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A Novel Protocol for Better Energy-Efficiency, Latency and Fault Tolerance in Wireless Sensor Network

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Abstract— Wireless sensor networks with thousands of small sensor nodes are becoming very popular due to their large use in many of applications such as monitoring and collecting data from undisturbed dangerous environments, emergency rescue operations, military surveillance etc. But the nodes in a sensor network are severely affected by energy. Reducing the energy consumption of the nodes to increase the network lifetime is considered as a most important challenge while designing a new routing protocol. In this paper we propose a new power-aware, hierarchical protocol that utilizes the regular assignments of the cluster head role to different nodes based on the highest remaining battery capacity for confirming the equal dissipation of power by all the nodes. Transmission from a single cluster head to the base station in each round and the distribution of the data collection workload among all the nodes, save the cluster heads from early damage. The use of data separation also reduces the amount of information to be transmitted to the base station. NEW Protocol offers the advantage of small transmit distances for most of the nodes and thus helps them to be operational for a longer period of time by conserving their limited energy. Use of a fresh set of parameter values in each round provides the users the ease to change these values in a way to handle the power consumption. Our New Protocol is highly suitable for time critical applications. From the performance evaluation we observe that New Protocol outperforms other protocols in terms of energy saving, life of the network, latency and fault tolerance.

***Index Terms*—Wireless Sensor Network, Energy, Life of the network, Latency, Fault Tolerance**

INTRODUCTION

The latest technical development in MEMS i.e., micro electrical mechanical systems have made the production and use of t iny, low energy and medium cost micro-sensors both technically and economically beneficial. A Wireless Sensor Network (WSN) consists of many low-power multi-functioning sensor nodes, operating in an undisturbed environment, having ability of sensing, calculations and communications. The basic parts of a node are the sensor unit, ADC i.e., Analog to Digital Converter , CPU (Central Processing Unit), a communication unit and an energy source, usually a battery. The sensor unit is used for collecting the required data from the area of interest. ADC converts the data collected by the sensor from analog to digital form and CPU processes data according to requirement. The last unit i.e. communication unit transfers data to another node. Generally, a sensor node is MEMS i.e., micro-electro-mechanical system and it can sense the environment regularly, combine data if necessary and transfer data to some other node. Wireless Sensor Networks are used for checking and storing information from an untouched environment and for informing events to the user. They

regularly check physical or environmental conditions like temperature, humidity, pressure, sound, vibration etc. Since a sensor node is restricted in terms of sensing and calculations capacities, communication performance and power - a large number of sensor nodes can be spread over an area of interest for storing information.

The reduction in size and cost of the sensor nodes has made it possible to have a network of large number of sensor nodes. Thus it has increased the performance and accuracy of data as well as the area of coverage. Due to the low-cost placement, the nodes are generally placed with more degree of attachment. After the initial working, sensor nodes are responsible for self-organizing an appropriate network infrastructure, through wireless communication between sensor nodes (as shown below in Figure 1.1). The onboard sensors then start storing data about the environment, using different working modes either continuous or event driven. After storing data, they process it and then send to base station. Base station behaves like an interaction between users and network. Users can get information of their interest from WSNs queries and collecting results at base station. End users collect information from WSNs by connecting it to internet or satellite via base station (as shown below in Figure 1.1

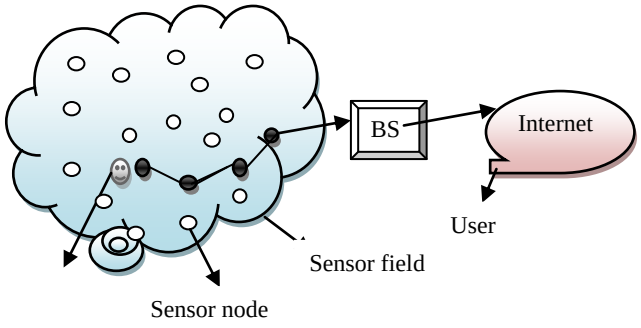

Figure1.1 Architecture of the Wireless Sensor network

For better understanding of sensor network it is essential to know about all the components of sensor node. Common sensor node architecture is as shown below in Figure 1.2. The architecture of a wireless sensor node consists of four subsystems a computing subsystem consists of a microprocessor, ALU and memory, a communication subsystem consists of a small range radio for wireless communication, sensing subsystem which links the node to the physical world and consists of many sensors and actuators, and a power supply subsystem, which contains the battery and the DC-DC converter, and gives power supply to the rest of the node. Each subsystem plays a very important role in the sensor node.

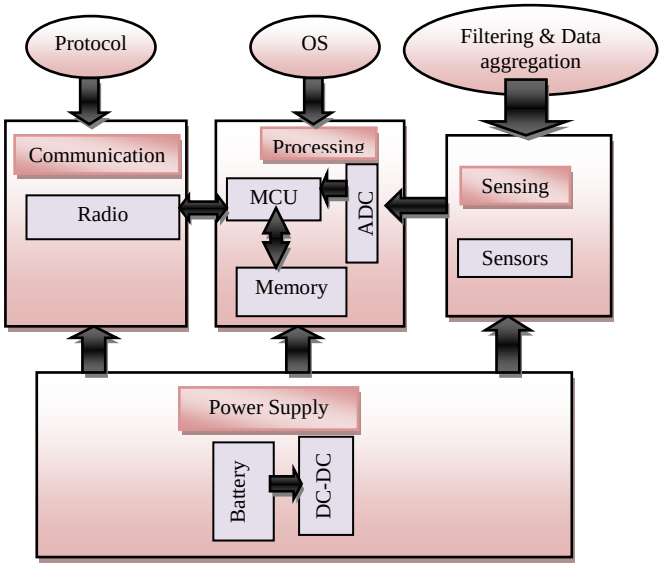

Figure 1.2 Sensor node architectures

The sensor network protocol stack is much like the traditional protocol stack, having layers: Physical, Data Link, Network, Transport, and Application as shown in given Figure 1.3.

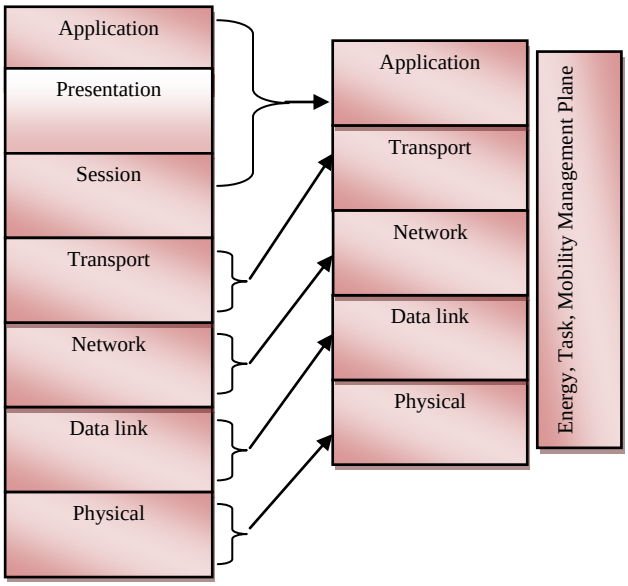

Figure 1.3 Protocol stack for Wireless Sensor Networks

REVIEW

There are many routing techniques for sending the data between the sensor nodes and the base stations. The most important problem related to the sensor nodes is their limited energy resources. Different routing protocols have been proposed for the wireless sensor networks like LEACH, TEEN, APTEEN, PEGASIS, and CCPAR. Low Energy Adaptive Clustering Hierarchy ("LEACH") is a TDMA-based protocol. LEACH is a hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station. It is less Energy Efficient and maximum nodes used to die. TEEN (Threshold sensitive Energy Efficient Sensor Network Protocol) is used for reactive protocol also. All the nodes take turns becoming the cluster head for a time interval *T*, called the cluster period in this protocol. This protocol is more energy efficient than LEACH. It senses data periodically at regular interval. It cannot send the critical data at an instant. APTEEN (Adaptive Periodic Threshold-Sensitive Energy Efficient Protocol) consists of a hard threshold (Ht) and a soft threshold (St).Ht is a particular value of an attribute beyond which a node can be triggered to transmit data. St is a small change in the value of an attribute which can trigger a node to transmit data again. If nodes near base station die the complete network would come to a halt. The main idea in PEGASIS i.e., Power Efficient Gathering In Sensor Information System is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the BS. Whenever a node dies it is bypassed thus increasing the complete network life. The chain may be long enough and in that case excessive delay would occur for critical data to be transmitted. In CCPAR i.e. Clustered Chain Based Power Aware Routing the cluster node selection is done by the base station. Thus base station gives the turn to nodes with more energy and thus increases life of complete network system. In this protocol the whole network is divided into several clusters and a cluster head is selected for each cluster. Within each cluster a chain of sensor nodes is formed. This result in small transmits distances and reduced power consumption. The chain is connected to the cluster head in each cluster. Each cluster head is also connected in a chain of cluster heads. Thus every cluster head needs to transmit data only to the next cluster head in the chain instead of transmitting to the far away base station.

RESEARCH

We have formulated a new network protocol for better energy-efficiency, latency and fault tolerance in wireless sensor networks which is far more superior to the existing protocols like LEACH, TEEN, APTEEN, PEGASIS and CCPAR. In our protocol we have added the advantages of all the existing protocol like our Protocol is a hierarchical protocol .All the nodes take turns becoming the cluster head. Whenever a node dies it is bypassed. Also consists of a hard threshold and soft threshold for critical situation. The cluster node selection is done by base station. We have compared the performance of the protocols on the basis of three parameters – Fault Tolerance v/s Number of Rounds, Energy Efficient v/s Time and Packet Interval Arrival Period v/s Latency. The first parameter gives an idea of the overall life of the network, the second parameter tells about the average energy dissipation per node over time as it performs various activities such as transmitting, receiving, sensing the environment, data selection etc and the third parameter tells about the speed of processing of network. From below Figure 1.4, Figure 1.5, Figure 1.6 we see that our New Protocol outperforms other protocols in terms of longevity of the network , energy saving and speed of processing.

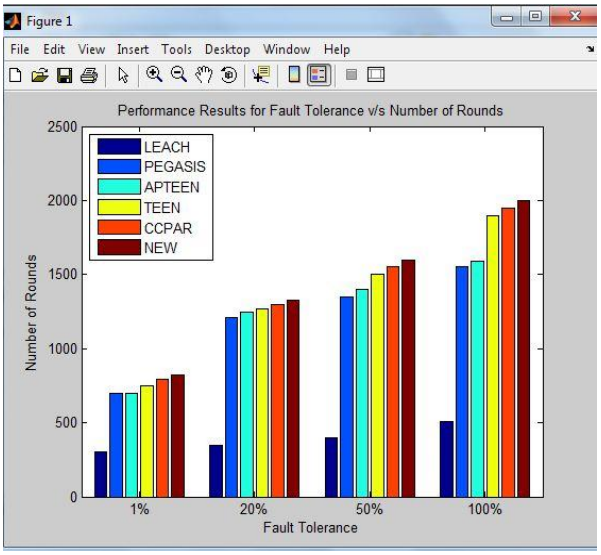

Fig: 1.4 Fault Tolerance v/s Number of Rounds

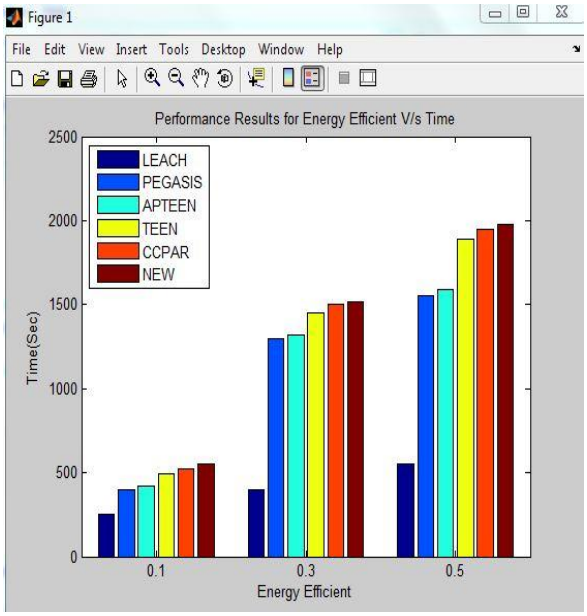

Fig: 1.5 Energy Efficient v/s Time

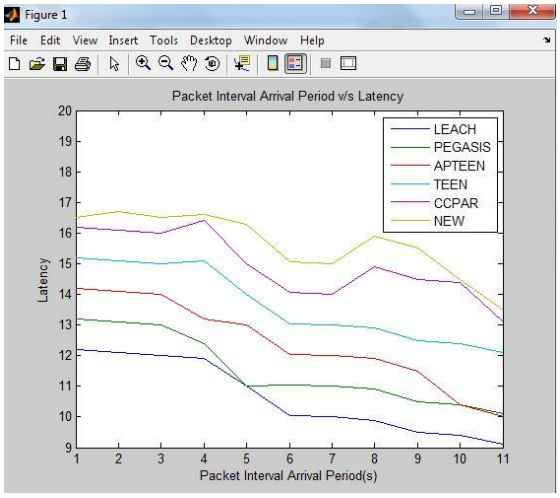

Fig: 1.6 Packet Interval Arrival Period v/s Latency

The reduced power consumption of our New Protocol is mainly due to the small transmit distances of most of the nodes as they need to transmit only to their closest neighbors instead of transmitting directly to the far away base station or cluster head, which was the case with LEACH, TEEN ,APTEEN, PEGASIS and CCPAR . This helps the nodes in saving their energy which ultimately enhances the system lifetime. Our New Protocol also relieves the sensor nodes from the workload related to cluster head selection as it is now the responsibility of the base station. The significant decrease in the number of data packets to be received by the cluster head and the even distribution of the data collection workload among all the sensor nodes in the cluster, help the cluster head in conserving its power and thereby increasing its lifetime. Instead of a single node acting as the cluster head for the entire duration and thus ending up its energy source quickly, in our new protocol the role of cluster head is assigned periodically to the different nodes based on the highest left energy contained by a node. This ensures the even distribution of power by all the nodes and therefore, increases their lifetime. In addition to that, the regular assignment of the cluster head role also saves the nodes closest to the cluster head from dying out early due to the heavy burden of data collection and data transmission, as all the nodes now share this responsibility periodically. Our scheme also offers superior performance than LEACH, TEEN, APTEEN, PEGASIS and CCPAR. This further helps the nodes in retaining their power for a longer time which finally increases the complete network life time. From Figure we also note that the power consumption increases with time.

CONCLUSION

In this paper first we have discussed some of the existing routing protocols for the wireless sensor networks and then proposed "A novel protocol for better energy-efficiency, latency and fault tolerance in wireless sensor networks". which is a hierarchical clustered based scheme that provides greater reduction in power consumption and therefore, increased lifespan of the entire network. The basic idea of our scheme is that the nodes within a cluster are connected closely and each node receives from and transmits to the closest neighbors in the chain. The data thus move from node to node, get collected and ultimately reach the cluster head. A separate connection is also made which connects the cluster heads. Each cluster head thus transmits the data only to its next neighbor in this way and in each round, instead of every cluster head transmitting to the base station only a single cluster head is selected on the basis of the highest remaining energy to send the data to the base station. Our New protocol outperforms other protocols by providing advantages over them in several steps. The use of multi-tier architecture enables this scheme to cover a wider network area thus making it suitable for sensor networks installed over larger area. The assignment of the cluster head selection function

solely on the base station coupled with the small transmit distances for most of the nodes, help the local sensors in saving their limited energy resources. Thus, together with the even distribution of the data collection workload between all the local sensor nodes and the significant reduction in the number of data packets to be received by the cluster heads, protect the cluster heads from quickly vanishing. In addition to that, the periodic assignment of the cluster head role to different nodes based on the highest remaining energy also confirms the even reduction of power by all the nodes. This effectively increases the life of the network. Our New Protocol offers superior performance over LEACH, TEEN, APTEEN, PEGASIS and CCPAR by constructing several links in different clusters and thus solving the problem of excessive delay in transmission experienced by the distant nodes. This protocol is also well suited for time critical applications. By allowing the users to set a new set of values for the parameters in each round, Our New Protocol provides the users the flexibility to change these values in a way to control the power consumption. Based on the simulation results it is evident that Our New Protocol outperforms other protocols by providing greater energy saving, increased system lifetime and increased network speed, which makes it more suitable for wireless sensor networks.

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