Load Repartition for Congestion Control in Multimedia Wireless Sensor Networks with Multipath Routing

Moufida Maimour, CongDuc Pham and Julien Amelot

CRAN Labs, Nancy University and LIUPPA labs, Pau University
France

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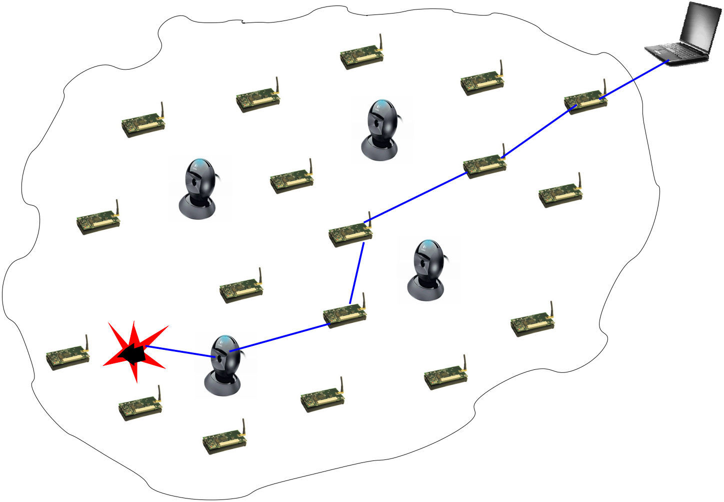
Introduction

Wireless Multimedia Sensor Networks (WMSN)

- WSN are very constrained (energy, processing, bandwidth, ...)
- Multimedia applications are resources hungry !
- A multipath routing allows for :
  - more bandwidth
  - load-balancing
  - congestion control/avoidance

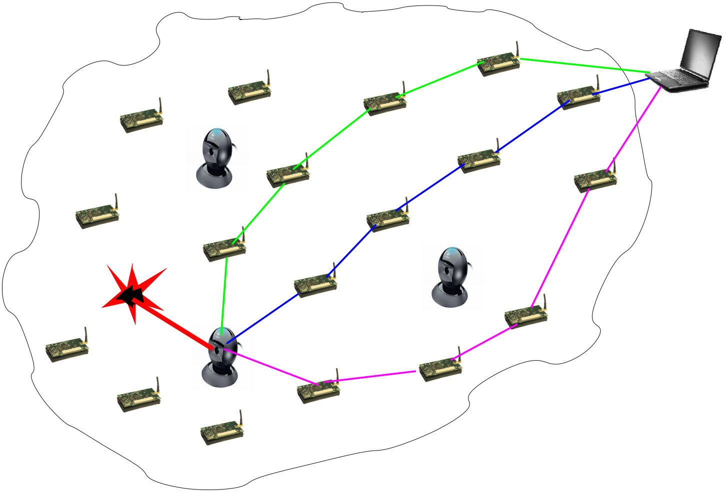
Introduction

Wireless Multimedia Sensor Networks



Introduction

Multipath Routing in WMSN



Content

1. SLiM (Simple Lifetime Multipath routing protocol)
2. Congestion Control on top of SLiM
3. Simulation Results
4. Conclusion and Future Work

SLIM

Simple Lifetime-based Multipath routing

- Multiple paths are built in one request flooding
- A request:
  - Path id, the first crossed sensor
  - Path lifetime from this sensor to the sink
- Use of path tables :
  - pathId
  - nextNode
  - quality : path_lifetime here
  - inUse

Energy Model

- Transmit a k-bit message a distance d ([Heinzelman et al.]):

$$E_{Tx}(k,d) = E_{elec}\ k + \epsilon_{amp}\ k\ d^2 \quad (1)$$

- Receive a k-bit message ([Heinzelman et al.]):

$$E_{Rx}(k) = E_{elec}\ k \quad (2)$$

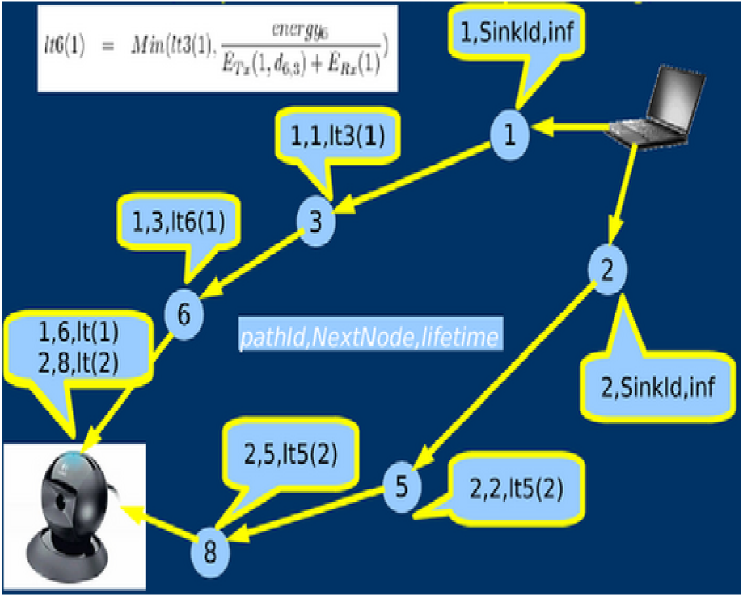
- Sensor node *i* lifetime in a given path *P* is estimated as the number of bits that can be handled, i.e. received and then forwarded :

$$lifetime_i(P) = \frac{energy_i}{E_{Tx}(1, d_{i,j}) + E_{Rx}(1)} = \frac{energy_i}{2\ E_{elec} + \epsilon_{amp}\ d_{i,j}^2} \quad (3)$$

- We define path lifetime as the minimum lifetime among all nodes belonging to this path :

$$lifetime(P) = Min_{i \in P}(lifetime_i(P)) \quad (4)$$

SLiM by Example



Congestion Control on top of SLiM

- Target application : video transport
- Aim : keep the transmission rate unchanged ($\Rightarrow$ video quality unchanged) as long as possible
- Mean : multipath routing

Explicit Congestion Notification :

- A CN (nodeId, pathId) is triggered when the reception queue occupancy is greater than a given threshold or when the collision rate is above a given threshold.

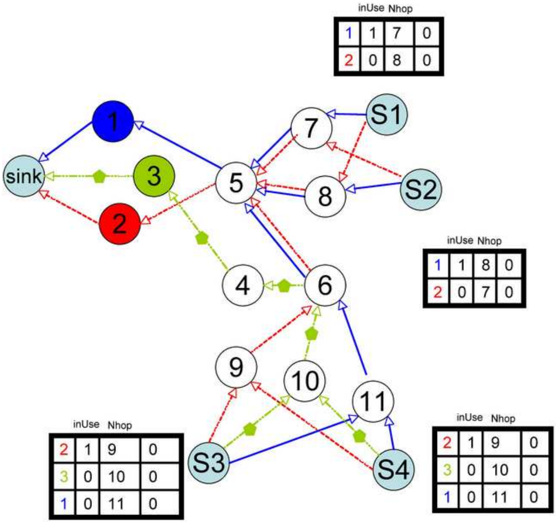
Congestion Control on top of SLiM

Load Repartition Strategies

- Mode 0 : no load repartition. Only the best path is used. No congestion control
- Mode 1 : All paths are used from the beginning. No congestion control
- Mode 2 : CN-based. The source starts with one path. For each CN(nid, pid) received, it adds a new path (the first available path different from *pid*) until all paths are active. The load is uniformly distributed on the active paths.
- Mode 3 : like mode 2. However, the source will uniformly balance the traffic of path *pid* on all available paths (including path *pid*). Therefore depending on the number of CNs received for each path, the transmission rate is not the same on all the active paths.

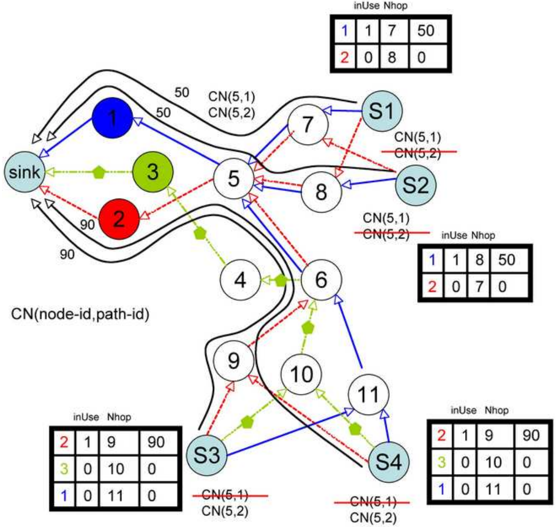
Congestion Control

Typical Multi-sources Scenario



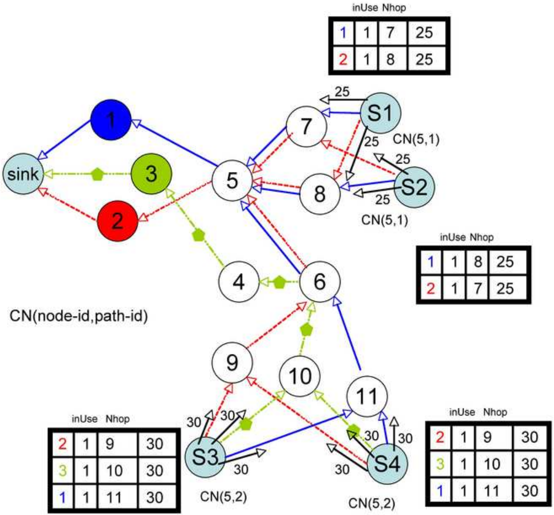
Congestion Control on top of SLiM

Modes 2 & 3 illustrated:



Congestion Control on top of SLiM

Modes 2 & 3 illustrated (cont.):



	inUse	Nhop	
1	1	7	25
2	1	8	25

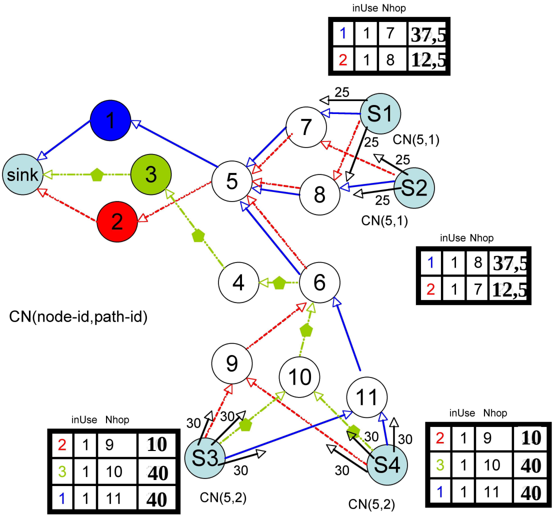
	inUse	Nhop	
1	1	8	25
2	1	7	25

	inUse	Nhop	
2	1	9	30
3	1	10	30
1	1	11	30

	inUse	Nhop	
2	1	9	30
3	1	10	30
1	1	11	30

Congestion Control on top of SLiM

Mode 3 illustrated

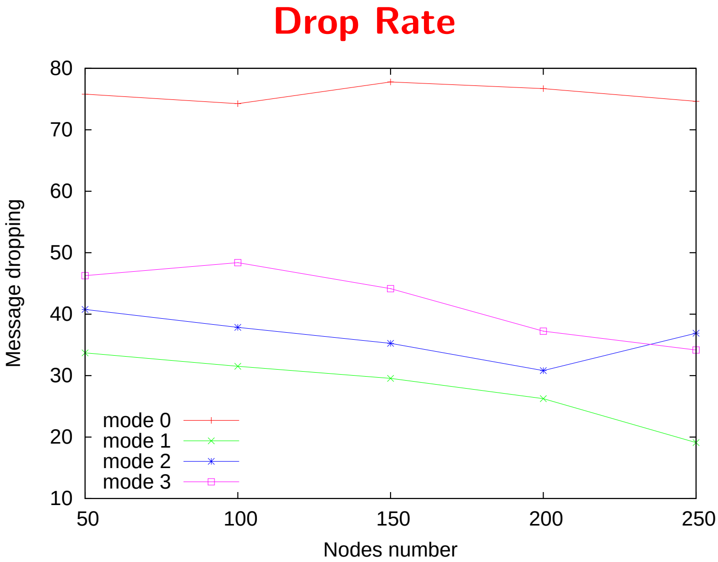


Simulation Results

Simulation Environment and Parameters

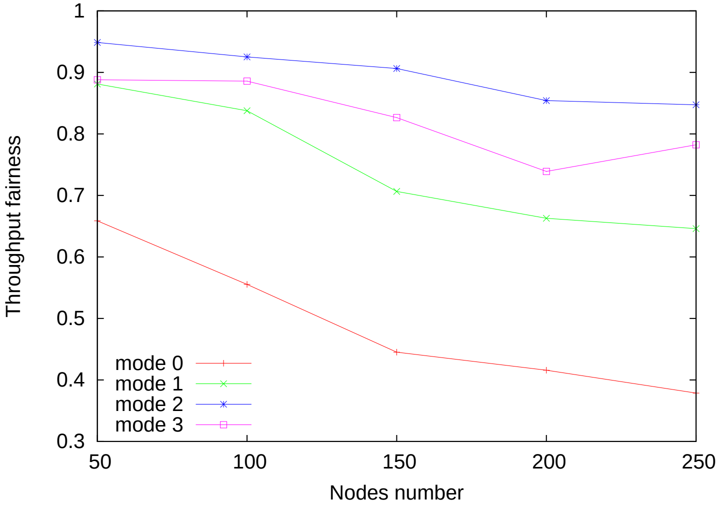
- TinyOS simulator TOSSIM
- Square sensor field $1000 \times 1000m^2$
- Static sensor nodes randomly generated (50 to 250)
- Scenario: sink located at upper right corner. Event occurance simulated at the opposit quarter of the field. Multiple sources are obtained.
- Results are averaged over 100 simulations with different randomly generated topologies (radio range of 400m) and initial energies between 0 and 0.4 Joules.

Simulation Results



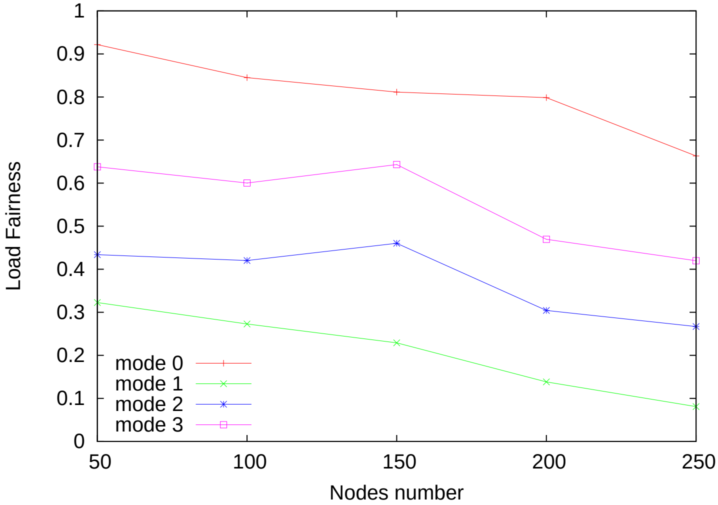
Simulation Results

Fairness among Sources



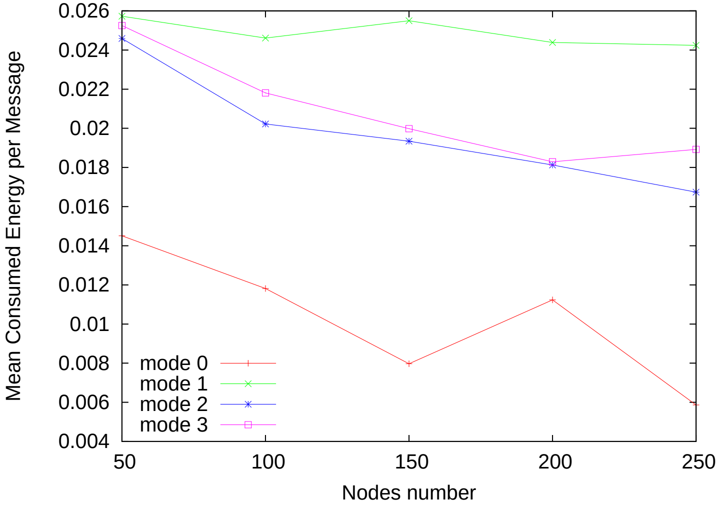
Simulation Results

Load Fairness among Active Sensors



Simulation Results

Mean Consumed Energy per Received Packet



Conclusion

- Load repartition strategies for the purpose of congestion control in the context of video flows in a wireless sensor network with multipath support
  - maintain the video quality unchanged by splitting a video flow on multiple paths instead of decreasing the transmission rate.
- Preliminary results :
  - load repartition improves congestion control by reducing the packet drop probability.
  - depending on the target applications on the sensor network, one may choose to prefer either fairness among sources or load fairness among active sensors.
  - distributing the traffic on all the available paths from the beginning is not efficient in terms of energy nor in terms of fairness. Although it achieves the best performances in terms of success rate.

Conclusion

Future Work

- Real Experimentations
- Image/Video Transport
- Interefrence-aware multipath routing