Conceptual Design of a Satellite Bus Using Internet Technologies

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Goals for Bus Design

- **Goal:** Provide end-to-end connectively between satellites and ground systems using IP-based protocols.

- Architecture Design Objectives:
  - IP Based
  - Plug-and-Play Design
  - Modular
  - Reconfigurable/Extensible
  - Security
  - Data Integrity
  - Distributed Architecture
  - Networked Environment

- Compare and Validate to an Existing Mission
  - TRMM
Space Communications and Protocols

Protocols:
- IP-based
- TCP/IP
- CCSDS

“Protocols”:
- IP-based
- SCPS
- MDP
- CCSDS

Internet

Government Agencies

Universities

Data Users

Commercial

Government Owned

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Benefits of an IP-Based Architecture

• Simple Access to Platforms
  – Users will be able to use standard applications
  – Data can be downloaded to either government or commercial installations

• Integration of heterogeneous space platforms
  – Important for constellations

• Focus on new missions
  – The infrastructure will be maintained independently

• Real-time Data Delivery
  – Users can retrieve the data directly from the spacecraft

• Instrument Failover Scenario
  – Eliminates the need for cross-strapping
  – When one instrument fails, another can be brought on-line dynamically
Generic IP-Based Satellite Bus Architecture

- ACS Subsystem
- HK Subsystem
- Additional Subsystem
- Instrument Subsystem 1
- Instrument Subsystem 2
- Instrument Subsystem N
- Additional Subsystem 1
- Additional Subsystem N

- Emergency_Commands
- Commands
- Data
- Ancillary_Data
- Recorder_Subnet
- Recorder
- Satellite Status & Maintenance Subnet
- Instrument Subnet
- Additional Subnet

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Validating the Design

• Validate the design by comparing against an existing mission.
  – The goal is to determine whether the design can be reconfigured to support the current set of instruments.

• Validate against the Tropical Rainfall Measuring Mission (TRMM)
  – US-Japanese joint mission
  – Launched in 1997

• Reasons for selecting TRMM:
  – Familiarity with Mission and Data Processing
  – Complement of Five (5) Instruments
    • TMI, PR, VIRS
    • CERES, LIS
  – At launch, TRMM was the highest data rate mission for NASA
    • New design has to maintain the data rates.
  – Communications Infrastructure contains typical space components.
    • 1773 Busses
    • Communications using CCSDS
Did the design meet the goals?

- **IP-Based**
  - Bus contains IP instruments connected to an Ethernet backbone.
    - Protocol will be TCP/IP
- **Plug-and-Play Design**
  - Instruments will plug directly into the backbone.
  - Instruments will dynamically configure themselves.
- **Modular**
  - The bus is divided into separate subnets.
    - Reduction of Data Traffic by keeping the type of traffic on its own subnet.
  - Instruments can collect, store, and transmit the data.
- **Reconfigurable/Extensible**
  - The design can be flexible to meet the requirements of the project.
    - Number of subnets or number of instruments on a subnet.
  - Components of the architecture can also be eliminated.
Did the design meet the goals?

• Security
  – Typical Internet Security measures can be applied
    • Firewall Protection – provides a degree of security
    • VPNs provides authentication and encryption of data.
  – Traffic will only be transmitted on the appropriate subnet.

• Data Integrity
  – Data will be TCP/IP packets which provides data integrity checks
    • May consider additional application checksums for sensitive data.
  – Sensitive data can be encrypted.

• Distributed Architecture
  – Eliminated ACS and S/C Processor
    • Primary function is Bus Controller
  – Distributed memory through the Bus
    • IP-Based Components contain memory, processors and buffers.
Did the design meet the goals?

- **Network Environment**
  - **Failover Scenario.**
    - If a primary instrument fails, it can be replaced by the secondary instrument
    - Secondary instrument will retrieve IP addresses dynamically
  - **Typical Networking Services**
    - DHCP
    - Routers
    - Firewalls
Future Work

• Complete a detail design of the bus architecture
  – Look at different designs and implementations
  – Flush out details with the individual components
  – Requires multi-disciplines to complete the task
  – Validate the designs with spacecraft bus designers

• Extend to different and more complex missions
  – Constellations
    • Communication between mother and daughter ships
  – Space Networks

• Emulate the architectures
  – Determine if one configuration is better than another?
  – Validate both normal and anomalous scenarios.

• Componentize the architecture
  – Determine the building blocks
  – Allow projects to “simply” build the communications infrastructure

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Publications:
“LEO Satellite IP Communications Concept and Design”
“Conceptual Design of a Satellite Bus Using Internet Technologies”