7th ACM Symposium on Performance Evaluation of
Wireless Ad Hoc, Sensor, and Ubiquitous Networks
October 18th, 2010 — Bodrum, Turkey

SEMI-FLOODING LOCATION SERVICE: A CROSS-LAYER DESIGN

É. Renault[1,2], H. Costantini[3], E. Amar[4] and S. Boumerdassi[3]

[1] Institut Télécom – Télécom SudParis, RS2M Dept.
[2] Samovar UMR INT-CNRS 5157
[3] CNAM – CEDRIC Laboratory
[4] UPMC – LIP6

BACKGROUND

- Routing protocols in MANETs
  - topology based
    - use of routing tables
    - pro-active (DSDV) vs. reactive (DSR, AODV...)
  - location based
    - use of location information
    - examples: LAR, DREAM, GPSR...
- Problem with location-based routing protocols:
  - distribute the location of nodes to all the others
    $\rightarrow$ use a location service

LOCATION SERVICES

Goal:

- Tracking nodes and resolve queries

Classification:

- Flooding based
  - either location updates (pro-active like DREAM)
  - or location queries (reactive like LAR and RLS)
- Rendez-vous based (e.g. SLS)
  - a heuristic is used to elect a node (or nodes) to store location updates and answer queries
  - there can be a single elected node for all the network
  - or a different elected node per (group of) node(s)

Goal

Take advantage of both categories
(preferedly without inheriting the drawbacks)

Flooding:

+ each node is aware of the position of all the others
– high number of messages

Rendez-vous:

+ low number of messages
– hardly handle node's disappearance and communication problems

PRINCIPLE

- All nodes periodically broadcast a packet with its position
- When a node receives a location packet:

  if packet's data are more recent than local data (or the node is not referenced yet)

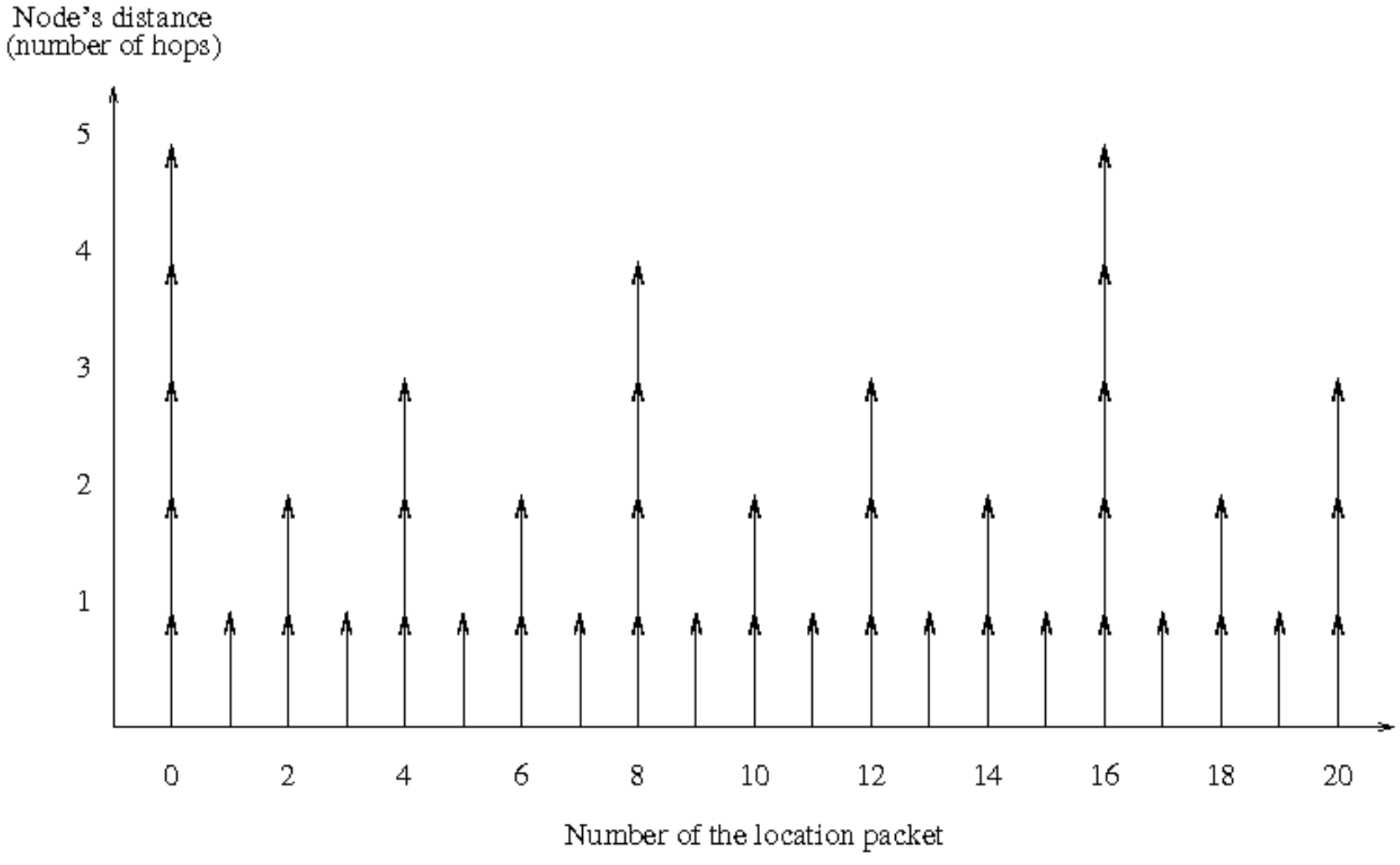
    update the local database

    half the time: (re-)broadcast the packet

  else

    just forget it!

PROPAGATION OF LOCATION PACKETS



MATHEMATICAL MODEL

- Parameters

  N: number of nodes in the network
  l_i: length of the longest path from i to any other node
  $p_i^{(h)}$: distribution of nodes at h hops for node i

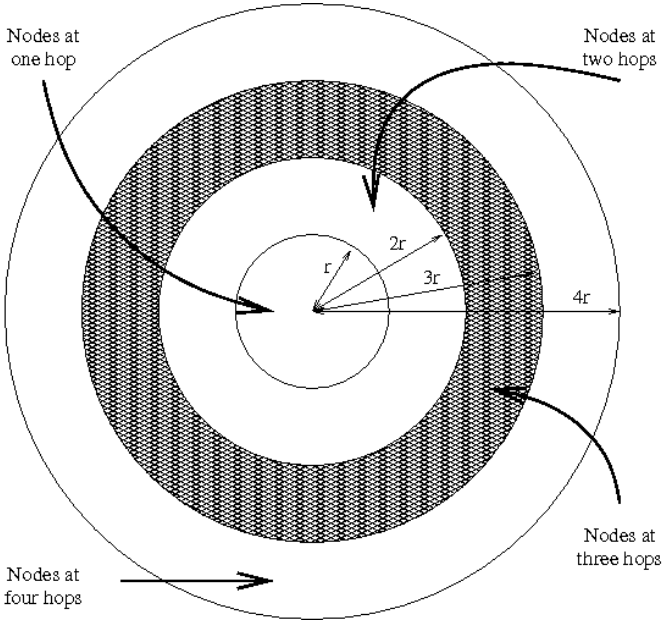
- Estimations

  $\overline{m_i}$: mean number of messages to update node i location
  $\overline{u_i}$: mean number of updates
  $\overline{r_i}$: mean number of messages to find node i location

$$\overline{m_i} = \sum_{h=0}^{l_i} \frac{1}{2^h} N\, p_i^{(h)} \qquad \overline{u_i} = 2 \times \overline{m_i} - 1 \qquad \overline{r_i} = 0$$

$\rightarrow \overline{m_i}$ and $\overline{u_i}$ depend upon the node distribution

NODE'S DISTRIBUTION



r: constant radius around node *i* based on transmission range

Uniform distribution:

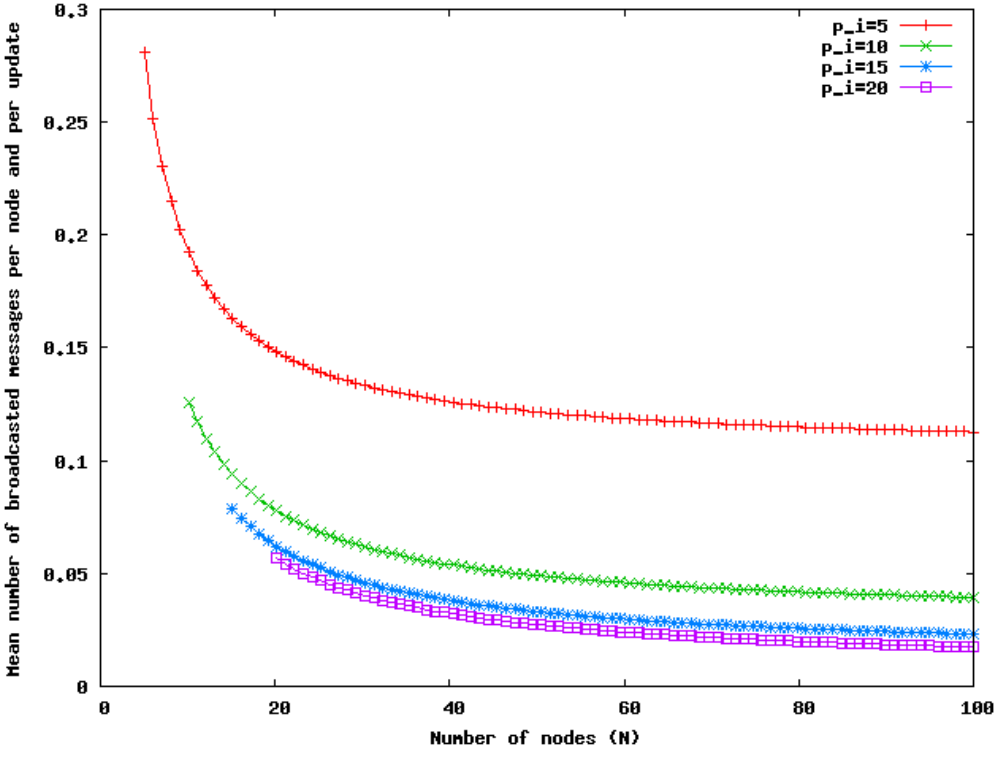
- density of nodes is the same all over the network
- distance between two nodes at *n* hops: $(r-1) \times n \rightarrow r \times n$

$$p_i^{(h)} = \begin{cases} \dfrac{1}{N} & \text{if } h = 0 \\ \dfrac{2h-1}{l_i^2} \times \dfrac{N-1}{N} & \forall\, h \in [1; l_i] \end{cases}$$

Note: $\sum_{h=0}^{l_i} p_i^{(h)} = 1 \quad \forall i$

ALGORITHM SCALABILITY

$$\overline{m_i} = 1 + \frac{N-1}{l_i}\left[\left(2+\frac{3}{l_i}\right)\left(1-\frac{1}{2^{l_i}}\right)-2\right]$$



$$O(\overline{m_i}) = O(N)$$

$$\lim_{l_i \to +\infty} \overline{m_i} = 1$$

The same for $\overline{u_i}$

Overview

Idea:

- Exchange inherent layer information between protocol layers to enhance the Quality of Service

Examples between MAC and routing layers:

- enhance scheduling by avoiding a single receiver to be transmitted data from several other nodes during a slot
- enhance power control by using Signal to Interference and Noise Ratio

Application to SFLS

- SFLS may be improved by regulating the broadcast forwarding depending upon some metrics

- Broadcast forwarding is not performed half the time, but:
  - more often if the SNR of other nodes is low (nodes are at long distance)
  - less often if there are lots of interferences (avoid the situation to get worse) or a lack of energy (energy saving)

In the following, only the impact of reducing the number of messages is taken into account (interference, lack of energy...)

MODIFICATION IN THE MODEL

- New parameters
  - N': number of nodes that do not satisfy the minimum requirements
  - $q_i^{(h)}$: distribution of these nodes at h hops for node i

- With the uniform distribution:

$$q_i^{(h)} = \begin{cases} 0 & \text{if } h = 0 \\ \dfrac{2h-1}{l_i^2} & \forall\, h \in [1; l_i] \end{cases} \qquad \overline{m_i} = 1 + \frac{N - N' - 1}{l_i}\left[\left(2 + \frac{3}{l_i}\right)\left(1 - \frac{1}{2^{l_i}}\right) - 2\right]$$

- $\overline{m_i}$ is significantly reduced, the limit remains unchanged and the order of magnitude becomes $N - N'$

Conclusion

SFLS is:

- a location service for MANETs
- simple to implement
- requiring few messages to be transmitted
- scalable

The cross-layer design allows to:

- take into account real-time measures of the network
- reduce the number of messages even more

FURTHER DIRECTIONS

Short term:

- These are theoretical results
- Next step is simulation
- At last, why not implementing?

Mid-term:

- Prediction can be used as a complement to SFLS to improve the knowledge of other nodes' location

Thank you for your attention.

Any questions ?