

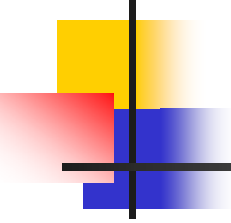


# Epidemic Routing for Partially-Connected Ad Hoc Networks

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Amin Vahdat and David Becker, “Epidemic Routing for Partially- Connected Ad Hoc Networks” , Department of Computer Science, Duke University, Durham.



# Outline

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- Introduction
- Epidemic Routing
  - Example
  - Goals and Components
  - Anti-Entropy sessions
- Messages
- Simulations
- Conclusions
- Limitations



# Introduction

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- Existing Ad Hoc Routing Protocols
  - Assume existence of connected path between source and destination
  - Network partition between source and destination
  - Message not delivered to destination
- Intermittently Connected Networks
  - Need for eventual and Timely Delivery
  - Weak and Episodic Connectivity
  - Mobile Sensor Networks, Smart Dust, Military/Disaster Recovery Applications

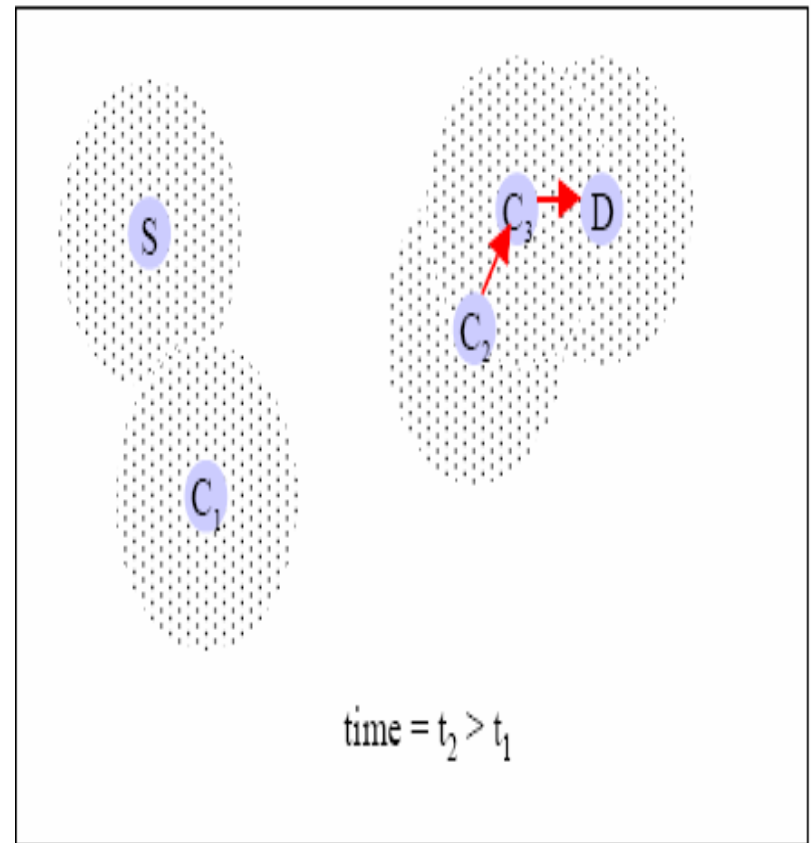
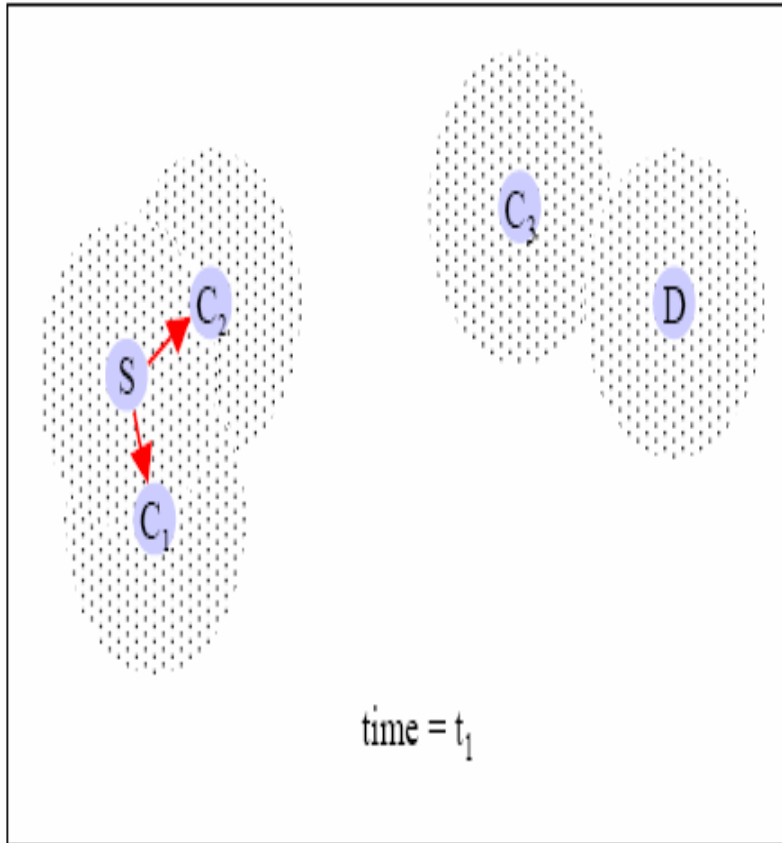


# Epidemic Routing

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- *Epidemic Routing*, random pair-wise exchange of messages among mobile nodes
- Eventual Message Delivery Model
- Distribute messages to hosts within connected portions of the network
- Relies on the mobility of the *carriers* to connect to other networks

# Epidemic Routing Example





# Goals and Components

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- Goals

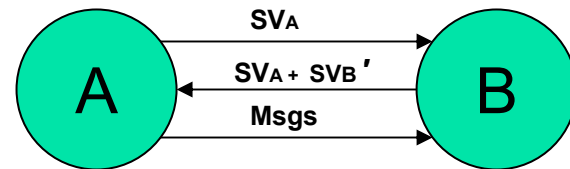
- Probabilistic distribution of messages through partially connected ad hoc networks
- Minimize amount of resources consumed
- Maximize the percentage of delivery

- Components

- Buffer, messages to be transmitted indexed by a hash table
- Summary vector, a compact representation of all the messages being buffered at that node.
- Cache, list of hosts that the node has spoken to recently

# Anti-Entropy Session

- Host A transmits its summary vector  $SV_A$  to B
- Host B determines the set difference  $SV_A + SV_B'$  between the messages buffered at A and the messages buffered locally at B.
- Transmits a vector requesting these messages from Host A
- A transmits the requested messages





# Messages

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- Each Message is associated with
  - Message Identifier, a 32 bit unique number
    - A Combination of Host Id and Message Id
  - Hop-Count, limits the no of anti-entropy sessions
    - Similar to TTL field in IP packets
    - High priority messages can be set with high Hop count to ensure delivery
  - Ack request, signals the destination of a message to provide an acknowledgement of the message delivery.
    - Acknowledgements can be modeled as simple return messages
    - PiggyBacking (with any other message back to sender)



# Simulation

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- Each simulated node has a *Epidemic Routing* agent layered on top of Internet MANET Encapsulation Protocol (IMEP) Layer.
- Epidemic Routing agent, consists of the Buffer, Summary vector for the buffer and the code for the anti-entropy sessions
- IMEP layer notifies the routing agent when a new node comes within/moves out of the radio range.
- Based on the neighbor notifications the routing agent initiates the anti-entropy sessions



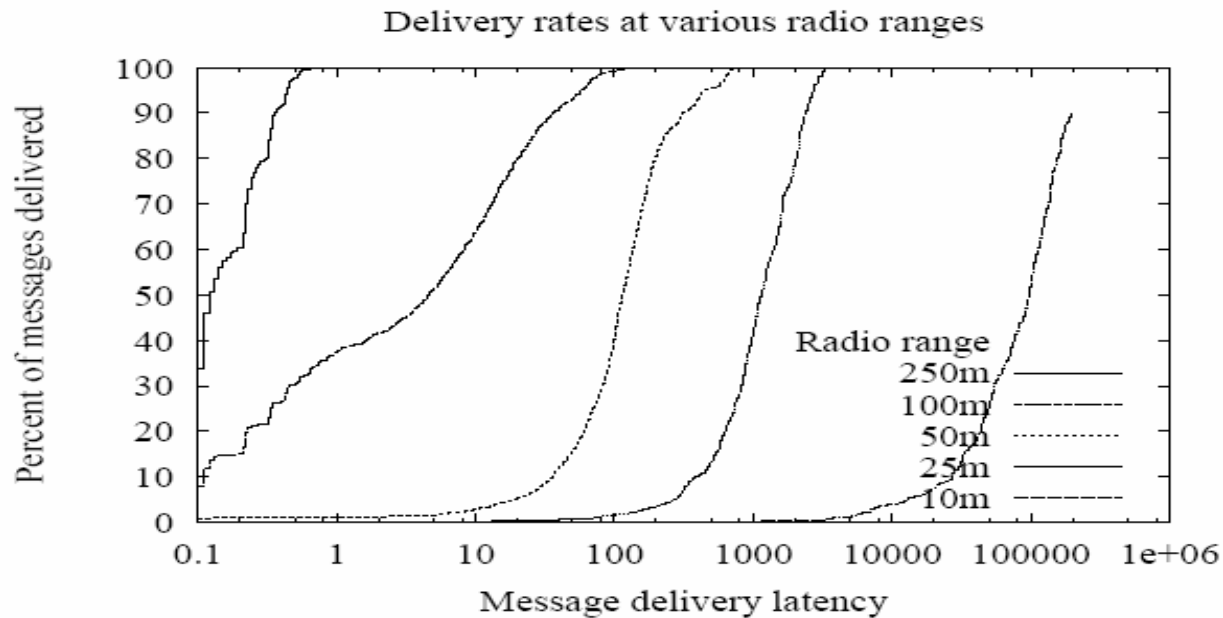
# Simulation Environment

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- 1500m X 300m rectangular area
- 50 mobile nodes
- Each node picks a random spot and moves towards it
- Speed uniformly distributed between 0-20 m/s
- Each message is 1KB in length
- 45 nodes send messages to other 44 nodes at 1 msg/sec
- $45 \times 44 = 1980$  messages after 1980 secs.

# Simulation Results

## Radio Ranges1



CDF for Message Delivery as a function of transmission range

# Simulation Results

## Radio Ranges 2

Range	Delivery Rate (%)	Baseline Rate	Latency		Hops		Coverage Floor
			Avg (s)	Max (s)	Avg	Max	
250 m	100.0	98.2	0.2	1	2.4	8	10.91%
100 m	100.0	34.3	12.8	177	6.3	21	1.75%
50 m	100.0	0.9	153.0	760	3.7	14	0.44%
25 m	100.0	0.0	618.9	3758	3.3	9	0.11%
10 m	89.9	0.0	44829.7	198107	3.4	9	0.02%

Characteristics of Epidemic Routing as a function of Radio Range

# Simulation Results

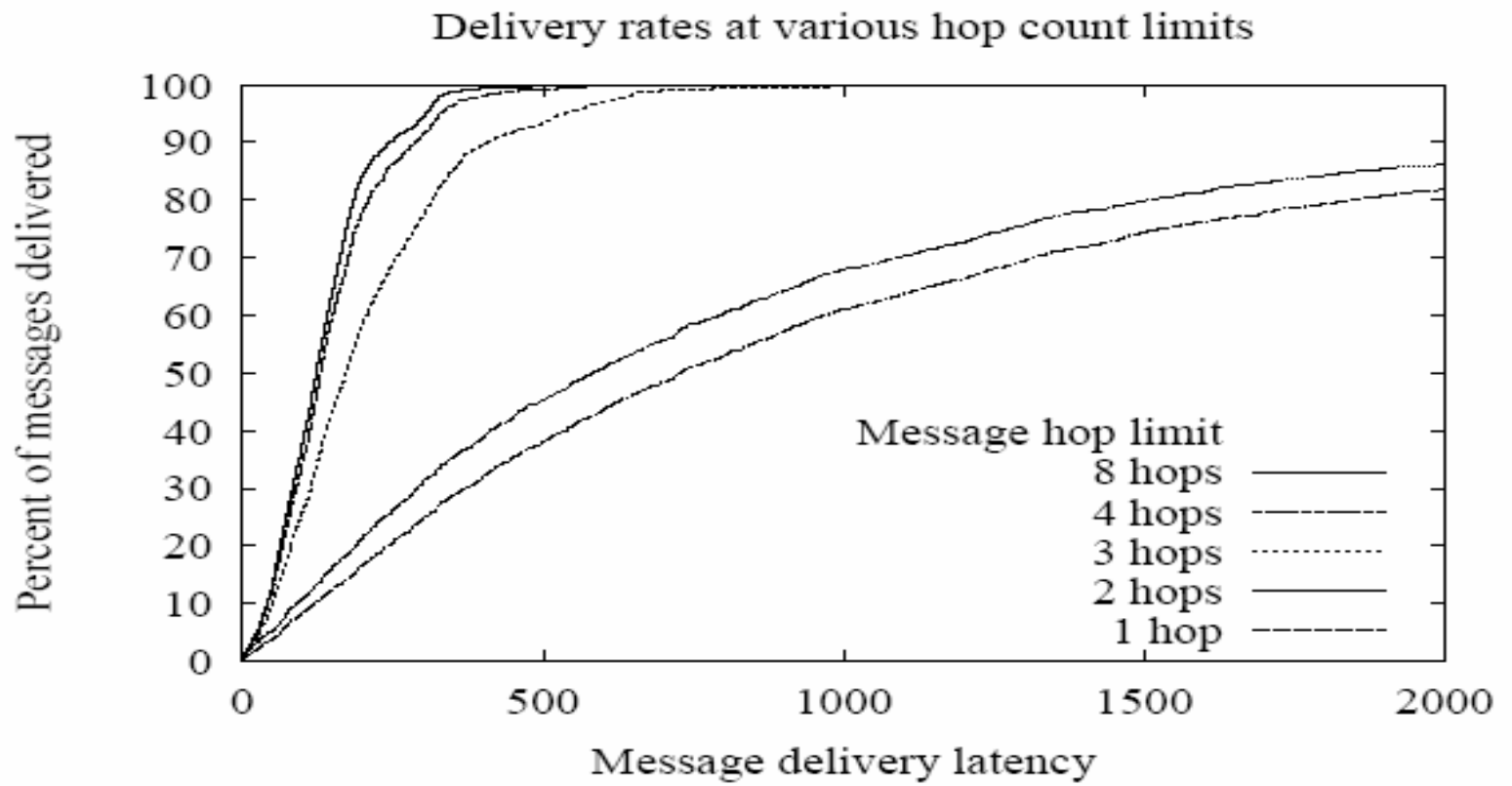
## Radio Ranges 3

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- Delivery Rate, % of messages delivered to destination
- Baseline Delivery, % of messages delivered using DSR
- Latency, Average and Maximum time to deliver the message
- Hops, Average and Maximum number of hops to deliver the message
- Coverage Floor, lower bound on the % of the area covered by the individual node's transmitter.

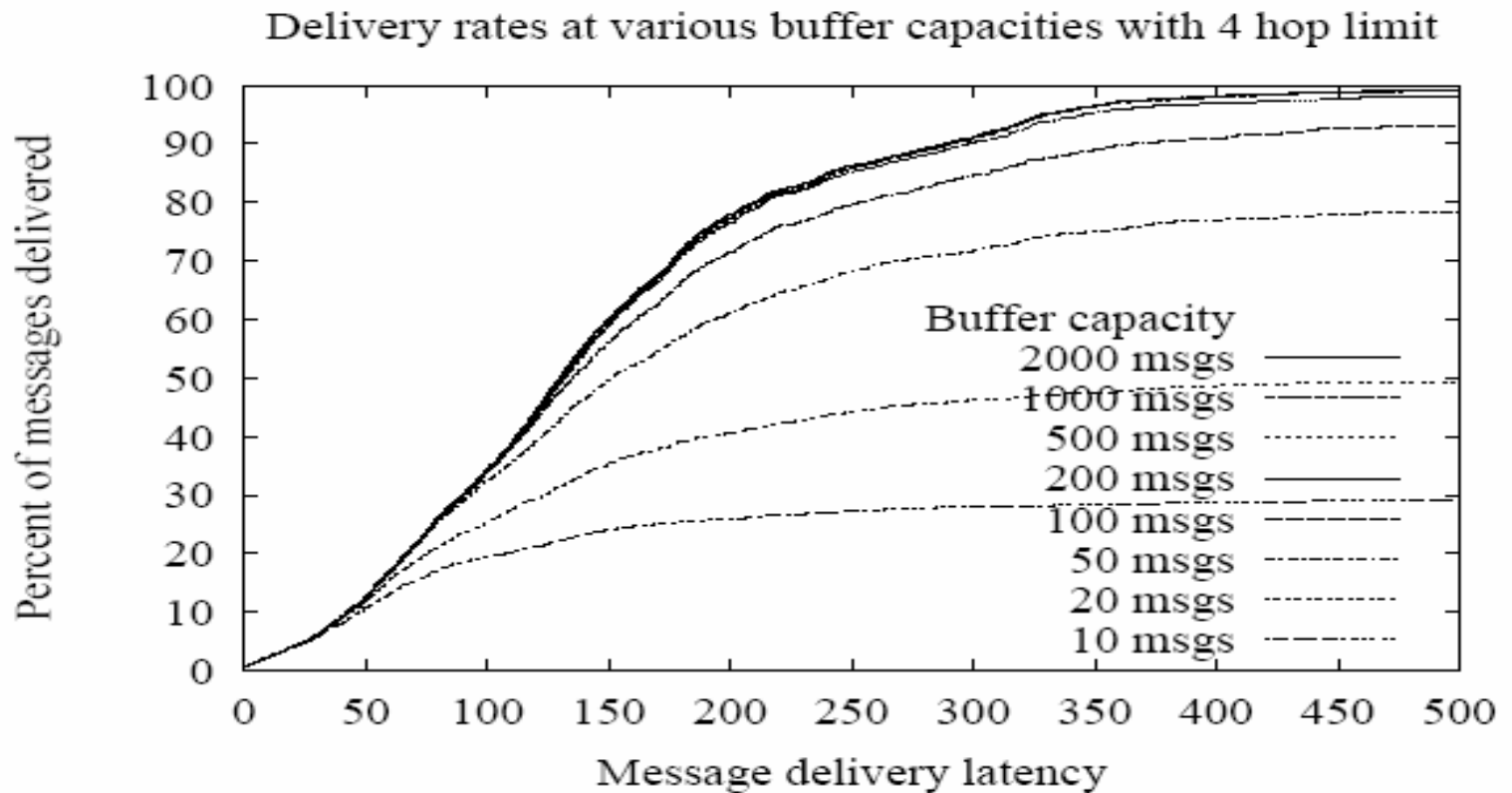
# Simulation Results

## Hop Count Limit



# Simulation Results

## Buffer Capacity





# Conclusions

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- Routing protocol designed to operate without end-to-end connected path
- Eventual Delivery Model
- Anti-Entropy sessions
- Summary Vectors to exchange messages
- High Delivery rate



# Limitations

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- Sensitive to node density and transmission coverage as a function of the total target area
- Large resource consumption (memory)
- Reduction in Hop Count increases the latency
- Increasing speed with high hop count causes congestion
- ???



## References

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- Amin Vahdat and David Becker, “Epidemic Routing for Partially- Connected Ad Hoc Networks” , Department of Computer Science, Duke University, Durham, [issg.cs.duke.edu/epidemic/epidemic.pdf](http://issg.cs.duke.edu/epidemic/epidemic.pdf)
- [home.himolde.no/~kd/in904/h04/](http://home.himolde.no/~kd/in904/h04/)