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Network Lifetime Improvement in Wireless Sensor Networks by Exploiting Sink Mobility

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ABSTRACT: Data gathering is a fundamental task of wireless sensor networks (WSNs). Its task is to collect sensor readings from sensor nodes that are spread over the sensory fields at predefined single sink or multiple sinks (*without aggregating at intermediate nodes i.e. relay nodes*) for analysis and processing. Researches show that energy expenditure of sensor nodes closer to sink is larger than the sensor nodes far from sink resulting in rapid depletion in their battery due to heavy overhead of relaying messages. This non uniform consumption of energy causes poor network performance and shortens network lifetime. In present work sink mobility has been exploited to balance the energy consumption rate. This has been demonstrated by experiment study using COOJA simulator and RPL as a Routing protocol. It is found that the lifetime of sensor field can be improved by exploiting sink mobility in place of stationary sink node. The proposed strategy moves the sink towards the nodes with highest residual energy. This approach doesn't need global knowledge; the residual energy information is available at each sensor site locally. This information is piggybacked with measurement data and reported to the sink. After receiving information by all leaf nodes of the network, the sink elects the node with greatest residual energy and moves towards that node. A sink is allowed to move only at instances when global DAG repair is made to mitigate the effect of large control message. The proposed algorithm is simulated using COOJA simulator of CONTIKI OS for sensor networks. The results clearly show that exploiting sink mobility, the lifetime of sensor network can be greatly increased and premature failure (i.e. energy holes) can be also avoided.

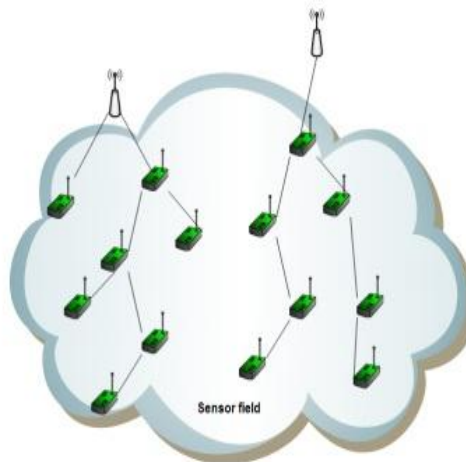
I. INTRODUCTION

Convergence of micro-electro-mechanical systems (MEMS), embedded systems and wireless communication has opened a new era in mobile networking and pervasive computing which is referred to as "wireless sensor networks". In WSNs, sensor nodes or motes are usually deployed in the order of hundreds or thousands. Motes perform sensing and perhaps limited processing. At last, wireless network of motes which is shaped on an ad hoc basis, is responsible to disseminate captured information. Currently, low production cost, tiny size and wireless communication make the embryonic idea such as *internet of things* and *ambient intelligence* more feasible than at any time before. Therefore, WSNs open a new research area which attempts to devise power efficient solutions.

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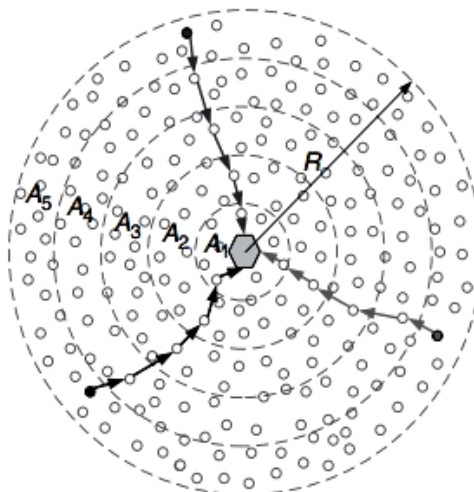
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II. PROBLEM STATEMENT

In this, sink mobility has been exploited to improve network lifetime & avoid energy hole problem resulting in premature network failure. The reason is quite simple; as sink moves. The role of “hotspot” (i.e. heavily loaded nodes) around sink rotates among sensors, resulting in balanced energy consumption. In contrast to traditional wireless sensor networks, where all the sensor nodes and sink are stationary, we have assumed stationary sensors and mobile sinks. The trajectory of the sink depends upon the energy profile of the network. At each data collection point, sink behaves as root and sensor nodes as branches and leaves of the tree.



METHOD: In contrast to traditional wireless sensor networks, where sensor nodes and sink are stationary, we have assumed stationary sensor and mobile sink. The trajectory of the sink depends upon the energy profile of the network. Sink visits the points with high energy. While collecting data, each sensor sends its remaining energy piggybacked with the measurement of data. At each collection point, sink behaves as root and sensor nodes as branches and leaves of the tree.

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III. ARCHITECTURE: FROM MOTES TO NETWORK

Consists of two subsections: hardware section & network section.

Hardware Architecture:

A sensor node has four main components: processor, transceiver, sensing unit and power unit.

- The processing unit is responsible for controlling and coordinating the operation of other components.
- Transceiver is the enabling component for wireless and ad hoc networking of sensor nodes
- The sensing unit contains to sub-units: sensors and ADC (Analog to Digital Converter). Sensors sense the phenomenon and its output analog signal so ADC is used to convert sensor output into digital.
- A power unit is necessary to supply power to the components while it meets their specific requirement.

Network Architecture:

Communication Architecture: The communication architecture in WSNs follow source to sink paradigm (converge cast) of routing algorithms. In WSNs sources are deployed in a large number but it is possible to have single sink or multiple sinks.

Protocol Stack:

Like other communication networks, wireless sensor networks also should be designed based on layering guidelines.

Physical Layers: Sensor nodes widely make use of IEEE 802.15.4 [8] as physical layer. CC2420 used in TmoteSky, is a radio chip that implements IEEE 802.15.4 core functionalities which can be summarized as follows:

- Activation and deactivation of radio transceiver
- Energy detection (ED) within Link quality indicator (LQI) for current packet.
- Clear channel assessments (CCA) for carrier sense multiple access with collision avoidance (CSMA/CA).
- Channel frequency selection.
- Data transmission and reception.
- Transmission power control (CC2420 support programmable output in 8 steps from approximately -24 to 0 dBm).

MANET vs. WSN

It seems that it is possible to use protocols that are developed in MANET, yet, WSN and ad-hoc networks have different characteristic. They are varying as follows:

1. The number of sensors in WSN can be much higher compared to that of nodes in MANET.
 2. Nodes' lifetime consideration has decisive influence on protocol design while in MANET energy issue is not the main concern
 3. Collecting data in a sink(s) is a promising goal in WSN, while in MANET; there is no source to sink communication.
- It is easy to see that using MANET protocols in WSN is not a trivial matter and each of them has their own requirements in the protocol design process.

PROTOCOL STOCK:

Like other devices, WSNs also require a design based upon the layering guidelines. Intrinsic limitation of WSNs require a lightweighted and power efficient power. Now for instance if TCP protocol is used in this wireless network then it is not applicable. Usually, protocol designers exploit cross layer optimization, where layers can communicate to their intermediate below and above layers. Also they can break layering boundaries in order to communicate to the other layers.

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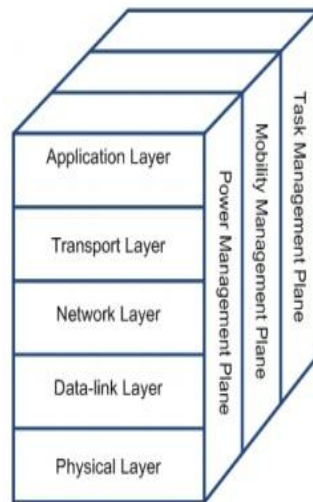


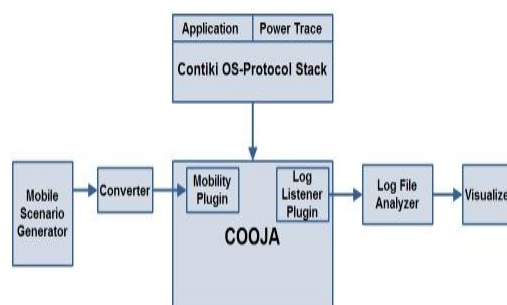
FIG 1: Protocol Stack of a typical Wireless Sensor Network

ORIGINS OF ENERGY CONSUMPTION:

The main origins of energy consumptions are:

- 1) **Idle hearing:** In this case, the “radio” stays turned on and listens to wireless channel without receiving any data or information.
- 2) **Collision:** When a receiver receives data from two or more sensors at same time, resulting in the collision of data.
- 3) **Overhearing:** This means that a sensor node receives a packet that is targeted to another node.
- 4) **Over-emitting:** Transmission of a packet, when its destination is sleeping and is not able to receive.

IV. IMPLEMENTATION AND DESIGN



A GENERAL VIEW OF IMPLEMENTATION PHASE

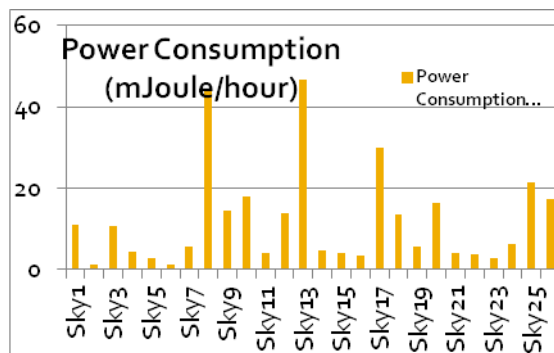
Here, all work is simulated using COOJA simulator, a part of CONTIKI Operating System. In order to provide promising performance, COOJA is being used for static scenarios. In the implementation phase power-trace tool and

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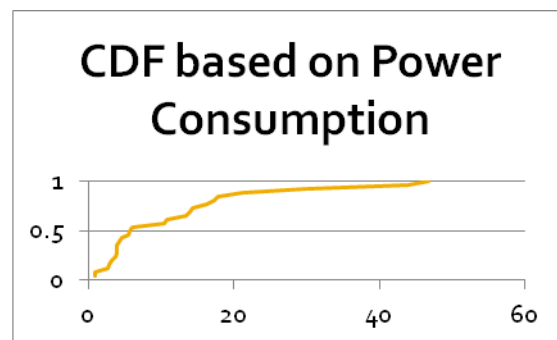
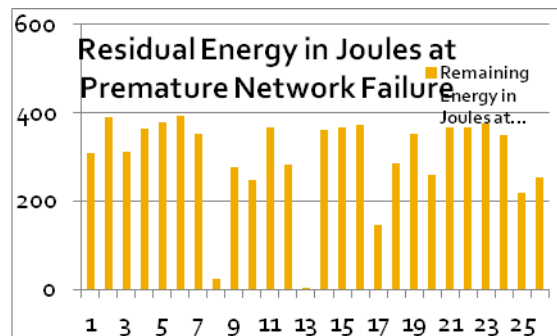
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mobility plugin is used. The purpose of power-trace is to get power log at each sensor site, i.e. how much power is used in transmission, how much in ideal etc. The mobility plugin creates sink mobility scenario. Here simulation is discrete in nature and as in mobility. This means, the sink is at one instance is at one place and at another instance it is at another place.



RESULT (STATIONARY SINK):

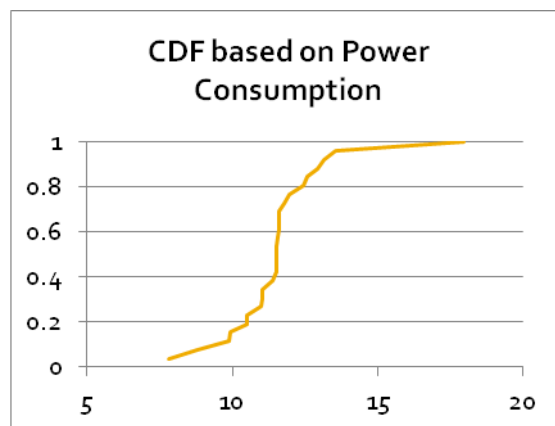
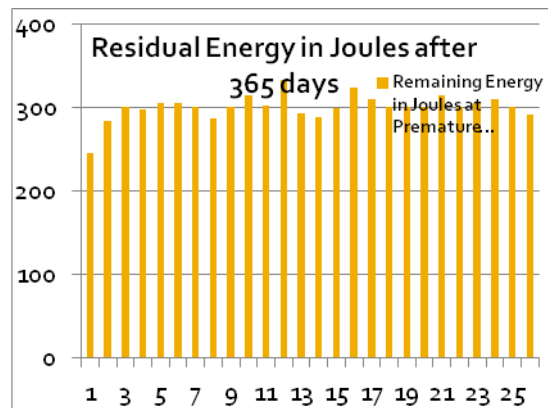
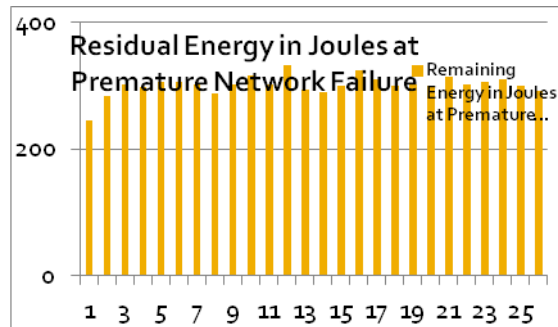


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RESULT (MOBILE SINK):



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V. CONCLUSION

In this technology, the sink mobility in the new RPL(Router protocol for low power and lossy network) has been investigated. Due to this, the battery assumption of the sensor nodes is also extended. Our proposed approach moves the sink towards the nodes with highest residual energy. Residual energy can be estimated at each sensor site and knowledge of this parameter is locally available. This approach does not need a global knowledge and prevents from collecting information from all the sensors since it only uses the leaf nodes of the DODAGs. . During experiment it is found the mobility extends lifetime but degrades the message reception rate i.e. due to mobility the knowledge of sink position is not known to all sensor nodes instantly, resulting in loss of data packets. Furthermore, to mitigate the overhead of the control messages, the sink is allowed to change its position only during the period of global DAG repair. Due to computing complexity we have performed the simulation with 25 nodes but in general we find large wireless sensor networks with hundreds or thousands of nodes. Our proposed strategy performs even better in large networks since in large networks the nodes are heavily loaded by relay messages. It is found that the effectiveness of proposed strategy can be easily experienced in large networks compared to small network.

Scope of future work

In my future work, I intend to improve the weight function and implement RPL with mobile sink in real-life deployment topology. I would also like to study its performance with different traffic patterns using a variety of metrics in DAG construction and mechanism of DAG global repair.

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