Mini-Sink Mobility with Diversity-Based Routing in Wireless Sensor Networks.

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Outline

WSN : Definition and Constraints

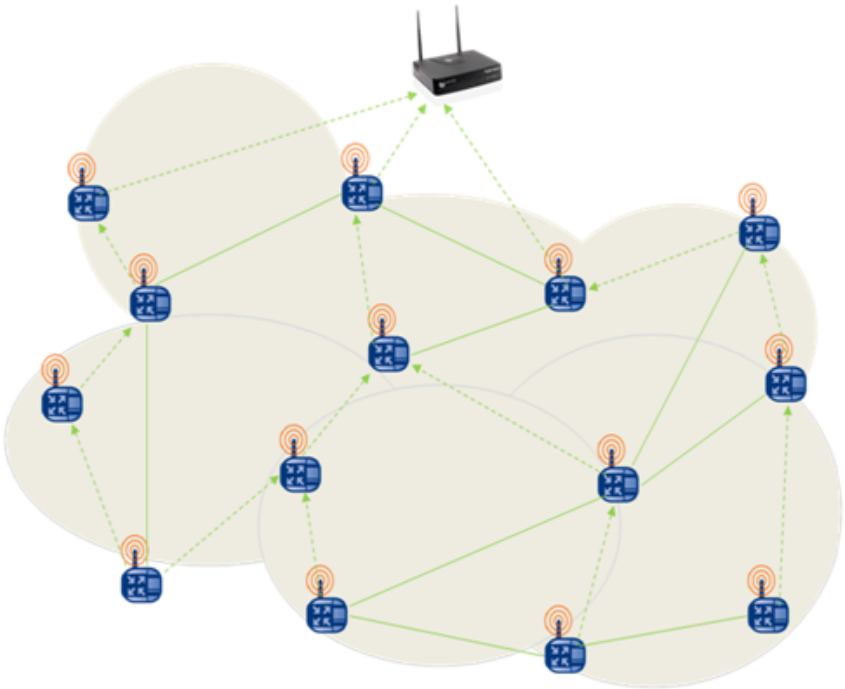


FIGURE: WSN

- Definition
  - Ad hoc, consist of small devices, known as sensors
  - Scattered over an area,
- Constraints
  - Low finite Battery,
  - Limited memory,
  - Communication,
  - Computation power...

Problem definition

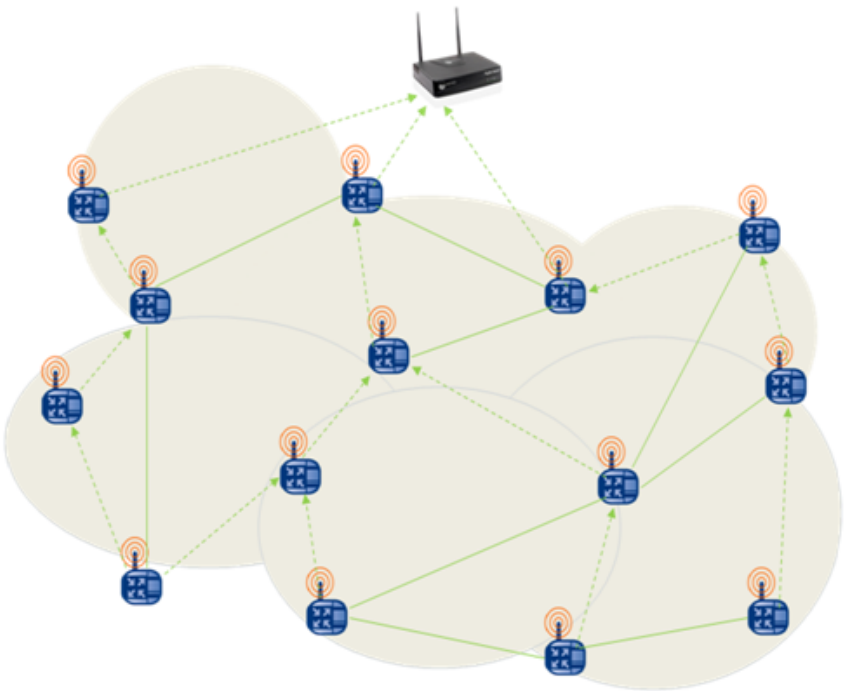


FIGURE: WSN

- Problem
  - The data collection rate dominates the data forwarding rate.
  - Sensors in the vicinity of the sink collect more data.
- Congestion starts to build at these sensors, increases data loss.
- Energy reserves of sensors around the sink becomes quicky depleted.

Proposition

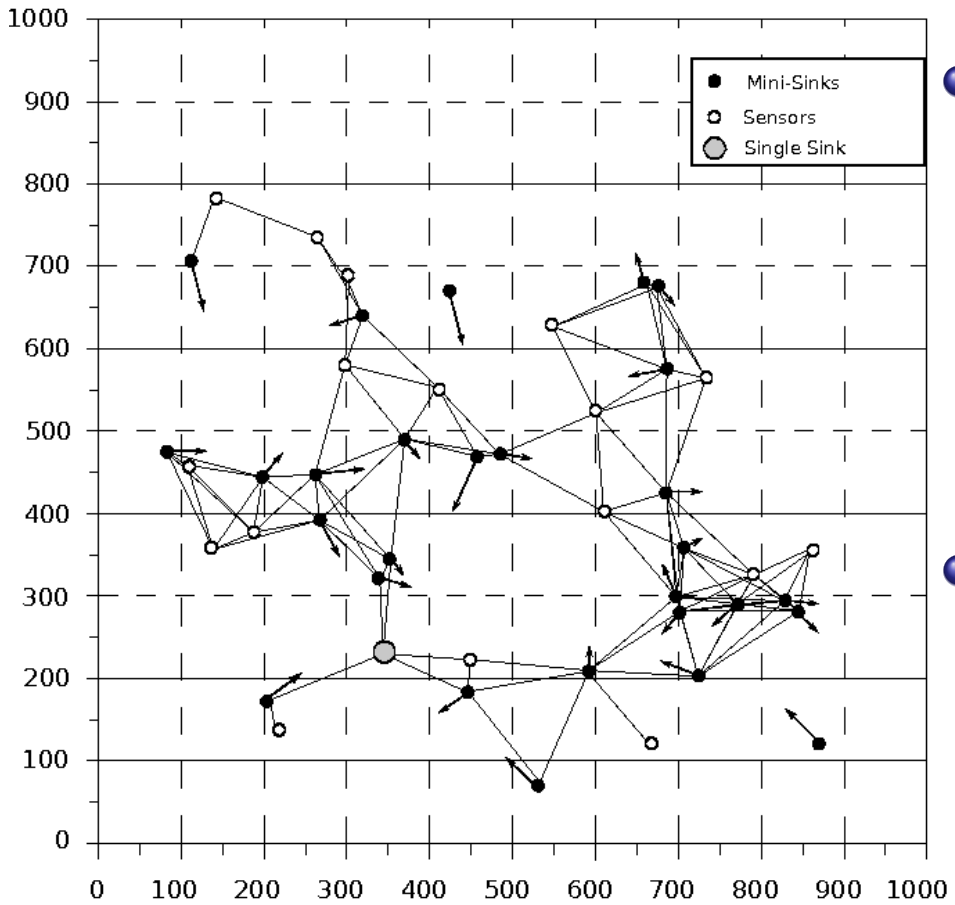


FIGURE: Mini-Sinks mobility

- A model based on Mini-Sinks.
  - MSs are mobile and move in the sensors field according to an arbitrary mobility model to :
  - Maintain a fully-connected network, collecting the data.
- Data forwarding
  - *ECRP* is implemented in *MS*s and sensors in order to generate a set of multiple paths.
  - The traffic can be distributed over the network.

Proposition

- Assumptions
  - Sensors and MSs are deployed randomly.
  - Sensors are homogeneous.
  - Sensors are fixed and are responsible for sensing the nearby environment and forward them to the most easily accessible MSs
  - MSs are responsible for collecting the data from sensors and forward towards the sink
  - MSs have an unlimited energy

Mobility Model

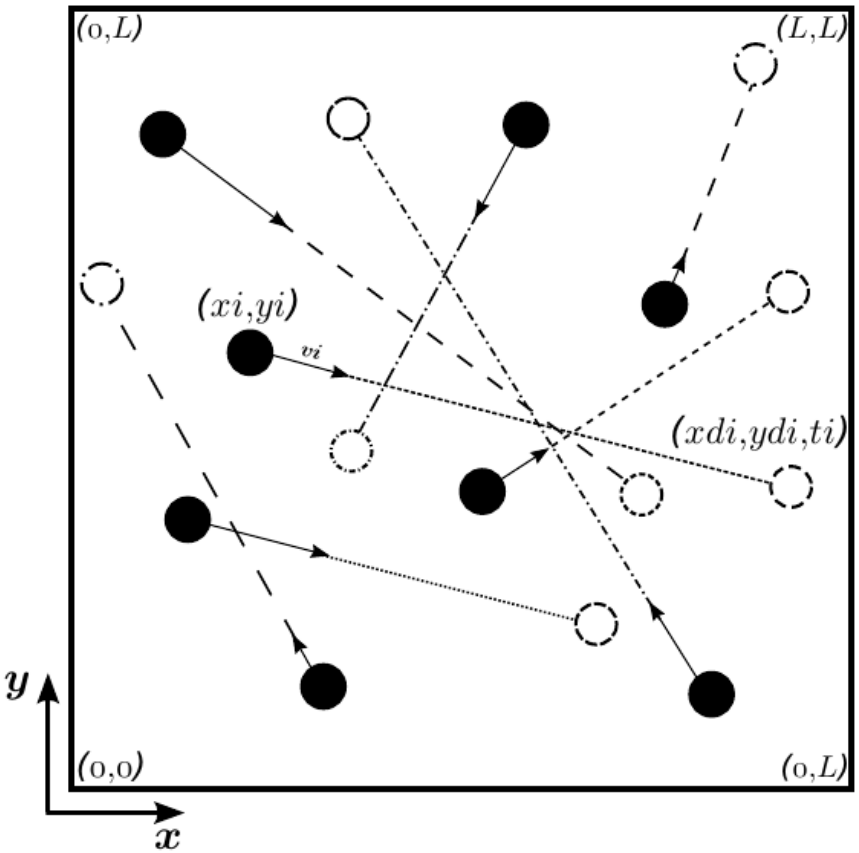


FIGURE: MSs mobility

- Each *MS* moves with a velocity $[v_{min}..., v_{max}]$.
- When a *MS* reaches the locality radius of the sink, it stays there for a time t_i, selected in the range $[t_{min}..., t_{max}]$.
- After this interval, the *MS* restarts its displacement process by selecting a new location, and so on.

ECRP : Algorithm overview

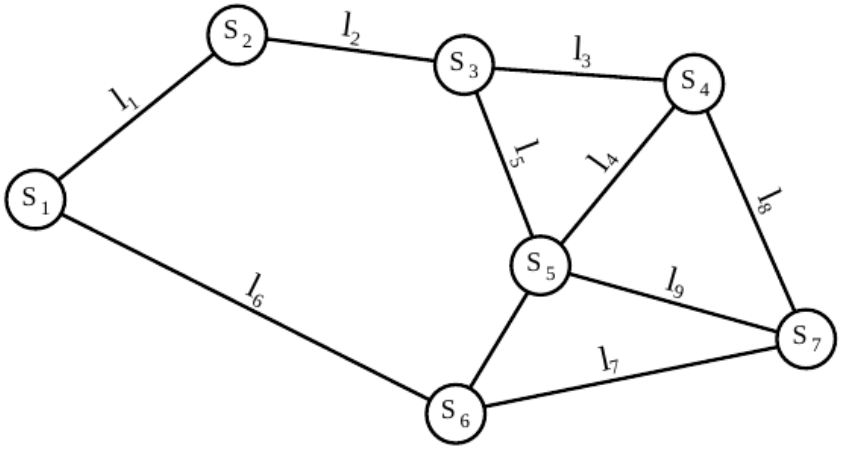


FIGURE: Network topology

TABLE: Path discovery between sensors S_1 and S_7

Path	Connection Links	Hop Count
P_1	$S_1 S_6 S_7$	2
P_2	$S_1 S_2 S_3 S_5 S_7$	4
P_3	$S_1 S_6 S_5 S_4 S_7$	4
P_4	$S_1 S_2 S_3 S_4 S_7$	4

Each sensor uses each path in turn for the transmission of successive packet to MSs.

Routing

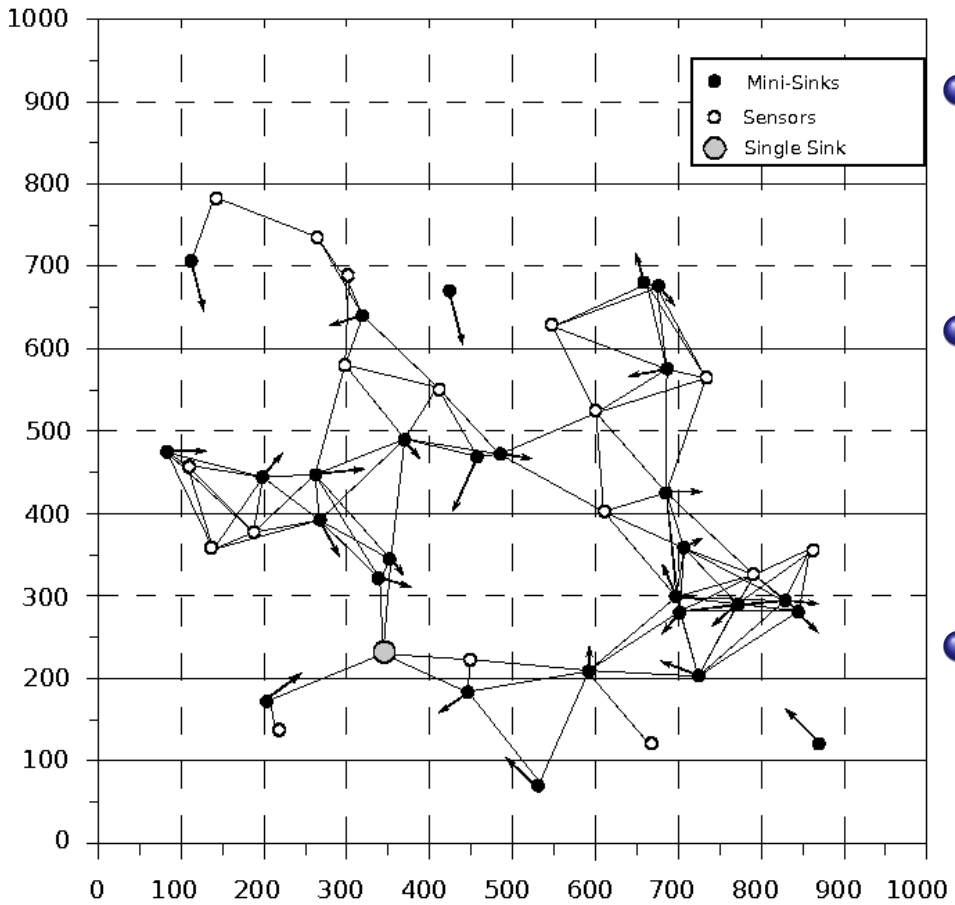


FIGURE: Mini-Sinks mobility

- Each *MS* broadcasts a packet to all sensors in its locality radius.
- Each sensor in direct communication with *MS*s calculates the lowest cost path using *ECRP*.
- When each *MS* arrives in the locality radius of the sink, it stays for a time t_i.

Analysis parameters and Criteria

- Parameters analysis

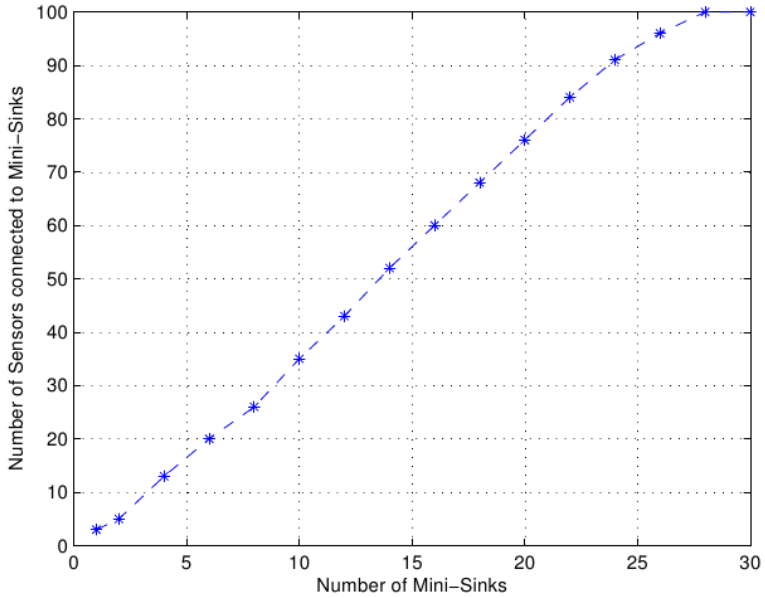
Parameters	Description	Value
E	Full Energy of Sensor	10^4 Joules (J)
L	Simulation area	1000m X 1000m
Traffic	Packet lengths	2 Kbits
D	Locality Radius (m)	75m
Movement	Random Way Point	
v_{max}	Maximum velocity	10_{mps}
t_i	Time Needed (s)	Between $[0..., 3_s]$
n	Number of Sensors	Between [5.., 100]
N	Mini-Sinks	Between [1..., 35]

- Analysis criteria
  - How many *MS*s should be used to have a fully-connected network.
  - How many *MS*s should be used to reduce the amount of packets broadcast
  - How much benefit can be obtained in terms of broadcast latency.
  - The effect of multiple paths on energy consumption.

Communication modes

- Multi-*MS* mode
  - Each sensor is allowed to connect itself simultaneously to several *MS*s in order to increase its connectivity capabilities. The sensor under consideration stores and updates the lowest cost path towards each accessible MS.
- Multiple paths *MS* mode
  - Multiple paths are used between a sensor and the closest *MS*s. These paths are discovered using *ECRP*.
- Point-to-point mode
  - Two *MS*s want to establish a connection with each other. The lowest cost path is discovered and updated when the network topology changes. Otherwise, packets always follow a single path if the topology stays stable.

Multi-*MS* mode : number of sensors connected to *MS*s



- The connectivity capability increases as the number of *MS*s increases.
- The fully-connected network can be achieved using more than 25 *MS*s.

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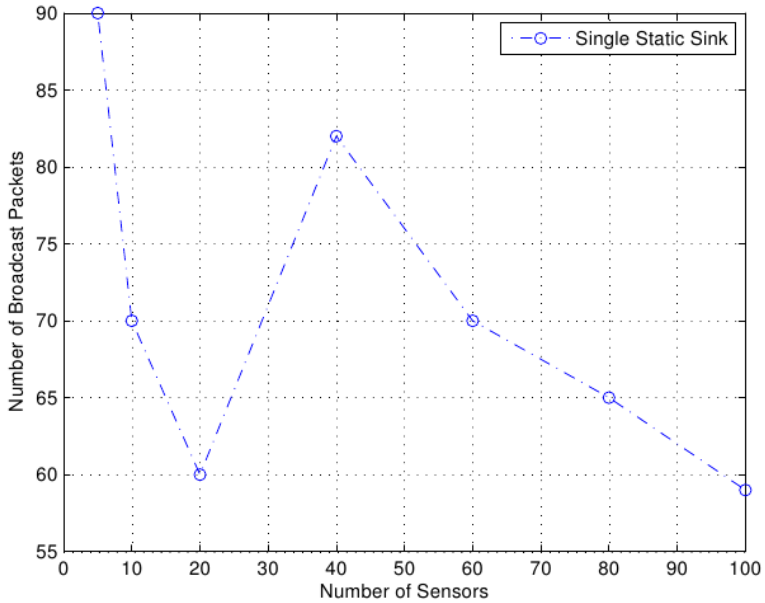
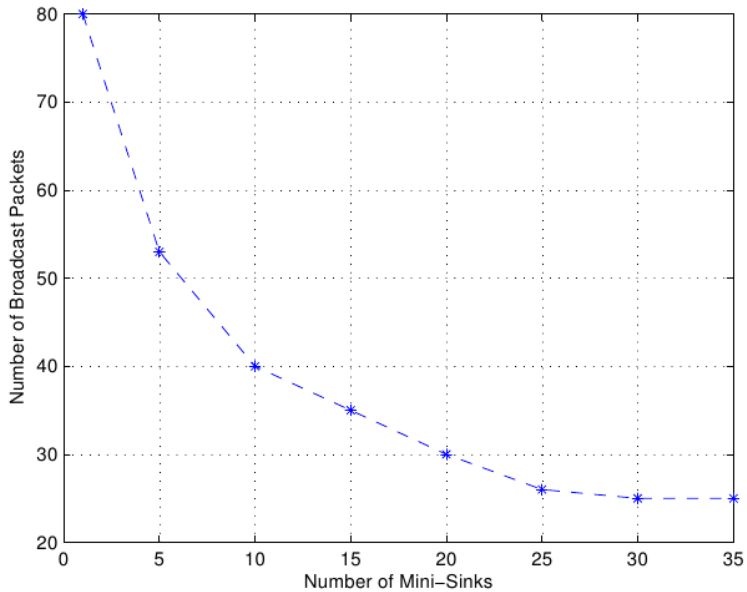
Multiple paths *MS* mode : number of packets broadcast by a sensor



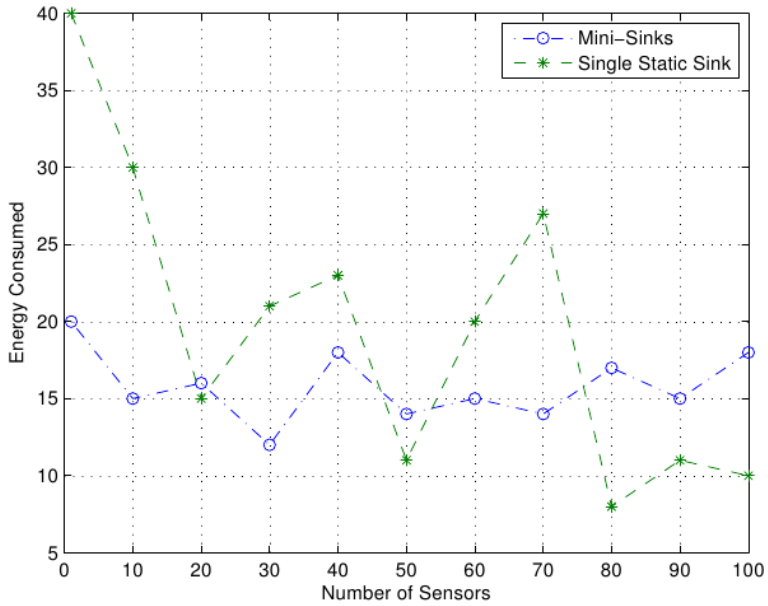
- When using a single static sink, the maximum number of packets broadcast per sensor is around 90, and the minimum is around 40.

Multiple paths *MS* mode : number of packets broadcast for different number of *MS*s



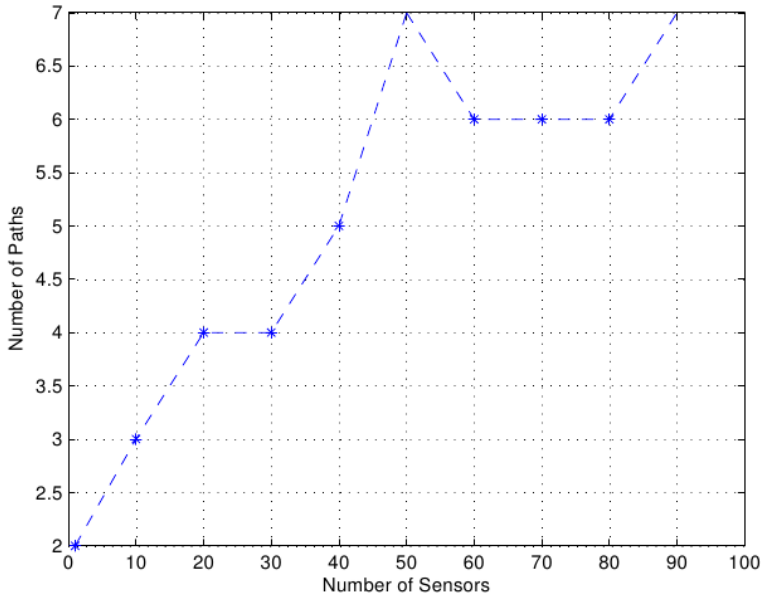
- The maximum number of packets broadcast per sensor decreases from 90 to 80. While the minimum number of packets decreases from 40 to 25.
- With 30 or more *MS*s, the number packets is around 25.

Multiple paths *MS* mode : evolution of energy consumption



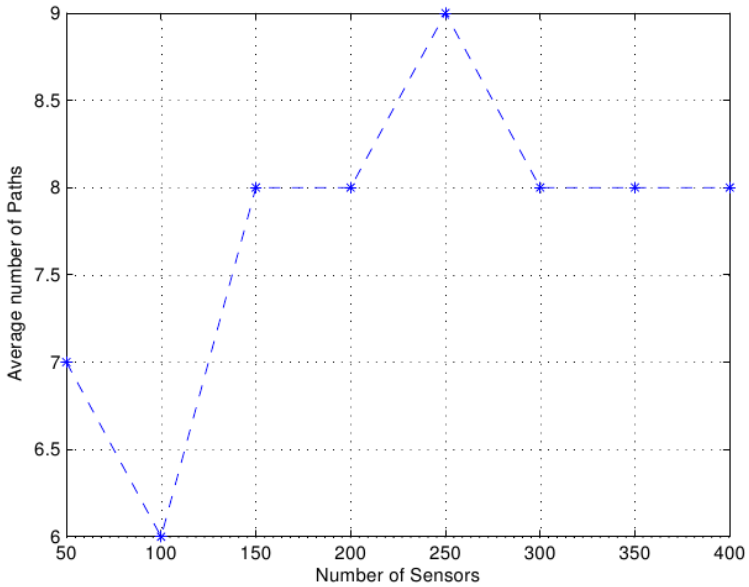
- In the case of single static sink, the energy expended varies between approximately 8 and 40 Joules.
- When using *MS*s, the energy consumed by each sensor varies between approximately 12 and 20 Joules.

Multiple paths *MS* mode : number of paths used per sensor



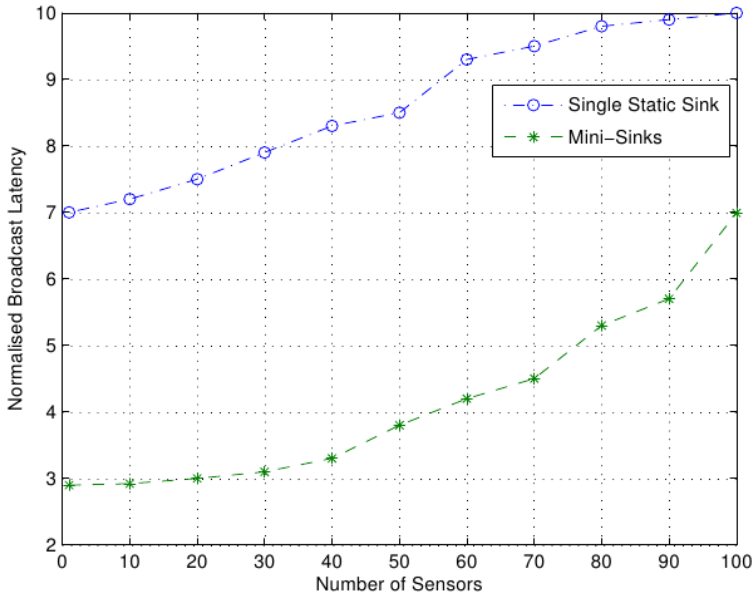
- The number of paths used per sensor for forwarding the data varies between $[2 - 7]$.
- Successive transmissions of data can be achieved efficiently with an average of 6 paths.

Multiple paths *MS* mode : average number of paths in dense *WSNs*



- When the density of the network varies between [50 – 400] sensors, the number of paths used per sensor for forwarding the data varies between [6 – 9], with an average of 8 paths.

Point-to-Point mode : broadcast latency during data forwarding



- In the case of a single static sink, broadcast latency varies between approximately 7 and 10, while with *MS*s, broadcast latency varies between approximately 3 and 7.
- *MS*s reduce the max latency by 30%, and the min by 57%.

Summary

- A model based on Mini-Sinks
  - Sensors and the main sink are fixed, but *MS*s are mobile.
  - *MS*s move among the sensors according to an arbitrary mobility model in order to :
  - Maintain a fully-connected network topology, collecting data within their coverage areas and forward towards the sink.
  - *ECRP* is implemented in *MS*s and sensors in order to optimize the transmission cost of forwarding.
  - A set of multiple paths between *MS*s and sensors is generated to distribute the global traffic over the entire network topology.
- Thus, the amount of data carried through the network, energy consumption and broadcast latency are reduced

Perspective

- Evaluate our model in a real tesbed scenario.

Thank You !
Questions ?