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Performance Analysis of Routing Protocols for Wireless Ad-Hoc Networks

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Roadmap

- Ad-Hoc Routing Protocols
- Ad-Hoc On-Demand Distance Vector (AODV) Algorithm
- Dynamic Source Routing (DSR) Algorithm
- Optimized Link State Routing (OLSR) Algorithm
- OPNET Simulated Network Topologies
- Simulation Scenarios
- Simulation Results
- Conclusion
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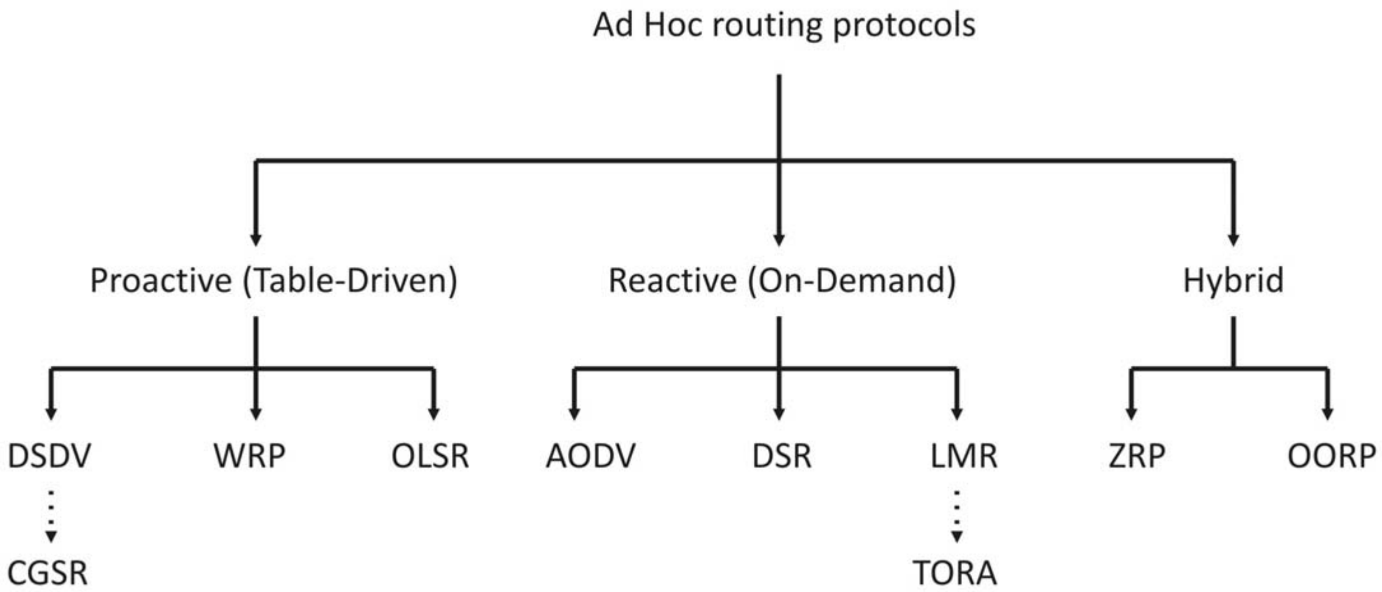
Ad-Hoc Routing Protocols

- Ad-hoc routing protocols control routing packets between computing devices in a mobile ad-hoc network
- Mobile Ad-hoc Network (MANET) routing protocols can be classified as unicast, multicast, and broadcast
- The unicast routing protocols can be classified as reactive (on-demand) and proactive (table-driven) based on the method of acquiring information



Ad-Hoc On Demand Distance Vector Algorithm

- AODV is a reactive routing protocol that is suitable for dynamic self-starting and ad-hoc networks
- AODV defines Route Request (RREQ), Route Reply (RREP), and Route Error (RERR) message types

AODV Parameters

Attribute	Value	
Route Discovery Parameters	Default	
Active Route Timeout (seconds)	3	
Hello Interval (seconds)	uniform (2, 2.1)	uniform (10, 10.1)
Allowed Hello Loss	2	
Net Diameter	16	

Dynamic Source Routing Algorithm

- DSR is an on-demand routing protocol based on the concept of source routing
- Each routed packet carries in its header a complete and ordered list of nodes
- The protocol consists of two major phases: route discovery and route maintenance
- The route maintenance mechanism uses RERR packets and acknowledgments

DSR Parameters

Attribute	Value
⊟ Route Cache Parameters	(...)
Max Cached Routes	Infinity
Route Expiry Timer (seconds)	60 300
⊞ Route Cache Export	Do Not Export
⊞ Send Buffer Parameters	Default
⊟ Route Discovery Parameters	(...)
Request Table Size (nodes)	16
Maximum Request Table Identifi...	16
Maximum Request Retransmissio...	16

Optimized Link State Routing Algorithm

- OLSR is a proactive routing protocol
- OLSR does not require reliable control message delivery and can sustain reasonable loss of control messages
- OLSR uses Topology Control (TC) messages to provide sufficient link state information

OLSR Parameters

Attribute	Value			
Willingness	Willingness Default			
Hello Interval (seconds)	2	10	2	10
TC Interval (seconds)	5	5	25	25
Neighbor Hold Time (seconds)	6.0			
Topology Hold Time (seconds)	15.0			
Duplicate Message Hold Time (seconds)	30.0			

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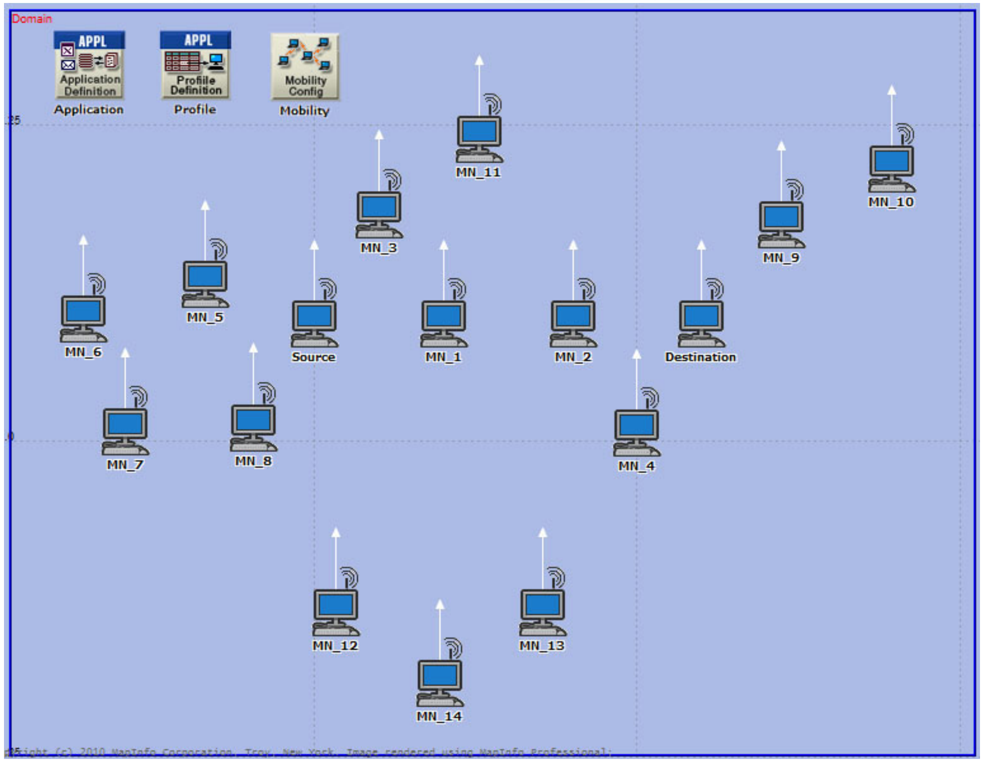
OPNET Simulated Network Topologies

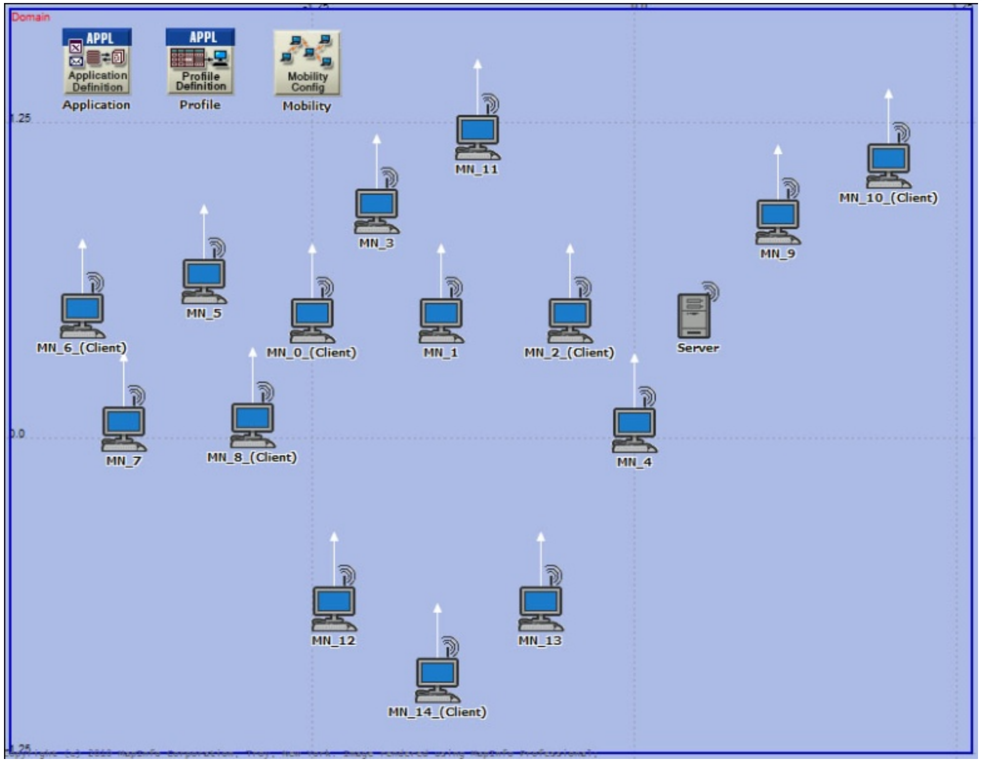
- OPNET models for an ad-hoc network in a highly dynamic environment with UDP and TCP connection scenarios were created
- The routing protocol and mobility differ in each scenario
- Each scenario consists of 16 wireless local area network (WLAN) nodes



UDP connection scenario

OPNET Simulated Network Topologies

- Each node covers an area of approximately 675 m
- Each node can only see its neighboring nodes because the distance between neighboring nodes is approximately 500 m



TCP connection scenario

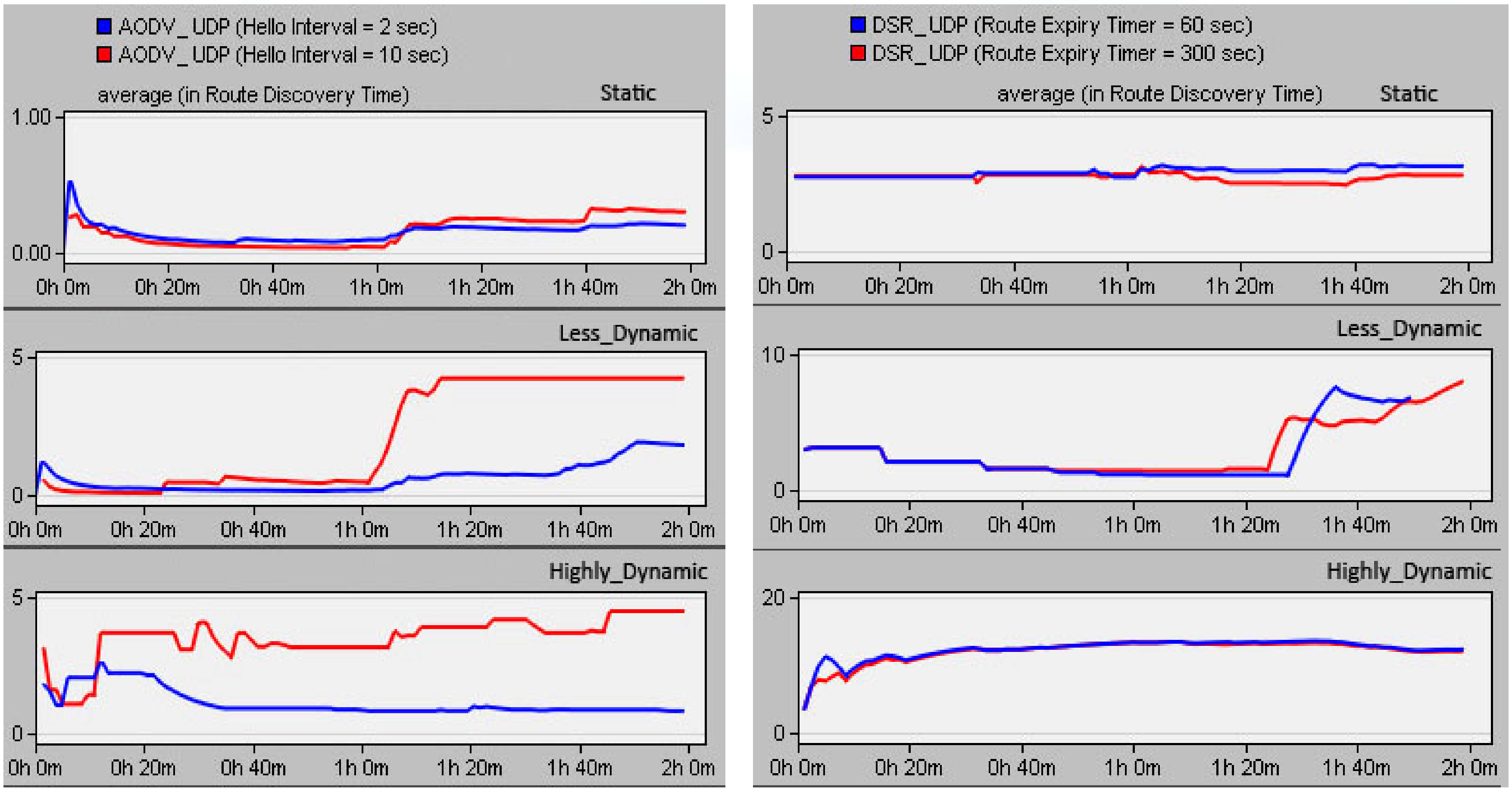
Simulation Scenarios

- Simulation tool: OPNET Modeler 16.0.A
- The first scenario: a static scenario used to compare its performance with other scenarios
- The second scenario: some nodes move with very low speed comparable to human walk (1 m/s)
- The third scenario: included are high-speed nodes that move with maximum speed equal to the speed of cars in a city (50 km/h)
- For each scenario, we consider two types of connections (UDP and TCP) and three ad-hoc routing protocols

OPNET Model of UDP Connection

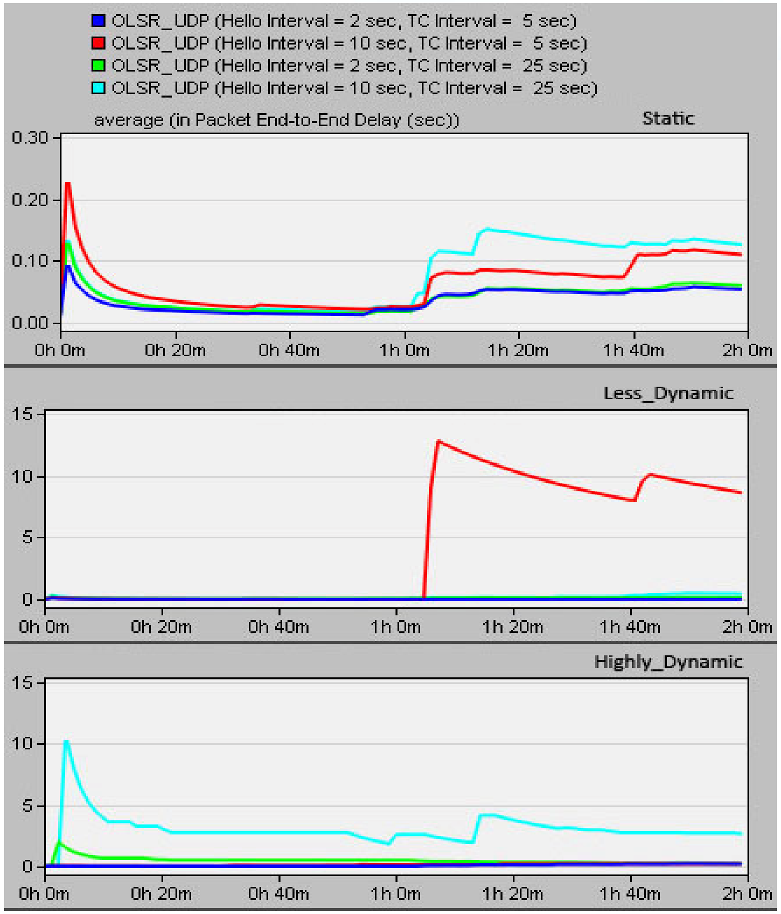
- UDP connection scenarios: a two-hour interval of the Matrix III movie trace was streamed
- We created 24 simulation scenarios for UDP connection
- The faster the nodes find a route, the faster they may send the video, which causes smaller end-to-end delay
- AODV routing protocol with hello message interval of 2 s has better route discovery time as compared to other scenarios
- DSR routing protocol with route expiry timer of 300 s has better route discovery time
- OLSR is a proactive routing protocol and has a route to the destination before it begins sending data

Average route discovery time in the UDP connection scenarios: AODV and DSR



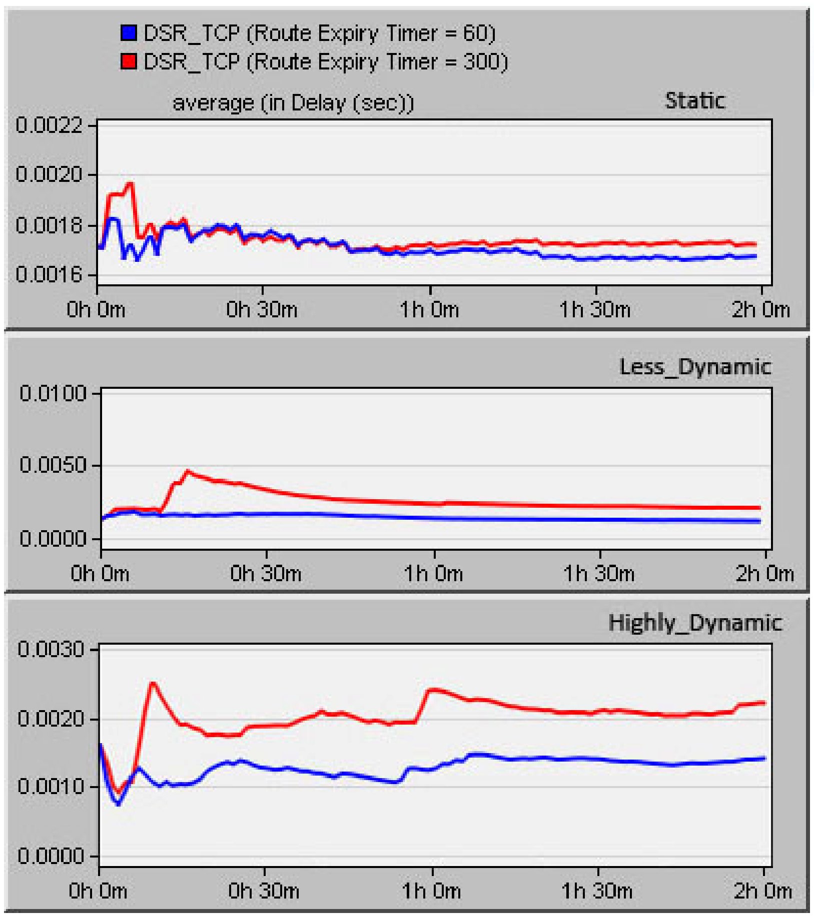
Average route discovery time in the UDP connection scenarios: OLSR

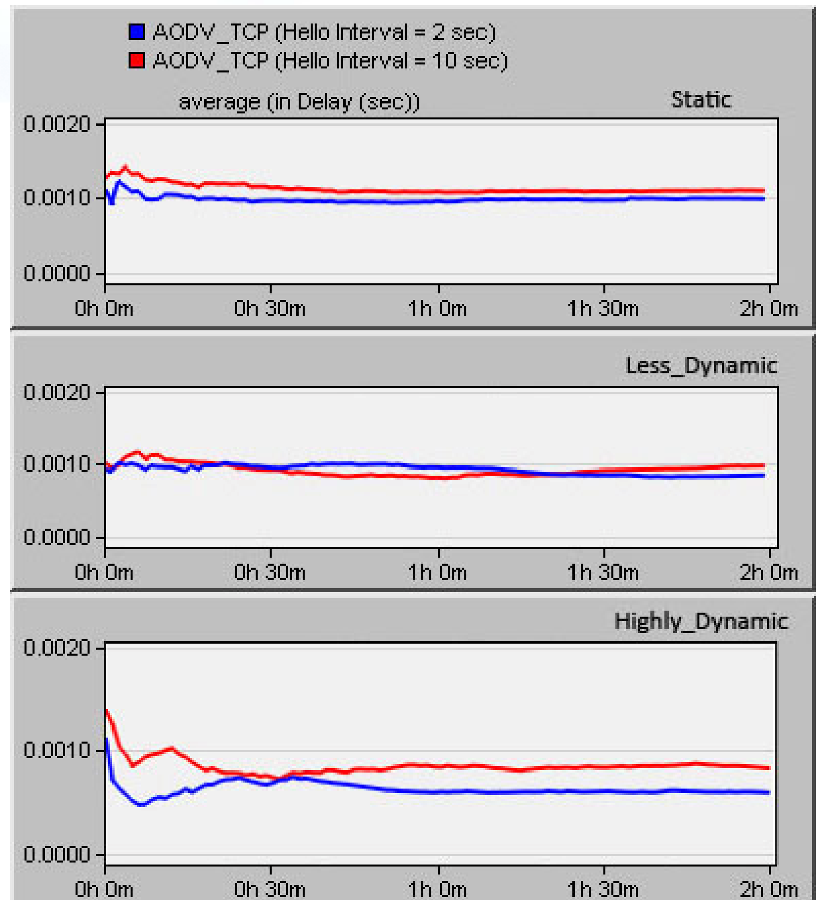
- The OLSR routing protocol with hello message interval of 2 s and topology control message interval of 5 s performs better in finding a route to the destination and in dealing with the node movement

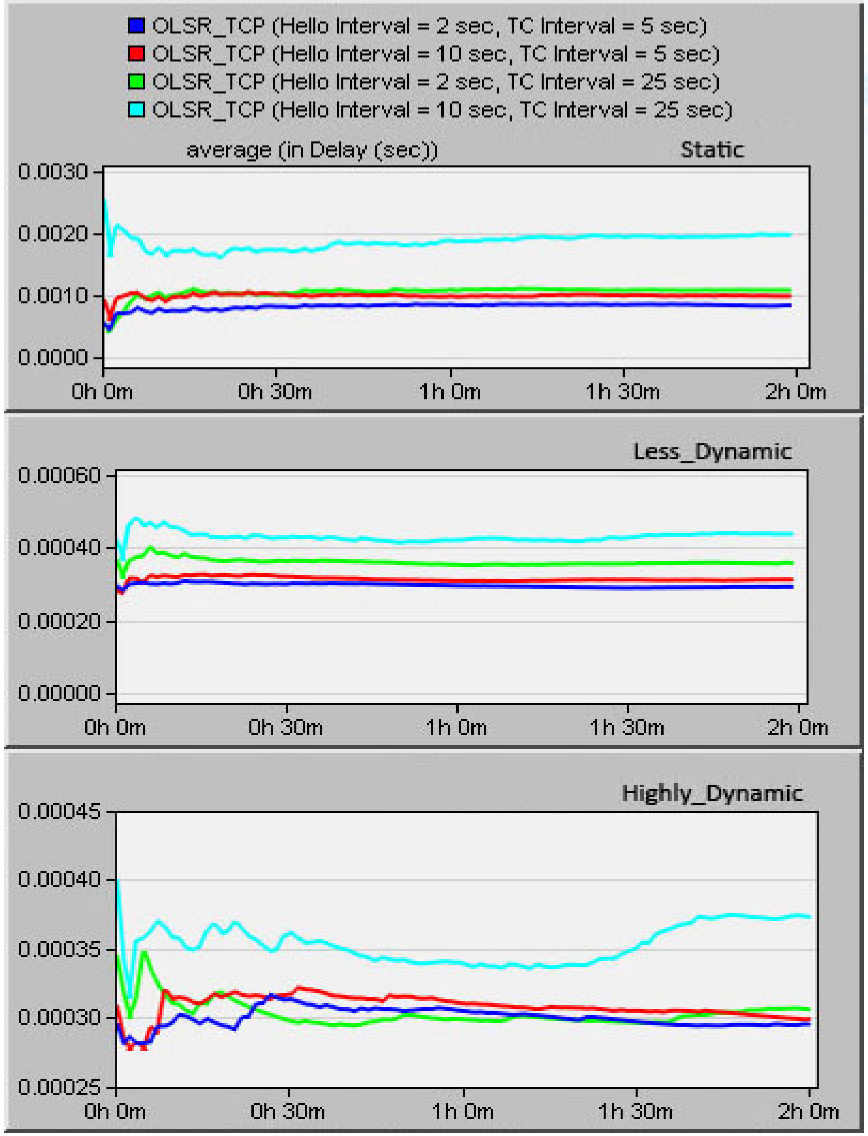


OPNET Model of TCP Connection

- TCP connection scenarios consist of six client nodes that download 50 kbytes of data
- In the scenarios with the DSR routing protocol, we used two route expiry timers: 60 s and 300 s



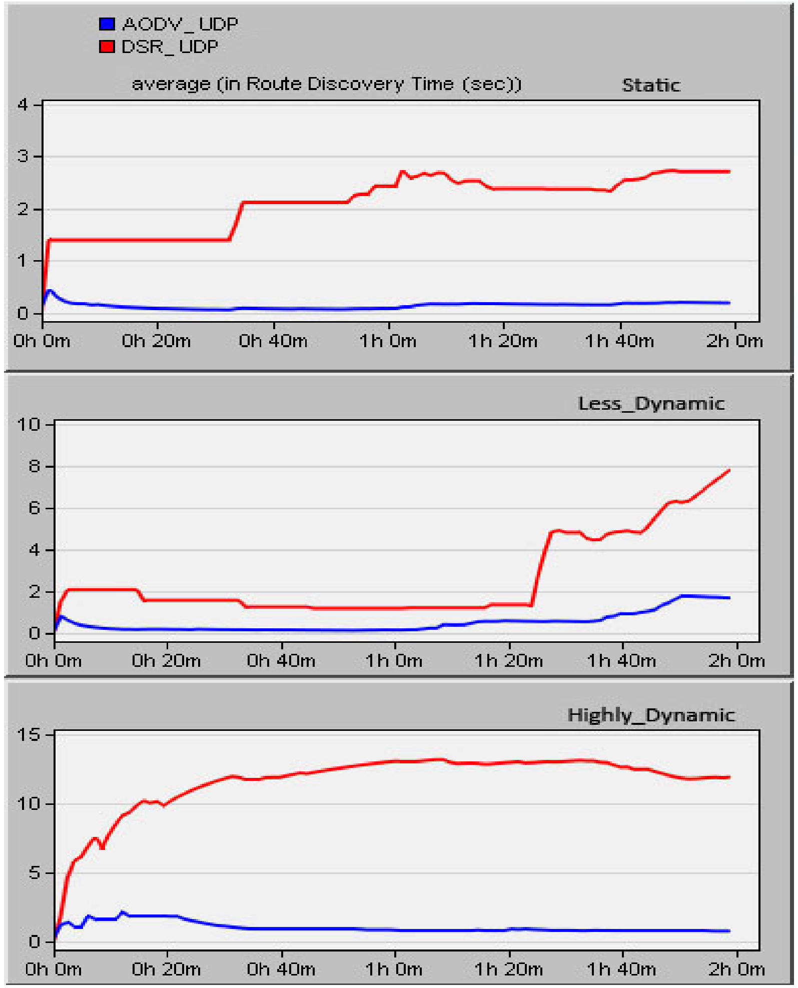




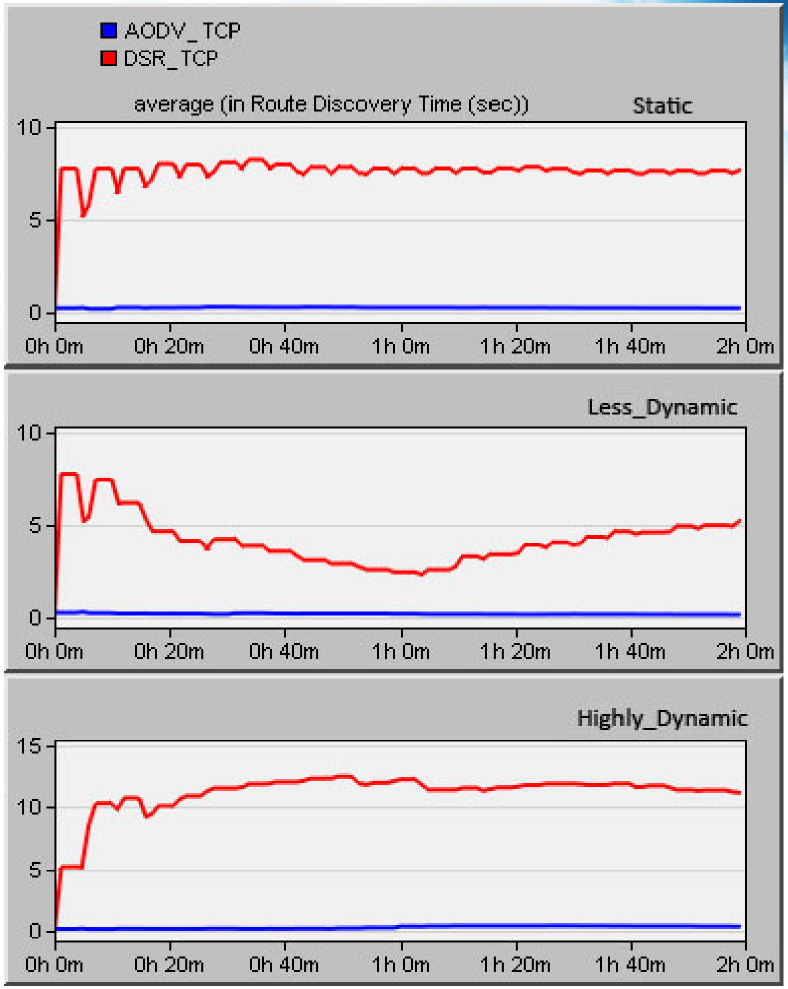
Average wireless delay in the TCP connection ad-hoc network for OLSR

Simulation Results: Route Discovery Time

- Large delays occur if the route discovery operation fails to find a route to the destination
- In the static UDP scenario, the route discovery phase in AODV is approximately 10 times faster than the route discovery phase of DSR
- The route discovery phase in AODV routing protocol is independent of the network topology
- The DSR route discovery time is higher in scenarios that include movements
- Unlike AODV, route discovery phase in DSR depends on network topology



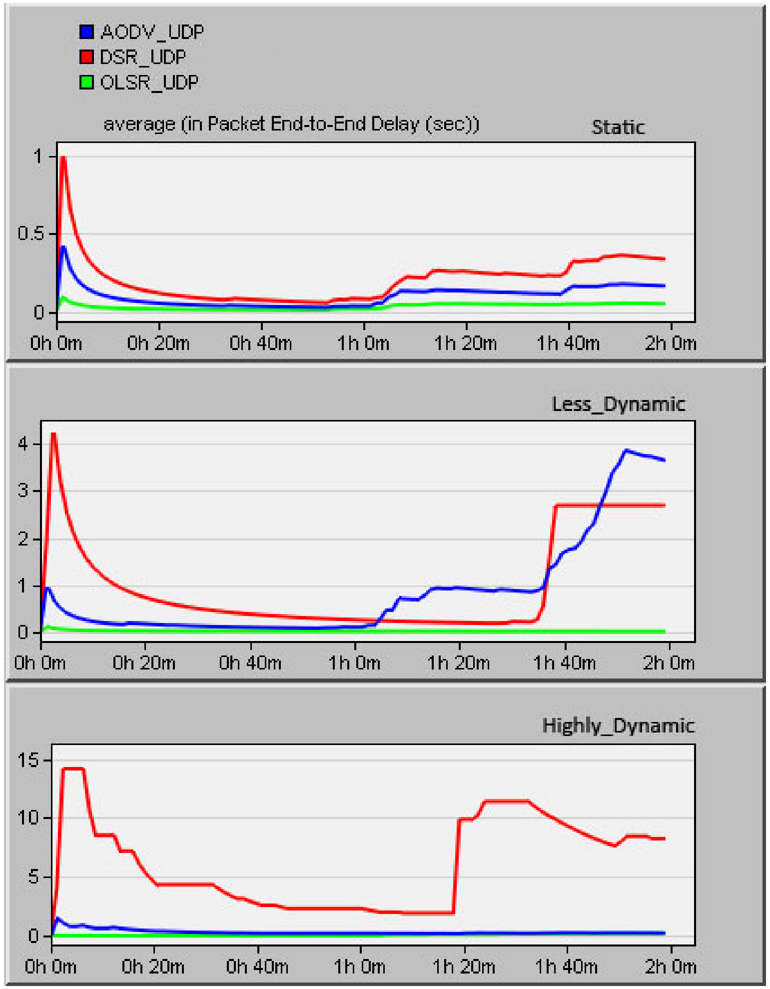
Average route discovery time (s) in UDP connection ad-hoc network scenarios: AODV and DSR cases.

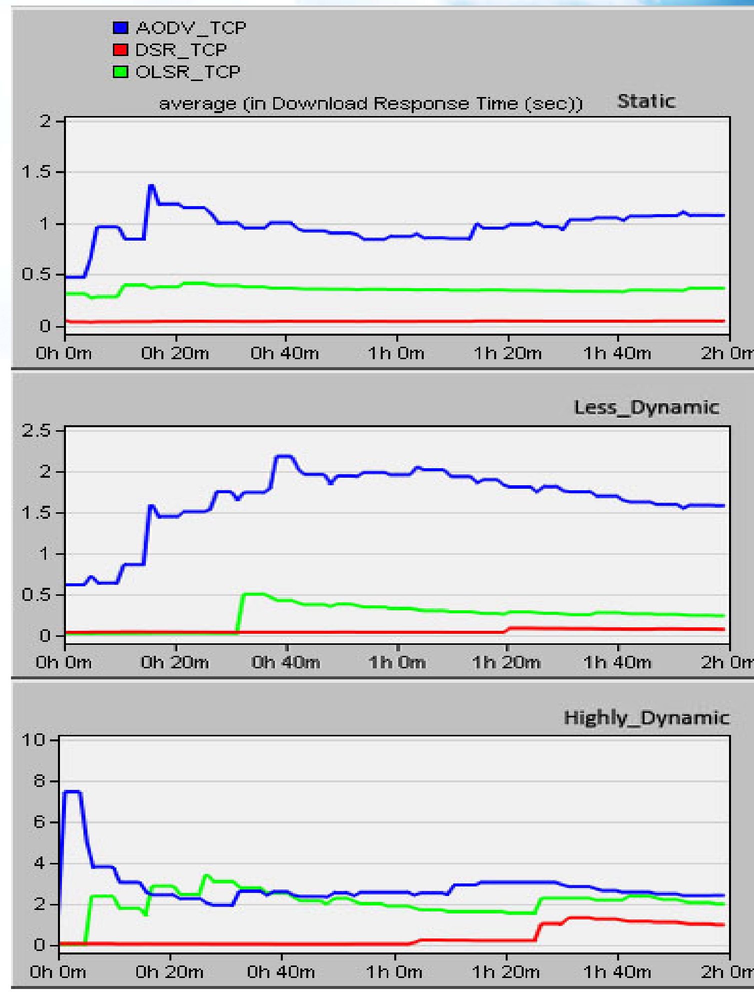


Average route discovery time (s) in TCP connection ad-hoc network scenarios: AODV and DSR cases

Simulation Results: End-to-End Delay/Download Response Time

- The end-to-end delay in the static network for all three routing protocols is less than approximately 0.5 s for most simulation scenarios
- AODV end-to-end delay is almost constant for all mobilities
- The OLSR has the smallest delay in all mobility scenarios as it discovers routes before attempting to send any data
- DSR has the smallest download response time



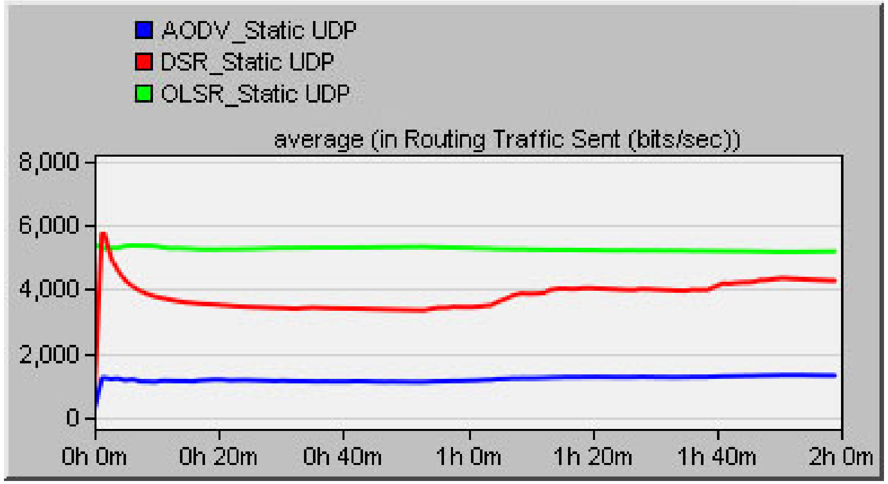


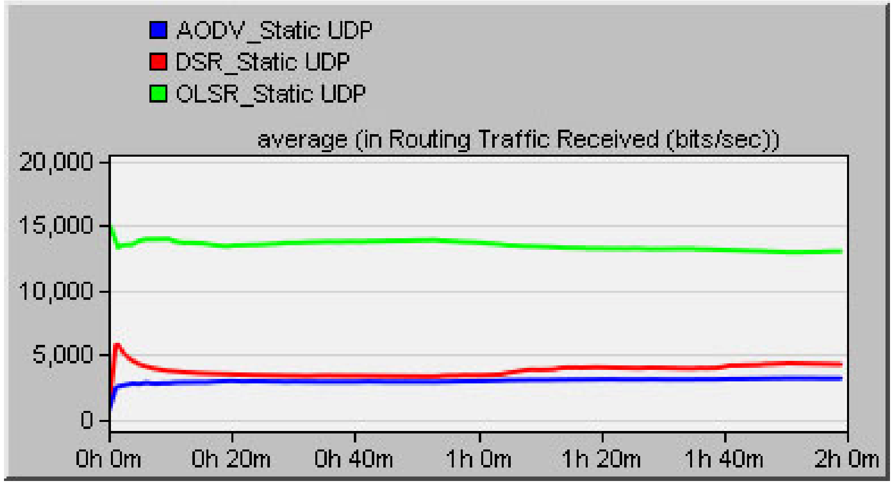
Average packet end-to-end delay (s) in all UDP connection ad-hoc network

Average download response time (s) in TCP connection ad-hoc network scenarios

Simulation Results: Routing Traffic Overhead

- OLSR has much larger routing traffic overhead in comparison to AODV and DSR
- The protocol sends approximately 5,500 bps and receives approximately 14,000 bps of routing traffic

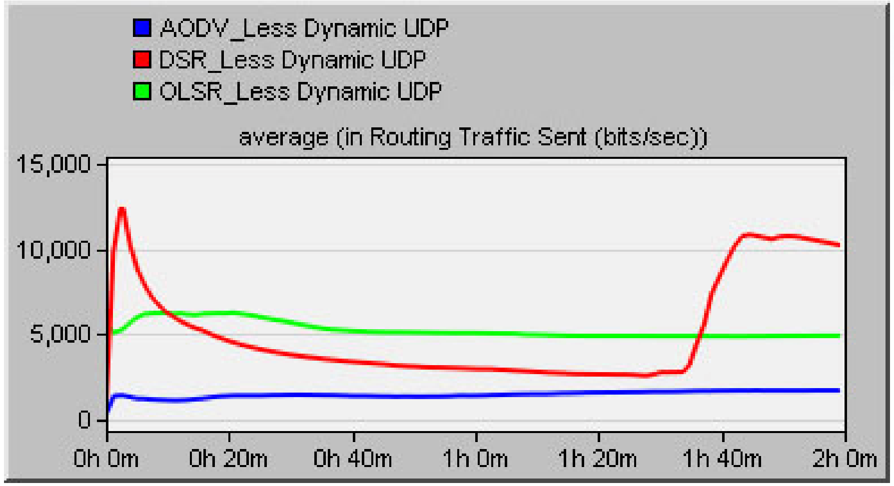


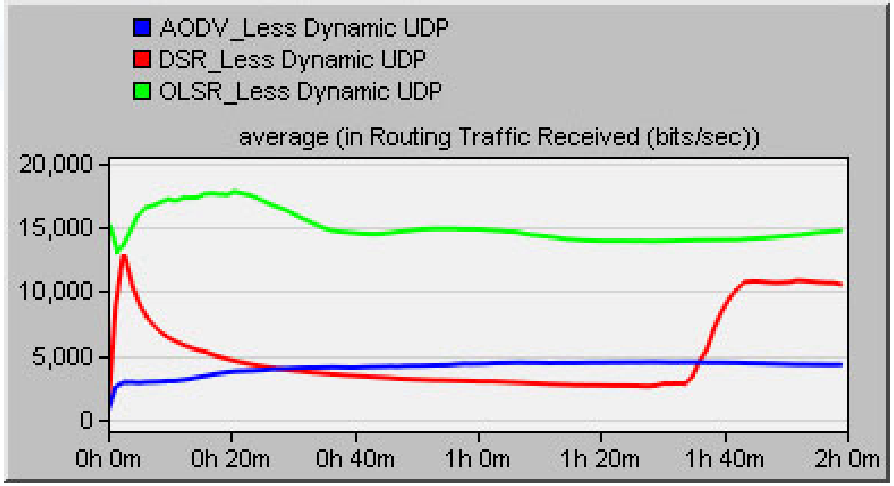


Average routing traffic sent and received in the static ad-hoc network in UDP connection

Simulation Results: Routing Traffic Overhead

- There is a slight increase in routing traffic sent and received in case of static UDP connection network

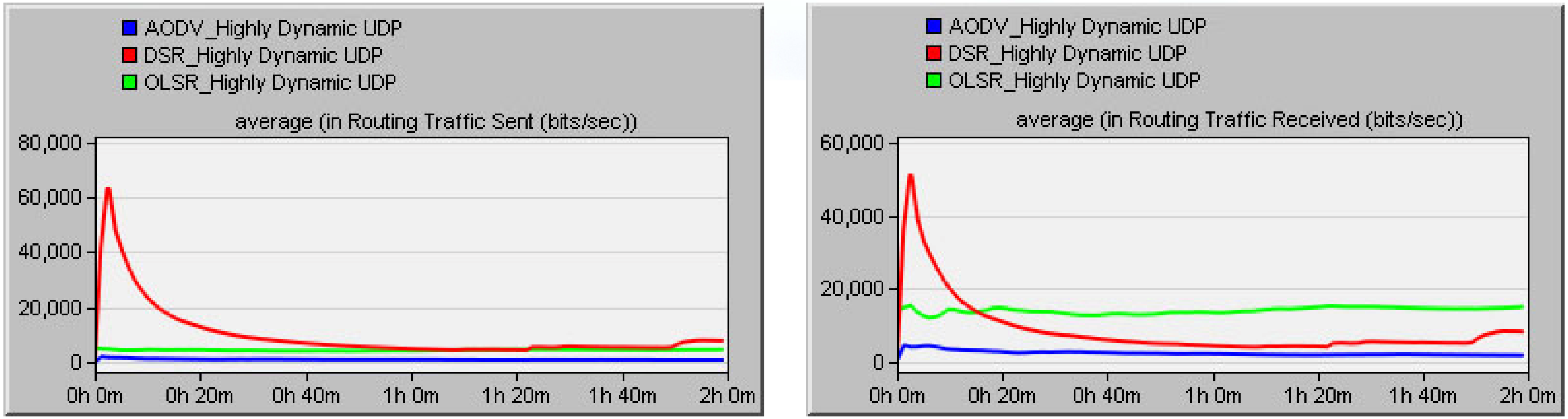




Average routing traffic sent (top) and received (bottom) in the less dynamic ad-hoc network in UDP connection scenarios

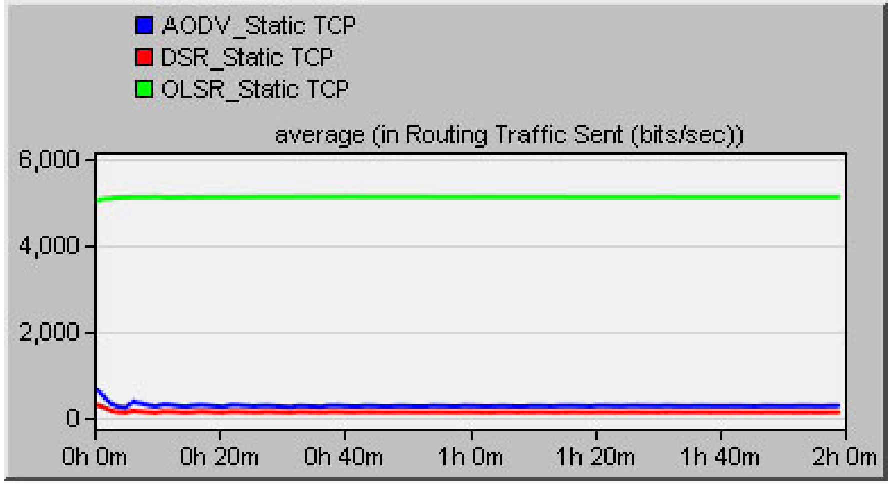
Simulation Results: Routing Traffic Overhead

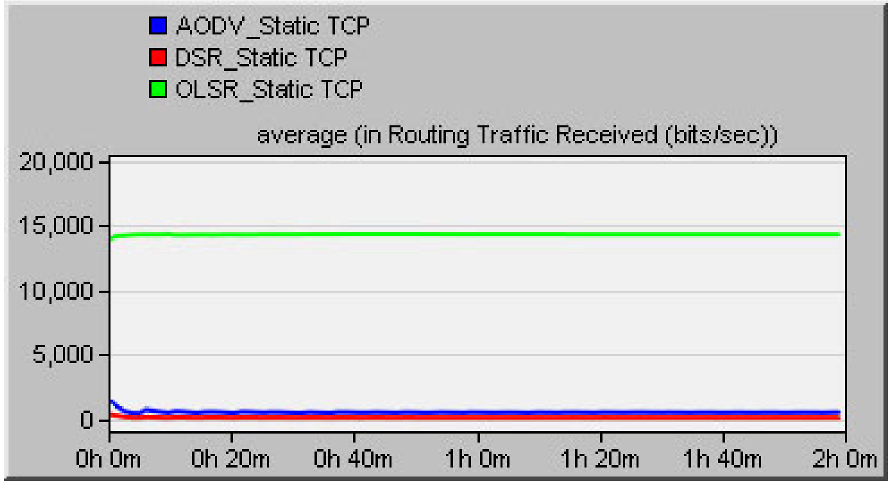
- The DSR sends more routing traffic in presence of highly dynamic nodes and in video streaming scenario



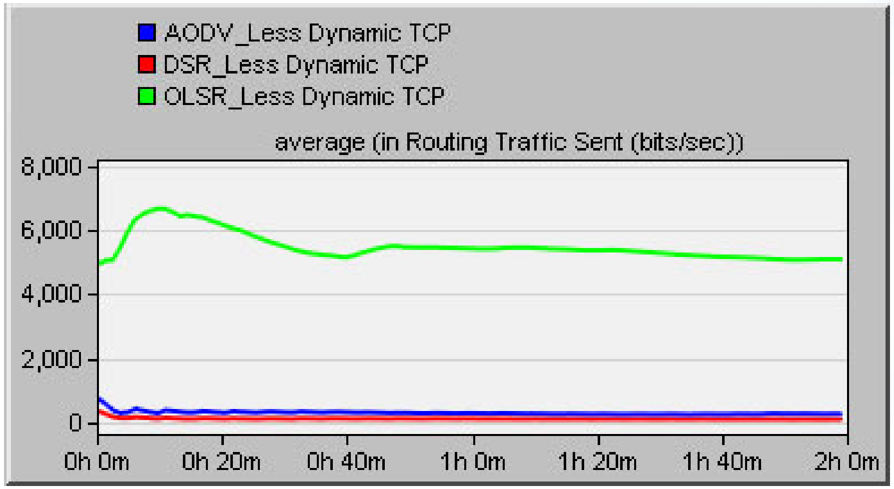
Average routing traffic sent and received in the highly dynamic ad-hoc network in UDP connection scenarios

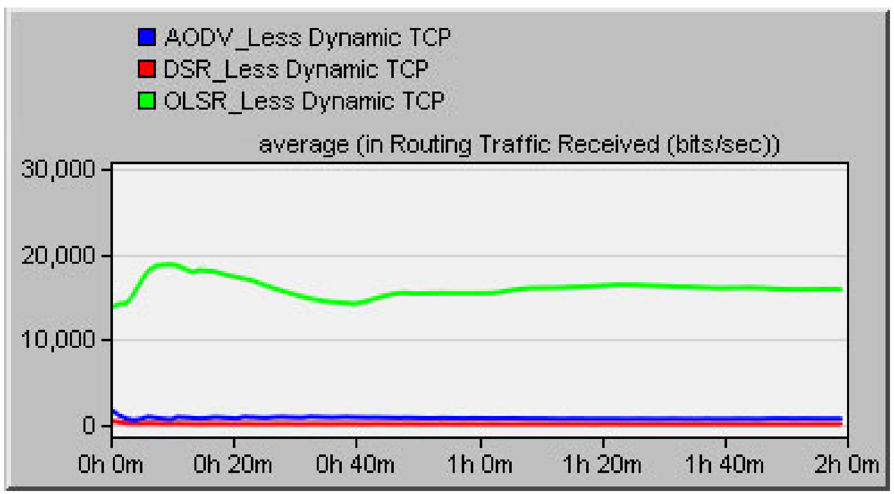
- DSR routing traffic in video streaming scenario increases as nodes movement increases.
- DSR has consistent results in file downloading and it generates the least amount of routing traffic compared to AODV and OLSR.
- OLSR generates a very large amount of traffic sent and received.



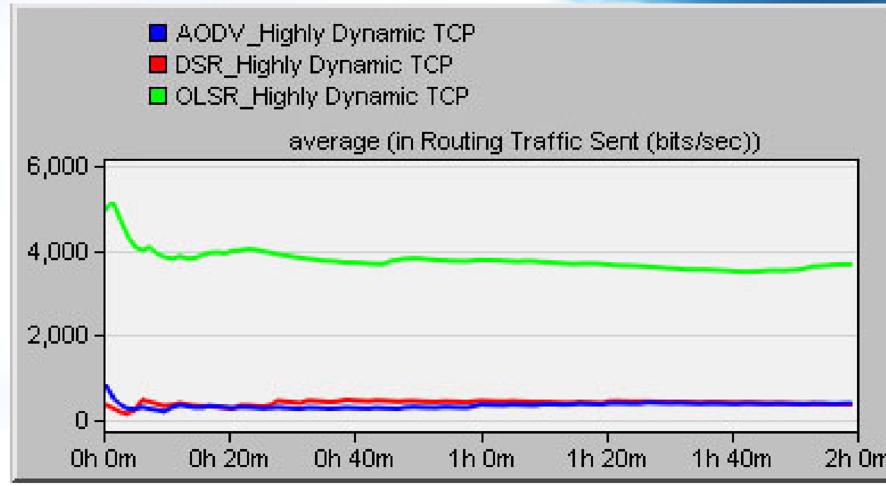


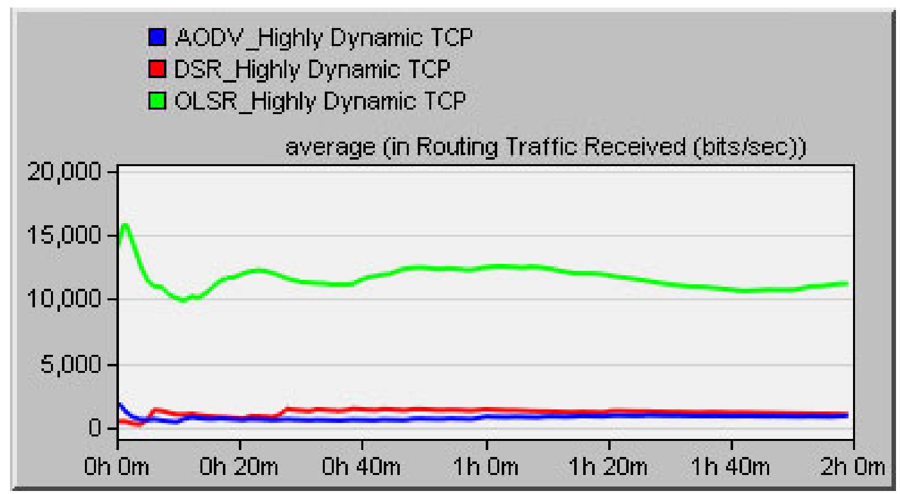
Average routing traffic sent and received in a static ad-hoc network in TCP connection scenarios





Average routing traffic sent and received in a less dynamic ad-hoc network in TCP connection scenarios





Average routing traffic sent and received in a highly dynamic ad-hoc network in TCP connection scenarios

Conclusions

- AODV is the most flexible routing protocol in the presence of movement
- DSR does not perform well in presence of movement
- DSR suffers from less flexibility in presence of movement
- In case of TCP connection scenarios, DSR shows good performance in download response time and has low routing traffic overhead
- OLSR routing protocol maintains the demand for end-to-end delay value less than 20 ms
- In case of TCP connection scenarios, OLSR does not perform well
- In the presence of movement, DSR and OLSR impose large routing traffic overhead

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