CS 525M – Mobile and Ubiquitous Computing Seminar

A performance comparison of multi-hop wireless ad hoc network routing protocols

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Contributions

- Extending NS2
  - Node Mobility
  - Realistic PHY layer radio propagation model (delay, capture effects, carrier sense)
  - Radio network interface (transmission power, antenna gain, receiver sensitivity)
  - IEEE 802.11 MAC layer Distributed Coordination Function (DCF)
  - Ad hoc routing protocols (DSDV, TORA, DSR, AODV)
- Methodology of studying MANET performance by simulation
  - Movement Model
  - Communication Model
  - Multiple Scenarios
  - Validations
- Performance Comparison of Ad Hoc routing protocols

Outline

- Introduction
- Background
- Ad Hoc Routing Protocols Studies
- Methodology
- Simulation Results
- Conclusions and Future work

Background

Mobile Ad Hoc Network (MANET) Routing

- Every Host is a Router
- High Dynamic (Topology Change)
- High Error Rate
- Low Bandwidth (?)
- Power Consumption

Categorization of MANET Routing Protocols

- Table-Driven
  - One or more table to store routing information
  - Propagating update throughout network
- Demand-Driven (Source-initiated)
  - Source initiates route discovery
  - Routs maintenance

Background

MANET Routing Protocols

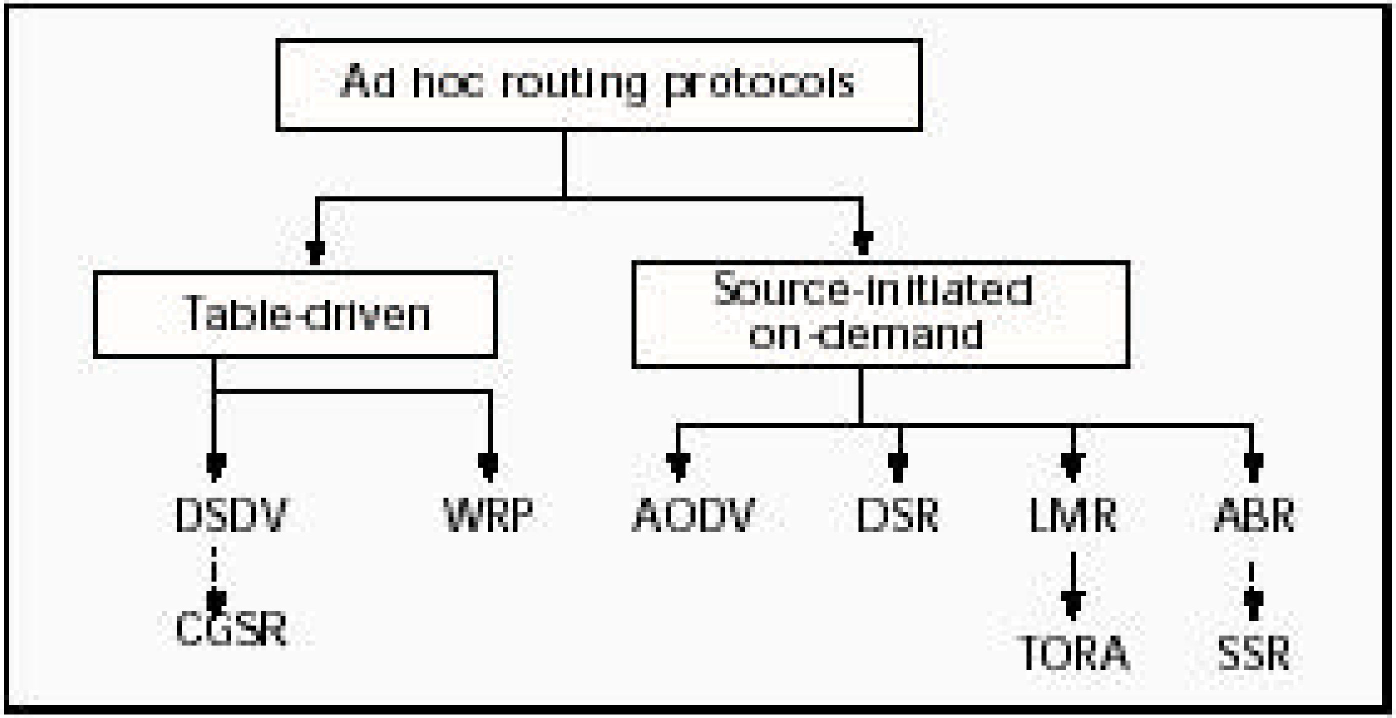

Figure. Categorization of ad hoc routing protocols. [1]

1. **A review of current routing protocols for ad hoc mobile wireless networks E. Royer and C.-K. Toh,**

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Destination-Sequence Distance Vector (DSDV)

- Table-Driven
- Routing Table
  - All available destination
  - Number of hops to destination (Metric)
  - Sequence number assigned by the destination
- Routing Update
  - time-driven: periodically transmit their routing tables to their immediate neighbors.
  - event-driven: on significant change in routing table
  - Full dump: full routing table, multiple packets
  - Incremental update: metric change since the last update.

DSDV Implementation Detail

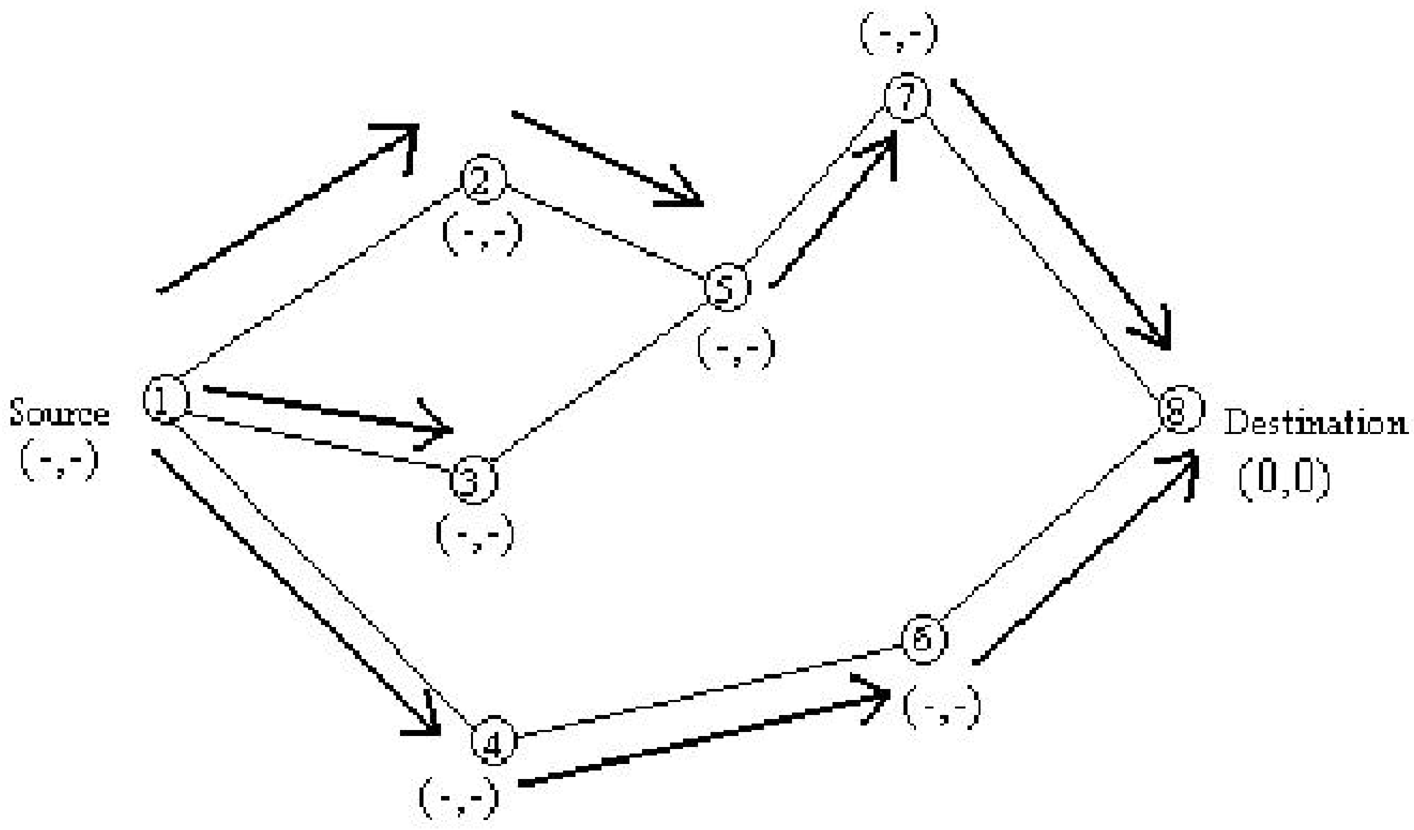
- DSDV-SQ (Sequence Number)
  - DSDV-SQ: Event-Driven update triggered by Sequence Number Change
  - DSDV (simple): Triggered by new metric
- Constant Used in DSDV-SQ

Periodic route update interval	15 s
Periodic updates missed before link declared broken	3
Initial triggered update weighted settling time	6 s
Weighted settling time weighting factor	7/8
Route advertisement aggregation time	1 s
Maximum packets buffered per node per destination	5

Temporally-Ordered Routing Algorithm (TORA)

- Demand-Driven
- “Water flowing downhill towards a destination” (“Height” change)
- Route creation
  - Source broadcasts a QUERY packet
  - Destination reply UPDATE packet
  - Intermediate nodes forward QUERY/ UPDATE, and change “height”
- Route maintenance
  - Reversal Link
- Route erasure
  - Send CLEAR packet on network partition

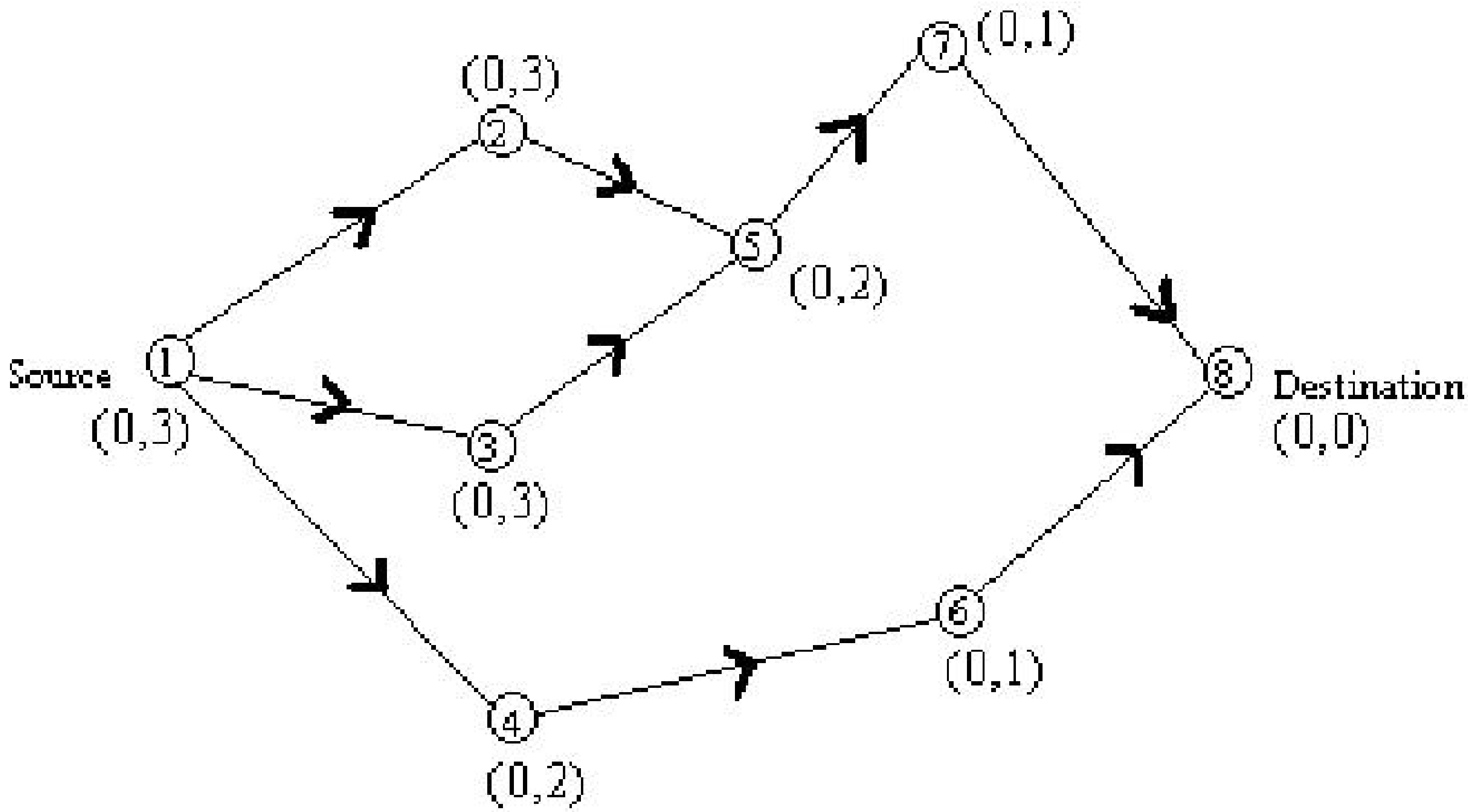
TORA Route Creation



(a) Propogation of QRY message through the network

2. Routing Protocols for Ad Hoc Mobile Wireless Networks http://www.cis.ohio-state.edu/~jain/cis788-99/ftp/adhoc_routing.pdf Padmini Misra

TORA Route Creation



(b) Height of each node updated as a result of UPD messages

TORA Implementation Detail

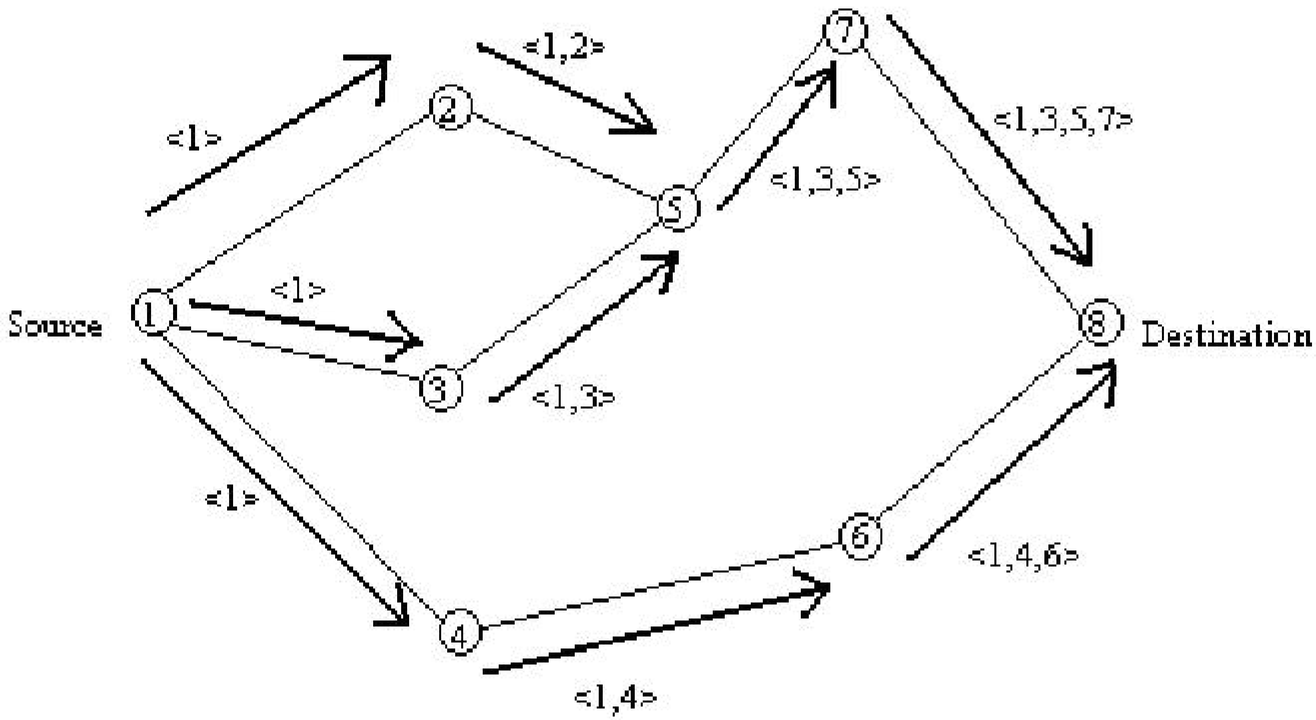
- Internet MANET Encapsulation Protocol (IMEP)
  - Reliable, in-order routing packet delivery
  - Link status sensing: BEACON/HELLO
- Link layer address resolution: ARP
- Constant Used in TORA

BEACON period	1 s
Time after which a link is declared down if no BEACON or HELLO packets were exchanged	3 s
Time after which an object block is retransmitted if no acknowledgment is received	500 ms
Time after which an object block is not retransmitted and the link to the destination is declared down	1500 ms
Min HELLO and ACK aggregation delay	150 ms
Max HELLO and ACK aggregation delay	250 ms

Dynamic Source Routing (DSR)

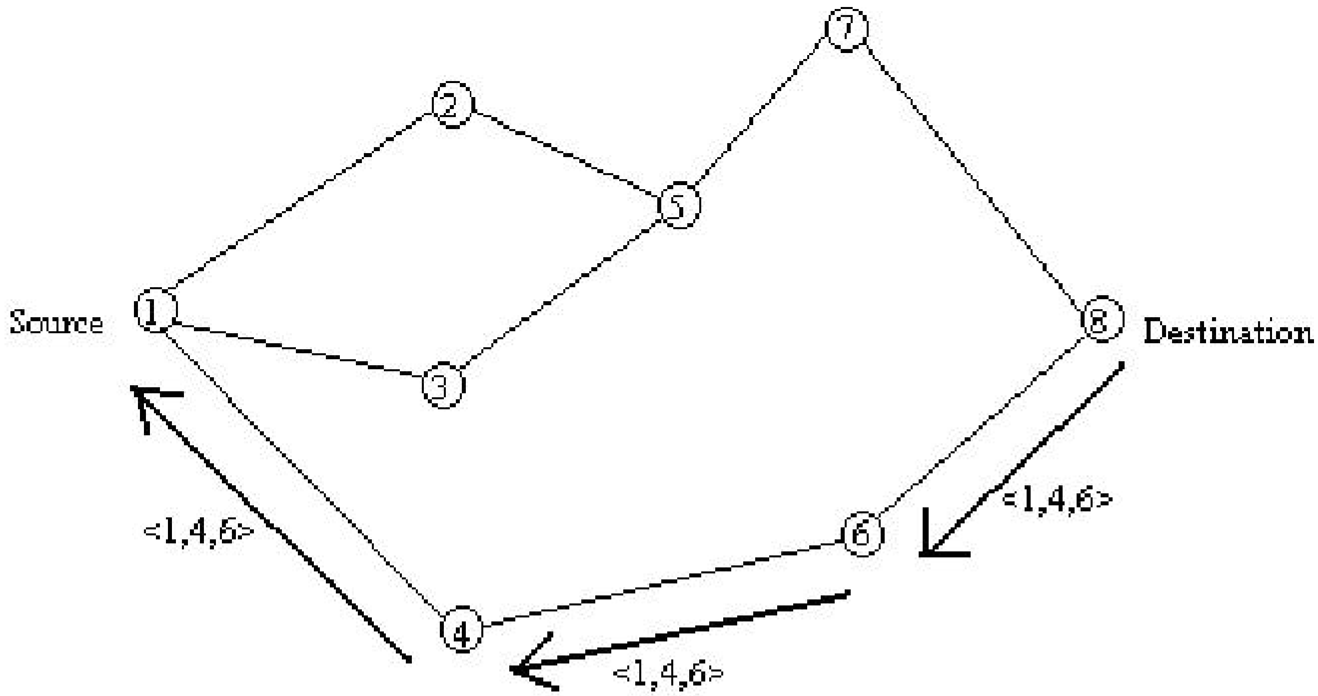
- Demand-Driven
- Source Routing
  - Each packet have the ordered node list as routing info in the header
  - Intermediate nodes do not need to maintain routing info.
- Route Discovery
  - Source floods REQUEST with unique ID
  - Destination or intermediate nodes having the route reply REPLY with node list
- Route Maintenance
  - Route Error Message

DSR Route Creation



(a) Building Record Route during Route Discovery

DSR Route Creation



(b) Propogation of Route Reply with the Route Record

DSR Implementation Detail

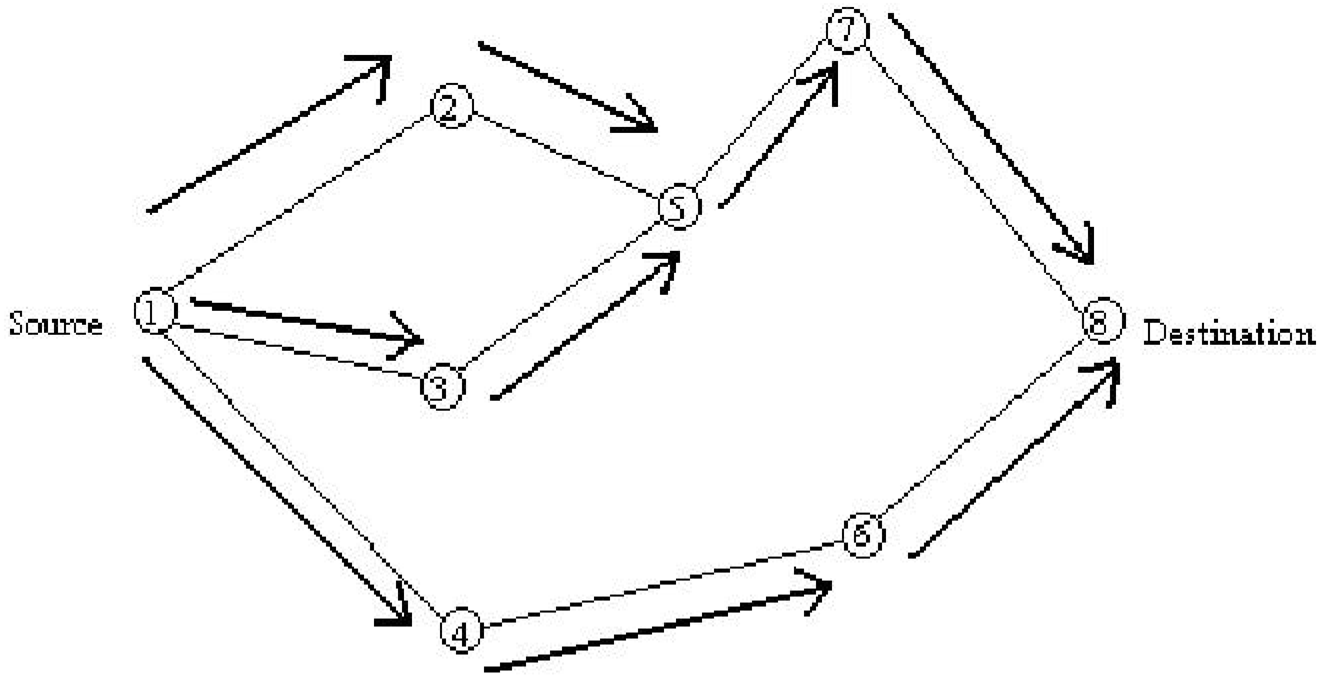
- Bi-direction Route implementation
- Route Cache optimization
  - Single hop QUERY
  - Forwarding to cached route on error
- Constant Used in DSR

Time between retransmitted ROUTE REQUESTS (exponentially backed off)	500 ms
Size of source route header carrying *n* addresses	$4n + 4$ bytes
Timeout for nonpropagating search	30 ms
Time to hold packets awaiting routes	30 s
Max rate for sending gratuitous REPLYS for a route	1/s

Ad Hoc On-Demand Distance Vector (AODV)

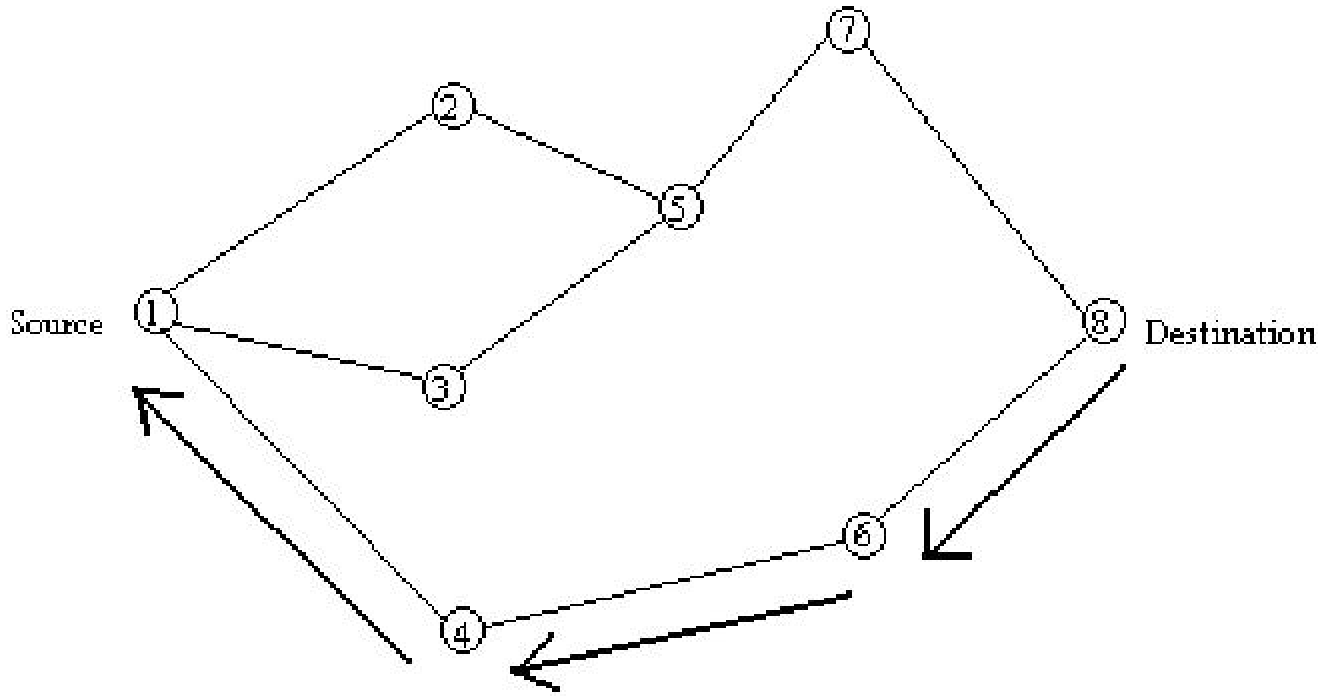
- Demand-Driven
- Combination of DSR and DSDV
  – DSR: Route discover and maintenance
  – DSDV: hop-by-hop routing, Sequence number, and periodic beacons
- Route Discovery
  – REQUEST/REPLY as DSR
  – Route record in each intermediate node's routing table
  – Hop-by-hop forwarding
- Route Maintenance
  – Detect link failure by periodically sending HELLO message
  – UNSOLICITED ROUTE REPLY on error

AODV Route Creation



(a) Propogation of Route Request (RREQ) Packet

AODV Route Creation



(b) Path taken by the Route Reply (RREP) Packet

AODV Implementation Detail

- AODV-LL (Link Layer)
  - Reduce overhead: No HELLO message used
  - Can't detect link breakage before transmission a packet
  - Perform better
- Constant Used in AODV

Time for which a route is considered active	300 s
Lifetime on a ROUTE REPLY sent by destination node	600 s
Number of times a ROUTE REQUEST is retried	3
Time before a ROUTE REQUEST is retried	6 s
Time for which the broadcast id for a forwarded ROUTE REQUEST is kept	3 s
Time for which reverse route information for a ROUTE REPLY is kept	3 s
Time before broken link is deleted from routing table	3 s
MAC layer link breakage detection	yes

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Methodology

- Simulation Setup
  - 50 nodes, 1500m*300m space, 900 seconds
  - Create scenario files for each run, using identical file for the 4 routing protocols, 10 run for each
  - Radio character: Lucent WaveLAN radio DSSS
- Movement Model
  - Move-pause-move
  - Pause time: from 0-900 secs
  - Speed: 1m/s and 20m/s
- Communication Model
  - UDP CBR Source 10, 20, 30
  - Packet size: 64 bytes

Methodology

- Scenario Characteristics

Pause Time	# of Connectivity Changes	
	1 m/s	20 m/s
0	898	11857
30	908	8984
60	792	7738
120	732	5390
300	512	2428
600	245	1270
900	0	0

- Validation
  - Propagation Model and MAC layer
  - Routing Protocol Implementation

Methodology

- Metrics
  - *Packet delivery ratio*: The ratio between the number of packets originated by the “application layer” CBR sources and the number of packets received by the CBR sink at the final destination.
  - *Routing overhead*: The total number of routing packets transmitted during the simulation. For packets sent over multiple hops, *each* transmission of the packet (each hop) counts as one transmission.
  - *Path optimality*: The difference between the number of hops a packet took to reach its destination and the length of the shortest path that physically existed through the network when the packet was originated.

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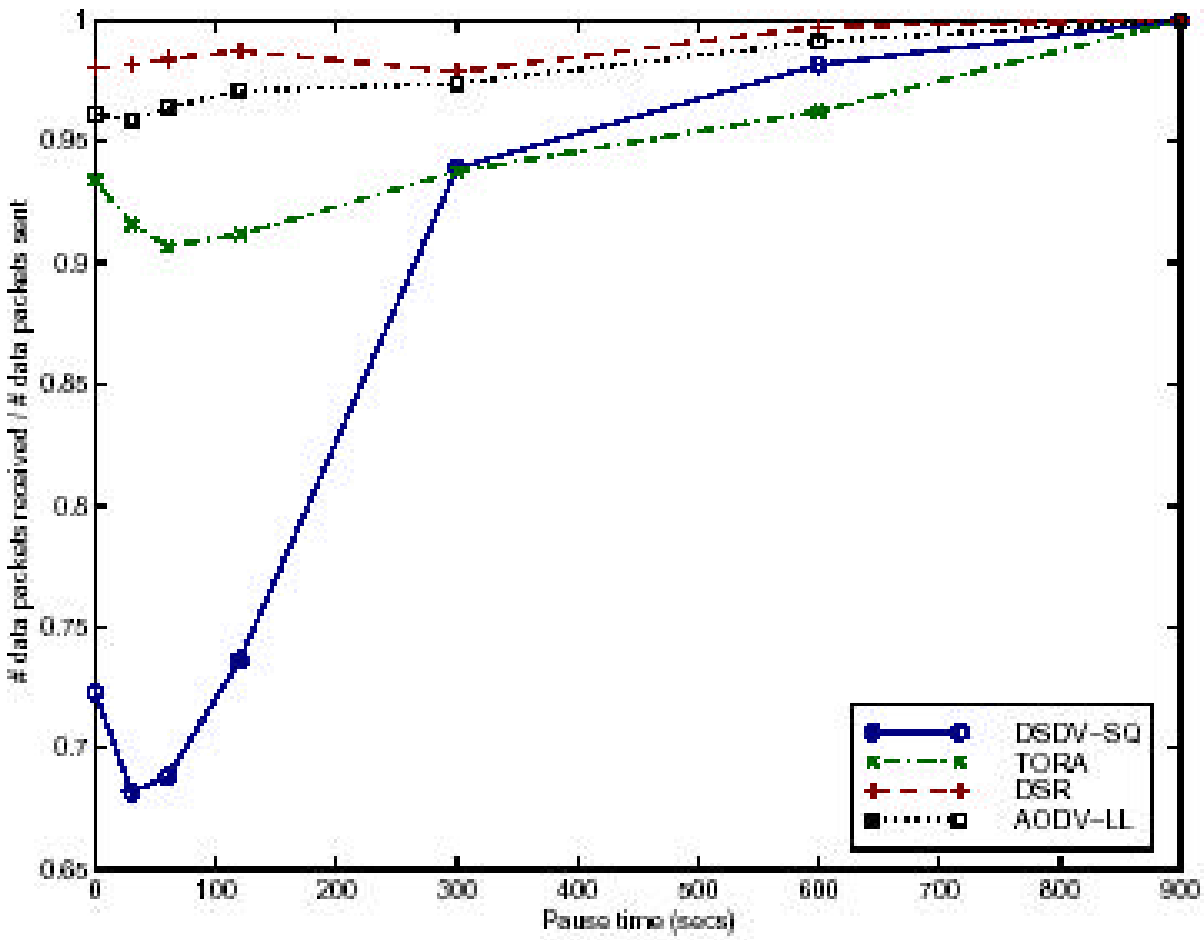
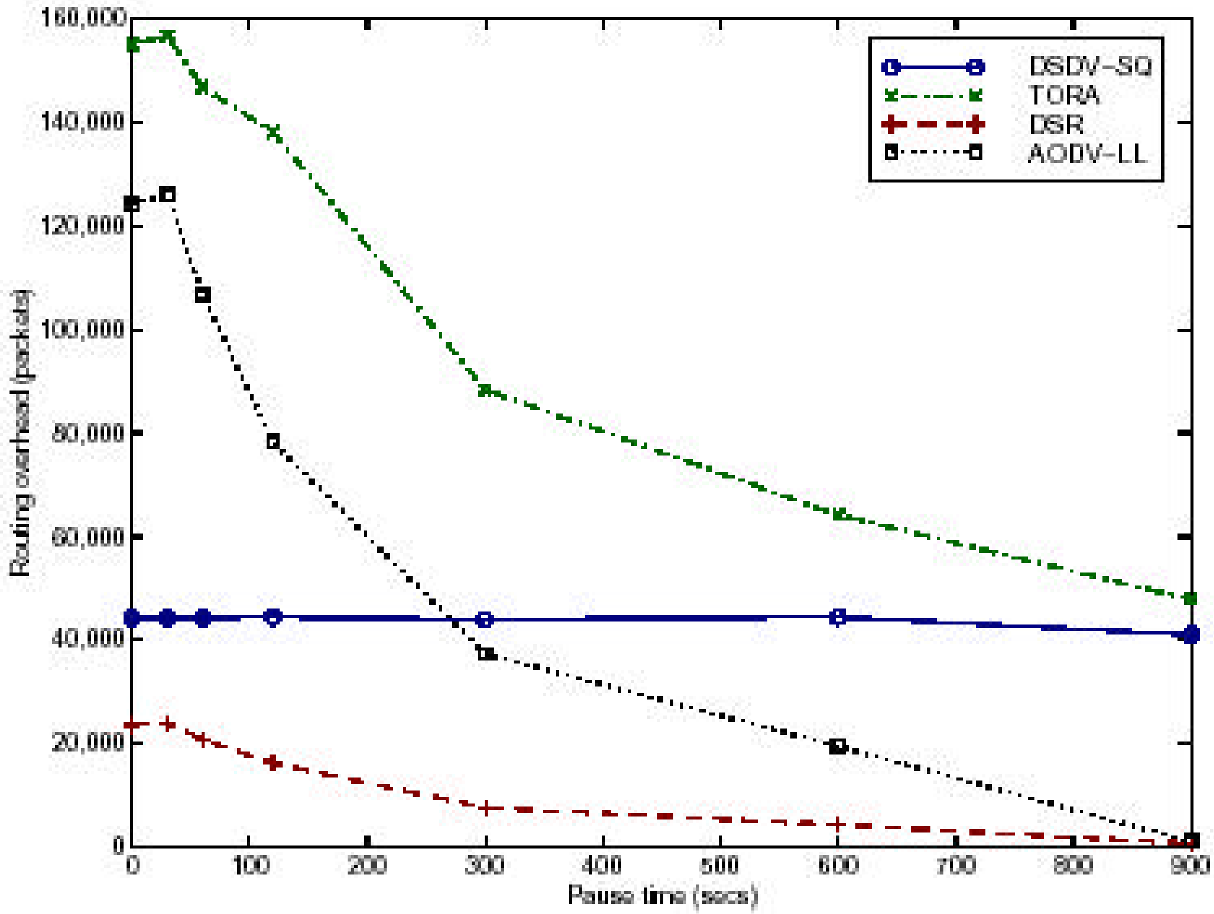
Simulation Results

1. **The fraction of application data packets successfully delivered (packet delivery ratio) as a function of pause time. (20 sources, 20m/s)**



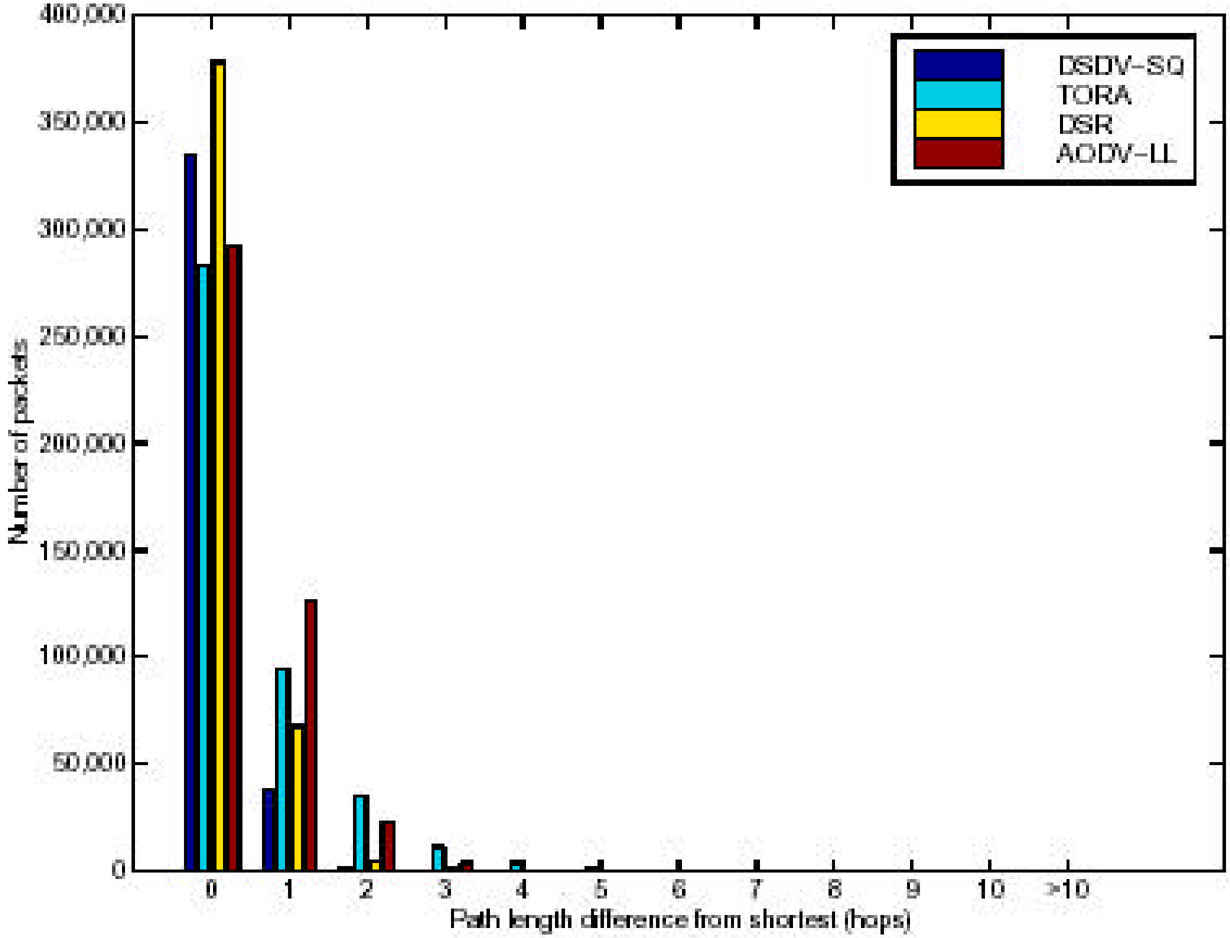
Simulation Results

2. **The number of routing packets sent (routing overhead) as a function of pause time. (20 sources, 20m/s)**



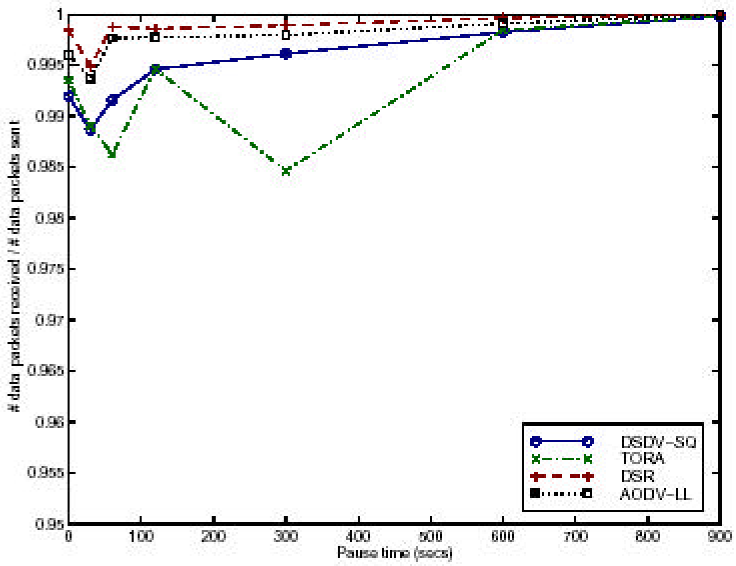
Simulation Results

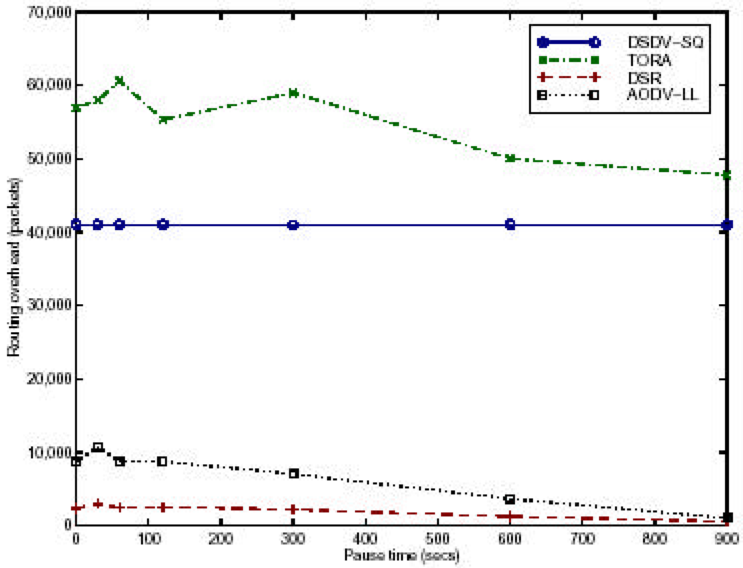
3. **Difference between the number of hops each packet took to reach its destination and the optimal number of hops (20 sources, 20 m/s)**



Simulations Results

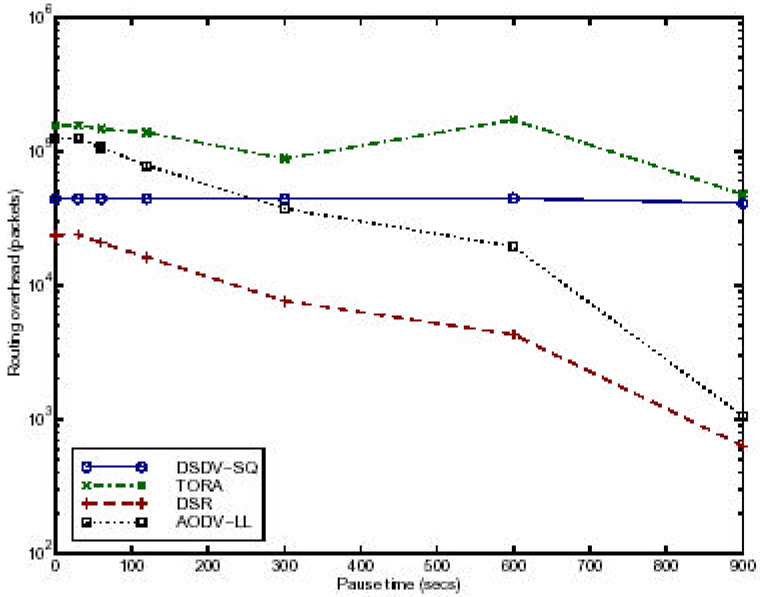
4. Low speed results:
The packet delivery ratio (left) and routing overhead (right) as a function of pause time. (20 sources, 1m/s)
DSR wins again!



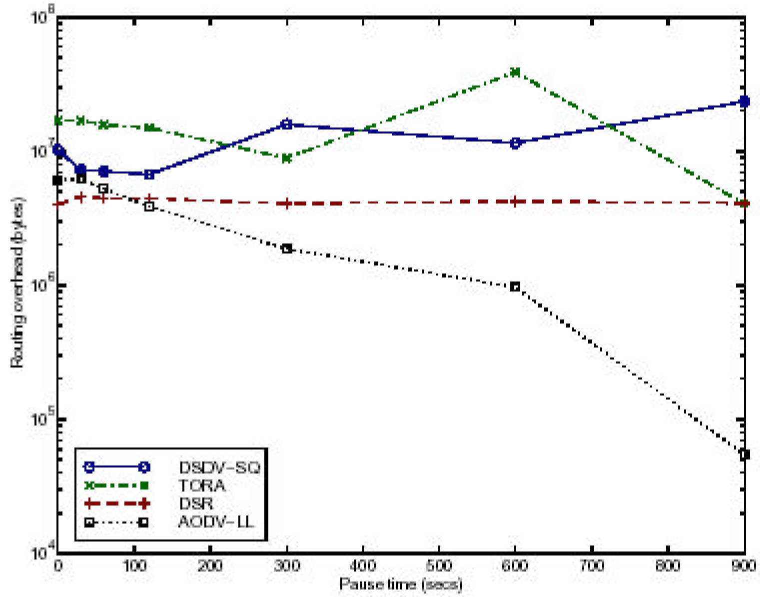


Simulations Results

5. Routing Overhead in packets (left) and bytes (right)
AODV-LL have fewer bytes overhead than DSR



(a) Routing overhead in packets.



(b) Routing overhead in bytes.

DSR: Few packets; More bytes
AODV-LL: More packets; Few bytes

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  - Radio network interface (transmission power, antenna gain, receiver sensitivity)
  - IEEE 802.11 MAC layer Distributed Coordination Function (DCF)
  - MANET routing protocols (DSDV, TORA, DSR, AODV)
- Performance Comparison of MANET routing protocols
  - DSR was good at all mobility rates and movement speeds
  - AODV-LL perform close to DSR, but have more packets over head

Thanks!

Questions?