Hybrid Topology Control based on Clock Synchronization in Wireless Sensor Network

Navneet Kaur* and Rajan Kumar

Department of Computer Science and Engineering, Chandigarh University, Mohali - 140413, Punjab, India;
navneetbajwa.kaur1@gmail.com, cucse.rajan@gmail.com

Abstract

Objectives: The main objective of this work is to lessen energy utilization of Wireless Sensor Network. The Radio Frequency Identification is the protocol of Wireless Sensor Network which provides channel access using TDMA protocol. Due to weak clock synchronization of sensor nodes TDMA protocols do not work efficiently. The improvement will be proposed in Radio Frequency Identification protocol to synchronize clocks of sensor nodes for efficient working of TDMA protocol. **Methods:** To reduce energy consumption of sensor networks various operation modes are used and these modes are sleep, active and ready mode. The TDMA protocol is used to assign time to sensor nodes for efficient execution of these modes. In the sensor network clocks of the sensor nodes are weakly synchronized due to which packet loss may occur due to which network lifetime get reduced. The proposed improvement and existing Radio Frequency Identification protocol is simulated in NS2 with finite number of sensor nodes on area of 800*800 meter. The LEACH protocol is used for clustering and for Cluster Head selection. **Findings:** In this paper, improvement is being proposed in Radio Frequency Identification protocol for clock synchronization and proposed improvement in based on time lay technique. In time lay technique base station takes initiative to synchronize clocks of the sensor nodes. It is been analyzed that proposed algorithm performs well in terms of energy consumption, throughput and delay.

Keywords: Cluster Head, Diffusion, Leach Protocol, RFID (Radio Frequency Identification) Protocol, Time Lay Protocol

1. Introduction

A Wireless Sensor Network includes a large number of nodes unfold over an exact discipline. The entire sensor nodes are allowed to keep in touch by means of a wireless medium[1]. Many techniques are proposed for energy saving, clustering is considered one of them. Through making use of the bully algorithm the Cluster Head is chosen signifies that node which has the very best power with the intention to be the Cluster Head. To hinder the collision the RTS-CTS based process is used the clock is synchronized on each and every Cluster Head. RFID is used for the channel sensing to preclude the collisions. In present work, all the sensor nodes are not synchronized which create the problem of energy consumption and packet loss. So, we have deployed a technique in which all the sensor nodes should be synchronized to avoid the packet collision.

1.1 There are many Challenging Issues of Wireless Sensor Network

- **Type of Service:** The service sort as perceived by a conventional communication network basically includes moving bits starting with one place then onto the next[2].
- **Fault Tolerance:** Due to some of factors, which may be physical damage to the node or dead battery, a node may run out of use. This leads to a broken link. Overall functioning of the network should not be affected by this. One way to overcome such a problem

---

is by deploying redundant nodes[3].

- **Scalability:** Number of nodes in real life is for the most part application subordinate. Since such number changes from hundreds and thousands of nodes per WSN, the utilized architectures and protocols must be capable to these numbers[4].

- **Wide Range of Densities:** Number of nodes per unit area otherwise known as node density is a variable amount per WSN or inside a network. Likewise node density is not homogeneous through put the network, density can differ after some time and space. Network ought to be sufficiently flexible to adjust to these varieties[5].

- **Routing Protocols:** There are countless quantities of routing protocols accessible for WSNs[6]. Routing is the procedure of discovering best path through which data can be sent from source to destination which is for the most part base station[1]. Different routing protocols can be comprehensively ordered into three categories as shown in Figure 1.
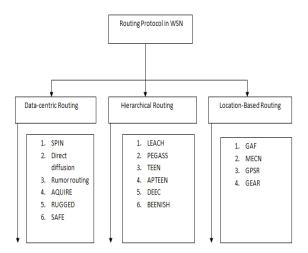

Figure 1. Routing protocol in WSN.

In[7] proposed a protocol named Efficient Sleep Awake Aware (EESAA) Intelligent Sensor Network Routing Protocol for homogeneous networks while keeping the merits of distributed clustering as well. Two nodes belonging to same application and nearest to each other are grouped into a pair. There is deployment of GPS (Global Positioning System) to collect location of all nodes. The paired nodes switch between Awake and Sleep mode. Cluster Heads are selected by distributed algorithm. In this way EESAA minimizes energy consumption while

optimizing stability of network much more than LEACH, SEP and DEEC. In[8] proposed Hierarchical Routing Protocols for performance investigation of four cluster based hierarchical routing protocols; LEACH, TEEN, SEP and DEEC. Correlation is finished by mimicking these in MATLAB. Performance matrices taken are number of alive nodes, number of dead nodes and packets are sent to BS. Sensor nodes can maintain their energy just for certain number of rounds. Making nodes to keep going for more number of rounds, expands network lifetime. Clustering procedure is clarified in form of three states: Advertisement state, Setup state and Steady state. At last after watchful examination of the outcomes acquired, author has reasoned that DEEC outperforms among different protocols by giving doable ideal arrangements against limitations of displayed edge work. In[9] proposed Centralized Energy-Efficient Clustering (CEEC) routing protocol. This protocol has been implemented for three levels of heterogeneity. It tries to address the drawbacks of SEP, E-SEP and DEEC. In these protocols there is no provision for uniform geographical dissemination of high-energy nodes which are most likely to assume the role of Cluster-Heads. Also the distributed clustering algorithm introduces the additional computational overhead. In CEEC, base station is fixed with additional responsibility of selecting optimum number of Cluster Heads. The network topology is segmented into three local regions for three types of nodes present with base station on top. Normal nodes are present nearest to BS while super nodes are placed at the far end. Guaranteed number of CHs increases the throughput of CEEC. In[10] introduces Distributed Topology Control Techniques for Extending the Lifetime of Battery Powered WSN's, nodes operate with a restrained battery supply they usually discontinue working as soon as their battery drain. Consequently, a network's existence span is strongly based on battery lifetime. In[11] proposed Novel energy effective and lifetime Maximization Routing Protocol in Wireless Sensor Networks which recommends another path for energy productivity through multipath routing plan. Rather than routing every one of the data through a solitary low cost routing path, EERP (Energy-Efficient data Routing Protocol) conveys the traffic crosswise over different great paths chose on the bases of cost function and node energy. All nodes keep up Neighbours Information Table to gaze upward for neighbour with least cost. Thus dispersion of Network Load delays some specific nodes to come up short on energy and produce

segment in the network. This upgrades network stability and lifetime. In[2] proposed an energy efficient dynamic power management technique. Network uses energy in communication. Another path for power consumption is at every node level itself. Author we can diminish power devoured by every sensor node by closing down a few components of sensors according to our algorithm which improves network lifetime and unused different resources. Energy consumption in Wireless Sensor Networks is impacted by numerous factors.

2. RFID Protocol

RFID (Radio Frequency Identification) is a programmed identifies ability which is established on radio reoccurrence.

2.1 Active Radio Frequency Identification

Active Radio Frequency Identification frame make the most an interior vigor source (battery) inward the tag to continuously abilities the tag and its RF conversation hardware. It permits low-level indicators to be constructed up through the tag. The tag can deliver abnormal state signals again to the each user, driven from its inside vigor cause[12].

2.2 Passive Radio Frequency Identification

Passive Radio Frequency Identification built upon RF energy which exchanged from the pursuant to the tag to potential the tag. Passive Radio Frequency Identification either 1. Reflects power from the pursuant or 2. Absorbs and transiently stores a next to no measure of power from the pursuant sign to bring its own quick reaction[13].

Active Radio Frequency Identification is much less beneficial than passive Radio Frequency Identification in respect to its tag fee, dimension and battery management[14].

Radio Frequency Identification offers the Point-To-Multipoint (P2MP) communication constitution the place the reader fees the tags[15]. To drain the energy ingesting of the tag, the reader reins the vigor that the radio module take in by way of making the tags are working in the lively and sleep durations. The reader transfers a set requirement to multiple tags which convey identity to the reader with contention. Information collection interval, the reader collects the information on the tags that are detected from the tag identification collection interval use their IDs with the support of the Point-to-Point (P2P)

system. The active period is partitioned into two periods initial one is the tag recognizable proof period and other is the information collection period. The identification interval is called contention period[16]. A reader can send a command to a couple of tags which also carry id to the reader by way of contention. In the know-how assortment period, the reader collects the information on the tags which are detected from the tag identification, by the use of the Point-to-Point (P2P) scheme. At that point the sleep command hit the radio module of the tag from which the info had been collected. That is often called the collection interval (CP). The reader repeats this process except the entire tags within its communication range are accrued. As proven in Table 1 difference amongst energetic and passive improvements as follows:

Table 1. Technical difference between Active Radio Frequency Identification and Passive Radio Frequency Identification

	Active RFID	Passive RFID
Tag Power Source	Internal to Tag	Energy transferred from the reader through Radio Frequency
Availability of Tag Power	Continuous	Only inside field of reader
Tag Battery	Yes	No
Available Signal Strength from Tag to Reader	High	Low
Required Signal Strength from Reader to Tag	Low	High

2.3 Network Time Protocol

NTP is a protocol build after exchanging of packets and gives clock synchronization within computer systems. It is a web protocol with few interfaces also. Network Time Protocol is a protocol that is spread on top of TCP/IP that ensure the time to time and clock on the radio that is inflexible. Within milliseconds, this protocol is prepared to do synchronization of spread clocks over long time periods[17].

2.4 Global Positioning System

Nodes synchronized there clock pursuant to the GPS which is drive about as a master clock. So GPS is a master clock and every other node which brings to slaves and set their clock according to the master clock. When the data is transfer from source to destination through the intermediate node and then these nodes send data on
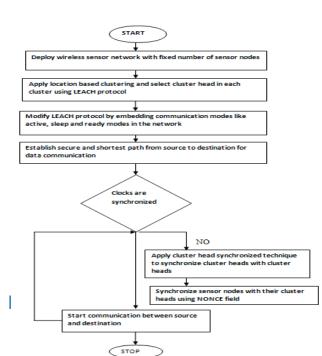
time immediately.

2.5 Clock Synchronization

Clock synchronization is a technique in which each of the nodes in a network combine in the meantime slot. In this procedure each of the nodes or Cluster Head of the node set their time slot according to the master node[18]. Clock synchronization has two techniques:

- Time-lay synchronization.
- Diffusion based synchronization.

In time-lay synchronization, all the nodes of the network set there clock pursuant to the third party clock. In diffusion based technique, any two nodes set there clock depend upon the communication with each other.

3. Proposed Methodology

To begin with send the sensor community with unlimited sensor nodes. The entire sensor nodes are gathered inside clusters. In step with the sensor nodes, clusters are shaped. Every staff has a Cluster Head. Cluster Heads are picks with the aid of alternative algorithm. A node in a cluster which has many assets and energy is chosen for Cluster Head. Every cluster node sends clock time to Cluster Head. After this Cluster Head calculate average clock time and set their clock pursuant to average clock. Presently Cluster Head convey its clock time to alternate nodes of the cluster. Nodes set their clock according to the Cluster Head node. All the Cluster Heads works in the comparable strategy. Presently to synchronize with the network, all the Cluster Head calculate their average time. According to the outcome, all the Cluster Head set their time as shown in Figure 2.

4. Experimental Results

As shown in Table 2, the various parameters values which are used for the simulation.

Table 2.   Parameter table

Antenna type	Omi directional
MAC layer	802.11
Number of nodes	40
Link layer type	LL
Channel type	Wireless channel
Area	800*800

The whole scenario is implemented on NS2.

In Figure 3 power consumption of past and novel process is seemed. The red lines exhibit the power of past approach. The green line demonstrates the energy utilization within the novel approach. The clocks previously procedure should no longer synchronize and constant route are from source to destination. Due to the fact the truth that of these two explanations retransmission of the parcels are required when parcels loss is there inside the network. Within the novel process clocks are synchronized with master clock. The virtual route is built up amongst source and destination. The power utilization is diminished seemed inside red line. This charts displaying as a novel process is effective than the present system.
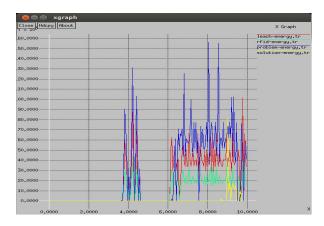

Figure 3.   Energy consumption.

Figure 4 determines the throughput of the novel as well as past method. The green line indicates the throughput of the network in earlier procedure. The throughput of the brand new method is appeared into red line. The mass creation of the network upgraded through the clock synchronization. The throughput of the approach is upgraded making use of new proposed procedure considering the parcels loss within the network is lessened.
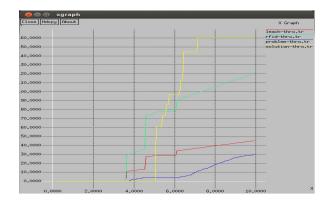
Figure 4. Throughput.

The packet loss diagram is appeared within Figure 5. The packet loss is larger in past procedure. Up to now performance clocks of Cluster Heads in most cases aren't well timed synchronized. That is the motive that packet loss is higher is extra previously procedure. The packet loss within the new procedure is diminished, in light of the truth that the clocks of the Cluster Heads are synchronized with the diffusion system.

Figure 5. Packet loss.

5. Conclusion

In present work, all the sensor nodes are not synchronized which create the problem of energy consumption and packet loss. So there is a need of novel technique which helps to reduce energy consumption in terms of energy, packet loss and delay. Now we have deployed a manner wherein all the sensor nodes should be synchronized to prevent the packet collision. In this scheme nodes are synchronized according to the Cluster Head clock. After that all the Cluster Head set their clock by calculating

average time of the clock. In this way, synchronized has been solved.

6. References

1. Akyildiz IF, Su W, Sankarasubramaniam Y Cayirci E. Wireless Sensor Networks: A survey. Computer Networks. 2002; 38:393–422.
2. Shelke R, Kulkarni G, Sutar R, Bhore P, Deshmukh N, t Belsare S. Energy management in Wireless Sensor Network. IEEE 2013 UKSim 15th International Conference on Computer Modelling and Simulation (UKSim); 2013 Apr. 668–71.
3. Hoglar K. Andreas W. Applications and challenges of Wireless Sensor Networks, Protocols and Architecture for Wireless Sensor Networks. 1st ed. England: John Wiley and Sons Ltd: 2005. p. 6–94.
4. Akyildiz IF, Su W, Sankarasubramaniam Y, Cayirici E. A survey on sensor networks. IEEE. 2002 Aug; 40(8):102–14.
5. Elbhiri B, Saadane R, Fkihi SE, Aboutajdine D. Developed Distributed Energy Efficient Clustering (DDEEC) for heterogeneous Wireless Sensor Networks. IEEE; 2010. p. 1–4.
6. Saini P, Sharma AK. E-DEEC - Enhanced Distributed Energy Efficient Clustering Scheme for heterogeneous WSN. International Conference on Parallel, Distributed and Grid Computing; 2010. p. 205–10.
7. Shah T, Javaid N, Qureshi TN. Efficient Sleep Awake Aware (EESAA) Intelligent Sensor Network Routing Protocol. IEEE; 2012. p. 1–6.
8. Latif K, Jaffar M, Javaid N, Saqib MN, Qasim U, Khan ZA. Performance analysis of hierarchical routing protocols in Wireless Sensor Networks. 5th International Workshop on Next Generation of Wireless and Mobile Networks; 2012. p. 1–6.
9. Aslam M, Shah T, Javaid N, Rahim A, Rahman Z, Khan ZA. CEEC: Centralized Energy Efficient Clustering a New Routing Protocol for WSNs. 2012 9th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), 2012. p. 103–5.
10. Aziz AA, Sekercioglu YA¸ Fitzpatrick P, Ivanovich M. A Survey on Distributed Topology Control Techniques for Extending the Lifetime of Battery Powered WSN's. IEEE Communications Survets and Tutorials. 2013; 15(1):121–44.
11. Boulfekhar S, Benmohammed M. A novel energy efficient and lifetime maximization routing protocol in Wireless Sensor Networks. Wireless Personal Communications. 2013; 72(2):1333–49.
12. Qureshi TN, Javaid N, Khan AH, Iqbal A, Akhtar E, Ishfaq M. BEENISH: Balanced Energy Efficient Network Integrated Super Heterogeneous Protocol for Wireless Senor Network. Elsevier. 2013; 19:920–5.
13. Yick J, Mukherjee B, Ghosal D. Wireless Sensor Network survey. Department of Computer Science. 2008; 52(12):2292–330.

14. Dargie W, Poellabauer C. Motivation for a Network of Wireless Sensor Nodes, Fundamentals of Wireless Sensor Networks. England: John Wiley and Sons Ltd; 2010. p. 3–9.

15. Al-Karaki JN, Kamal AE. Routing techniques in Wireless Sensor Networks: A survey. IEEE Wireless Communication; 2004. p. 6–28.

16. Ravi Kumar K, Raghu SreePraneeth K, Sreeja G. Efficient usage of resources through RFID Cards. Indian Journal of Science and Technology. 2016; 9(17):1–4.

17. Priyanka DD, Jayaprabha T, Florance DD, Jayanthi A, Ajitha E. A survey on applications of RFID Technology. Indian Journal of Science and Technology. 2016; 9(2):1–5.

18. Somasundaram K, Saritha S, Ramesh K. Enhancement of network lifetime by improving the leach protocol for large scale WSN. Indian Journal of Science and Technology. 2016; 9(16):1–6.