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RESEARCH ARTICLE

Prolonged Network Lifetime and Data Wholeness by Clusters Using B-Ct Algorithm

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Abstract— The unique characteristics of cost and rapid deployment of sensor networks feigns exciting applications in the areas of communication and in industrial automation, which makes the wireless sensor networks as an integral part of our lives. The key challenge in the design of WSN is being the power consumption of the entire network thereby prolonging the network lifetime. This is possibly being achieved with the help of introducing the cluster head in the multicast routing communication. The existing methods lacks in minimizing the power consumption of data transmission from source to destination due to network overhead. Thus, the cluster head is built to overcome the deficiencies of existing works. The basic concept of cluster head is to perform filtering of raw data collected from its clusters and transmitting the filtered packets to the destination. This paper deals in performing the clustering in two different topologies which abruptly reduces the network overhead and achieves in the reduction of total power consumption of WSN. Further, the implemented algorithm is validated through simulations and has proven its mere performance and scalability.

Key Terms: - Mobile sinks, wireless sensor networks, information retrieval, clustering, sensor islands, rendezvous nodes.

I. INTRODUCTION

A Wireless Sensor Network (WSN) is formed from a large number of tiny nodes deployed in a particular area to sense, monitor, and measure certain events via wireless communication. Each node has a microprocessor, a radio chip and a power source. The specifications of these nodes vary, depending on the requirements and the application. Typically, the nodes are low-cost, low-power, limited in terms of memory, and programmable. Such specifications enable the WSN to be applied in many fields and environments, and to work well wherever it is used. However, at the same time, WSNs pose a variety of challenges and difficulties. The typical WSN consists of two main components: sensors and a sink. Essentially, the sensors' task is to sense and collect the desired data and then send it to where it is needed. The sink, or base station (BS), is the place where the gathered data is received and then delivered to the user.Providing Quality of Service (QoS) support in Wireless Sensor Networks (WSNs) for improving their timing and reliability performance under severe energy constraints has attracted recent research works. The standardization efforts of the IEEE task have contributed to solve this problem by the definition of the IEEE 802.15.4 protocol for Low-Rate, Low- Power Wireless Personal Area Networks (WPANs). In fact, this protocol shows great potential for flexibly fitting different requirements of WSN applications by adequately setting its parameters (low duty cycles, guaranteed time slots (GTS)). A PAN composed of multiple devices that have to transmit data to the PAN coordinator through single or multiple hops.

We assume that the application requires periodic data at the PAN coordinator each node, upon reception of a query coming from the PAN coordinator, generates a packet and attempts to access the channel to transmit it.

Therefore, each node has only one packet per query to be transmitted. If the node does not succeed in accessing the channel before the reception of the next query, the packet is lost, and a new one is generated in beacon-enabled mode, the IEEE 802.15.4 protocol uses slotted CSMA/CA as a Medium Access Protocol (MAC). Even though the IEEE 802.15.4 protocol provides the GTS allocation mechanism for real-time flows, the allocation must be preceded by an allocation request message. However, with its original specification, the slotted CSMA/CA does not provide any QoS support for such time-sensitive events, including GTS allocation requests, alarms, PAN management commands, etc., which may result in unfairness and degradation of the network performance, particularly in high load conditions.

II. TECHNICAL OVERVIEW

Zigbee is a low-cost, low-power, wireless mesh networking standard. First, the low cost allows the technology to be widely deployed in wireless control and monitoring applications. Second, the low power-usage allows longer life with smaller batteries. Third, the mesh networking provides high reliability and more extensive range. It is not capable of power line networking though other elements of the Open HAN standards suite promoted by open AMI and Utility AMI deal with communications co-extant with AC power outlets. In other words, Zigbee is intended not to support power line networking but to interface with it at least for smart metering and smart appliance purposes. Utilities, e.g. Penn Energy, have declared the intent to require them to interoperate again via the open HAN standards.

III. PROTOCOLS

The protocols build on recent algorithmic research (Ad-hoc On-demand Distance Vector, neu RFon) to automatically construct a low-speed ad-hoc network of nodes. In most large network instances, the network will be a cluster of clusters. It can also form a mesh or a single cluster. The current profiles derived from the ZigBee protocols support beacon and non-beacon enabled networks.

In non-beacon-enabled networks an unslotted CSMA/CA channel access mechanism is used. In this type of network, ZigBee Routers typically have their receivers continuously active, requiring a more robust power supply. However, this allows for heterogeneous networks in which some devices receive continuously, while others only transmit when an external stimulus is detected. The typical example of a heterogeneous network is a wireless light switch: The ZigBee node at the lamp may receive constantly, since it is connected to the mains supply, while a battery-powered light switch would remain asleep until the switch is thrown. The switch then wakes up, sends a command to the lamp, receives an acknowledgment, and returns to sleep. In such a network the lamp node will be at least a ZigBee Router, if not the ZigBee Coordinator; the switch node is typically a ZigBee End Device.

In beacon-enabled networks, the special network nodes called ZigBee Routers transmit periodic beacons to confirm their presence to other network nodes. Nodes may sleep between beacons, thus lowering their duty cycle and extending their battery life. Beacon intervals may range from 15.36 milliseconds to 15.36 ms * 214 = 251.65824 seconds at 250 kbit/s, from 24 milliseconds to 24 ms * 214 = 393.216 seconds at 40 kbit/s and from 48 milliseconds to 48 ms * 214 = 786.432 seconds at 20 kbit/s. However, low duty cycle operation with long beacon intervals requires precise timing, which can conflict with the need for low product cost. In general, the ZigBee protocols minimize the time the radio is on so as to reduce power use. In beaconing networks, nodes only need to be active while a beacon is being transmitted. In non-beacon-enabled networks, power consumption is decidedly asymmetrical: some devices are always active, while others spend most of their time sleeping.

The basic channel access mode is "carrier sense, multiple access/collision avoidance" (CSMA/CA). That is, the nodes talk in the same way that people converse; they briefly check to see that no one is talking before they start. There are three notable exceptions to the use of CSMA. Beacons are sent on a fixed timing schedule, and do not use CSMA. Message acknowledgments also do not use CSMA. Finally, devices in Beacon Oriented networks that have low latency real-time requirements may also use Guaranteed Time Slots (GTS), which by definition do not use CSMA indispensable in the IVC system to have the ability to selectively revoke the group memberships of the compromised vehicles either through updating keys or releasing Certificate Revocation Lists (CRLs).

IV. CLUSTERING TECHNIQUE

The network is sectioned into a set of sub networks, each of which is called a cluster. In each cluster, one node represents the others and is called the cluster head (CH). Since the CH is responsible for all of the events inside its cluster, the probability of it to being down is high, and when that happens, its task will be moved to another node which will then become the CH, depending on its essential algorithm. One of the notable protocols that follow this technique is LEACH and EDACH. Since LEACH was first introduced, a huge development in WSNs has occurred. The LEACH (Low-energy Adaptive Clustering Hierarchy) protocol, presented by Heinzelman et al., is a well-known protocol that follows the clustering scheme. LEACH assumes that the nodes inside the network are fixed, and that the base station is far from them. All nodes in the network are homogenous and energy constrained. However, in LEACH protocol, some nodes consume more energy than others, which leads, over time, to some nodes being disconnected from their network. The main idea behind the LEACH protocol is to divide the network into a number of sub-networks called clusters.

Each cluster consists of a fixed number of sensors, which, by voting, elect a representative node, the CH. Each sensor inside the cluster should send its data to the CH, which is responsible for delivering data to the sink. As mentioned above, this process can lead the CH to handle the most significant tasks inside the cluster, which means the CH loses its energy faster than the other nodes. LEACH is a Time Division Multiple Access (TDMA) –based protocol that provides time slots for each node to exchange data between the member nodes and their CH. Moreover, the TDMA measure the probability of each node becoming a CH, depending on its energy in a round algorithm. The rounds are the cornerstones of the LEACH protocol and algorithm. Each round is composed generally of two phases: setup phase and a steady-state phase. During the setup phase, the cluster is created and the CH is elected. The second phase is responsible for distributing the time slots among the network nodes.

V. BACK-BONE CLUSTER PROTOCOL

In the proposed protocol, MSs are mounted upon public buses circulating within urban environments on fixed trajectories and near-periodic schedule. Namely, sinks motion is not controllable and their routes do not adapt upon specific WSN deployments. Our only assumption is that sensors are deployed in urban areas in proximity to public transportation vehicle routes. Also, an adequate number of nodes are enrolled as RNs as a fair compromise between a small numbers which results in their rapid energy depletion and a large number which results in reduced data throughput. Finally, SNs are grouped in separate cluster.

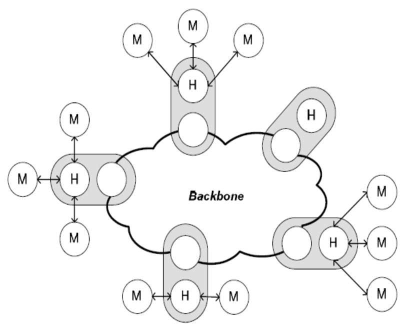


Fig: The structure of a protocol node in the B-CT protocol

The Figure shows the structure of a protocol node in the B-CT protocol. The node contains a node of the backbone protocol and a node of the CT protocol. However, cluster members do not join the backbone overlay topology. In these nodes, the backbone node is inactive. The B-CT node exploits a property of the overlay node design that permits an overlay node to contain multiple internal overlay nodes. Internal protocol nodes communicate via a virtual adapter, called a dummy adapter, and protocol messages from the internal protocol nodes are multiplexed on a single node adapter using an encapsulation header. The encapsulation is performed by an additional protocol, called the Multiplexing (MUX) protocol.

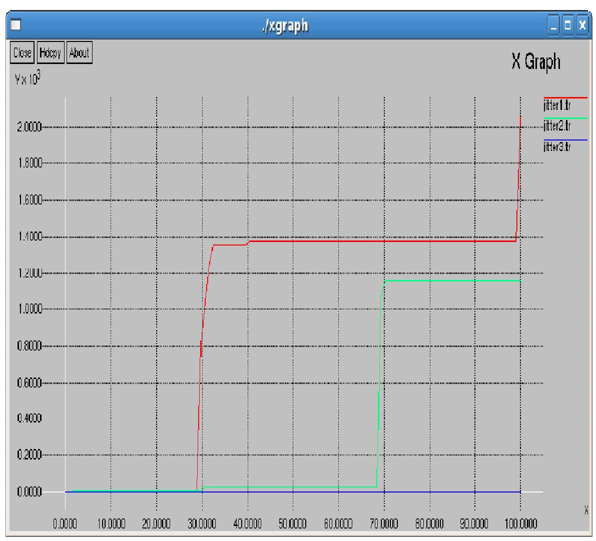
The B-CT protocol has only a single exchange of protocol messages, whose purpose is to assign a backbone logical address LABBone to a cluster member. A cluster member sends a request for a backbone address to its cluster head. The cluster head returns its address in the backbone network. In Hyper Cast, application data is forwarded in spanning trees that are embedded in the overlay topology. Each node forwards data to one or more of its neighbours in the overlay topology. A multicast message is forwarded downstream in a rooted tree that has the sender of the multicast message as the root. A unicast message is forwarded upstream in a rooted tree that has the destination of the message as the root. In Hyper Cast, each node can locally compute its upstream neighbour (parent) and its downstream neighbours (children) with respect to a given root note. In the B-CT protocol, the computation must consider neighbours in a cluster topology as well as in the backbone topology. If a B-CT that contains a CT node that is a cluster member, the situation is simple since a node has only one neighbour, i.e., its cluster head. Let us now look at a B-CT node that contains a cluster head.

The neighbourhood of this node is the union of the neighbours in the cluster and the backbone network. When this node calculates the downstream neighbours in the overlay network, the distinguishes whether the root node is one of its cluster members. If so, the downstream neighbours are all other cluster members and all downstream neighbours in a spanning tree that has the local node as the root. If the root is not one of its cluster members, then the downstream nodes consists of its downstream neighbours with respect to the given root in the backbone and all cluster members. An upstream neighbour is either one of its cluster members (if the root is in its cluster), the upstream node in the backbone network (if the root node is not one of its cluster members).Thus, the overhead of multihop data relaying to the edge RNs is minimized. Given that the communication cost is several orders of magnitude higher than the computation cost [34], in-cluster data aggregation can achieve significant energy savings. A basic assumption in the design of Mobi Cluster protocol is that SNs are location unaware, i.e., not equipped with GPS capable antennae. Also, we assume that each node has a fixed number of transmission power levels. Finally, we assume the unit disk model, which is the most common assumption in sensor network literature. The underlying assumption in this model is that nodes which are closer than a certain distance (transmission range R) can always communicate. However, in practice, a message sent by a node is received by the receiver with only certain probability even if the distance of the two nodes is smaller than the transmission range. It will describe how our protocol can be adapted so that it can still work on the top of a more realistic physical layer.

VI. SIMULATION RESULTS

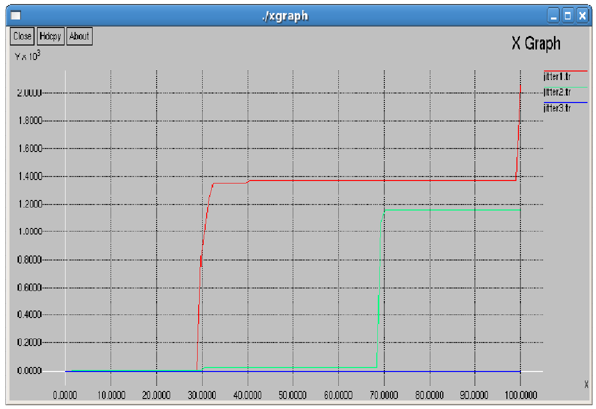
Distribution of traffic:

graph 1, pstree as a function of N1, for different values of N, D, and SO, having set BO = 5, is shown. There exists an optimum value of N1 maximizing pstree , and this value obviously increases by increasing N and is approximately equal to √N; therefore, it is independent of D and SO. This means that, once we fix N, there exists an optimum split between level one and level two nodes, maximizing the probability of success traffic are showed.



Throughput:

In graph 2, results related to the two topologies, showing the success probability as a function of N for different values of SO and BO by setting D = 5, are compared. For a fair comparison, the success probability is computed by fixing the same value of TB and, therefore, by giving to nodes the same time to transmit the data to the coordinator



To this aim, we set SO = BO for the star topology y, and we compare the case "star" with SO = BO = 1 with the case "tree," with BO = 1 and SO = 0, whereas the case "star" with SO = BO > 1 (note that the cases SO = BO = 2, 3, etc., bring the same ps) are compared with the cases "tree" with BO > 1, whatever SO is. In the "tree" case, N1 is set to the optimum value maximizing pstree obtained from Fig. 10. As we ca n see, when BO = 1, the "star" is preferable since in the "tree" only one router has a part of the super frame allocated; therefore, many packets of level two nodes are lost. For BO > 1, instead, the "tree" outperforms the "star." The difference between the "star" and the "tree" obviously increases by increasing BO and SO, resulting in an increase in pframe and ps, respectively.

Probability of success changes when different loads:

The average delays obtained in case of star and tree-based topologies as a function of N are shown. The curves are obtained by setting D = 5 and N1 = 3 in the case of trees. The delays increase by increasing N since the probability of finding the channel busy and delaying the transmission gets larger. A horizontal asymptote is also present due to the maximum delay that a packet may suffer, which is equal to the super frame duration TA in the "star" case and to TB + TA in the "tree" case. As expected, the delays are larger for trees since packets coming from level two nodes need two super frames to reach the coordinator. Also note that by increasing BO, delays get significantly larger. The curves "tree" with SO=0, BO=3 and "tree" with SO = 1 and BO = 3 overlapped since TB assumes the same value and the delays of level one nodes are approximately the same (in fact, the curves "star" with SO =BO = 0 and SO = BO = 1 are also approximately the same).By comparing Figs. 11 and 12, we can finally deduce that the choice of the topology depends on the application requirements.

VII. CONCLUSIONS

This paper introduced backbone clustering protocol that proposes the use of urban buses to carry MSs that retrieve information from isolated parts of WSNs. It mainly aims at maximizing connectivity, data throughput, and enabling balanced energy expenditure among SNs. The connectivity objective is addressed by employing MSs to collect data from isolated urban sensor islands and also through prolonging the lifetime of selected peripheral RNs which lie within the range of passing MSs and used to cache and deliver sensory data derived from remote source nodes. Increased data throughput is ensured by regulating the number of RNs for allowing sufficient time to deliver their buffered data and preventing data losses.

Unlike other approaches, B-CT moves the processing and data transmission burden away from the vital periphery nodes (RNs) and enables balanced energy consumption across the WSN through building cluster structures that exploit the high redundancy of data collected from neighbour nodes and minimize intercluster data overhead. The performance gain of Backbone cluster over alternative approaches has been validated by extensive simulation tests.

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