

SmartSSR DTN Router

*2010 Workshop on Spacecraft Flight Software
FSW-10, 12/8/2010*

NOT SUBJECT TO EXPORT (ITAR) CONTROL

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Delay Tolerant Networking

- **Space communications must tolerate intermittent connectivity and high latency:**
 - **One-way trip times, at the speed of light, from the Earth to the moon incurs a delay of around 1.7 seconds; one-way trip times to Mars incur delays on the order of minutes to tens of minutes.**
 - **High bit error rate due to solar radiation**
 - **Celestial bodies are in constant motion, which can block the required line-of-sight between transmit and receive antennas, resulting in links that at best are only intermittently connected.**
- ***Store-and-forward* techniques can be used to compensate for intermittent link connectivity and high latency.**
- **Delay tolerant networking (DTN) is a set of protocols that act together to enable a standardized method of performing store and forward communications.**

Source: NASA ISS DTN Experiment Fact Sheet http://www.nasa.gov/mission_pages/station/research/experiments/DTN.html

ION – Interplanetary Overlay Network

- **Standard DTN protocols have been defined:**
 - **Bundle Protocol (BP) DTN Routing**
 - **Licklider (Long-haul) Transmission Protocol (LTP)**
- **Several applications have made use of these protocols:**
 - **CCSDS File Delivery Protocol (CFDP)**
 - **Asynchronous Message Service (AMS)**
- **The Interplanetary Overlay Network (ION) is an implementation of the DTN protocols:**
 - **Product of the Jet Propulsion Laboratory**
 - **Supports high-speed, small-footprint deployment of DTN in embedded systems (i.e. ROBOTIC SPACECRAFT!)**
 - **Runs on various Linux platforms, OS/X, FreeBSD, Solaris, VxWorks, and RTEMS.**
 - **ION includes the Interplanetary Communication Infrastructure (ICI) facility for simple embedded object database management system, efficient management of shared memory segments, and a zero-copy objects system.**
 - **Open source from the [Open Channel Foundation](http://www.openchannel.org/).**

Source: <http://www.dtnrg.org/wiki/Code>

DTN Router on APL's SmartSSR

- In a Delay Tolerant Network, data is incrementally moved and stored throughout the network in advance of establishing a complete end-to-end route from sender to receiver.
- The DTN “store and forward” approach suggests that routers should be coupled with the capability to store large amounts of data.
- The SmartSSR is a component that combines a large NAND flash array and FPGA controller with a general purpose processor that provides data recorder functions to the other components of a spacecraft.
- Integrate the ION software on the SmartSSR to create a DTN router with large capacity store and forward capability.

Value Proposition

Advance DTN Readiness by placing ION on the SmartSSR to provide a single component DTN solution that can be easily deployed in a variety of spacecraft architectures.

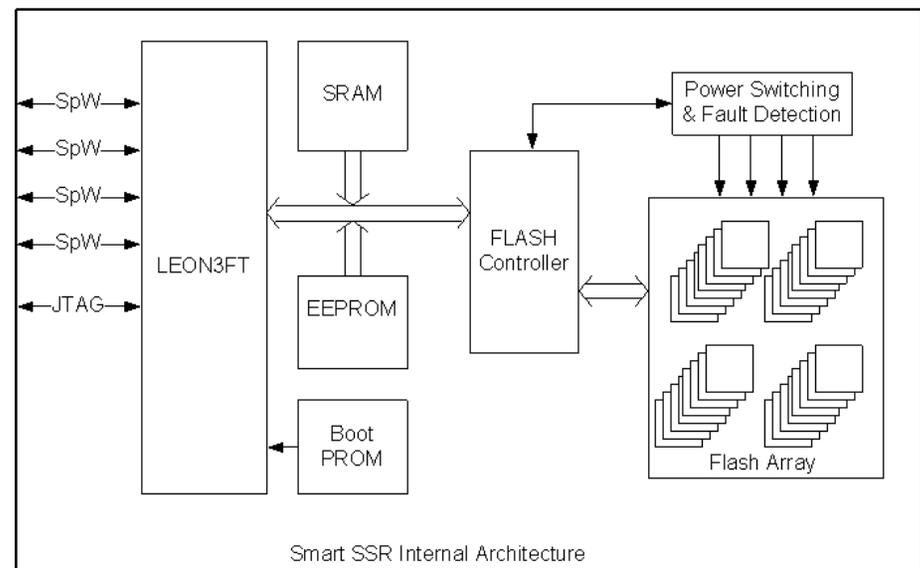
- **The SmartSSR DTN Router will provide multiple related functions within the spacecraft:**
 - **High Capacity, High Performance Solid State Data Recorder**
 - **Local Area Network File System Server**
 - **CFDP File Transfers and Management (ION)**
 - **Remote AMS Gateway (ION)**
 - **DTN (Bundle Protocol) Routing (ION)**
 - **Local Area SpaceWire Router**
 - **Telemetry Framing**

The SmartSSR

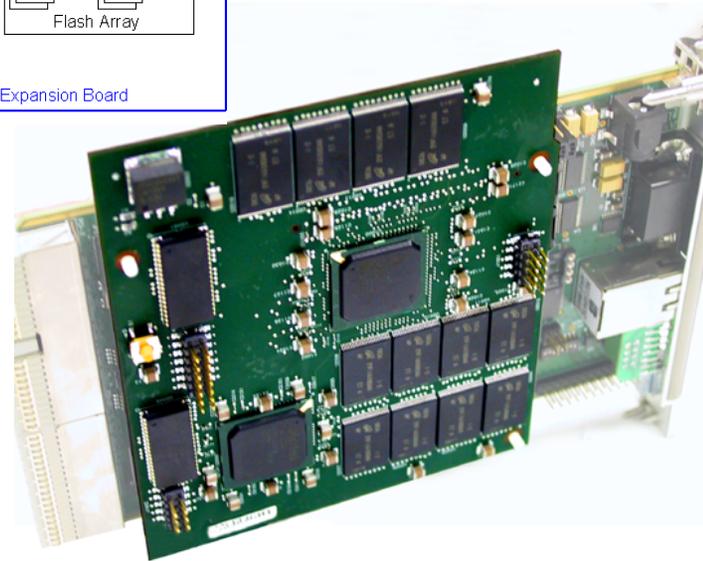
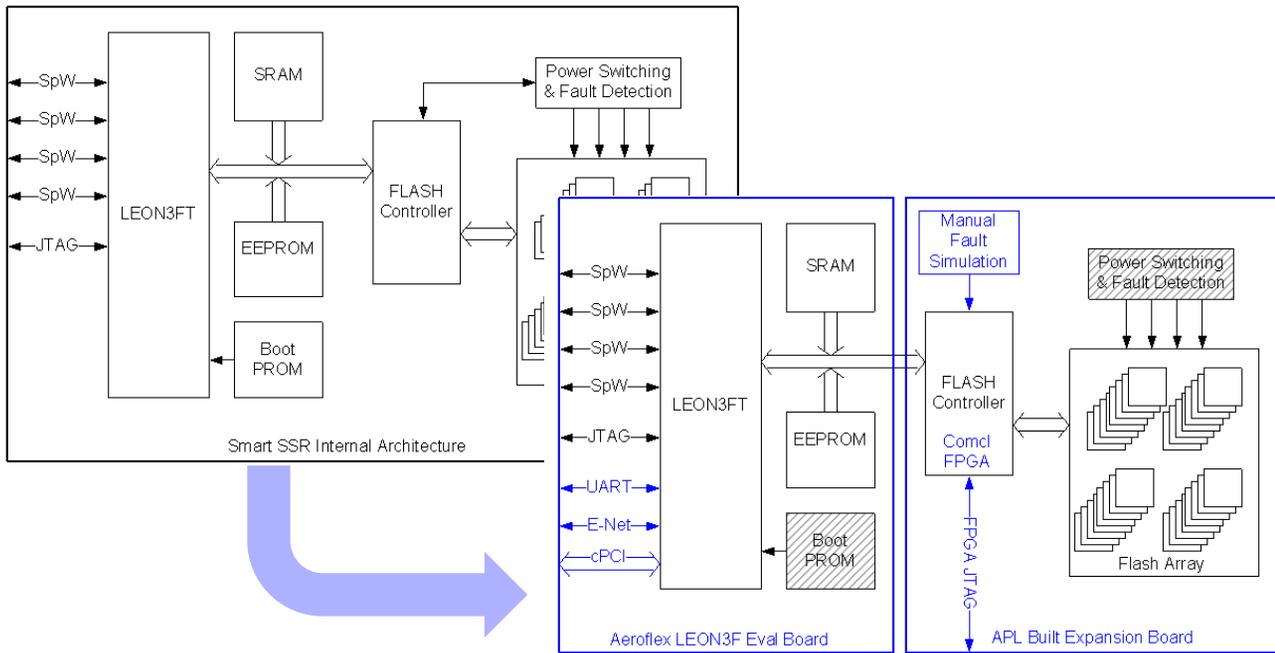
- **IRAD effort to develop a general SSR capability that offloads the details of flash memory, file system management and CFDP control from the main processor.**
 - **Enables a distributed spacecraft architecture based on inexpensive, flexible and low-power processors.**
 - **Enables low power, redundant configurations, for instance recording to two SSRs while only one side of the spacecraft avionics is fully powered.**
 - **Enables flexible data routing allowing more efficient, reliable data paths from instrument to recorder.**
- **Performance Objectives:**
 - **Large Capacity (1 Terabit)**
 - **High Speed Data Capture (100 Mbit/sec)**
- **File system interface and DTN/CFDP simplifies mission operations and expedites software development.**
- **DTN enables automated relay mission operations and participation in the Interplanetary Internet.**

SmartSSR Hardware Components

- **LEON3FT Processor**
 - SPARC V8 Instruction Set / Architecture
 - Fault Tolerant (FT)
 - Scalable over a wide range of speeds/power ratings
 - Flexible:
 - Several RAD Hard ASIC “system on a chip” packages, including SpaceWire interfaces
 - Mix-n-match “IP” implemented in FPGA
- **High Density NAND Flash Array**
 - Nonvolatile, Low Power
 - High Density / Low Mass

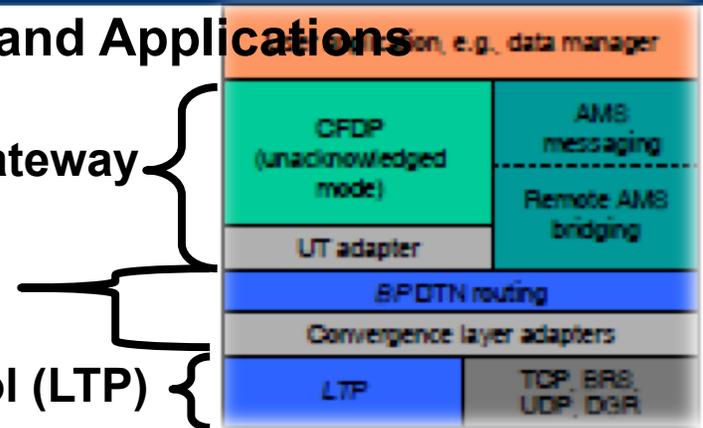


SmartSSR Prototype Test Bed

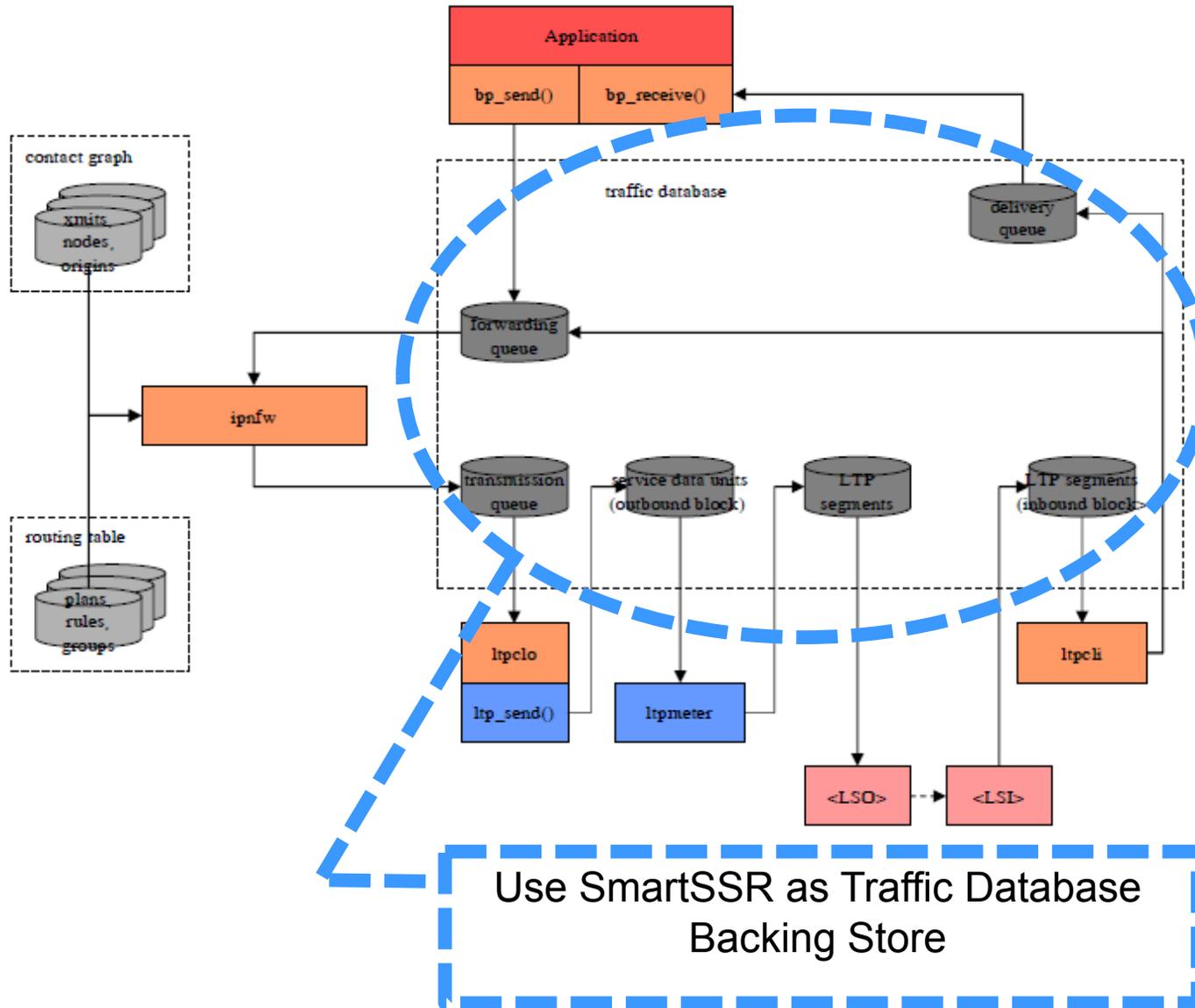


SmartSSR Software Components

- ION Implementation of the DTN Protocols and Applications
 - CFDP (Unacknowledged) – Remote AMS Gateway
 - Bundle Protocol (BP) DTN Routing
 - Licklider (Long-haul) Transmission Protocol (LTP)
- RTEMS Real Time Operating System
- YAFFS-3 (aka APL Flash File System)
 - Journaling (Logging) File System – Simplicity and Reliability
 - Specifically Designed for NAND Flash, will accommodate other memory technologies
 - Specifically Designed for Embedded Systems
 - Performance Improvements Made to YAFFS2 for Large Devices
 - Functional / Performance Improvements Made to YAFFS2 for Space Operations



Approach



Objectives

- **Working demonstration of the ION software running on a SmartSSR test bed with SpaceWire interfaces.**
- **Any modifications or extensions made to the ION software will be proposed for inclusion and distribution by the ION Working Group.**