Revisiting Gossip-based Ad-hoc Routing

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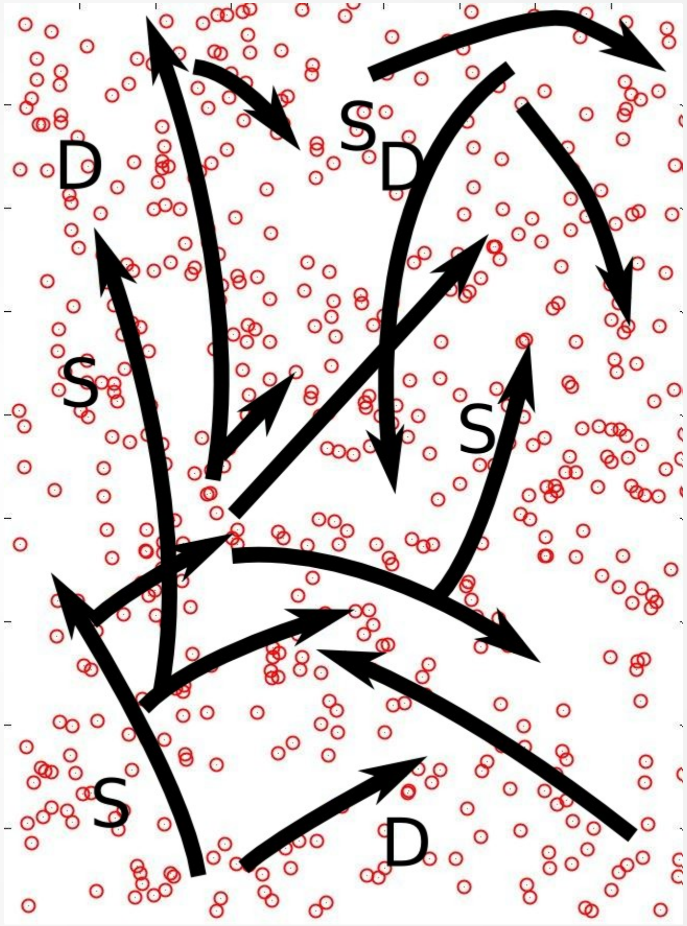
Introduction

Peer communication in the crowd (multicast)

- Heart beat messages for group communication
- Mobile wireless ad-hoc network

Scalability Issues

- Relatively large network (1000+ nodes)
- All nodes act as sources



Problem Statement

All-to-all broadcast scenario generates high traffic

Goal:

- High coverage of messages
- Minimal use of resources -> minimum number of forwarders

Context on message dissemination

Probabilistic [Haas02],[Ni99]

- Nodes forward with a given probability p
- Pros: simple
- Cons: choice of p is critical

Overlay-based [Peng00],[Wu03]

- Connected subset of nodes to forward messages
- Pros: minimal number of forwarders
- Cons: not suitable for dynamic networks and not resilient to packet loss

Local knowledge [Ni99],[Haas02],[Ellis09],[Pleisch06]

- Nodes forward based on local information from neighbors: message counter, RSSI, location etc.
- Pros: simple, local information required
- Cons: parameters are topology dependent

Gossip3

Probabilistic + local information

probabilistic

1. Forward a received data packet D with probability p

compensation

2. Otherwise, store D and wait for a short interval t

Forward D if it has not been received back by at least m neighbors during interval t

Parameters of Gossip3:

- p - initial probability of forwarding a message
- m - minimum expected number of neighbors to receive a packet from

Outline and contribution

Thorough evaluation of Gossip3

- Parameter space
- Best performing parameters for various network configurations

Revisit Gossip3 algorithm for self-determining the optimal parameters in any network configuration

Experimental setup

529 nodes

uniform random distribution

torus (no borders)

topologies: avg. node distance

- 5, 10,15, 20 m

max communication range: 50m

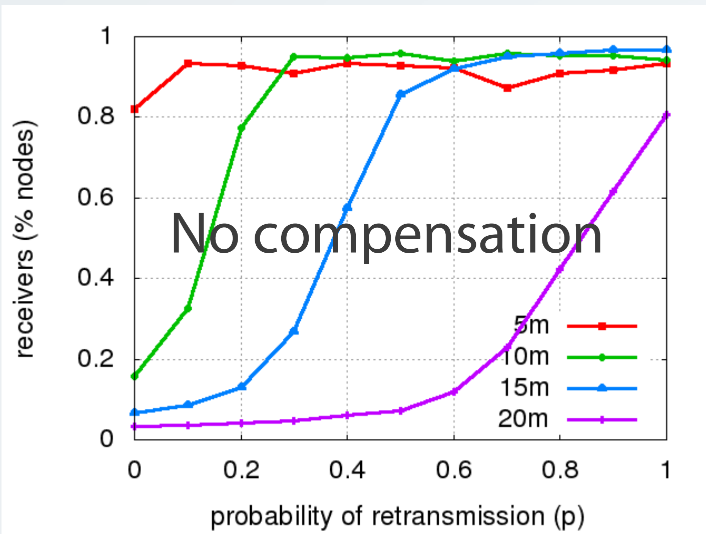
dummy packets at MAC layer to simulate congestion

Omnet++

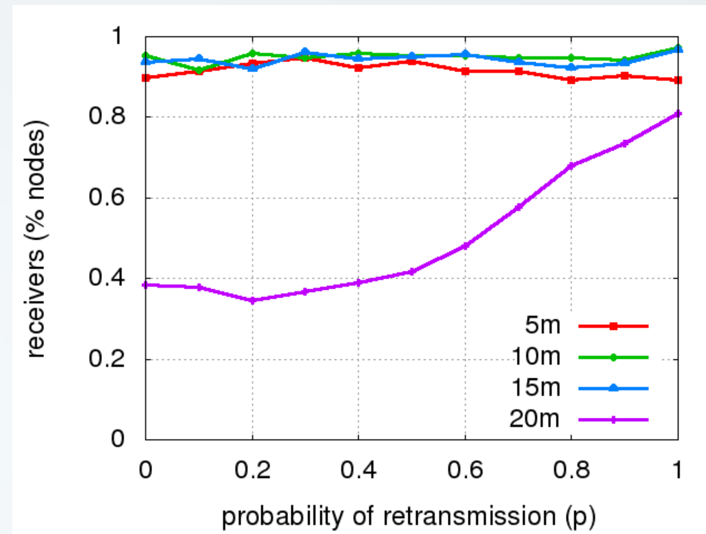
Avg. Node Distance	Avg. Neighbors	Network Diameter	MAC TX success Ratio
Δ = 5m	105	2	0.39
Δ = 10m	19	5	0.52
Δ = 15m	10	10	0.53
Δ = 20m	5	27	0.53

Gossip3 evaluation: Coverage

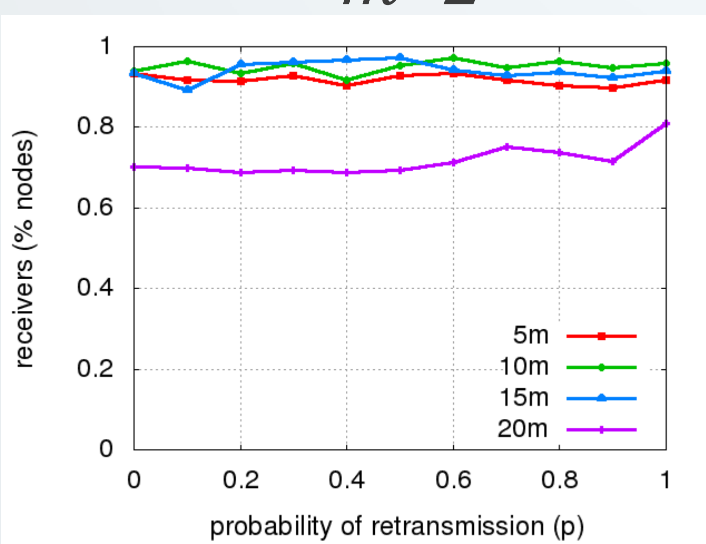
m=0



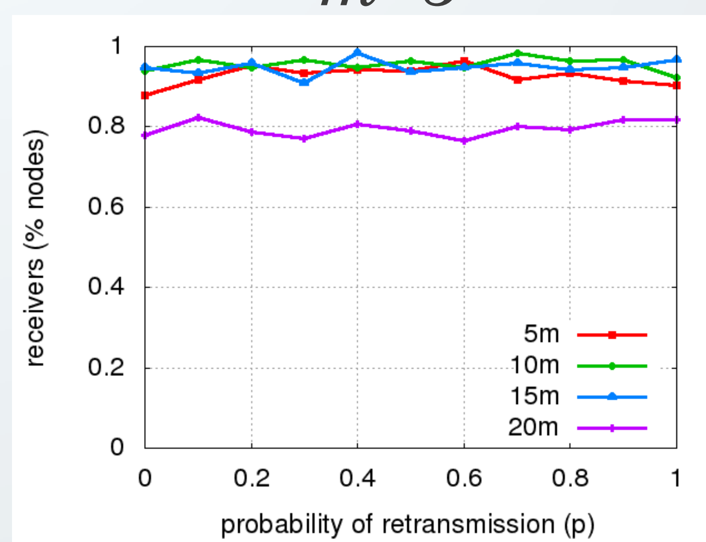
m=1



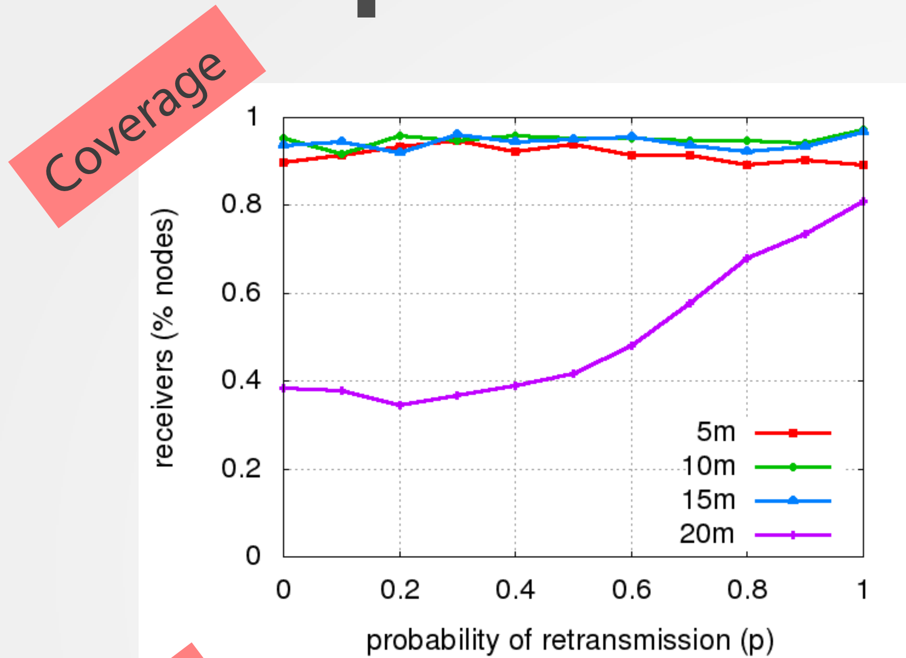
m=2

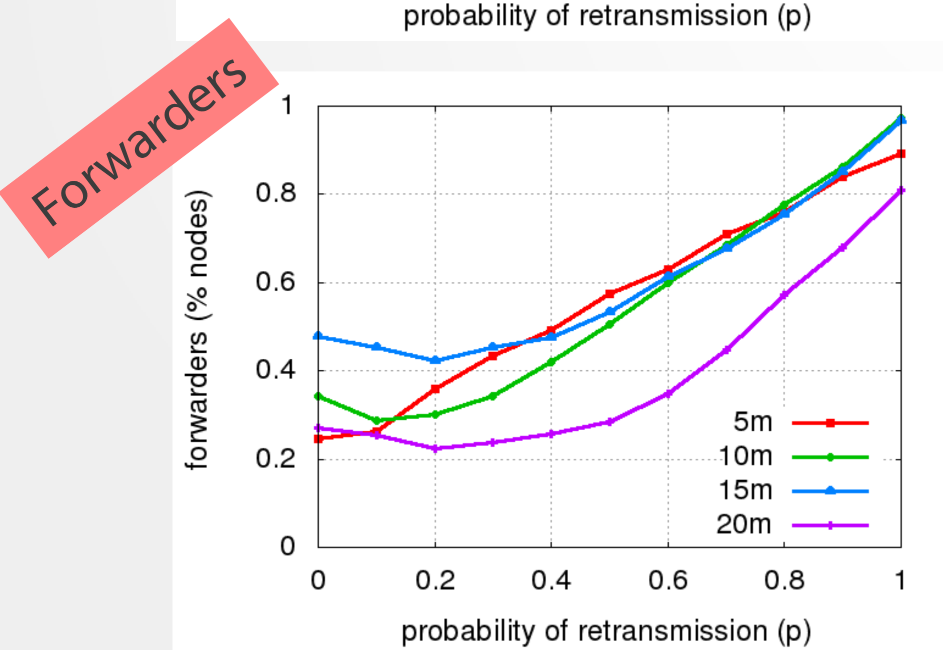


m=3



Gossip3 evaluation: forwarders



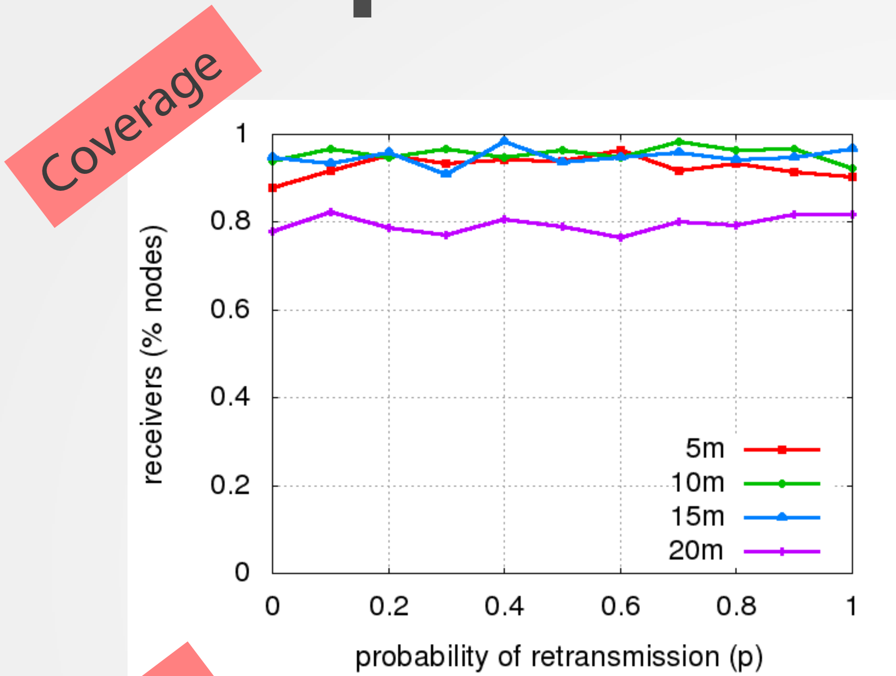


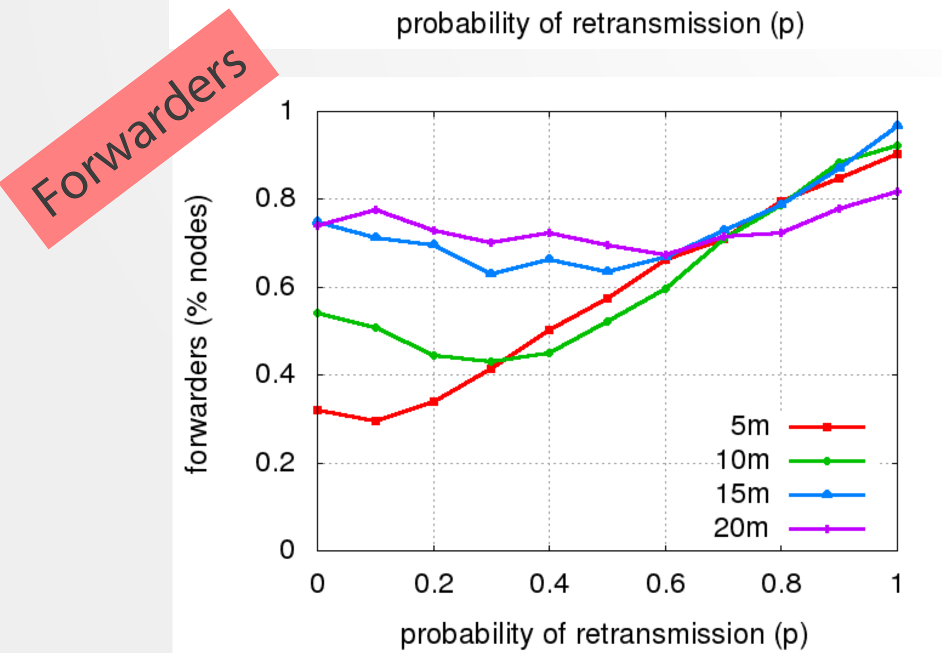
m = 1

Forwarding probability (p) impacts greatly on forwarders

(!) Very low p is not suitable

Gossip3 evaluation: <u>forwarders</u>





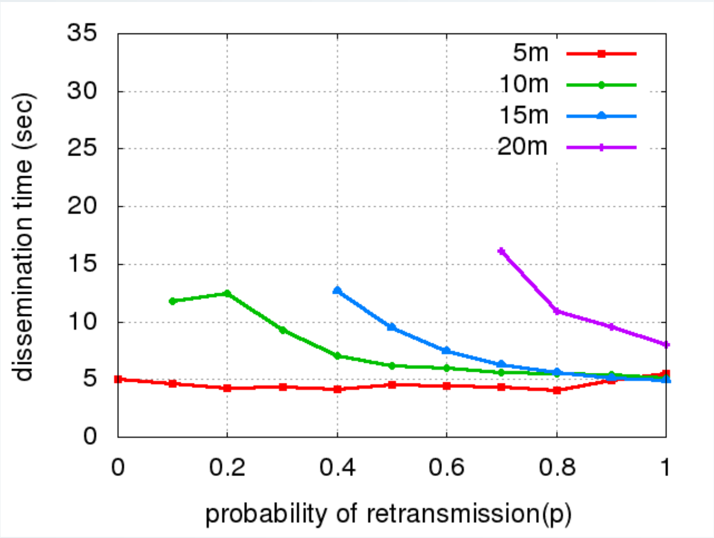
m = 3

Max coverage for Δ=20m

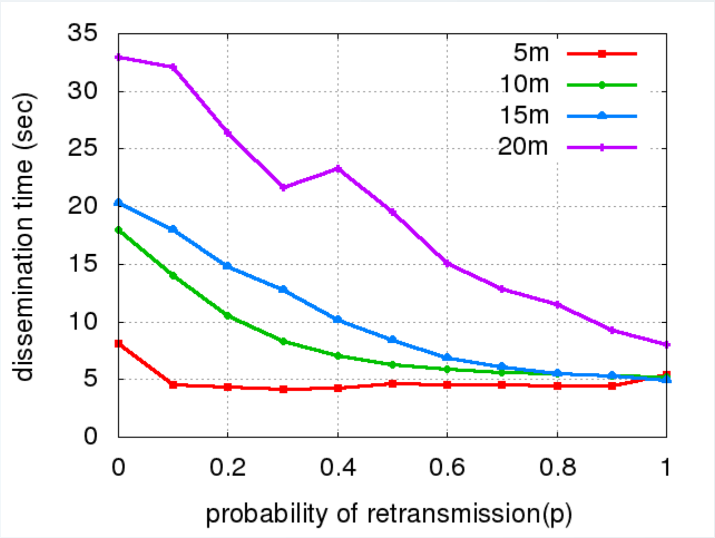
High ratio of forwarders

Gossip3 evaluation: Latency

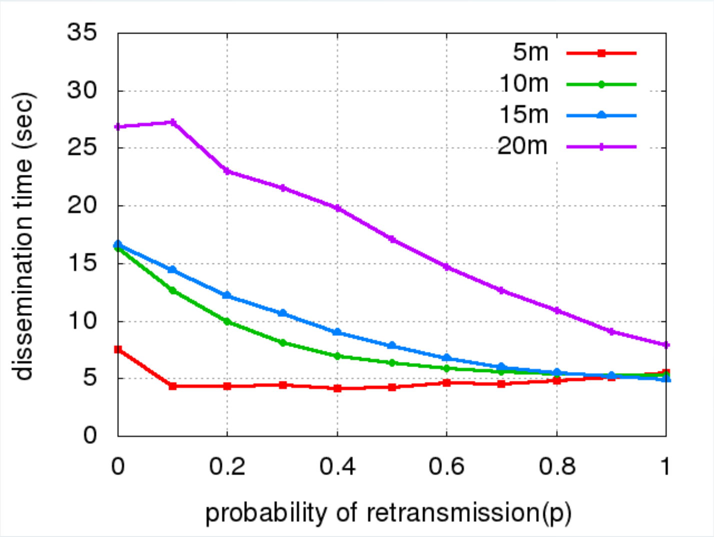
m=0



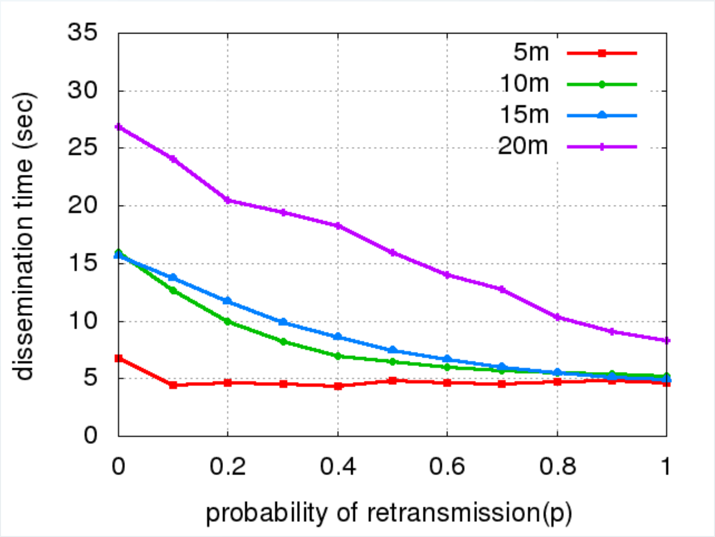
m=1



m=2



m=3



Observations

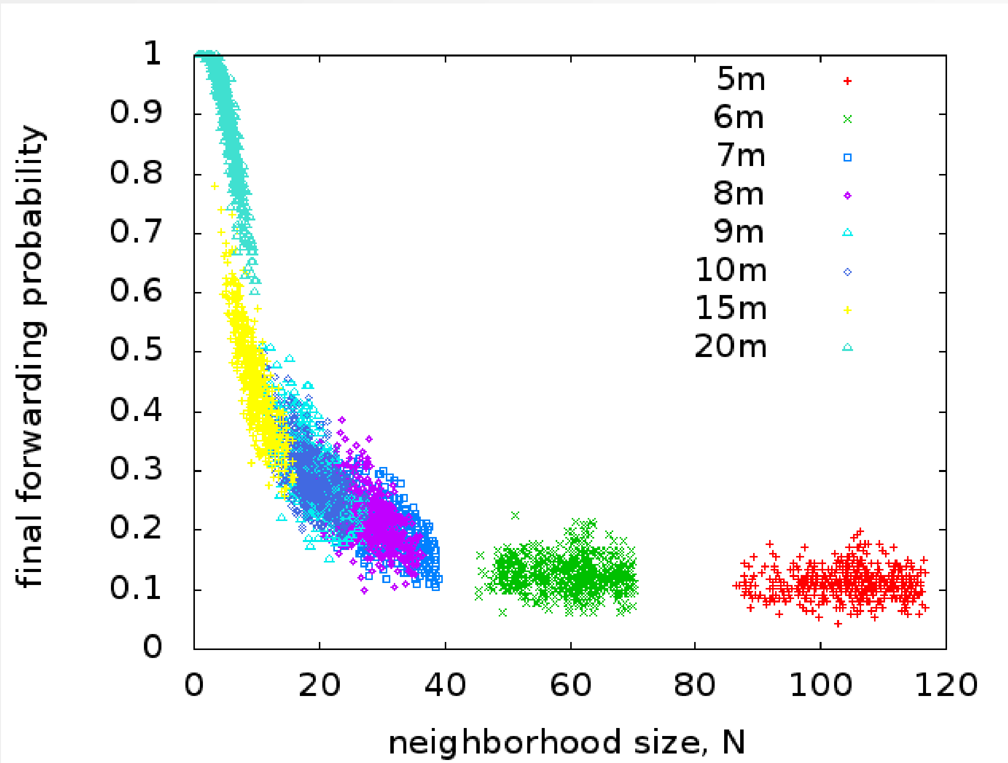
To reach optimal performance, one set of parameters cannot fit all networks.

- Relatively dense networks strive for keeping forwarders to minimum
- In sparse networks, high number of forwarders is required to reach maximum coverage

Question:

can we decide the set of parameters based on the network density?

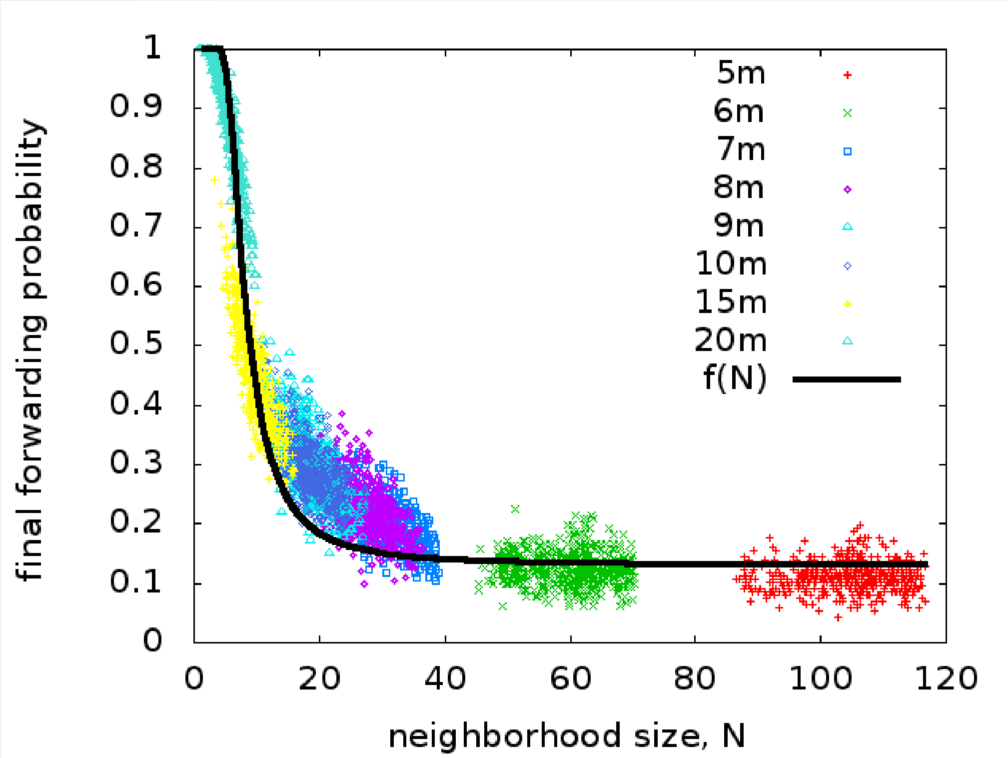
Observations on Gossip3



Best performing configurations for various network densities

Forwarding probability (p) of each node as function of their neighborhood size

Observations on Gossip3



Best performing configurations for various network densities

Forwarding probability (p) of each node as function of their neighborhood size

(!) The forwarding probability (p) follows a pattern.

Curve fitting technique to determine the forwarding probability.

$$f(N) = 1 - 0.87 * e^{\frac{-50}{N^{2,3}}}$$

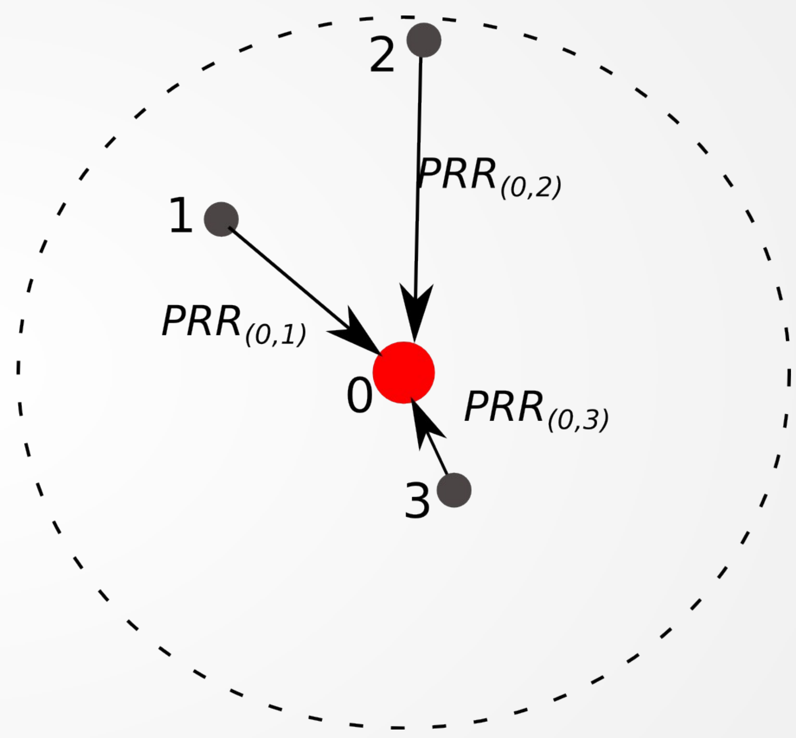
Estimation of neighborhood size

In wireless networks due to *signal attenuation*, *packet collisions*, etc., it is hard to define a neighbor

Neighborhood size estimation:

- Upon packet transmission nodes include packet sequence number
- Compute Packet Reception Ratio (PRR) for each neighbor
- Compute neighborhood size of a node i:

$$N(i) = \sum_{k \in \{nodes \in the\ radio\ range\ of\ i\}} PRR(i,k)$$



Revisiting Gossip3

Traditional Gossip3:

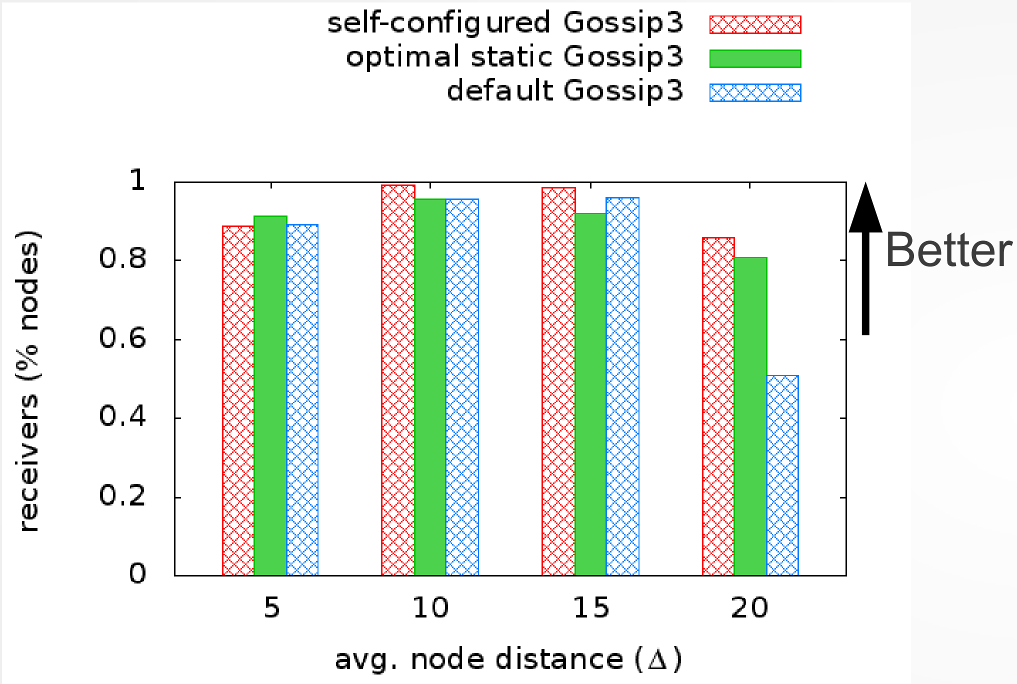
1. Probabilistic (p)
2. Compensation mechanism
   - Forward when a message is received back by <u>less than m neighbors</u>

Adaptive Gossip3:

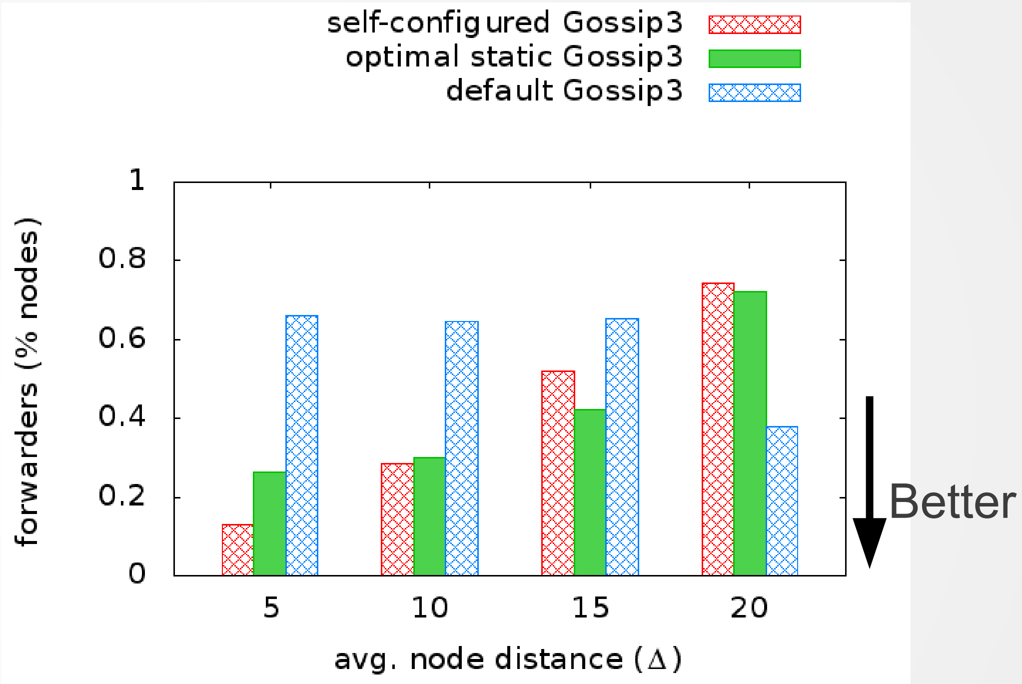
1. Dynamic assignment of forwarding probability
2. Compensation with m=3 only for sparse areas (#neighbors < 7)

Results

Coverage



Forwarders



Default Gossip3: p=0.65, m=1

Optimal Static Gossip3: optimal p and m

Self-configured Gossip3: dynamic p and m based on neighborhood size

(!) Default configuration of Gossip3 is not optimal for any network

(!) Our self-configured Gossip3 reaches similar performance as the optimal static Gossip3 configuration

Conclusions

The optimal Gossip3 parameters are highly related to the network density

We identified the parameters for which Gossip3, can give maximum coverage at the lowest number of forwarders for several network configurations

Our algorithm alleviates shortcomings of Gossip3:

- Max coverage , while
- Keeping forwarders to a minimum
- Self adapts to the network density

thank you!

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