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To Study the Wireless Sensor Networks, Architecture and Design Issues Related To WSN

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Abstract:-

This research work is carried out to study wireless sensor networks (WSNs) are composed of many stumpy cost, little power devices with sensing, local processing and wireless communication capabilities. Minimizing energy dissipation and maximizing network lifetime are important issues in the design of routing protocols for sensor networks. The clustering algorithms are a kind of key technique used to reduce energy consumption, increase the scalability and lifetime of the network. Many routing protocols have been designed which have used the clustering mechanism to improve the energy efficiency and lifetime of the network. In the clustering protocols the cluster heads for every particular round are selected among the nodes that have the highest energy and they aggregate the data from their associated cluster members to transmit it to base station. Traditionally homogeneous networks are only used

where the nodes have limited resources and limited computation capabilities as all the nodes are equipped with the same amount of energy and as a result, they cannot take full advantage of the presence of node heterogeneity. Heterogeneous networks are especially useful in extending the lifetime of the network, providing more stability to the network and increasing the throughput of the network, as here total energy of the network is increased due to node heterogeneity. Our protocol comprises of four level heterogeneity as here four types of nodes i.e normal, intermediate, advanced and super-advanced nodes are used to boost the network energy.

Keywords: Wireless sensor network, LEACH, SEP, Energy-efficient, Network-lifetime.

I. Introduction

Wireless sensor networks consist of hundreds to thousands of low-power multi-functioning sensor nodes, operating in an unattended environment, with limited computational and sensing capabilities. Recent developments in low-power wireless integrated micro sensor technologies have made these sensor nodes available in large numbers, at a low cost, to be employed in a wide range of applications in military and national security, environmental monitoring, and many other fields. In contrast to traditional sensors, sensor networks offer a flexible proposition in terms of the ease of deployment and multiple functionalities [31]. Networking unattended sensor nodes may have profound effect on the efficiency of many military and civil applications such as target field imaging, intrusion detection, weather monitoring, security and tactical surveillance, distributed computing, detecting ambient conditions such as temperature, movement, sound, light, or the presence of certain objects, inventory control, and disaster management. Deployment of a sensor network in these applications can be in random fashion (e.g., dropped from an airplane) or can be planted manually (e.g., fire alarm sensors in a facility).

For example, in a disaster management application a large number of sensors can be dropped from a helicopter. Networking these sensors can assist rescue operations by locating survivors, identifying risky areas, and making the rescue team more aware of the overall situation in the disaster area. Basically, each sensor node comprises sensing, processing, transmission, mobilizer, position finding system, and power units (some of these components are optional like the mobilizer). Figure 1.1 below shows the schematic diagram of sensor node components

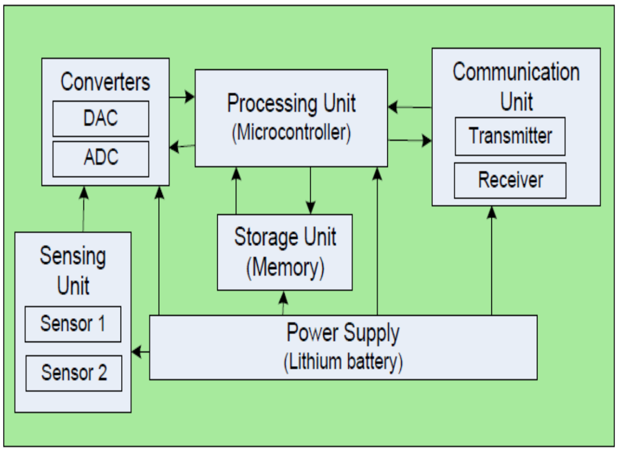

Fig 1.1- The Components of a sensor node.

The sensors in the sensing unit interact physically with the deployed environment. The sensed data is transferred to the ADC/DAC converters for analog to digital conversion. The communication and processing units are the two main parts where most of the energy consumption occurs. The life of sensor node depends on the battery life. The node dies immediately when its battery charge vanishes.

1I. Network Model and Architecture

The sensor nodes are usually scattered in a sensor field as shown in Fig 1.2 Each of these scattered sensor nodes has the capabilities to collect data and route data back to the sink and the end users [31]. Data are routed back to the end user by a multi-hop infrastructure less architecture through the sink as shown in Fig. 2. The sink may communicate with the task manager node via Internet or Satellite.

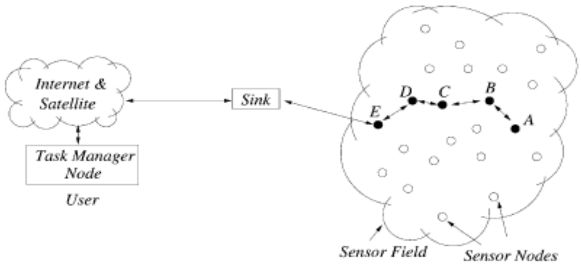

Fig 1.2-Wireless Sensor Network Architecture

This protocol stack combines power and routing awareness, integrates data with networking protocols, communicates power efficiently through the wireless medium, and promotes cooperative efforts of sensor nodes. The protocol stack consists of the application layer, transport layer, network layer, data link layer, physical layer, power management plane, mobility management plane, and task management plane.

III.Design Issues of Wireless Sensor Networks

Despite the innumerable applications of WSNs, these networks have several restrictions, e.g., limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes. One of the main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation by employing aggressive energy management techniques. The design of routing protocols in WSNs is influenced by many challenging factors . These factors must be overcome before efficient communication can be achieved in WSNs. In the following, we summarize some of the routing challenges and design issues that affect routing process in WSNs

3.1. Node deployment:- Node deployment in WSNs is application dependent and affects the performance of the routing protocol. The deployment can be either deterministic or randomized. In deterministic deployment, the sensors are manually placed and data is routed through predetermined paths. However, in random node deployment, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner. If the resultant distribution of nodes is not uniform, optimal clustering becomes necessary to allow connectivity and enable energy efficient network operation. Inter-sensor communication is normally within short transmission ranges due to energy and bandwidth limitations. Therefore, it is most likely that a route will consist of multiple wireless hops.

3.2. Data Reporting Model:- Data sensing and reporting in WSNs is dependent on the application and the time criticality of the data reporting. Data reporting can be categorized as either time-driven(continuous), event-driven, query-driven, and hybrid. The time-driven delivery model is suitable for applications that require periodic data monitoring.

3.3. Fault Tolerance:- Some sensor nodes may fail or be blocked due to lack of power, physical damage, or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network.

3.4. Scalability:- The number of sensor nodes deployed in the sensing area may be in the order of hundreds or thousands, or more. Any routing scheme must be able to work with this huge number of sensor nodes. In addition, sensor network routing protocols should be scalable enough to respond to events in the environment. Until an event occurs, most of the sensors can remain in the sleep state, with data from the few remaining sensors providing a coarse quality.

3.5. Connectivity:- High node density in sensor networks precludes them from being completely isolated from each other. Therefore, sensor nodes are expected to be highly connected. This, however, may not prevent the network topology from being variable and the network size from being shrinking due to sensor node failures. In addition, connectivity depends on the, possibly random, distribution of nodes.

3.6. Coverage:- In WSNs, each sensor node obtains a certain view of the environment. A given sensor's view of the environment is limited both in range and in accuracy; it can only cover a limited physical area of the environment.

3.7. Data Aggregation:- Since sensor nodes may generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmissions is reduced. Data aggregation is the combination of data from different sources according to a certain aggregation function, e.g., duplicate suppression, minima, maxima and average. This technique has been used to achieve energy efficiency and data transfer optimization in a number of routing protocols. Signal processing methods can also be used for data aggregation. In this case, it is referred to as data fusion where a node is capable of producing a more accurate output signal by using some techniques such as beam-forming to combine the incoming signals and reducing the noise in these signals.

3.8. Quality of Service:- In some applications, data should be delivered within a certain period of time from the moment it is sensed, otherwise the data will be useless. Therefore bounded latency for data delivery is another condition for time-constrained applications.

3.9. Transmission Media:- In a multi-hop sensor network, communicating nodes are linked by a wireless medium. The traditional problems associated with a wireless channel (e.g., fading, high error rate) may also affect the operation of the sensor network. In general, the required bandwidth of sensor data will be low, on the order of 1-100 kb/s.

3.10. Energy consumption without losing accuracy:- Sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy-conserving forms of communication and computation are essential. Sensor node lifetime shows a strong dependence on the battery lifetime . In a multihop WSN, each node plays a dual role as data sender and data router. The malfunctioning of some sensor nodes due to power failure can cause significant topological changes and might require rerouting of packets and reorganization of the network.

3.11. Network Dynamics:- Most of the network architectures assume that sensor nodes are stationary. However, mobility of both BS's or sensor nodes is sometimes necessary in many applications. Routing messages from or to moving nodes is more challenging since route stability becomes an important issue, in addition to energy, bandwidth etc. Moreover, the sensed phenomenon can be either dynamic or static depending on the application, e.g., it is dynamic in a target detection/tracking application, while it is static in forest monitoring for early fire prevention.

IV Comparison of WSNS with MANETS and WMNS

The Wireless Ad-hoc Network (WANET) is a temporary wireless network between different nodes to satisfy the urgent needs of communication. The three classes of WANETs are Mobile Ad-hoc Networks (MANETs), Wireless Mesh Networks (WMNs), and Wireless Sensor Networks (WSNs). A large number of protocols are available for WANETs. The unique requirements of WSNs are the major problem of using the existing WANET protocols for WSN. WSNs differ from other WANETs in seven main areas [7][32].

4.1, TDMA (Time Division Multiple Access):- The best choice for an energy efficient MAC protocol in WSNs is TDMA. TDMA protocols create a time schedule for transmitting and receiving data for each node in the network. Based on the schedule nodes are just active during the assigned time slots and shut down their radio interfaces other times. Shutting down the radio interface during inactive period leads to energy saving.

4.2. S-MAC (Sensor MAC):- S-MAC protocol designed merely for wireless sensor networks. In this protocol time is divided into long frames and each frame has an active part and sleeping part. Nodes turn off their radio during sleeping time to preserve energy and communicate with their neighbours during the active part. In fact during the active part all the messages that have been queued during sleeping part would be sent. However, if message generating event occurs during the sleeping part the latency increases because in that case the message should be queued until the start of the active part.

4.3. Routing Protocols in Wireless Sensor Networks:-
The WSN routing protocols can be classified in three ways: by its protocol operations, by network structure, and by packet destinations. The details of this classification are given below:-

4.4. Protocol operation based classification:- In this classification, different routing functionalities of the routing protocols are considered. The protocol operation based routing protocols are divided into different types as given below:-

a) **Multipath-Based Routing:** The routing protocols in this category use the multiple paths between a source and destination for data transmission to enhance the network performance. The directed diffusion protocol is an example of multipath-based routing.

b) **Query-Based Routing:** These protocols depend upon the queries from a destination. The source node sends its sensed data in response to a query generated by the destination node. A natural language or high level query language is used to generate these queries. An example of these protocols is the rumour routing protocol. The directed diffusion protocol is also counted in query-based routing protocols.

c) **Negotiation-Based Routing Protocols:** In these protocols, a high level of descriptors is used for the negotiation between the nodes to prevent redundant data and reduce duplicate information.

V. Applications of Wireless Sensor Networks:-

Sensor networks may consist of many different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic and radar, which are able to monitor a wide variety of ambient conditions that include temperature, humidity, vehicular movement, lightning condition, pressure, soil makeup, noise levels, the presence or absence of certain kinds of objects, mechanical stress levels on attached objects.We categorize the applications into military, environment, health, and other commercial areas. It is possible to expand this classification with more categories such as space exploration, chemical processing and disaster relief.

5.1. Military applications:- Wireless sensor networks can be an integral part of military command, control, communications, computing, intelligence, surveillance, reconnaissance and targeting (C4ISRT) systems. Some of the military applications of sensor networks are monitoring friendly forces, equipment and ammunition; battlefield surveillance; reconnaissance of opposing forces and terrain; targeting; battle damage assessment; and nuclear, biological and chemical (NBC) attack detection and reconnaissance.

5.2.Environmental applications:- Some environmental applications of sensor networks include tracking the movements of birds, small animals, and insects; monitoring environmental conditions that affect crops and livestock; irrigation; macro instruments for large-scale Earth monitoring and planetary exploration; chemical/biological detection; precision agriculture; biological, Earth, and environmental monitoring in marine, soil, and atmospheric contexts; forest fire detection; meteorological or geophysical research; flood detection; bio-complexity mapping of the environment; and pollution study.

5.3. Health applications:- Some of the health applications for sensor networks are providing interfaces for the disabled; integrated patient monitoring; diagnostics; drug administration in hospitals; monitoring the movements and internal processes of insects or other small animals; telemonitoring of human physiological data; and tracking and monitoring doctors and patients inside a hospital.

5.4. Other commercial applications:- Some of the commercial applications are monitoring material fatigue; building virtual keyboards; managing inventory; monitoring product quality; constructing smart office spaces; environmental control in office buildings; robot control and guidance in automatic manufacturing environments; interactive toys; interactive museums; factory process control and automation; monitoring disaster area; smart structures with sensor nodes embedded inside; machine diagnosis; transportation; factory instrumentation; local control of actuators; detecting and monitoring car thefts; vehicle tracking and detection.

VI Problem Definition:-

The use of WSNs in different applications is increasing with the rapid advancements in technology. Energy limitation is the major issue that needs to be considered. Most often, a battery is the only source of energy and the wireless sensor node consumes power during iterations. The node will immediately die when its battery runs out. The sensor node changes its states to resolve the energy problem. Typically, the three states of a sensor node are used: active state, idle state, and sleeping state. In the active state, the node transmits and receives data packets. To stop transmissions in the idle mode is the basic reason for saving the battery power [17]. In the sleep mode, the node turns off its radio part completely to save the node energy. Energy consumption in sleep mode is less than in the idle and active state.

The whole physical area of WSN is divided into sectors and clusters to diminish the effect of overhearing. The node transmission range can be adjusted by considering the size of the cluster. A sensor node needs to capture the channel for data transmission. The node may start overhearing the carrier during the process of channel acquiring. This overhearing causes the unwanted waste of energy. To elude overhearing a technique called Time Division Multiple Access (TDMA) is used. In TDMA a specific time slot is assigned to each sensor node in WSN. This information is passed to all nodes in the network. A node only transmits the data on its turn; meanwhile all the other nodes do not try to capture the channel. This process helps to save energy consumption by avoiding overhearing. The network and Media Access Control (MAC) layers in a sensor node play an important role during the data transmission between transmitter and receiver. Network layer finds the best route and MAC layer is used for carrier sensing and data forwarding. A significant amount of energy can be saved by using the proper Network and MAC layer protocols [16].

In this research work clustered heterogeneous protocols for wireless sensor networks are studied and a energy efficient protocol is proposed for maximizing the energy efficiency of WSN. In the proposed protocol a heterogeneous wireless sensor network is developed and also some additional energy powered sensor nodes are incorporated which will provide more stability to the network, apart from that here the mobile sensor nodes [40] are also used which will be used when the nodes in the proposed protocol start dying and then the mobile nodes will replace them by taking their positions and start the sensing process.

VII Simulation Results

The simulations have been conducted by using the MATLAB simulation environment to compare the performance of our proposed protocol with the

Stable Election Protocol (SEP). The results show that the proposed protocol extends the network lifetime.

1 Simulation with 8 mobile nodes and heterogeneity values as q=0.05,y=6 ,m=0.1,a=0.3,x=0.2,b=1.5:-

Here the network is randomly deployed and mobile nodes are deployed at predetermined locations that will provide better coverage for deployment area. Now when the nodes in the proposed protocol start dying then the mobile nodes will take their positions and in our simulation experiment the dead nodes along with the mobile nodes.

Mobile node activated	Node dead	Node dead at round	Node replaced at round
95	31	1285	1285
96	19	1287	1290
99	55	1287	1289
100	42	1299	1302
98	32	1328	1332
97	45	1338	1342
94	24	1339	1344
93	81	1348	1353

Fig 7.1 Replacement of dead nodes with mobile nodes

The simulation results showing the number of dead and alive nodes are shown in the fig shows where the existing and proposed protocols are compared in respect of their network lifetime. As shown in the results the proposed protocol performs better than the existing protocol as the lifetime of proposed protocol is greater than existing one.

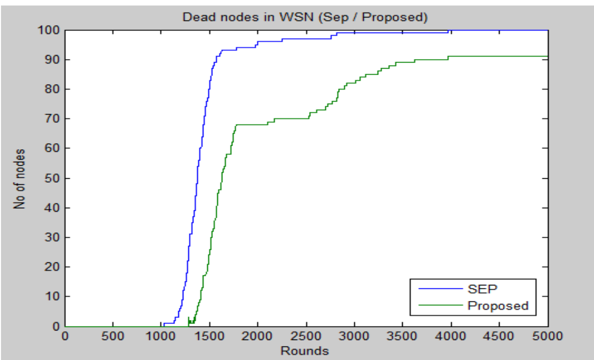

Fig-7.2 Comparison of dead nodes among existing and proposed protocols

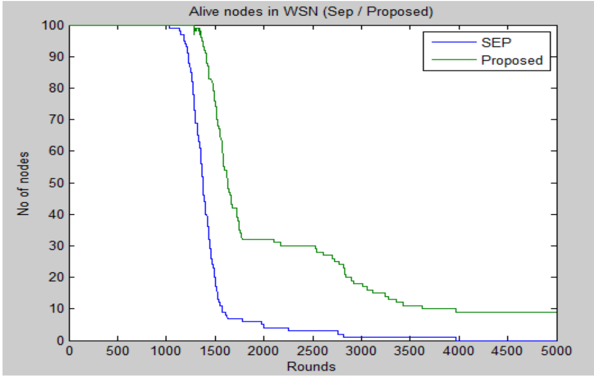

Fig-7.3 Comparison of alive nodes between existing and proposed protocols

Here as shown in the simulation results the nodes in the existing protocol are dead after 3900 rounds but as in the proposed protocol 91 nodes are still alive after 5000 rounds, thus network lifetime is far greater in proposed protocol. Now through excel chart the comparison is done between protocols at different number of rounds and number of dead nodes are shown at each particular round as shown below:-

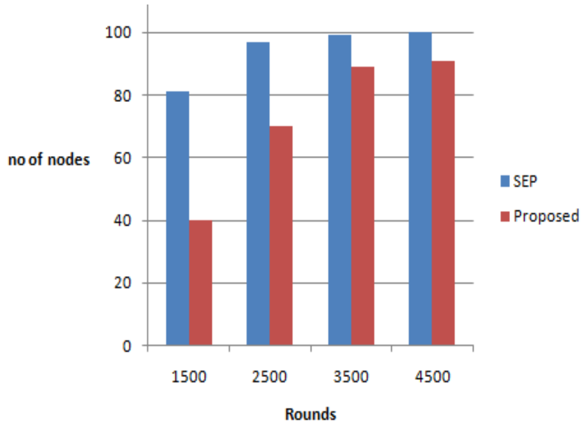

Fig-7.4 Comparison of dead nodes between protocols at different rounds

VIII Conclusions

The research work is carried out to study and analysis architectures for wireless micro sensor networks, it is important to consider the function of the application, the need for ease of deployment, and the severe energy constraints of the nodes. These features led us to design LEACH, a protocol architecture where computation is performed locally to reduce the amount of transmitted data, network configuration and operation is done using local control, and media access control (MAC) and routing protocols enable low-energy networking.

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