ENSC 895: COMMUNICATION NETWORKS

FINAL PROJECT PRESENTATIONS

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Performance Analysis and Comparison of Three Wireless Ad Hoc Network Routing Protocols

Reza Qarehbaghi

www.sfu.ca/~rqarehba/ENSC895_OPNET.html

rqarehba@sfu.ca

Roadmap

- Introduction
- Related Works
- OPNET Model
- Simulation Results
- Conclusions and Future Work
- References

Introduction

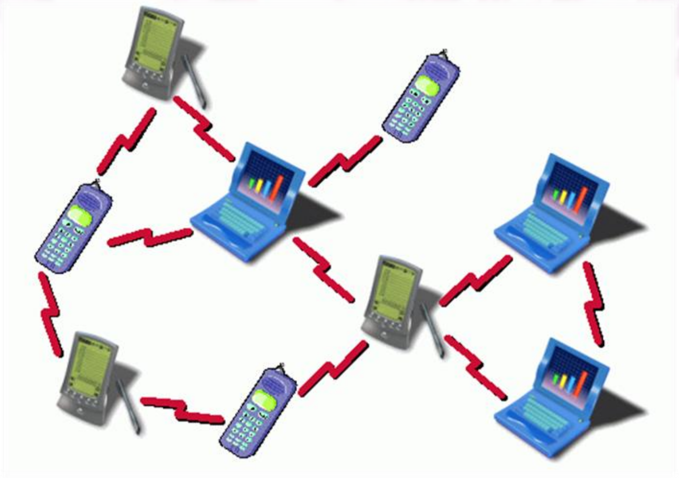
Cellular Network

- A radio network consists of a number of cells.
- served by at least one fixed location known as base station.

Wireless LAN

- Centralized wireless network.
- provides a connection through an access point.
- Provides mobility within a local coverage area.

Wireless Ad Hoc Network



- Decentralized wireless network.
- Does not rely on a preexisting infrastructure such as base stations or access points.
- Each node acts as a router as well as source node for sending data.
- "Packet Radio" networks were the earliest wireless Ad Hoc networks from the 1970s, sponsored by DARPA after the ALOHAnet project.

Applications

- **Mobile Ad Hoc networks (MANETs):**
  - self-configuring network of mobile devices connected by wireless links.
  - Nodes are free to move in any direction.

- **Types:**
  - Vehicular Ad Hoc Networks (VANETs)
  - Intelligent Vehicular Ad Hoc Networks (InVANETs)

Applications

- **Wireless Sensor Network (WSN):**
  - consists a large number of inexpensive autonomous sensors that are spatially distributed and are networked via low power wireless communications.
  - Monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, …

- **Applications:**
  - Area monitoring: e.g. presence of enemy in battle field.
  - Environmental monitoring: e.g. forest fire detection.
  - Agriculture: e.g. monitoring water tank levels for gravity fed water systems.
  - …

Routing Protocols

- **Reactive Routing Protocols (On-Demand):**
  - Routing paths are searched only when needed with route discovery operation.
  - Source nodes may suffer from long delays.
  - Less routing overhead.
- **Proactive Routing Protocols (Table-Driven):**
  - Nodes continuously evaluate routes to all reachable nodes.
  - Nodes attempt to keep consistent, up to date routing information.
  - A source node can get a routing path immediately if it needs one.
  - High routing overhead.
- **Hybrid Protocols:**
  - Combines the merits of both proactive and reactive routing protocols.
  - Overcome proactive and reactive routing protocols shortcomings.

Routing Protocols

- **Reactive Routing Protocols (On-Demand):**
  - AODV: Ad hoc On-Demand Distance Vector
  - DSR: Dynamic Source Routing
  - ACOR: Admission Control enabled On-demand Routing
  - ABR: Associatively-Based Routing
- **Proactive Routing Protocols (Table-Driven):**
  - OLSR: Optimized Link State Routing
  - DSDV: Destination-Sequenced Distance Vector
  - AWDS: Ad Hoc Wireless Distribution Service
  - CGSR: Clusterhead Gateway Switch Routing
- **Hybrid Protocols:**
  - TORA: Temporally-Ordered Routing Algorithm
  - ZRP: Zone Routing Protocol
  - OORP: Order One Routing Protocol

Dynamic Source Routing

- Uses source routing that means intermediate nodes do not need to maintain update routing information.
- Each routed packet carries complete, ordered list of nodes in its header through which the packet must pass.
- Eliminates the need for the periodic route advertisement and neighbor detection packets present in other protocols.
- Has two major phases: Route Discovery and Route Maintenance.
- Route Discovery is the mechanism by which source wishing to send a packet to a destination obtains a source route to it and then "Route Reply" is generated when the destination receives a route request.
- When Route Maintenance indicates a source route is broken, source is notified with a Route Error packet.

Ad hoc On-Demand Distance Vector

- Needs periodic route advertisement and neighbor detection.
- Borrows the basic on-demand mechanism of Route Discovery and Route Maintenance from DSR .
- Three type of control packets:
  - RREQ (Route REQuest):
    - Broadcasts into the network to search for a specific destination.
    - Sets up reverse path to the source as it travels node to node.
    - Contains hop count and source and destination address and sequence number.
  - RREP (Route REPly):
    - Travels back to the source, based on the reverse path.
  - RERR (Route ERRor):
    - when an intermediate node discovers a link breakage due to moving nodes, it propagates an RERR packet.

Optimized Link State Routing

- Each node periodically broadcasts its routing table allowing each node to build a global view of the network topology.
- Periodic routing tables create a large amount of overhead.
- Reduces overhead by limiting number of nodes can forward network wide traffic through Multi Point Relays (MPRs).
- MPRs are responsible for forwarding routing messages and optimization for controlled flooding and operations.
- After detecting a broken link, it does not notify the source immediately and source node notifies when the intermediate node broadcasts its next packet.

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Related Works

- G. Jayakumar and G. Ganapathy, “Performance Comparison of Mobile Ad-hoc Network Routing Protocol,” *IJCSNS International Journal of Computer Science and Network Security*, vol.7, no.11, pp. 77-84, Nov 2007.
  - ➢ Simulation of AODV and DSR with ns-2.
- A. Suresh, “Performance Analysis of Ad hoc On-demand Distance Vector routing (AODV) using OPNET Simulator,” M.S. Mini Project, University of Bremen, Bremen, Germany, 2005.
  - ➢ Simulation of AODV with OPNET.
- J. Broch *et al.*, “A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols,” in *Proceedings of the 4th annual ACM/IEEE international conference on Mobile computing and networking*, Dallas, Texas, United States, October 1998, pp. 85–97.
  - ➢ Simulation of AODV, DSR, DSDV, and TORA with ns-2.

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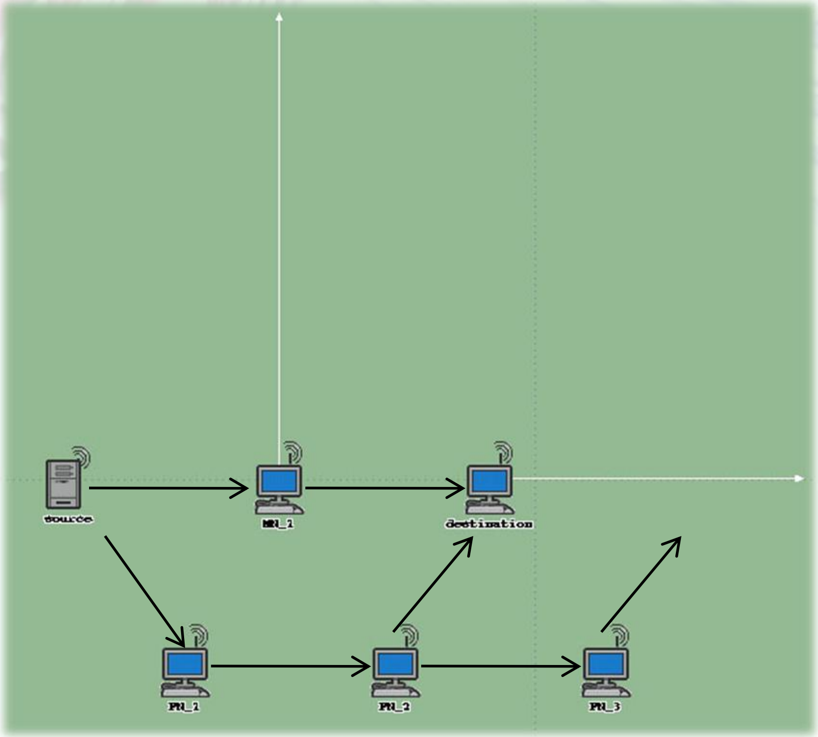
OPNET Model

- Twelve Scenarios:
  - Three Scenarios for AODV:
    - FTP
    - MPEG4 Video
    - MPEG2 Video
  - Three Scenarios for DSR:
    - FTP
    - MPEG4 Video
    - MPEG2 Video
  - Three Scenarios for OLSR with “Hello” messages (every 1 sec):
    - FTP
    - MPEG4 Video
    - MPEG2 Video
  - Three Scenarios for OLSR with “Hello” messages (every 5 sec):
    - FTP
    - MPEG4 Video
    - MPEG2 Video

OPNET Model

- Mobile Node starts moving after 3 minutes.
    - It takes 2 minute to move 1km.
- Destination starts moving after 8 minutes.
    - It takes 80 seconds to move 650m.
- Each node has 450m distance with its neighbor nodes.



Network Design Parameters

- FTP Traffic:

(Ftp) Table

Attribute	Value
Command Mix (Get/Total)	0%
Inter-Request Time (seconds)	constant (30)
File Size (bytes)	constant (500000)
Symbolic Server Name	FTP Server
Type of Service	12
RSVP Parameters	None
Back-End Custom Application	Not Used

Details Promote OK Cancel

- MPEG4 Video:
    - 352x288 at 25 fps
- MPEG2 Video:
    - 1280x720 at 30 fps
- Ideal wireless environment.

Network Design Parameters

- DSR Routing Parameters:
  - Route Expiry Timer: 30s
  - Request Table Size (nodes): 6
  - Send Buffer Maximum Size: Infinity
- AODV Routing Parameters:
  - Route Request Retries: 5
  - Hello Interval (seconds): uniform (1, 1.1)
  - Net Diameter: 6
  - Local Repair: Enabled
- OLSR:
  - Willingness: High
  - Hello Interval (seconds): 1 (High Traffic Hello Message Scenario)
  - Hello Interval (seconds): 5 (Low Traffic Hello Message Scenario)

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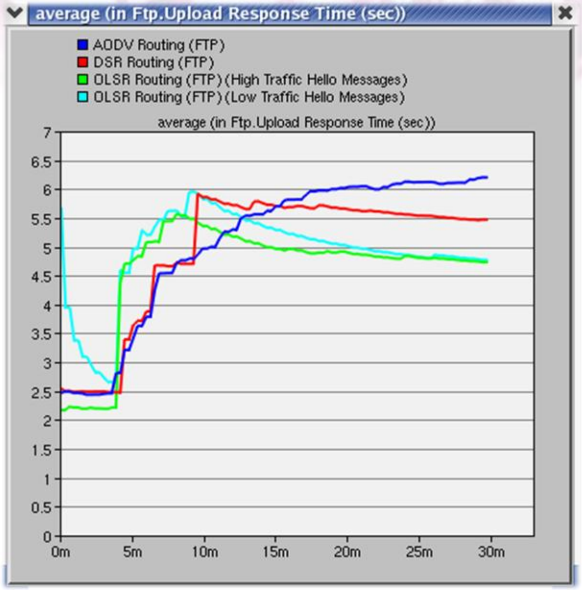
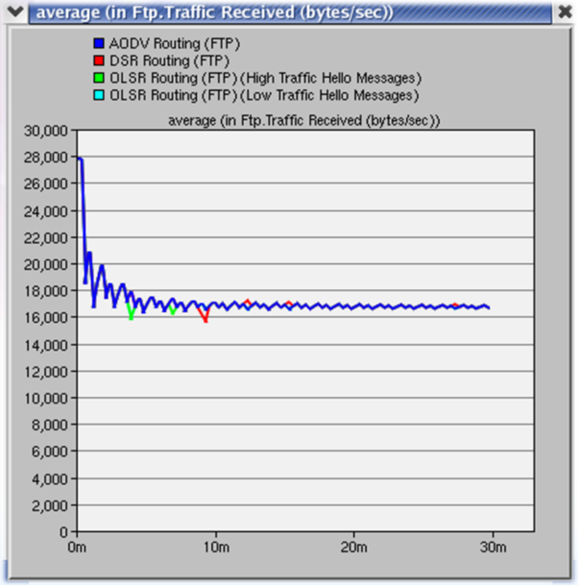
FTP General Statistics

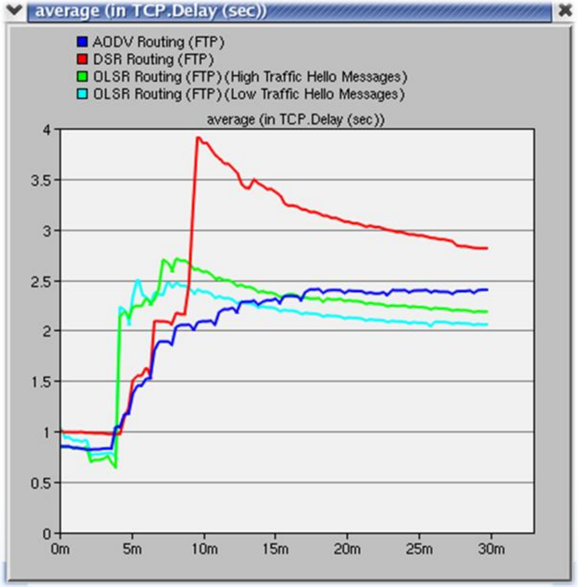
- AODV
- DSR
- OLSR (High Traffic)
- OLSR (Low Traffic)



Average Upload Response Time (sec)



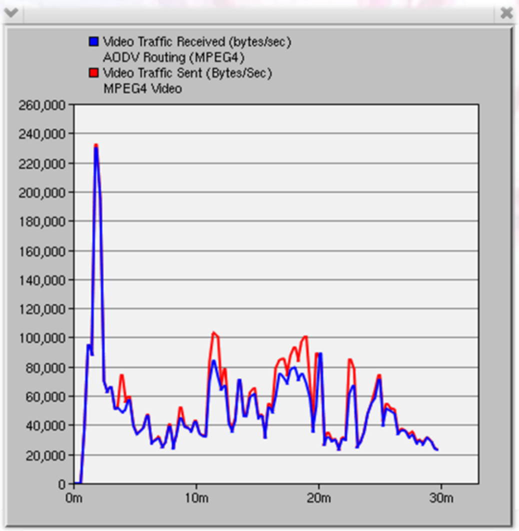
Average FTP Traffic Received (bytes/sec)

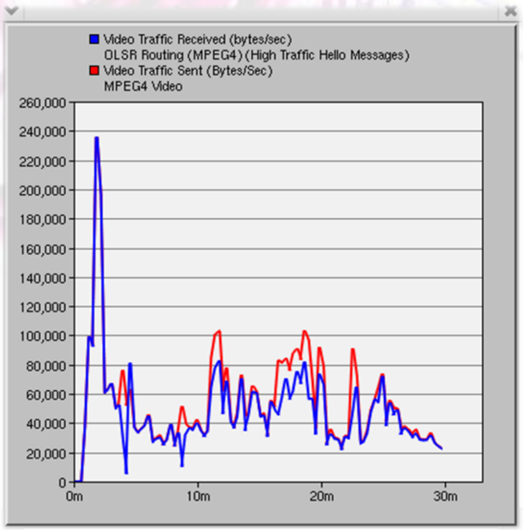


Average TCP Delay (sec)

MPEG4 Traffic Throughput

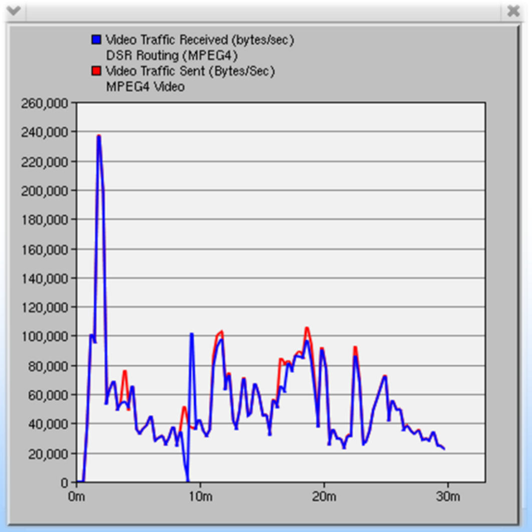
- AODV
- MPEG4 Traffic:
  - Sent
  - Received
- (Bytes/sec)

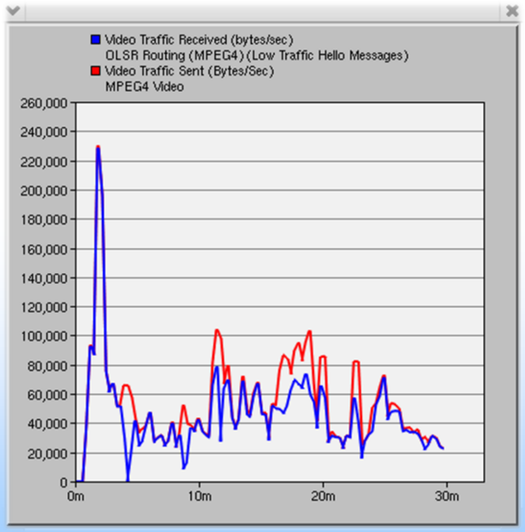




- OLSR (High Traffic)
- MPEG4 Traffic:
  - Sent
  - Received
- (Bytes/sec)

- DSR
- MPEG4 Traffic:
  - Sent
  - Received
- (Bytes/sec)

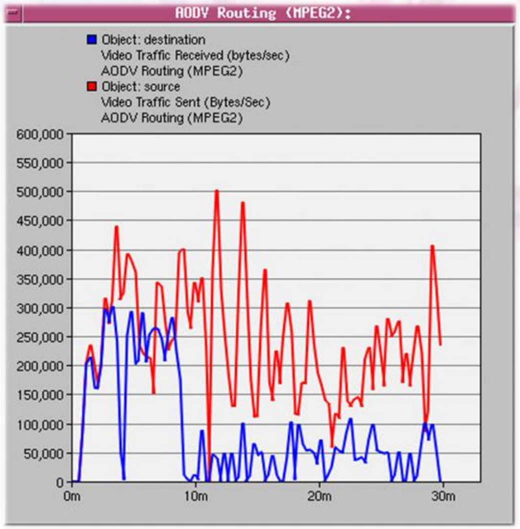


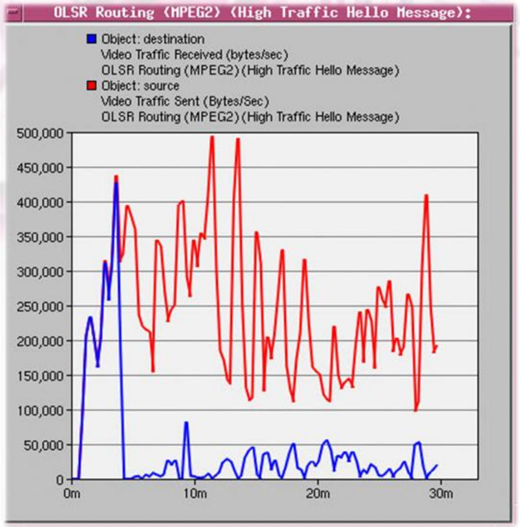


- OLSR (Low Traffic)
- MPEG4 Traffic:
  - Sent
  - Received
- (Bytes/sec)

MPEG2 Traffic Throughput

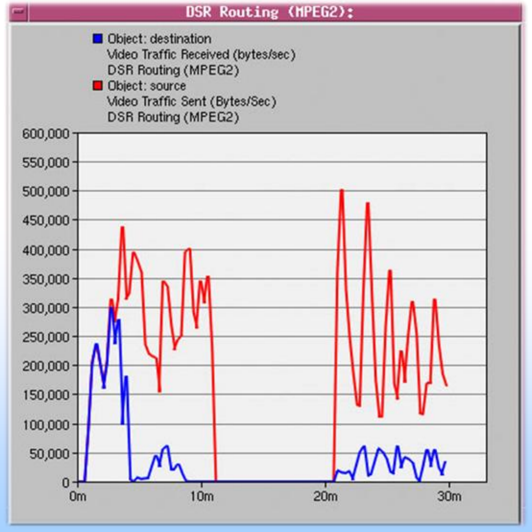
- AODV
- MPEG2 Traffic:
  - Sent
  - Received
- (Bytes/sec)

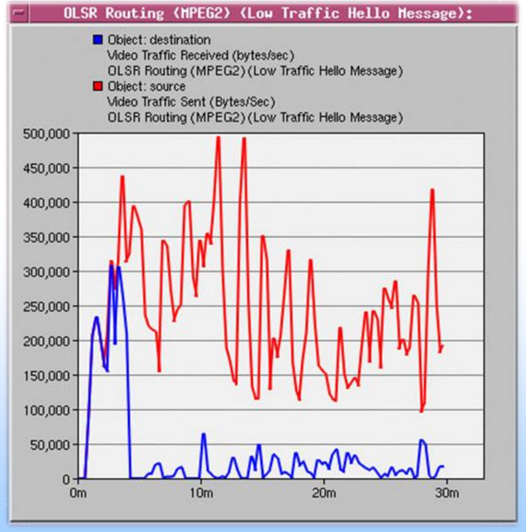




- OLSR (High Traffic)
- MPEG2 Traffic:
  - Sent
  - Received
- (Bytes/sec)

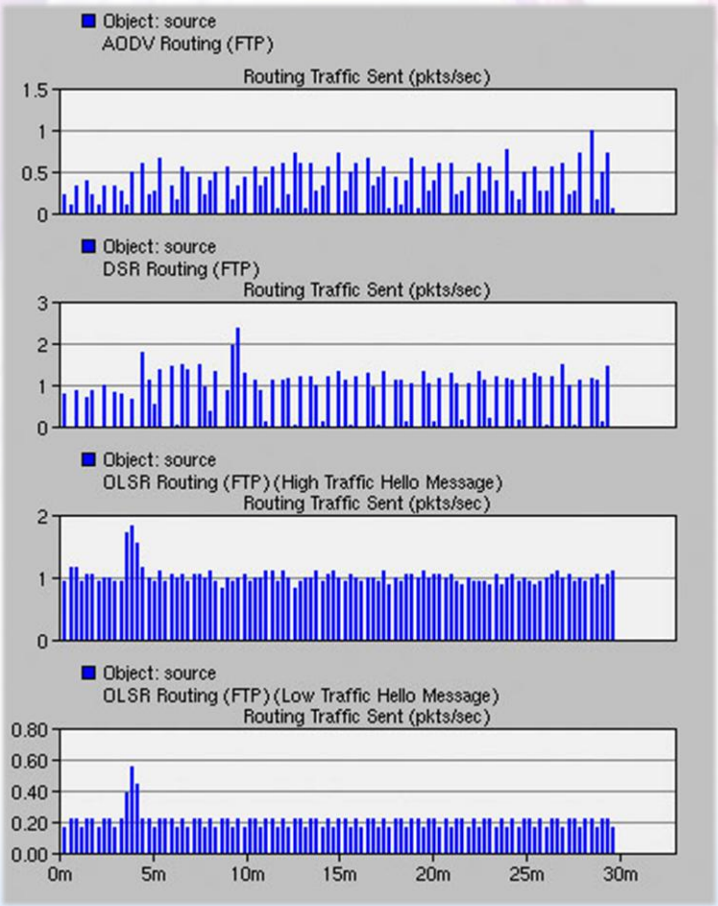
- DSR
- MPEG2 Traffic:
  - Sent
  - Received
- (Bytes/sec)





- OLSR (Low Traffic)
- MPEG2 Traffic:
  - Sent
  - Received
- (Bytes/sec)

Routing Traffic (FTP)

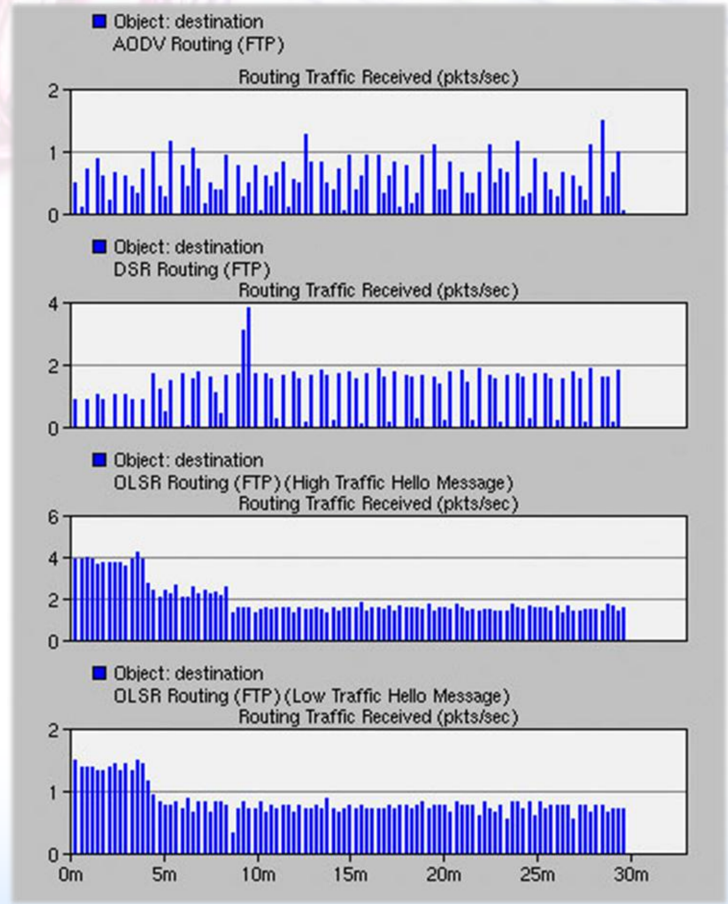


AODV

DSR

OLSR (High Traffic)

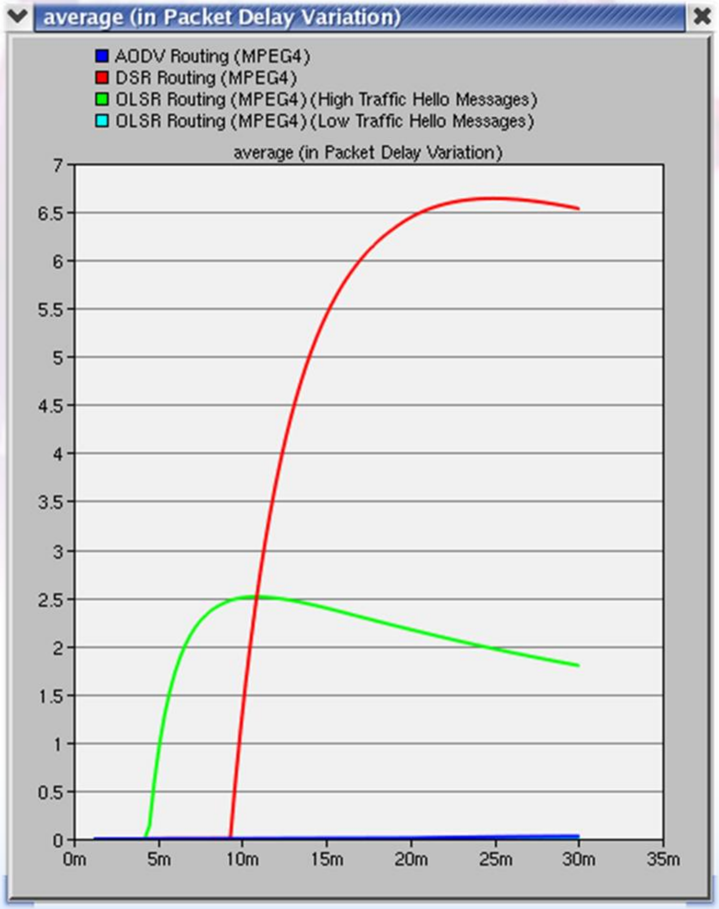
OLSR (Low Traffic)



Routing Traffic sent pkts/sec

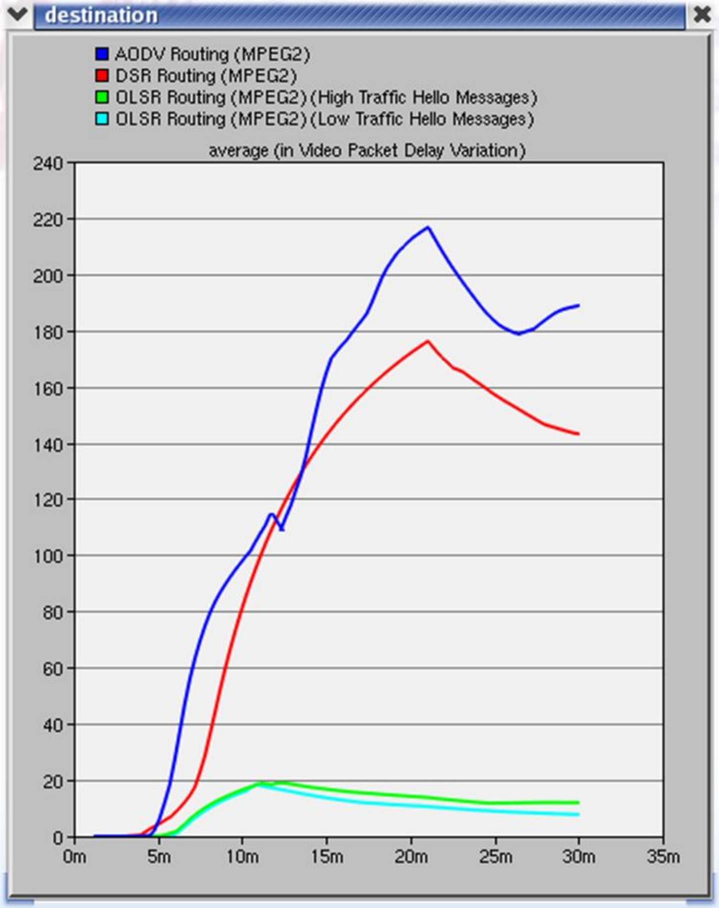
Routing Traffic Received pkts/sec

Video Packet delay variation



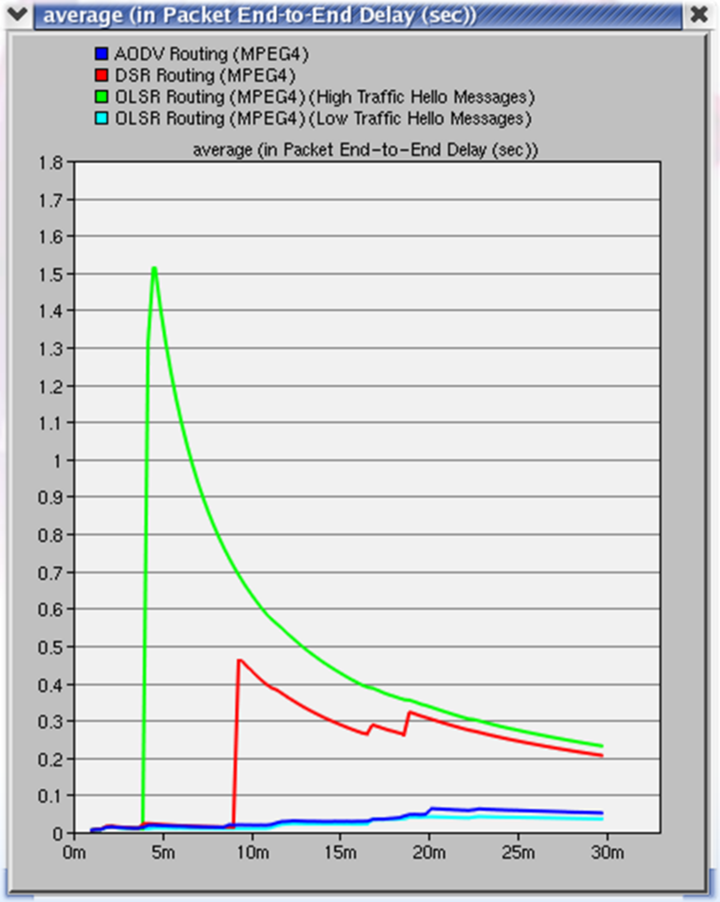
video packet delay variation (MPEG4)

- AODV
- DSR
- OLSR (High Traffic)
- OLSR (Low Traffic)



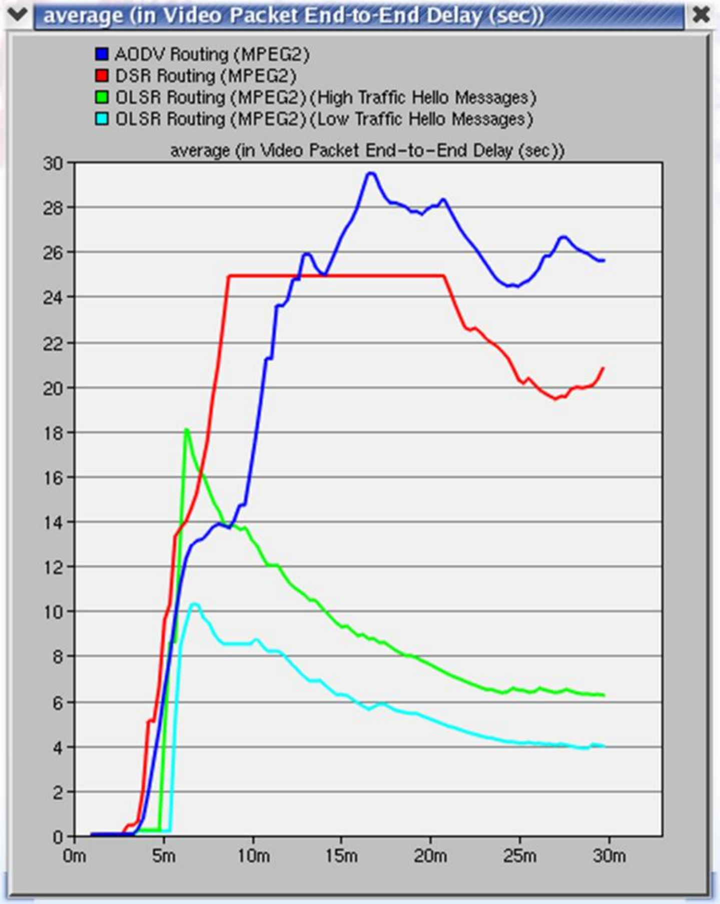
video packet delay variation (MPEG2)

Video Packet Delay



video packet E2E delay (MPEG4)

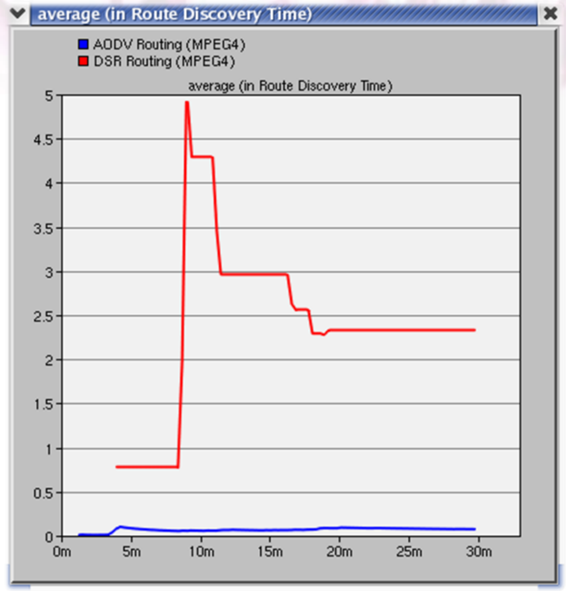
- AODV
- DSR
- OLSR (High Traffic)
- OLSR (Low Traffic)



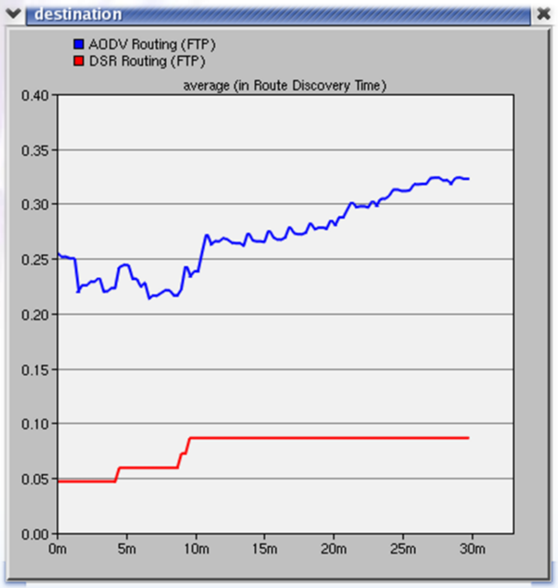
video packet E2E delay (MPEG2)

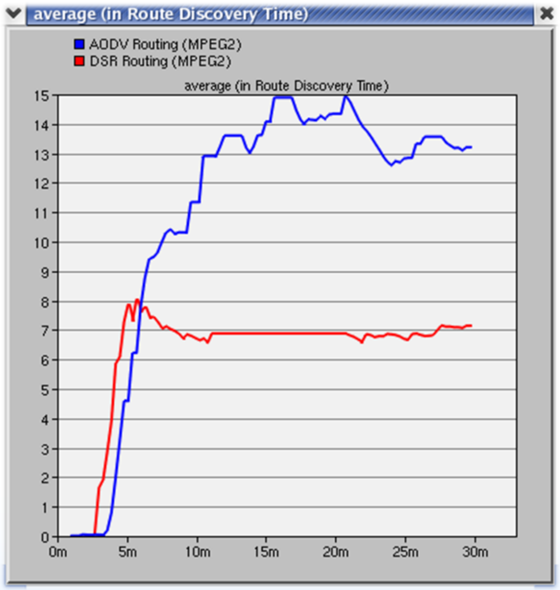
Route Discovery Time

- AODV
- DSR



MPEG4





FTP

Average in Route Discovery Time

MPEG2

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Conclusions

- 12 Scenarios, 30 min simulation time each:
  - 6 hours of simulation time / Actual time ≈ 7 hours.
- OLSR with low traffic hello message acts better in FTP.
  - High routing traffic.
- AODV acts better in MPEG4 video transfer.
  - Low routing traffic.
  - Good throughput.
  - Low packet jitter and E2E delay.
- All of protocols act poorly in MPEG2 video transfer.
  - They are not able to transfer high rate video traffic.
- On-demand routing protocols are better in order to save more battery power in WSNs.

Future Work

- Develop complex scenarios with more nodes and more mobility.
- Realistic wireless environment.
- Use workstations with actual properties.
- Compare more Ad Hoc routing protocols.
- Develop a Short Message Service (SMS) system based on wireless Ad Hoc network for sending and receiving text messages in mobile phones.

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- S. K. Sarkar, T. G. Basavaraju, and C. Puttamadappa, Ad Hoc Mobile Wireless Networks: Principles, Protocols, and Applications, New York, Auerbach Publications, 2007, pp. 77-94.
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Any Question?