Autonomous Wireless Sensor Networks for Intersection Monitoring

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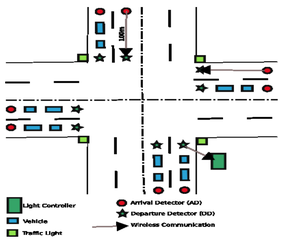
1 – CONTEX AND PROBLEM STATEMENT

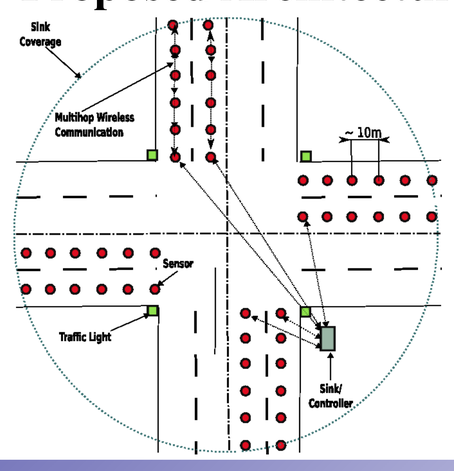
- Urban population growth implies new challenges for authorities : traffic jam, accident, pollution, etc
- Intelligent traffic management as a solution.
- How to measure vehicles queue length at an intersection? Many WSN based solutions



Standard Architecture

- ***Unrealistic communication range assumptions***
- ***A vehicle can change lane : low precision on queue length estimation***

Proposed Architecture



- Building on experimental results
- Multihop WSN
- The number of sensors per lane depends on communication and application constraints

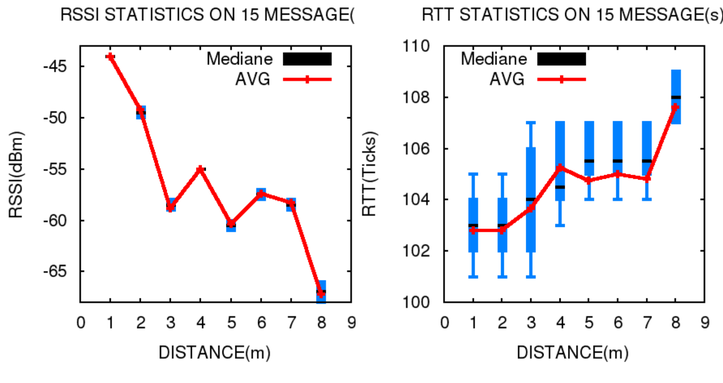
Challenges

- Self-Organization, Low financial cost
- Traffic-model : Event-based or Periodic Transmissions
- Routing, Energy Harvesting

2 – SELF-ORGANIZATION

- The logic position of a node is composed of the lane on which it is deployed and its relative position to the controller.
- How can the network autonomously determine logic position of nodes ?
- It is a neighbors ordering problem in the case of a linear network
- What network properties can be used to characterize relative distance between a node and its neighbors? RSSI, RTT, neighborhood, etc

RSSI and RTT as a function of distance [1]



RSSI or RTT alone cannot be used as a perfect metric for neighbors ordering in many situations

- Two neighbors located at 1m and 2m cannot be discriminated by RTT
- Two neighbors located at 3m and 6m cannot be discriminated by RSSI

Ongoing Works

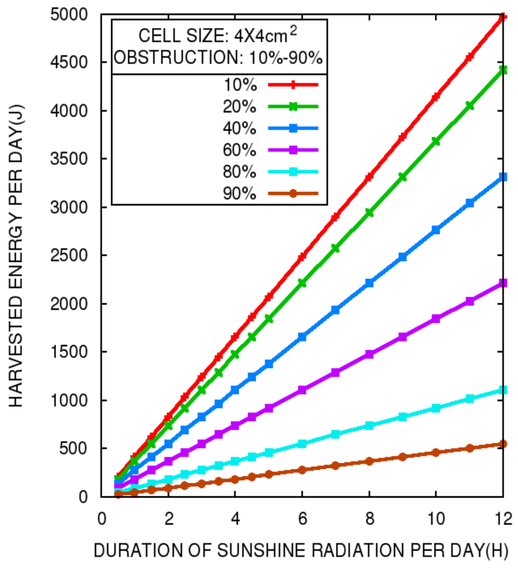
- Communication link characterization
- Combine RSSI and Neighborhood

3 – ENERGY HARVESTING

- Exploit small size solar cell to power sensor nodes
- Energy availability is seasonal and depends on time and deployment area
- According to node deployment area, what is the energy consumption per day? What is the quantity of energy harvested per day?

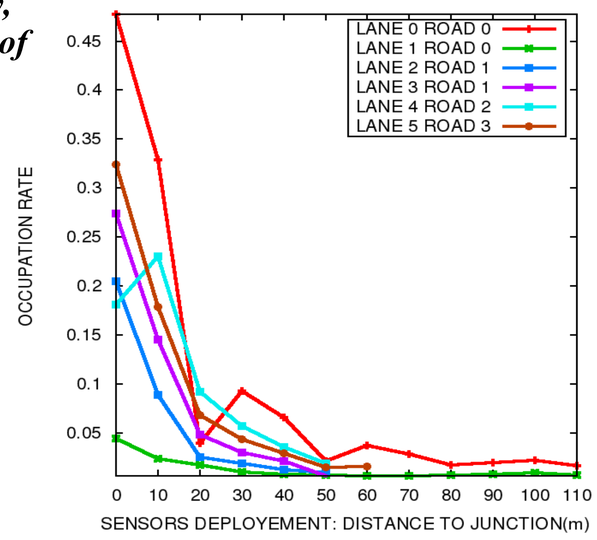
The traffic data of the Koln City [2] are used to understand and analyze vehicles traffic at the intersections

Harvested Energy = f(Power density, Power efficiency, Cell size, Duration of radiation, Cell obstruction)



Theoretical energy production per day

Sensors obstruction rate for the period from 6 AM to 6 PM

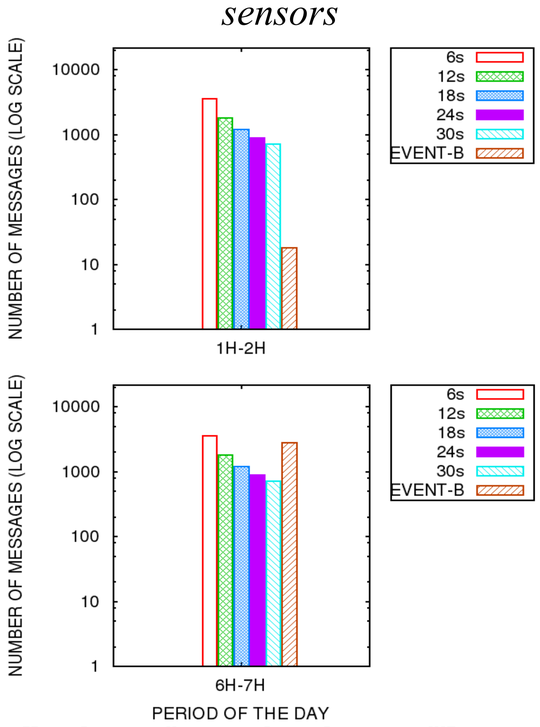


- **Low energy availability for sensors close to the intersection**
- **For some time intervals, sensors can be shadowed by the vehicles more than 80% of the time**

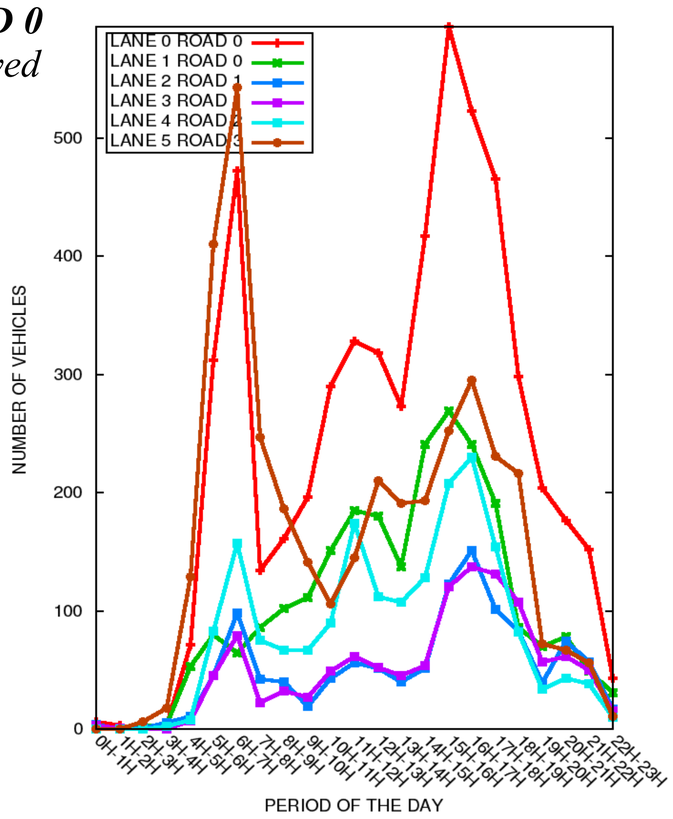
4 – TRAFFIC MODEL AND DATA FORWARDING

- How to efficiently and reliably forward data from the originator to the controller/sink? “Geo-forwarding” : only nodes closer to the controller are candidates for message forwarding.
- Forwarding node should be selected according to its **Energy Potential** (EP). **EP = f(battery level, harvesting opportunity)**
- Load-balancing : Vehicular traffic is not uniform on all lanes at the intersection
- What network traffic model? Event-based (when a vehicle is detected) or periodic? What impact on application performance?

*Traffic generated on **LANE 0 ROAD 0** at two different period with 6 deployed sensors*



Design of an adaptive traffic model for each lane



Number of vehicles per lane during each period of the day at a given intersection

5 - CONCLUSIONS

A proposed WSN architecture with interesting challenges such as self-organization, “energy management” in energy harvesting WSN, traffic model and routing

Future works

- What networks properties could be used for self-organization problem?
- An adaptive traffic model which takes into account vehicular traffic conditions and application requirements
- A forwarding scheme taking into account node position and energy potential

6 - SOME REFERENCES

[1] INRIA, www.senslab.info
[2] http://kolntrace.project.citi-lab.fr/
[3] Zhong, Z. and He, T., Achieving range-free localization beyond connectivity, ACM SenSys '09, P 281-294, Berkeley, California, 2009
[4] Sudevalayam, S. and Kulkarni, P. Energy Harvesting Sensor Nodes: Survey and Implications. Communications Surveys Tutorials, IEEE. Vol 13, Num 3, Page 443-461, 2011