International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064

Clustering Techniques for Network lifetime Improvement: A Survey

Sanjay Madaan[1], Dinesh Kumar[2], Robin[3]

[1]Student, GZS PTU Campus, Bhatinda, Punjab, Bathinda-Dabwali, India

[2]Assistant Professor, GZS PTU Campus, Bhatinda, Punjab, Bathinda-Dabwali, India

[3]Assistant Professor, IGCE, Abhipur, Mohali, Punjab, India

Abstract: ***This paper focuses on the theoretical aspects of clustering techniques in wireless sensor networks, as a mean to improve network lifetime and time synchronization between sensors. Wireless sensor networks (WSNs) are large-scale networks of small low-cost and low-power sensors, to observe and monitor various aspects of physical world. In WSN, data from each sensor is ag-glomerated using data fusion to form a single meaningful result, which makes time synchronization between sensors highly desirable. In this paper, some of the clustering protocols, which have been implemented to improve the network lifetime and clock synchronization, are illustrated. It has been investigated that employing these protocols to select the cluster head results in better performance as compared to non-clustered network and summarize existing clock synchronization protocols based on a palette of factors like precision, accuracy, cost, and complexity.***

Keywords: WSN, Clock Synchronization, Clustered Network, Sensor Network

1. Introduction

The recent developments in making energy efficient Wireless Sensor Network is giving new direction to deploy these networks in applications like surveillance, industrial monitoring, traffic-monitoring, habitat monitoring, cropping monitoring, crowd counting etc [1]. The growing use of these networks is making engineers to evolve innovative and efficient ideas in this field. Main issues in such networks are summarized here. First, minimizing the battery backup of each sensor's in such a vast network and the sizes of sensor restrict the amount of energy that can be stored and procured. Second, clock synchronization protocols, used to provide common notion of time for fusion of individual sensor readings, which is possible only by exchanging messages that are time stamped by each sensor's local clock.

1.1 Sensor Network Architecture

In sensor network architecture, we can possibly deployed in extremely large number of sensor nodes or devices. Sensor network consist of a sensor field, where the sensor nodes are deployed that is physical environment, which is shown in Figure1. A low-cost device can thus be expected to have fairly limited computational and communication capabilities, considering the fact that sensing capabilities are also to be included in the device. Sensor nodes are deployed in many applications, where human intervention is not easy to maintain the sensor node. These type of sensor nodes where human intervention is not possible there sensor nodes are operate on limited battery power. These batteries are not easily replaced. Sensor nodes have a limited power, so they have to be designed in such a way, that sensor nodes use the power in an efficient way. Sensor nodes automatically shut down when they are not in use.

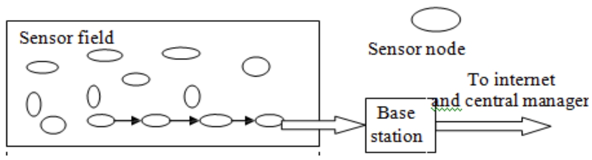

Figure 1.1: A Wireless Sensor Network

For more specific applications like physical intrusion detection, sensor nodes have more advanced capabilities which are not in other nodes that are used in simple fields. Thus, sensor devices may range from millimeter-sized devices fabricated on custom silicon to more general purpose cell-phone-sized devices with advanced capabilities. Figure1.1shows simple sensor network architecture, in this sensor nodes are deployed with limited capabilities in a sensor field. The sensor nodes are communication to a powerful base station. Base station links sensor nodes with internet and a central manager for processing the sensed data which is given by sensor nodes. All the sensor nodes will not able to communicate direct to base station, so sensor nodes go through from several nodes, which are connected to each other. May be sensor nodes are not in range of base station, due to limited communication range and soon. Base station or gateway may have other storage and processing capabilities that are useful for other applications. The base station is more powerful in sensor network.

1.2 Structure of a Wireless Sensor Node

As shown in Figure1.2 internal architecture of a sensor node. It consists of:
- Power management
- Sensing unit
- Processing unit
- Storage and timing sync
- Transceiver
- Medium access

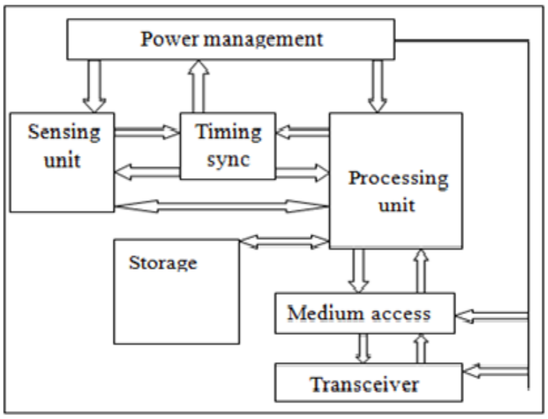

Figure 1.2: Schematic of a Sensor Node

A desirable sensor network should be able to meet following requirements:

- Reduce energy usage
- Improve security
- Provide convenience
- Reduce labor expenses

2. Classification of Clustering Techniques

Clustering algorithms for wireless sensor networks can be further divided into two main categories depending on cluster formation criteria and parameters used for cluster head election [2]:

a) Probabilistic (random or hybrid) clustering algorithms: Low Energy Adaptive Clustering Hierarchy (LEACH), Energy-Efficient Hierarchical Clustering (EEHC), Hybrid Energy-Efficient Distributed Clustering (HEED), etc.
b) Non probabilistic clustering algorithms: Node Proximity and Graph-Based Clustering Protocols, Weight-Based Clustering Protocols, Biologically Inspired Clustering Approaches. Clustering in WSNs involves grouping nodes in to clusters and electing a cluster head such that [3]:
   - The members of a cluster can communicate with their cluster head (CH) directly.
   - A cluster head can forward the aggregated data to the central base station through other CHs.

2.1 LEACH Protocol

LEACH Protocol is a clustering-based protocol that utilizes randomized rotation of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network. There are many more improved forms of LEACH like E-LEACH, LEACH-SM, multi-hop-LEACH, ENCM and so on. LEACH protocol contains two phases [5]:

- **Cluster set up phase**
  In this phase the each node describes whether or not to become a cluster head for current round. All the nodes choose a random number 0 or 1 for made a decision. A threshold value is setup, if the number of the node is less than threshold value, then the node becomes a cluster head for current round.
- **Steady phase**
  The network will enter the steady phase when the cluster head assign time slots to its members for using TDMA mode. The steady phase is divided into frame, where nodes send their data to the cluster head at most once per frame during their allocated transmission slot [4].

2.1.1 Improvement on LEACH Protocol

a) Energy-LEACH protocol
Energy-LEACH protocol improves the choice method of the cluster head, makes some nodes which have more residual energy as cluster heads in next round [5].

b) Multi hop-LEACH protocol
Multi hop-LEACH protocol improves communication mode from single hop to multi-hop between cluster head and sink. Simulation results show that energy-LEACH and multihop-LEACH protocols have better performance than LEACH protocols Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol is a clustering based protocol to collect data from wireless network.

c) LEACH-SM protocol
The LEACH-SM protocol modifies the prominent LEACH protocol by providing an optimal energy-saving spare management, including spare selection. LEACH-SM adds the spares election phase to LEACH [6].

d) HARP protocol
HARP, a Hierarchical Adaptive and Reliable Routing Protocol, a clustering algorithm which builds inter-cluster and intra-cluster hierarchical trees, which are optimized to save power. This architecture is scalable and can be used in both homogeneous and heterogeneous wireless sensor networks. By means of the addition of a recovery slot in the scheduling scheme, HARP provides efficient link fault tolerance and also supports node mobility management. The same process can additionally function as a joining mechanism for newly deployed nodes. This architecture is highly adaptive to specific application requirements and provides bounded-time data transmissions. This protocol optimizes and balances the energy consumption in the network [7].

e) E-LEACH Algorithm
In the E-LEACH algorithm, the original way of the selection of the cluster heads is random and the round time for the selection is fixed. In the E-LEACH algorithm, we consider the remnant power of the sensor nodes in order to balance network loads and changes the round time depends on the optimal cluster size [8].

f) HEED protocol
HEED (Hybrid Energy-Efficient Distributed clustering) protocol periodically selects cluster heads according to a hybrid of the node residual energy and a secondary parameter, such as node proximity to its neighbors or node degree [9].

3. Clock Synchronization in Wireless Sensor Networks

Sensor networks can be best exploited by applications that perform data fusion to synthesize global knowledge from raw data on the fly. Although data fusion requires that nodes be synchronized, the synchronization protocols for sensor networks must address the following features of these networks [10].

Challenges of sensor networking
- Limited Energy
- Limited Bandwidth
- Limited Hardware
- Unstable Network Connection
- Tight coupling between sensors and physical world

Several clock synchronization protocols have been developed in the past few decades. Some of the representative protocols are: Remote clock reading method (Cristian's protocol), Time Transmission Protocol (TTP), Offset Delay Estimation method (Network Time Protocol (NTP)), set-valued estimation method and so on. One of above mentioned clock synchronization protocol is summarized below:

3.1 Network Time Protocol (NTP)

Network Time Protocol (NTP), which is widely used for clock synchronization, uses Offset Delay Estimation method [10]. The design of NTP involves a hierarchical tree of time servers. The primary server at the root synchronizes with the UTC. The next level contains secondary servers, which act as a backup to the primary server. At the lowest level is the synchronization subnet which has the clients [11].

3.1.1 Clock offset and delay estimation [11]

It is difficult for a source node to accurately estimate the local time on the target node due to varying message or network delays between the nodes. In this protocol several trials are performed and the trial with the minimum delay is chosen. The Cristian's remote clock reading method also relied on the same strategy to estimate message delay.

The NTP protocol is best explained in [11]. Here we are summarizing the protocol as follows.

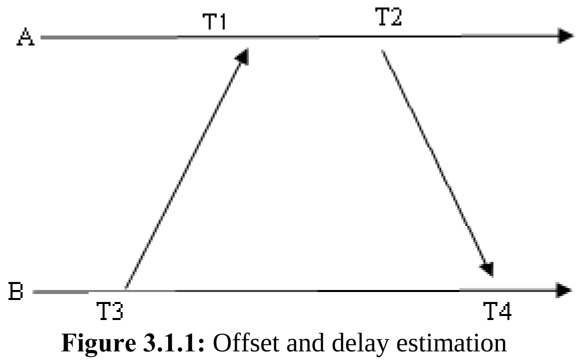

Figure 3.1.1: Offset and delay estimation

Figure 3.1.1 shows how NTP time stamps are numbered and exchanged between peers A and B. Let T1, T2, T3, T4 be the values of the four most recent timestamps. Supposed that clocks A and B are stable and running at the same speed. Let a=T1−T3 and b=T2−T4. If the network delay difference from A to B and from B to A, called differential delay, is small, the clock offset θ and roundtrip delay δ of B relative to A at time T4 are approximately given by the following.

$$\theta = (a+b)/2,\ \delta = a-b$$

Each NTP message includes the latest three timestamps T1, T2 and T3, while T4 is determined upon arrival. Thus, both peers A and B can independently calculate delay and offset using a single bidirectional message stream [12].

3.1.2 Demerits

The disadvantage is that it leads to a high synchronization overhead in terms of message complexity and reduced accuracy. However, accuracy of the network time protocol is better than for Cristian's protocol because delays are partly compensated [12].

4. Conclusion

The energy consumption and clock synchronization of sensor nodes is a major issue in wireless sensor networks. A lot of research is available in the literature and more is needed to be done to reduce the energy consumption in wireless sensor networks. The clustering of sensor nodes and clock synchronization protocols are efficient technique to improve lifetime of the sensor network and synchronization respectively. The protocols which have been used to achieve satisfactory results have been discussed in this paper and more efficient protocols can be used with clustering to reduce energy consumption.

5. Future Scope

In this paper, we discuss the various protocols that have been used for clustering, process of dividing the WSN in to group of nodes known to be clusters, and how the concept of clustering is employed in WSN to increase the lifetime of the network. We also discuss the NTP protocol, which can be further implemented in WSN with enhancement, to achieve the better results in terms of less packet drop and increase in network throughput. The future scope of this paper is to achieve satisfactory results and more efficient protocols can be used with clustering to reduce energy consumption in low powered sensor nodes and to synchronize the nodes in WSN.

References

[1] M. Asha Kiran B. Poorna Satyanarayana "Analyzing the Peer to Peer Traffic using Cache Nodes in Wireless Sensor Networks" International Journal of advanced and innovative research (IJAIR), Oct. 2012.
[2] Basilis Mamalis, Damianos Gavalas, Charalampos Konstantopoulos and Grammati Pantziou "Clustering in Wireless Sensor Networks" RFID and Sensor Networks, pp.323, june2009.
[3] OssamaYounis, Marwan Krunz, and Sri nivasan Rama Subramanian "Node Clustering in Wireless Sensor Networks: Recent Developments and Deployment Challenges", Volume 20, Issue3, pp. 20-25, 2006IEEE.
[4] JiaXu, Ning Jin, Xizhong Lou, Ting Peng, Qian Zhou, Yanmin Chen "Improvement of LEACH protocol for WSN" International Conference on Fuzzy Systems and Knowledge discovery(FSKD), pp. 2174-2177, 2012IEEE.
[5] Fan Xiangning and Song Yulin "Improvement on LEACH Protocol of Wireless Sensor Network" 2007 IEEE.

[6] Bilal Abu Bakr and Leszek Lilie "A Quantitative Comparison of Energy Consumption and WSN Lifetime for LEACH and LEACH-SM"2011 IEEE.
[7] F.J. Atero, J.J.etal. "A Low Energy and Adaptive Architecture for Efficient Routing and Robust Mobility Management in Wireless Sensor Networks" 2011 IEEE.
[8] DahlilaP. Dahnil, etal. "Energy-Efficient Cluster Formation in Heterogeneous Wireless Sensor Networks: A Comparative Study" Feb.2011.
[9] Peyman Neamatollahi, et al. "A Hybrid Clustering Approach for Prolonging Lifetime in Wireless Sensor Networks" 2011 IEEE.
[10] D. L. Mills. "Internet Time Synchronization: the Network Time Protocol." IEEE Trans. Communications, Vol 39,no 10, pp. 1482–1493, Oct. 1991.
[11] Bharath Sundara raman, Ugo Buy, and Ajay D. Kshemkalyani. "Clock Synchronization for Wireless Sensor Networks: A Survey" University of Illinois at Chicago, March 22, 2005.