Removing Probabilities to Improve Efficiency in Broadcast Algorithms

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Broadcast algorithms

Goal Best effort delivery of a message to the nodes in a multi-hop MANET

Applications Resource location

- Routing protocols (e.g. DSR, AODV)
- Reputation systems

Desirable features

- The *usual* for MANETs
  - Fully decentralised
  - Cope well with:
    - Node movement/disconnection/addition
    - Variable network conditions
  - Low power consumption
  - Low bandwidth consumption

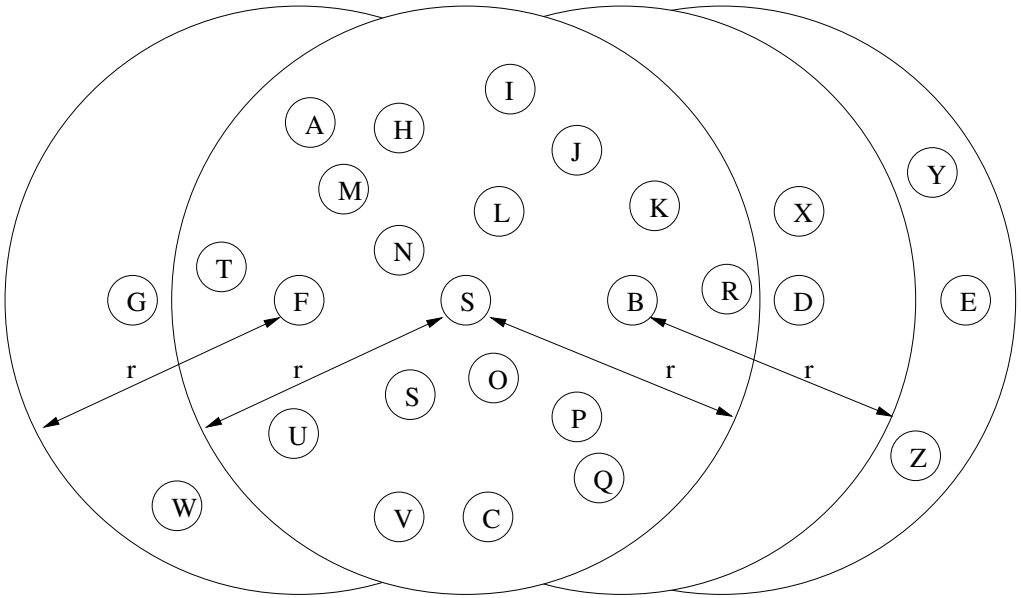
Flooding

- A popular broadcast algorithm
- Every node receiving a message for the first time retransmit it.
- Highly inefficient (broadcast storm)
  - Too many useless retransmissions
  - Consumes battery at every node
  - High probability of collisions

Reducing resource consumption

- Alternatives to flooding should:
  - Limit as much as possible the number of transmitters
  - Ensure message propagation
    - Specially in varying network densities
- Three classes of alternatives
  - Probabilistic
  - Counter-based
  - Distance-based

Probabilistic Algorithms [Haas:02]



- Nodes retransmit with a probability $0 < p < 1$
- The number of retransmissions is proportional to the number of neighbours
  - doesn't adapt well to different node densities
- Mitigation: counter-based algorithms

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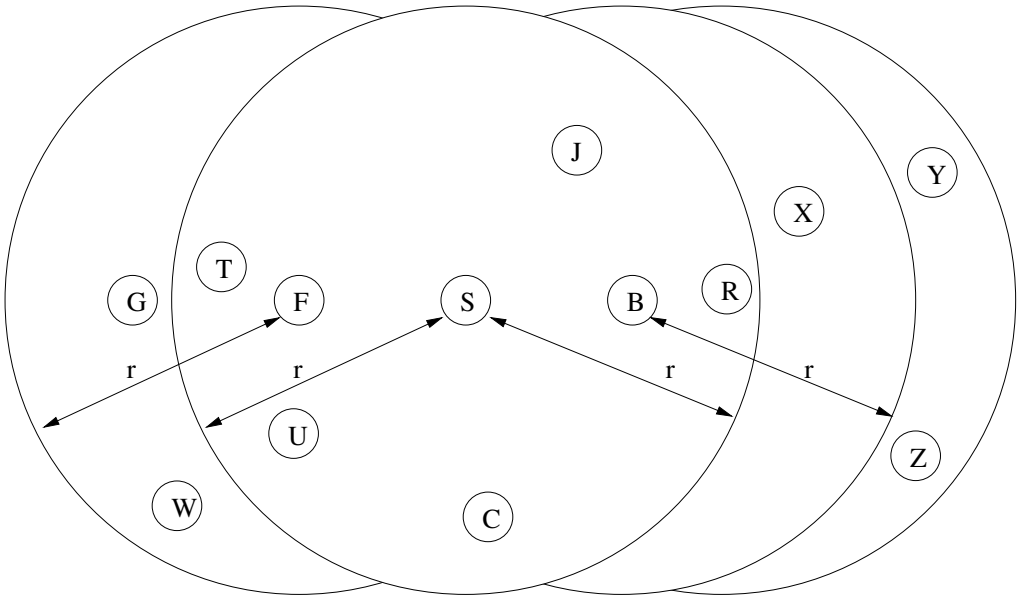

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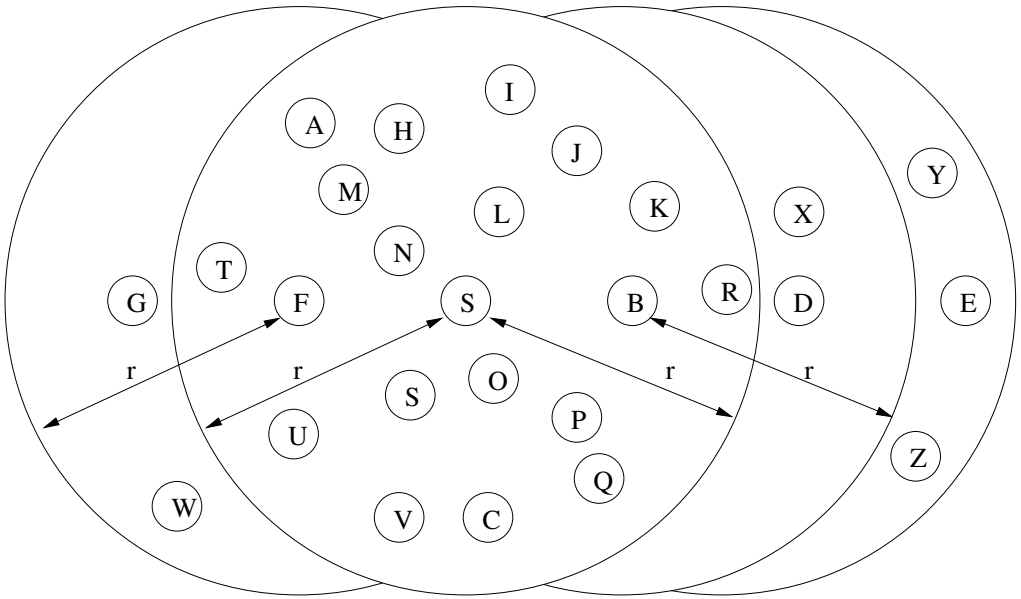
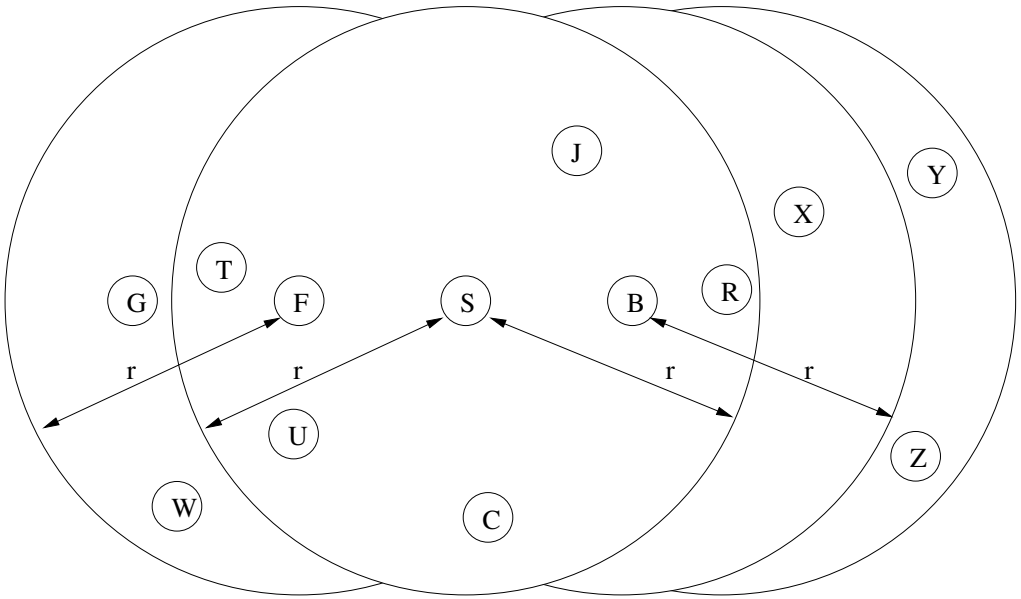
Counter-based [Haas:02,Tseng:02,Huang:06]



- After receiving the first copy
  - Nodes wait a random time
  - Retransmit if the number of copies received is below a threshold n
- Adapts well to different densities
- Non-optimal selection of the nodes that retransmit

Counter-based [Haas:02,Tseng:02,Huang:06]



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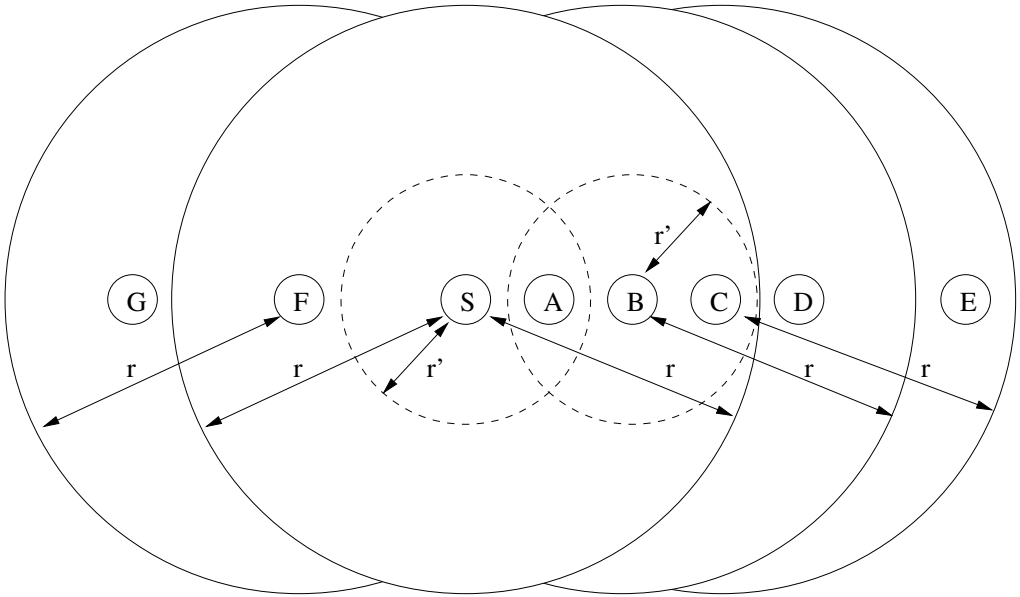
Distance-based approaches [Tseng:02]



- After receiving the first copy
  - Nodes wait a random time
  - Retransmit if the signal strength of any copy is below a threshold
- The higher the signal strength, the lower the distance
  - Discards transmissions with a negligible additional coverage

Node Selection...

- Related work exhibits a pattern:

nodes are selected at random

Probabilistic algorithms An explicit **random** number generator

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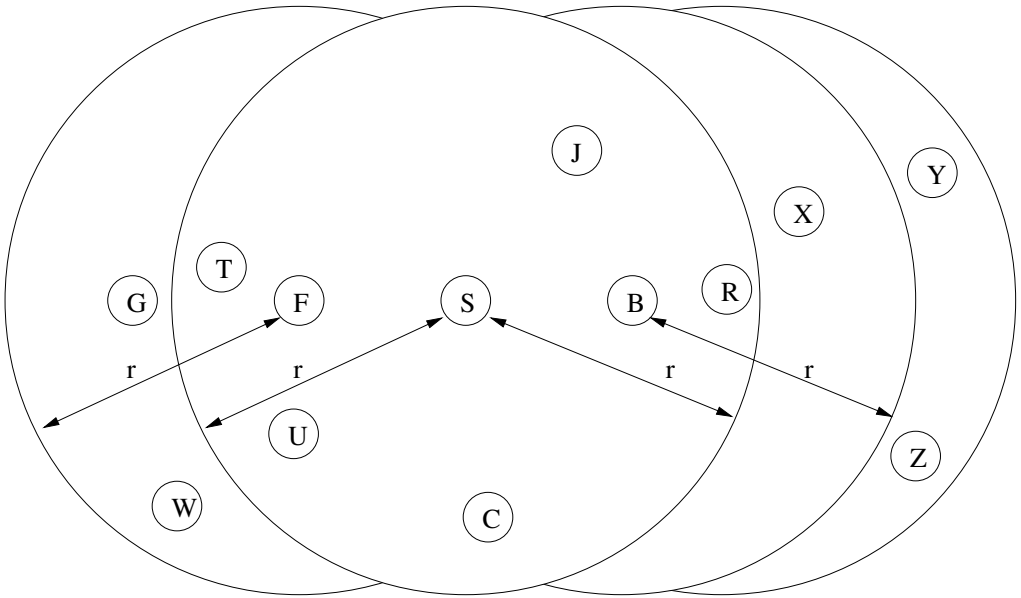
  Probabilistic algorithms An explicit **random** number generator

  Counter-based algorithms The one that expires the **random** timer first

  Distance-aware algorithms The one that expires the **random** timer first and is above some distance

- Can we do better?

Improving node selection...



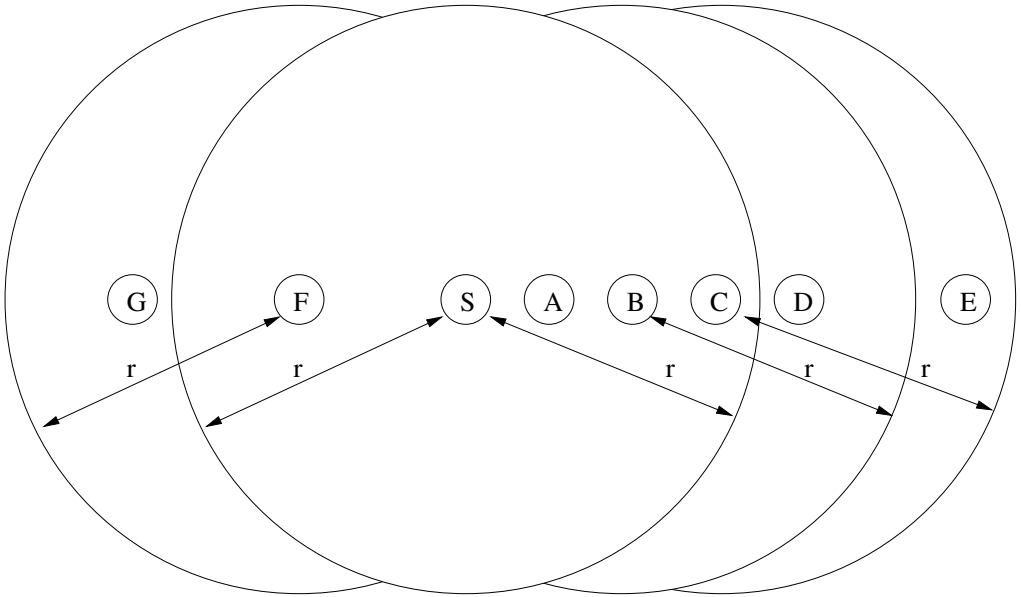
- A retransmission adds from 0 to 61% to the coverage of a previous transmission [Tseng:02]
- Which neighbours should retransmit?
  - The more distant the retransmission is from the source, the better

Improving Node Selection

PAMPA Power-Aware Message Propagation Algorithm

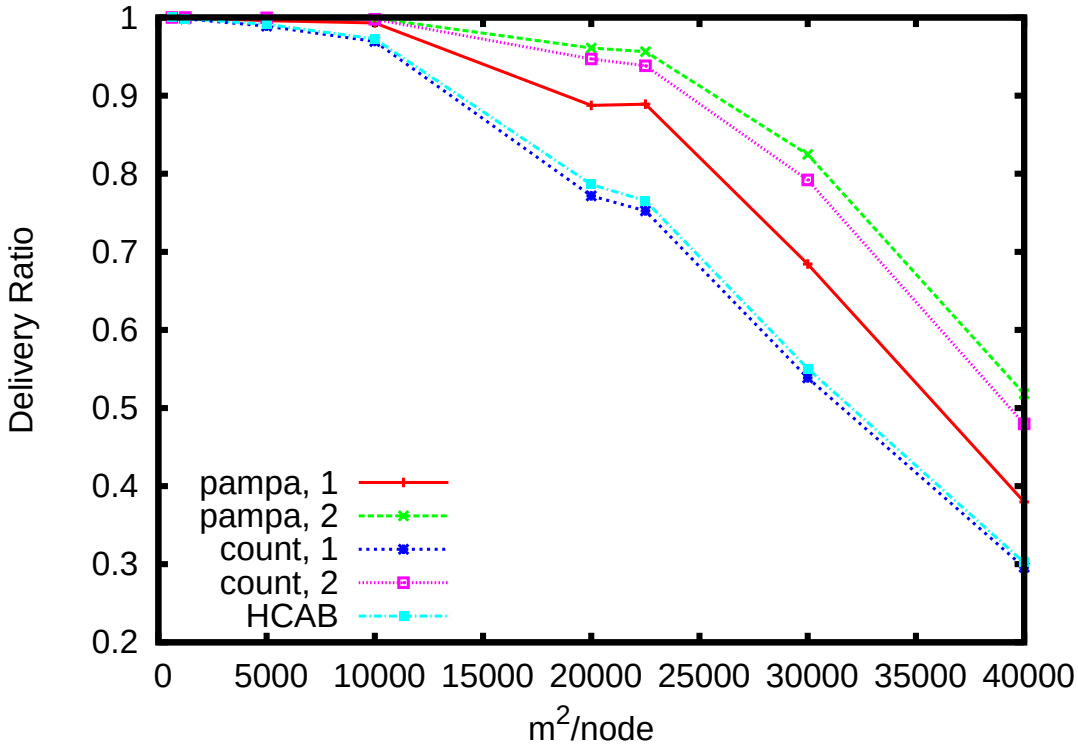
- After receiving the first copy
  - Nodes wait a time *proportional to the signal strength*
  - Retransmit if the number of copies received is below a threshold
- Rank nodes for retransmission according to their distance to the source

PAMPA



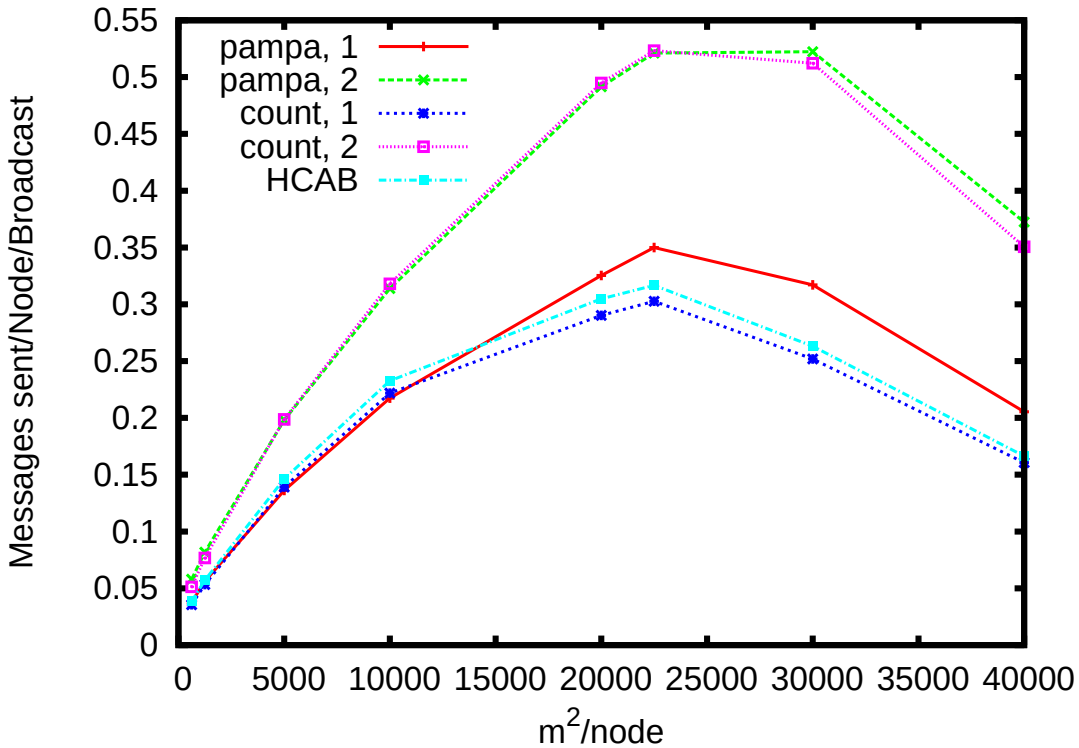
- Higher distance to the source ⇒ lower signal strength ⇒ smaller wait time
  - Nodes to retransmit will be those that provide higher contribution to coverage
- Listens to the number of retransmissions
  - Adapts well to different densities

Evaluation - coverage



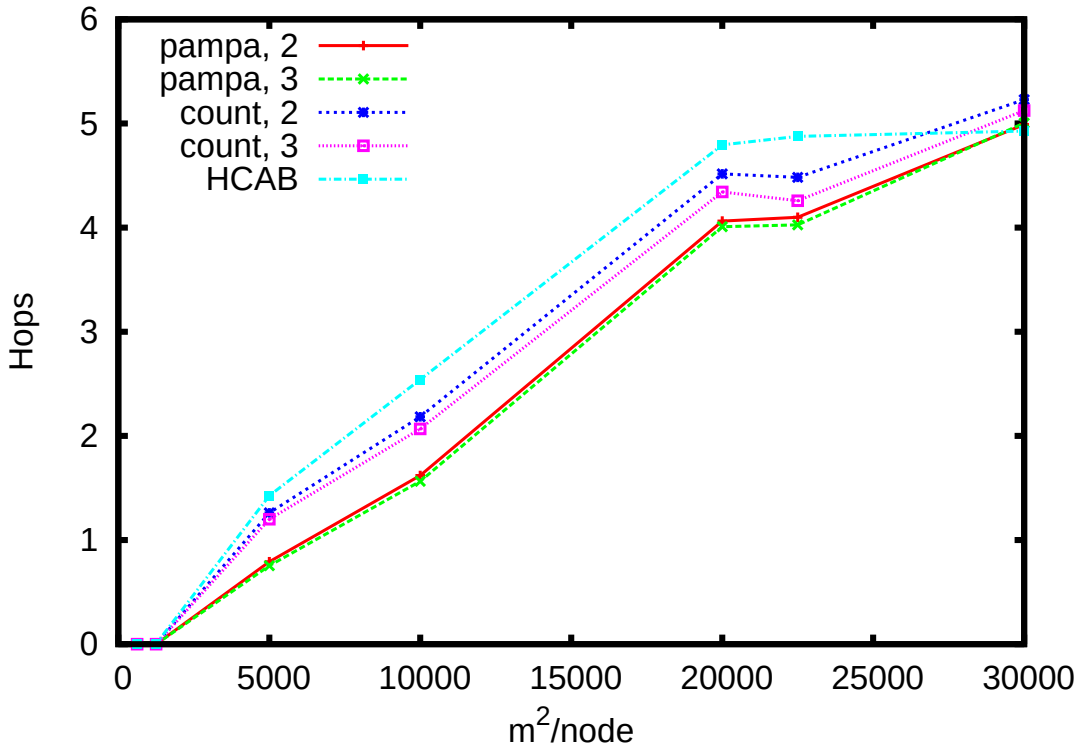
- Simulations in *ns–2*, Two Ray Ground, 100 nodes
- Pampa vs Counter-based (for the same thresholds)
  - Doesn't matter which if nodes are close
  - Pampa has a higher delivery ratio
    - More evident in sparser networks

Evaluation - Number of transmissions



- Number of transmissions/broadcast/node
- Pampa requires as much as the remaining when coverage is comparable
- A little bit more when coverage is higher

Evaluation - Number of Hops



- Number of hops travelled by a message before being delivered to each node
- Smaller in Pampa
  - Each retransmission covers more nodes

Conclusions

- Broadcasting appears to be unavoidable in MANETs
  - Flooding wastes resources
- Existing alternatives to flooding
  - Don't take full advantage of the location of the nodes
- PAMPA
  - Uses RSSI to make nodes more distant to the source to retransmit first
  - Prevents nodes with a negligible contribution from retransmitting
- Evaluation
  - Improves coverage in sparse networks
  - Reduces the number of hops required to deliver the message