Analysis of Inconsistent Routing Components in Reactive Routing Protocols

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Outline

- Introduction
  - How to Improve Reactive Routing?
  - The Problem: Use of Prior-to-demand Collected Routing Data??
- Analysis of AODV
  - Objectives and Nature of Analysis
  - AODV-TTL
  - AODV-RS
  - Simulation Setup/Results
- Conclusions

How to Improve Reactive Routing?

- Reactive Routing
  - On-demand operations
  - High Response Time
    - Connection set up/recovery
- Typical Approach
  - Use prior-to-demand collected routing data
  - Share more-than-demanded routing data
    - route request/reply packets carry additional data
  - Collect more-than-required routing data
    - overhear the routing packets for others
  - Use in route interruptions or subsequent route discoveries

Use of Prior-to-demand Collected Routing Data

- Examples
  - DSR maintains alternate routes by overhearing routing packets
  - AODV uses previously known hop-count in new route discoveries
  - Overhearing: a common practice among multiple path protocols
    - For example: AOMDV, AODV-BR

- An Inconsistent Approach
  - No proactive mechanism to refresh stored routing data
  - Due to ever changing topology future and fortune of such acts
    - Totally dependent on network and topology conditions
    - Unpredictable and volatile behavior/effects/benefits

This Paper

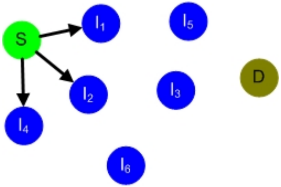
- Analyze: use of prior-to-demand collected routing data
  - Understand the effect on
    - Protocol operations
    - Protocol/Network performance
- Approach
  - Analyze the deviation in the behavior of a reactive routing protocol after
    - Increasing the use of previously collected routing data
    - Decreasing the use of previously collected routing data

Analysis

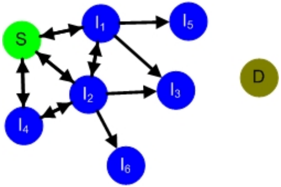
- Standard AODV vs. two modified versions
  - AODV-TTL
    - less dependent on previously collected routing data
    - more reactive
  - AODV-RS
    - shares more routing data for subsequent use
    - subsequent actions: less reactive
  - Compared performance metrics
    - MAC overhead
    - Routing overhead
    - Data packet delivery ratio
    - Route discovery time

AODV-TTL

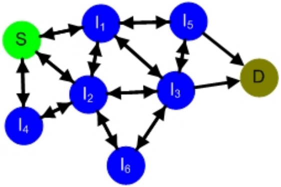
- Expanding ring search during the route discovery
  - TTL field determines how many hops a RREQ will travel
- In AODV: in case of an existing entry
  - TTL = last known hop count + TTL_INCREMENT > TTL_START
- In AODV-TTL
  - TTL = TTL_START
  - Route recovery or route discoveries: completely on-demand



Expanding ring search: TTL=1



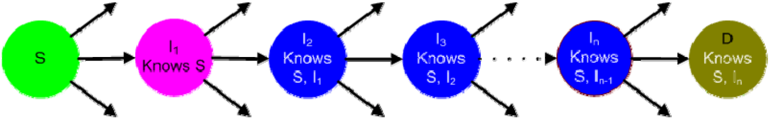
Expanding ring search: TTL=2



Expanding ring search: TTL=3

AODV-RS

- Routing messages carry the information on two nodes only
  - The originator and the previous hop
- Route Sharing
  - Include all the nodes along the path into a RREQ/RREP message
  - In AODV-RS
    - every intermediate node appends its previous hop
    - shares ample amount of prior-to-demand routing data
    - effect the subsequent actions



Learning during route discovery

Simulations

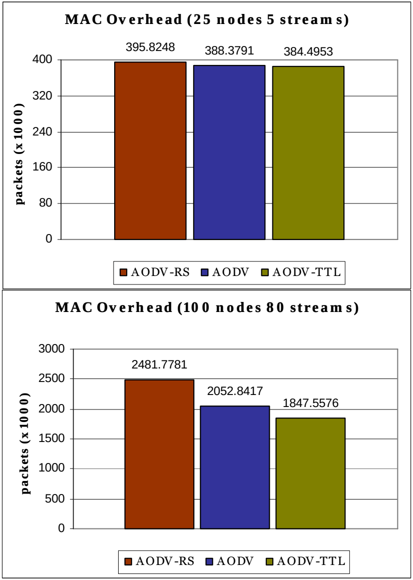
- OPNET Modeler
  - manet_station node model
  - Random way point mobility
- Simulation scenarios
  - Varying network size and data streams
  - Varying mobility parameters

Simulation Scenarios			
Nodes	Area	Data Streams	Active Nodes
25	800 m X 800 m	5	8
		20	20
100	2000 m X 500 m	20	30
		80	85

Simulation settings for Pause Time, Node Speed and Packet Rate			
Variation of	Pause Time (seconds)	Node Speed (m/sec.)	Data Packet Rate (packets/second)
Pause Time	0, 30, 60, 300, 900, 1800	1	4
Node Speed	0	1, 2, 5, 10, 25	4
Packet Rate	0	1	1, 2, 5, 10, 20

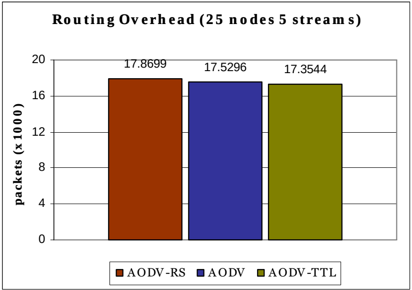
Results: MAC Overhead

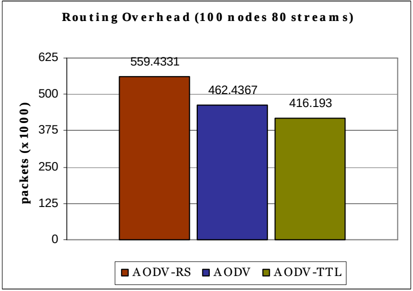
- AODV-RS
  - 2-20 % higher
- AODV-TTL
  - 1-11 % less



Results: Routing Overhead

- AODV-RS
  - 2-20 % higher
- AODV-TTL
  - 1-11 % less
- Quite similar to MAC overhead
  - In reactive routing protocols, Routing traffic dictates the overhead





Results: Overhead

- Why the packet overhead is high in AODV-RS?
    - Higher initial value of TTL
        - Less controlled flooding
    - Higher contribution of RREP messages
        - More nodes are able to respond during route discovery

Initial value of the TTL field

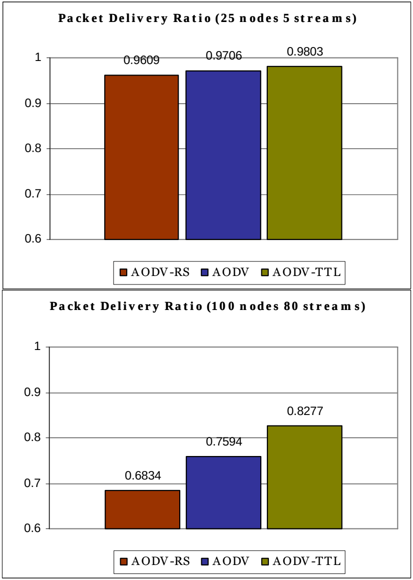
	AODV-RS	AODV
25 nodes 5 stream	**1.69**	1.21
25 nodes 20 streams	**2.27**	1.52
100 nodes 20 streams	**3.03**	1.81
100 nodes 80 streams	**4.77**	2.56

Percentage of RREQ and RREP packets

		AODV-RS	AODV
RREQ	25 nodes 5 stream	**81.73**	82.42
	25 nodes 20 streams	**77.69**	80.53
	100 nodes 20 streams	**75.89**	78.10
	100 nodes 80 streams	**72.69**	77.84
RREP	25 nodes 5 stream	**13.66**	13.53
	25 nodes 20 streams	**18.32**	17.10
	100 nodes 20 streams	**21.73**	18.59
	100 nodes 80 streams	**25.34**	19.29

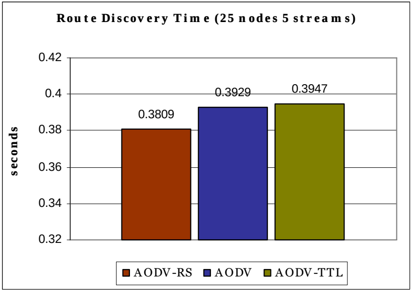
Results: Packet Delivery

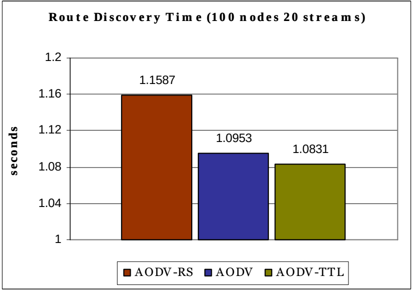
- Data Packet Delivery Ratio
  - AODV-RS
    - 1-10 % less
  - AODV-TTL
    - 1-8 % higher
  - Higher overhead
    - causes more saturation
    - results in less throughput



Results: Route Discovery

- Route Discovery Time
  - Inconclusive
  - 802.11 is a contention-based MAC
  - AODV-RS
    - 3 % less in (25 nodes 5 streams) scenario
    - 2-6 % higher in others
    - RREP requires RTS/CTS exchange
  - AODV-TTL
    - 1 % less in (100 nodes 20 streams) scenario
    - 0.5-3 % higher in others
    - Requires more expansion steps of ring search





Conclusions

- More prior-to-demand routing data present in the network
  - Less RREQs but more RREPs
  - AODV loses the benefit of expanding ring search
    - suffers due to higher TTL
  - More overhead
    - AODV-RS > AODV > AODV-TTL
  - Less packet delivery ratio
    - Mainly due to higher overhead, contention
  - Route discovery time
    - unpredictable in contention based scenarios

Conclusions

- Expanding ring search without exceptions
  - Less overhead
  - Higher route discovery time
- Sharing more routing data: Not a good approach
  - Higher overhead
  - Collecting more routing data might work in some cases

Thank you very much for your attention

Questions/Comments/Suggestions

Why AODV?

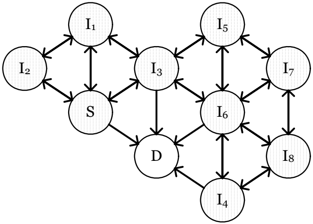
- Popular and well reputed
- A very simple protocol
- Based on fundamental reactive principles
  - Route discovery
    - purely reactive
    - except the TTL adjustment
    - expanding ring search: a good approach to control flooding
- Presence of prior-to-demand routing data
  - Works the same in most of the reactive protocols

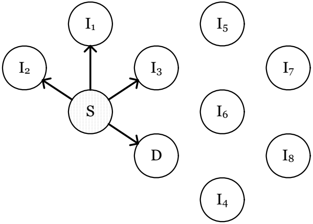
AODV Routing Protocol

- Route Discovery
  - Floods RREQ, unicast RREP
  - Expanding ring search approach
    - start TTL with TTL_START
    - step by TTL_INCREMENT on every failed attempt
    - until reaches NET_DIAMETER
    - in case of an existing entry, start TTL with HOP_COUNT+TTL_INCREMENT
    - only RREQ_RETRIES attempts at TTL=NET_DIAMETER
- Route Interruption
  - Informs using RERR
  - Performs local repair or source initiates a new route discovery

Effect of the Initial Value of TTL Field

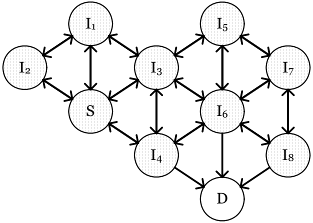
- When destination is closer than the previously known hop count
  - The destination was previously two hops away
  - The shaded nodes are those which have transmitted a RREQ packet
  - Left: the initial value of the TTL field is (2 + TTL_INCREMENT = 4)
  - Right: The initial value of the TTL field is TTL_START i.e. 1

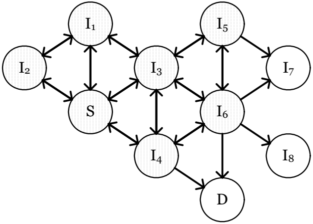




Effect of the Initial Value of TTL Field

- When destination is at the same distance as the previously known hop count
  - The destination was previously two hops away
  - The shaded nodes are those which have transmitted a RREQ packet
  - Left: the initial value of the TTL field is (2 + TTL_INCREMENT = 4)
  - Right: The initial value of the TTL field is TTL_START i.e. 1
    - Requires another phase with expanded ring TTL+=TTL_INCREMENT=3





Simulation Parameters

- OPNET Modelere with wireless suite
- SMP machine with 2 Intel Xeon 3.0 GHz processor
- 2 GB RAM
- Microsoft Windows Server 2003
- Simulation run duration: 1800 seconds
- 1024 Bytes per packet
- Every combination of settings repeated with 5 different seeds
- Random waypoint mobility traces are first evaluated to avoid
  - Density wave
  - Speed decay

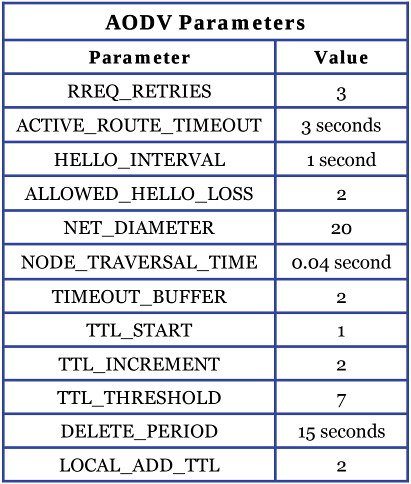
Simulation Parameters

- Node coverage ≈ 250m (radius)
  - Transmit power = 0.04 watt
  - Packet Reception-Power Threshold = 73 dBm

Simulation Environment				
Network Size	**Geographical Area**	**Node Density (per sq. km)**	**Network Diameter (nodes)**	**Neighbor Count**
25 nodes	800 m X 800 m	39.06	4.52	7.67
100 nodes	2000 m X 500 m	100	8.25	19.63

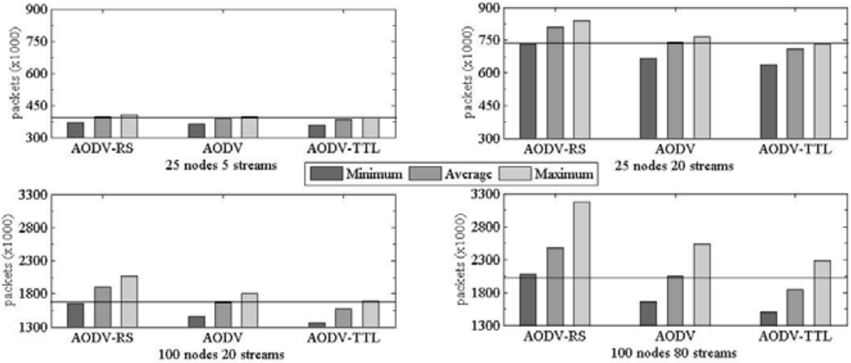
Simulation Parameters

- AODV settings

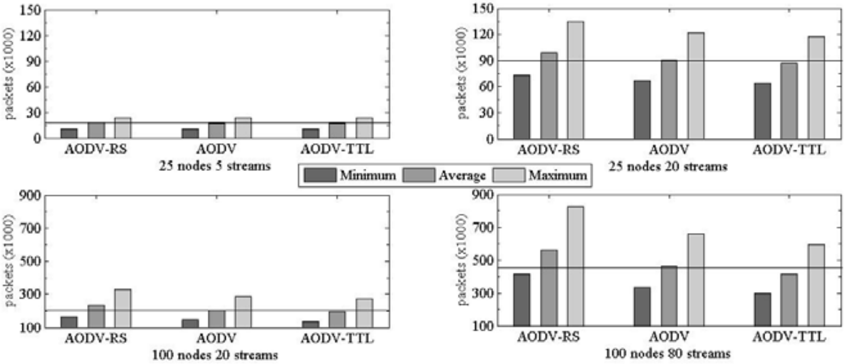


AODV Parameters	
Parameter	**Value**
RREQ_RETRIES	3
ACTIVE_ROUTE_TIMEOUT	3 seconds
HELLO_INTERVAL	1 second
ALLOWED_HELLO_LOSS	2
NET_DIAMETER	20
NODE_TRAVERSAL_TIME	0.04 second
TIMEOUT_BUFFER	2
TTL_START	1
TTL_INCREMENT	2
TTL_THRESHOLD	7
DELETE_PERIOD	15 seconds
LOCAL_ADD_TTL	2

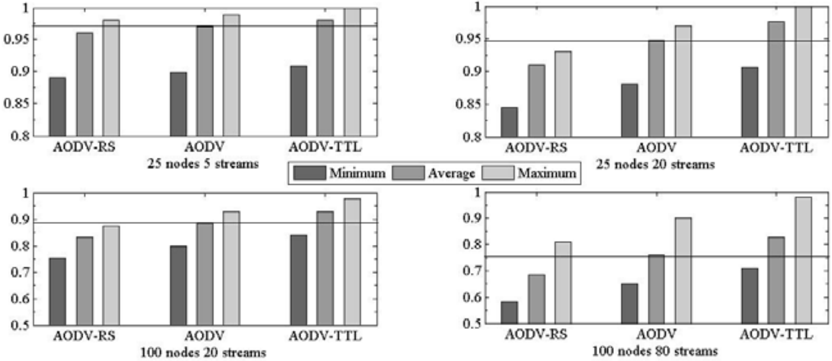
MAC Overhead



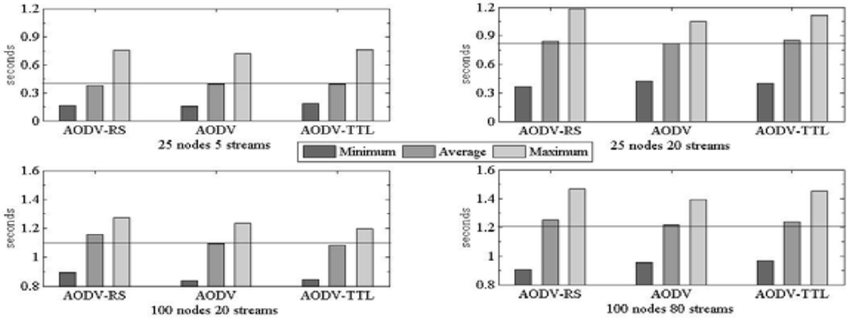
Routing Overhead



Data Packet Delivery Ratio



Route Discovery Time


seconds
AODV-RS
AODV
AODV-TTL
25 nodes 5 streams
seconds
AODV-RS
AODV
AODV-TTL
25 nodes 20 streams
Minimum
Average
Maximum
seconds
AODV-RS
AODV
AODV-TTL
100 nodes 20 streams
seconds
AODV-RS
AODV
AODV-TTL
100 nodes 80 streams