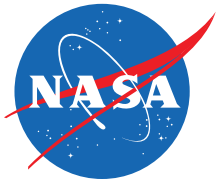

Automated Contact Graph Generation with SPSCGR

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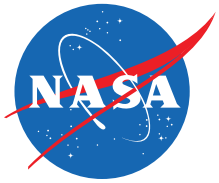
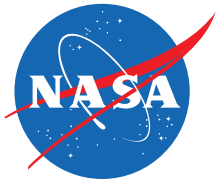


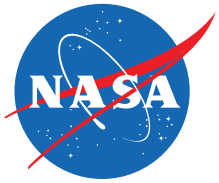
Outline

- Background
  - DTN
  - SPS
  - Contact Graphs
- Implementation
- Summary
- Acknowledgments



Background

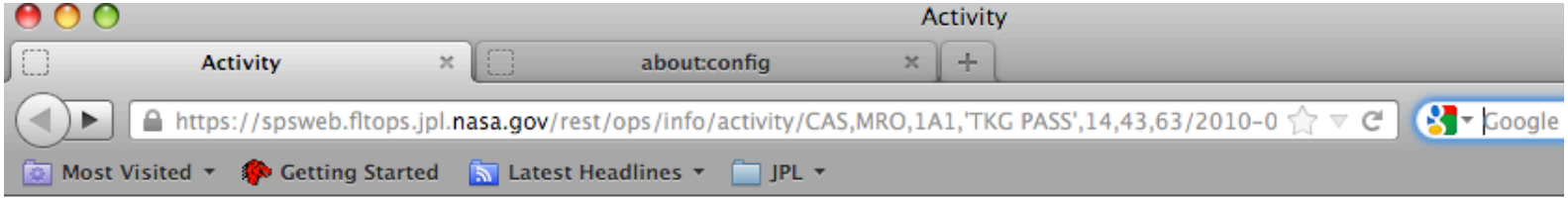
- Traditional Internet protocols have been widely deployed for a variety of applications.
- However such protocols generally perform poorly in situations in which
  - round trip delays are very large (interplanetary distances)
  - persistent connectivity is not always available (widely dispersed MANET).
- Delay/Disruption Tolerant Network (DTN) technology was invented to address these issues
  - Relay nodes “take custody” of blocks of network traffic on a hop-by-hop basis and retransmit them in cases of expected or unexpected link outage
  - Bundle lifetime may be configured for long round trip light times



Background

- The JPL Service Preparation Subsystem (SPS) provide near term (past and future) DSN schedule information indexed by antenna or spacecraft
- SPSCGR paves the way toward modeling and simulation efforts (and eventually infusion) based on actual DSN scheduling information

SPSWeb output



Number of rows: 47

STARTTIME	BOT	EOT	ENDTIME	FACILITY	PROJUSER	ACTIVITY
2012-226T00:10:00	2012-226T01:10:00	2012-226T04:25:00	2012-226T04:40:00	14	MRO	TKG PASS
2012-226T15:10:00	2012-226T16:10:00	2012-226T20:25:00	2012-226T20:40:00	63	CAS	TKG PASS
2012-227T12:00:00	2012-227T13:00:00	2012-227T20:45:00	2012-227T21:00:00	63	CAS	TKG PASS SEQ
2012-230T01:15:00	2012-230T02:15:00	2012-230T04:15:00	2012-230T04:30:00	14	MRO	TKG PASS
2012-231T18:00:00	2012-231T19:00:00	2012-232T04:00:00	2012-232T04:15:00	14	CAS	TKG PASS SEQ
2012-233T18:00:00	2012-233T19:00:00	2012-233T23:00:00	2012-233T23:15:00	14	CAS	TKG PASS SEQ
2012-234T23:10:00	2012-235T00:10:00	2012-235T04:00:00	2012-235T04:15:00	14	MRO	TKG PASS
2012-235T17:45:00	2012-235T18:45:00	2012-236T03:45:00	2012-236T04:00:00	14	CAS	TKG PASS SEQ

Contact Graph

```
.
.
.
a range +375369600 +375398700 0 3 5322
a contact +375369600 +375398700 0 3 10000
a contact +375364278 +375393378 3 0 10000
a range +375713700 +375744900 0 3 5304
a contact +375713700 +375744900 0 3 10000
a contact +375708396 +375739596 3 0 10000
a range +375800400 +375828300 0 3 5298
a contact +375800400 +375828300 0 3 10000
a contact +375795102 +375823002 3 0 10000
a range +375972900 +376005600 0 3 5289
a contact +375972900 +376005600 0 3 10000
a contact +375967611 +376000311 3 0 10000
.
.
.
```

"CONTACT" or "RANGE" keyword

Start/end time up (seconds)

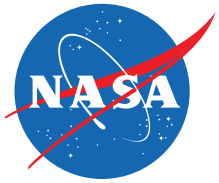
Start/end time down (seconds)

Source, Destination nodes

Data rate in octets/second

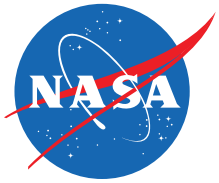
Light time delay in seconds

Contact Graph provides information about present and future DTN network configuration so data bundles can be efficiently routed.



Implementation

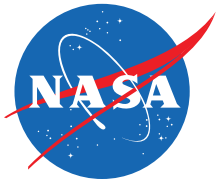
- SPSCGR parses HTML output of SPS website
  - Scheduled DSN antenna time represents a superset of the actual useful communication window (need setup and tear down time)
  - SPS has no knowledge of spacecraft pointing, data rate, spacecraft health
- SPSCGR uses SPICE toolkit to determine occlusion and light time latency
  - SPICE ephemeris kernels should be periodically updated to keep up with trajectory correction maneuvers
  - DTN protocols less sensitive to Earth orientation and leap second data (updates are not required as frequently)
- SPSCGR written in portable C
  - Tested on Mac, Windows, Linux
  - SPICE is the only library dependence (downloaded from naif.jpl.nasa.gov)
  - Performance is adequate for foreseeable modeling and simulation efforts but there is room for optimization
    - Majority of runtime spent in SPICE routines
    - Two pass parser (first pass assigns node numbers, second pass generates Contact Graph)



Summary

- SPSCGR is a tool that generates Contact Graphs using data from SPS and SPICE suitable for DTN modeling, simulation and eventual deployment
- Future work
  - Add estimated link budget
  - Incorporate spacecraft state information (antenna pointing, task sequencing, etc.)
  - Merge with MaROS*-to-CG tool
- Contact Graph data structures represent current and future link and node availability, capacity and latency
- Contact Graphs may be useful to the DSN even before full DTN infusion.

*Mars Relay Operations Service



Acknowledgments

- *This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology and was funded by grants from the National Aeronautics and Space Administration.*
- Thanks to Daniel Allard, Scott Burleigh, Loren Clare, Esther Jennings and Shan Malhotra