Solar System Internet

April 2021
First Three-Network Test of Internet Protocols

Heterogeneous networks and computers

November 22, 1977
Initial Considerations

- 1998: Use TCP/IP?
- Round-trip times to Mars: 7 – 40 minutes
- TCP Flow control?
- DNS Lookup?

- Delay and Disruption Tolerant Networking (DTN)

- Bundle Protocol (layered architecture)
  - Delayed Name Resolution (two steps)
  - Store (in the network) and forward when links are available
  - Redefinition of network management in a DTN environment (no PING)
  - Built in strong authentication and encryption
Prototyping

• 2004: Spirit and Opportunity land on Mars
• 28.5 Kb/s Direct to Earth radio link
• Radio overheats – reduce duty cycle
• Version of CCSDS File Delivery Protocol (CFDP) exported to Rovers and Orbiters (2007 CCSDS 727.0-B-4)
• Use “manual” CFDP since 2004 for data delivery to/from Mars
• Contract Graph Routing (orbital dynamics)
MARS RECONNAISSANCE ORBITER, MARS EXPRESS, PHOENIX, MARS ROVERS, MARS SCIENCE LABORATORY
Refining and testing DTN


- 2009-2018 – Testing of DTN on the International Space Station (messaging applications)

- 2012-2016 – Multi-purpose End-to-End Robotic Operations Network (METERON) DTN tests conducted on ISS by ESA. Remote real-time control of a robotic vehicle at ESA Operations Center in Germany.

- October 2013 – April 2014 – Lunar Laser Communications Demonstration (Earth to Moon Orbit and back) at 622 Mb/s using the Lunar Atmosphere and Dust Environment Explorer (LADEE) spacecraft.
Further Refining of the DTN protocols

- 2013: Interoperability testing of Interplanetary Overlay Network (ION) implementation of DTN between NASA and JAXA

- 2014 - Present: IETF Working Group: DTNWG
  - Bundle Protocol V6 and V7

- 2008 – Present: Continued Consultative Committee on Space Data Systems (CCSDS) standardization of the Bundle Protocol, Licklider Transmission Protocol, etc.

- 2008 - Present N4C project at Luleå University in Sweden to use DTN to provide communications for the Sami reindeer herders in the Arctic.
Further Refining of the DTN Protocols

- Present: Technische Universität Braunschweig, IBR-DTN implementation for RouterBoard 532A or Ubiquiti RouterStation Pro and for Android (see IBR-DTN GooglePlay)

- Present: NASA, ESA, JAXA, KARI deployment activities

- Software available at Github.com
  - IBR-DTN (TU Braunschweig)
  - ION (from NASA)

- Future plans or expectations:
  - Implementation of DTN for 2020’s missions to Moon
  - IPNSIG.ORG long-term proposals and public engagement
Interplanetary Internet

- End-to-end information flow across the solar system
- Layered architecture for evolvability and interoperability
- IP-like protocol suite tailored to operate over long round-trip light times
- Integrated communications and navigation services
Next Stop: Alpha Centauri?