Ad-hoc On-Demand Distance Vector Routing

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Proseminar: Algorithms for Computer Networks
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Structure

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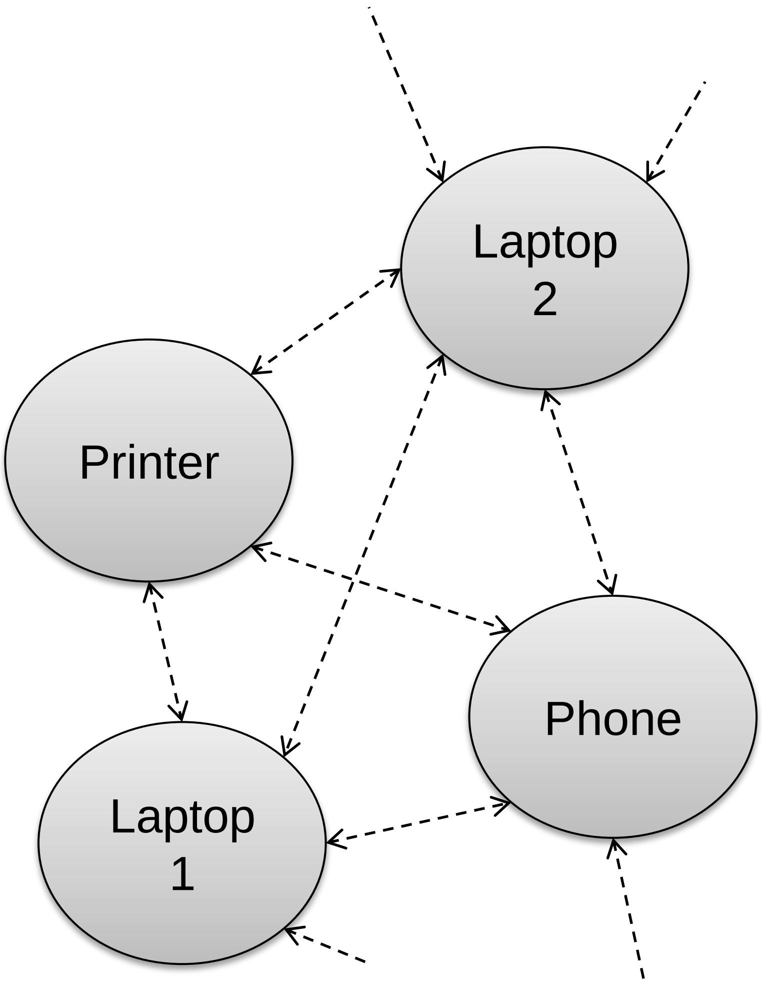
1. Motivation

- Technological progress
  - Wireless networks
  - Increasing amount of nodes
- On-the-fly ad-hoc networks
- Research groups
  - Algorithmic complexity
  - New routing solutions



1. Motivation

- Destination-Sequenced Distance Vector (DSDV)
  - Ad-hoc network
  - Complete lists of routes
  - System-wide advertisement
    - Periodic and event triggered

Pros

- Low route request latency

Cons

- High overhead

→ Small amount of nodes with low mobility

1. Motivation

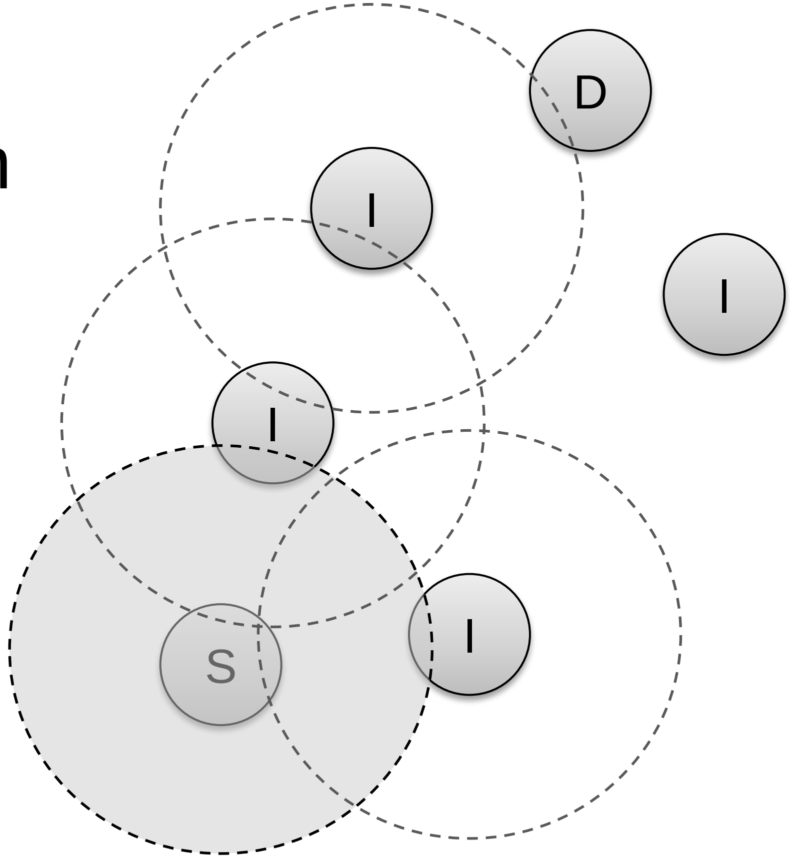
- Ad-hoc On-Demand Distance Vector Routing

Goals

- ➢ Scalable to large networks
- ➢ Few and only local broadcasts
- ➢ Quick adaption to network changes
- ➢ Acceptable route acquisition latency

2. Concept of AODV Routing

- Specialized routers
  - Local broadcasts
- Distance Vector Algorithm
- Route discovery cycle



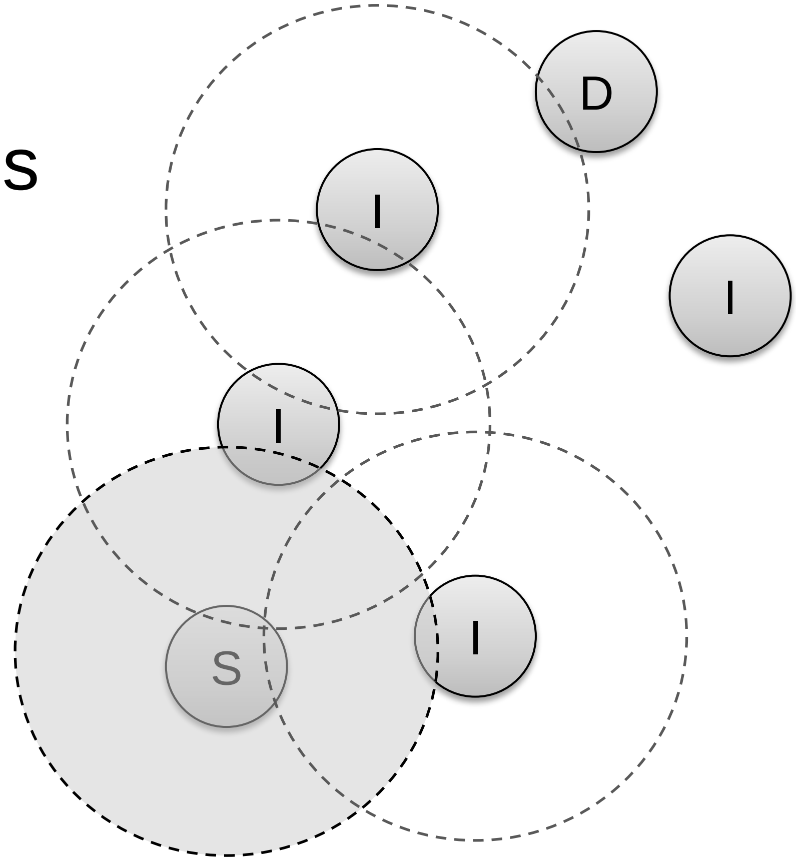
S Source node

I Intermediate node

D Destination node

2. Concept of AODV Routing

- Create routes on demand
  - Dynamic lists
- Maintain only active routes
- Sequence numbers
  - Ensure loop-free routes
  - Freshness of routes and information



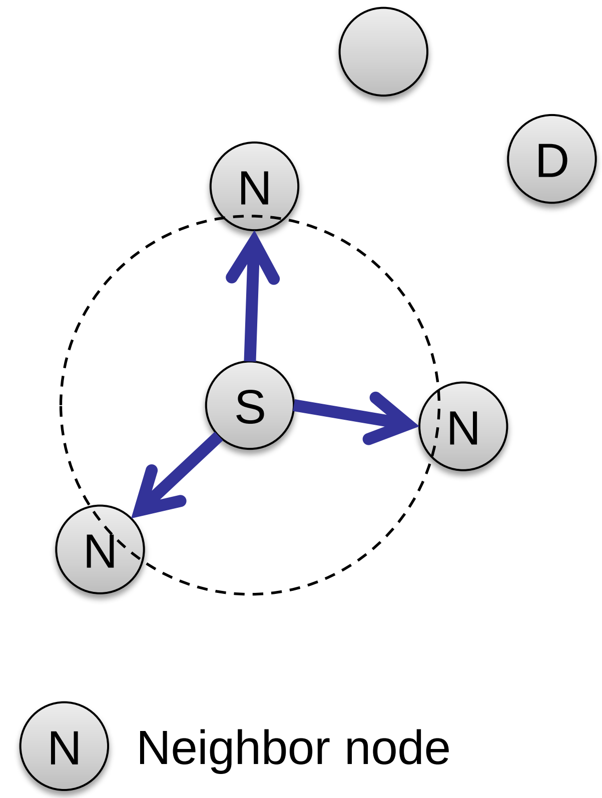
3. The Routing Algorithm

- Path Discovery
  - Reverse Path Setup
  - Forward Path Setup
- Path Maintenance
- Local Connectivity Management

Path Discovery

- Two nodes need to communicate, no information in its table
- Local broadcast
  - Route Request →

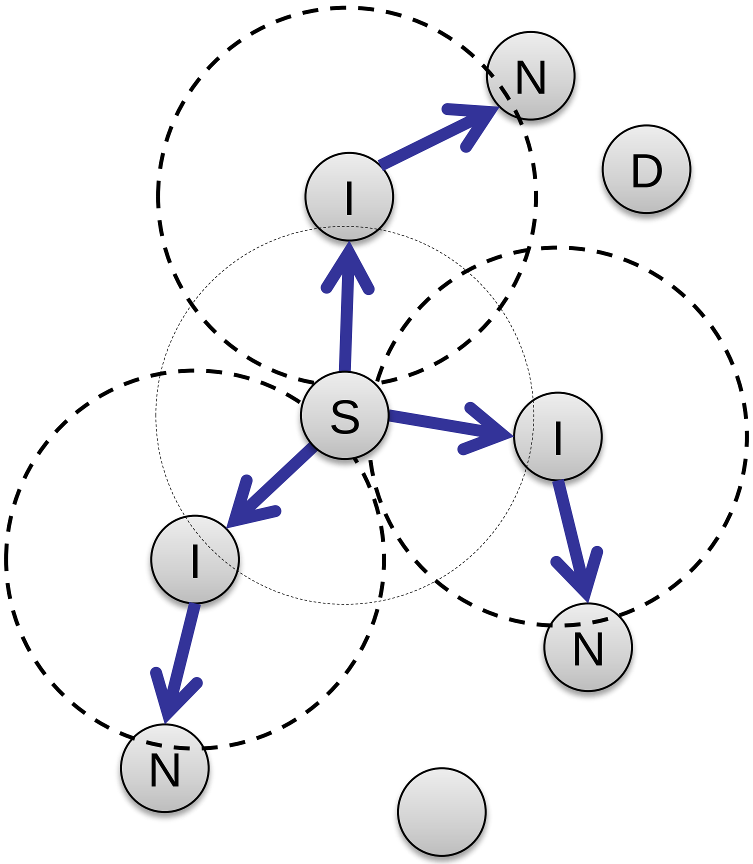
Route Request
Hop Count
Broadcast ID
Destination IP Address
Destination Sequence Number
Source IP Address
Source Sequence Number



Path Discovery

- Two options for neighbors:
  1. Rebroadcast request and keep information
     - Check DSN

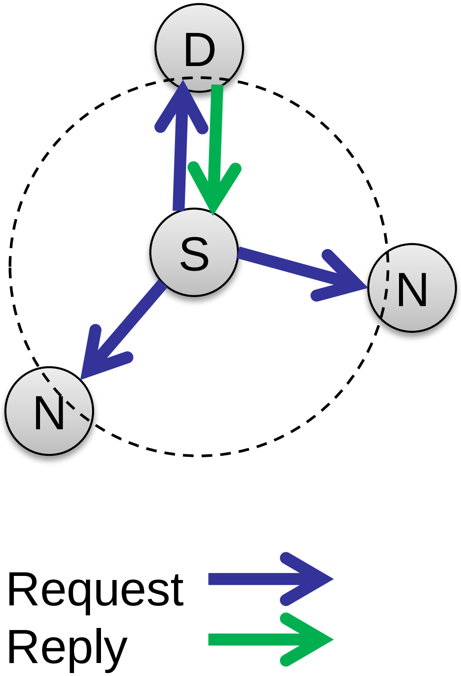
Route table entry
Broadcast ID
Source IP Address
Destination IP Address
Source node's sequence number
Expiration time



Path Discovery

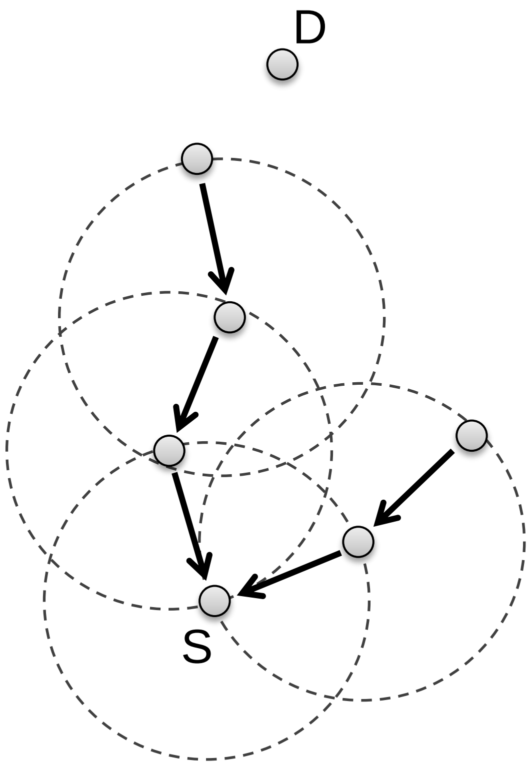
- Two options for neighbors:
  2. Satisfy request and send a Route Reply

Route Reply
Hop Count
Destination IP Address
Destination Sequence Number
Source IP Address
Lifetime



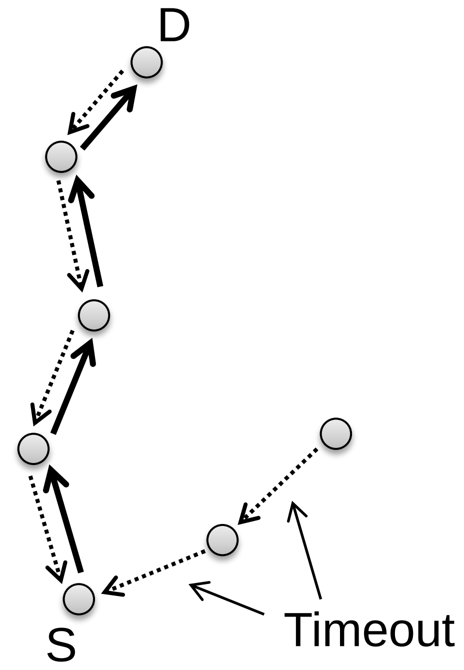
Path Discovery – Reverse Path Setup

- RREQ: Source → various Destinations
- Set up reverse path to source
- Destination sequence number
  - Freshness of route to destination
  - Loop-free routes
- Source sequence number
  - Freshness of information
    about the route to source



Path Discovery – Forward Path Setup

- Arrival at destination or node with current route to the destination
- Unicast Reply to the source node
  - Check destination sequence number
  - If equal check Hop Count
- Each node:
  - Sets up forward pointer
  - Update its timeout information
  - Records latest DSN
- Timeout: Delete reverse pointers

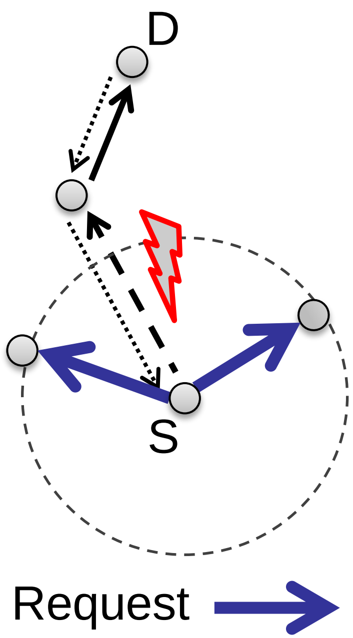


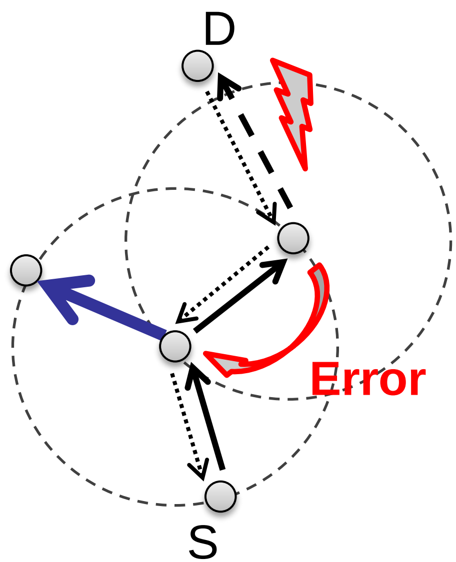
3. The Routing Algorithm

- Path Discovery
  - Reverse Path Setup
  - Forward Path Setup
- Path Maintenance
- Local Connectivity Management

Path Maintenance

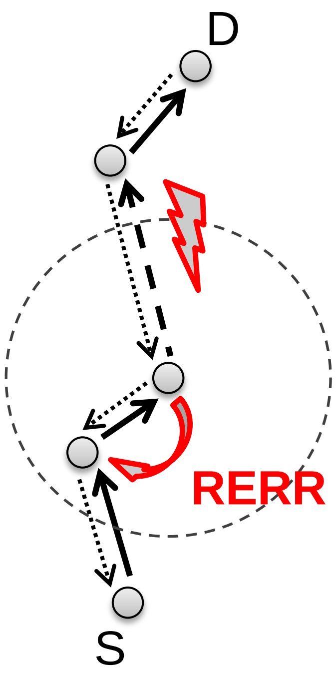
- Two cases for rebuilding:
  1. Source node moves
     - Route discovery procedure
  2. Destination or inter-mediate node moves
     - Error to source nodes
     - Route discovery procedure





Path Maintenance

- Detect link failures
  - Hello messages
  - Next hop unreachable



- Route Error Message

Route Error (RERR)
Unreachable Destination IP
Unreachable DSN
Destination Count

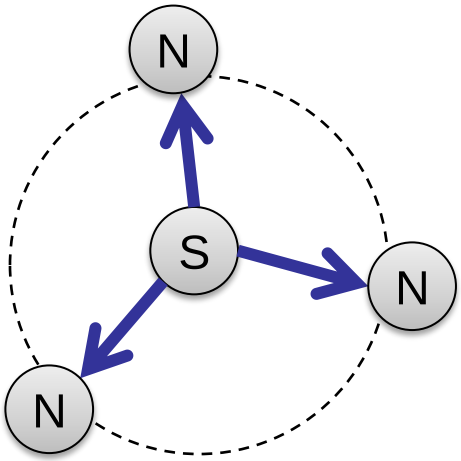
3. The Routing Algorithm

- Path Discovery
  - Reverse Path Setup
  - Forward Path Setup
- Path Maintenance
- Local Connectivity Management

Local Connectivity Management

- Nodes learn of their neighbors in two ways
  - Hello messages
  - Receiving broadcasts

Hello Message	
Source IP	TTL
Source Sequence Number	



⇨ Local connectivity has changed

4. Simulation and Results

Objectives

- Scales well to large networks
- Quick and accurate route establishing
- Determining optimal values for parameters

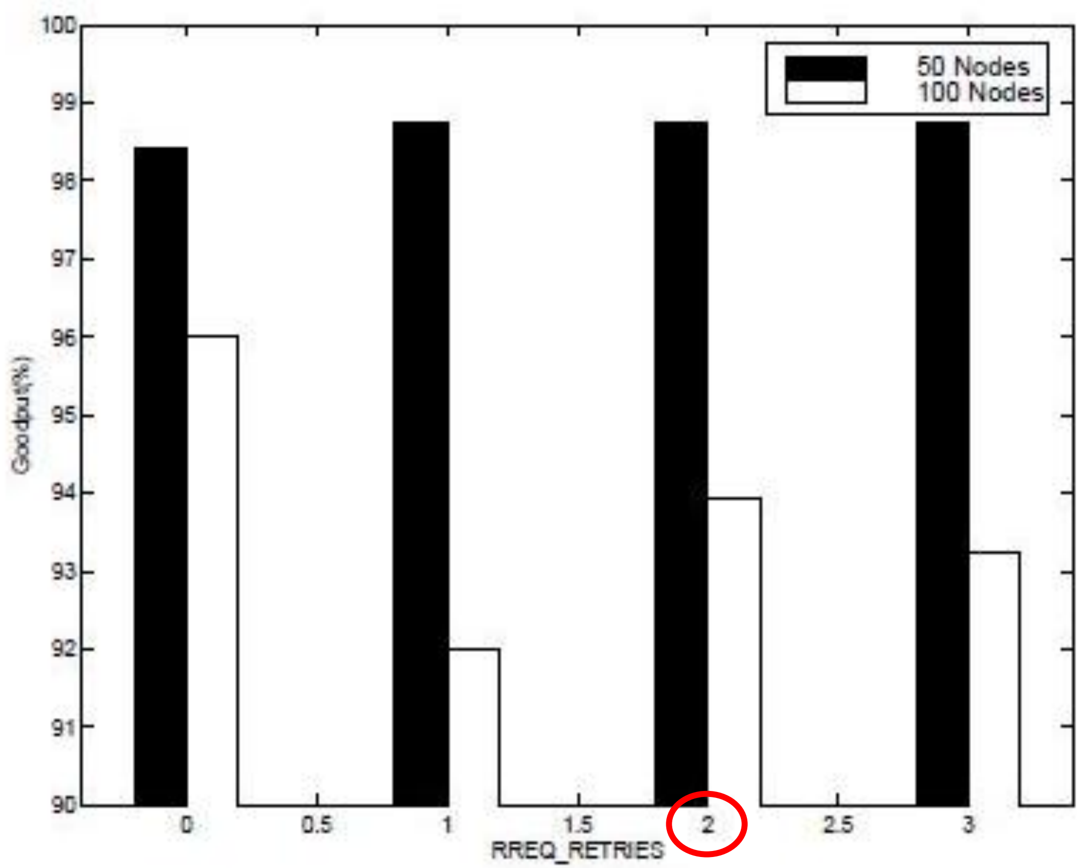
4. Simulation and Results

Environment

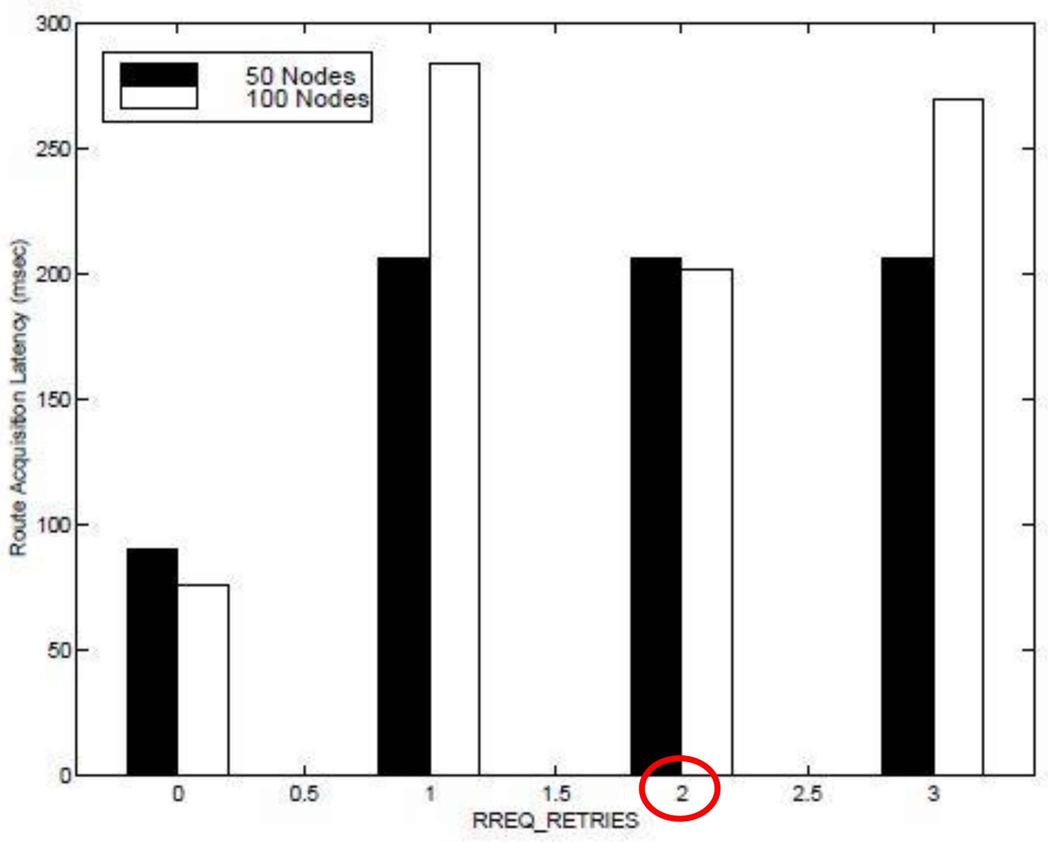
- 50, 100, 500 and 1000 nodes
- L x L, 0.4 to 0.8 m/s, $R_{max} = 10\ m$
- Random session creation
- Carrier sensing → *max_retrans*
- S_DATA and VOICE_DATA

4. Simulation and Results

- Achieved Goodput for varying rreq_retries [1]



- Route Acquisition Latency for varying *rreq_retries* [1]

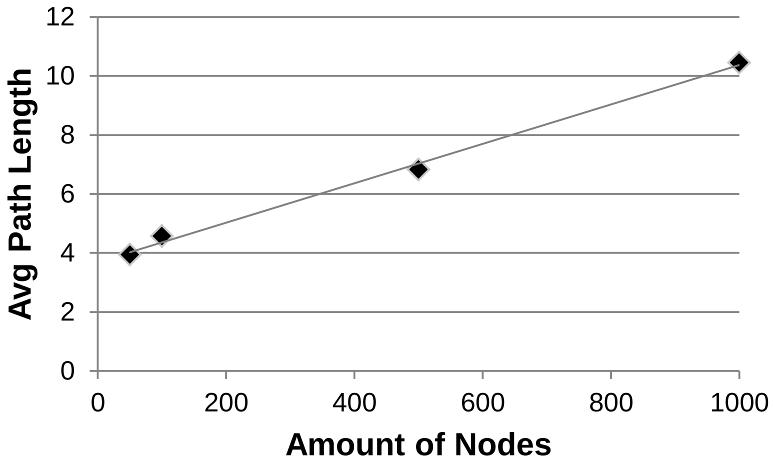


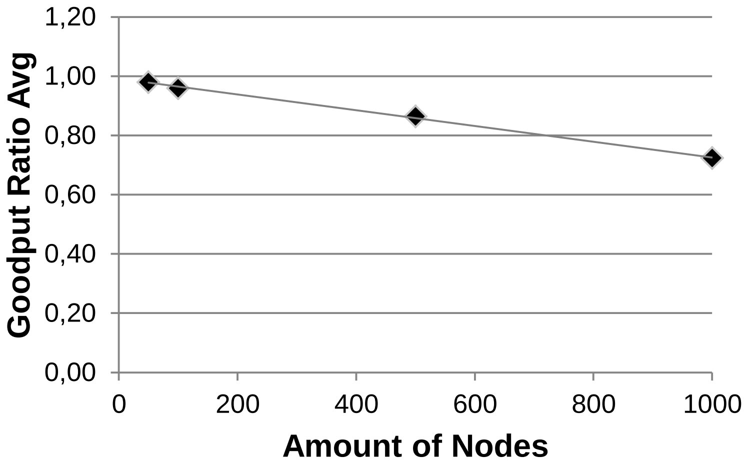
4. Simulation and Results

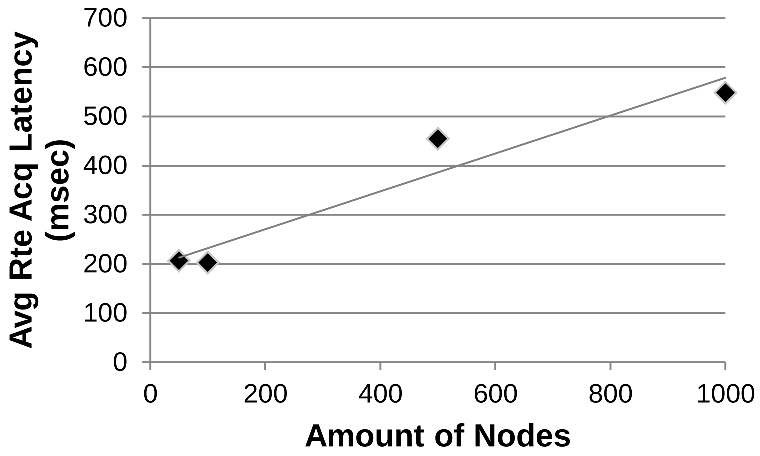
- Comparison of S_DATA Results [1]

# of Nodes	50	100	500	1000
Goodput Ratio avg	97,98 %	95,91 %	86,43 %	72,32 %
Avg Rte Acq Latency (msec)	206	202	454	548
Avg Path Length (hops)	3,94	4,57	6,83	10,45
Room Size (m)	50x50	50x50	100x100	150x150
Simulation Length (sec)	600	600	600	300
# Generated Sessions	24	62	172	263
# Completed Sessions	21	46	117	120
# Aborted Sessions	0	2	32	83

4. Simulation and Results







5. Conclusion

Pros

- Nodes store only routes that are needed
- Fewer broadcasts needed
- Reduces memory requirements
- Quick response to link breakage in active routes
- Loop-free routes
- Scalable to large populations of nodes

Cons

- Longer latency for route establishment

5. Conclusion

Future work

- Multicast
- Combination with Table-driven Protocol
- Elimination of Hello Messages

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Thank you for your attention!

Albert-Ludwigs-Universität Freiburg

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Proseminar: Algorithmen für Rechnernetze
Dozent: Prof. Dr. Christian Schindelhauer
Referent: Nikolas Simon, ESE
Semester: SS 2012

6. References

[1] C. E. Perkins and E. M. Royer. Ad-hoc on demand distance vector routing. *Mobile Computing Systems and Application*, 1999

[2] C. E. Perkins, E. Belding-Royer and S. Das. Ad-hoc on demand distance vector routing. *Experimental Memo*, 2003

[3] E. M. Royer and C. Toh. A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks. *Personal Communications*, IEEE 1999

[4] C. E. Perkins and P. Bhagwat. Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers. *Proceeding*, SIGCOMM 1994

[5] http://de.wikipedia.org/wiki/Distanzvektoralgorithmus, 08.07.2012, 3.15 pm

Loop-free routes

- **Assumption:**
  There is a loop in a route to destination Z
- Nodes in the loop: $X_i \;\; i = 1, 2, \dots, n$ $X_i \rightarrow X_{i+1}$ $X_n \rightarrow X_1$
- T_i is the DSN for the route table entry of X_i to Z

$$\left.\begin{array}{l} T_i \le T_{i+1} \;\; for \;\; X_i \rightarrow X_{i+1} \\ T_i \le T_{i+1} \le \; \dots \; \le T_n \le T_1 \end{array}\right\} \; T_i = T_{i+1}$$

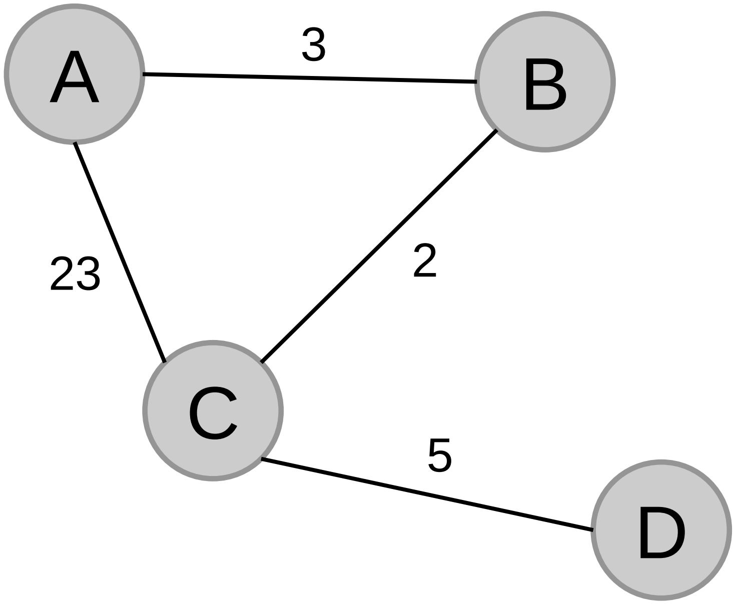
- Comparison of hop_counts m_i

$$m_i = m_{i+1} + 1 \;\; for \;\; X_i \rightarrow X_{i+1}$$

$$\left.\begin{array}{l} m_1 = m_n + (n-1) \\ m_n = m_1 + 1 \end{array}\right\} \; \text{n= 0}$$

Count-to-infinity

- A problem of Distance-vector routing protocols



[5]

- C → D: expensive
- A → D: ABCD → 10
- B → D: expensive
- B → D: 13 – BABCD
- A → D: 16 – ABABCD
- …