Logic Model Checking of the Delay Tolerant Networking's Bundling Protocol

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2010 Workshop on Spacecraft Flight Software
8 December 2010

NASA ESMD (ESAS/6G) Intelligent Software Design Project

Outline

- Context
- DTN Bundling Protocol Overview
- BP Protocol Verification
- ION Implementation Verification
- Conclusions

Context

- Interoperability between N subsystems, based on a defined interface protocol, may require as many a N^2 pairwise verifications.
  - Can logic model checking be applied effectively?
  - Does logic model checking offer advantages beyond what a comprehensive protocol test suite would?
- Task: Identify a protocol w/ multiple implementations; build and apply a logic model

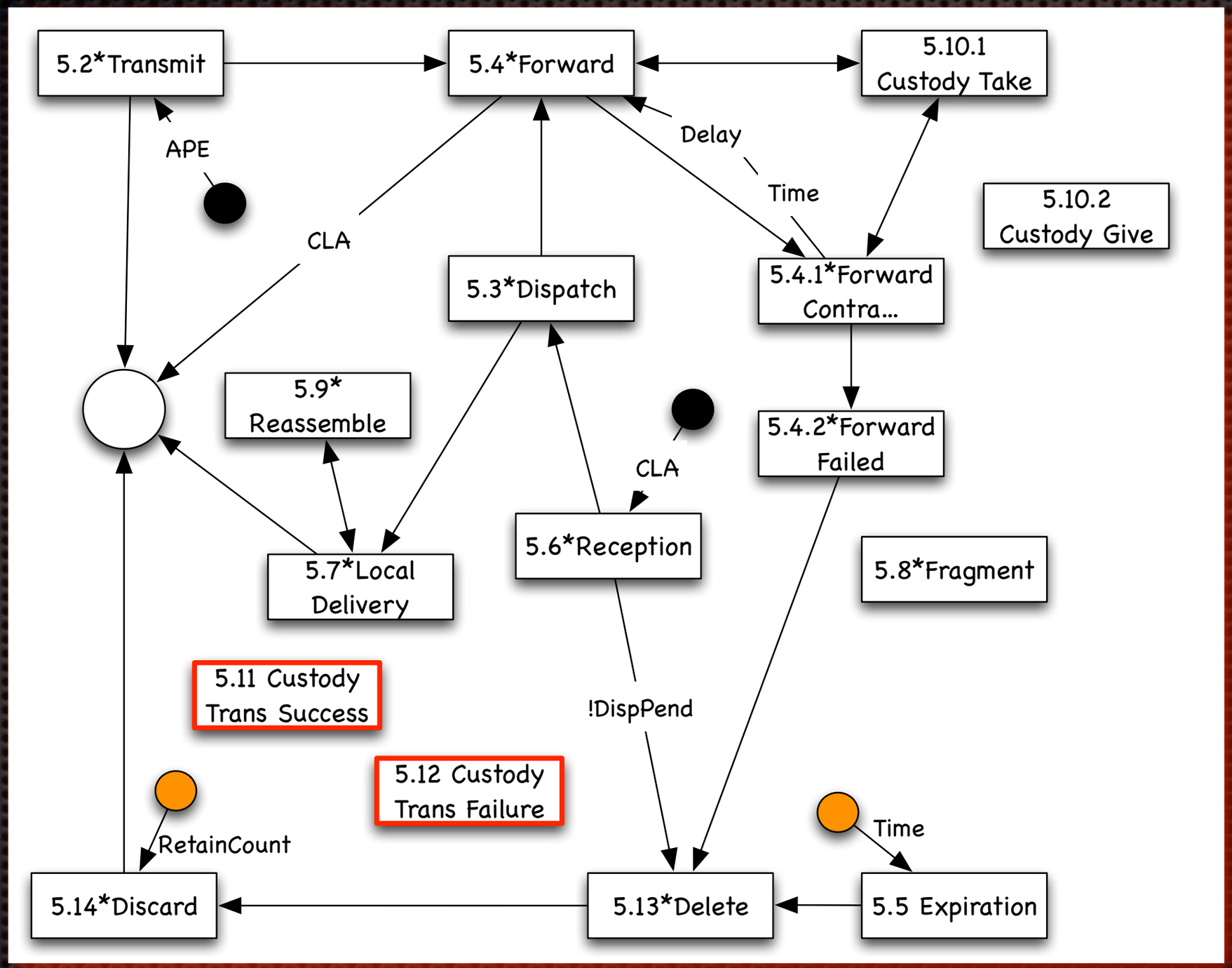
DTN Bundling Protocol

- The DTN Bundling Protocol reliably routes and forwards ‘application data units’ between defined endpoints across a delay tolerant network.
- Bundling Protocol Characteristics:
  - Well-Defined - based on RFC 5050
  - Multiple Implementations - Notably ION, at JPL
  - Small Size - logic model is computationally feasible
  - Expert Consultant - BP co-author at JPL

DTN Bundling Protocol

- Key Capabilities:
  - custody-based retransmission
  - cope with intermittent connectivity
  - exploit scheduled, predicted and opportunistic connectivity
  - late binding of overlay network endpoints.
- Logic model focuses on the first two

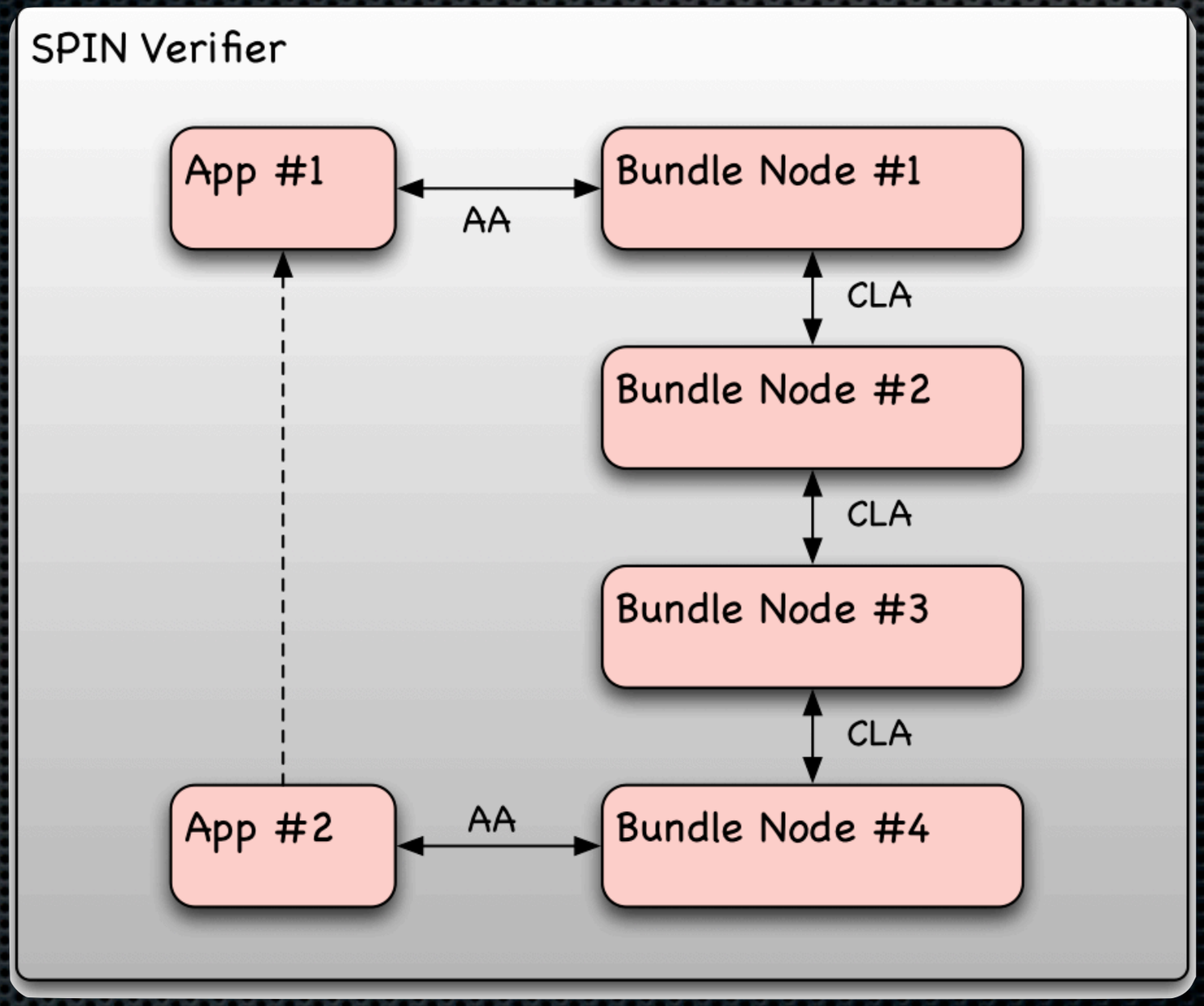
DTN Bundling Protocol



DTN Bundling Protocol

- Correctness Claims
  - ADU Receipt w/o Errors: In the absense of errors, an ADU that is transmitted (by the source EID) must always be received (by the target EID)
  - ADU Accountability: An ADU transmitted with a request for one or more types of ‘bundle status reports’ shall eventually receive each and every one of the requested status reports.

BP Logic Model Architecture



BP Logic Model Results

- Both correctness claims were partially verified.
  - The SPIN verification runs did not fail but could not run to completion - owing to computational resource constraints.
    - SWARM technology applied; no errors identified.

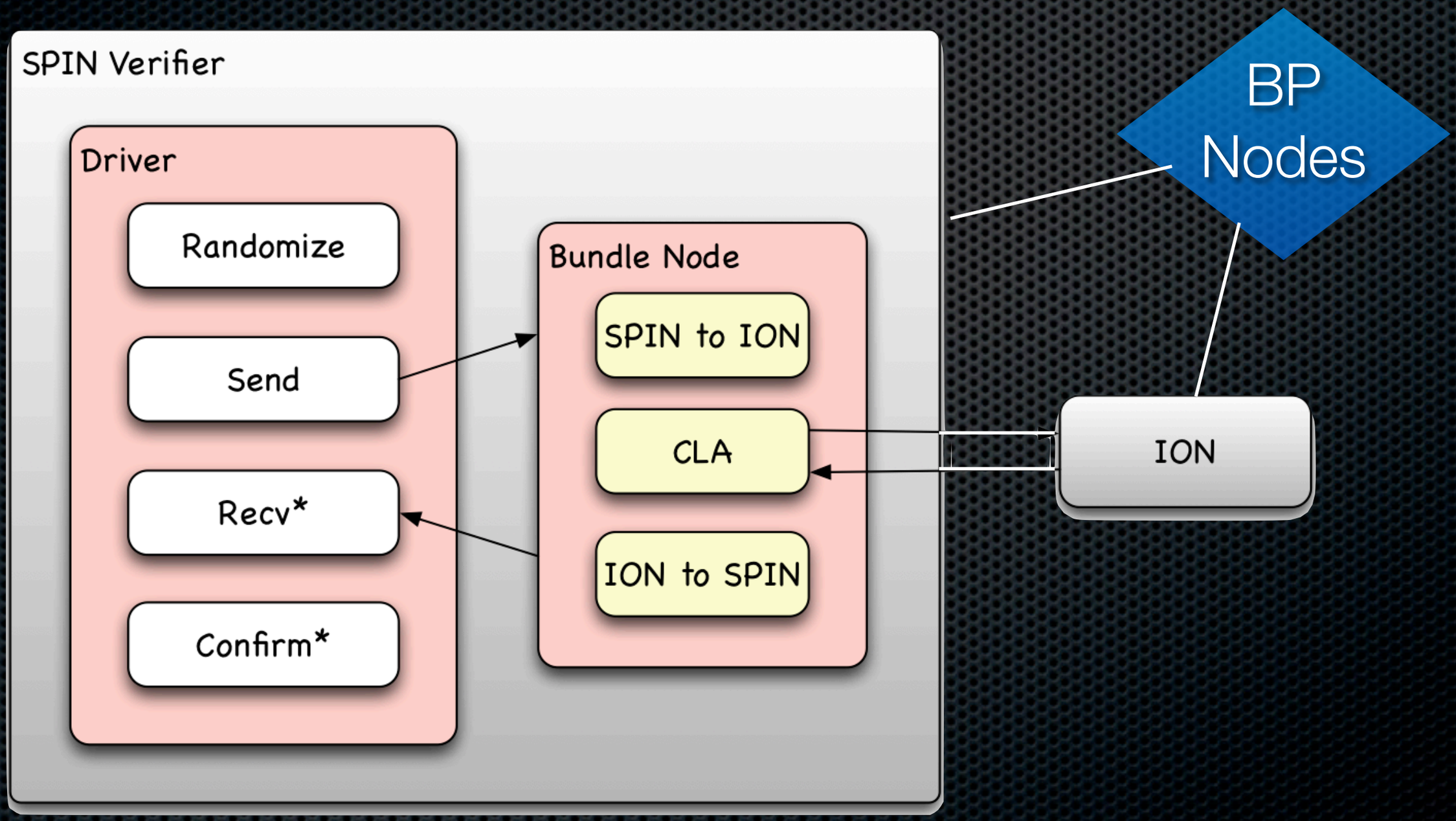
ION - A BP Implementation

- ION - Interplanetary Overlay Network - Designed specifically for interplanetary communication:
  - Slow, asymmetric, over-subscribed links
  - Limited computational resources
  - High reliability; predictable performance

ION Logic Model

- Primary Constraint: The internal state of a networking node (ION implementing BP) is not accessible to the SPIN verifier.
  - Implications:
    - SPIN cannot backtrack through ION's state
    - The BP behavior must appear to be atomic.

ION Logic Model Architecture



ION Logic Model Results

- For the two BP correctness claims:
  - ADU Receipt w/o Errors: Pending
  - ADU Accountability: Fully verified

Conclusions

- A viable N subsystem intercommunication verification process is:
  - Identify a protocol; identify correctness claims
  - Develop a ‘comprehensive test case’ logic modeling architecture supporting fully randomized test state.
  - Test the protocol (if modeled); test implementations.