A Group Management Scheme for Wireless Sensors` Networks

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ABSTRACT: Wireless Sensor Networks are used in situations where it becomes difficult to deploy and utilize networks with fixed infrastructure. Group Management within such network is an important challenge which is considered as a fundamental objective of such deployment. A good number of schemes have been proposed as a solution to this problem in the existing literature; however it is a well known fact that none of the existing schemes has fully addressed the group management issues. We have proposed a novel mechanism known as Cluster Based Group Management Scheme for Wireless Sensor Networks.
Cluster Based Group Management Scheme (CBGMS) adopts an intermediate path in between the known solutions and additional novel features. It is important to mention that CBGMS not only provide a comprehensive Group Management solution but also addresses some of the known inter-related issues of Wireless Sensor Networks which is presented and explained in this paper.

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Introduction

Group Management for Wireless Sensor Networks [WP02, ALM05, A+02] is an important area awaiting a reliable solution. This solution must be able to address Group Management in a manner which can reflect the true nature of Wireless Sensor Networks. Cluster Based Group Management Scheme (CBGMS) adopts an intermediate path in between the known solutions and additional novel features. It is important to mention that CBGMS not only provide a comprehensive Group Management solution but also addresses some of the known inter-related issues of Wireless Sensor Networks;

examples of such issues are Battery Power and Bandwidth constraints. CBGMS evolves around the idea of dividing the network into chunks of Wireless Sensor Nodes called clusters establishing communication with each other via Cluster-Heads (CH). In this context CBGMS defines functions to add in Network Formation, Cluster Formation, Cluster-Head formation, Intra-Cluster Communication, Inter-Cluster Communication and Power Saving mode. In this context, this paper presents an overview of the related work in section 1. An explanation of the proposed scheme is given in section 2. A brief detail of the ongoing implementation has been discussed in section 3. Contribution of this research has been presented in section 4 while conclusion and future work is given in last section.

1. Related Work

Group Management in Wireless Sensor Networks attained a specific focus since it plays an important role in the success of communication of Wireless Sensor Networks. At present there are number of different schemes [NB04, HL05, XHE01, BCP08, YSM07], some of which are based on the traditional methods of Group Management while the rest introduced new thoughts to this field. Examples include Topology Based [LY06, SSS03] and Complex Formula calculations. In the light of conducted research as a part of this project various weaknesses in the existing solutions has been identified. Some of the known weaknesses are limitations: theses schemes don not address some of the related issues along with the Group Management in addition theses schemes do not meet some of the essential requirements of Wireless Sensor Networks. Moreover conserving energy resources within such operations are important, however existing schemes shows weak performance in this context.

In summery there is a need of Group Management solution which can fulfill the typical requirements of Wireless Sensor Networks while delivering reliable solution at the same time.

2. Cluster Based Group Management Scheme

CBGMS specifications define several functions to perform various tasks associated with the Group Management of Wireless Sensor Networks. It is worthwhile to mention that routing has been taken as one of the key factor

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in establishing Group Management within this scenario. It is known that routing requirements in wireless sensor's network is relatively same as in ad-hoc sensor's network. Routing protocols in mobile ad-hoc network can be categorized into one of two types i.e. tables driven and on-demand routing protocols [Bak10]. Some of the commonly known protocols of ad-hoc network are Dsdv [Bak10], Aodv [Bak11], Dsr [Kab10] and Maoddp [Bak11, IET11].

In the following section detailed explanation of each individual function is presented. It should be noted that some of these functions also define some sub functions. Description of such sub functions is covered in the definition of the main functions.

2.1. Network Formation

Network formation is an important aspect within the Wireless Sensor Networks therefore it is necessary to have a Group Management scheme which can organize a Wireless Sensor Network from the establishment to one of the crucial purpose i.e. communication. CBGMS is based on the same concept. This is one of the features that distinguish CBGMS than the other previously reported schemes. In addition due to the nature of proposed scheme, task of network formation attain primary importance. In the light of background research this can also be noted that most of the analyzed schemes lack with this feature. This further backups our arguments and additionally highlights the fact as to why it is crucial for group management schemes to have well defined functions in place. In CBGMS a network is established if there is sufficient number of Wireless Sensor Nodes placed in defined vicinity. A Network Formation Packet (NFP) is initiated by the node which is considered closest to the Base Station (BS). The phenomenon of initiating network formation request by the nodes closest to the Base Station broadcasting NFP to other nodes could also be understood from figure. 1. That node 'A' and 'B' being closest nodes to the Base Station are broadcasting NFP to other nodes.

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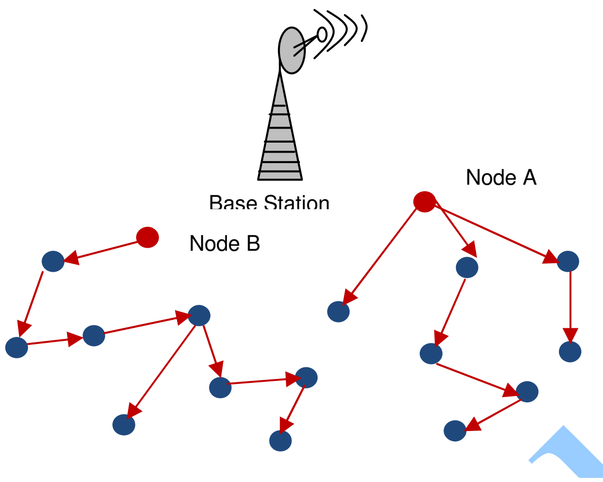

Figure 1: Closest nodes to Base Station are broadcasting NFP

Network Formation Packet (NFP): It is the packet which is sent by the node closest to the Base Station towards other nodes in the network. Network Formation Packet (NFP) contains the Sequence Number, Broadcast ID and Node Location information.

Forwarding Network Formation Packet: It becomes the responsibility of the node which receives NFP to forward this packet to its neighboring nodes. This process serves two purposes, firstly, it makes the NFP receiving node as a potential part of the network and lastly it helps updating NFP receiving nodes with the information about other nodes of the network.

Network Joining Request Packet (NJRP): If a node is not part of an active network it will first broadcast a Network Joining Requests to join the network. This packet will pass among the Cluster Heads (CH) of different clusters until it is eventually accepted by one of the Cluster Head among the group of clusters closest to the requesting node. On acceptance, Cluster-Head will send a Packet f Acceptance (POF) using the same reverse path to the initiator of Network Joining Requesting.

Cluster-Head sending Packet of Acceptance (POA): This packet is sent by any of the Cluster-Head which is ready to accept the initiator of NJRP as its Group Member (GM) and the node becomes a member of that cluster.

Node sending Network Leaving Request Packet (NLRP): When a node wants to leave the network it sends a Network Leaving Request Packet (NLRP) to the Cluster-Head to which it is associated, who in turn sends a Confirmation Network Leaving Request Packet (CNLRP) to the initiator of

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the NLRP and also sends a request to all other cluster heads within its region to update their records.
Cluster-Head sending Confirmation Network Leaving Request Packet (CNLRP): On receiving NLRP the Cluster-Head takes the following steps. First of all it sends a CNLRP back to the initiator of the NLRP and lastly it broadcast the same information to all the Cluster-Heads of the network.
Cluster-Head Broadcasting Network Leaving Request Packet (CHNLRP): when a cluster head of a cluster receives node leaving request of a member node, after sending the CNLRP it broadcasts this information to all other Cluster-Heads in the network.
Node Joining other Cluster: There are situations where a Wireless Node wants to join another cluster within the same network. In this case node will send a Cluster Joining Request Packet (CJRP) to the Cluster-Head of the cluster to which it is already associated. The Cluster-Head in turn will forward this packet to the Cluster-Head to which the node wants to join. If the request is accepted by the other Cluster-Head then it will send a Confirmation Cluster Joining Request Packet (CCJRP) to the Cluster-Head to which the node is currently attached. The Cluster-Head in return will forward this joining confirmation packet to the node and will broadcast an Update Node Leaving Packet (UNLP) for the remaining nodes of the cluster. Once the node has merged with the other cluster a Merge Update Packet (MUP) is sent to the cluster head to which the node was previously attached.
Cluster Joining Request Packet (CJRP): This packet is sent by a member node of a cluster who wants to join another cluster.
Confirmation Cluster Join Request Packet (CCJRP): This packet is sent by the Cluster-Head who is willing to accept join request of a node associated to another Cluster-Head.
Merge Update Packet (MUP): This packet is sent by the new cluster head of the joining node to the previous cluster head with which it was previously associated.

2.2. Cluster Formation

This is one of the essential and necessary aspects of the proposed scheme. Since, the whole idea evolves around the cluster formation and their management, it could be well understood from the explanation of network formation procedure as adopted by CBGMS that it can serve one of the many purposes. Initially when NFP is sent it has an ‘Initiator Sequence

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Number' and 'Broadcast ID'. Whenever the NFP is received by any receiving node it increases the Broadcast ID by 1 and rebroadcast this packet for the other closest neighboring nodes with an incremented sequence number until the Sequence Number reaches to the maximum of '6'. It is important to note the node who receives this information will record it and being passed on to the next closest neighboring nodes. Once the Broadcast ID reaches to a maximum number of '7' the nodes will form a cluster and this process will continue until the packet reaches the final wireless sensor node.

2.3. Cluster-Head Formation

The selection of cluster head has been a topic of focus in schemes follow cluster based solutions. It could be noticed in the light of background literature that most of the proposed and reported schemes utilize relatively complex procedure for the selection of cluster head. With no doubt cluster head is one of the essential component in all the cluster based management schemes. In other words cluster based management is not possible without having a cluster head. Likewise no communication irrespective weather it is an intra-communication or Inter-Communication is achievable. Cluster Based Group Management Scheme introduces a novel and a new mechanism of cluster head selection. The initiator of the NFP will be considered as the cluster head of the first cluster and same procedure will be adopted for the selection of other cluster heads. To explain further, the nodes which receive NFP with a reset Broadcast ID will be taken as the cluster head of the next cluster and vice versa.

2.4. Intra-Cluster Communication

Intra-Cluster communication of wireless sensor nodes within a Wireless Sensor Networks is an important component of CBGMS. In general nodes gather information and pass this information to the Cluster-Head of the cluster with which it is associated. It arise the need of a procedure to assist Wireless Sensor nodes to communicating with each other. CBGMS relies on the following function to add Intra-Cluster communication among Wireless Sensor nodes of cluster.

Updating Cluster Information: In CBGMS sensor nodes are bound to initiate a Location Update Packet (LUP) for other nodes of the cluster. This packet contains node location information in the form Sequence Number

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and Broadcast ID. It helps nodes forming a path from itself to the cluster-Head of the cluster.
When LUP reaches to the Cluster-Head it broadcasts Location Confirmation Packet (LCP) using the same path through which it received ULP. This makes nodes aware of other nodes positions in the cluster.
Location Update Packet: This packet is sent by the Wireless Sensor Node towards the Cluster-Head containing node location information.
Location Confirmation Packet: This packet is sent by the Cluster-Head to the initiator of the LUP as a sign that the path has been established and the packet has been received.

2.5. Inter-Cluster Communication

Inter-Cluster communication is necessary to achieve the main objective for the formation of Wireless Sensor Network. An in-depth explanation of Intra-Cluster communication has been given above. Inter-Cluster communication in CBGMS is performed using the same principles as in the case of Intra-Cluster communication. It differs only by the fact that the former takes place within a cluster while the later is carried out between the cluster heads of a Wireless Sensor Network. It can be well understood that sensor node can be used for one of the many reasons i.e. data collection, monitoring etc. Sensor nodes collect the data and send it to the cluster head for further processing; cluster head in turn needs a path to transfer this data to the base station. This path is provided by the fellow cluster heads that form a chain from any cluster to the base station. Apart from some of the above mentioned scenario any change of any kind is notified using an update notification packet. For instance if a cluster head wants to change its location or finds a path break it broadcast an update notification packet to all other cluster heads of the network.
Update Notification Packet (UNP): This packet is sent by a cluster head that notices any change or wants to inform about a change to rest of the cluster head.

2.6. Power Saving Mode

Battery power is a valuable asset in the case of Wireless Sensor Networks. There could be one of many affects a node can leave on the network if its battery life is exhausted. On the other hand a Wireless Sensor node with higher battery power can play a significant role in overall operation of a

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Wireless Sensor Network. In order to conserve battery power of Wireless Sensor Nodes CBGMS introduces following measures. Nodes are allowed to switch between active and sleep state after a regular interval of time or if they are not engaged in an active session for a fixed period of time. This technique could be useful to increase the life of a Wireless Sensor node and to have better result from the deployment of such networks.

3. Implementation

We are in the process of implementation. The proposed scheme has been written in Java. SWANS has been selected as a simulation tool. The selection of SWANS is due to its capability of supporting large number of nodes. In other words, SWANS is known as highly scalable software. Initial results which have been taken so far show a satisfactory performance of the scheme. In addition, these results also confirm the practicality of the proposed scheme. However, detail results are yet to be obtained which will be presented in the future contributions.

4. Contributions

It is evident from the reported literature that group management within wireless sensors networks has attained primary focus. It is due to the fact that it is directly related to the main scope of such network deployment. In essence there was a need to have such solution that can full-fill the general requirements without posing additional burden on some of the essential resources of the participant nodes. Examples of such resources could be battery life and bandwidth. CBGMS has been developed after considering some of the related issues of wireless sensors networks. It has proved as beneficial in terms of saving battery life and bandwidth. It is due to the CBGMS capability of reducing control packets which otherwise are required in some of the traditional schemes. In addition, an effective structure of group communication has been added in a manner where minimum load has been placed on nodes of a group. With no doubt, another benefit of having group based schemes lies in the fact that such schemes has been showing better performance in supporting communication than schemes following different patterns. We are confident that this work could

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further be extended to be accepted as a standard communication solution for wireless sensors networks.

Conclusion and Future Work

Cluster Based Group Management Scheme (CBGMS) is a new addition in the family of Group Management schemes of Wireless Sensor Networks. CBGMS has been proposed and designed by taking into account main weaknesses of the existing solutions. We believe that CBGMS offers a reliable, cost effective and energy conserving way of Group Management within Wireless Sensor Networks. In the future we will be conducting various experiments to monitor the performance of the developed scheme in various simulation environments. We are committed to share our research findings with the ongoing research of this area.

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