionals available
  - Tested via general use by 100s of 1000s daily

The Cisco router in low Earth orbit (CLEO)

- Put a COTS Cisco router in space
- Determine if the router could withstand the effects of launch and radiation in a low Earth orbit and still operate in the way that its terrestrial counterparts did.
- Ensure that the router was routing properly
- Implement mobile network and demonstrate its usefulness for space-based applications.
  - Since the UK–DMC is an operational system, a major constraint placed on the network design was that any network changes could not impact the current operational network



Virtual Mission Operations Center (VMOC)

- Enable system operators and data users to be remote
- Verify individual users and their authorizations
- Establish a secure user session with the platform
- Perform user and command prioritization and contention control
- Apply mission rules and perform command appropriateness tests
- Relay data directly to the remote user without human intervention
- Provide a knowledge data base and be designed to allow interaction with other, similar systems
- Provide an encrypted gateway for “unsophisticated” user access (remote users of science data)

Mobile Networking Solutions

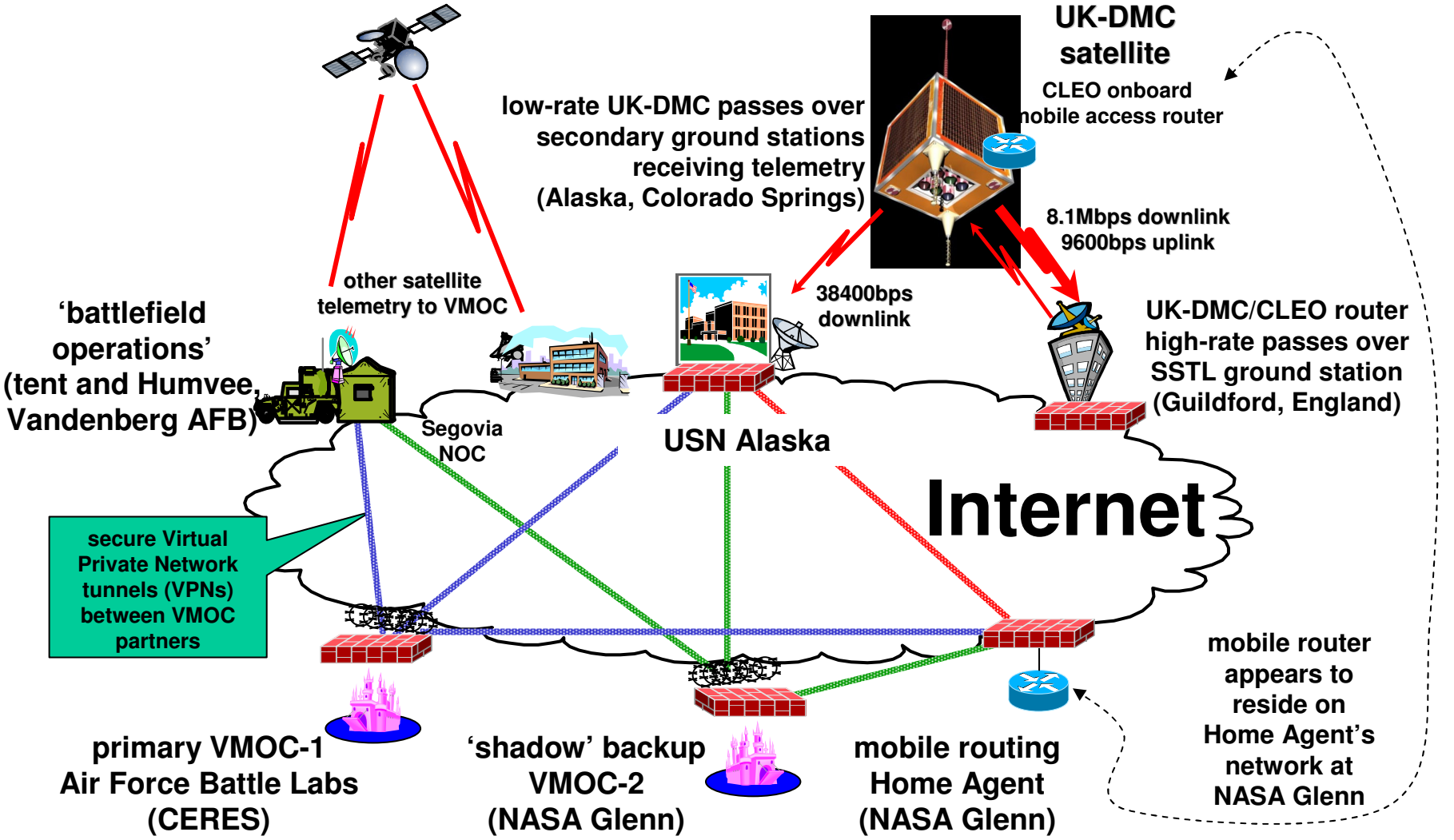
- Routing Protocols
  - ☺ Route Optimization
  - ☹ Convergence Time
  - ☹ Sharing Infrastructure – who owns the network?
- Mobile-IP
  - ☹ Route Optimization (but being worked)
  - ☺ Convergence Time
  - ☺ Sharing Infrastructure
  - ☺ Security – Relatively Easy to Secure
- Domain Name Servers
  - ☺ Route Optimization
  - ☹ Convergence Time
  - ☹ Reliability

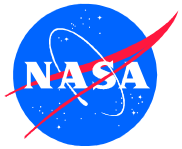
Mobility at What Layer?

- Layer-2 (Radio Link)
  - Fast and Efficient
  - Proven Technology *within the same infrastructure*
    - Cellular Technology Handoffs
    - WiFi handoffs
- Layer-3 (Network Layer)
  - Slower Handover between varying networks
  - Layer-3 IP address provides identity
  - Security Issues
    - Need to maintain address
- Layer-4 (Transport Layer)
  - Research Area
  - Identity not tied to layer-3 IP address
  - Proposed Solutions
    - HIP – Host Identity Protocol
    - SCTP – Stream Control Transport Protocol

Participating Organizations

CLEO/VMOC Network

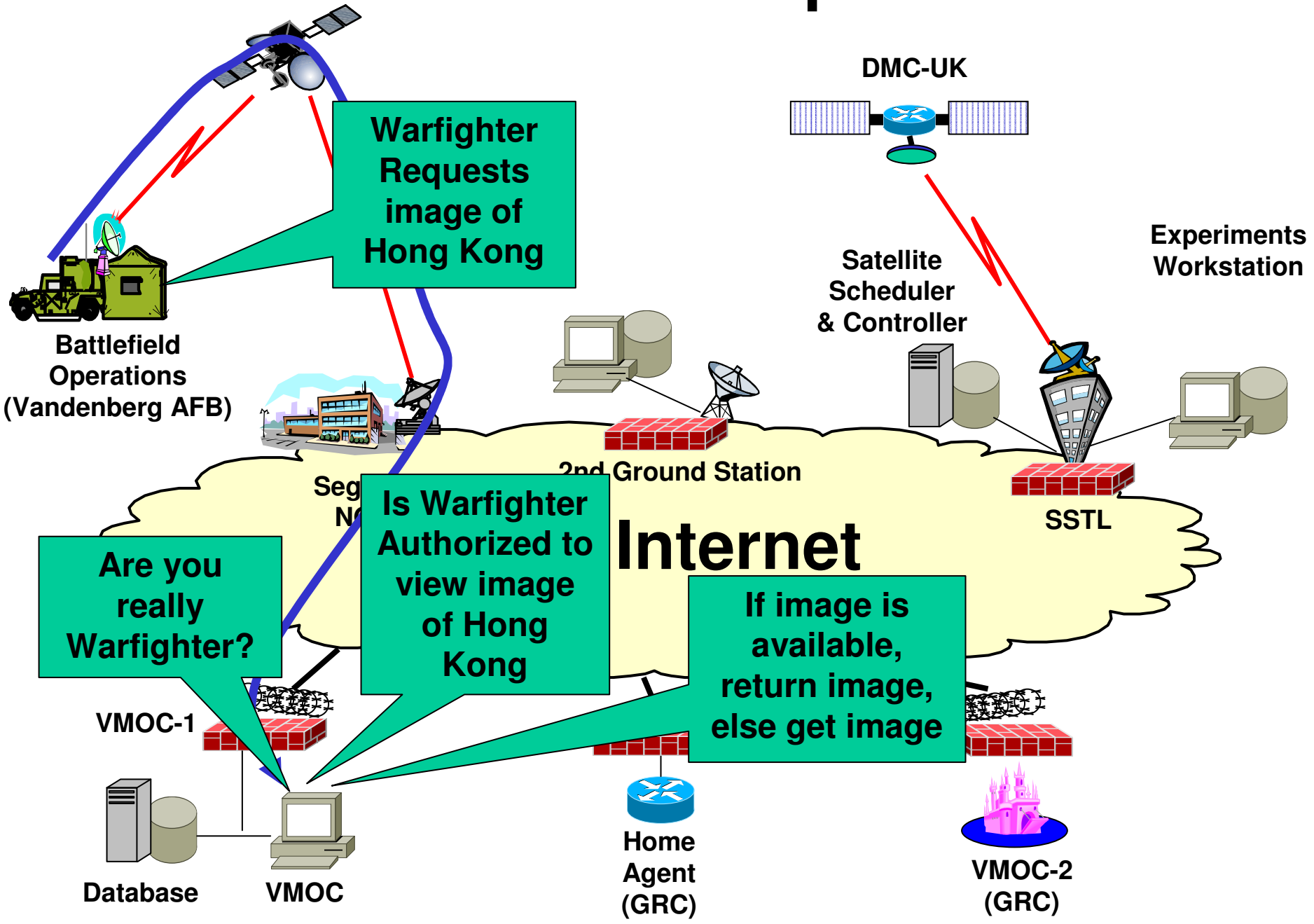




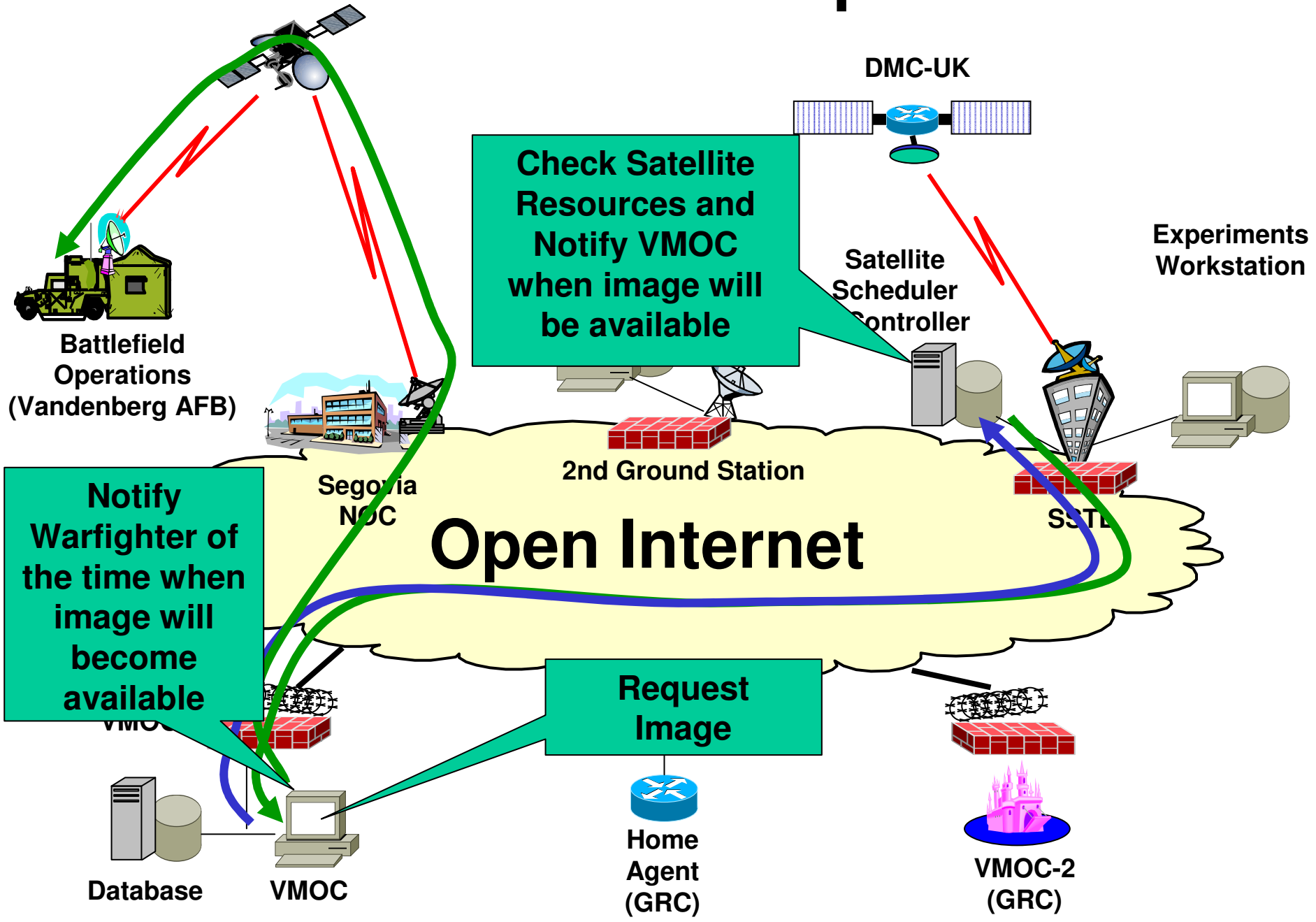
Data Flow

Mobile Router
Using Mobile-IPv4 and
Triangular Routing

Remote Request



Schedule Request



Command Satellite

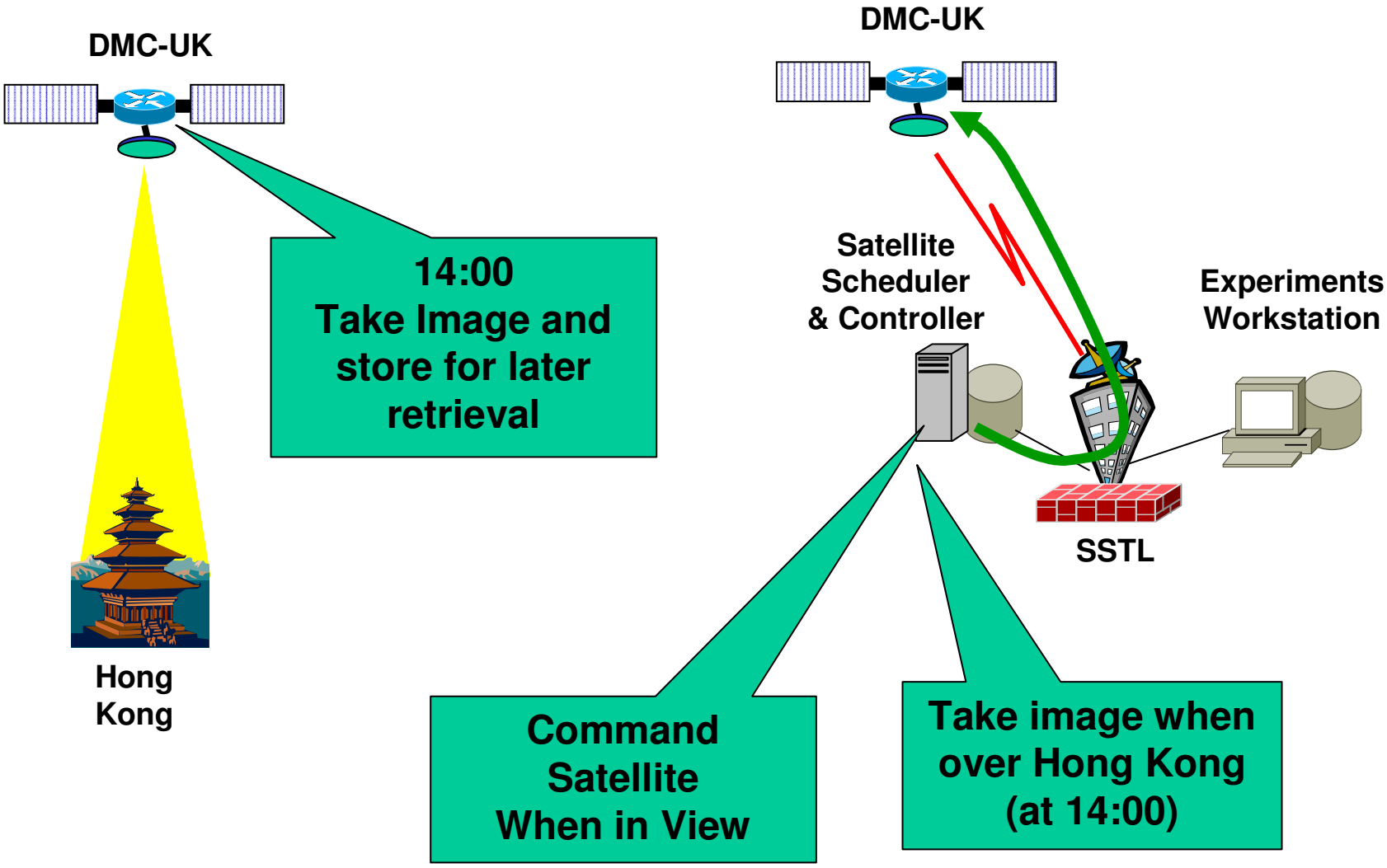
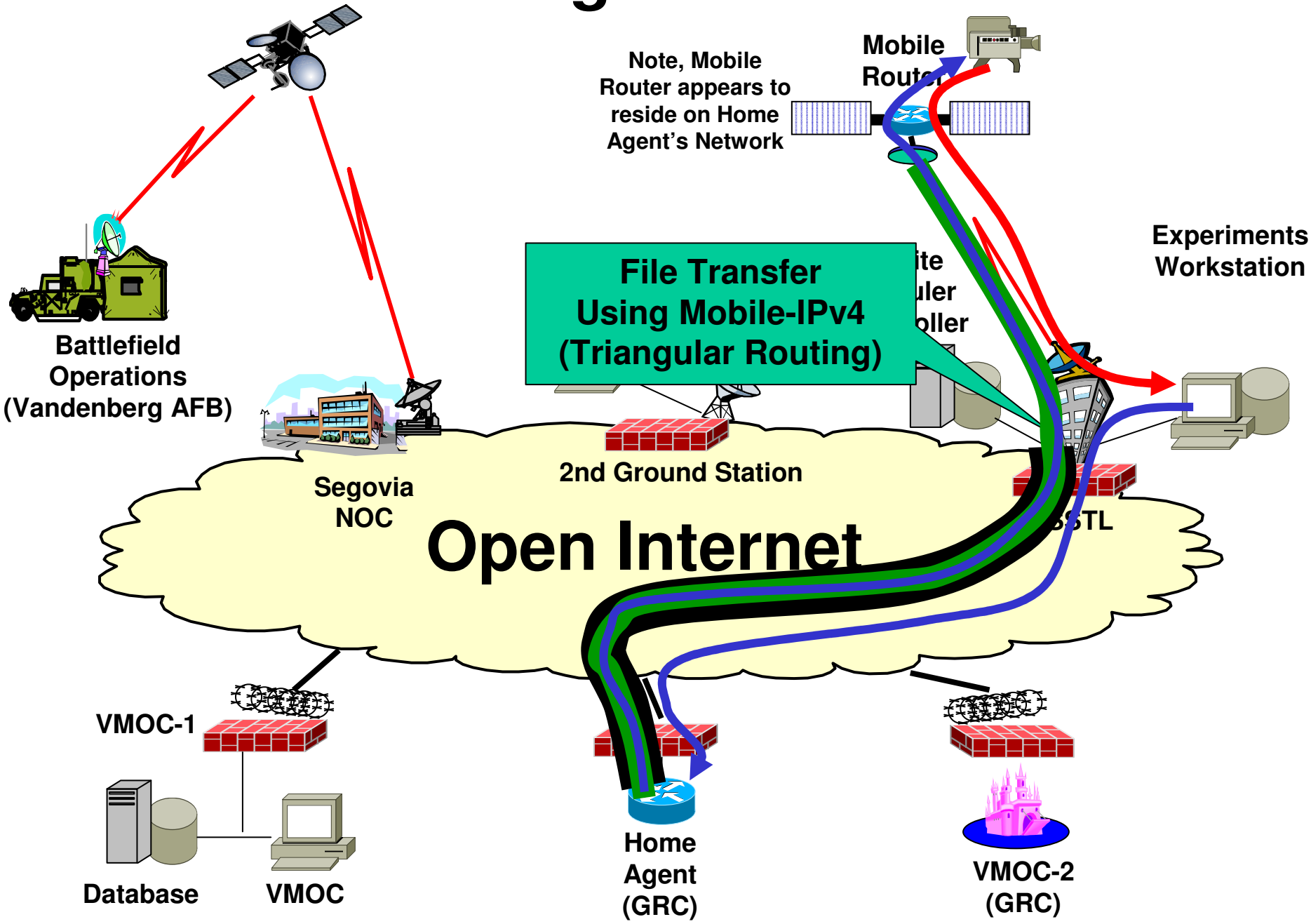
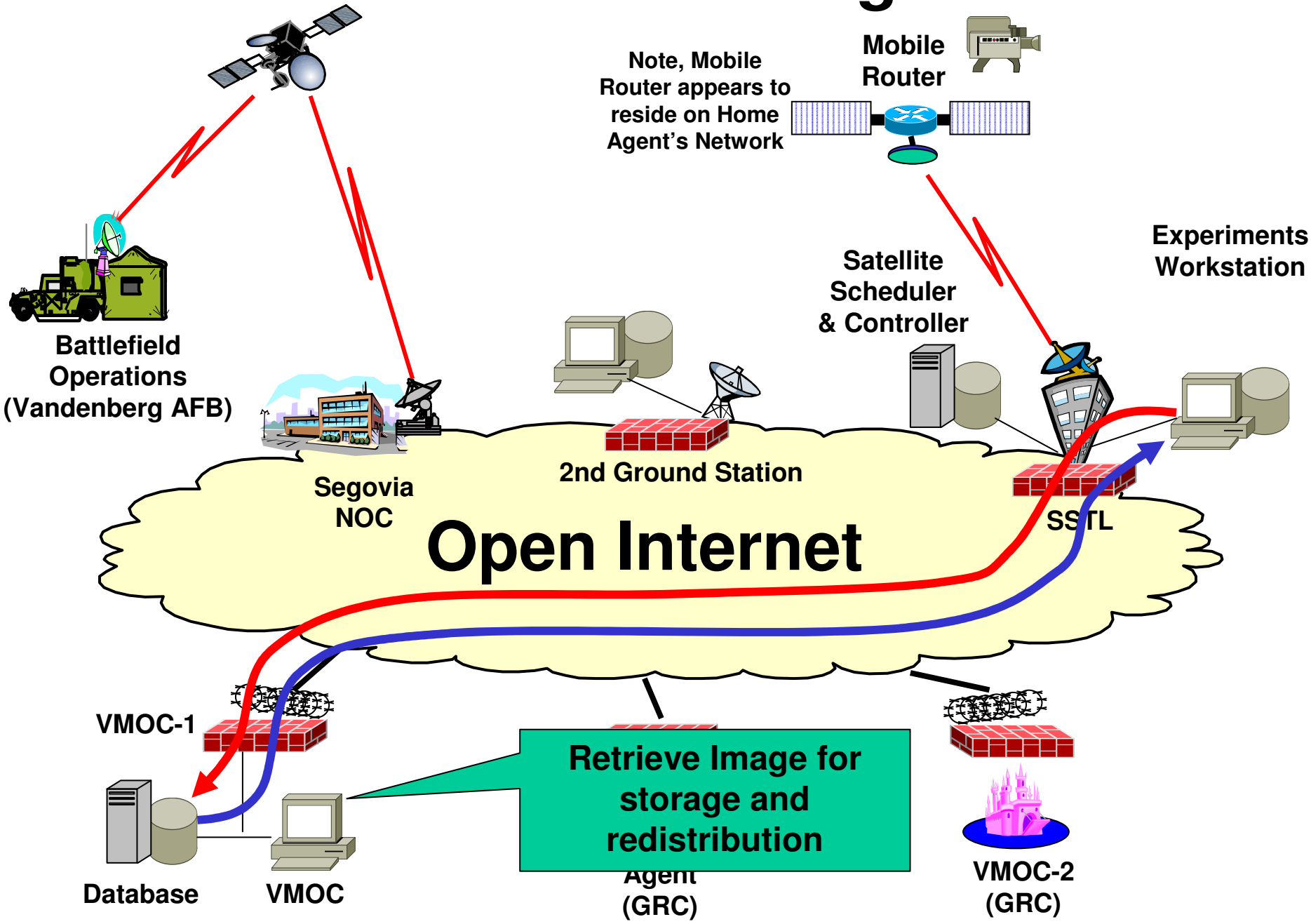


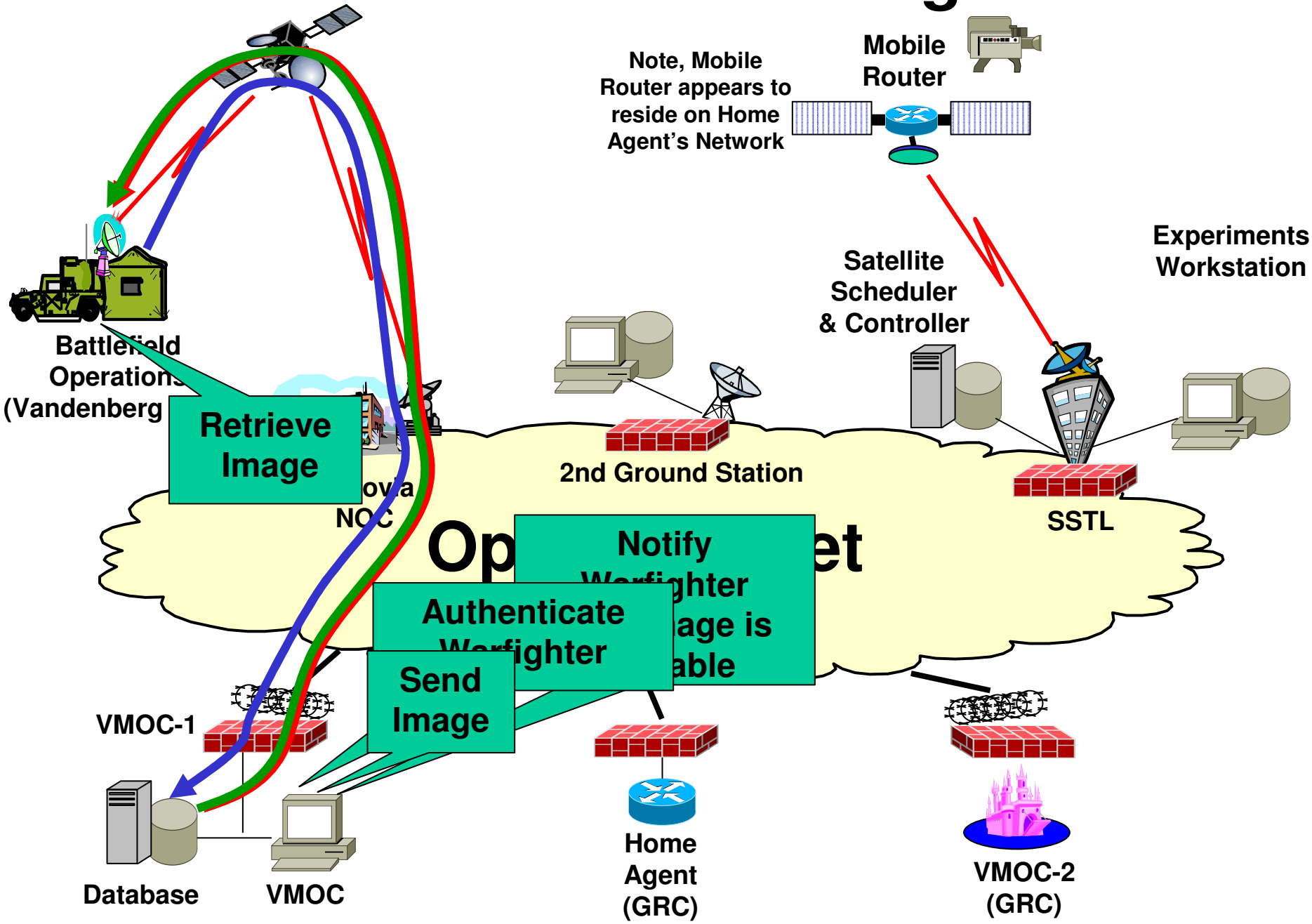
Image Transfer



Retrieve Image

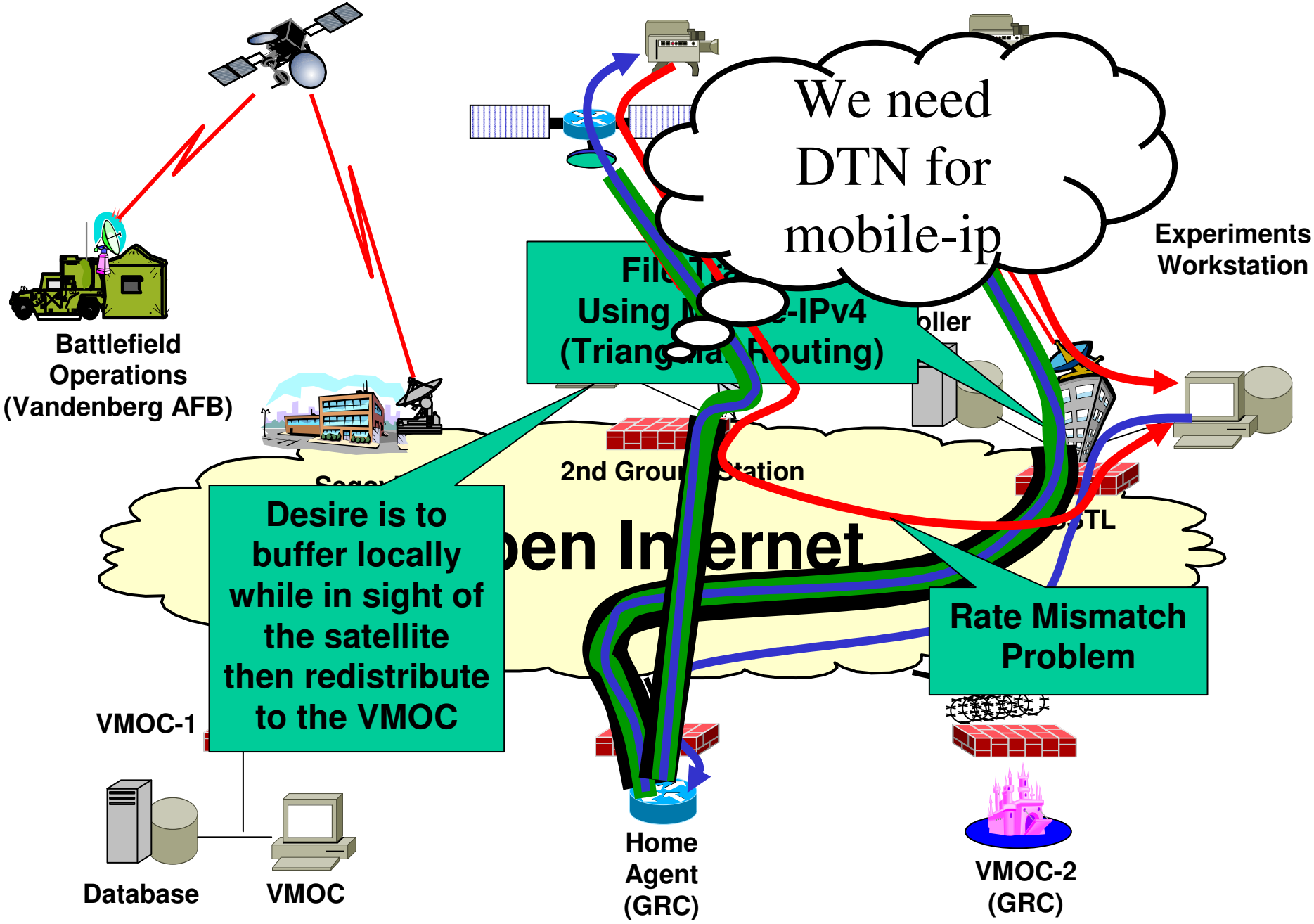


Redistribute Image

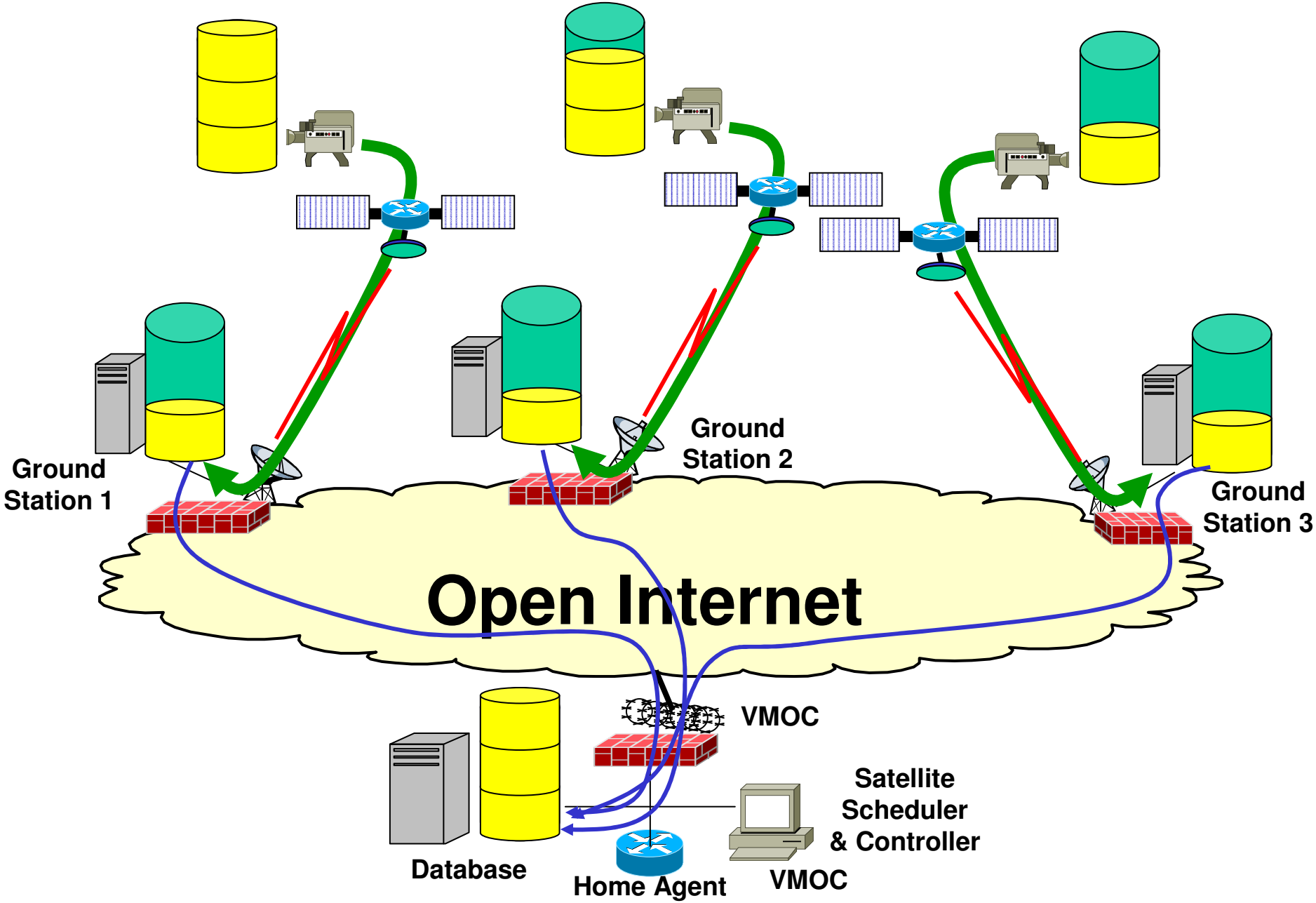


Delay/Disruption Tolerant Networking (DTN)

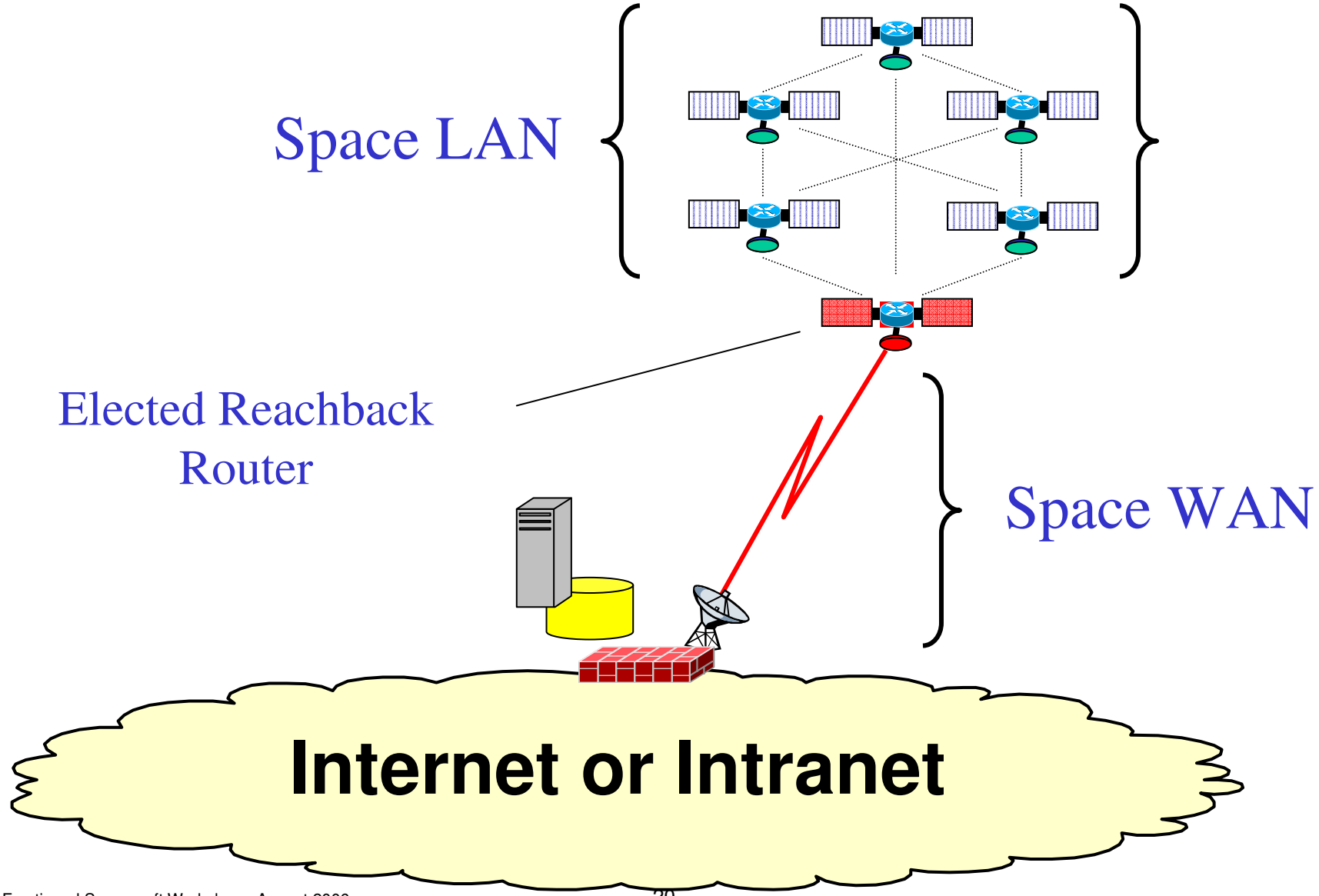
Image Transfer using 2 Ground Stations and Mobile-IP

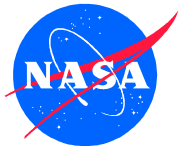


Ideal LARGE Image Transfer – Multiple Ground Stations (New DTN Capability – Application Not Yet Developed)



Fractioned Spacecraft





New Capabilities

- **Onboard router enables standard payloads to be placed on a local area network and be commanded and controlled using commercial standard Internet Protocols.**
- **VMOC's distributed architecture provides for survivability and rapid reconfiguration**
  - Needed in the battlefield, science, and business environments.
  - Enables remote secure command and control of spacecraft, sensors, and manned and unmanned aerial vehicles.
- By using commercial standard equipment and commercial standard protocols
  - Competition and standardization results in significant cost savings
  - Increases number of available assets
    - Ground and Space assets may be available from multiple commercial and government providers
    - Multiple assets results in more available contacts, greater contact time, and quicker response time
      - Use multiple ground stations enables large file transfers to take place over multiple ground stations' contact times
      - Allows system implementers tremendous flexibility in the design of the space system
      - Possible reduction of the downlink transmit rate and corresponding transmit power because of the increased contact time