A Survey On Sleep Schedule In Wireless Sensor Networks

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***Abstract* – Energy efficiency is a major consideration in Wireless Sensor Networks, while designing the sensor nodes. The lifetime of sensor nodes are expected to be of long period without recharging their batteries. MAC protocols are designed for wireless sensor networks in order to extend the network lifetime. Sleep scheduling techniques are employed in wireless sensor networks, which may cause communication delay in large scale WSNs. In this paper, we present the comparison of different approaches in MAC protocols in terms of energy consumption and broadcasting delay in WSNs.**

***Key Terms* – Wireless Sensor Network, Energy consumption, Medium Access Control.**

I. INTRODUCTION

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure etc. and to cooperatively pass their data through the network to a main location. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. When a critical event occurs in monitoring area and it is detected by a sensor node, an alarm needs to be broadcast to the other nodes as soon as possible. Wireless sensors, and the arrangement of these small, electronic devices into radio networks, have introduced the capability of remotely monitoring a physical environment for a wide variety of parameters. Wireless Sensor Networks have a number of unique characteristics such as small-scale sensor nodes, dynamic network topology, limited power supply, harsh environmental conditions, node failures, mobility of nodes, energy harvesting, mobility of detected events, large scale deployments, and unattended operation etc.

In sleep scheduling method, sender nodes should wait until receiver nodes are active and ready to receive the message. Sleep scheduling should increase the network life time. But sometimes it may increase broadcasting delay. Whenever the network scale increases, the broadcasting delays also increase. So, delay efficient sleep scheduling methods needs to be designed to provide low broadcasting delay from any node in the WSN. Most of sleep scheduling methods focuses to minimize the energy consumption. To minimize the broadcasting delay in WSN, the time wasted for waiting during the broadcasting needs to be minimized. So there is a need for balance both energy consumption and broadcasting delay in wireless sensor network. The destination node wakes up immediately when the source nodes obtain the broadcasting packets. Fig.1 shows the basic diagram of wireless sensor networks.

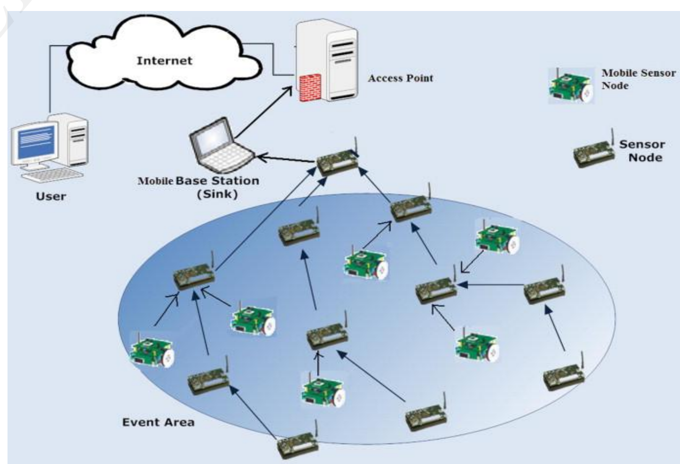

Fig.1.Wireless Sensor Network

II. REASON FOR ENERGY WASTAGE

Energy is a very scarce resource for sensor systems and has to be managed wisely in order to extend the life of the sensor nodes for the duration of a particular mission [1].

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Maximizing the lifetime of sensor is one of the most challenging and complex problem.

Two types of energy consumption in a sensor node could be due to either "useful" or "wasteful" sources. Due to transmitting or receiving data, useful energy consumption can occur. Wasteful energy consumption can be due to one or more of the following facts. We identified the following major sources of energy wastage. The first one is collision. When a receiver node receives more than one packet at the same time, these packets are called "collided packets" even when they coincide partially. When a transmitted packet is corrupted it has to be discarded, and the follow on re-transmission increase energy consumption. So latency will increase. Although some packets could be recovered by a capture effect, a number of requirements have to be achieved for its success. The second is overhearing, meaning that a node picks up packets that are intended for send to other nodes. The third source is control packet overhead. Sending and receiving control packets consumes energy too, and less useful data packets can be transmitted. So minimal number of control packets should be used to make a data transmission. The last major source of inefficiency is idle listening, i.e., listening to receive possible traffic that is not sent. If nothing is sensed, nodes are in idle mode for most of the time. This is especially true in many sensor network applications. The last reason for energy waste is over- emitting. This is caused by the message transmission when the destination node is not ready. The most effective energy-conserving operation is putting the radio transceiver in the sleep mode whenever communication is not required. Duty cycling is one of the energy saving mechanism in wireless sensor networks. Duty cycle is the fraction of time nodes which are active during their lifetime.

III. MAC LAYER PROTOCOLS

This section, describes a number of MAC protocols defined for sensor networks [2]. This also presented the essential behavior of these protocols, the advantages and disadvantages.

A.SENSOR-MAC

Sensor MAC (S-MAC) [3] is a contention based protocol specifically designed for wireless sensor networks. S-MAC adopts an effective mechanism to solve the energy wasting problems, that is periodical listening and sleeping to avoid idle listening & to reduce the energy wastage. The basic principle of S-MAC is Carrier Sense Multiple Access with Collision Avoidance. There are two states in a time frame: active state and sleep state. In active state, the node senses the network, if found idle, the node performs listening and communicate with other nodes. When sleep state comes, the nodes try to sleep by turning off their radios. This significantly reduces the time spent on idle listening. In this protocol the nodes use the following commands like, RTS (Ready to send), CTS (Clear to send) and Data Acknowledgement (ACK) to communicate [4]. When a node finds a RTS or CTS packet destined for some other node, it goes to sleep mode. This is a periodic process. At the end of sleep mode the node wakes-up and look for some event, if not found it again go to sleep mode. Each node follows a periodic sleep and active schedule as shown in fig 2.

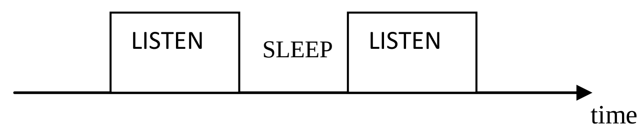

Fig.2. Periodic listen and Sleep

Advantages

In the case of S-MAC protocol, reduces the energy consumption by introducing periodic listen and sleep. To avoid the collision a synchronization mechanism is used.

Disadvantages

In S-MAC protocol there is a fixed duty cycle for active and sleep states. It is not optimal because, if a message rate is less then energy is still wasted in idle listening. Sleep and listen periods of sensors are predefined and constant which decreases the efficiency of the algorithm under variable traffic load. Long listening interval is expensive

B.TIMEOUT-MAC

TMAC [5] is an extension of S-MAC protocol. It is more energy efficient than S-MAC because in T-MAC protocol which adaptively adjusts the sleep and wake periods. It is based on estimated traffic flow to increase the power savings and reduce delay. TMAC also reduces the inactive time of the sensors compared to S-MAC. To reduce the idle listening all the messages are transmitted in variable length. The gap between this duration is called sleep time. In TMAC, all the nodes periodically wake up and communicate with the neighbors. Nodes communicate for a long period at the time of high loads. It uses RTS, CTS and ACK scheme. So it avoids collision and reliable transmission. TMAC gives better results under variable load.

Advantages

To reduce the idle listening time, solution with S-MAC is not optimal. Because S-MAC has two important parameters: the total frame time, which is limited by latency requirements and buffer space, and the active time. The active time depends mainly on the message rate: it can be so small that nodes are able to transfer all their messages within the active time. S-MAC wastes much energy at times when no events happen. By adaptively changing the duty cycle of time frame, T -MAC can decrease the used energy.

Disadvantages

Disadvantage is the early sleeping problem. If a node goes to sleep when a neighbor still has messages for it, then early sleeping problem will occur. In the nodes-to-sink communication pattern, the early sleeping problem reduced the total possible throughput of T-MAC to less than half of the maximum throughput of traditional protocols or S-MAC.

C.TRAFFIC-ADAPTIVE MEDIUM ACCESS PROTOCOL

The traffic-adaptive medium access protocol (TRAMA) [6] is introduced for energy-efficient collision-free channel access in wireless sensor networks.Transmission scheduling are based on two-hop neighbourhood information and one-hop traffic information.A traffic adaptive distributed election scheme is used in TRAMA. This scheme selects receivers based on schedules announced by transmitters. Nodes using TRAMA exchange their two hop neighborhood information and the transmission schedules specifying which nodes are the intended receivers of their traffic in chronological order, and then select the nodes that should transmit and receive during each time slot. TRAMA consists of three components: Neighbor Protocol (NP) ,Schedule exchange protocol(SEP) and Adaptive Election Algorithm(AEA).The Neighbor Protocol and the Schedule Exchange Protocol which allows nodes to exchange two-hop neighbor information and their schedules. The Adaptive Election Algorithm (AEA),is the third component which uses neighborhood and schedule information for selecting the transmitters and receivers for the current time slot. Nodes without any data to send are removed from the election process, thereby improving the channel utilization. There are two time slotted channel for both data transmission and signaling transmission. Here data transmission time slot propagate only one hop neighbor information among the nodes.

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Advantages

TRAMA differs from S-MAC in different ways. TRAMA is inherently collision free as its medium access control mechanism is schedule-based as opposed to S-MAC's which is contention-based. TRAMA uses an adaptive, dynamic approach based on current traffic patterns to switch nodes to low power mode, while S-MAC's scheme is static based on a pre-defined duty cycle.

Disadvantages

In TRAMA all nodes are defined to be either in receive or transmit states during the random access period for schedule exchanges. For a time slot, every node calculates each of its two-hop neighbors' priorities on that slot. In addition, this calculation is repeated for each time slot, since the parameters of the calculation change with time.

D.DELAY EFFICIENT SLEEP SCHEDULE

The communication protocol used in the sensor networks should be light weight and should not consume more energy. Sensor node in WSN is small, its power supply unit should be very small and also it should support all its operations without degrading the performance. Hence, we are going for a good scheduling protocol and while applying it, power consumption is the one which should be kept in mind.

Delay efficient sleep scheduling method [7] define two traffic paths. One path for uplink and other path for downlink traffic. Uplinks are predetermined traffic path for sending an alarm packet to the center node from the event detection node. Downlinks are the path for broadcast alarm from center node to the entire network according to level-by-level offset schedule. Each node needs to wake up properly for both of the two traffics. To minimize the broadcasting delay establish a breadth first search (BFS) tree for the uplink traffic and a colored connected dominant set for the downlink traffic, respectively. For the construction of uplink traffic divides all nodes into layers H1, H2, H3,…, HD where Hi is the node set with minimum hop i to center in the WSN. To establish the downlink traffic path, establish the Colored Connected Dominated Set with three steps: 1) construct a maximum independent set (MIS) ; 2) select connector nodes to form a connected dominated set (CDS), 3) color the CDS to be CCDS with no more than 12 channels.

After all nodes get the traffic paths, a wake-up pattern is needed for sensor nodes to wake-up and receive alarm packet to achieve the minimum delay for both of the two traffic paths. Here different slots are used for different hopes. All nodes in H obtain slots for uplink traffic according to their hops in H and the sequence number of duty cycles and nodes in $H^{'}$ obtain slots for downlink traffic according to their hops in $H^{'}$ and the sequence number of duty cycle. For example, a sensor node nj in H_1 obtains slot L - 1 in odd duty cycles for uplink traffic and node, nj may also be in $H^{'}_2$, and it obtains slot 2 in even duty cycles for downlink traffic. So in this scheme the alarm can be quickly forwarded to center node in uplink path and center node could immediately begin to broadcast the alarm with downlink path, the broadcasting delay is much lower. Similarly the energy consumption of nodes is also very low, because most nodes stay awake for only one time slot in each duty cycle.

Advantages

This combination of the sleep scheduling in wireless sensor networks with level-by-level offset can be reduce the energy consumption and communication delay. This method also avoid the collision during the broadcasting the alarm in wireless sensor networks.

Disadvantages

The broadcasting delay and energy consumption are much lower than that of the previous methods. But also it's a challenge in this paper too. ie ,the upper bound of the delay is 3D + 2L.

IV.CONCLUSION

Recently several sleep scheduling techniques for wireless sensor network have been proposed by the researchers. This paper gives the performance analysis of some protocols that have been proposed for wireless sensor networks. S-MAC and T-MAC reduces the energy consumption in the network. But the problem of early sleep is observed in T-MAC and energy wastage issues are being observed in S-MAC. TRAMA reduces the collision. As compared to S-MAC and T-MAC techniques delay efficient sleep schedule are considered to be better as far as efficiency and performance of wireless sensor networks.

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