Topology Control Based On Demand Mac Protocol For Energy Conservation In Wireless Sensor Network

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Abstract - A wireless sensor network is a special network with large numbers of nodes equipped with embedded processors, sensors and radios. These nodes collaborate to accomplish a common task such as environment monitoring or asset tracking. Though the nodes are operated by the battery, the lifetime of the node or battery can be increased by the effective utilization of power by the node. The critical aspect of sensor network is how to reduce the Energy consumption of nodes. There are several approaches are used for Energy conservation. They are Duty cycling, Data Driven and Mobility based Schemes. In our work, we propose a new Hybrid Scheme to extend the battery life of the sensor nodes. The simulation analysis is done by using NS2 simulator.

I.INTRODUCTION

A wireless sensor network consists of a large number of sensor nodes deployed over a geographical area for monitoring physical phenomena like temperature, humidity, vibrations, and seismic events. The power breakdown heavily depends on the specific node. Each sensor node is a tiny device that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission to a central collection point (sink node or base station). In addition, a power source supplies the energy needed by the device to perform the programmed task. This power source often consists of a battery with a limited energy budget.

Radio Options for the Physical Layer in Wireless Sensor Networks, defines the operating frequency, modulation scheme, and hardware interface of the radio to the system. There are many low power proprietary low power radio integrated circuits that are appropriate choices for the radio layer in wireless sensor networks.

The sensor network model depicted in fig.1.1. and consisting of one (or more) sink(s) and a high number of sensor nodes deployed over a large geographic area (*sensing field).* Data are transferred from sensor nodes to the sink through a multi-hop communication paradigm [3].

II. SENSOR NETWORK ARCHITECTURE [1]:

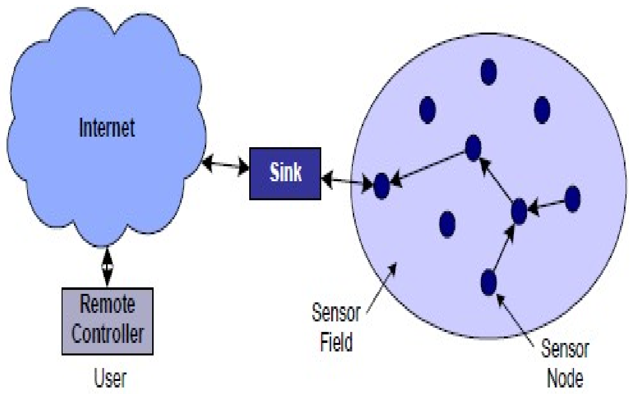

Fig .1.1. Sensor Network Architecture:

III.ARCHITECTURE OF A TYPICAL WIRELESS SENSOR NODE [1]

Fig.1.2 shows the architecture of a typical wireless sensor node. It consists of four main components:

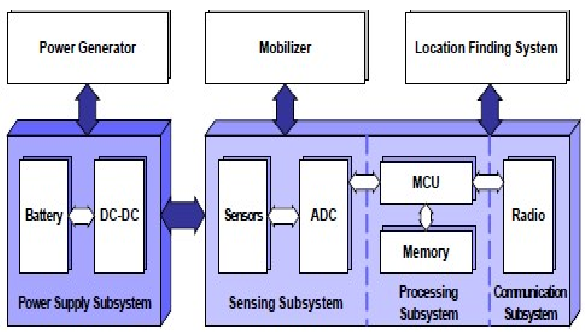

Fig.1.2. architecture of a typical wireless sensor node

(i) a *sensing subsystem* including one or more sensors (with associated analog-to-digital converters) for data acquisition; (ii) a *processing subsystem* including a micro-controller and memory for local data processing; (ii) a *radio subsystem* for wireless data communication; and (iv) a *power supply unit*. Depending on the specific application, sensor nodes may also include additional components such as a *location finding system* to determine their position, a mobilizer to change their location or configuration (e.g., antenna's orientation), and so on. the power breakdown heavily depends on the specific node. In [1] it is shown that the power characteristics of a Mote-class node are completely different from those of a Stargate node. However, the following remarks generally hold [1].

IV. DUTY CYCLING SCHEMES

Duty cycling in wireless sensor network design is to provide energy efficient communication, since most of the nodes in sensor networks have limited battery power and it is not feasible to recharge or replace the batteries

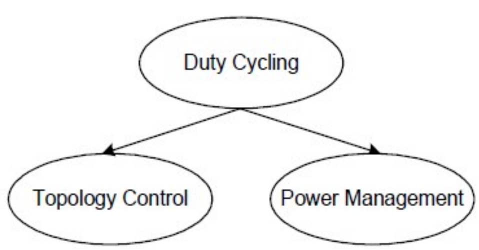

Fig.1.3.Duty cycling schemes

Duty cycling[8] in Fig.1.3. can be achieved through two different and complementary approaches. From one side it is possible to exploit node redundancy, which is typical in sensor networks, and adaptively select only a minimum subset of nodes to remain active for maintaining connectivity. Nodes that are not currently needed for ensuring connectivity can go to sleep and save energy.

V. TOPOLOGY CONTROL

Finding the optimal subset of nodes that guarantee connectivity is referred to as topology control. Therefore, the basic idea behind topology control is to exploit the network redundancy to increase the network longevity. On the other hand, active nodes (i.e., nodes selected by the topology control protocol) do not need to maintain their radio continuously on. They can switch off the radio (i.e., put it in the low-power sleep mode) when there is no network activity, thus alternating between sleep and wakeup periods. Throughout we will refer to duty cycling operated on active nodes as power management. Therefore, topology control and power management are complementary techniques that implement duty cycling with different granularity.

Topology control protocols can be broadly classified in the following two categories:

Location driven: The decision about which node to turn on, and when, is based on the location of sensor nodes which is assumed to be known.

Connectivity driven: Sensor nodes are dynamically activated/deactivated in such way to ensure network connectivity, or complete sensing coverage.

Topology control protocols can extend the network longevity by a factor of 2-3 (depending on the network redundancy) with respect to a network with nodes always on However, many sensor network applications require a much longer network lifetime, e.g., 100 times longer . To further increase network longevity topology control must be combined with power management which introduces duty cycling even in active (i.e., non-redundant) nodes. In our work we consider the connectivity driven scheme for doing energy conservation in wireless sensor network.

VI.CONNECTIVITY DRIVEN.

Sensor nodes are dynamically activated/deactivated in such way to ensure network connectivity, or complete sensing coverage. SPAN is a Connectivity-driven protocol that adaptively elects “coordinators” of all nodes in the network. Coordinators stay awake continuously and perform multi hop routing, while the other nodes stay in sleeping mode and periodically check if there is a need to wake up and become a coordinator. The protocol achieves the following four goals. First, it ensures that there is always a sufficient number of coordinators so that every node is in the transmission range of at least one coordinator. Second, to spread energy consumption as uniformly as possible among network nodes Span rotates the coordinators. Third, it tries to minimize the number of coordinators (to increase the network lifetime) while avoiding a performance degradation in terms of network capacity and message latency. Fourth, it elects coordinators in a decentralized way by using only local information. To guarantee a sufficient number of coordinators Span uses the following *coordinator eligibility rule*: if two neighbors of a non-coordinator node cannot reach each other, either directly or via one or more coordinators, that node should become a coordinator. However, it may happen that several nodes discover the lack of a coordinator at the same time and, thus, they all decide to become a coordinator. To avoid such cases nodes that decide to become a coordinator defer their announcement by a random *backoff delay*. If at the end of the backoff delay, the node has not yet received any announcement from other potential coordinators, it send its announcement and becomes a coordinator. Otherwise, it re-evaluates its eligibility based on announcement messages received, and makes its announcement if and only if the eligibility rule is still satisfied. A key point in the above coordinator election algorithm is how to select the random backoff delay. Each node uses a function that generates random time by taking into account both the number of neighbors that can be connected by a potential coordinator node, and its residual energy. The fundamental ideas are that (**i**) nodes with a higher expected lifetime should be more likely to volunteer to become a coordinator; and (**ii**) coordinators should be selected in such a way to minimize their number.

It is possible to exploit node redundancy, which is Typical in sensor networks and adaptively select only a minimum subset of nodes to remain active for Maintaining connectivity. It elects the Coordinators stay awake continuously and performs multi-hop routing, while the other nodes stay in sleeping mode and periodically checks if it is needed to wake up and become a coordinator. Coordinator Eligibility rule two nodes of non coordinator cannot reach other should become coordinator.

Each coordinator periodically checks if it should withdraw as a coordinator

A node withdraws as coordinator if each pair of its neighbors can reach each other directly of via some other coordinators

To ensure fairness, after a node has been a coordinator for some period of time, it withdraws if every pair of nodes can reach each other through other neighbors (even if they are not coordinators)

After sending a withdraw message, the old coordinator remains active for a “grace period” to avoid routing loses until the new coordinator is elected

VII. POWER MANAGEMENT TECHNIQUES

Power management techniques[7] in Fig 1.4. can be subdivided into two broad categories depending on the layer of the network architecture they are implemented at. power management protocols can be implemented either as independent sleep/wakeup protocols running on top of a MAC protocol (typically at the network or application layer), or strictly integrated with the MAC protocol itself. The latter approach permits to optimize medium access functions based on the specific sleep/wakeup pattern used for power management. On the other hand, independent sleep/wakeup protocols permit a greater flexibility as they can be tailored to the application needs, and can be used with any MAC protocol. Independent sleep/wakeup protocols can be classified in three broad categories, depending on the general approach they take to decide when sensor nodes should be switched on: on-demand, scheduled rendezvous, and asynchronous protocols .

VIII.ON-DEMAND PROTOCOLS

On-demand protocols take the most intuitive approach to power management. The basic idea is that a node should wakeup only when another node wants to\ communicate with it. This maximizes energy saving since a node remains active only for the minimum time required for communication. In addition, there is only a very limited impact on latency because the corresponding node wakes up immediately as soon as it realizes that there is a pending message. The main problem associated with on-demand schemes is how to inform the sleeping node that some other node is willing to communicate with it. .

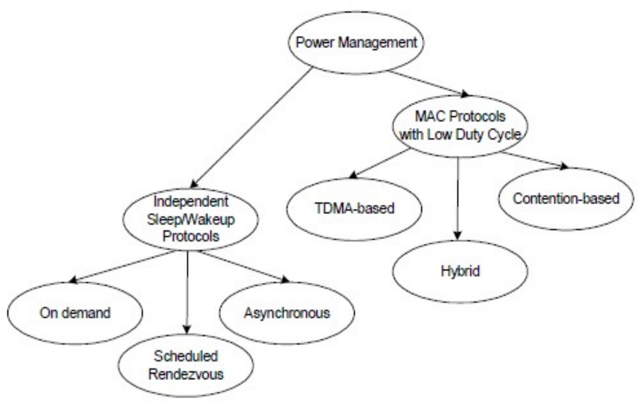

Fig.1.4.Classification of Power management schemes

X. HYBRID SCHEME

- New hybrid scheme was proposed to extend the battery life of the sensor nodes. In this Hybrid scheme, the connectivity driven approach and on-demand schemes are combined for better energy conservation. The protocol that adaptively elects “coordinators” of all nodes in the network. Coordinators stay awake and perform multi hop routing, while the other nodes stay in sleeping mode and periodically check if there is a need to wake up and become a coordinator. Whenever the data need to be transmitted from the sensor node, it is transferred to the coordinator node which is simply used for relaying the data to the next coordinator node and so on. In this way a path is established between the source and the destination where the coordinator nodes are active participants. The important point to be noted here is having found the path from source to destination, during the data transfer phase, The IEEE 802.11 medium access control of the sensor node sends the RTS control packet to the neighbouring coordinator node.

- The RTS control packet contains the WAKE UP SIGNAL.
- Once wake up signal is received, the coordinator node is turned ON. It will send the CTS control packet to the sender.
- Data transfer takes place followed by ACK which makes the sender to SLEEP .
- The process continues until the data reaches the destination.

Main advantage of the combined scheme

- All the nodes are in sleep mode
- They are awakened only whenever there is any sensed data to be transmitted.
- Data transmission takes place via the coordinator nodes only. This will reduce the energy consumed by the sensor network

XI.SIMULATION RESULTS AND ANALYSIS

1.5. Performance analysis of **Stationary node** by varying **number of traffic.**

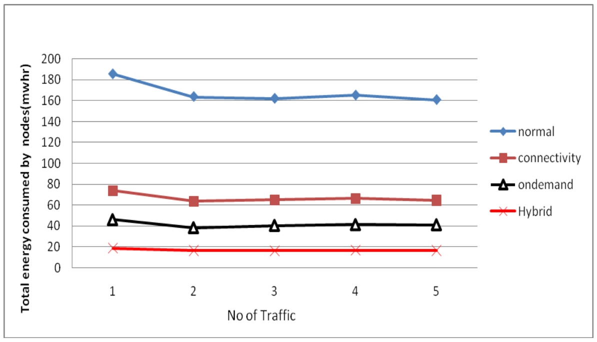

Fig.1.5 Energy Consumption Vs Number of traffic

Fig 1.5 shows total energy consumption of twenty Stationary nodes for different traffic.x-axis denotes number of traffic and y-axis denotes total energy consumed. In this fig 1.5 when increasing the number of traffic, the energy consumed for normal mode is Very high and for Connectivity mode is medium and for on demand is low and for Hybrid mode is very low. When compared to all these four schemes, hybrid scheme(Combination of connectivity driven and on demand)proves to be better method to conserve energy in wireless sensor network for stationary nodes.

1.6. Performance analysis of mobile node by varying number of traffic

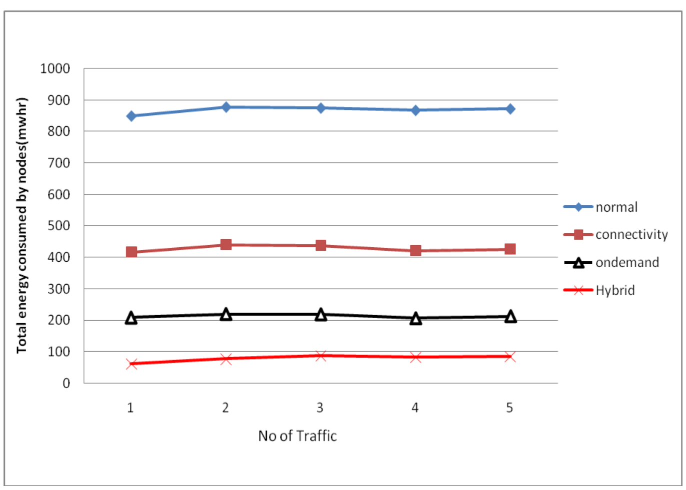

Fig.1.6 Energy Consumption Vs Number of traffic

Fig.1.6 shows total energy consumption of twenty mobile nodes for different traffic. x-axis denotes number of traffic and y-axis denotes total energy consumed. In this fig 1.6, when increasing the traffic, the energy consumed for normal mode is Very high and for Connectivity mode is medium and for on demand is low and for Hybrid mode is very low. When compared to Stationary network the energy consumed by the mobile nodes itself is very high which is clear from the values on the y-axis But still, the Hybrid Scheme is found to be the best energy saving scheme among all others.

1.7. Performance analysis of Stationary node by increasing number of nodes.

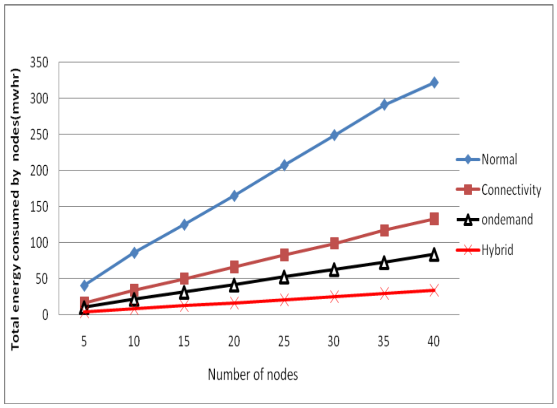

Fig.1.7 Energy Consumption Vs Number of nodes

Fig 1.7 follows the discussion of fig.1.8. It is evident from the graph that as the network size increases; the energy consumption by the network is also increasing. By analyzing the various energy saving scheme given, on-demand method shows reduced energy consumption compared to connectivity driven method. Because the coordinator nodes are always on in latter but the nodes are awaken only when there is data for transmission in former. Finally we conclude that proposed Hybrid scheme proves to be the best method as it combines the advantages of both connectivity driven and on-demand Mac scheme

1.8. Performance analysis of **Mobile node** by increasing **number of nodes.**

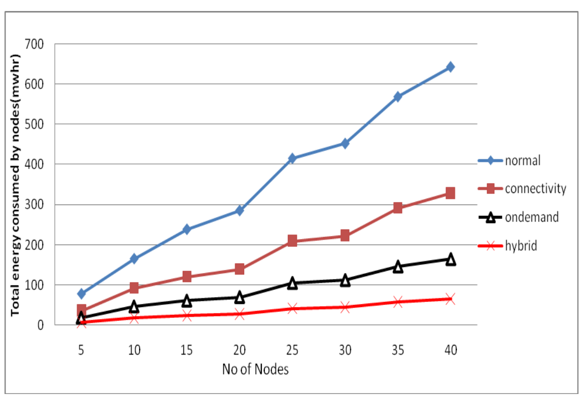

Fig.1.8 Energy Consumption Vs Number of nodes

Fig 1.8 follows the discussion of fig 1.7. Fig 1.8 shows total energy consumed by the nodes versus network density. It is observe that since mobile environment is considered, the total energy consumed by the mobile nodes is slightly higher than the stationary network. This may be because of more number of packet retransmission and repeated route discovery process in the network, as the moving nodes creates link Breakage.

1.9. Performance analysis of Stationary node by varying number of traffic

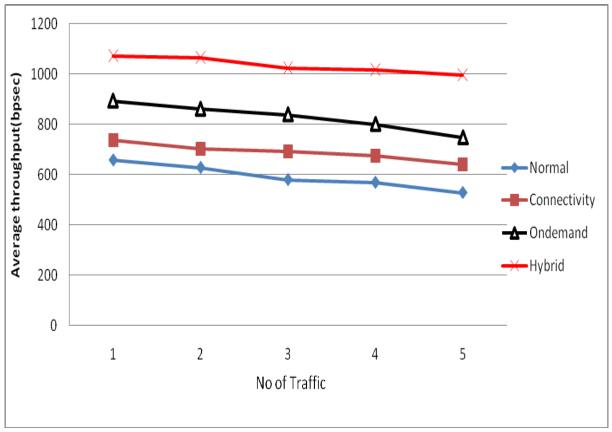

Fig.1.9. Average throughput Vs Number of traffic

Fig.1.9. Depicts how the Average Throughput varies as the no of traffic increases. For various schemes analyzed, the average throughput is found to be more for Hybrid scheme. This shows that our hybrid method to reduce energy consumption does not affect other Qos metric like Throughput. It is clear that when the nodes which are not involved in data transmission are switched to sleep node, it reduces the number of collisions, unnecessary packet transmissions thereby increasing the average Throughput effectively.

1.10 Performance analysis of mobile node by varying number of traffic

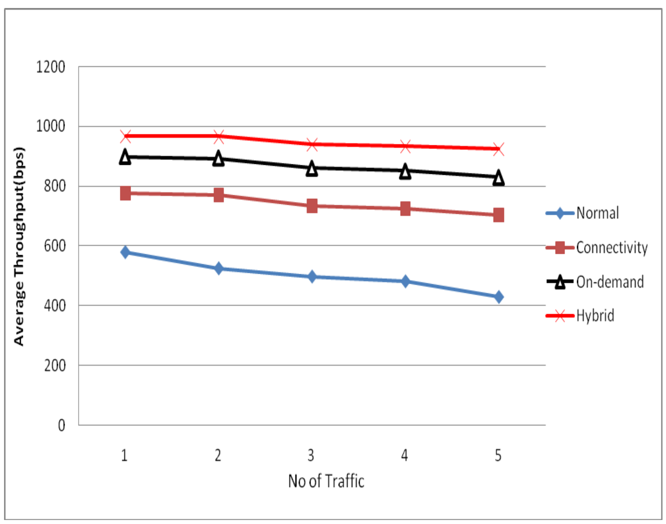

Fig.1.10.Average Throughput Vs Number of traffic

Fig 1.10. shows Average throughput vs No of traffic for mobile network. It is obvious that the average throughput in mobile environment is comparatively low than Stationary node environment.However the characteristics obeys the discussion of section 1.9.

XII.CONCLUSION

Energy conservation is the critical aspect in Wireless Sensor network. The various methods to conserve energy in wireless sensor network were investigated. A New Hybrid Scheme was proposed to extend the Battery life of the sensor nodes. Combining the Connectivity driven and On-demand scheme we are able to achieve increased network performance in terms of Energy conservation and Throughput. The proposed Scheme works well in both

Static as well as Mobile environment. The variation in performance metrics are analyzed by changing the traffic density and node density in the network. The Simulation results shows that when the energy conserving algorithms like Topology control method and power management method are used independently increases the performance. But when integrating different approaches together, hybrid energy saving scheme provides better results as compared to the algorithms that are operated independently.

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