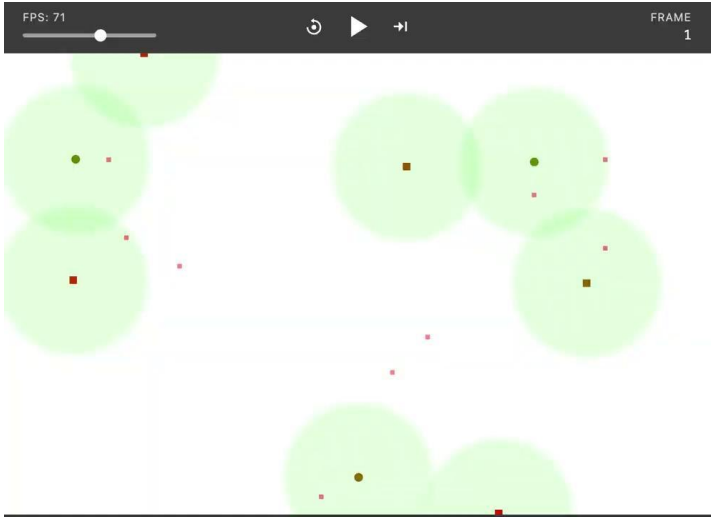
Roaming DTN: Integrating Unscheduled Nodes into Contact Plan Based DTN Networks

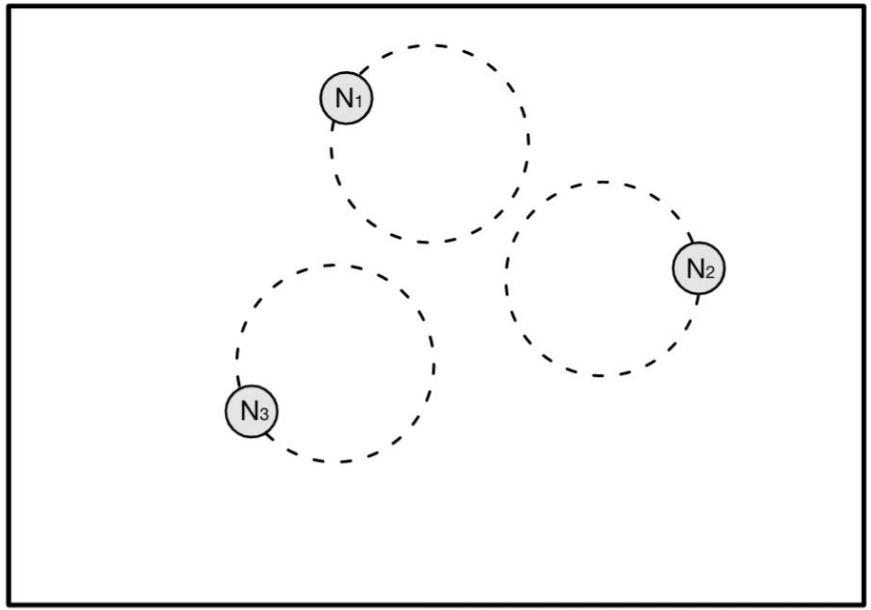


Dominick Ta, Rohan Menon, John Taggart, Andrew Tettamanti,
Seth Feaser, Pablo Torrado, and Joshua Smith

COMPUTER SCIENCE & ENGINEERING
UNIVERSITY of WASHINGTON

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

Motivation: DTN Routing Approaches



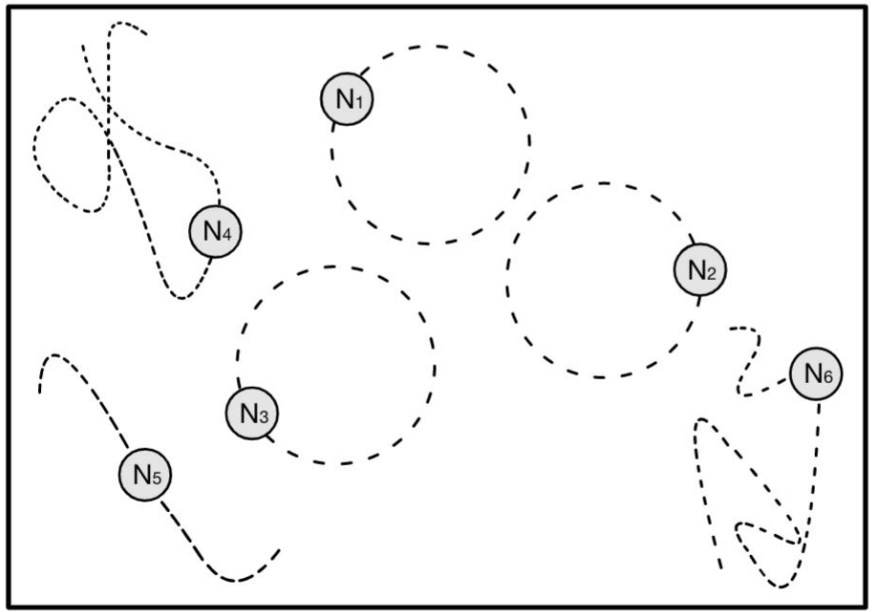
Network containing:

- Scheduled nodes (N1, N2, N3)

Routing Approaches:

- Epidemic
- PRoPHET
- Spray and Wait
- Contact Graph Routing

Motivation: DTN Routing Approaches



Network containing:

- Scheduled nodes (N1, N2, N3)
- Unscheduled nodes (N4, N5, N6)

Routing Approaches:

- Epidemic
- PRoPHET
- Spray and Wait
- ~~Contact Graph Routing~~

Motivation

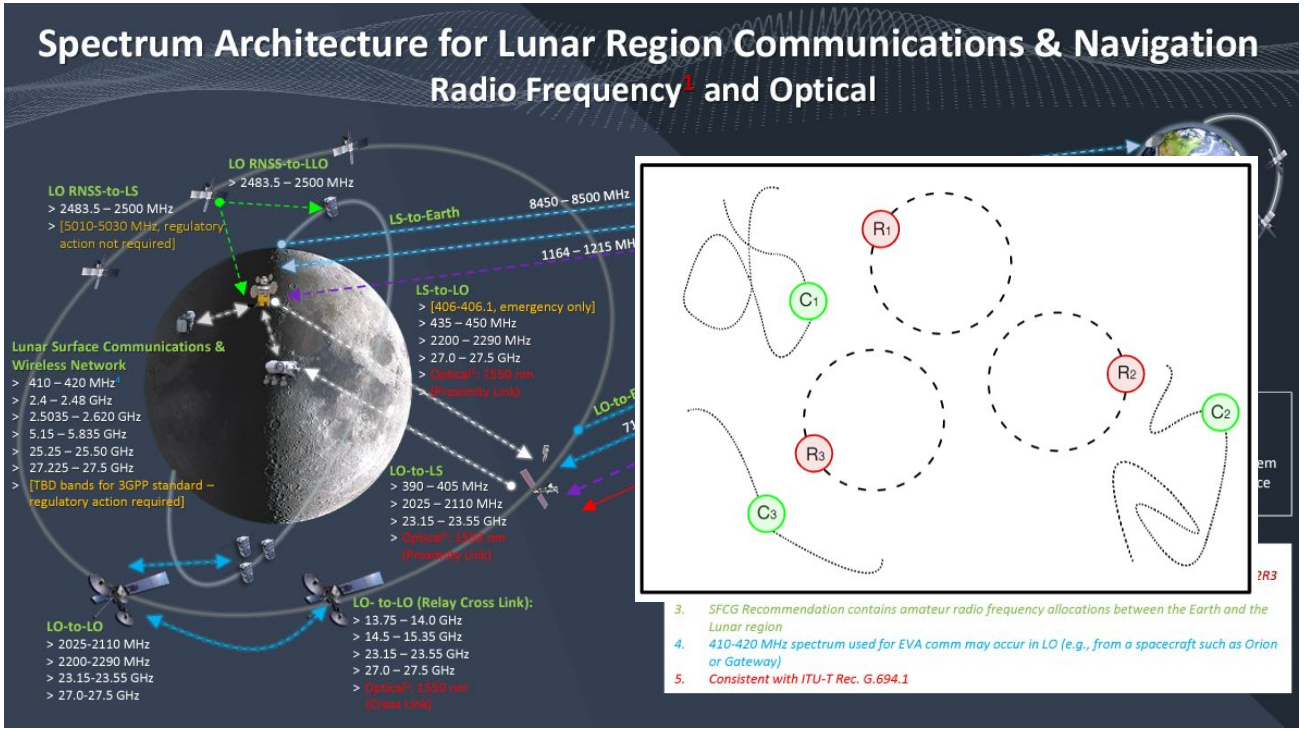


Image Source: https://nescacademy.nasa.gov/video/ddf2b306796040828c7b3bba225099cd1d

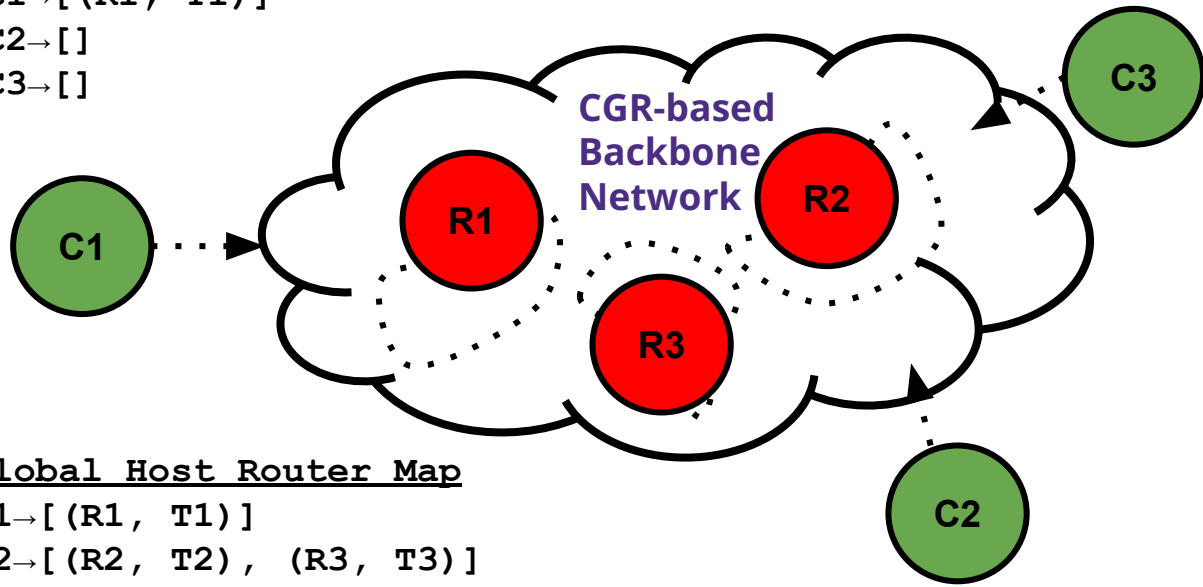
Roaming DTN Overview

Key Terms:

- Backbone Network
- Routers
- Clients
- Connection Range
- Detection Range
- Beacon Messages
- Host Routers
- Host Router Map

R1's Host Router Map

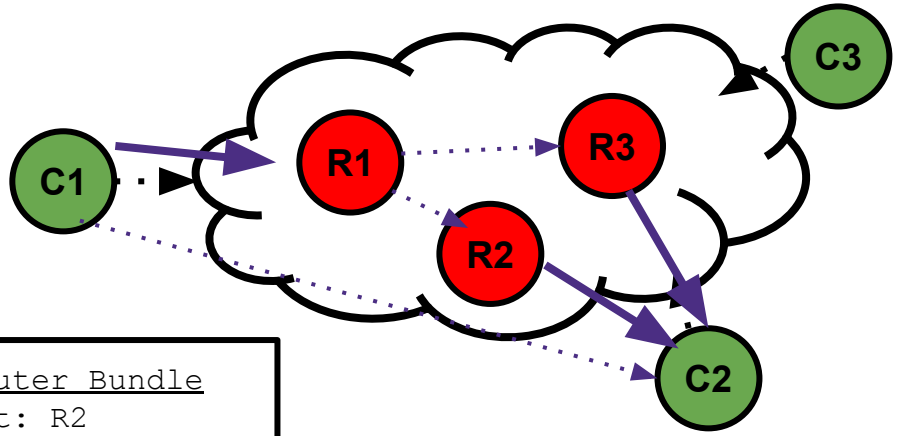
```
C1→[(R1, T1)]
C2→[]
C3→[]
```



Global Host Router Map

```
C1→[(R1, T1)]
C2→[(R2, T2), (R3, T3)]
C3→[(R2, T4)]
```

RDTN Tunneling



Global Host Router Map
C1→[(R1, T1)]
C2→[(R2, T2), (R3, T3)]
C3→[(R2, T4)]

Client Bundle
Src: C1
Dst: C2

1) C1 wants to send a bundle to C2

2) C1 gives the bundle to R1
3) R1 consults its map & creates 2 bundles destined to R2 & R3

Router Bundle
Dst: R2

Client Bundle
Dst: C2

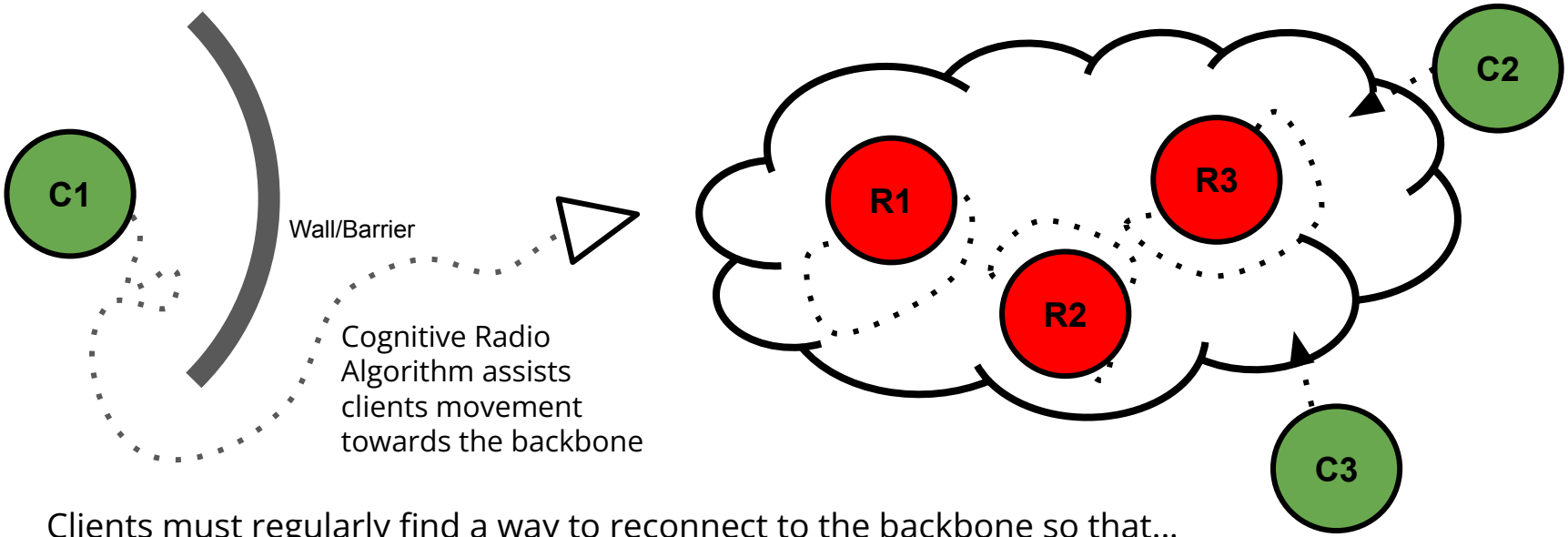
Router Bundle
Dst: R3

Client Bundle
Dst: C2

Client Bundle
Dst: C2

4) Bundle arrives at R2 or R3 via CGR and they unpack it
5) R2 or R3 waits for C2 to pick up the bundle, or the bundle expires

Reconnecting to the Backbone



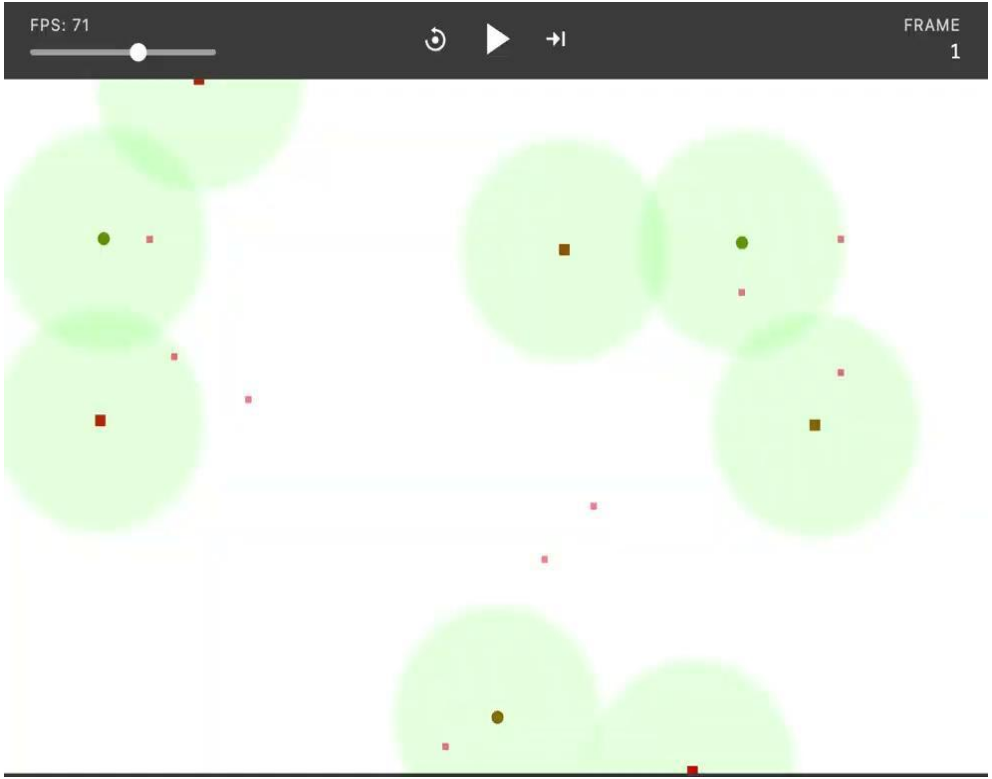
Clients must regularly find a way to reconnect to the backbone so that...

- host routers/client locations are regularly updated
- clients can regularly offload data from its disk

Simulation Experiments

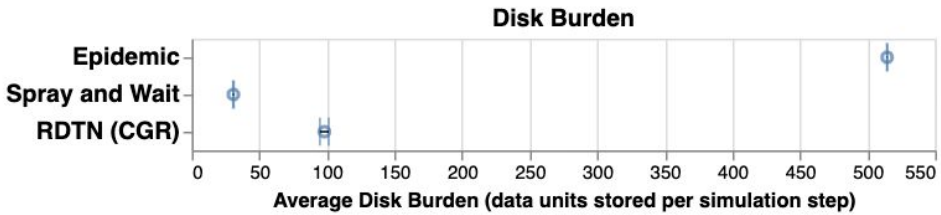
Developed a simulator to evaluate custom implementations of Routing Algorithms

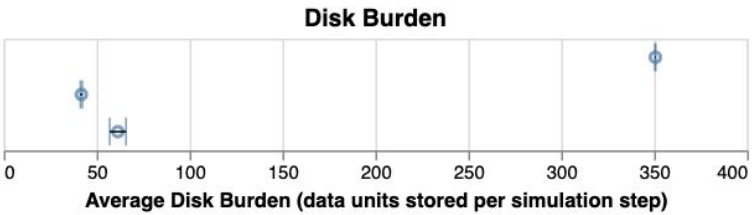
- Supports Epidemic, Spray and Wait, and RDTN
- Web-based visualization
- Python-based implementation
    - CGR support from pyCGR by Juan Fraire

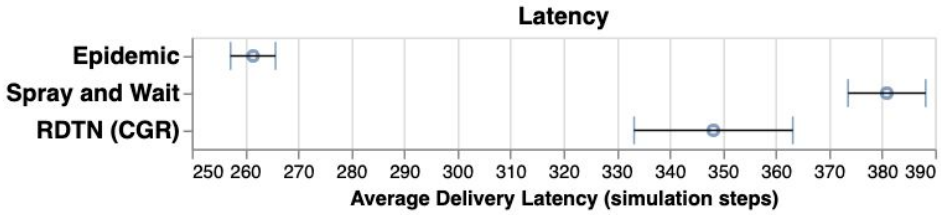


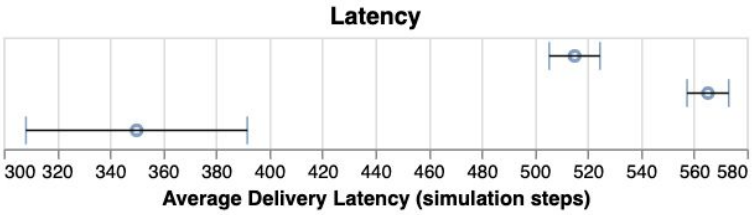
Simulation Results

Success rate was high for all routing approaches



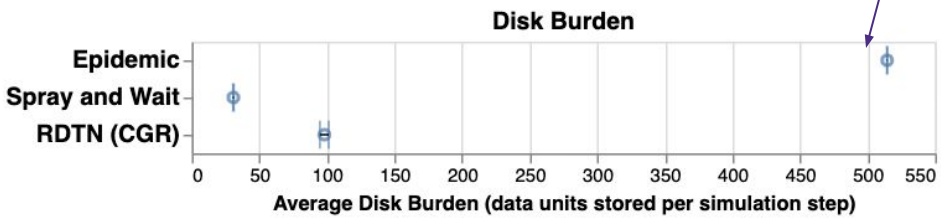


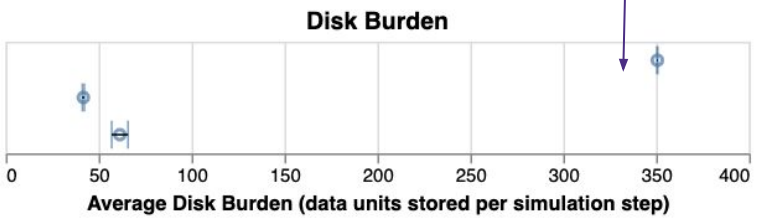


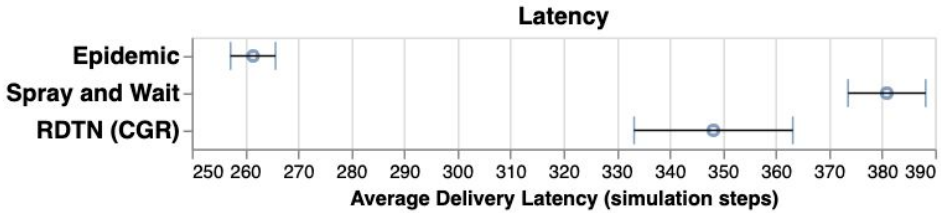


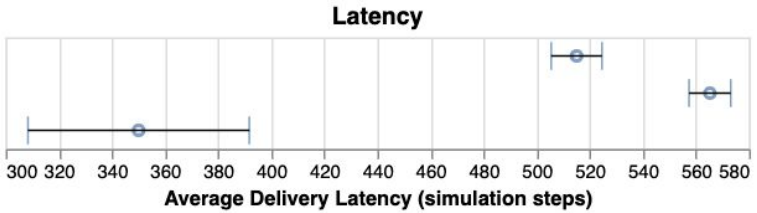
Simulation Results

Epidemic consistently used the most disk space, with Spray and Wait using the least, and RDTN close behind.





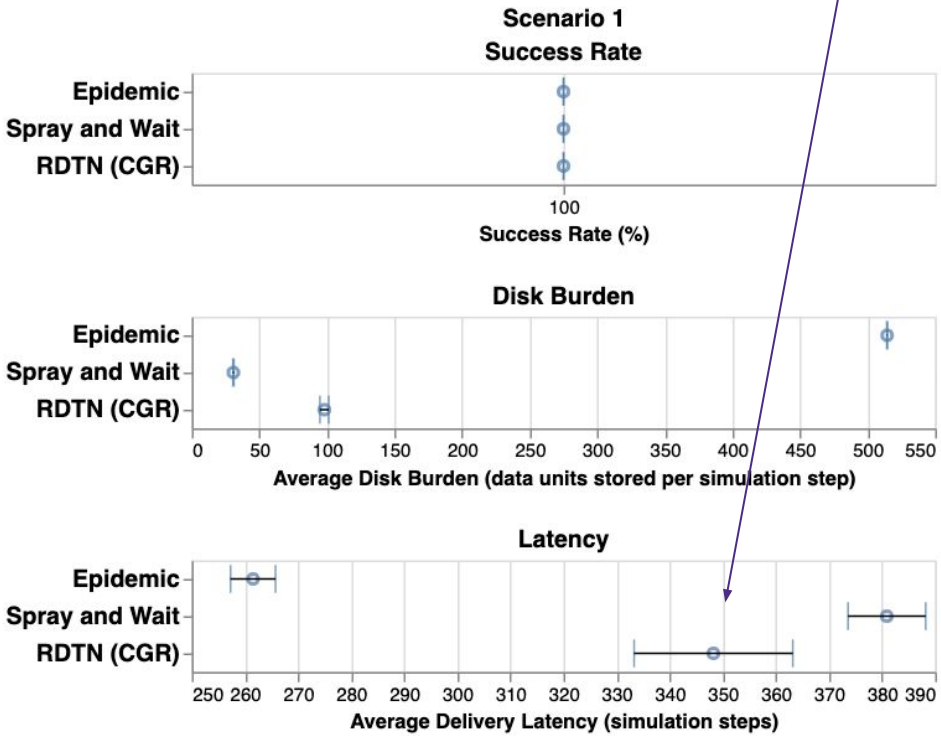


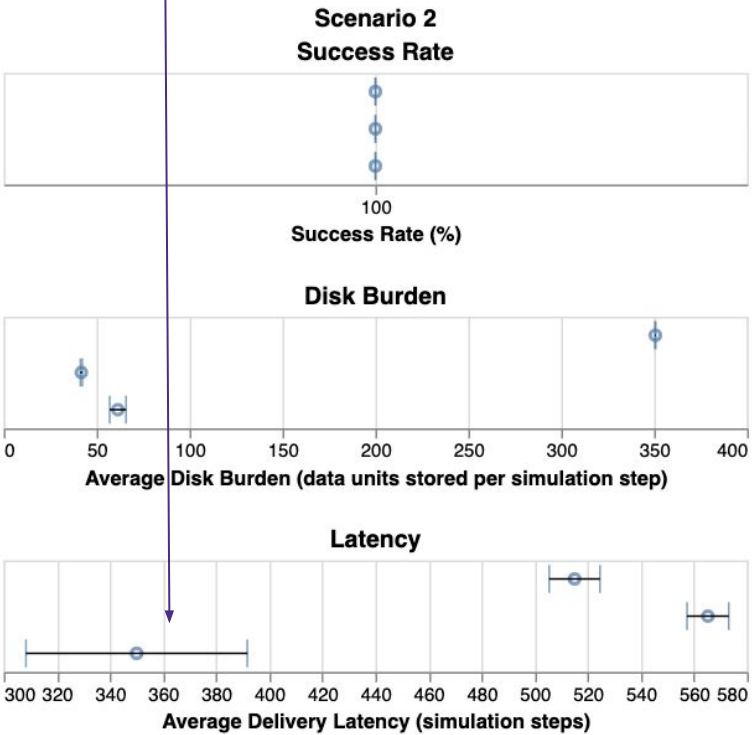


Simulation Results

Epidemic usually had the lowest delivery latency, with RDTN and SAW having higher delivery latencies.

However, we saw one scenario where RDTN had the least latency





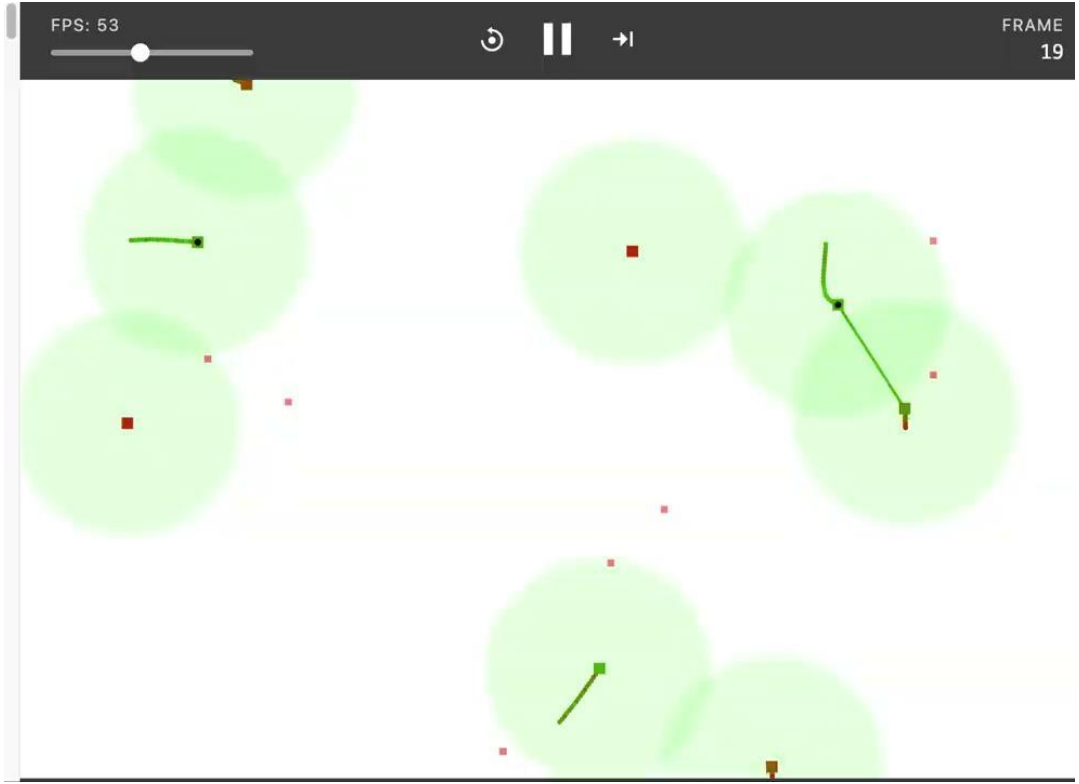
Simulation Results

Scenario where RDTN had best latency:

- Very sparse connectivity
- Very slow routers

Clients are using Epidemic

- If a client happens to connect to another node, they will flood
- This is a sparse network so connections happen rarely



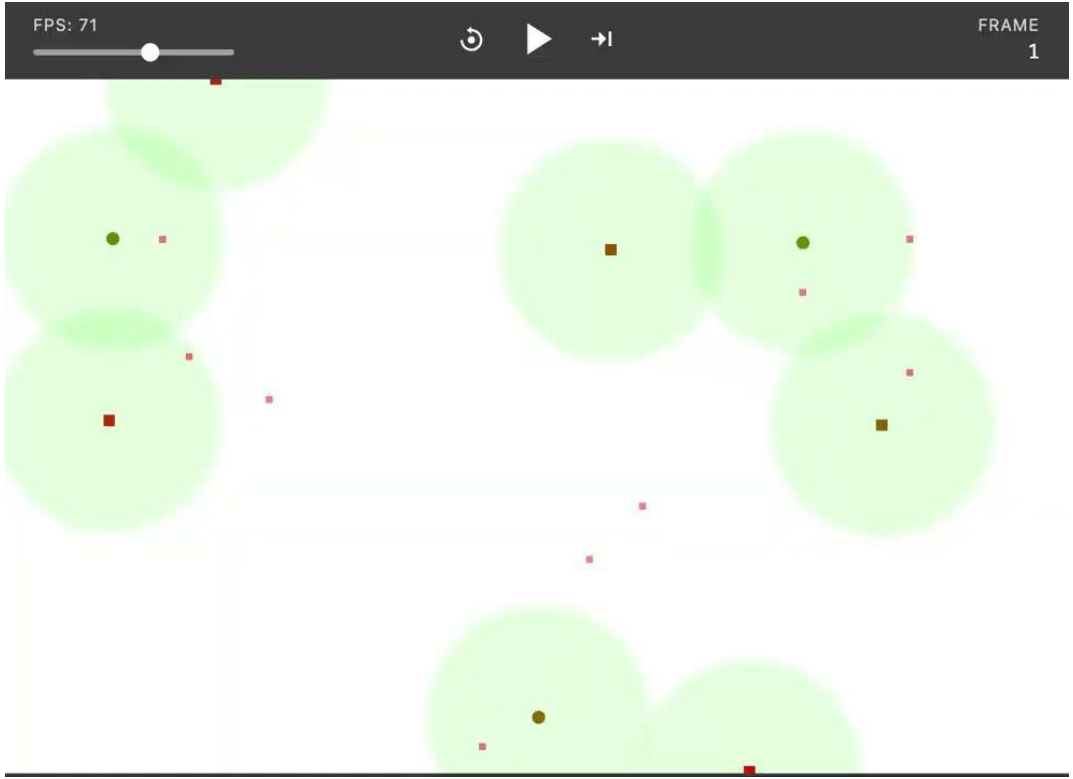
Simulation Results

Scenario where RDTN had best latency:

- Very sparse connectivity
- Very slow routers

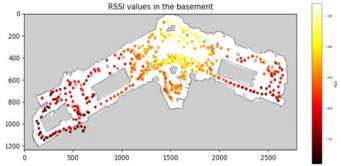
Clients are using RDTN

- Every so often, clients use a cognitive radio algorithm to navigate towards a router and force a connection
- This results is more connectivity and ultimately lower latency

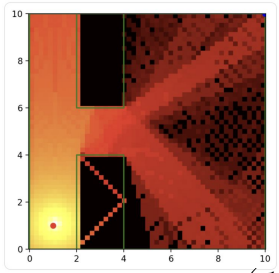


Future Work

RSSI Data Collection

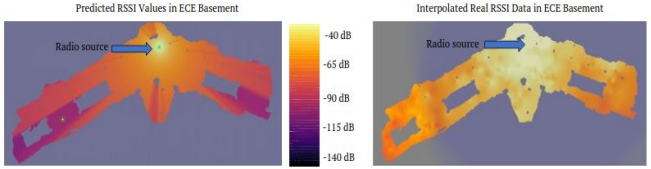


Simulated Data Generation



$$RSSI = 10 \cdot C \cdot \log_{10}\left(\frac{1}{D}\right)$$

Comparison of Simulated vs Collected RSSI Highlights Complexities



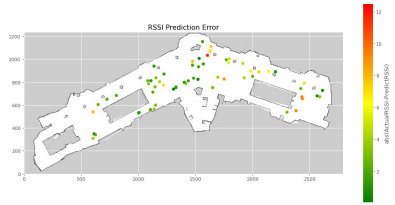
Total Least Squares Converging on a Source

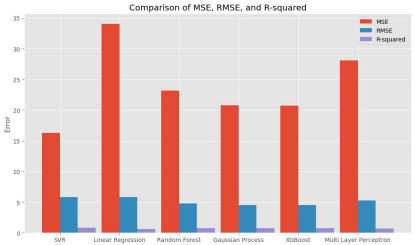
Simulated RSSI Data

Real RSSI Data

$$RSSI = 10 \cdot C \cdot \log_{10}\left(\frac{1}{\sqrt{(a-x)^2 + (b-y)^2}}\right)$$

Currently working alternative ML models





Conclusions

Roaming DTN is a simple but effective approach that enables unplanned nodes to communicate over a CGR-based network.

- Allows clients to communicate w/ CGR despite not being part of the contact plan
- Preserves network topology of a structured CGR backbone network
  - Enables unplanned nodes to be untethered & free to connect to any router
  - Enables cognitive radio algorithms that help disconnected clients reconnect to the backbone network

Further research is needed to determine the characteristics of scenarios in which RDTN would provide the most benefit.

Thank you!

Any questions?