Studies on Dynamic Power Management and Routing Techniques in Wireless Sensor Network

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Abstract – Recent developments in Micro–Electro-Mechanical Systems technology lined up a way for low power wireless applications. Sensor networks are highly resource constrained network where networking of sensors enhances the collection of information where human interventions are difficult. The major research challenges in the fields of Wireless Sensor Networks (WSN) are to maintain the battery of sensor node thereby increasing the life time of the network. There are many schemes through which the battery life could be increased. One such technique is increasing the lifetime using routing. Hence the paper focuses a detailed survey study on various routing protocols of WSN.

Index Terms – WSN, Energy efficient, Routing Protocol, Power Management.

1. INTRODUCTION

Efficient monitoring system is essential for statistical analysis of any data. There are few regions such as mining, dense forest, volcano occurring places where survival of human is not possible for a continuous monitoring. Hence an unmanned continuous monitoring system becomes essential. The development of best monitoring system in such regions could be done using WSN. This network comprises of a node with sensors, memory, battery and computing unit. Hence it is a highly resource constrained network. The node consumes energy during sensing, computing, transmitting and receiving process. Out of all process transmission energy of the node is greater.

Once a node fails in the network, replacement of battery should be done. Frequent battery replacement cannot be done by humans. Hence implementation of energy efficient network becomes critical. Network can be made energy efficient by adopting many techniques and protocols. The low power design of the node at hardware level could be done and network can be made energy efficient. Design at hardware level makes the node to consume lesser power. The other way to increase the lifetime of the network is to design an energy efficient protocol at various layers of the network.

The best way to increase the lifetime is to manage with the power consumption. Various techniques involved in managing the power consumption are through topology control and routing. The topology of the network varies when any of the sensor node power drains and switched off. Even few nodes are switched off the routing protocol should be efficient enough to maintain the Quality of Service (QoS).

2. ARCHITECTURE OF WSN (WIRELESS SENSOR NETWORK)

Wireless sensor network is a network that comprises of large number of low power sensor nodes in it. It is commonly employed in the region where human intervention is not possible. The sensor nodes are multifunctional where multiple parameters could be measured with a single node. The network shall give information of single data and multiple data. This type of network differs from traditional wireless Ad-Hoc networks. Sensor node is tiny in size where installation of the nodes in remote area is feasible. Hence the other resources such as memory, bandwidth is lesser in nature. The node on the whole is operated with normal batteries. Hence it is also power constrained. Frequent changing or charging of batteries as in Ad-Hoc networks is not possible in this case.

Wireless Sensor network is architectural less networks, because if battery of any node drains making the node to switch off, then the node is not involved in communication. There are likely chances for the sensor nodes to die off in due course of time. The traditional wireless networks have seven layers of network where the layers vary in sensor networks. This network is best suitable for data gathering applications rather than distributed computing. Given in Figure 1 is the architecture of wireless sensor network and it comprises of the following units such as sensor unit, computing unit, memory unit and computing unit etc...

(A). Sensor Unit:

It consists of sensors either for information gathering. It is a device that tags physicals quantity and quantitative measurement. The invention of low power micro sensors finds its intense application in wireless sensor network. The sensors deployed in the network could be homogeneous or heterogeneous in nature i.e. either sensor for single variable of sensors for multi variable could be deployed in single node.

(B). Controller Unit:

The functionality of this unit is to process the collected information to either memory or transmission. The decision is taken by the controller unit. Memory stores the intermediate data before transmission. Usually separate memory spaces are maintained for program and data storage.

(C). Communication Unit:

The communication unit involves in communicating the collected sensory information to either the base station or router. It consists of a transceiver that receives and transmits information over a wireless channel.

(D). Power Supply Unit:

It is the unit where batteries are connected to the node. The entire node receives energy form this unit. Due to the advancement in renewable energy sources, nowadays to manage with the power consumption even solar powered nodes also come in to effect.

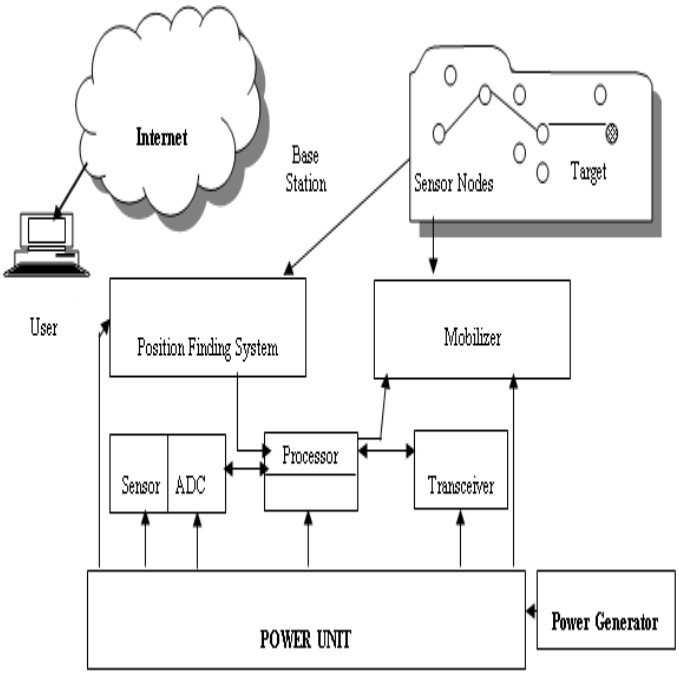

Figure 1 Architecture of Wireless Sensor Network

There are enormous research challenges in the field of wireless sensor network. The various metrics involved in working out are latency, quality of service, packet reception ratio and energy consumed by the node. All these metrics could be efficiently handled through congestion control techniques, routing protocols, power management schemes, topology management techniques etc... Hence this paper attempts to make a survey study on dynamic power management schemes and routing protocols.

3. DYNAMIC POWER MANAGEMENT SCHEMES

Design of energy efficient algorithms has made a predominant research in the field of wireless sensor networks. WSN is a resource constrained network. It does not maintain the conventional topological arrangement of traditional network. It is an infrastructure less network. The sensor node that consists of controller unit, sensing unit and communication unit all are together worked only with a normal two AA batteries. It is also established in the region where human intervention is highly risk. Hence frequent changing of battery is not possible which attempts to work in the area of power management. Dynamic power management is a way to reduce the consumption of power by trading off the performance of the network and work load. Based on the consumption of power it is possible to operate only a set of components during an instant of time and operating the remaining at various instants. The state transition of the components could be decided in these schemes. The lifetime of the wireless battery powered network could be enhanced by making the nodes to sleep periodically. The sleep state entails minimal power consumption by a wireless device but it also increases the average packet delay that the device encounters. The power management can also be established by varying the gating period of the system. Power management is a component that dissipates negligible power. This management has various techniques to implement. They are given in the Figure 2.

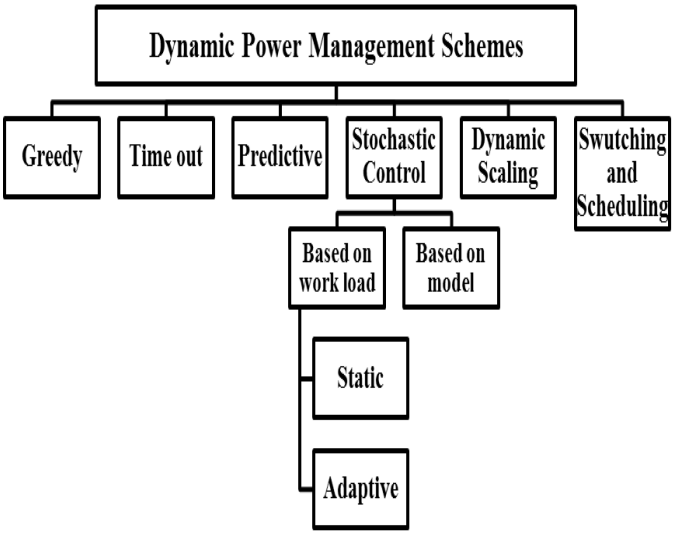

Figure 2. Various Schemes of Dynamic Power Management

Sinha A et.al (2001) [6] proposed OS directed power management technique. The basic idea of the protocol is to switch off the unnecessary nodes in the network and make only essential nodes to be active. It concentrates majorly on the sleep time of the node and sleep to wake up transition time. If the

transit time of the node is large then the power consumed by the node will also be higher during transit. Hence the author claims to reduce the latency during transition. Once transition is achieved a simple greedy algorithm performs in data transmission. It is argued that power-aware methodology uses an embedded micro operating system to reduce node energy consumption by exploiting both sleep state and active power management.

Passos RM (2005) [6] modelled a real time network that works best for fire detection. It is an application driven power management technique where the sensor node operation is modelled. Every subsystem of the node is analyzed and power management is implemented using hybrid automata frame work. The technique has been optimized. The author attempts to compare the power consumption with an ideal model and Naive approach. They also claim that their proposed technique outperforms better than any other technique.

Yoash Levron (2011) [7] also proposed a technique of dynamic power management schemes switching on and off the nodes in the network at regular interval. The interval of switching varies and the author concentrates on the sleep time of the nodes. As per the functioning of the subsystems the sleep time of the nodes are finalized. The node selection and the number of nodes attempted to force to sleep are not optimized. But still the protocol outperforms better than any other techniques. It is a sentry based power management.

Akansha Tomar et.al (2016) [8] made a survey on dynamic power management techniques in wireless sensor network. He proposed many algorithms where frequently self configuration of node is done. It is also claimed that dynamic power management could be done with either global or local strategy. Local strategy attempts to increase the lifetime of individual nodes where global attempts to increase the life of the network.

Maya M. Warrier et.al (2016) [9] proposed a technique of energy harvesting rather energy savings. The authors also claims that the recent work involves designing routing protocols that requires less energy during communication thereby extending the networks lifetime. For most of the applications, a replacement of energy is too expensive. An energy harvesting wireless sensor networks is proposed to make use of nodes that are able to harvest energy from environment.

Dargie W. (2015) [27] have studied dynamic power management (DPM) in wireless sensor networks. The subsystems such as memory, Processing unit, communication interfaces are monitored and made to sleep alternatively which enhances the battery of the node thereby increasing the lifetime of the network. Here two types of DPM techniques are proposed viz. Selective Switching and Dynamic power and frequency scaling. Both the methods have their relative merits and demerits.

4. ROUTING TECHNIQUES

The routing protocol has been designed and analyzed in many aspects such as cluster based routing, geographic information aware routing, energy aware routing, computational intelligence based routing etc... Among the classification few protocols are being discussed in this paper.

Karp B et.al (2000) [11] proposed a Greedy Perimeter Stateless Routing (GPSR) an algorithm based on the GPS position of router, source and destination. It makes greedy forwarding decisions when it is impossible and it uses routing around the perimeter of the region. Through this attempt the router forwards the packet to the node that is nearest to the sink and the memory size in the routing table is reduced. Besides GPSR, there are also protocols that take both the angle and distance into consideration.

Amit Sarkar et.al (2016) [10] tries to categorize the routing techniques of wireless sensor network. Initially the techniques are attempted to analyze in chronological way later they categorize and analyzed. They also proposed many techniques for energy efficient protocol.

Shu L et. Al (2008) [12] introduces a Two-Phase geographical Greedy Forwarding (TPGF) scheme builds multiple node-disjoint paths to increase the node utilization. It does not adopt face routing to bypass holes which makes it different from other algorithms. It uses greedy algorithm, where one node is assigned to only one path. It is fast and simple but it suffers from the inter-path interference.

Voigt T et.al (2005) [13] proposed an On-demand geographic routing scheme that routes data through two paths. The routing protocol consists of a fixed rectangular forbidden zone where the width of the zone has twice the transmission range and length lesser than the distance between source and destination. The nodes are assumed to be energy aware nodes.

Salim El Khediri et.al (2015) [14] introduces a cluster based routing called Fixed Computation Based clustering Approach (FCBA). The priority for cluster head nodes are given with highest energy and closer to the centre of density. Then the CHs are made to move and hand over the information to sink. The author claims that by comparing their contribution to the recent clustering algorithms, simulations results show that their scheme are effective in saving energy and power consumption.

Subramanian et al (2000) [25] propose a new algorithm with addressing schemes implemented to all nodes. All sensor nodes are identified with the help of the router that is connected with. The algorithm is implemented in four phases. They are discovery, organization, maintenance and self-organizing phase. In discovery phase neighbour nodes are identified by all sensor nodes. Clusters are formed and grouped in organization phase. Along with that routing table is created for all nodes in the cluster. Where updating of routing table is done in the next

phase and energy cost is estimated. Finally in the last phase if any path repairs occur nodes are again reorganized. The disadvantage is in the organization phase of algorithm, which is not on-demand, therefore introducing extra overhead. Another possible problem in case of hierarchy forming is when there are many cuts in the network. This will be expensive since network-cuts increase the probability of applying reorganization phase.

Sajid Hussain et.al [29] proposes hierarchical cluster-based routing (HCR) which is the extension of LEACH protocol. It is a self organized protocol. In this protocol every cluster is managed by a node that long last. The cluster head selection and management is optimized using genetic algorithm. It is best suitable for continuous monitoring applications.

Taruna S et.al (2013) [39] surveyed routing protocol. They claim that the routing could be either even driven or continuous communication. They attempt to claim even driven protocol aids to power management rather continuous. Analytical studies were made and concluded event driven consumes lesser energy than continuous.

Akan O.B. et.al (2005) [40] proposed a protocol Event-to-Sink Reliable Transport (ESRT) Protocol that makes the decision based on information collected from a number of source nodes where the event has occurred. Here sink only collects the information from all the event occurred sources. The protocol works well for reliable transport rather than energy efficiency. Since it has a central control method it is not energy efficient.

Radhika A Radhe (2014) [32] has proposed a fuzzy based clustering protocol which is involved in the selection of next hop in during communication. The basic variables considered in fuzzy computation are trust, length and energy consumed.

Asma Messaoudi et.al (2016) [33] implements an extension of LEACH protocol that makes use of fuzzy techniques in the selection of cluster heads. The CHs are selected based on the residual energy of the member node, cluster head and distance. To insure an optimal energy management, each cluster-head have to compare his residual energy with the Relative Energy Level before the initiation of a new round.

The relative energy level is estimated by the equation 1.3

$$E_{limit=} \frac{E_{node} - E_{min}}{E_{max} - E_{min}}$$

Balaji S et.al (2014) [34] presents fuzzy based particle swarm optimization routing technique to improve the network scalability. Cluster heads play an important role to reduce the energy consumption using particle swarm optimization algorithm, the cluster head sends its information along data packets to the heads with link. The author claims that three important factors such as distance, energy and density are improved through this algorithm.

Goel A et.al (2018) [18] considers the detection of target in the network. The uncertain information such as the signal decay is exponent of the wireless medium, the power attenuation constant and the distance between the target and the sensors. The protocol attempts to increase the robustness of the network.

Sukhchandan Randhawa (2014) [26] has analyzed the applications of WSN and few of the routing protocol. He also claims that the design of a WSN depends significantly on the application, and it must consider factors such as the environment, the application's design objectives, cost, hardware, and system constraints.

Jegan Govindasamy et.al (2017) [28] claims that though Zigbee protocol is the standard protocol for WSN, still zigbee based wireless sensor & ad-hoc networks routing protocol facing the severe security risks due to wormhole attacks in network layer. He works on the investigation of security issues in routing. The metrics used to analyze the performance of reactive routing protocol (AODV), proactive (OLSR) and hybrid routing protocol (ZRP) in WSNs are throughput, average end-to-end delay, Packet Reception Ratio (PRR) and total energy consumption of sensor network. The simulation is done by using qualnet simulator 5.0.

5. CONCLUSION

After a deep analysis of various methodologies of routing protocol and dynamic power management schemes the following inference is made and the same has been tabulated in table 1. Using dynamic power management schemes the nodes in the network are made to sleep alternatively. Depending upon the sleep time of the node in the network, few nodes are made active to communicate. Dynamic power management is achieved through proper hardware designs by many authors. The power management is also done by adjusting the transit time from sleep to active state which aids is lesser power consumption by individual nodes thereby enhancing the lifetime of the entire network.

ROUTING AND DPM SCHEMES	MAJOR FOCUS	METHODOLOGY ADOPTED
Cluster based routing	Selection of cluster head	Residual energy, Number of hops, distance
	Formation of cluster	Hierarchical cluster Cluster based on next hop information
Location based routing	Identification of location of nodes	Location of nodes are already aware Location awareness using GPS

Multipath routing	Selection of path	Based on residual energy of the path Handles link failure
Dynamic power management schemes	Only few nodes made active	Selection of active nodes

Table 1 Analysis of various protocols

Apart from dynamic power management through hardware schemes it is also achieved through routing protocol, topology control and congestion control that helps in power management without affecting the behaviour of the network. Framing of proper protocol in network layer i.e routing protocol will aid in power management. Plenty of research have already undergone in routing protocol. Many methodologies such as cluster based routing, data aggregation routing, data centric routing, flooding, singe path and multi path routing, computational intelligence based routing etc... Hence power management along with routing will aid the research to take to next step ahead in enhancing the lifetime of the network.

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