International Journal of advancement in electronics and computer engineering (IJAECE)
Volume 1, Issue 2, May 2012, pp.82- 87, ***ISSN 2278 - 1412***

Quality of Service and Energy Management in Wireless Sensor Networks

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Abstract - *Recent technological improvements have made the deployment of small, inexpensive, low-power, distributed devices, which are capable of local processing and wireless communication, a reality. Such nodes are called as sensor nodes. Each sensor node is capable of only a limited amount of processing. But when coordinated with the information from a large number of other nodes, they have the ability to measure a given physical environment in great detail. Thus, a sensor network can be described as a collection of sensor nodes which co-ordinate to perform some specific action. Unlike traditional networks, sensor networks depend on dense deployment and co-ordination to carry out their tasks. Previously, sensor networks consisted of small number of sensor nodes that were wired to a central processing station. However, nowadays, the focus is more on wireless, distributed, sensing nodes. But, why distributed, wireless sensing. When the exact location of a particular phenomenon is unknown, distributed sensing allows for closer placement to the phenomenon than a single sensor would permit. Also, in many cases, multiple sensor nodes are required to overcome environmental obstacles like obstructions, line of sight constraints etc. In most cases, the environment to be monitored does not have an existing infrastructure for either energy or communication. It becomes imperative for sensor nodes to survive on small, finite sources of energy and communicate through a wireless communication channel.*

I. Problem Statement

The objective of the proposed research is to address the problem of energy consumptions in wireless sensor networks. Since wireless sensor networks typically consist of tiny sensors with a scarce energy resource, energy consumption is a critical issue to be addressed. This synopsis addresses the efficient energy management in wireless sensor network by three fundamental ways: Data aggregation, Power-efficient clustering protocol, energy efficient communication protocol.

II. Energy Efficient Routing Algorithm

There is a need for delivering queries to nodes that have observed particular events in the network and getting the data back to the point where the interest was expressed. One way to achieve this is to establish a global coordinate system and perform geographic routing. Another simpler approach would be to just flood the query or the event. However, the sheer number of sensor nodes, which must operate under stringent power constraints, and the data centric nature of sensor networks make such schemes very inefficient. The authors present a method for routing queries to nodes based on the event observed; not based on a unique id or geographic location of a node. This allows data to be retrieved from the network keyed on the event and not on the underlying network addressing scheme or geography.

III. Energy-efficient communication protocol for wireless sensor networks

Hierarchical routing protocol which attempts to minimize global energy dissipation and distribute energy consumption evenly across all nodes. This is achieved by the formation of clusters with localized coordination, by rotating the high-energy cluster heads and by locally compressing data. The nodes self-organize into local clusters with one node in each cluster acting as a cluster head. Once a cluster has formed, the cluster members send their data to the cluster head (low energy transmission) which in turn combines the data and sends it to the base station (high energy transmission)

IV. Energy concerns in wireless networks

For any wireless node there are three major modes of operation: transmitting, receiving and listening. When the node is in listening mode the energy expenditure is minimal. However, if the node spends most of the time listening then this mode is responsible for a large portion of the consumed energy (as is the case in sensor networks).

In multi-hop wireless networks it is energy efficient to choose long paths along a series of short hops rather than short paths along a series of long hops. However, even though energy efficiency is our paramount interest it is not the only one. Communication performance is also very important. By choosing many short hops we may lower the energy expenditure, but only to a certain degree, since delay increases, processing energy increases and control overhead increases. Therefore, the choice of how to incorporate energy is not as clear as it seems.

V. Literature Review

Recent advances in micro-electro-mechanical systems (MEMS) technology, Wireless communications and digital electronics have enabled the development of low-cost, low-power, multifunctional smart sensor nodes [1]. Smart sensor nodes are autonomous devices equipped with heavily integrated sensing, processing, and wireless communication capabilities [19][20]. When these nodes are networked together in an ad-hoc fashion, they form a sensor network. The nodes gather data via their sensors process it locally or coordinate amongst neighbors and forward the information to the user or, in general, a data sink. Due to the node's limited transmission range, this forwarding mostly involves using multi-hop paths through other nodes [20]. A node in the network has essentially two different tasks: (1) sensing its environment and processing the information for onward transmission, and (2) forwarding traffic from other sensors as an intermediate relay in the multi-hop path.

The major design challenge for this type of network is to increase the operational lifetime of the sensors as much as possible [1][21]. Indeed, sensor nodes are miniature devices and operate on a tiny, non-replaceable battery. Energy efficiency is therefore the critical design constraint. Research can address two different perspectives of the energy problem: (1) an increase in battery capacity and (2) a decrease in the amount of energy consumed at the wireless terminal. The focus of battery technology research has been to increase battery power capacity while restricting the weight of the battery. However, unlike other areas of computer technology such as microchip design, battery technology has not experienced significant (compared to Moore's Law) advancement in the past 30 years. Therefore, unless a breakthrough occurs in battery technology, a goal of research should be to decrease the energy consumed in the wireless terminal [22].

In terms of energy consumption, the wireless exchange of data between nodes strongly dominates other node functions such as sensing and processing [23][24]. Moreover, actual radios

Consume power not only when sending and receiving data, but also when listening. Energy models have been developed [24][25] which show that the energy consumption ratio of listen: receive: send is about 1:1:1.5. With this model, node listening time dominates energy consumption in light or moderate traffic scenarios. Significant energy savings are only obtainable by putting the node into a sleep mode when there is no traffic [21][26]. Given the importance of energy conservation in sensor networks we now describe a simple model that allows us to investigate a) the relationship between energy consumption and network traffic and b) the tradeoff between energy consumption and network performance.

Nodes in a sensor network, operating on power limited batteries, must save power to minimize the need for battery replacement.[19] The range of transmission has a significant effect on the power consumption of both the transmitting node and listeners. A Geographical Power Efficient Routing (GPER) protocol for sensor networks. Each sensor node makes local decisions as to how far to transmit: therefore, the protocol is power efficient, localized, highly distributed, and scalable. In GPER, given a final destination, each node first establishes a sub destination within its maximum radio range. The node, however, may decide to relay the packet to this sub destination through an intermediary node or alter the sub destination if this will preserve power. Traditional deterministic geographic routing algorithms aim at achieving close to the shortest weighted paths. However, they normally stick to the same paths for the same source/destination pairs. This may conversely drain the nodes on these paths and result in short network life when the communication in the network is unevenly distributed. Thus, further investigate a set of probabilistic multipath routing algorithms, which generate braided multi-paths based only on local information. The algorithms have less communication and storage overhead than conventional on-demand multipath routing algorithms, while providing greater resilience to node failures. Simulations on NS2 show that GPER almost halves the power consumption in the network relative to alternative geographic routing algorithms. Furthermore, in situations where the communication tasks are non-uniformly distributed, probabilistic multipath routing contributes up to an additional 30% to network lifetime.

Communication architecture for sensor networks and proceeds to survey the current research pertaining to all layers of the protocol stack: Physical, Data Link, Network, Transport and Application layers. A sensor network is defined as being composed of a large number of nodes which are deployed densely in close proximity to the phenomenon to be monitored. Each of these nodes collects data and its purpose is to route this information back to a sink. The network must possess self-organizing capabilities since the positions of individual nodes are not predetermined. Cooperation among nodes is the dominant feature of this type of network, where groups of nodes cooperate to disseminate the information gathered in their vicinity to the user.

VI. Methodology

The proposed algorithm uses a set of long-lived agents (packets that move between nodes) that create paths (state in every node) toward the events they encounter. Whenever a node witnesses an event it probabilistically generates an agent which travels the network and is initialized with the node's event forwarding table (distance and next hop for events that the node knows about directly or that it can route queries to). As the agent travels, it synchronizes its event table with each node it visits. As a result, it propagates path information and learns about new events that it can propagate further.

The agent employs a straightening algorithm to determine its next hop and avoid loops. Due the broadcast nature of the medium, the agent leaves a fairly thick path as it travels, since nodes close to the agent's path can update their own event tables as well. Any node can generate an agent, but it makes more sense for nodes which have observed events to do so, so that useful information can be disseminated immediately.

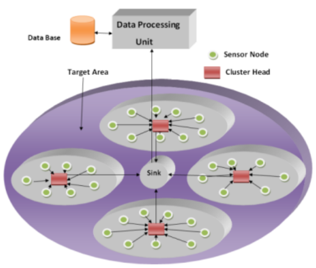

Fig. 1. Wireless Sensor Network

Proposed Architecture of Efficient Energy Management in Wireless Sensor Network

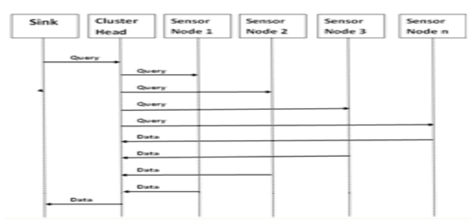

Fig. 2. Proposed Sequence Diagram

The operation of the protocol is broken up into rounds, during which the clusters are dissolved and recreated. During each round, a node decides probabilistically whether to become a cluster head. This decision is based on the suggested percentage of cluster heads for the network (determined a priori) and the number of times the node has been a cluster head so far. The cluster heads advertise their intention and the rest of the nodes decide which cluster to join, usually based on signal strength. Once the clusters are formed, the cluster head creates a TDMA schedule and sends it to its cluster members. To reduce interference, each cluster communicates using different CDMA codes.

Energy consumption is the most important factor to determine the life of a sensor network because usually sensor nodes are driven by battery and have very low energy resources. This makes energy optimization more complicated in sensor networks because it involved not only reduction of energy consumption but also prolonging the life of the network as much as possible. This can be done by having energy awareness in every aspect of design and operation. This ensures that energy awareness is also incorporated into groups of communicating sensor nodes and the entire network and not only in the individual nodes.

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