The Analysis & Design of Energy Efficient Wireless Sensor Networks

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1. Introduction

Mobile Ad Hoc Networks (MANET) propose a dynamic model to support this paradigm: devices setup temporary connections as they want to communicate, without the need of any previously deployed infrastructure. Mobile Ad Hoc Network is a infrastructure less network where there is no need of any base station where Every node is responsible to handle the data & transmit the data. Each & Every node utilize a protocol to transmit the data and maintain the collision . This critical lack calls for cooperative behavior of all devices to allow communication beyond the wireless coverage of a single node. In fact, in case the receiver is located outside the radio range of the sender, intermediate relay nodes are needed to route messages (multi-hop communications). Thus participant devices, even if with different capabilities and widely heterogeneous as for the set of locally available resources, are functionally equivalent, i.e., they are required to carry analogous tasks such as packet routing. The traditional distinction between routers and end-points faints, since all nodes undertake both tasks. Finally, in common cases, MANET nodes are carried by humans or embedded in moving objects, e.g., vehicles. On the one hand, mobility increases model dynamicity; on the other hand, it aggravates communication issues, since recipient mobility may complicate message delivery.

Wireless Sensor Networks are generally self-organized wireless ad hoc networks which incorporate a huge number of sensor nodes that have characteristics of sensing, computing, data transferring and wireless communication capabilities. Normally, the wireless sensor and adhoc networks has possibility of huge applications which are based on the following equation: Processing Unit Functions + Sensing Capacity + Radio Signal. The core issue in wireless sensor networks (WSN) is the energy consumption and usage. In WSN, to design a node energy model that can perfectly reveal the energy consumption of sensor nodes is one of the best part of protocol development, system design and performance evaluation. Wireless Sensor Network technique's development in the computation capability needs the sensor nodes to be used more to deal with more complex functions. Each and every sensor is mainly limited by its energy status.

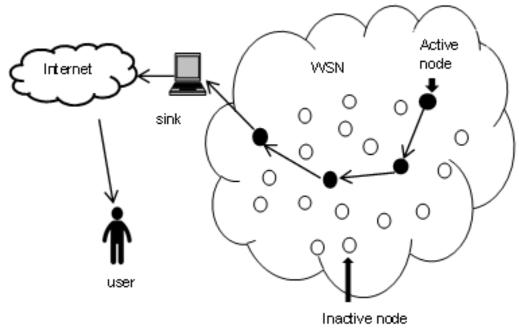

Figure1. Active nodes in a wireless sensor network

The main components in a WSN are as follows:

a) an assembly of sensors that covers the particular region,

b) an interconnecting wireless network,

c) a central point of information clustering, and

d) a set of computing devices at the main point to solve data correlation, event trending, queuing status and data mining.

One of the core design issues for a sensor network is conservation and optimal use of the energy stored at each sensor node. The lifetime of the sensor network can be divided into equal periods of time known as rounds. All base stations are identified at the beginning of a round. The basic method uses an integer linear program to find out new dimesions for the base stations and a flow based routing protocol to ensure energy efficient routing during each round. The applications of wireless sensor network have drastically improved by the rapid advances in Micro-Electro-Mechanical System based sensor technology coupled with low power, low cost digital signal processor and radio frequency circuits.

Enhancing the network lifetime is also based on the better managing of sensing node energy resource. Recent development in Micro Electro Mechanical System (MEMS) technology has given us the development of low cost and low power utilizing micro sensor nodes in this area. Wireless Sensor network is a power consuming scheme because nodes executes on restricted power batteries which reduces its lifetime. Energy efficient routing protocol has been found very effective techniques in wireless sensor networks because sensor nodes are fully energy dependent. As a result, several researchers have designed different routing protocol for sensor networks, specially routing protocols which are based on cluster protocols. This is reason that's why usage of cluster based routing has many advantages like optimum control messages, bandwidth re-usability and high power control.

As we know, the energy matter is of much importance in wireless ad hoc and sensor networks. This energy can be very expensive, difficult and even impossible to regenerate till now. Energy efficient strategies are required in such type of networks to maximize network lifetime. We have divided into four categories of strategies: 1. Energy efficient routing, 2. Node activity charting, 3. Topology control by tuning node transmission power, and 4. Reduction of the volume of information transferred.

The one of solutions called Energy efficient Optimized Link State Routing Protocol is based on the link state OLSR routing protocol which shows by modelling and simulation that outperforms the solution that selects routes minimizing the end-to-end energy consumption, as well as the solution that builds routes based on node residual energy. Information provided by the Media Access Control layer improves the re-scheduling of the routing protocol and robustness of routes. Further, taking into account the specificities of some applications like collection of data allows the routing protocol to reduce its overhead by maintaining routes only to the sink nodes.

In general, sensor nodes gather sensor readings and use several signal processing techniques to get meaningful results from the raw data. The applications envisioned for sensor networks vary from monitoring hostile habitats and disaster areas to operating indoors for intrusion detection and monitoring of equipments. In such kind of situations, the signal-processing techniques require better synchronization among sensor node clocks, so that a right chronology of every event can be detected. On the other side, the sensor network applications such as detecting brushfires, gas leaks, etc., the time of occurrence of an event is itself a very significant parameter. For such kind of applications, the synchronization of complete network with all the nodes that maintain a unique global time scale becomes more important.Time synchronizing protocol to maintain global time is the Time Synchronous Protocol for Sensor network. Low duty cycle approach has been found one of the best consideration for energy efficient WSNs.

Fairness in scheme and operation is also an important attribute to be achieved in a wireless sensor network and it should be guaranteed for all computing nodes. So, while deferring transmission through a poor quality link in an attempt to optimize energy efficiency, the traffic load should be considered. Thus, this sparked the development of a new algorithm, which is an energy efficient channel adaptive MAC scheme [2]. This protocol integrates different aspects, incorporates the cross layer interaction of the channel adaptive MAC layer and network layer; thus making it channel adaptive DPM scheme. Thus, both energy efficiency and fairness in wireless sensor networks traffic are aimed here.

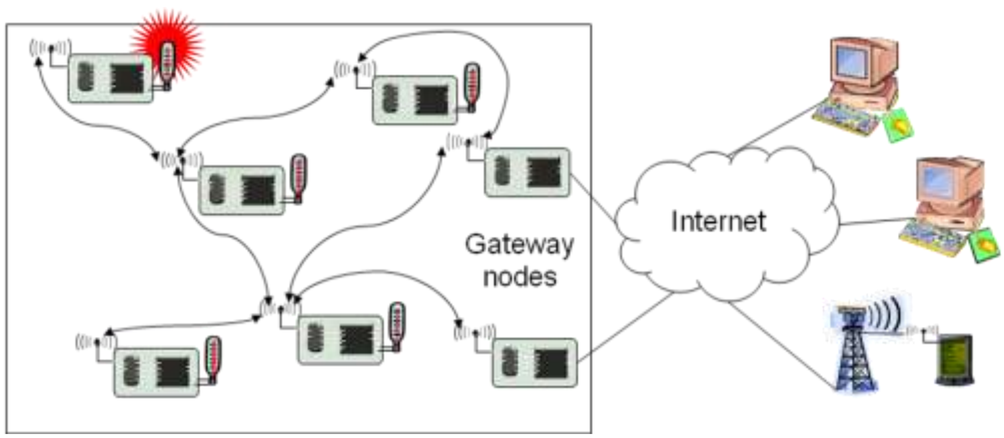

Figure2. Sensor Network Architecture

2. Catagories of Sensor Networks

A wireless sensor network receives challenges and constraints according to the environment in which it is deployed. Wireless sensor networks are deployed on land, air, underground, and underwater. There are usually five categories found in the wireless sensor networks:

1. Mobile Wireless sensor network
2. Multi-media Wireless sensor network
3. Areal Wireless sensor network
4. Underground Wireless sensor network
5. Underwater Wireless sensor network

2.1 Applications

WSN applications can be classified into two major categories:

a) Monitoring, and b) Tracking.

Monitoring applications include inside and outside environmental monitoring, public health and wellness monitoring, power monitoring, inventory status monitoring, factory and process automation, and seismic/non-seismic and structural monitoring.

Tracking applications include moving objects, humans, animals, and vehicles and other similar kind of applications.

The applications like sensing information in remote locations, military purpose in spy work, national security and so on are also the part of wireless sensor networks.

For example, the underwater acoustic sensor networks can enable a vide range of applications, like: Ocean Sampling Networks, Environmental Monitoring, Undersea Explorations, Disaster Prevention, Assisted Navigation, Distributed Tactical Surveillance, Mine Reconnaissance, etc.

1. Energy Scavenging

Energy source	Energy density
Batteries (zinc-air)	$1050 - 1560\,mWh/cm^3$
Batteries (rechargable lithium)	$300\,mWh/cm^3$ (at $3 - 4\,V$)
Energy source	**Power density**
Solar (outdoors)	$15\,mW/cm^2$ (direct sun)
	$0.15\,mW/cm^2$ (cloudy day)
Solar (indoors)	$0.006\,mW/cm^2$ (standard office desk)
	$0.57\,mW/cm^2$ ($< 60\,W$ desk lamp)
Vibrations	$0.01 - 0.1\,mW/cm^3$
Acoustic noise	$3 \cdot 10^{-6} mW/cm^2$ at $75\,Db$
	$9,6 \cdot 10^{-4} mW/cm^2$ at $100\,Db$
Passive human-powered systems	$1.8\,mW$ (shoe inserts)
Nuclear reaction	$80\,mW/cm^3$, $10^6\,mWh/cm^3$

Transmitter power/energy consumption of n bits is defined as follows:

- Amplifier power: $P_{amp} = \alpha_{amp} + \beta_{amp} P_{tx}$

  Where, P_{tx} = radiated power , and

  α_{amp}, β_{amp} are constants depending on model

  - Highest efficiency ($\eta = P_{tx} / P_{amp}$) at maximum output power

- Transmitter electronics needs power = P_{txElec}

- Time to transmit n bits: $n / (R \times R_{code})$

Where, R = nominal data rate, R_{code} = coding rate

- To leave sleep mode
  - Time T_{start}, average power P_{start}

$$E_{tx} = T_{start} P_{start} + n / (R \times R_{code}) (P_{txElec} + \alpha_{amp} + \beta_{amp} P_{tx})$$

The above shown description of limitations has motivated us for recent research in the energy efficient discovery for wireless sensor networks. Fading dip disturbs wireless communication and its promise to enable a wide varieties of application by providing a revolution in the areas of distribution, both remote and wireless sensing. Nodes in WSNs are generally heavily energized and also limited in computation and memory constrained. It creates a requirement for research and development into low computation resource aware algorithms for WSN. Targeting small, heavily resource constrained, embedded sensor nodes. One of the main important constraints on sensor nodes is the low power consumption requirement. Some protocols focus primarily on power conservation. They did not have inbuilt trade-off mechanisms that give the end user option of prolonging network lifetime without affecting the throughput or transmission delay. Deep performance even during the rare, unpredicted situation dips the transmitter and it needs to use an output power that is much larger than a non-fading channel. Therefore, to overcome these problems and to develop an effective, reliable and energy efficient wireless sensor networks, we get motivated to focus on these constraints.

2. Vehicular Sensor Networks

Vehicular Sensor Networks can be built on top of VANET by equipping vehicles with onboard sensing devices as shown in below figure3. VSN are emerging as a new network paradigm for effectively monitoring the physical world, especially in urban areas where a high population of vehicles, working as mobile sensors, is expected to be always exist. Vehicles are usually not affected by strict energy constraints and can be easily equipped with powerful processing units, wireless transmitters, and sensing devices even of some complexity, cost, and weight. We have observed that VSN represent a significantly novel and challenging deployment scenario, relevantly.

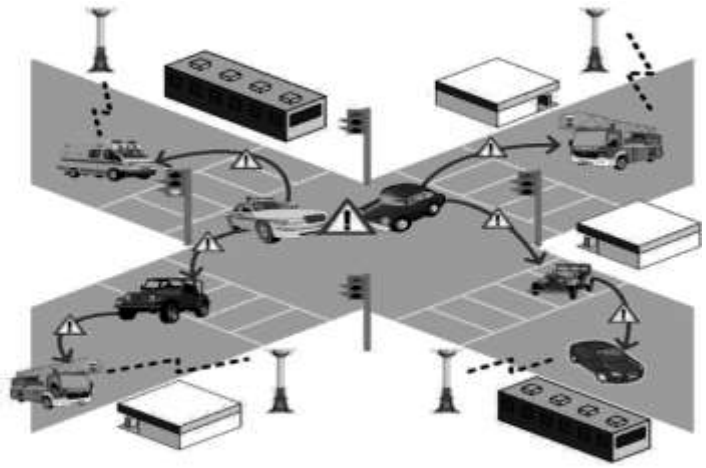

Figure 3. Vehicular Sensor

3. MobEyes for opportunistic dissemination in Vehicular Sensor Networks

REPLICA IN DMANET middleware component running on D's device sends the descriptions of D's resources to the REPLICA IN DMANET replica manager M, running in another node of the dense MANET . The replica manager is in charge of enforcing the needed replication degree and of maintaining information about other resources replicated in the dense region. For any shared resource, the corresponding SRT entry may have some target replication degree and poor consistent information.

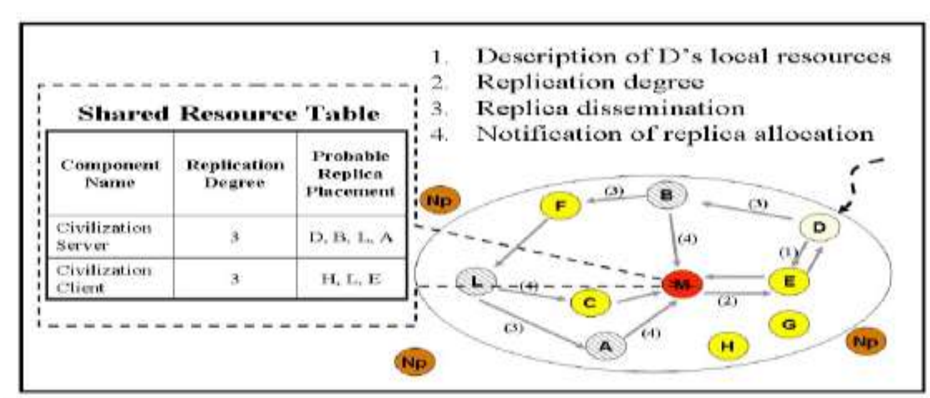

Figure 4. Replica in DMANET-based application under Civilization server

The methodology involved in these research may have three phases, like:

i) Deep investigation

ii) Analysis, Designing and Implementation

iii) Modeling and Simulations : Simulation is a process of mechanism of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the working of the system or evaluating various strategies for the operation of the system. Hence, mathematical modeling & simulation is the main part of the research in which application of different simulation techniques will be developed with the help of simulators like NS-2, OMNET, Tossim, WSNSim, Jsim, etc.

4. Future Scope

Finally, the development of new improved schemes of WSNs model and the efficiency of a network can be achieved by selecting the best suitable clustering algorithms based on the sensor network requirement after comparing the existing algorithms in WSNs.

Our futuristic scenarios bring out the two key requirements of sensor networks: i) support for very large numbers of unattended autonomous nodes, and ii) energy efficient adaptive to environment and task dynamics.

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