Developing and Testing the Interplanetary Overlay Network: Lessons Learned and Suggestions for GENI

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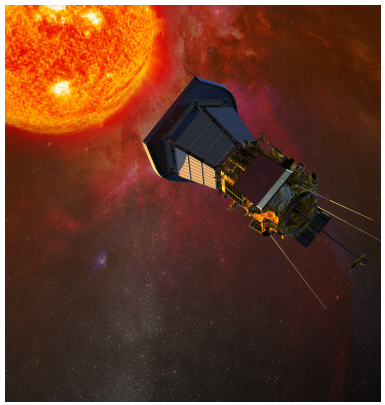
November 3, 2010

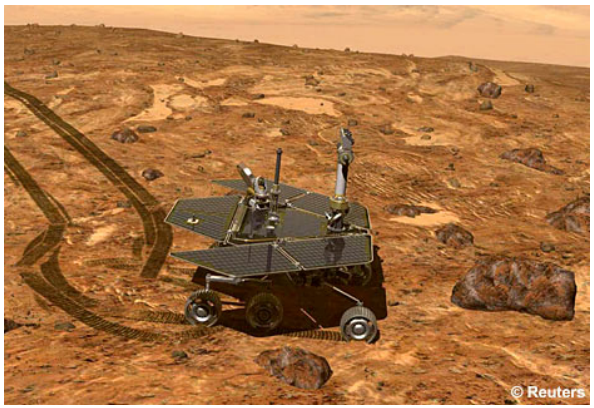
Overview

- What is the Interplanetary Overlay Network (ION)?
- Our Setup and Experiments
- What do we need for future experiments?
- What would help us out?

Networking in Space

- Space: the final frontier





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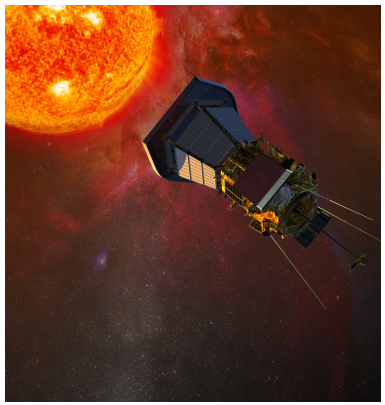

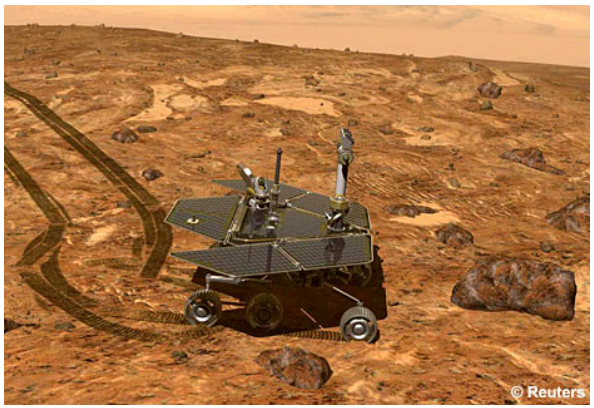

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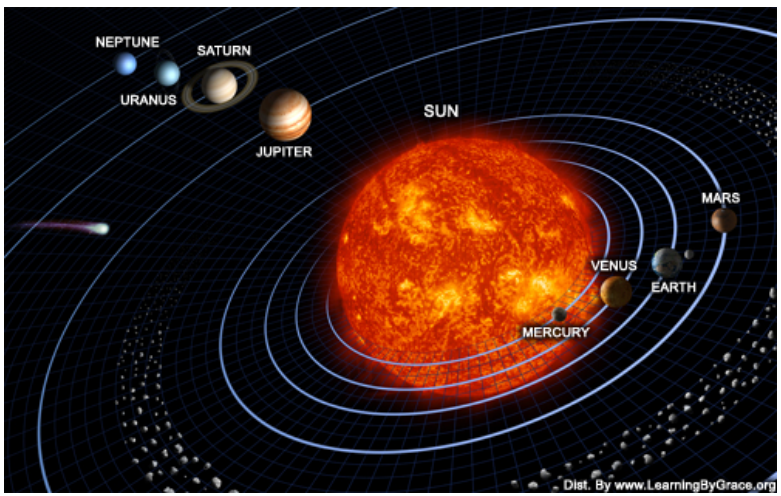


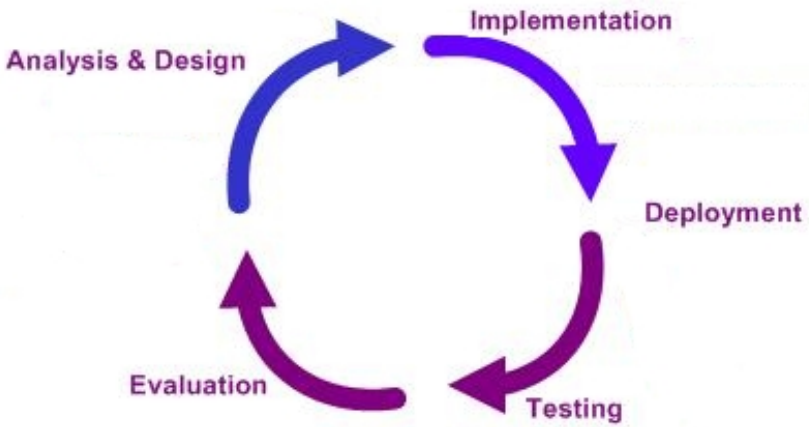
- Signal propagation
- Moving nodes
- Interference
- Resource constraints
- Convergence layers

The Interplanetary Overlay Network (ION)

- Delay-tolerant Networking (DTN) - RFC4838
- Bundle Protocol (BP) - RFC5050
  - Store and Forward Routing
- ION
  - Disruption-tolerant
    - Disruption
    - Delay
  - Low-energy
  - Low-processing
  - Fault-tolerant
  - Space Vehicles
  - Scientific Exploration

What did we use the system for?

- Development and Testing



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- Reliability
- Security

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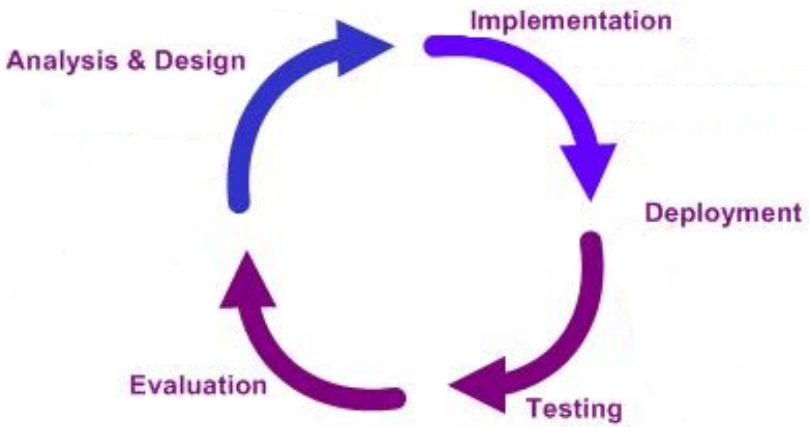

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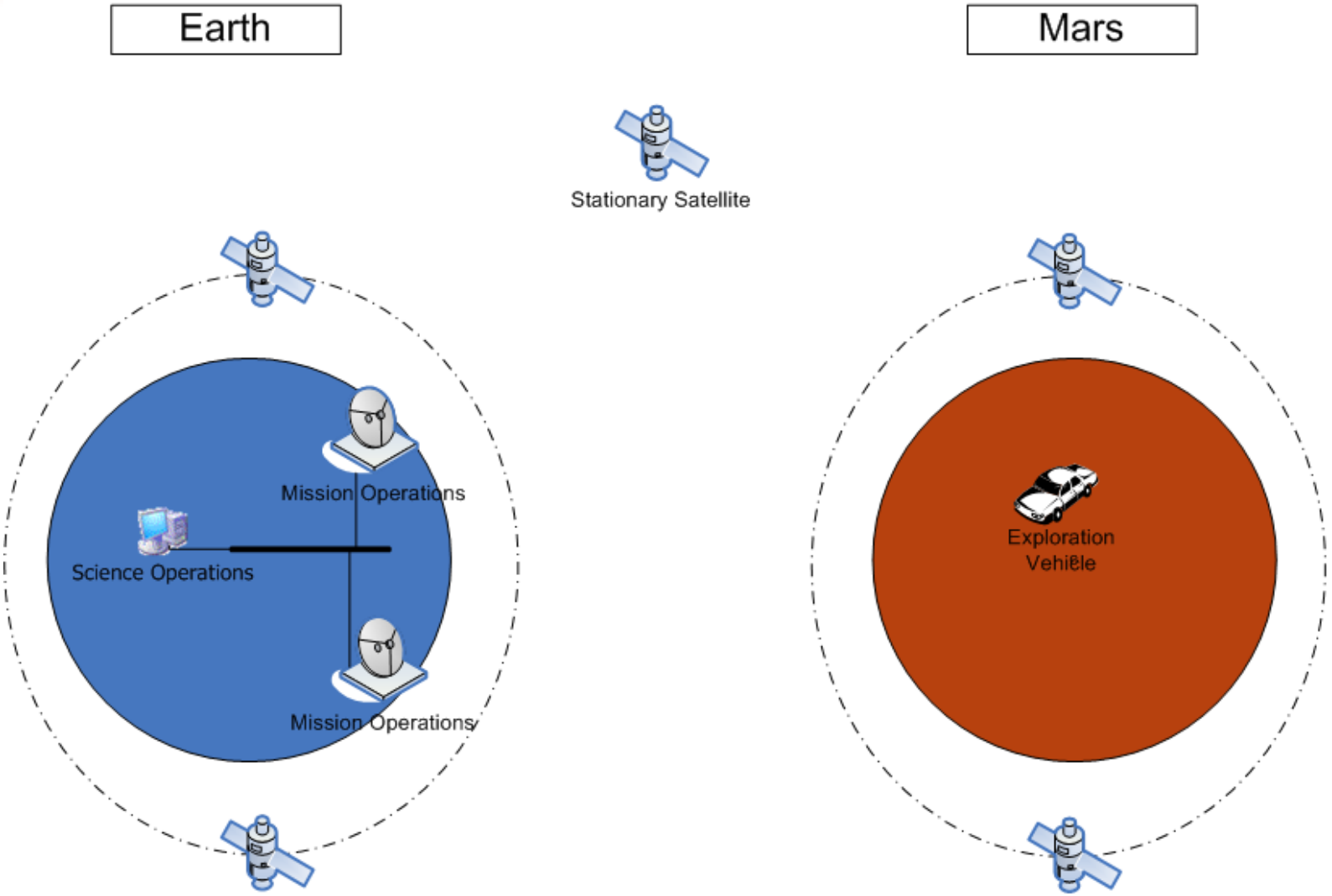
- Experiments

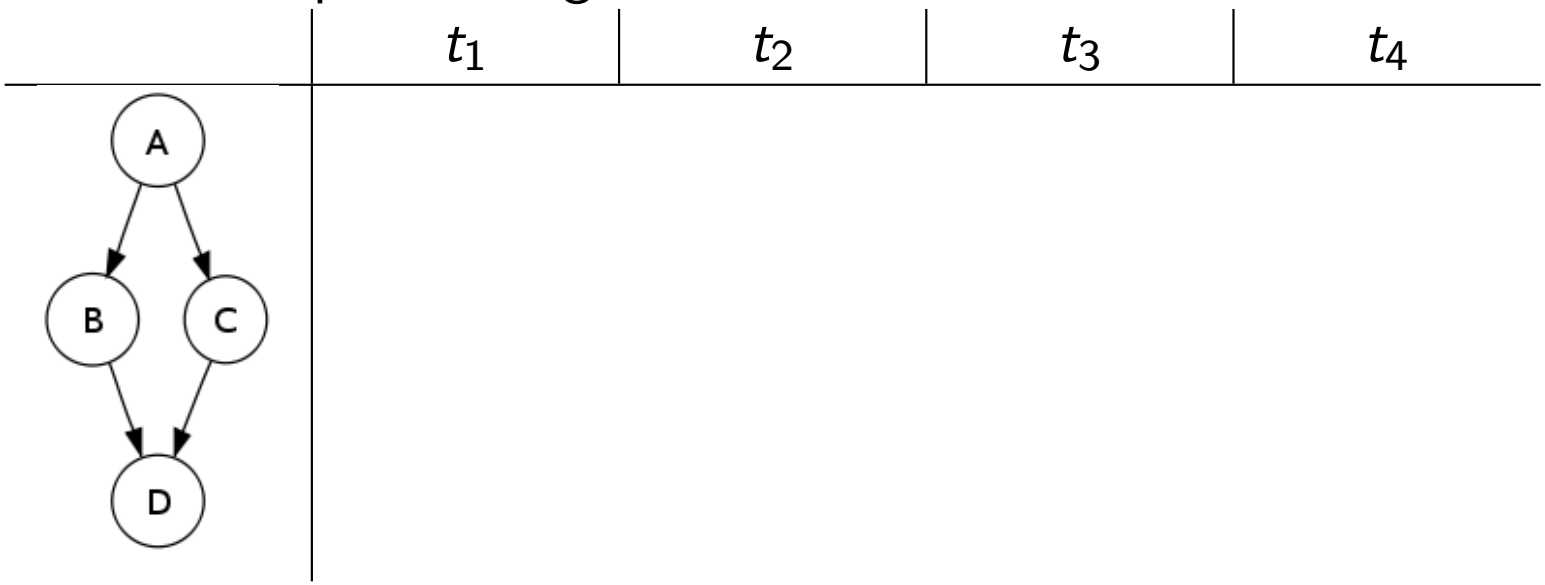
  - Proof of Concepts (e.g. Bundle Size)
  - Routing Protocols
  - Feasibility

An Example Network



Experiments

- Contact Graph Routing



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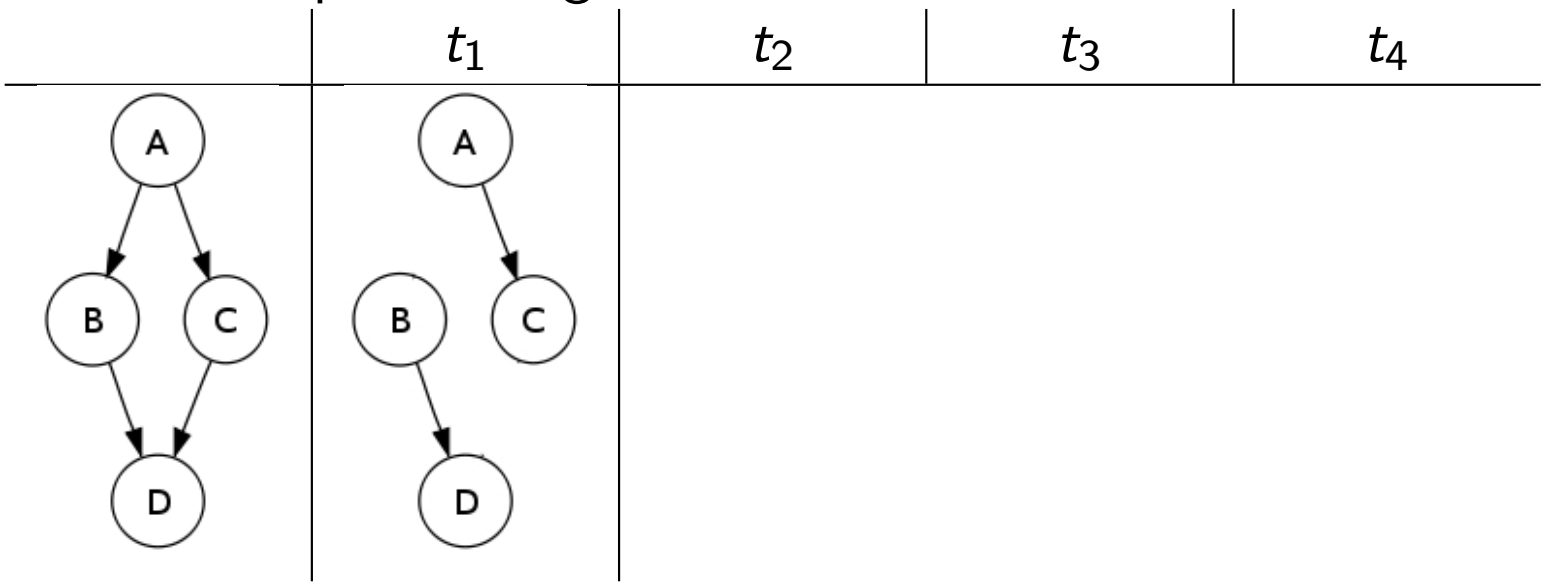

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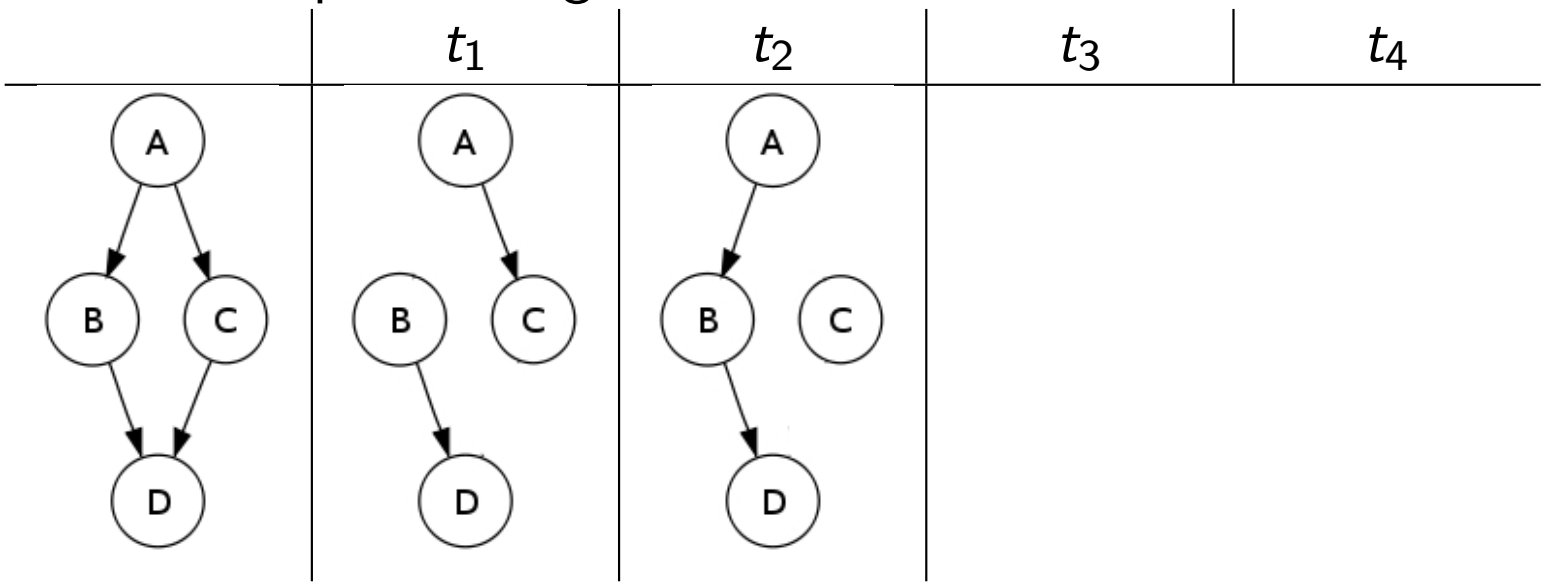

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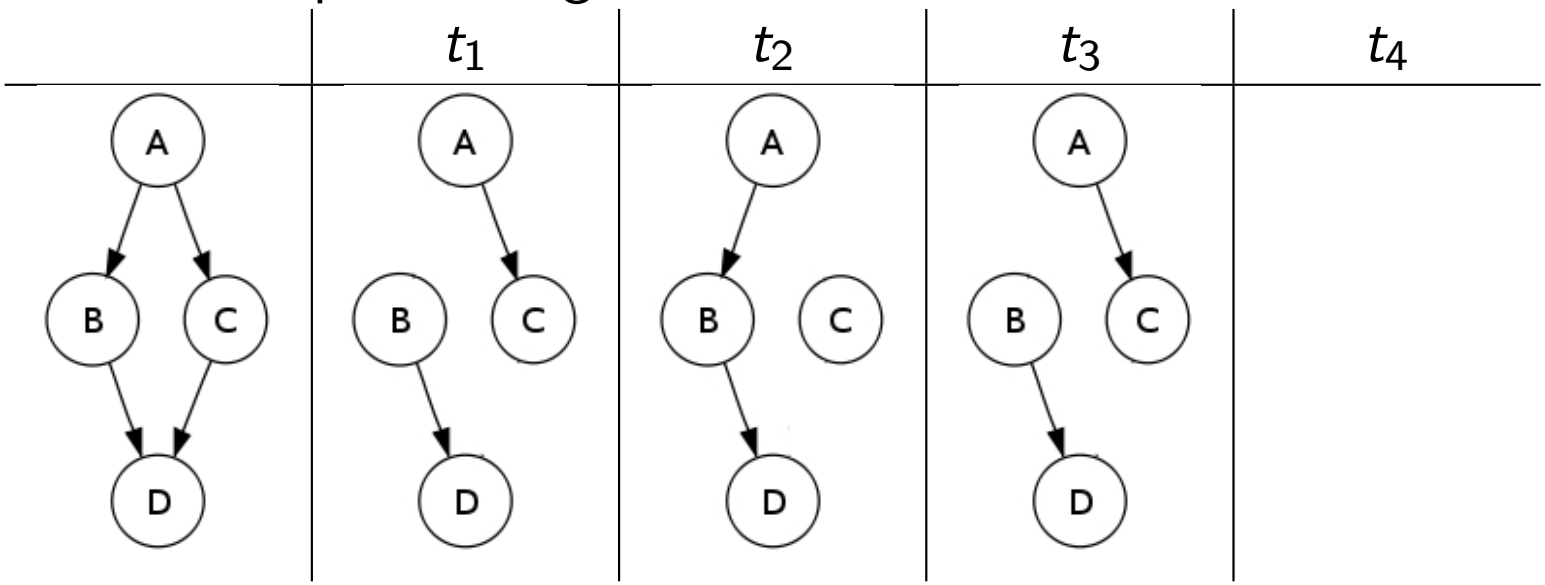

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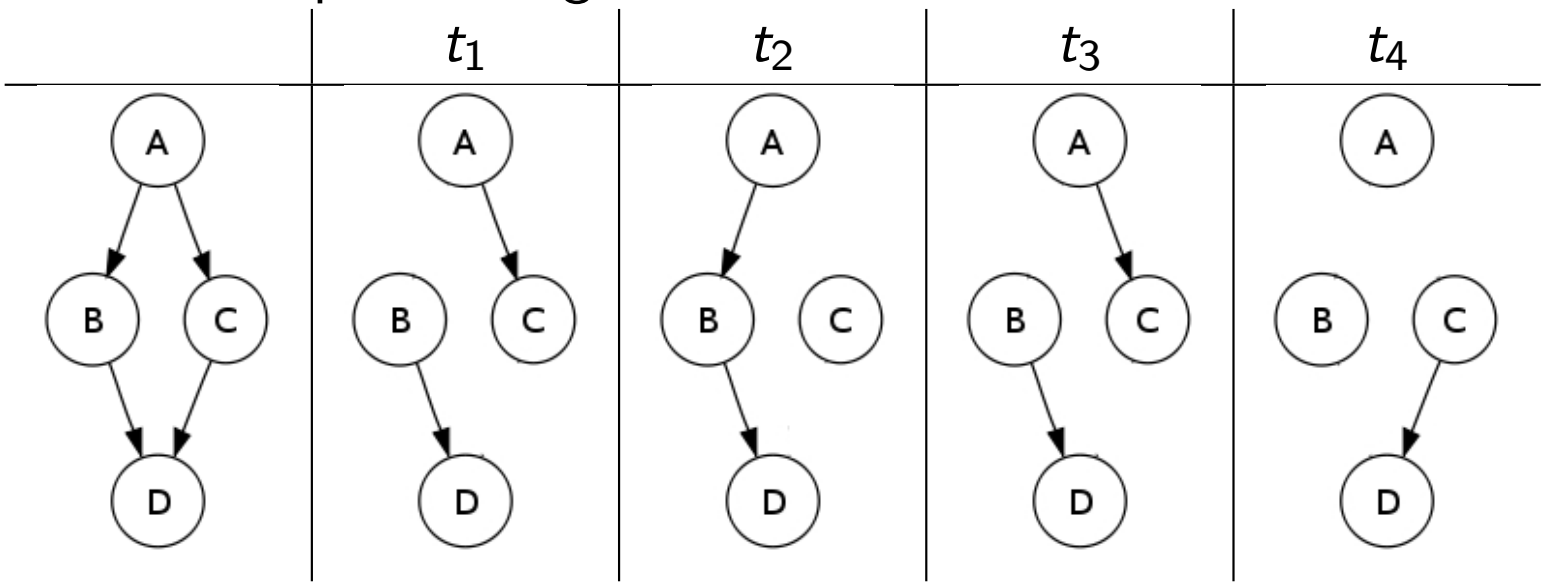

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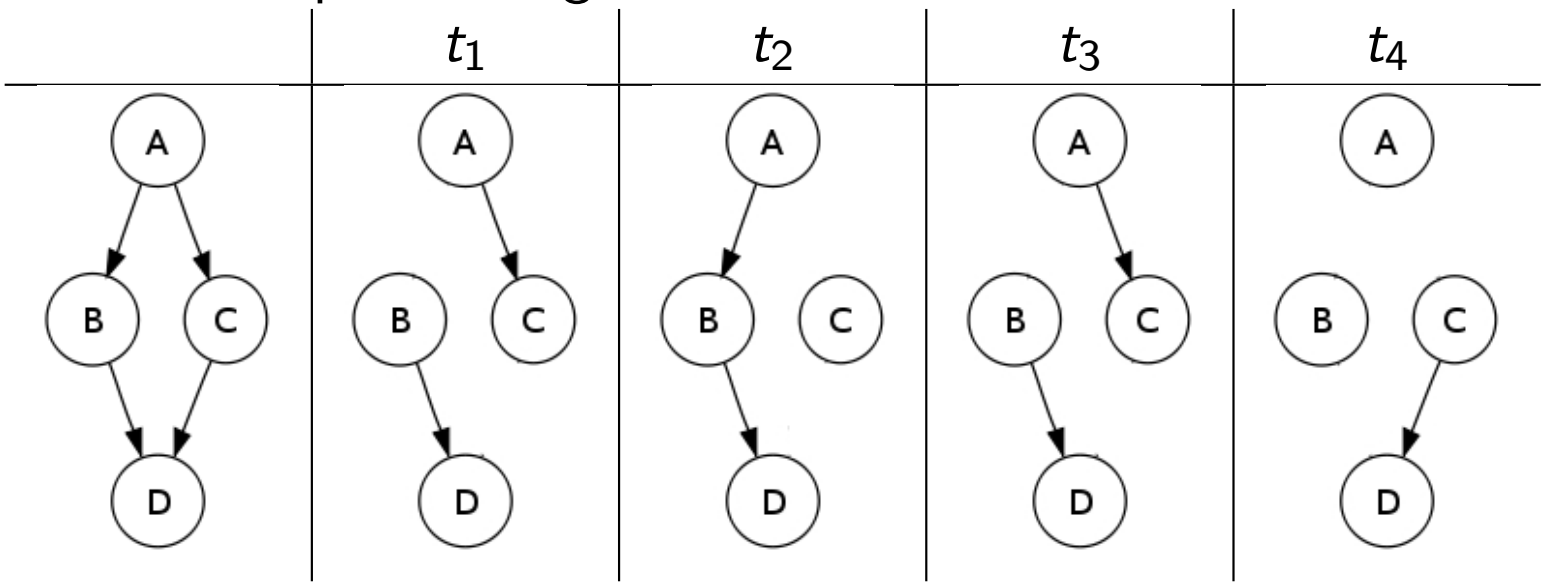

Is delivery time the main criterion?

- Network Utilization
- Security Destinations (NP-complete)
- Other cost functions ...

Experiments

- Bundle Protocol Security
  - Integrity
  - Privacy
  - Attack Vectors

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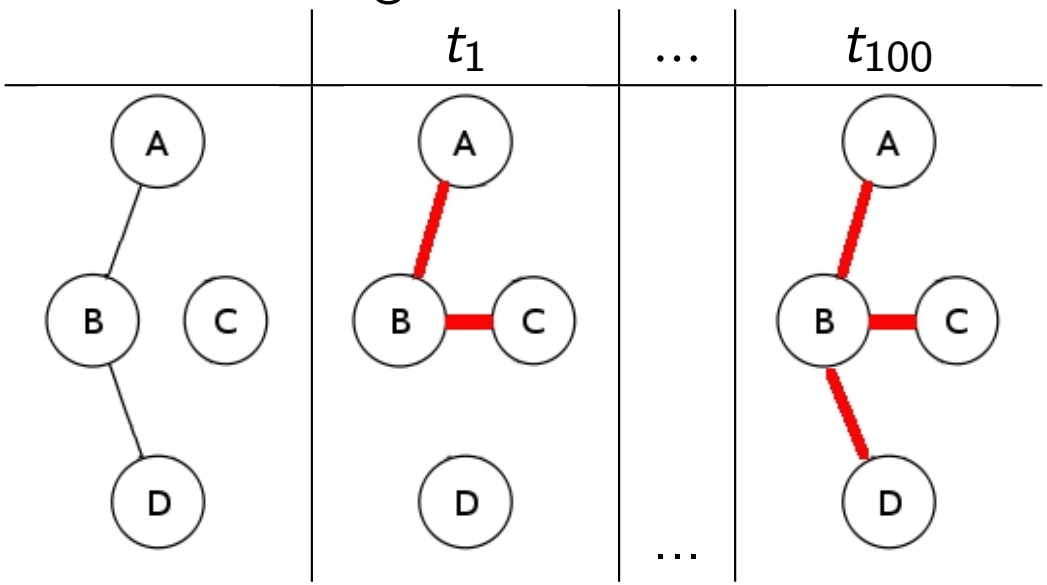
- Network Management



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  - Node Announcement
  - Node Removal

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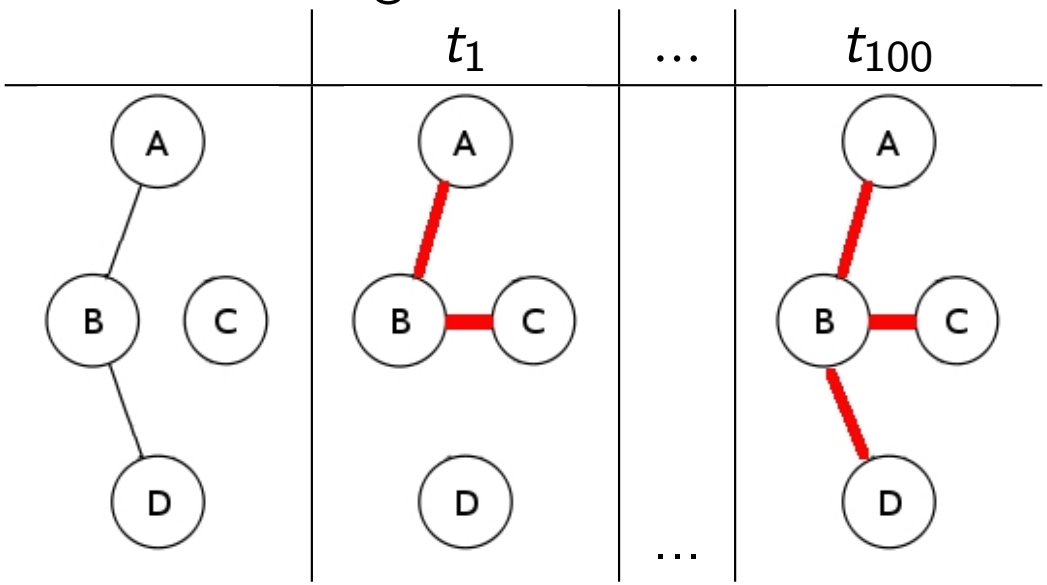

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Network updates can be slow and costly!

Recommendations and Wishes

- Custom hardware + OS

  Simulate flight hardware

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  Simulate spacecraft, rovers, earth-bound mobile agents

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- Link/Physical Layer Experimentation
  - Transmission Medium (e.g., Bands: X, K, UHF)
  - Protocols (e.g., LTP)

  Test convergence layers,
  Simulation using actually used Protocols

Links

- Issues:
  - Distances in Space
  - Moving Systems

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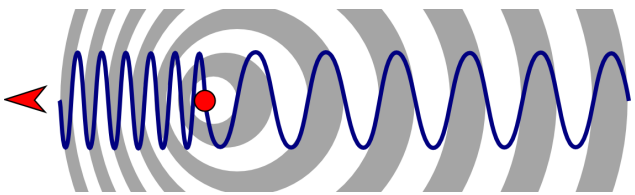
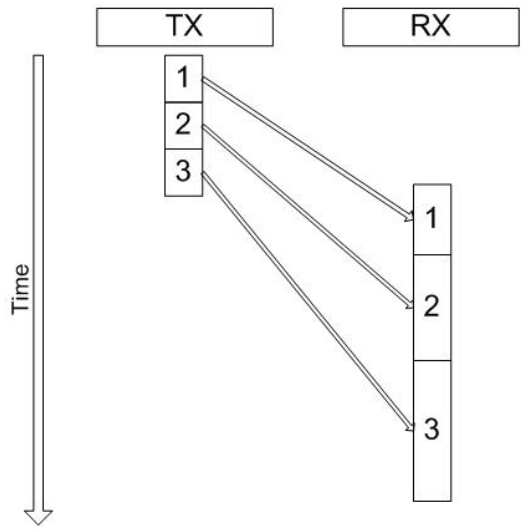
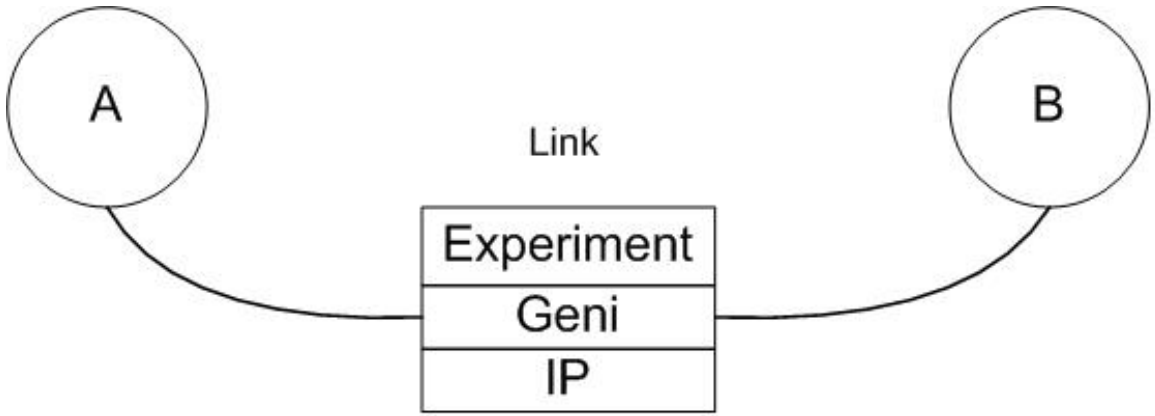




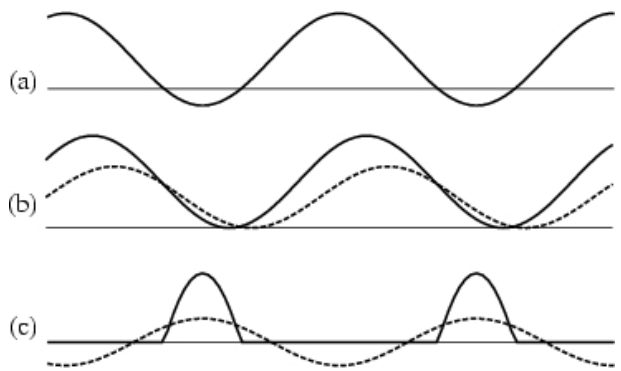
- Doppler Effect
- Propagation Delay as a Function of Time
- Error as a Function of Time

Our Wish for Links

- Management Interface



- Layer for Custom Code
- GUI for Common Configurations
  - Upload, define, or draw a Curve / Function
  - Delay
  - BER
  - Power levels
  - Distance
  - Up/Down status



Where did we get help?

- Wiki
- Tutorials

> The quick start examples are extremely useful!

- DTN example by Mark Berman
- Subscription to Mailing List

Thanks

- The Global Environment for Network Innovations (GENI)
- Flux Group, School of Computing at the University of Utah
- Raytheon BBN Technologies
- The NASA Jet Propulsion Laboratory
- The JHU Applied Physics Laboratory

Questions?