

Contention Window based MAC Protocol in WSN

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Abstract

In the proposed work, the virtue of RL-MAC Protocol have been exploited and for the purpose of clustering much efficient LEACH protocol is utilised where the selection of cluster head is done keeping distance and energy into consideration. In this new proposed work, additional elevation in efficiency is proposed in RL-MAC protocol by using the concept of clock synchronization. In the proposed protocol the sensor node's clocks will be synchronized according to the MAC time. Whenever the time of the various cluster heads mismatches, then the cluster heads of each cluster corrects their clocks time according to the time of sink node. Further Sensor nodes are synchronized with cluster heads. The presented new technique's network behaviour has been modelled and simulated in software environment on NS2 platform. The graphical curves advocate that this technique excells previous RL-MAC protocol in terms of parameters like energy, throughput and packet loss in the network.

Keywords- Minimum contention window, Crosslayer routing, Adaptive time synchronization.

Introduction

The novel research and developments have resulted in providing significant energy efficient Wireless Sensor Network and have opened new avenues to deploy sensor networks in applications as, works in a military surveillance, smart agriculture, industrial monitoring, smart home and bridge system, traffic monitoring, natural habitat monitoring, crowd counting, animal rearing etc. The extensive deployment of these networks is attracting and motivating researchers and engineers to evolve and experiment new innovative ideas in same fields and naive fields also. WSN as being used for information gathering thus a lot of work is exclusively done and still have scope in areas like data routing, data streaming, data aggregation and data compression [1].

A sensor network containing the sensor nodes utilizes various means of wireless medium for communication [1]. The sensor network's wireless communication may either use radio frequencies, infrared or WIFI. These nodes are spatially power consumption. So energy conservation during data communication needs to be addressed. The lifetime of wsn nodes defines the lifespan of any Wireless Sensor Networks. Maximum the no of energised nodes more efficient is the network. Sensor nodes can get drained out of power causing node failure. In such case to get reliable, continuous and non hindered utility from the network, the network must be equipped with logically self

distributed within the network and communicate forming an ad-hoc network. Since WSN's nodes are very small and that can be charged initially only, thus the major problem concern is limited battery life of the sensor nodes [2]. Apart from the limited battery life, the size of the sensor nodes also restricts capacity and size of processers and data storage. So with the limited energy resource the main inviting area of concern is obtaining efficient energy consumption and conservation for adequate wireless sensor networks functioning. WSN being like an ad-hoc network a lot of routing information along with the sensed data has to reach within nodes and to base station as well and there are applications like industrial monitoring, health monitoring etc where information need to be conveyed quickly to avoid occurrence of any mishap [3]. In Wireless Sensor Networks the major power drain occurs due to data communication, while internal processing comparatively amounts to very little

regulating and surviving sensibility every instant. It may happen that a cumber node gets dead due to meagre battery residue [4]. Thus for said conditions the used network protocol should be sufficiently astute to mitigate and handle such collapses and drive network functional. In this field Among various MAC Protocols the intelligent and flexible RL-MAC protocol outperforms others in terms of mitigating energy consumption, using duty cycling

mechanism, cross-layer routing and location based organisation scheme to provide adaptive nodes which starts with un-uniformly configured minimum sized contention window value. RL-MAC protocol also reduces the amount of useless communication [5].

Since the main concern is to extend the lifetime of the battery in order to increase the efficiency ie. Quality of service of WSN system, this could be obtained by reducing the useless communication. Another way is to manage and use such sensing system which utilizes low power components, also sensing over regular intervals or required instants could be used. The consumption of energy in power supply subsystem which owns the battery, can also be reduced by mitigating the current significantly or even stopping the unnecessary current drive by turning it off during dormant periods. CLUSTER formation method is another great method for saving the energy of sensor nodes [6]. In clustering approach the nodes are organised in a two-tier hierarchy, all the node involved in the sensor network are partitioned into different small groups called clusters, within the cluster's member nodes one having the maximum resilient energy is made cluster head. a two tier hierarchy within WSN is formed, higher tier consisting of all Cluster heads, while lower tier consisting of member nodes, and for this to be done we require efficient network organisation. Choosing cluster heads is a periodic process, and cluster heads acts as an interface between other cluster nodes and sink. Cluster head gathers data from the other member nodes within cluster, which it further communicate and the aggregated data is given to base station [7]. RFID (Radio Frequency Identification) a fantastic technique clubbed with wireless sensors which perform contactless detection and orientation finding of varying objects. Prime task of wsn's is sensing objects and capturing information regarding the condition of the object, RFID enables this by using electromagnetic fields for automatic identification. The purpose of RFID is to enhance the duration of storage and sensing of physical information, and thus improve on the quality of the system apart from performing usual navigation for information [8].

Proposed Time Synchronization

Since the sensor nodes are thrown randomly into the environment or area which is to be sensed. These nodes mostly works on TDMA system to avoid collision and qiosk. Still collisions occur corrupting data and requirring retransmission of data, this happens because the time notion at different sensor nodes may vary or drift with time. Thus all the nodes need to have a unified concept of time, granting a common notion of time to all the sensor nodes. To make the WSN work efficiently time synchronization within sensor network as well with the outside world is to be maintained. To provide a global clock uniformity Time Synchronization with the outside world is required. But in our paper we are concerned with the synchronization of sensor nodes within the system. When the gathering of data or information from various sensor nodes in a system area is done, this event of gathering should be synchronized in an order to avoid collisions and corruption of data, and also synchronised data is efficient for data fusion giving meaningful output. Thus very precise Time Synchronization is required to know the order of events sensed by the nodes, and for providing accurate data fusion. These precaution and accuracy saves from retransmission of data, collision, unnecessary overhead traffic and unnecessary communication. Hence resulting in providing much energy efficient RL-MAC WSN network system. Since RL-MAC itself utilizes duty cycle and thus to have an accurate and precise sleep/listen schedule sensor nodes need to be perfectly synchronized in order to avoid over hearing.

Since WSN's are different from adhoc and wired Network thus the Time synchronization protocol for them is also exclusive, it must be capable to address certain issues of WSNs like limited available energy, limited bandwidth, limited hardware, limited transmission range, limited storage space and restricted computational abilities of a node. Thus challenge is to design an energy efficient light weight clock synchronization mechanism for WSNs requirring less communiation overheads [8].

Being such an attractive field, since past decade Researchers have been working and investigating on time synchronization in WSNs. And have proposed various Time Synchronization protocols,

like RBS,TPSN,PBS,IPBS, DMTS,FTSP,ATSP and many more.but most of the protocols concentrated on improvement of synchronization accuracy , not giving much heed toward energy consumption and multilayer clustering and hopping.Thus we need to generate and apply an Adaptive Time Synchronization technique concentrating on removal of drawbacks discussed and providing faster execution speed and refined performance.

Research Methodology

The proposed approach utilizes the concept of MAC time for establishing precise clock synchronization of sensor nodes within the network. The information sending node would send its current time header along with the gathered data to its cluster head. On receiving the packet, cluster head scans the time header, if the scanning finds a mismatch of time between the sensor nodes and their cluster heads , then modification and correction of clock is done according to the present time. The second and the final phase of clock synchronization involves modification of the cluster heads clocks in accordance to the current time stamp from the nearby cluster heads.Once the synchroniation of

the complete network is done ,the efficiency of the wsn system rises.Since all the sensor nodes and cluster heads work in sync and harmony ,thus there is reduced collisions and packet loss.This scenario results in upraising the performance of the network ,increasing throughput and packet delivery ratio, along with significant energy saving steadily.With the increased energy efficiency lifetime of the wsn system elongates.

We simulate a WSN system consisting of N no of nodes which is grouped into K no of clusters . Time Synchronization procedure begins from sink node, according to it cluster heads get synchronized,further cluster nodes CNs get into synch with their cluster heads CHs ,for that they need time synchronization node (TSN)as mediator ,where CHs decides which node would act as TSN [8]. In order to mitigate the handshaking messages for synchronization amongst sensor nodes our new proposed algorithm incorporate broadcasting of messages amongst clusters. The nodes within network can easily identify each other and messages ment for them as each sensor node acquire unique ID .If there exist any time difference between these nodes its calculated as offset [8].

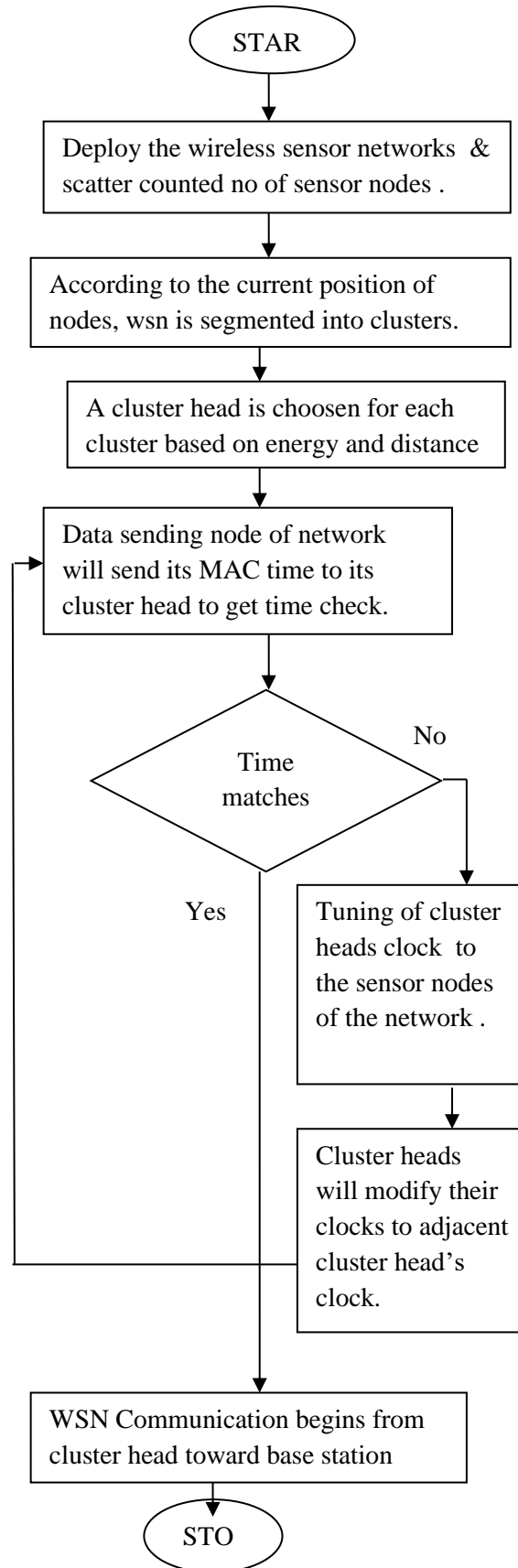


Fig. 1 Proposed Flowchart

Algorithm 1. Time Synchronization

1. By using leach clustering clusters are organized and cluster heads are chosen

2. Initially cluster heads are synchronized according to Sink following algorithm2.
3. Then each member nodes of the cluster is synchronised with their cluster head following algorithm3.

Algorithm 2. Synchronization between cluster heads and sink. (Inter Cluster Head Synchronization)

1. Sink sends synchronization message having time information toward cluster head.
2. Cluster head responds with another synch message and sends back to the sink and notes its sending time T1.

3. Now Sink receives this message from cluster head and records its receiving time T2.
4. To calculate difference in their clocks time at T3 Sink sends information about time instant T2 and T3 to their cluster head.

5. On reception of this message tag from sink, cluster head notes its receiving time T4 and as shown in fig.2 calculates the time gap between sink and itself.

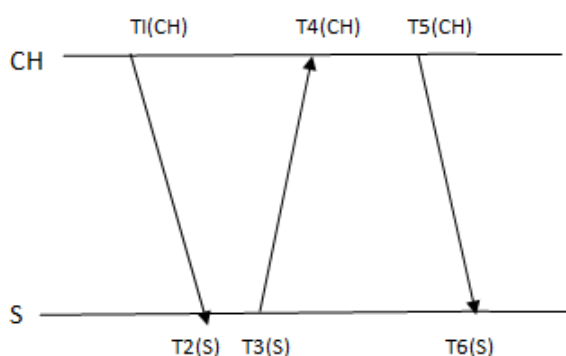


Fig. 2

$$T6(S) = T5(CH) + \delta + d$$

$$T4(CH) = T3(S) - \delta + d$$

$$d = (T6(S) + T4(CH)) - (T5(CH) + T3(S)) / 2$$

6. Cluster head modifies its clock according to the Sink's current time HSink(t) added with the calculated delay.

$$HCH(t) = HSK(t) + d$$

Algorithm 3 Intra Cluster Head Synchronization, occurs between cluster members inside the same cluster with respect to cluster head.

1. Here Cluster Head (CH) chooses one of the sensor node from cluster as TSN (time synchronizing node)
2. Now CH adds its time stamp T1(CH) to a message and broadcasts it, which is received by TSN and node N at time T2(TSN) and T3(N) respectively.
3. Now a message is sent to N from time synchronizing node at time instant T3(TSN) carrying its time stamp T2(TSN), which N receives at its time T4(N) [5]. fig.3

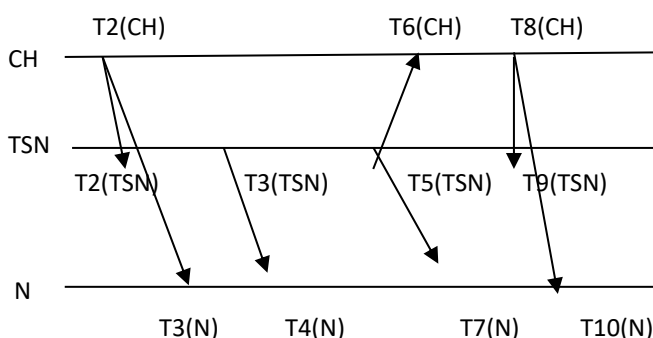


Fig.3

Thus we can represent

$$T3(N) = T1(CH) + \delta_n + d_n$$

$$T2(TSN) = T1(CH) + \delta_{tsn} + d_{tsn}$$

Here δ_n and δ_{tsn} is the clock offset between clocks of sensor node and its cluster head and similarly between clocks of TSN and cluster head, while d_n and d_{tsn} is the calculated delay of cluster node and

chosen TSN in accordance with cluster head. Now the offset of node N with regard to the node TSN, we calculate it by

$$\delta' = T3(N) - T2(TSN) = (\delta_n - \delta_{tsn}) \text{ (delay is same)}$$

in case the delay is differing then the offset will have an additional factor of delay, and offset will be

$$\delta' = T3(N) - T2(TSN) = (\delta_n - \delta_{tsn} + d_n - d_{tsn})$$

Sine the clock pulse is generated by the oscillator which is influenced by the factors like temperature ,battery voltage,pressure etc,which results in creating skew (ρ) in clock.then by using clock skew as well as nodes offset referred to sink, $H(t)$ which is the Logical clock is set. After every clock cycle the Logical clock $H(t)$ is incremented . Assuming the time span of one clock pulse as Δt and

time involved for logical clock ,incorporating increment , is Δh then

$$\Delta h = (1 \pm \rho)\Delta t$$

Then after every clock pulse the clock will be incremented as

$$H(t + \Delta t) = H(t) + \Delta h$$

$$H(t + \Delta t) = H(t) + (1 \pm \rho)\Delta t$$

EXPERIMENTAL RESULTS –

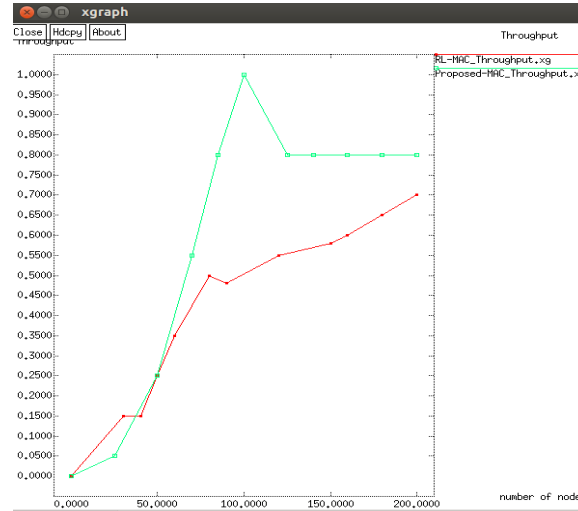


Figure 4: Throughput Comparison(in kbps)

In the given figure 4, A graph is obtained between throughput response of proposed technique and previous scheme. In above graph red line curve defines the throughput of previous method while green line curve is representing the throughput response of proposed scheme. The curves shows a significant enhancement in the throughput by

incorporation of clock synchronization. This improvement in throughput efficiency through the use of new proposed technique of using clock synchronization occurs due to the reduction of packet loss .

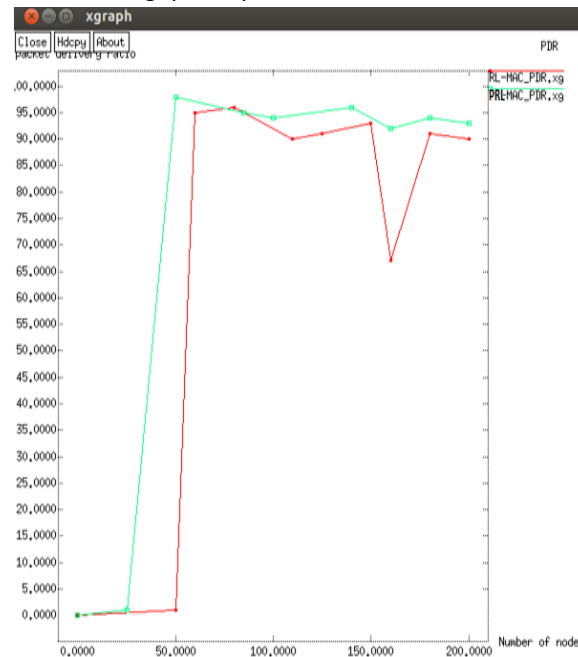


Figure 5: Packet Delivery ratio(in %)

In figure 5, an improved packet delivery ratio is shown by green line. Due to Clock Synchronization the result outcomes of the new protocol advocates

gain of packet delivery, also the throughput is enhanced. Hence serving the major task of energy efficiency improvement.

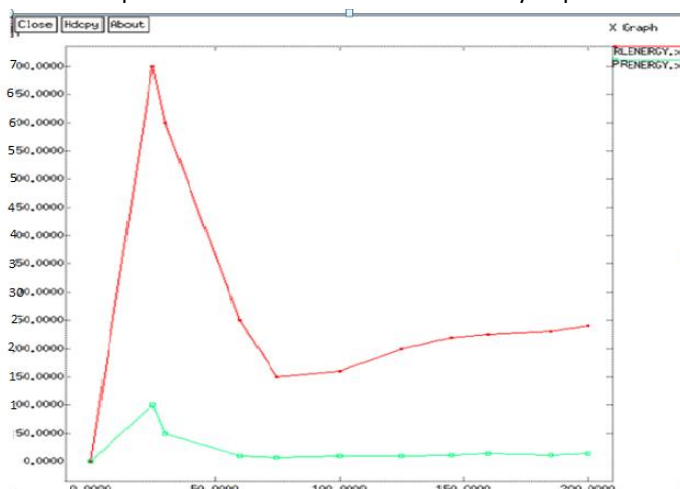


Figure 6 : Energy Comparison(in mj/bit)

Here in the figure 6, a comparative graph of energy expenditure of existing and proposed technique is drawn. The red curve represents the energy usage of previous scheme while, green lines are used to show the energy usage of new proposed method. In the previous technique, the clock synchronization is missing and source is having a fixed path to destination. These two reasons cause collision and packet loss within network resulting in retransmission of the packet hence more traffic. In the proposed technique clocks of each sensor node are synchronized according to the master clock. The source and destination are connected by adaptable virtual paths. This results in significant reduction in energy consumption as is visible by the gap between green and red line. This graph displays how the new proposed scheme significantly excels the existing scheme in terms of energy efficiency.

Conclusion

In this thesis, the sensor network has been deployed using synchronization technique, where all the sensor nodes are tuned through their cluster heads for a single clock thus avoiding packet collision and thus reducing packet loss. This scheme gains synchronization of cluster's sensor nodes, matching their clock time with MAC time of cluster

head, meanwhile cluster heads will modify their clock in accordance to the MAC time of sensor nodes.

References

- [1] Gouvy, N., Hamouda, E., Mitton, N., & Zorbas, D. (2013, April). Energy efficient multi-flow routing in mobile Sensor Networks. In *Wireless Communications and Networking Conference (WCNC), 2013 IEEE* (pp. 1968-1973). IEEE.
- [2] Kaur, K., & Kumari, N. Evaluation and Analysis of Active RFID Protocol in Wireless Sensor Networks.
- [3] Jiang, L., Bing Fang, & Li. (May, 2013) Energy optimized approach based on clustering routing protocol for wireless sensor networks. *CCD Conference. IEEE+*
- [4] Wang, Y., & Guo, S. (2013, August). Optimized energy-latency cooperative transmission in duty-cycled wireless sensor networks. In *Mechatronics and Automation (ICMA), 2013 IEEE International Conference on* (pp. 185-190). IEEE.
- [5] Cheng, B., Ci, L., Tian, C., Li, X., & Yang, M. (2014,). Contention Window-based MAC Protocol for Wireless Sensor Networks. *International Conference on Dependable, Autonomic and Secure Computing. 2014 IEEE* (pp. 479-484). IEEE.
- [6] Zhang, D., Li, G., Zheng, K., Ming, X., & Pan, Z. H. (2014). An Energy-Balanced Routing Method Based

on Forward-Aware Factor for Wireless Sensor Networks. *Industrial Informatics, IEEE Transactions on*, 10(1), 766-773.

[7] Gouvy, N., Hamouda, E., Mitton, N., & Zorbas, D. (2013, April). Energy efficient multi-flow routing in mobile Sensor Networks. In *Wireless Communications and Networking Conference (WCNC), 2013 IEEE* (pp. 1968-1973). IEEE.

[8] Tolentino, Randy S.; Lee, Kijeong; Kim, Yong-Tae; Park and Gil-Cheol, "Next Generation RFID Based Medical Service Management System Architecture in Wireless Sensor Network" *Communications in Computer and Information Science*, Volume 119. (pp. 147)g, 2010.

[9] Siddhartha Chauhan, S., & Kumar, L. "Adaptive Time Synchronization for Homogeneous WSNs", *International Journal of Engineering Business Management*, vol. 4, 2012.

[10] Xiangning, F & Yulin, S., (2007). Improvement on LEACH Protocol of Wireless Sensor Network *International Conference on Sensor Technologies and Applications*. (pp. 260 -264). IEEE

[11] Nikodem, M., & Wojciechowski, B. (2011, February). Upper Bounds on Network Lifetime for

Clustered Wireless Sensor Networks. In *New Technologies, Mobility and Security (NTMS), 2011 4th IFIP International Conference on* (pp. 1-6). IEEE

[12] Soltan, M., and Hwang, I., (2007) "Modulation-Aware Energy Balancing in Hierarchical Wireless Sensor Networks", *EURASIP Journal on Wireless Communications and Networking*, pp. 355-359

[13] Bharathidasan, A., & Ponduru, V. A. S. (2002). *Sensor networks: An overview*. Department of Computer Science, University of California, Davis, CA, 95616

[14] Raj, E. D. (2012). An Efficient Cluster Head Selection Algorithm for Wireless Sensor Networks—Edrleach. *IOSR Journal of Computer Engineering (IOSRJCE)*, 2(2), 39-44

[15] Kumar, V., Jain, S., & Tiwari, S. (2011). Energy efficient clustering algorithms in wireless sensor networks: A survey. *IJCSI International Journal of Computer Science Issues*, 8(5)

[16] Zhenzhen Liu, Z., & Elhanany, I. (,). RL-MAC: A QoS-Aware Reinforcement Learningbased MAC Protocol for Wireless Sensor Networks.