Minimizing Mission Risks Through Emulating Space Communications Architectures

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18th Annual AIAA/USU Conference on Small Satellites
August 10, 2004

Introduction

- ***Goal:*** Provide an environment that allows researchers to emulate space missions and/or custom on-board components.
- Emulation Testbed under development by NASA/GRC
  - Called the Space Communications Emulation Facility (SCEF)
- End users can create scenarios via mission parameters:
  - Number of satellites
  - Number of instruments on the satellite
  - Orbital Parameters
  - Space environment characteristics (e.g., latency, BERs).
- Customize on-board satellite components
  - Research code can be added into the emulation system.
- Output can be shown textually and graphically
  - Visualize the satellite orbits via STK
  - Text output will show the throughput for the links
- Originally based on University of Kansas' Space Based Internet (SBI) software.

Motivation

- NASA is designing more complex missions with stringent communications and coordination requirements.
- Trend is to move from single satellite missions toward multiple satellite missions.
- Example Future Missions
  - Loosely coupled constellations
    - Little communication between each of the nodes.
    - Data will be assimilated on the ground.
  - Tightly coupled constellations
    - Communications and coordination is essential among nodes.
    - Requires inter-satellite communications.
  - NASA's new focus is on Moon and Mars missions.
- Current testbed focus is Low Earth Orbit (LEO) missions
  - Future development will include Lunar and Deep Space Missions.
- National Facility for use by Government, Universities and Industry.
  - Testbed resides at the Glenn Research Center (GRC)

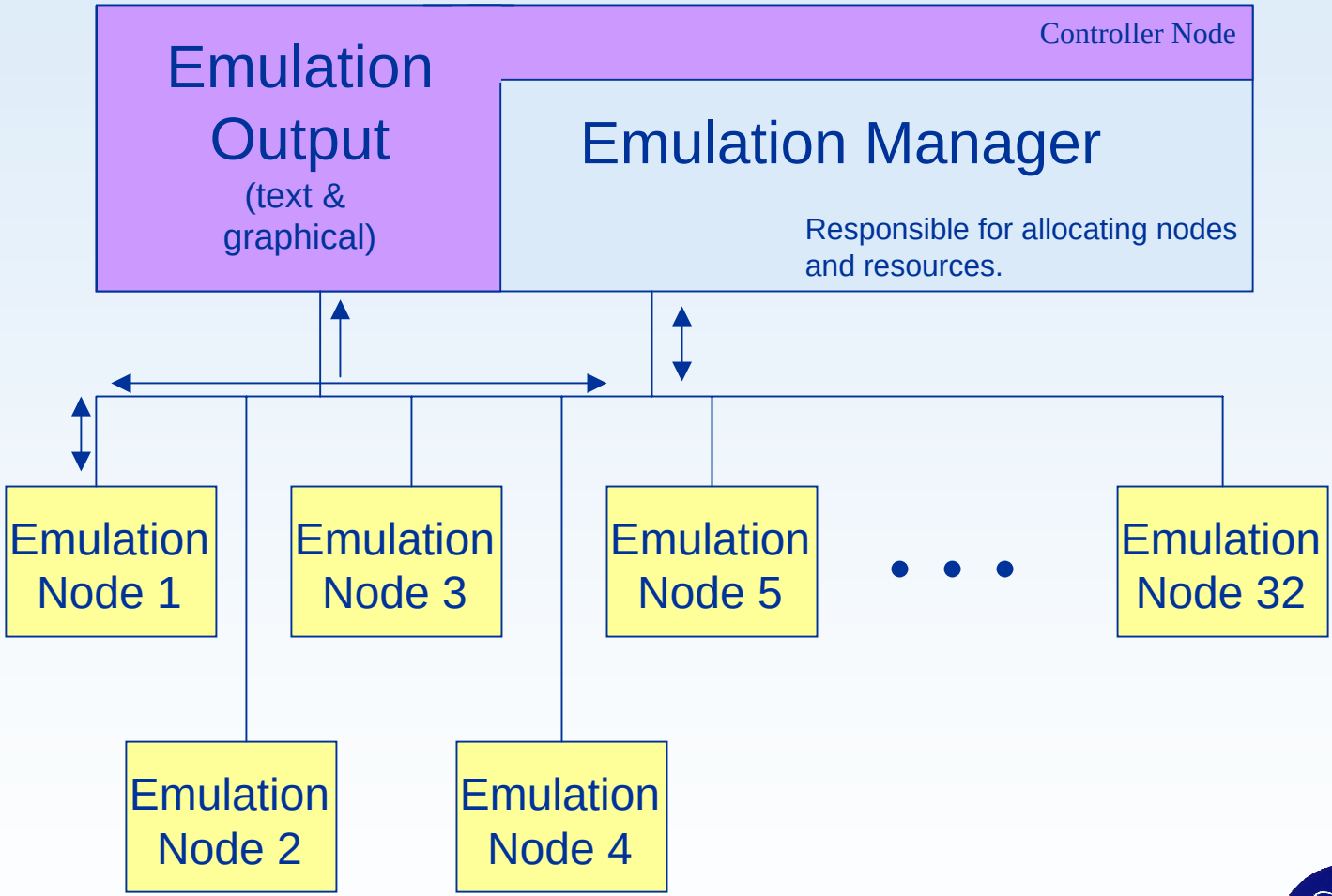
Minimizing Mission Risks

- Emulation systems can be powerful tools.
  - Determine the liabilities and validate requirements before a mission launches.
- Some of the risks include:
  - Communication Problems.
  - Satellites/Constellations with inaccurate orbit information.
  - Satellite functionality in deep space.
  - Using new components/technologies on satellites.
- SCEF can minimize the risks by:
  - Running the actual code/components in the environment.
  - Modeling satellites based on orbital information.
  - Modeling missions based on the space environment.

Advantages of SCEF

- Common Infrastructure
  - Projects can share results and data from the emulation.
  - Promotes more interaction between projects during design.
- Space Characteristics
  - Implements latency, Bit Error Rates (BERs), QoS, etc.
- Satellite Components
  - Provides default algorithms for C&DH, ACS, Instruments, on-board clock, etc.
- Cost Reduction
  - Multiple use of common software.
  - Evaluate missions and concepts during design.
- Simplified Integration using Common Tools
  - SCEF developed utilities for researchers home environment.

SCEF Architecture



SCEF Node Architecture

- Each node represents a satellite or ground station.
- Each component is modeled as a UNIX process.
  - Components are customizable.
  - Examples include Command and Data Handling (C&DH), Recorder, Simulated Instruments, On-Board Scheduler, Antenna and Control Systems
- Open standards
  - TCP/IP and Ethernet
  - UNIX Operating Systems
    - Standardized on RedHat Fedora Core I
- Third-party Software
  - Satellite Toolkit (STK) for orbit generation visualization.
  - NetSpec (U. of Kansas) for data throughput.

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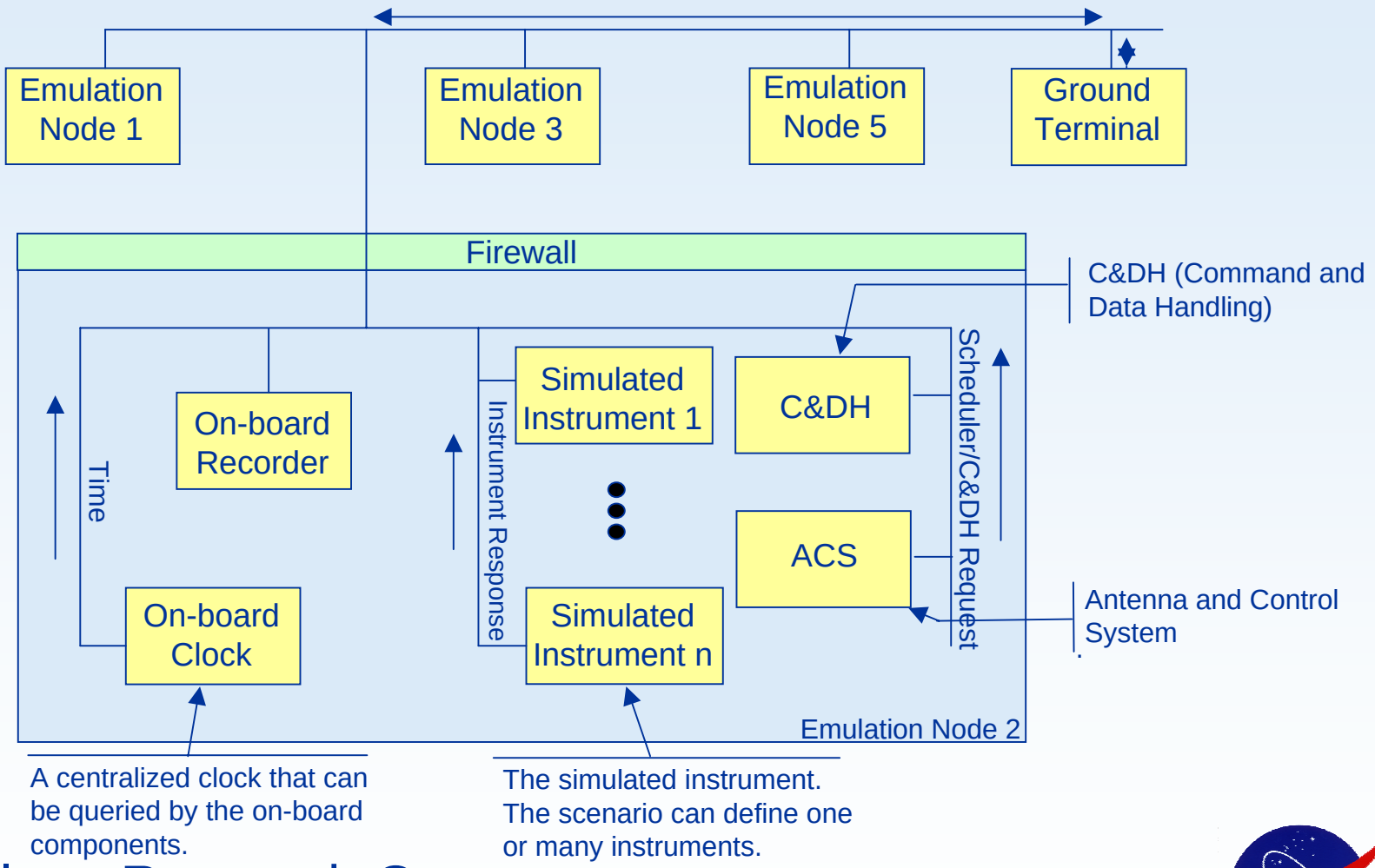

Hardware Architecture

- SCEF contains 32 nodes and 2 controllers.
  - Controller is responsible for starting the emulation and controlling the nodes.
- Controllers
  - Pentium III Class Machines (900 MHz)
  - 4 GB Memory
  - 234 GB On-line Storage
  - Gigabit Interfaces
- Nodes
  - Pentium IV Class Machines (3.06 GHz)
  - 1 GB Memory
  - 80 GB On-line Storage
  - Gigabit Interfaces

Example Scenarios for SCEF

- Mission Types
  - LEO-based, GEO-based
  - Constellations, Single Satellite Missions
- Research Algorithms
  - Scheduling Algorithms
  - Command and Data Handling (C&DH)
  - Antenna Control
- Security
  - Modifications to Firewalls and Routers
  - IP Sec, VPNs
- Communications
  - Modifications to the TCP/IP Stack
  - Throughput
- Networking Issues
  - Modifications to Routing Algorithms

Conclusions

- Researchers from academia, government and industry will have access to a satellite emulation facility for modeling satellite missions.
- SCEF has two objectives:
  - Models entire missions by defining scenarios that contain mission parameters.
  - Integrates custom code into the environment to test algorithms for certain aspects of the mission.
- Testbed uses open standards
  - Linux
  - TCP/IP
- Serves the need for future missions.
  - NASA is current designing complex future missions.
  - Designed for both Earth-centric and Deep Space missions.

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