AN INSTRUMENT-CENTRIC MODULAR AND DISTRIBUTED AVIONICS ARCHITECTURE

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Overview

- Background
- Motivation
- What we wish to accomplish.
- How we plan to implement.
- Concerns/Implications
- Your thoughts?

Background

- Modular and Distributed Avionics Architecture has been championed by the industry for years.
  - Reduce functional complexity
  - Reduce mass/power/cost
  - Adapt common system buses, such as MIL-1553B, 1394b, or SpaceWire to tie the subsystems together.
- Meanwhile, science objectives drive instrument developments, which then drive the evolution of avionics suites.
  - Better landing capabilities -> lower latency
  - Higher resolution images -> higher data throughput
  - More instruments -> more interfaces
- Command and Data Handling (CDH) continues to act in a central role in the avionics evolution.
  - Desire to keep design legacy.
  - Challenges in adding new interface: hardware, software, testing, verification, integration.

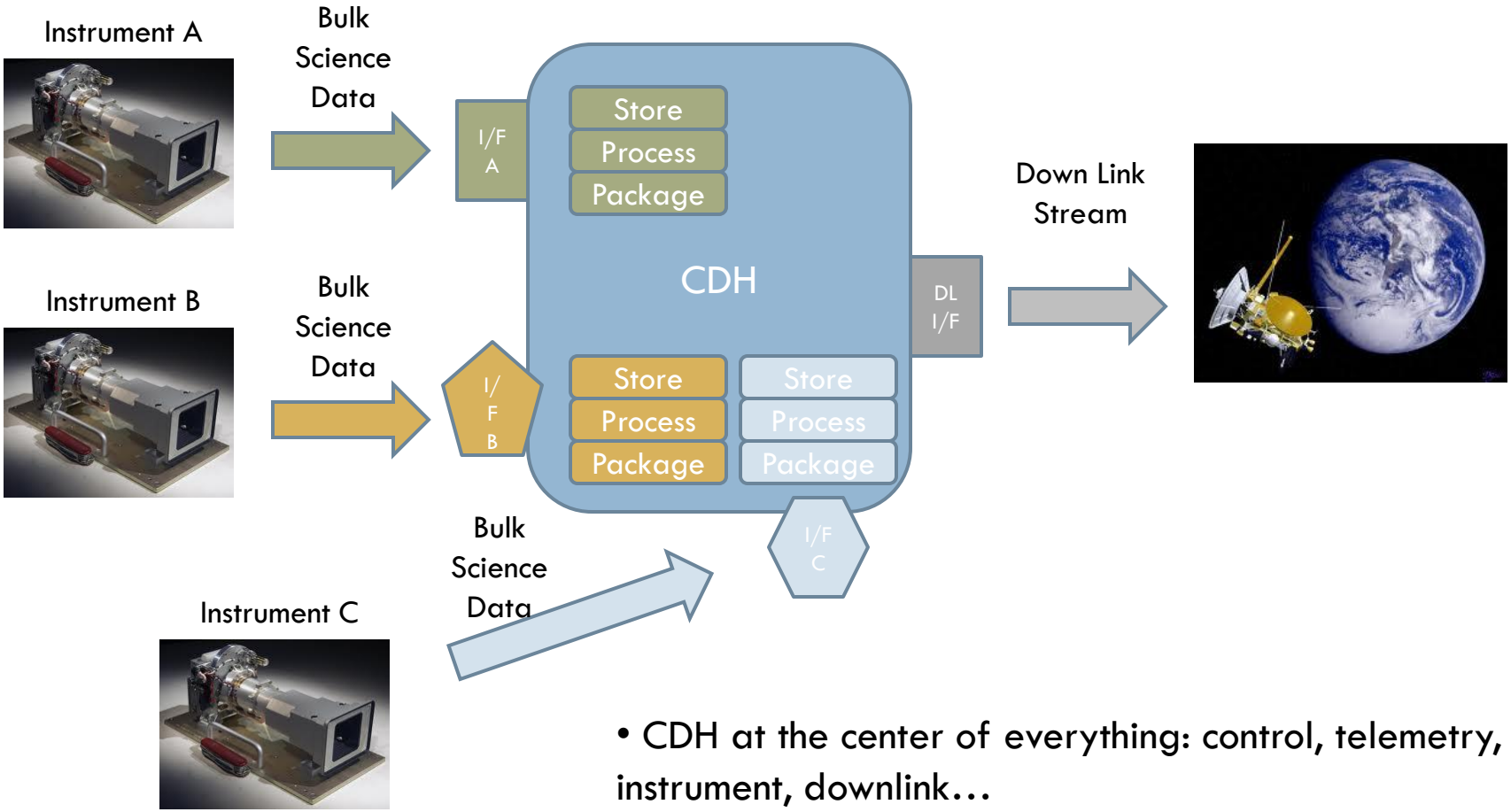
Recent Mars Missions

Mission	Lauch Year	Number of Instruments	Mass (kg)	Solar Power (W)
Pathfinder	1996	3	10.6	16
Polar Lander	1999	5	338	500
MER	2003	6	174	140
Phoenix	2007	6	350	400
MSL	2011	11	900	N/A

Motivation

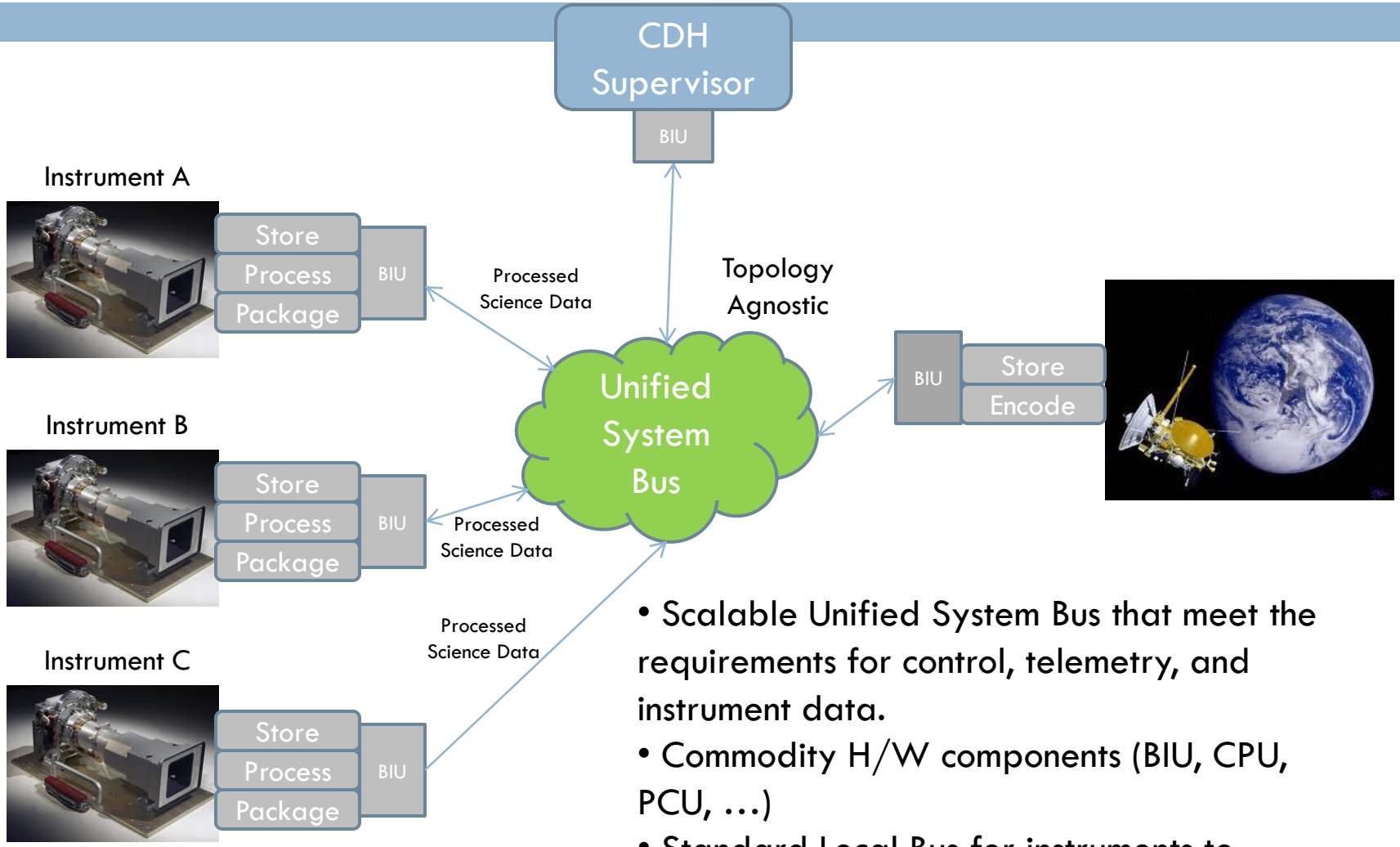
- Typical process to send science data to earth:
  - Transmit bulk science data to CDH to store in solid-state memory.
  - CDH retrieves bulk data to process.
  - Processed data is packaged as downlink frames.
  - Downlink frames are encoded and sent to radio.
- The bulk of this process depend on the data handling capacity of the CDH:
  - Data need to move in and out of CDH.
  - Processing power shared by all instruments.
  - Total peak instrument throughput must not exceed CDH's capacity.
- Need to get around the bottleneck of monolithic CDH.

Interfacing with Monolithic CDH



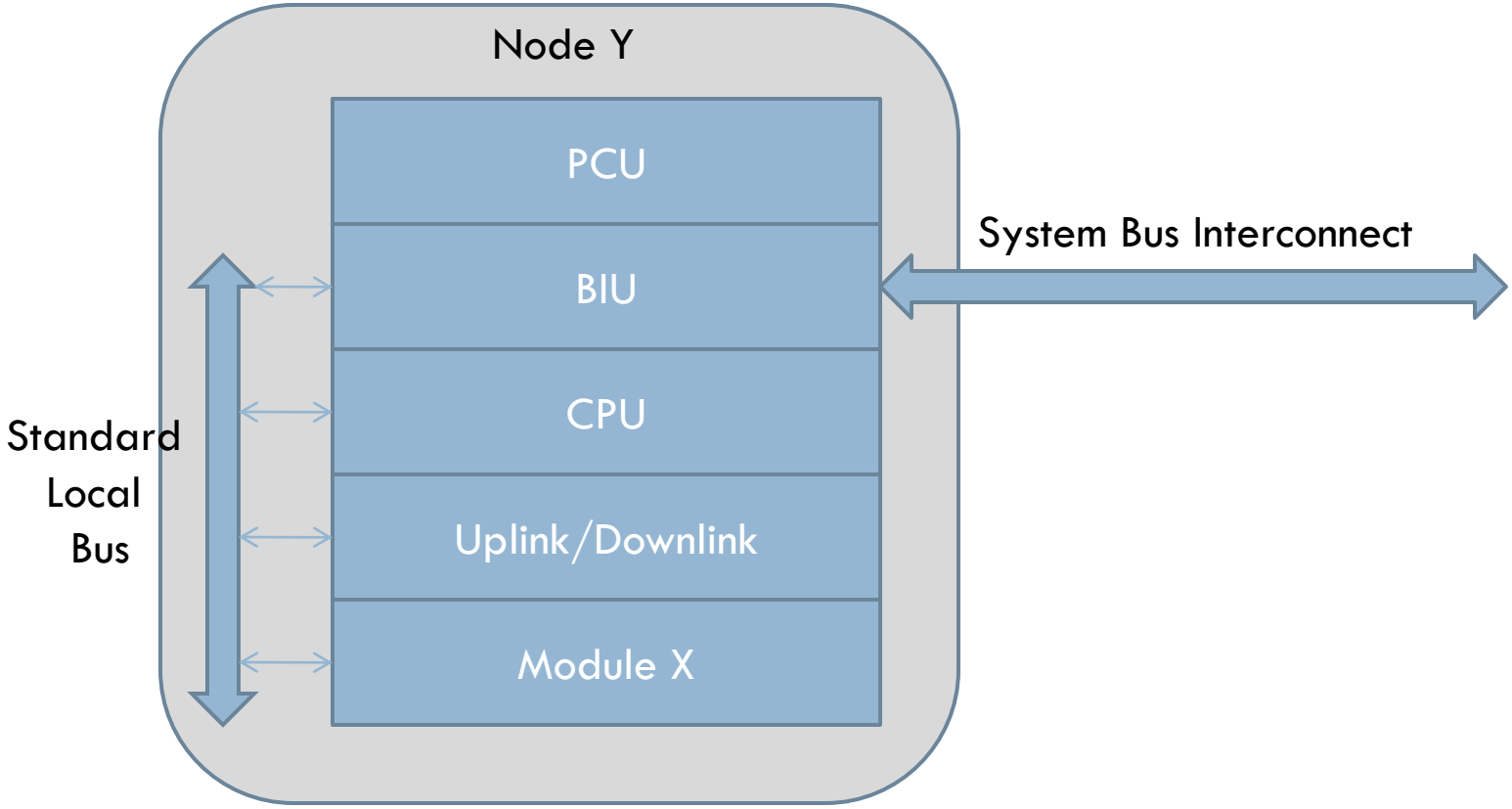
- CDH at the center of everything: control, telemetry, instrument, downlink…
- Instruments each have its own optimized interface.
- How to add instrument data handling capacity?

True Modular Distributed Avionics



- Scalable Unified System Bus that meet the requirements for control, telemetry, and instrument data.
- Commodity H/W components (BIU, CPU, PCU, …)
- Standard Local Bus for instruments to interface with local CPU/Storage modules.

Commodity H/W Components



Design Implications

- CDH acts as a supervisor or orchestrator.
- Instruments get localized processing power and storage via standardized local bus. Additional processing power via offloading.
- Downlink can be standalone with own BIU and encoding processor.
- System software is decentralized.
  - Robust concurrent/distributed programming model.
  - Alternatively, instrument firmware with shared libraries.

Verification, Integration, and Testing

- All standardized components are available as pre-validated commodities. Less testing before integration.
- Local and system bus compliance tested with standard test equipments and plans.
- More “decentralized” testing (analogy: testing 2 10-bit counters versus 1 20-bit counter).
- Subsystem boxes are integrated by putting commodity components in a common chassis.
- System-level integration and testing focus more on instrument and flight software.

Efficiency/Cost Considerations

- Monolithic systems, tailored for specific instrument combinations, are generally more efficient than distributed systems.
- As monolithic systems evolve, the efficiency is eroded.
- Modular Distributed systems with standardized components are better for incremental design evolution.
  - Less “band-aids”, more manageable complexity.
  - Truly reusable test and integration environment.
  - CDH is no longer the bottleneck of data handling capabilities.
  - Less Non-Recurring Engineering (NRE) cost.

Conclusion

- We have presented an instrument-centric avionics architecture that will scale easier than a monolithic architecture.
- There is obviously a lot of work to do.
- What are your thoughts and ideas?

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