Lunar Internetworking with GNU Radio

Integrating LNIS with GNU Radio for Advanced Lunar Communications

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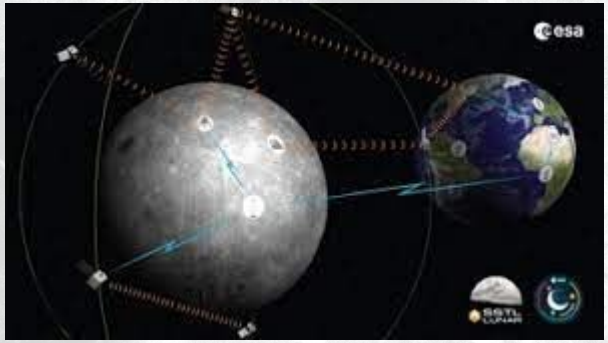
GRCon23 TEMPE, ARIZONA

Chris Donohue - Engineer - MTI Systems

- MTI Systems:
  a. Aerospace, 5g, SDN, AI, cybersecurity, and both software/hardware engineering.
  b. Built, tested, and deployed high-performance networks & components.
- Some projects we support:
  a. NASA Goddard: Propelled LunaNet & Artemis with strategic tech solutions.
  b. Google Loon: Pioneered Minkowski for balloon-powered internet.
  c. Google WearOS: Merged software & hardware for next-gen wearables.
  d. Aalyria: Amplified Spacetime network's resilience & efficiency.
- Certifications: Certified Ethical Hacker, Graduate Certificate in Cybersecurity, Security+
- Education:
  a. MSc in Computer Science Monmouth University
  b. MSc in Cybersecurity, MBA from University of Maryland Global Campus

Challenges in Lunar Communication



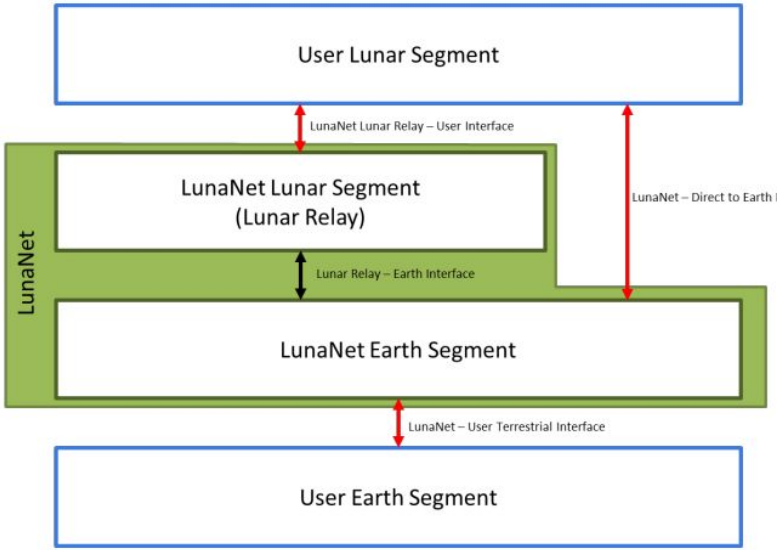
- Vast Distances:
  - Approximately 384,400 km from Earth.
  - Propagation delays and potential lag.
- Harsh Lunar Environment:
  - Extreme temperatures affect equipment.
  - Lack of atmosphere leads to radiation challenges.
- Dynamic Mission Needs:
  - Varied communication requirements.
  - Different data types, from telemetry to imagery.

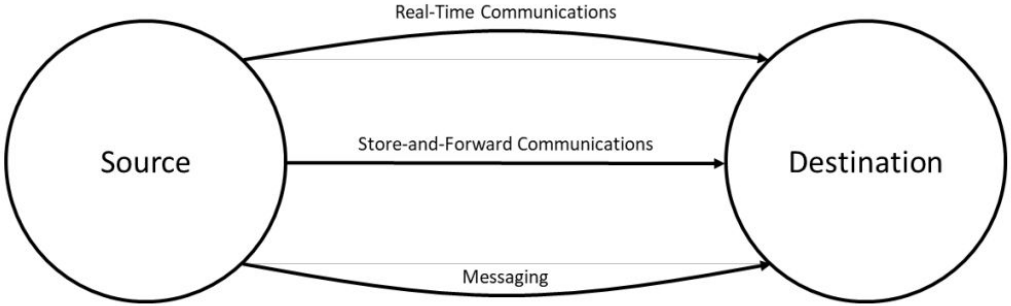
Introduction to LunaNet Interoperability Specification

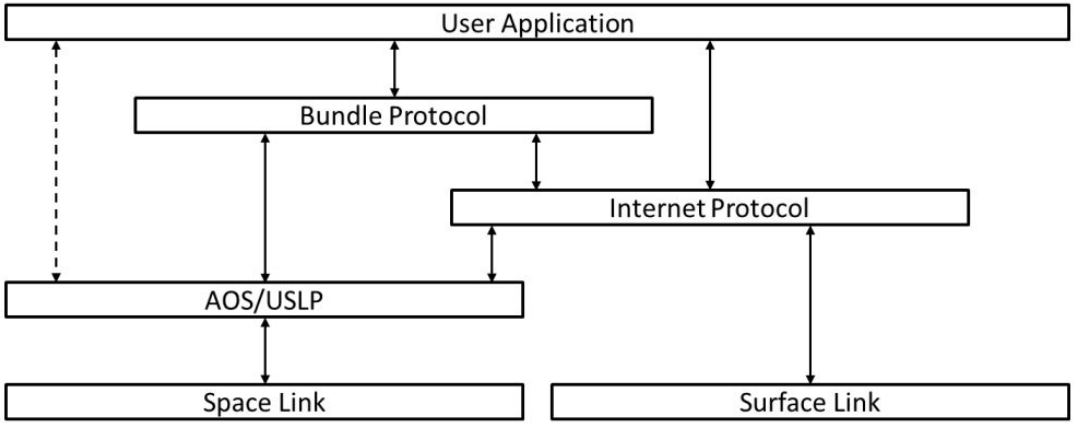
- LunaNet Interoperability Specification (LNIS)
- Designed for lunar communication and navigation challenges.
  - Adapted to long-distance transmissions.
  - Resilient against disrupted connectivity.
- Ensures interoperability across systems.
  - Seamless integration with various hardware.
  - Standardized protocols for consistent data relay.

- Facilitates data relay between lunar missions and Earth.
  - Supports varied data types and transmission rates.
  - Enables real-time and delayed communication modes.
- Paving the path for a connected lunar future.

LunaNet Interoperability Specification







GNURadio's Role in Lunar Communication

- LNIS Modulation and Demodulation Blocks:
  - These custom blocks are tailored for lunar-specific signal modulation and demodulation.

Benefits of LunaNet GNU Radio Library

- Simplified Development: Integrate LNIS functionalities seamlessly, preserving the core GNU Radio framework.
- Interoperability: Standards based approach to communication across lunar missions with LNIS protocol suite adherence.
- Rapid Prototyping: Prototype lunar communication systems swiftly for advanced research in a controlled setup.
- Community Collaboration: Foster a collaborative lunar communication ecosystem with open-source tools for researchers and institutions.

Example flowgraph

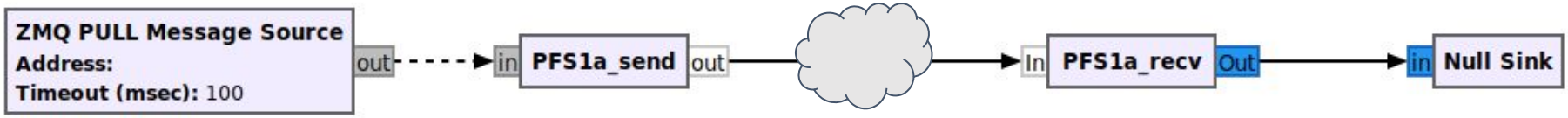


Table 8– LNSP–User Proximity Link Layer Service Interfaces

Interface	Frequency Range & Symbol Rate	Modulation & Coding	Ranging Supported [8]	Applicable Documents [4]	Explanation
Proximity Forward S-Band Data Only (PFS1a)	2025-2110 MHz 2 ksps ≤ Rs ≤ 2 Msps	BPSK See Note [3]	No	CCSDS 131.0-B CCSDS 401.0-B	See Note [1]

Potential Roadmap for Future development

Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5

Foundation

Establishing basic framework for the LNIS module.

Implementing essential data structures and interface definitions.

Basic Functionality

Developing core LNIS waveform modulation and demodulation blocks.

Testing basic communication between simulated nodes.

Advanced Features

Adding error correction and robustness mechanisms to the LNIS blocks.

Integrating real-world GNURadio components for signal processing.

Performance Optimization

Profiling and optimizing the LNIS module for efficient resource utilization.

Conducting comprehensive tests under varying conditions.

Documentation & Release

Providing detailed documentation and usage guides.

Releasing the LNIS GNURadio module to the community.

Example Use Case: Lunar Rover Comms

- Scenario: Lunar rover exploration mission.
- Challenge: Reliable communication in the presence of signal disruptions.
- Potential Solution:
  - Store-and-forward mechanism for data transmission.
  - Delay-tolerant networking for handling interruptions.
  - Enhanced navigation through orbit determination.
- Implementation Steps:
  - Configure rover with LNIS-enabled transceiver.
  - Deploy relay satellites in lunar orbit.
  - Relay packets between rover and Earth station.
- Benefits:
  - Seamless communication despite challenges.
  - Enhanced navigation and situational awareness.
  - Redundancy through multiple relay nodes.

Facilitating Innovation Through Open Standards

- Lunar Innovation Catalyst: LunaNet parallels the early Internet's impact by spurring innovation in lunar communications.
- Moon's Internet Equivalent: LunaNet serves as the lunar counterpart to the Internet, enhancing lunar connectivity and exploration.
- Inclusive Participation: LunaNet's open-standard approach welcomes diverse players, from small businesses to academia, driving widespread lunar connectivity.
- Accelerating Technology: LNIS's open standards fuel innovation, especially in emerging areas like delay-tolerant networking and lunar navigation, facilitated by GNU Radio's lab-friendly approach.

Resources

- LNIS Documentation: Comprehensive guides and usage instructions.
- Community: Engage with developers and users, share insights, and seek assistance
- Collaboration Opportunities: Join our efforts in shaping the future of lunar communication.
- Specific examples and blocks shown in our paper
- Look for a link to the presentation, paper, and source on our MTI website soon.
  - http://mti-systems.com

Questions

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