



Performance of Mobile Ad Hoc Networking Routing Protocols in Realistic Scenarios

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Introduction

- Ad hoc networks
 - No fixed infrastructure
 - Node routes and forwards data
 - Routing plays a significant role
- Next generation military devices and routing protocols need to adapt to the large network populations and dynamic network topology of ad hoc networks
- The many definitions of scalability (details to follow):
 - Scalability to network size, node density, mobility, and number of hops
 - Robustness to network load, and numbers of sources and destinations
 - Graceful degradation of network performance in the presence of excessive amounts of any of the above

Scalable Routing

- A scalable routing protocol must continue to provide:
 - High throughput
 - Low end-to-end delay
 - Minimal routing control overhead
 - High packet delivery ratio
- as a function of

Scalable Routing Criteria

- Network Size
 - Maintain routing table size and low control overhead as network size grows
- Node Density
 - Manage the effects of interference, multiple or no paths, hidden and exposed terminal problems
- Number of Hops
 - Minimize control overhead and search latency and select appropriate metrics for choosing from multiple paths
- Mobility
 - Discover breaks in old routes quickly and acquire new routes with minimal control overhead
- Number of Sources and Destinations
 - Maintain only active routes efficiently
- Network Load
 - Achieve rapid route stabilization despite increased interference with control packets as network load increases

Experimental Metrics Analyzed

- Mean throughput per node
 - Determines how well protocols permit applications to optimize use of the available bandwidth
- Control overhead
 - Ratio of the number of control packets processed divided by the total number of data and control packets processed
 - Assesses the efficiency of the protocol in terms of available bandwidth for data packets and the effect of control packets on latency and the packet delivery ratio

Experimental Metrics Analyzed (cont'd)

- End-to-end delay or latency
 - Measures the time to traverse the path and the time cost of the protocol's route discovery
- Packet delivery ratio
 - Ratio of the number of packets actually received over the number of packets that are supposed to be received
 - Quantifies how well applications are able to perform given the routing overhead

Routing Protocols Compared

- OSPFv2
 - Traditional wired link state routing protocol
- AODV and DSR
 - Wireless ad hoc on-demand routing protocols
 - Route acquisition latency, path quality issue
- OLSR
 - Wireless ad hoc link state routing protocol
 - Subset of nodes act as relays
- ZRP
 - Wireless ad hoc hybrid routing protocol
 - Parameter sensitive

Realistic Scenario

- DARPA FCS Communications Program Live Exercise
- GPS logs of node positions for initial placement and mobility
- Traffic generation scripts using MGEN in the field and the simulation
- 4 hour simulation, 1 base station, 19 mobile nodes
- Wireless routing protocols: **AODV**, **DSR**, **OLSR**, **OSPFv2**, and **ZRP**
- MAC Layer: IEEE 802.11 DCF with a channel bandwidth of 2Mbps
- Terrain effects modeled by path attenuation routine

Terrain Effects

- Terrain effects modeled by custom path attenuation model from MITRE
- Dual counter-rotating rings with 5 inner and 14 outer loop nodes

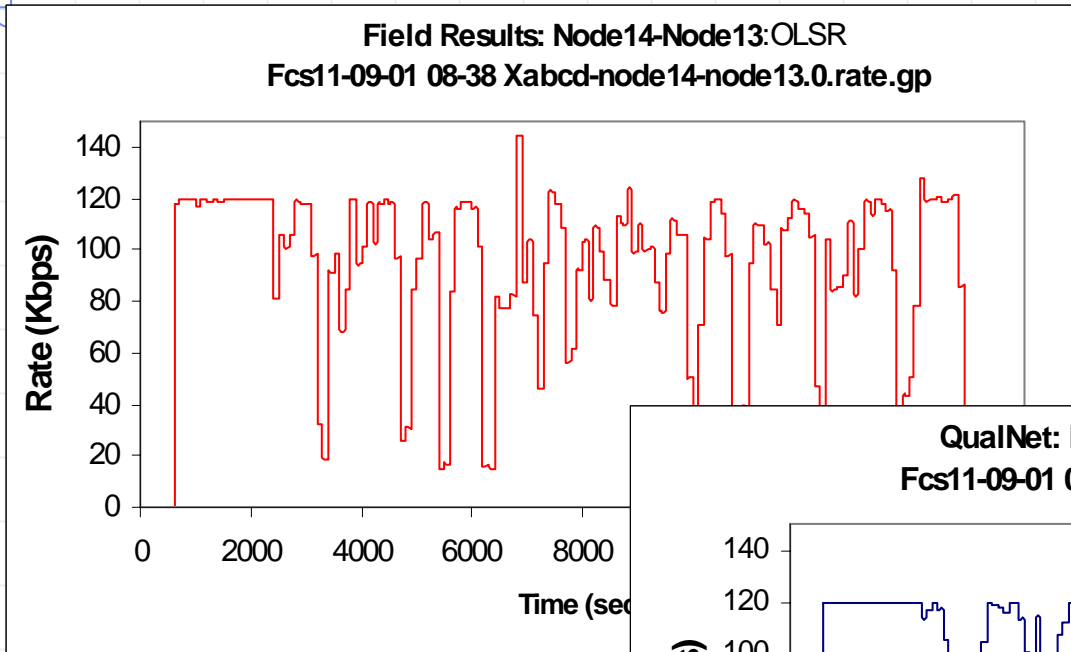


QualNet Network Simulator

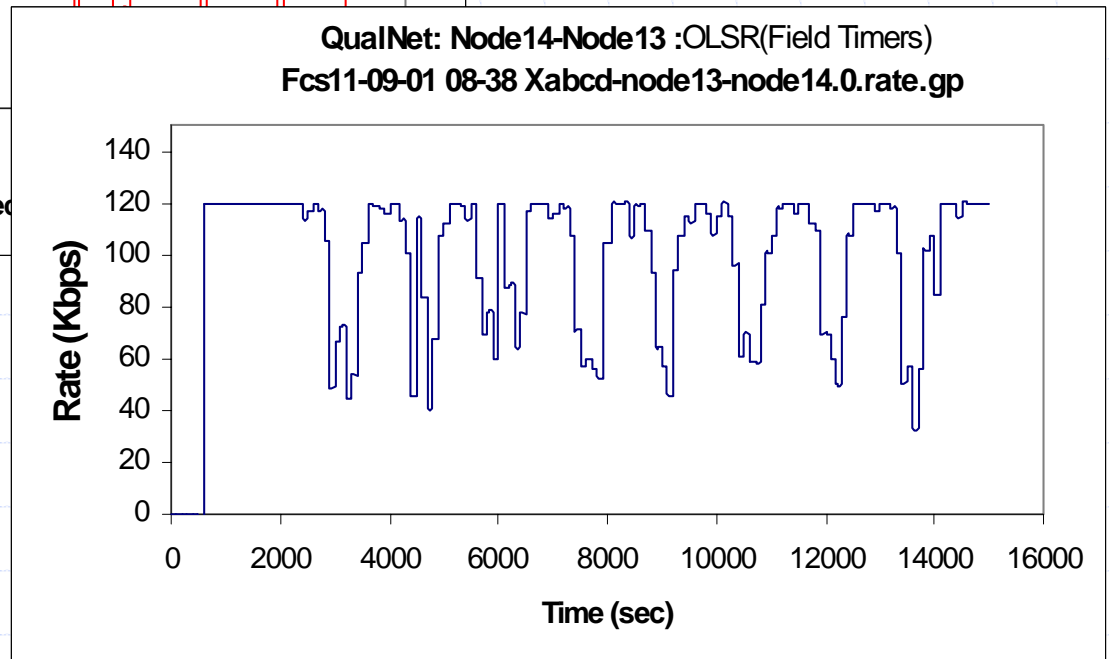
- Simulator used for research
- <http://www.qualnet.com>
- Commercial version of GloMoSim developed at UCLA
- Fast, efficient and detailed network simulator for both wired and wireless networks
- Ability to simulate thousands of nodes without using abstraction

Simulator Validation

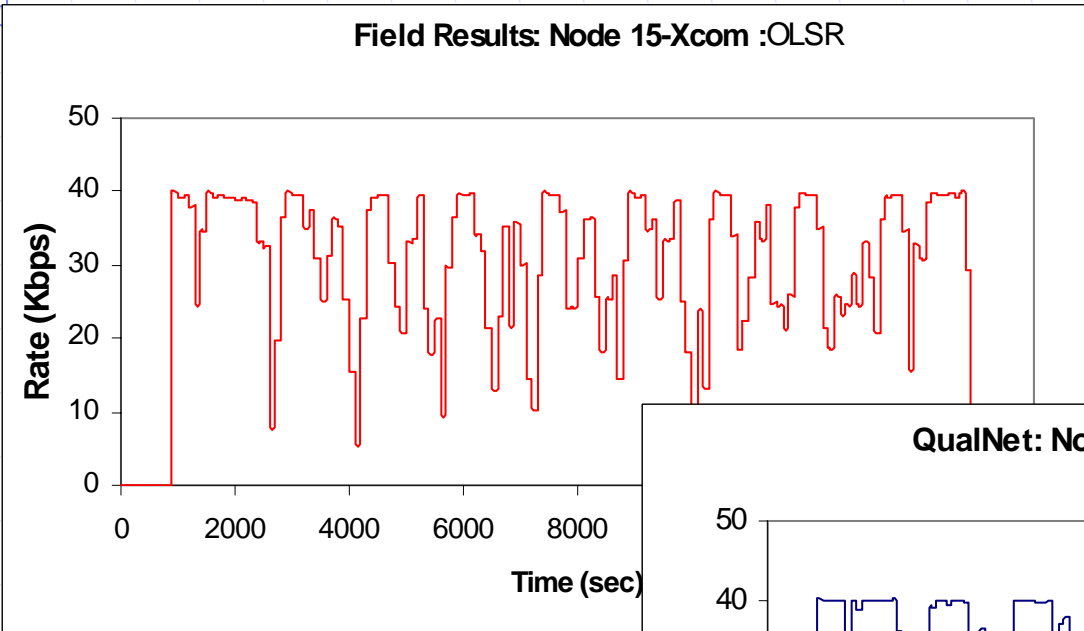
- Node by Node Validation of MGEN's received traffic logs



- High Rate Traffic

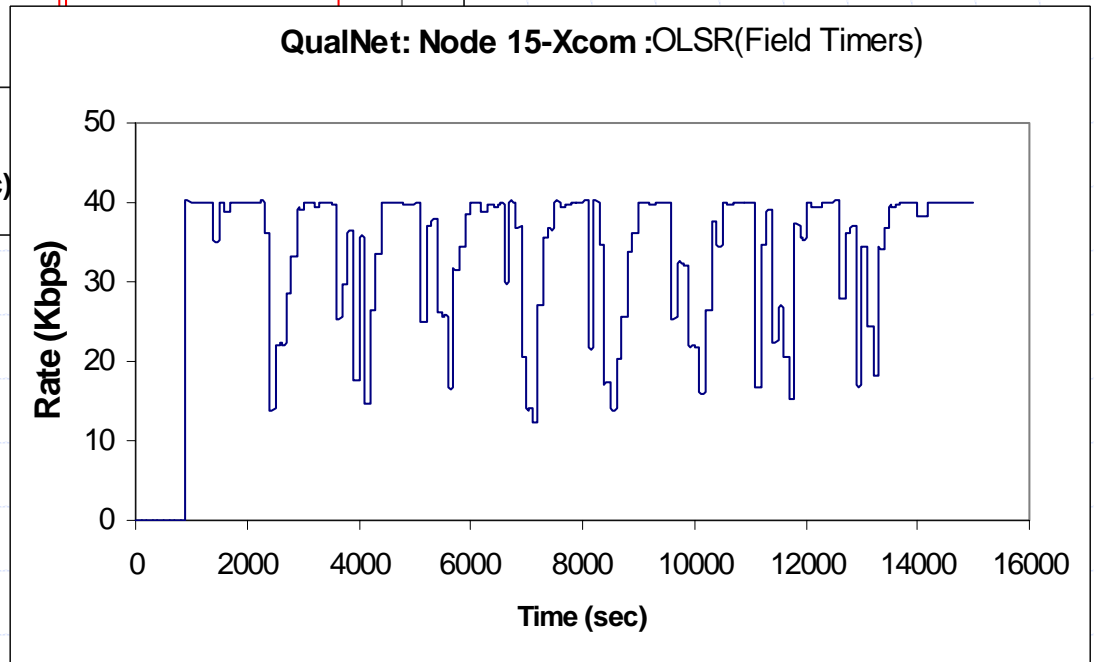


Simulator Validation



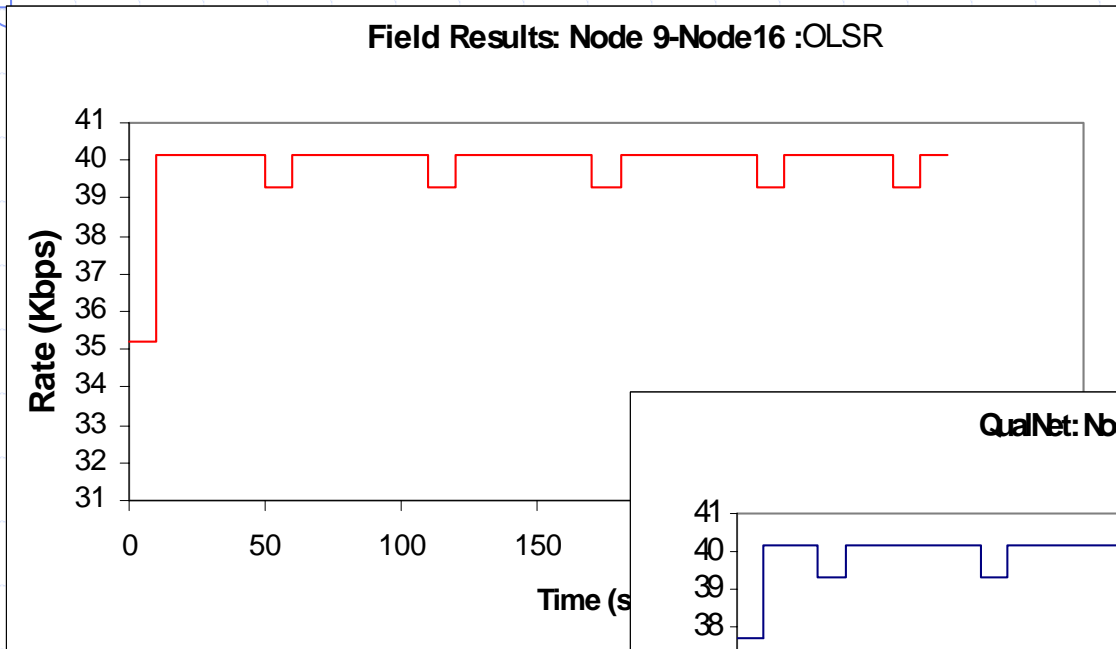
- Selected nodes showing typical correspondence for each flow type

- High Rate Report Traffic

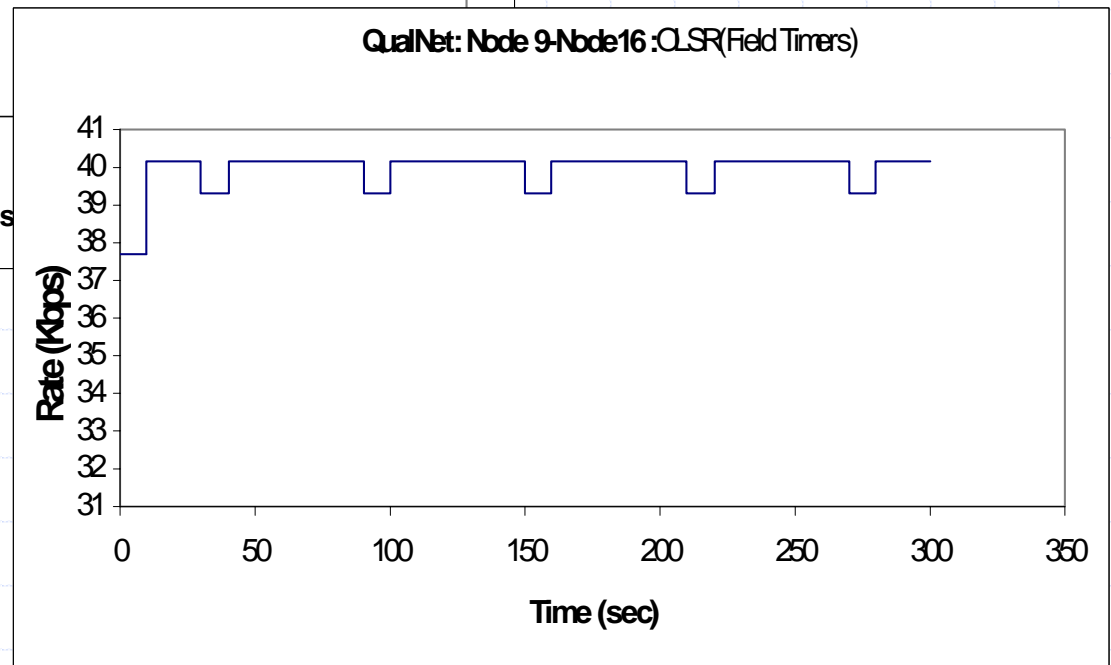


Simulator Validation

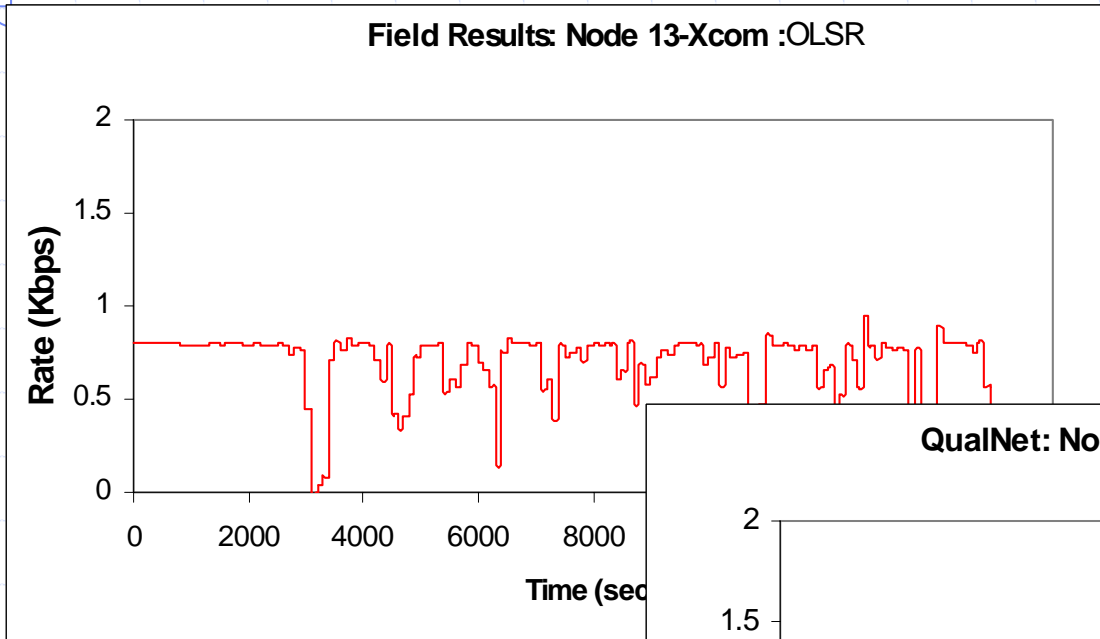
- Mostly single hop



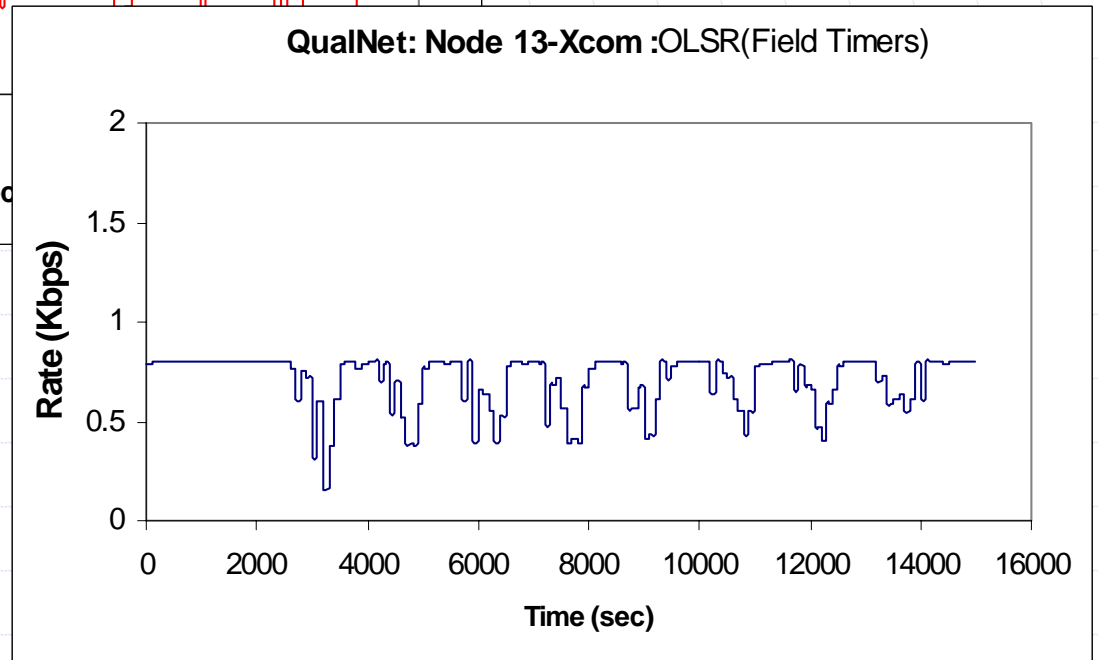
- Bidirectional Traffic



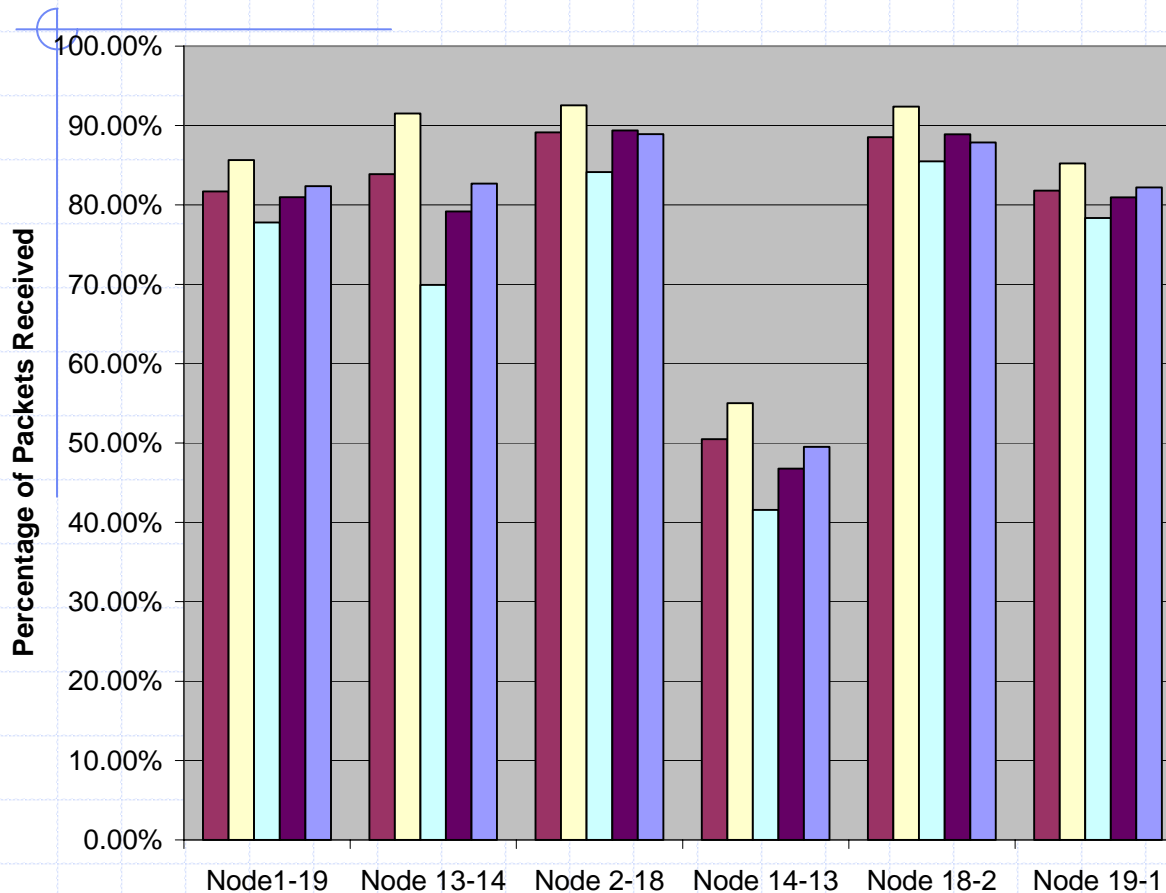
Simulator Validation



- Low Rate Report Traffic

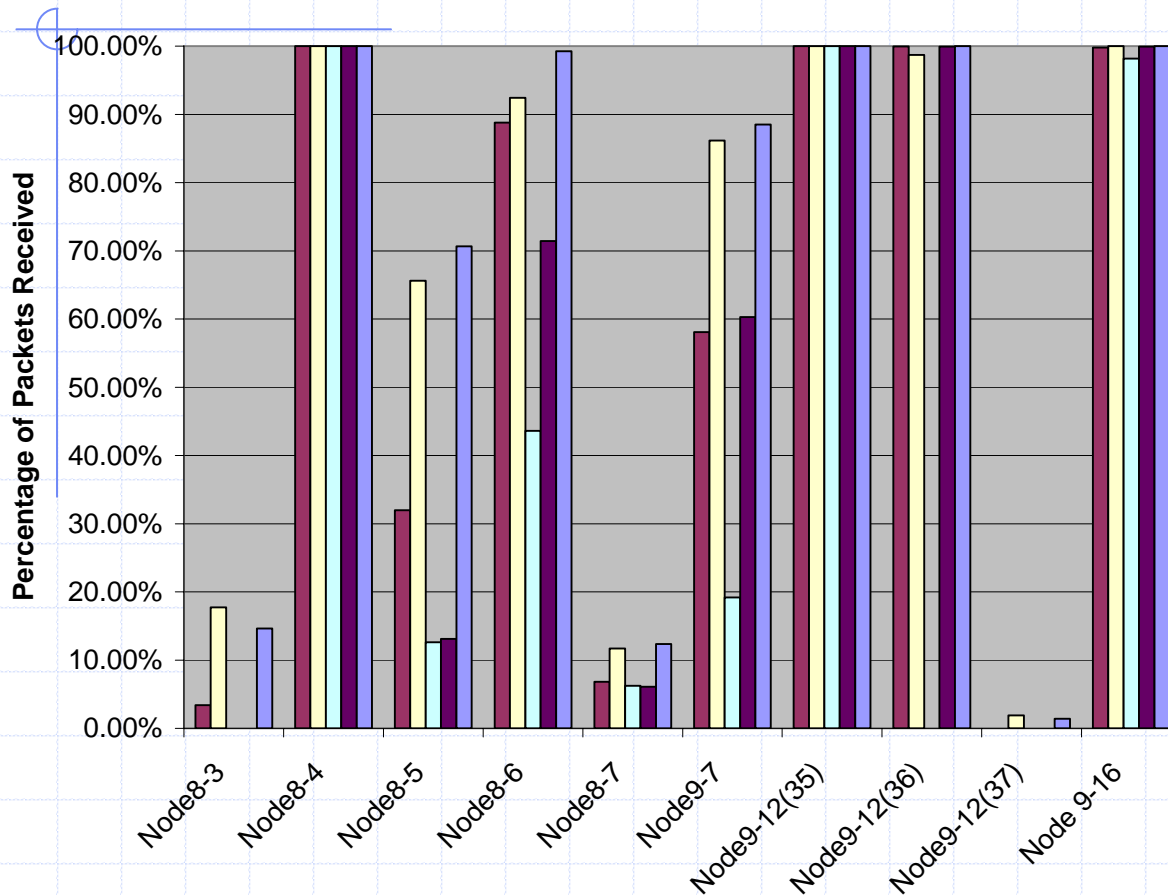


Protocol Comparison: High Rate Traffic



- 6 120 kbps or 200 kbps flows of 1 KB packets
- Transmitting throughout the entire simulation.
- Highest data rate flows

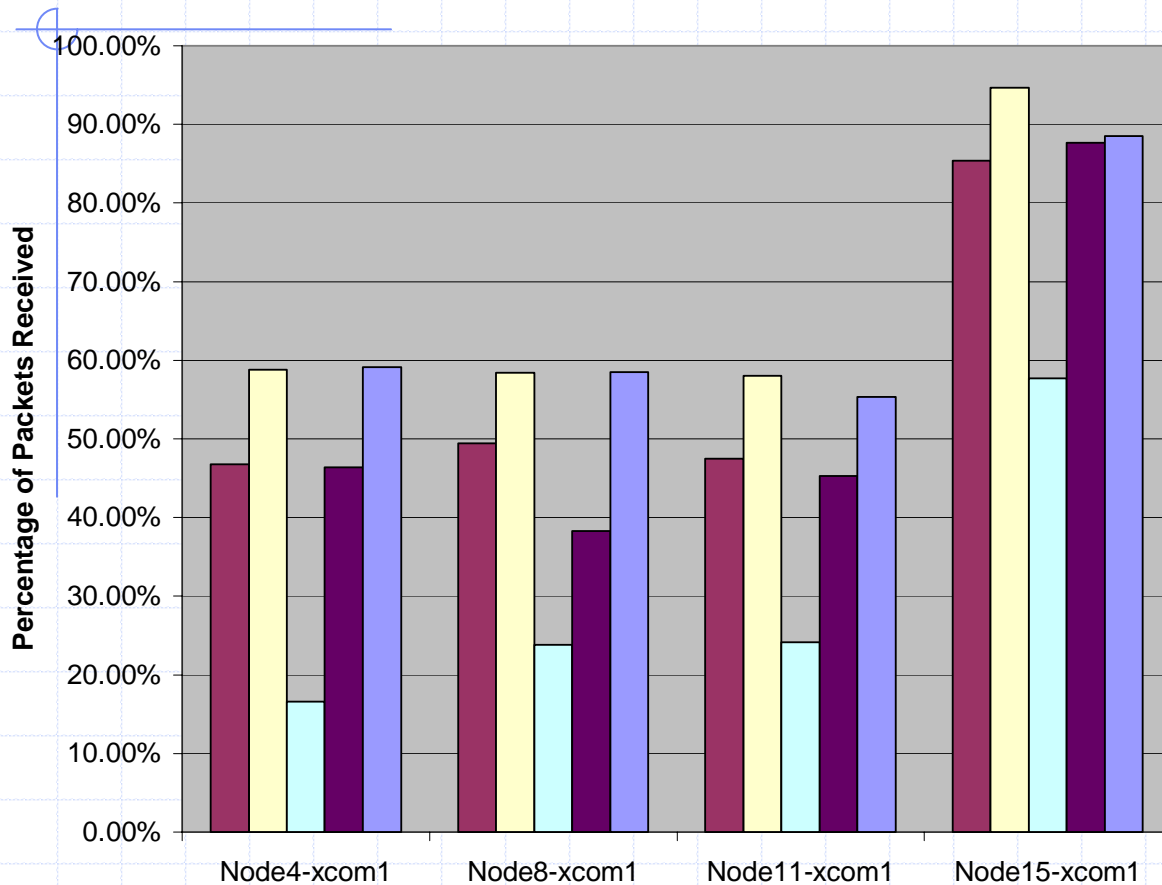
Protocol Comparison: Bidirectional Flows



- Representative subset of the 69 bidirectional flows

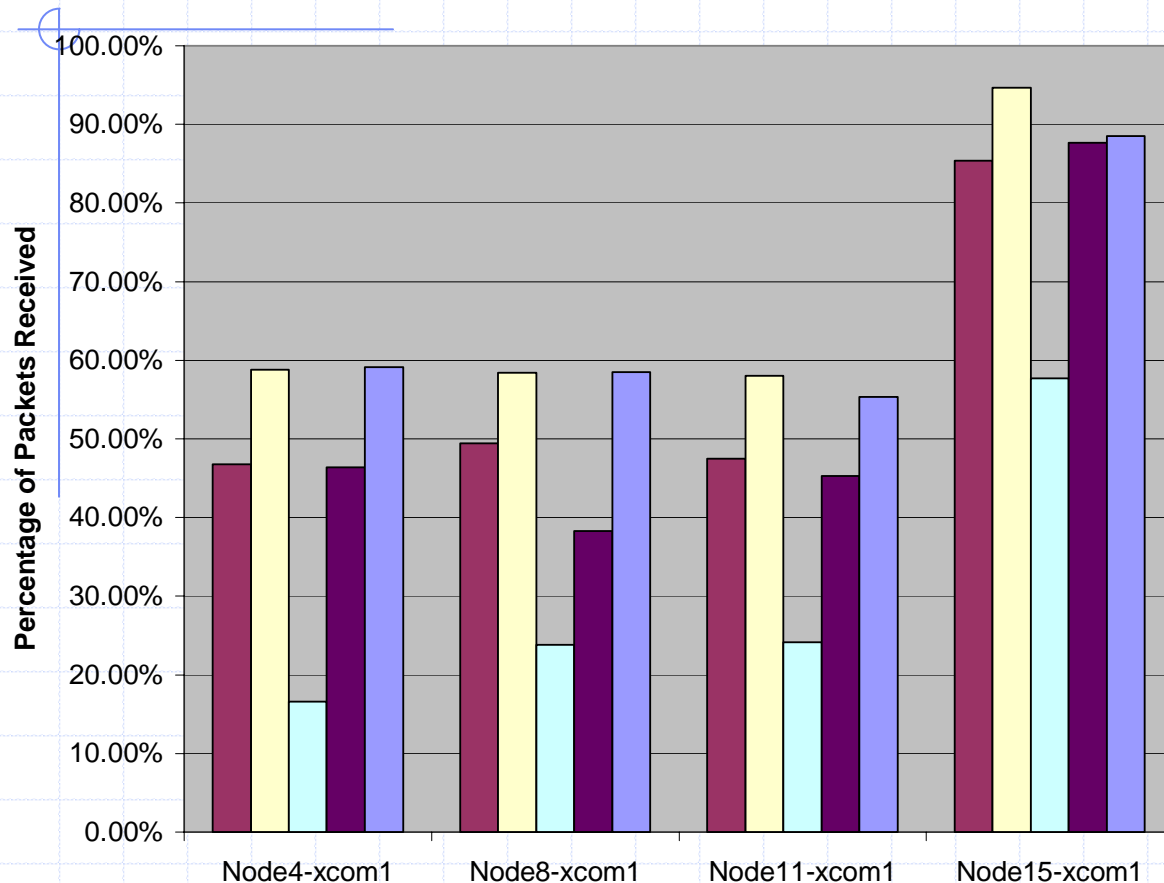
- 40 kbps between randomly selected node pairs, for 300 seconds each flow.

Protocol Comparison: High Rate Report



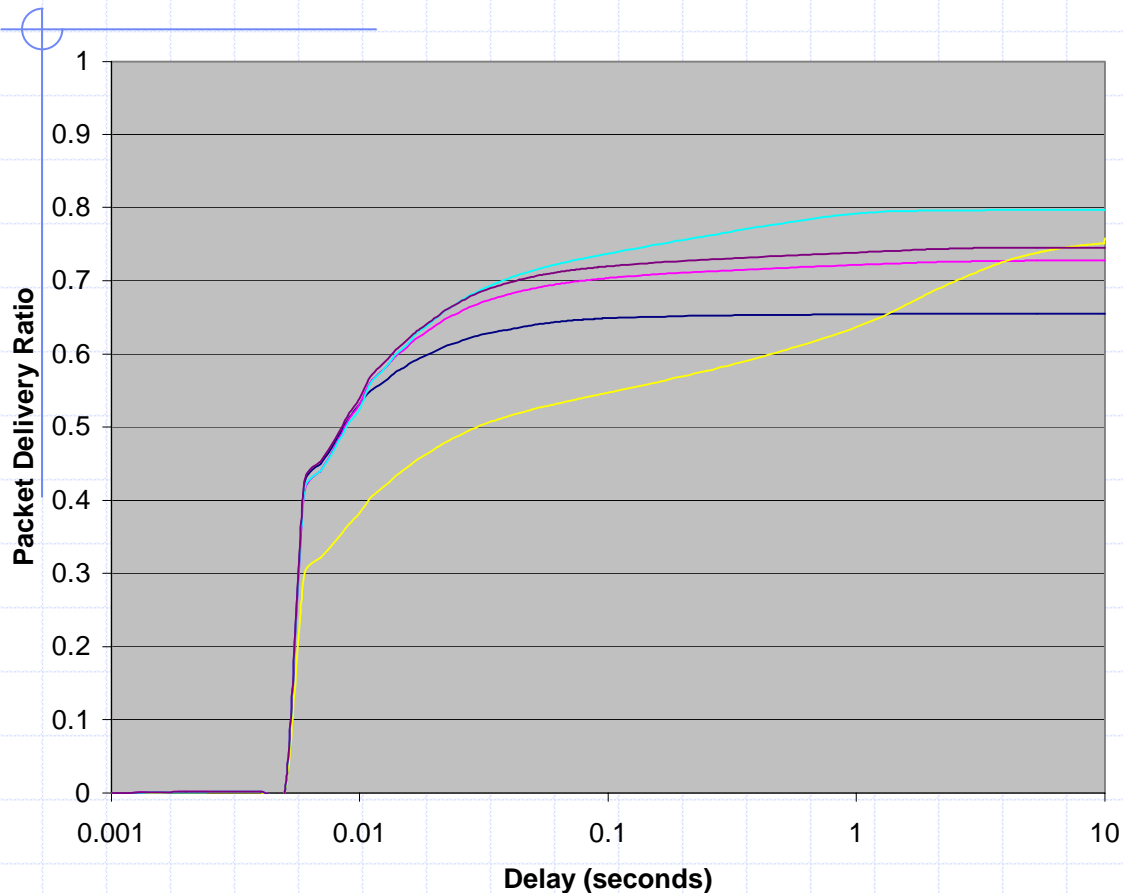
- 40 Kbps between four nodes and the base station.

Protocol Comparison: Low Rate Report



- 15 Low Rate Report traffic sessions
- 100 byte packets to the base station at an average of 0.8 kbps throughout the simulation.

Delay vs. Packet Delivery Ratio



- Similar Overall PDR can mask variances in average delay to deliver those packets

Conclusion

- Modeling and Simulation and Live Exercises complement each other well
 - Validation with the real world
 - Ability to re-run scenarios with adjustments to protocols, variables, without redeploying assets
- MANET routing protocols more suited to this type of mobile scenario than traditional wired protocols
- Results are specific to this set of protocol parameters and scenario characteristics