DTN Reference Scenarios

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IETF 122 - 17.03.2025

Agenda

- Introduction
- Scenarios structure
- DTN Scenarios
- File composition
- Version control and distribution

Introduction

- Definition of DTN Reference Scenarios to allow **demonstration and validation of Bundle Protocol and extensions**, such as BP QoS, Compressed Custody Transfer, BPSEC Key Management, Network Management, Multi-destination, video streaming, …
- DTN Reference scenarios **abstract from specific mission / network topologies** but should expose relevant **characteristics in terms of data rates, contacts, traffic, error model, etc**. which allow meaningful demonstration and validation
- DTN Reference scenarios may not be fully adequate for the various topics above but could at least build a common basis
- For CCSDS, DTN Reference scenarios shall be limited to scenarios which could reasonably expected in the **next 3 – 10 years** (limited number of nodes, focus on agency activities)
- They may not be sufficient for more research type activities which need to address scalability; still, they could be a basis for larger scenarios (not in CCSDS scope)

Scenarios and structure

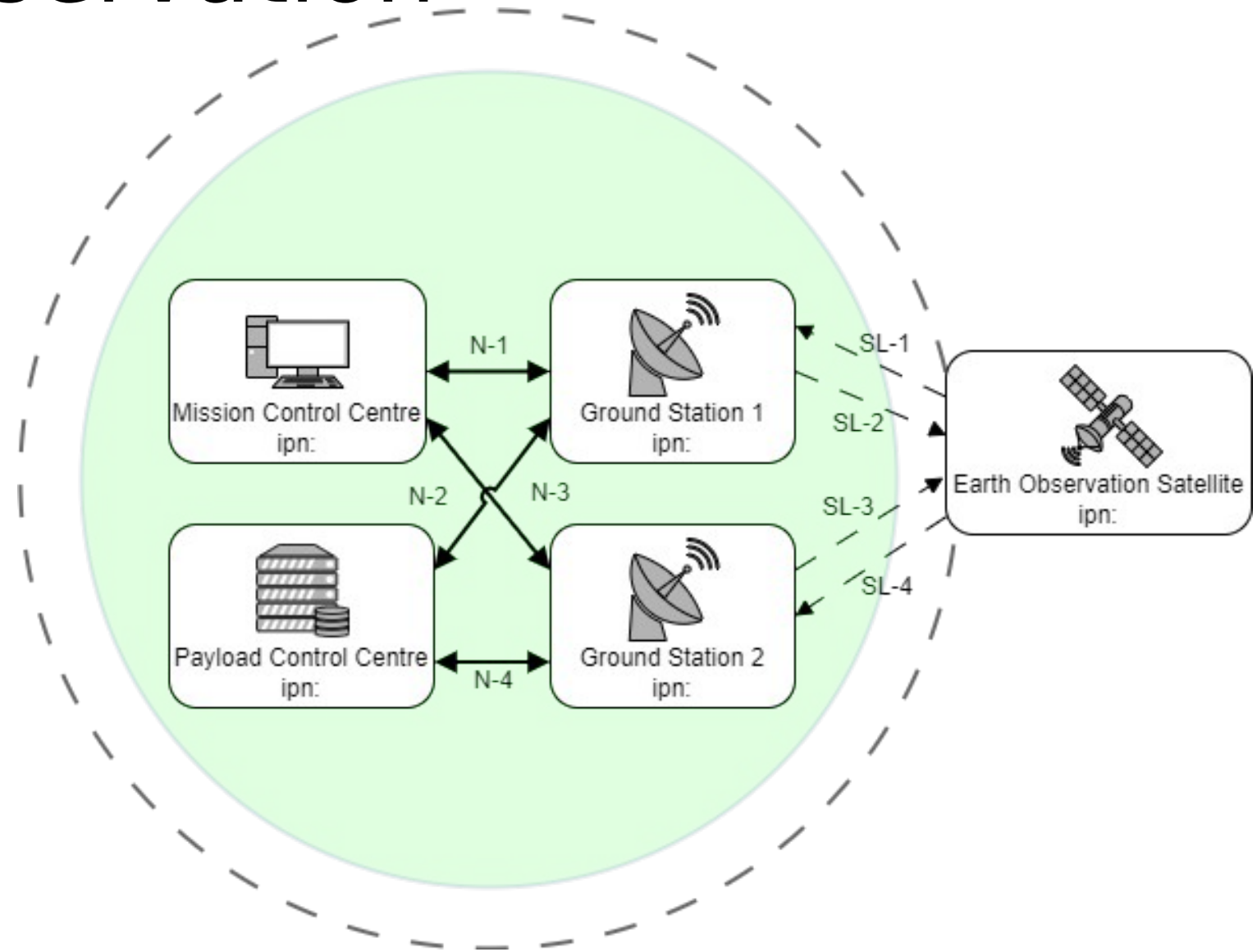
DTN Reference scenarios:

- Earth Observation
- Lunar Communication
- Mars Communication

Scenario characteristics:

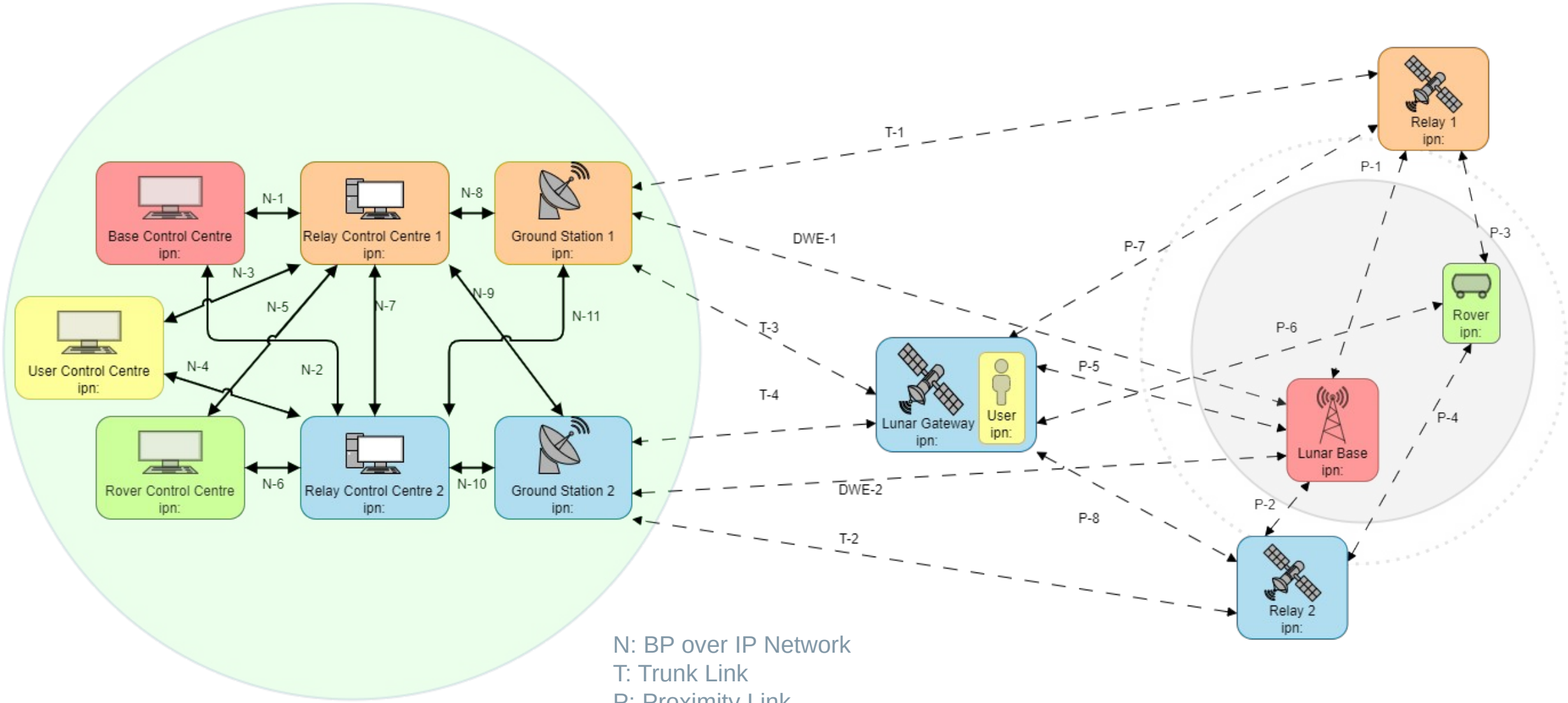
- Topology
- Data rates
- Latency
- Error model
- Application traffic volumes

Earth Observation



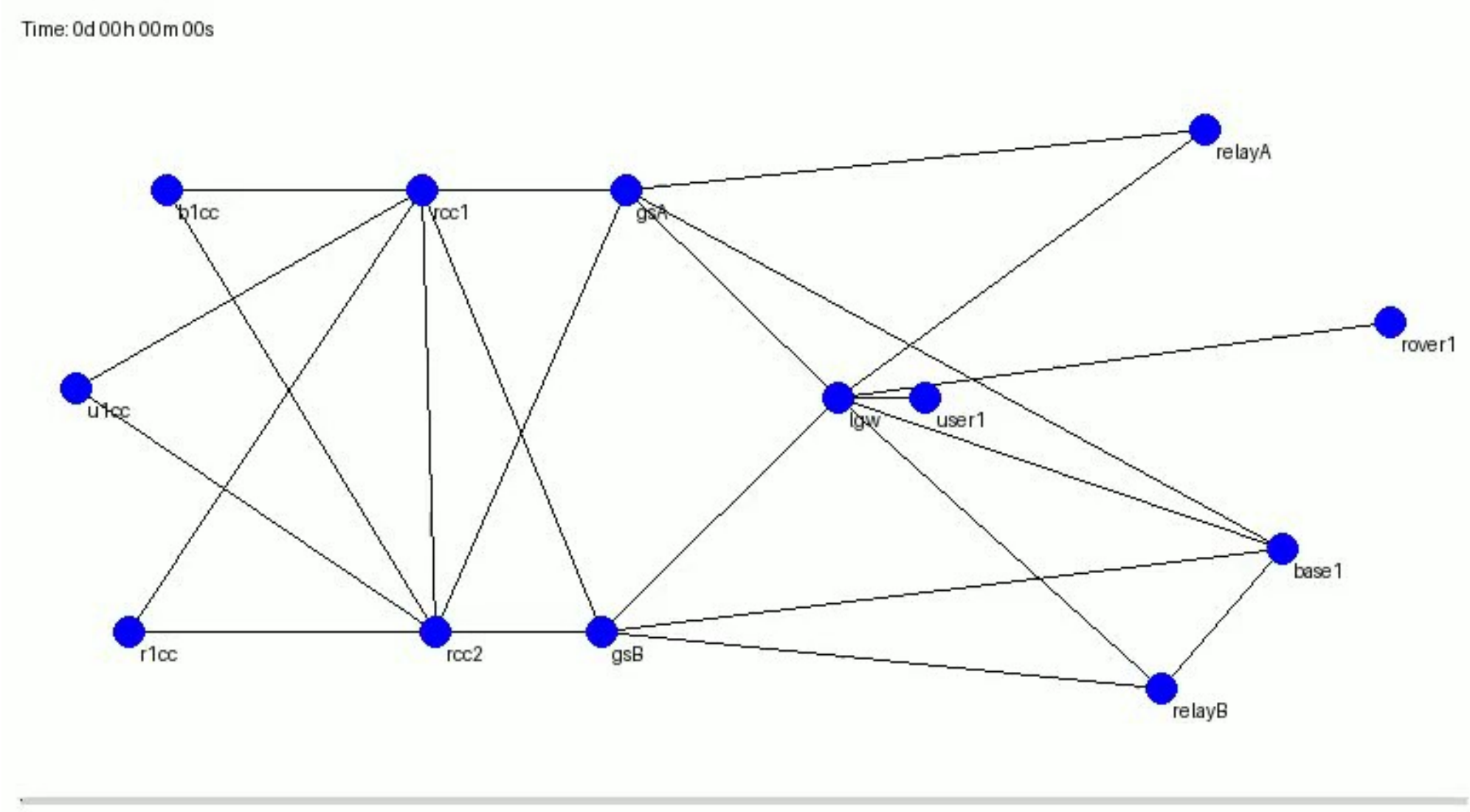
N: BP over IP Network
SL: Space Link

Lunar Communication

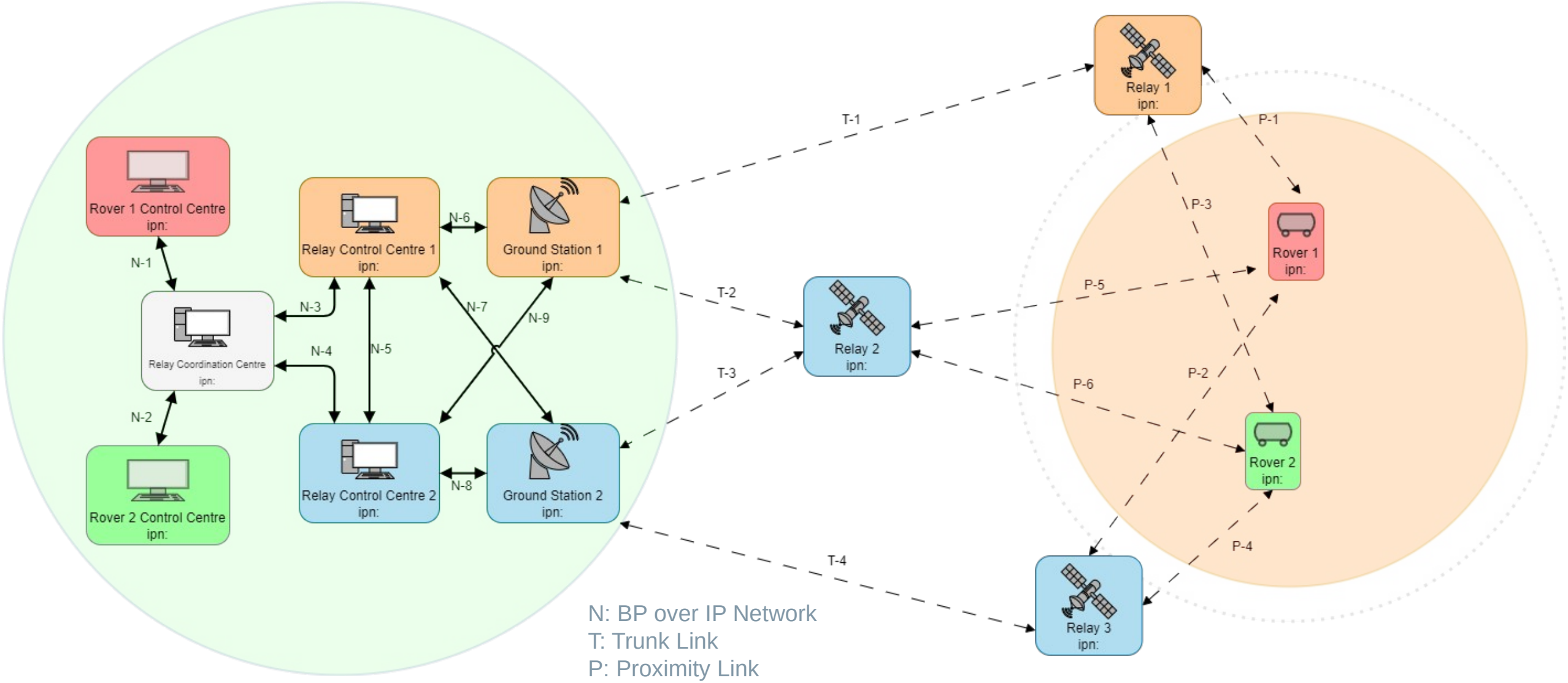


N: BP over IP Network
T: Trunk Link
P: Proximity Link

Lunar Communication



Mars Communication



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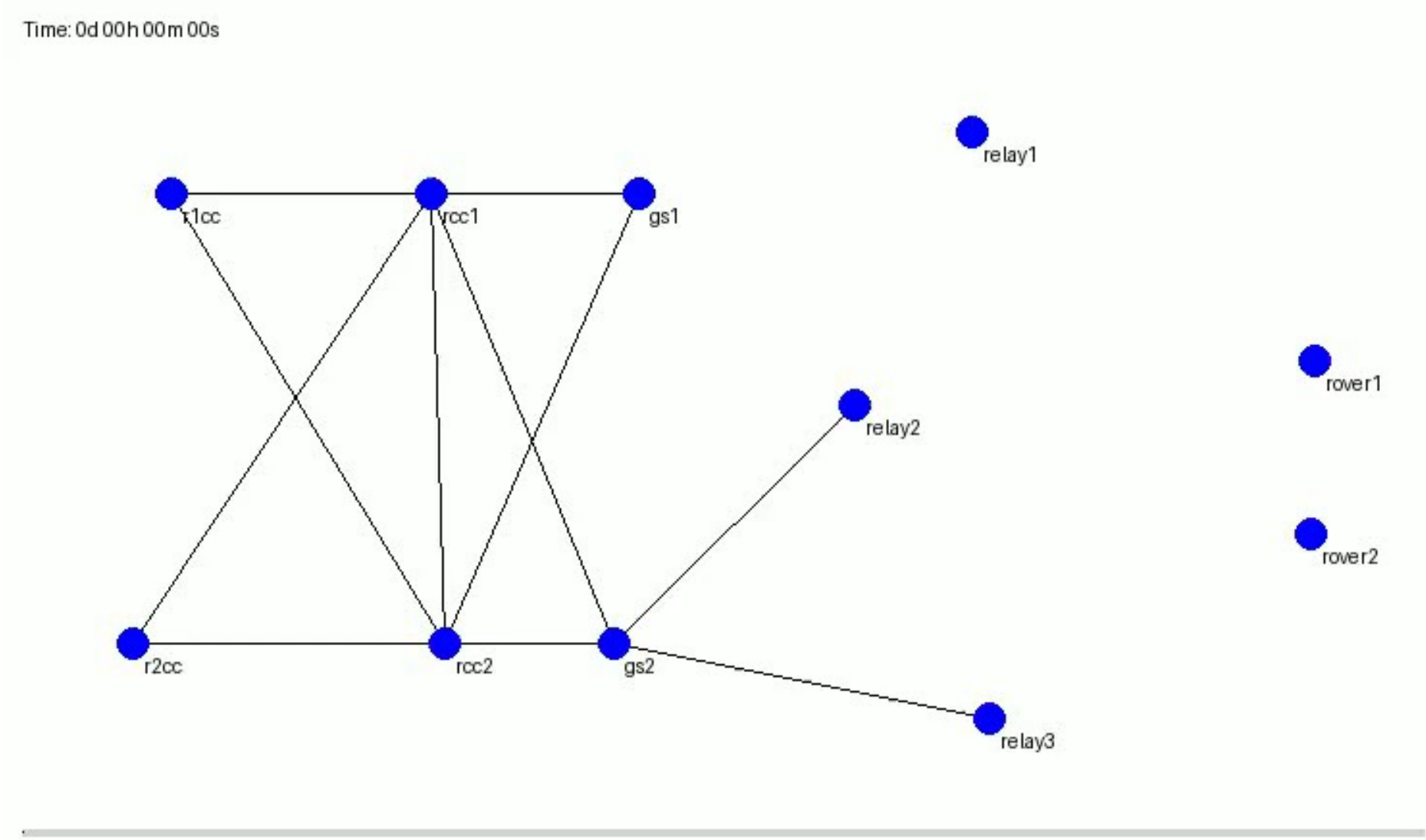
Mars Communication



Scenario files

Every scenario is defined by 3 CSV files and a mapping file, defining the network behaviour:

1. **Planned contacts:** CSV providing all information related to the expected network behaviour.
2. **Actual contacts:** CSV providing the real link availability of the scenario.
3. **Application Data:** CSV providing application data volumes produced by the nodes in the network.
4. **Mapping:** A human-readable mapping file that expand names and acronyms from the CSV.

Scenario file 1 – Planned contacts

```
source,destination,contact_start(s),contact_end(s), data_rate(bps), latency(s)
gs1,mcc,0,-1,100000000,0.010
mcc,gs1,0,-1,100000000,0.010
gs1,eosat,1270.982,1370.139,0.064,0.007
gs1,eosat,1375.305,1378.958,0.060,0.010
gs1,eosat,1504.294,1704.443,0.064,0.007
```

CSV providing all information related to the expected network behaviour, it is targeting the BPA of the nodes for activation/deactivation of the CLAs and network routing.

- The file contains unidirectional links and the topology can be fully derived from it.
- Fixed links are added at the beginning of the file.
- Represent the contacts expected in the network after mission and ground station planning have been applied based on calculated visibility.

Scenario file 2 – Actual contacts

```
source,destination,contact_start(s),contact_end(s), data_rate(bps), latency(s)
gs1,mcc,0,-1, 100000000,0.010
mcc,gs1,0,-1, 100000000,0.010
gs1,eosat,7126.126,7623.214,0.064,0.007
gs1,eosat,12964.874,13498.538,0.064,0.007
```

CSV providing the real link availability of the scenario.

- The file is the input for a network simulator that manages the link availability.
- It is derived from the planned contacts file where an error model has been applied.
- Ongoing work to describe an availability/error model that considers various parameters (mispointing, weather, misconfigurations).

Scenario file 3 – Application Data

```
source,source_eid,destination,destination_eid,time_start,time_end,bundle_generation_
rate(bundle/s),bundle_size(KB)
gsA,ipn:1.1,orbiterA,ipn:2.1,10045,11000,10,64000
```

CSV providing application data volumes produced by the nodes in the network.

- The file is input to applications producing bundle that the BPAs inject into the network.
- For simplicity, a node may jut relay bundles and produce none.

Scenario file 4 – Mapping

```
== Earth Observation ==
Mission Control Centre      --> eomcc   --> ipn:10
Payload Control Centre      --> eopcc   --> ipn:100
Ground Station 1/A          --> eogs1   --> ipn:20
Ground Station 2            --> eogs2   --> ipn:30
Earth Observation Satellite --> eosat   --> ipn:50
```

The mapping file provides information useful to setup the topology and aids debugging.

- The format is currently work in progress (JSON is considered) and will be easy to parse.

Version Control and Distribution

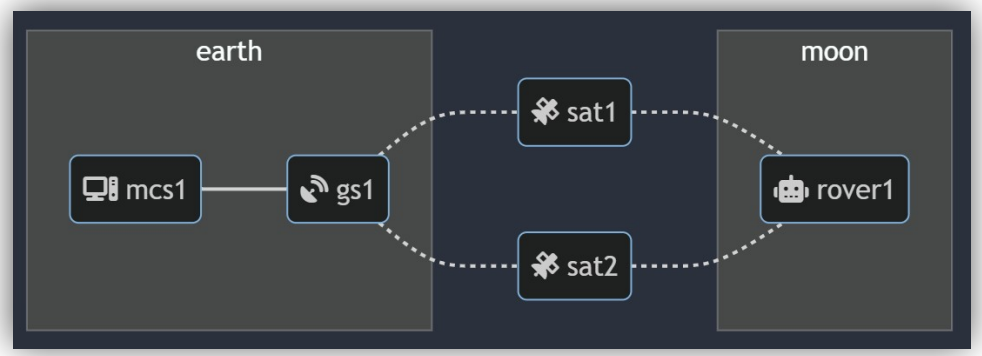
- The Reference scenarios will be published as (yellow) book in CCSDS. They will be presented in the next Spring meeting.
- Each scenario can have its own version and changes in topology would be reflect in a new major version, changes to data rates, latencies etc. in a new minor version.
- Configurations for reference scenarios can be included in BP implementations.

References

- IOAG, The Future Lunar Communications Architecture.
- R. Gladden et al., Lessons Learned from the Mars Relay Network: Considerations for Future Relay Networks.
- International Communication System Interoperability Standards (ICSIS).
- Moonlight LCNS ESA Service Requirements Document (ESRD).

Network Simulation & Emulation Environment

- Docker compose-based network topologies
- Containerized nodes
- Fluctuating network links
- Automated execution of actions
- Visualization or headless execution
- Management interface for interactive control of simulations



Visibility

```
source,destination,contact_start(s),contact_end(s), data_rate(bps), latency(s)
gs1,eosat,1270.982,1370.139,0.064,0.007
gs1,eosat,1375.305,1378.958,0.060,0.010
gs1,eosat,1504.294,1704.443,0.064,0.007
```

CSV containing all the point-to-point visibility between two nodes, as computed by the ESA flight dynamics library.

- The lines are temporarily ordered by contact start.
- Not necessary to run a simulation.
- Starting point to derive the other files.

EO

source**destination**	**Mission Control Centre**	**Payload Control Centre**	**Ground Station 1**	**Ground Station 2**	**Satellite**
Mission Control Centre		0	100 Mbps	100 Mbps	0
Payload Control Centre	0		100 Mbps	100 Mbps	0
Ground Station 1	100 Mbps	100 Mbps		0	64 Kbps
Ground Station 2		100 Mbps	0		64 Kbps
Satellite	0	0	8Mbps	10 Gbps	

source**destination**	**Mission Control Centre**	**Payload Control Centre**	**Ground Station 1**	**Ground Station 2**	**Satellite**
Mission Control Centre		0	10	10	0
Payload Control Centre	0		10	10	0
Ground Station 1	10	10		0	0.1
Ground Station 2	10	10	0		0.1
Satellite	0	0	1	1000	

Moon

source\destination	Base Control Centre	User Control Centre	Rover Control Centre	Relay Control Centre 1	Relay Control Centre 2	Ground Station 1	Ground Station 2	Gateway	Relay 1	Relay 2	Rover	Lunar Base
Base Control Centre		0	0	100	100	0	0	0	0	0	0	0
User Control Centre	0		0	100	100	0	0	0	0	0	0	0
Rover Control Centre	0	0		100	100	0	0	0	0	0	0	0
Relay Control Centre 1	100	100	100		100	100	100	0	0	0	0	0
Relay Control Centre 2	100	100	100	100		100	100	0	0	0	0	0
Ground Station 1	100	100	100	100	100		0	30	30	30	0	5
Ground Station 2	100	100	100	100	100	0		30	30	30	0	5
Gateway	0	0	0	0	0	100	100		15?	15?	1	1
Relay 1	0	0	0	0	0	100	100	15?		15?	100	100
Relay 2	0	0	0	0	0	100	100	15?	15?		100	100
Rover	0	0	0	0	0	0	0	15	15	15		0
Lunar Base	0	0	0	0	0	25	25	15	15	15	0	

Mars

source\destination	Rover Control Centre 1	Rover Control Centre 2	Relay Coordination Centre	Relay Control Centre 1	Relay Control Centre 2	Ground Station 1	Ground Station 2	Relay 1	Relay 2	Relay 3	Rover 1	Rover 2
Rover Control Centre 1		0	100	0	0	0	0	0	0	0	0	0
Rover Control Centre 2	0		100	0	0	0	0	0	0	0	0	0
Relay Coordination Centre	100	100		100	100	0	0	0	0	0	0	0
Relay Control Centre 1	0	0	100		100	100	100	0	0	0	0	0
Relay Control Centre 2	0	0	100	100		100	100	0	0	0	0	0
Ground Station 1	0	0	0	100	100		0	30	100	30	0	0
Ground Station 2	0	0	0	100	100	0		30	100	30	0	0
Relay 1	0	0	0	0	0	30?	30?		0	0	1	1
Relay 2	0	0	0	0	0	30?	30?	0		0	1	1
Relay 3	0	0	0	0	0	30?	30?	0	0		1	1
Rover 1	0	0	0	0	0	0	0	15	15	15		0
Rover 2	0	0	0	0	0	0	0	15	15	15	0	