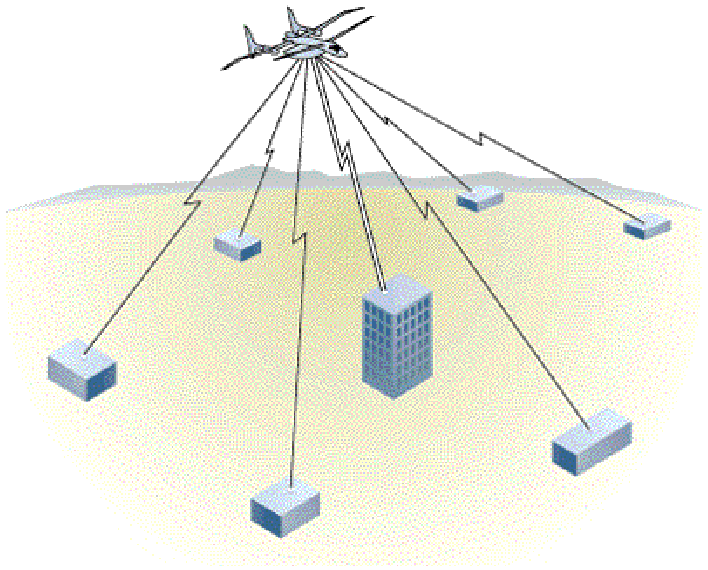
Simulating Large-Scale Airborne Networks with ns-3

Ben Newton, Jay Aikat, Kevin Jeffay

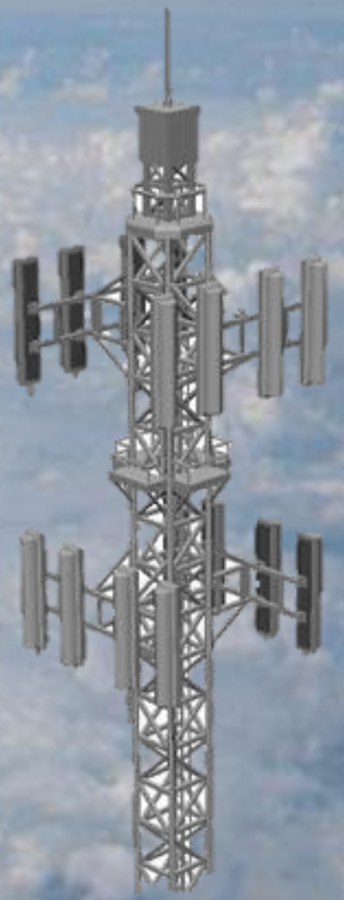
May 13, 2015 – Workshop on NS-3 – Barcelona Spain

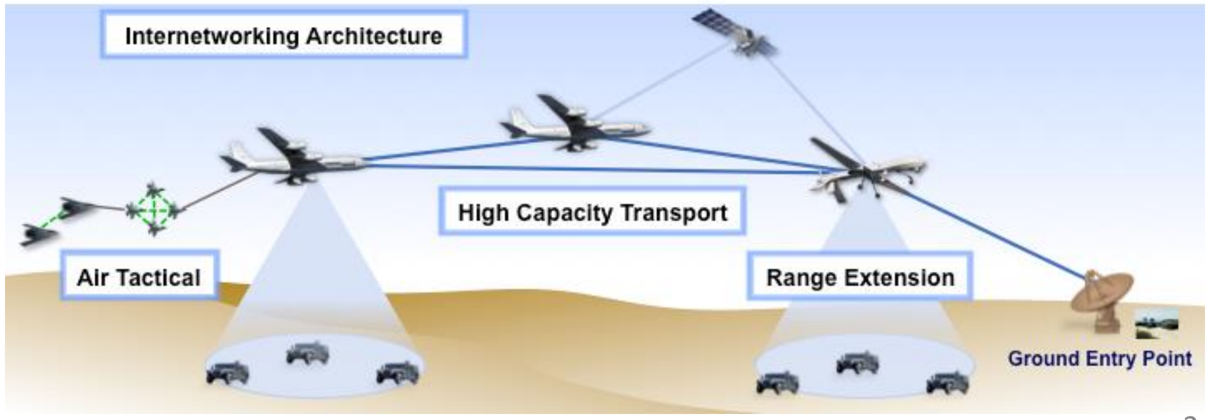
THE UNIVERSITY *of* NORTH CAROLINA *at* CHAPEL HILL

Airborne Networks



Angel Technologies - 1998





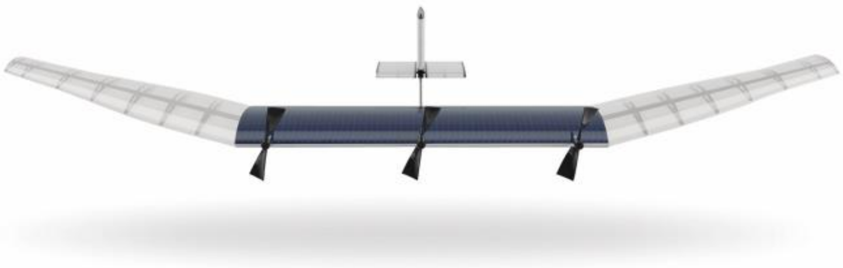
Google Vs. facebook

"How do we get access points up high and cheaply?"

–Larry Page
March, 2014 [1]

"We've been working on ways to beam internet to people from the sky."

–Mark Zuckerberg
March 27, 2014 [2]



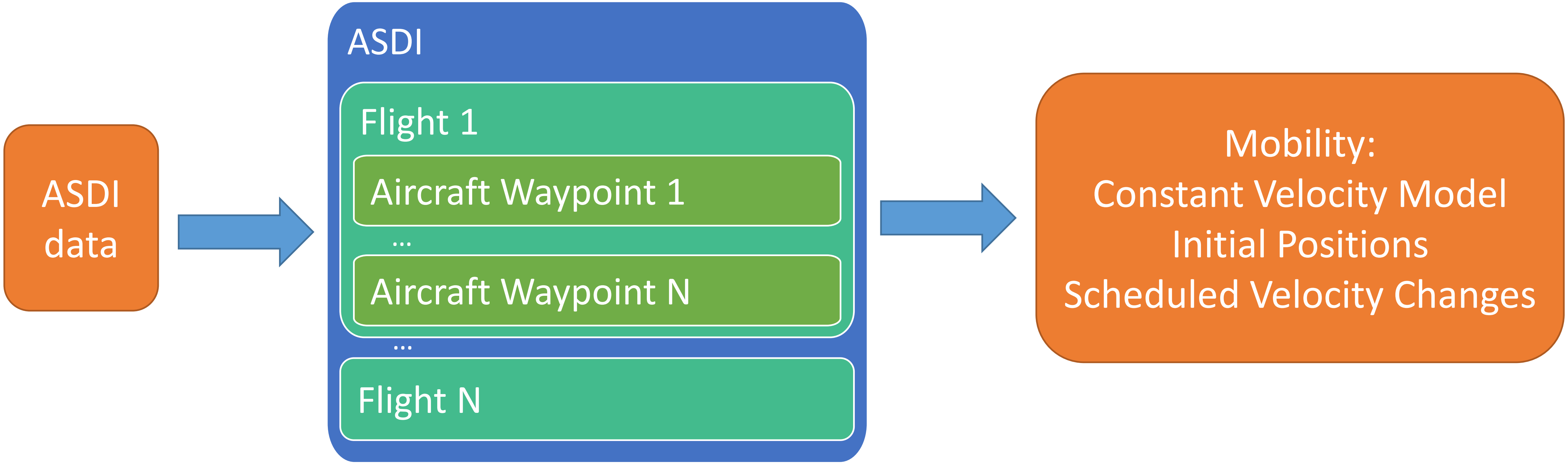
Overview

- Airborne Networks must be simulated
- New Models
  - ASDI Model
  - Steerable Directional Antenna Model
  - Wireless Point-to-Point Channel
  - Wireless Point-to-Point Net Device
- Topology Control Application
- Adapted PyViz
- Preliminary Results - OLSR

ns-3 NETWORK SIMULATOR

ASDI Model

- Aircraft Situation Display to Industry (ASDI)
  - Position, velocity, call sign, some flight plan information

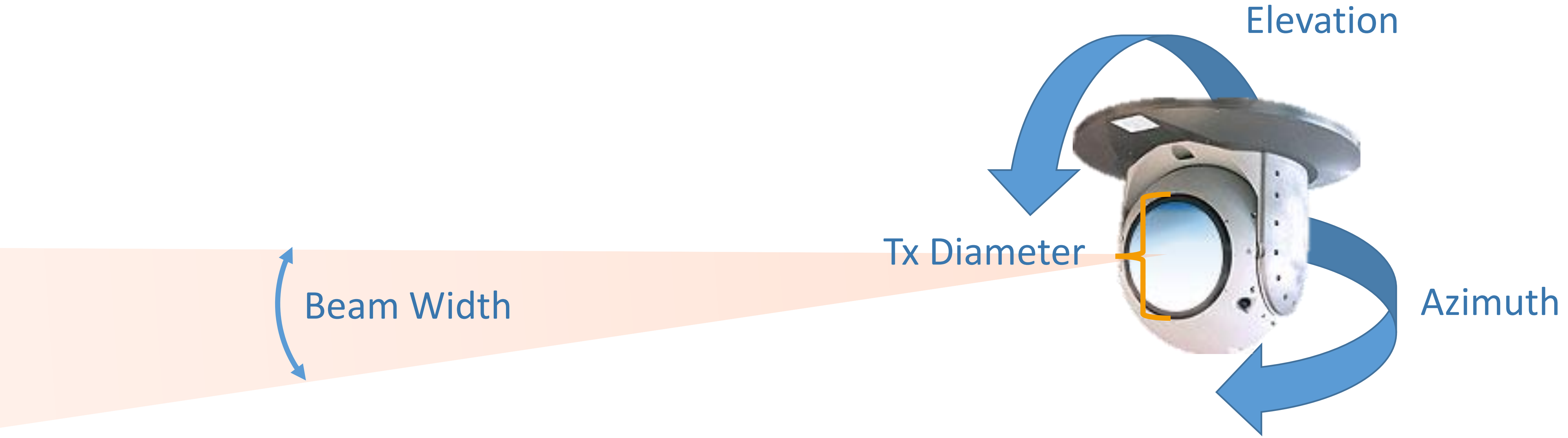


Free Space Optics (FSO)

- Wireless fiber-optics
- Infrared lasercom
- With a hybrid RF/FSO link DARPA has demonstrated: [3][4]
    - Techniques that can effectively counteract severe turbulence
    - Ranges up to 200 km (air-to-air)
    - Data Rates up to 9 Gbps

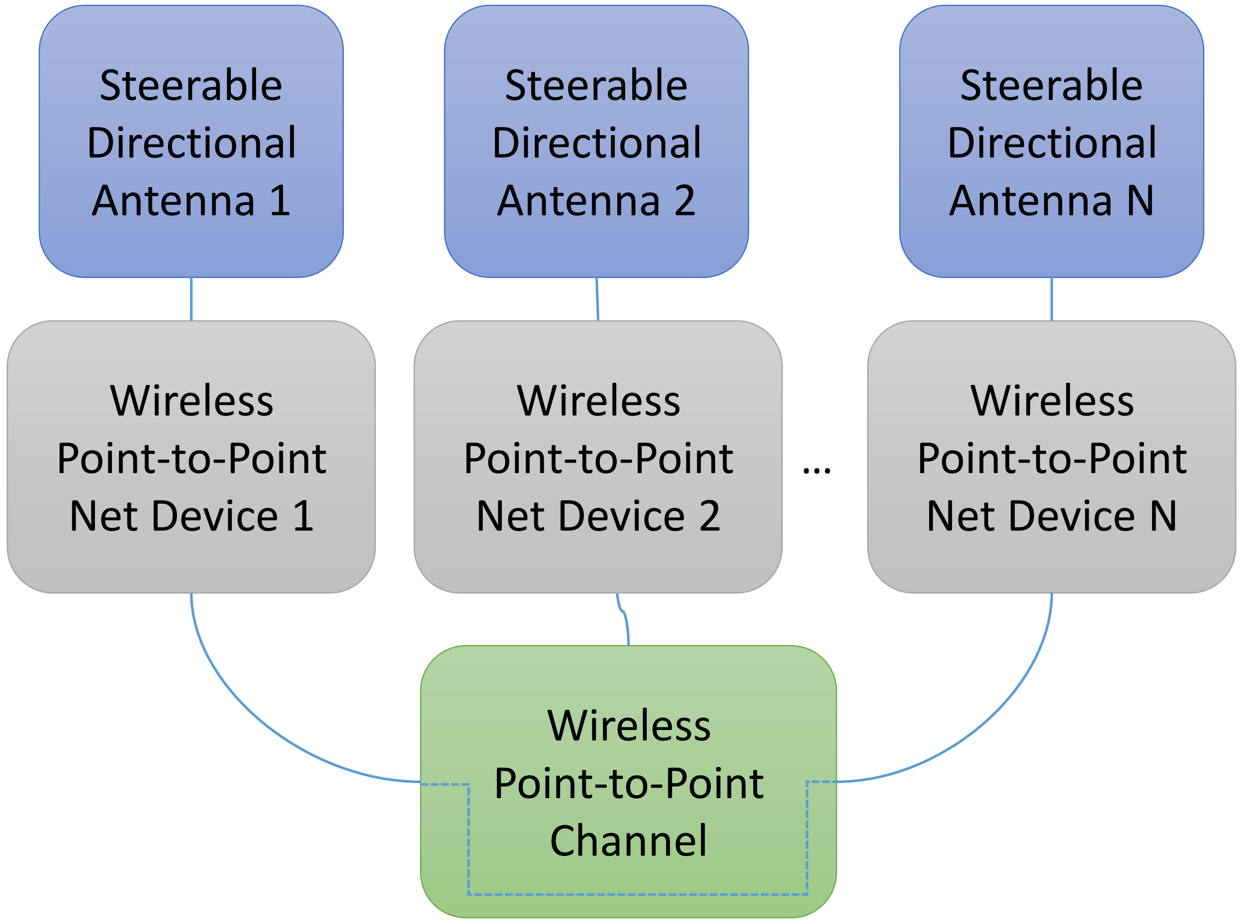
Steerable Directional Antenna

- Inherits from AntennaModel and adds:
  - Location - Pointer to a mobility Model



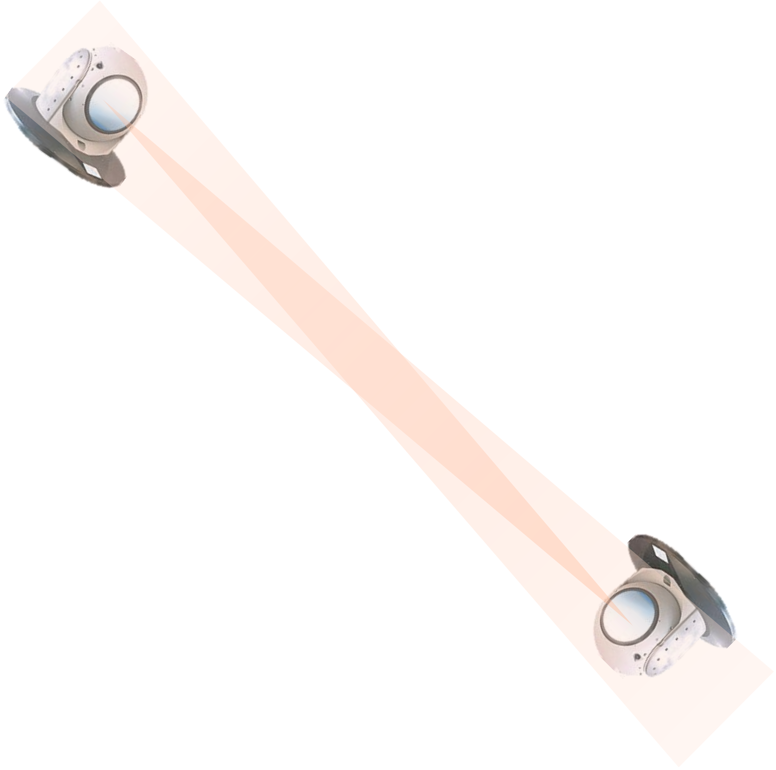
Wireless Point-to-Point Channel and Net Device

- Directional = Minimal Interference,
  - For now, ignore interference
- Channel need only forward packets between Net Devices whose antennas are aligned.
- When packet arrives at the channel it:
  - Determines which NetDevice is aligned with the source NetDevice
  - Schedules the future receipt of the packet on the destination NetDevice
  - or drops it.



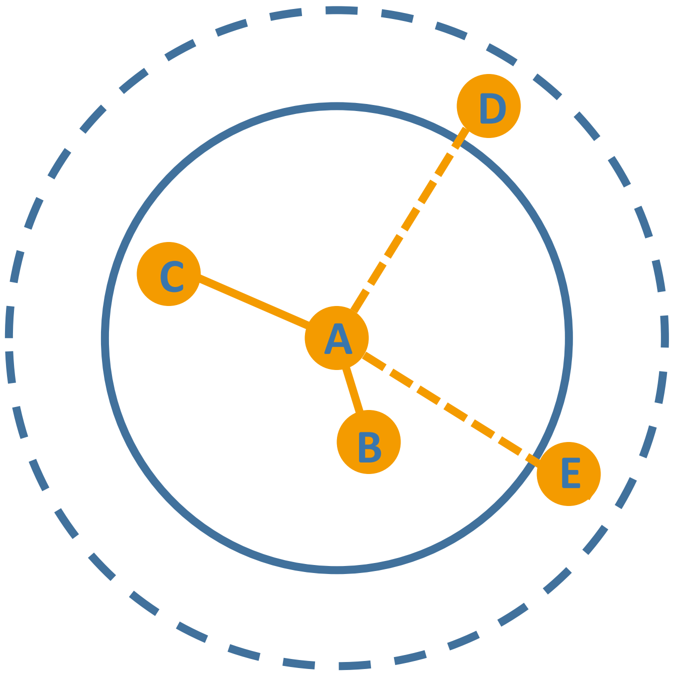
Two Modes

- Checked Alignment Mode
  - Actual pointing of the antennas is simulated
  - Two antennas pointed at one another are considered aligned
  - Alignment checked periodically
- Commanded Alignment Mode
  - Assumes tracking system manages pointing once connected
  - Less overhead
  - Alignment controlled explicitly



Omnidirectional

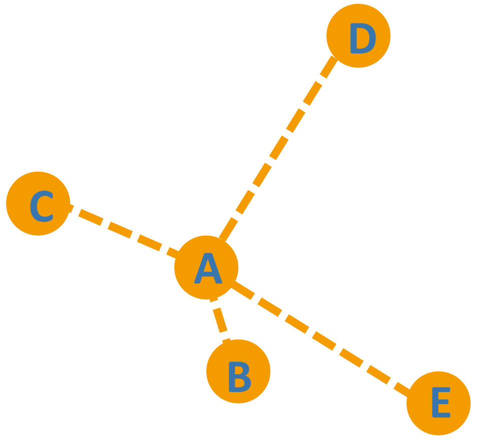
Implicit Topology Control



More Tx Power = Larger Range
Degree virtually unlimited

Directional

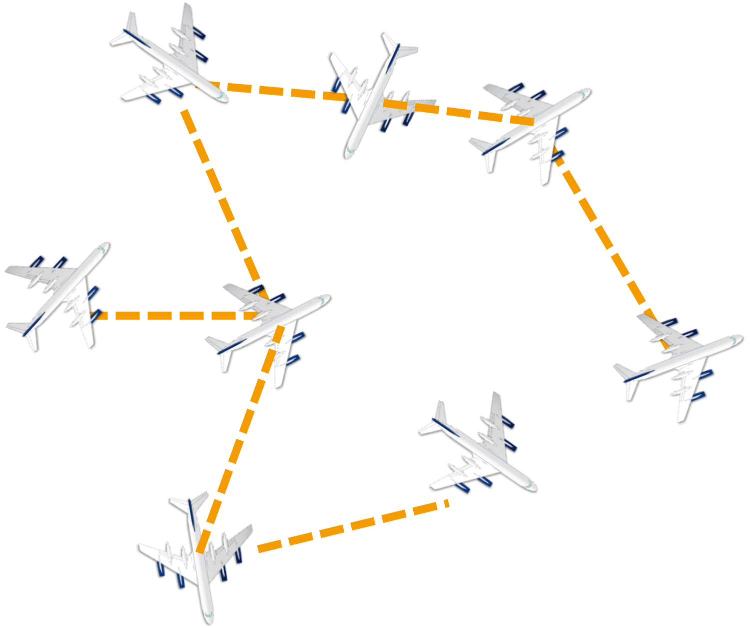
Explicit Topology Control



Explicitly choose which nodes to connect with.
Degree limited to the number of links on each node.

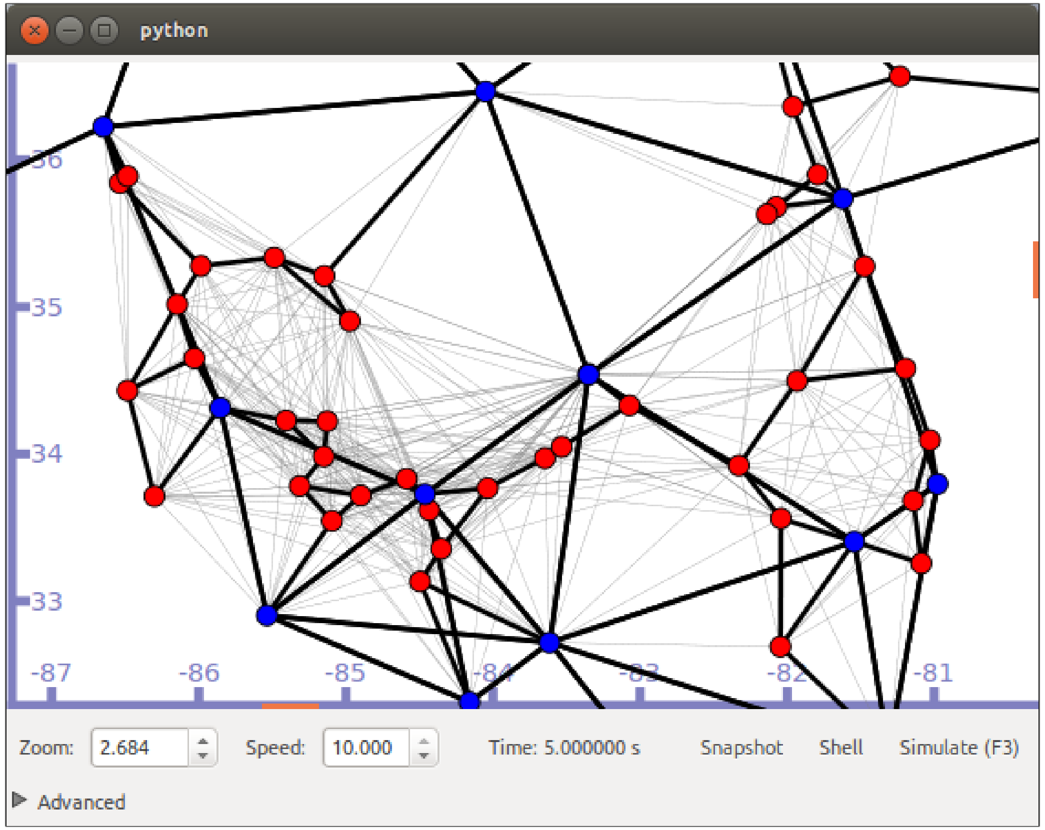
Topology Control Application

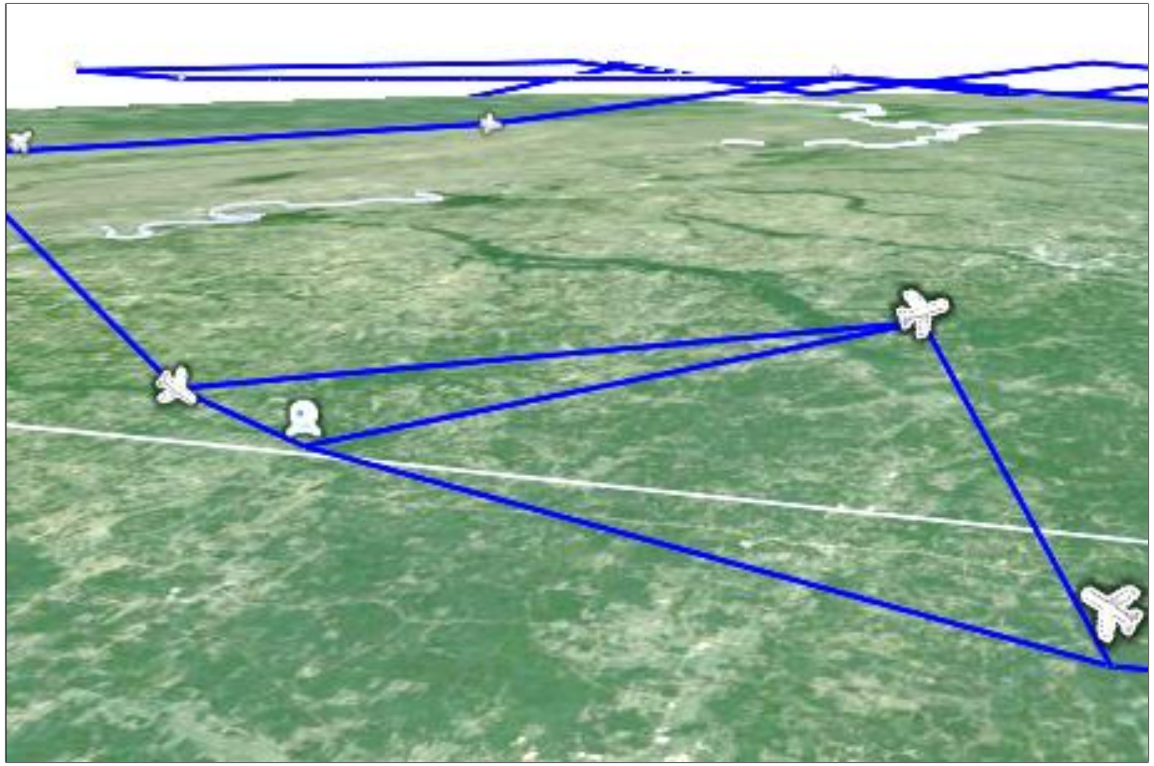
- Which connections should be formed?
  - Physical Topology not routing topology
- Given a set of nodes each with N links, which N neighbors should each node connect with?
- Experimenting with a distributed Topology Control Protocol
- Topology Algorithm
  - Robust
  - Inclusive
  - Honors degree constraints



Ben Newton, Jay Aikat, Kevin Jeffay, "Analysis of Topology Algorithms for Commercial Airborne Networks", 2014 IEEE 22nd International Conference on Network Protocols (ICNP), pp. 368-373, doi:10.1109/ICNP.2014.60

Demo


python
36
35
34
33
-87
-86
-85
-84
-83
-82
-81
Zoom: 2.684
Speed: 10.000
Time: 5.000000 s
Snapshot
Shell
Simulate (F3)
Advanced

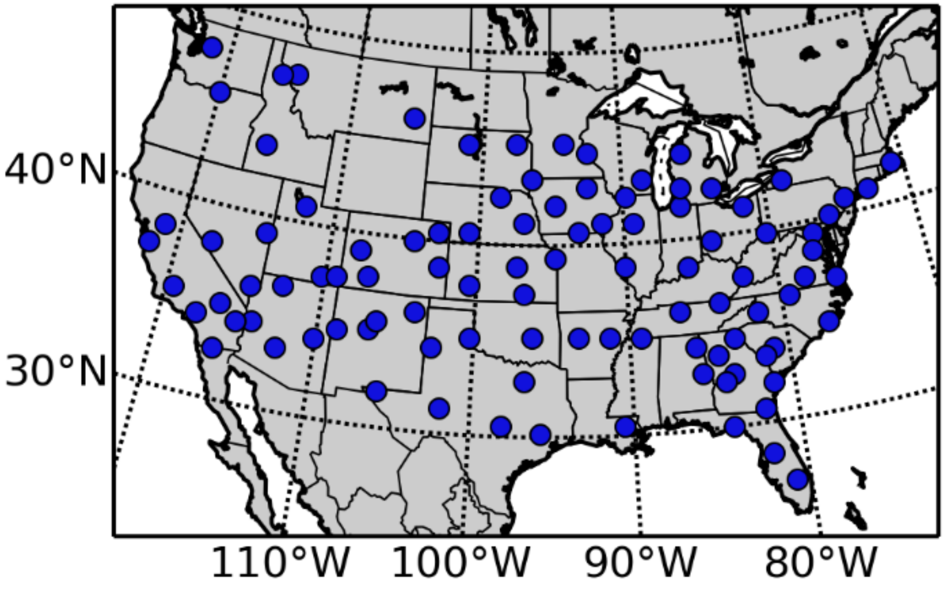


Experiment

- Optimized Link State Routing Protocol (OLSR)
  - Proactive mobile ad-hoc network routing protocol
  - High overhead, low latency.
  - Adjustable Hello Interval
- Attributes
  - Area – Contiguous United States
  - Nodes – 3 to 588 – real aircraft positions
  - Link Data Rate - 10 Gbps
  - UDP Flows to each aircraft from the nearest ground station
  - UDP Flow Rate – 1 Mbps
  - Simulation Time - 10 minutes
  - Air-to-air range – 200 km
  - Hello interval values – 2.0, 0.5, 0.125

Assumptions:

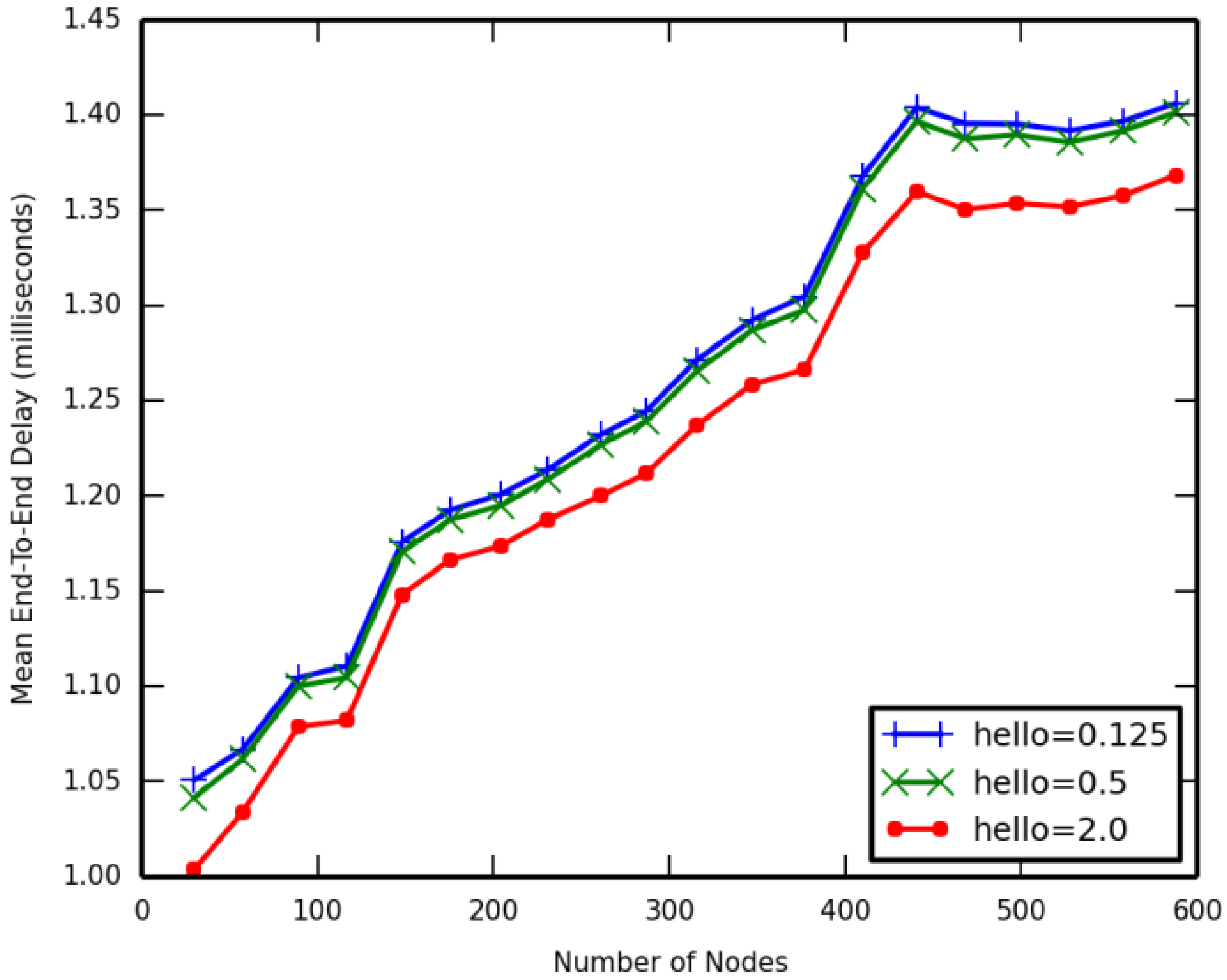
- 3 links per node
- No clouds
- Perfect links (no bit errors)
- Simple MAC and PHY



100 Ground Stations

End-to-end Delay

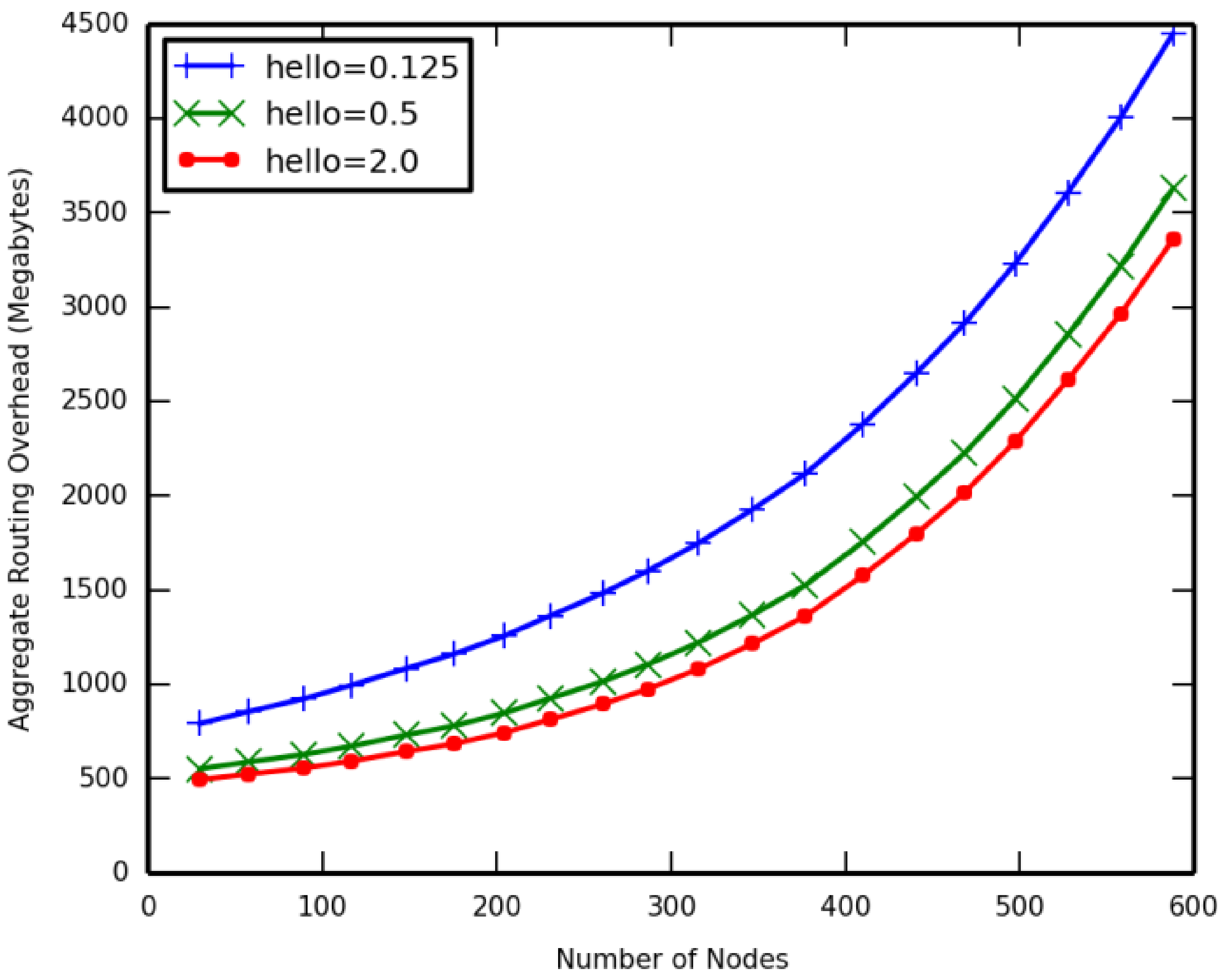
Small delay values: Simple MAC



More nodes -> More hops -> More delay

Routing Overhead

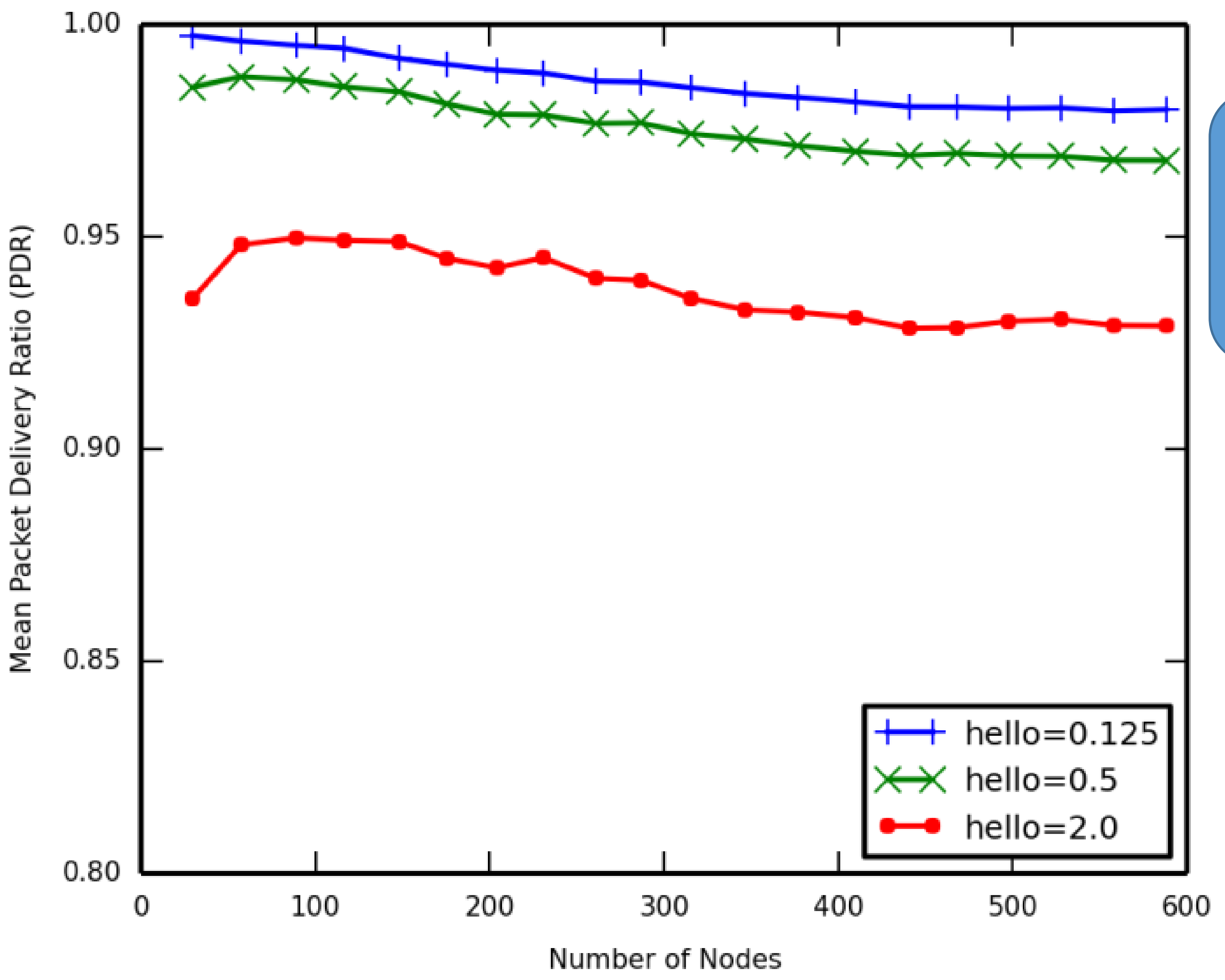
Quadratic growth in overhead



Won’t scale well

Packet Delivery Ratio

Very small hello interval required for reliable delivery



More nodes -> More hops -> Higher probability packet will be lost

Conclusion

- New Models
- Visualization
- Preliminary Results – OLSR
- Future
  - Increase realism
  - Remove limitations.

Questions?