International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 15 Issue 2, February-2026

Survey of Overlapping Schedules with Hierarchical Clustering for Wireless Network

Shalini Gaur[1], Dr. Anil Dudy[2]

[1]Ph.d Scholar, ECE Department, Baba Mastnath University, Rohtak, Haryana
[2]Professor, ECE Department, Baba Mastnath University, Rohtak, Haryana

ABSTRACT

Energy efficiency is the main concern in any wireless network. Since data transmission is an energy-intensive task, energy aware data gathering techniques are used to extend the lifetime of the WSN. Existing MAC protocol provide solution to some problems of wireless protocol. This paper provides an overview of existing MAC protocol. This paper also discusses performance evaluation of the OLS-MAC proposed by Ibrahim Ammaret et.al

Keywords: PDR, WSN, MAC.

INTRODUCTION

Recent advances in micro-electro-mechanical systems, low power and highly integrated digital electronics have led to the development of micro- sensors [1]. Such sensors are generally equipped with data processing and communication capabilities. These sensors have the ability to communicate either among each other or directly to an external base station (BS). A greater number of sensors allow for sensing over larger geographical regions with greater accuracy. These sensors can be networked in many applications that require unattended operations, hence producing a wireless sensor network (WSN) [2].

A Wireless Sensor Network (WSN) consists of a large set of sensor nodes that cooperate to monitor environmental conditions (e.g., temperature, precipitation, and radio-activity) in a given geographic area. WSNs are often designed for long term operation in remote unattended environments, despite the limited battery capacity of the wireless sensor nodes.

Since data transmission is an energy-intensive task, energy aware data gathering techniques are used to extend the lifetime of the WSN. An effective way to conserve energy is to avoid reporting redundant data that occurs due to the spatial correlation between nearby readings. However, minimum cost network correlated data gathering is NP-complete [3].

It is widely accepted that the energy consumed in one bit of data transfer can be used to perform a large number of arithmetic operations in the sensor processor. Moreover in a densely deployed sensor network the physical environment would produce very similar data in near-by sensor nodes and transmitting such data is more or less redundant. Therefore, all these facts encourage using some kind of grouping of nodes such that data from sensor nodes of a group can be combined or compressed together in an intelligent way and transmit only compact data. This can not only reduce the global data to be transmitted and localized most traffic to within each individual group, but reduces the traffic and hence contention in a wireless sensor network. This process of grouping of sensor nodes in a densely deploy enlarge-scale sensor network is known as clustering.[4]

The applications for WSNs involve tracking, monitoring and controlling. WSNs are mainly utilized for habitat monitoring, object tracking, nuclear reactor control, fire detection, and traffic monitoring. Area monitoring is a common application of WSNs. Wireless sensor networks can use a range of sensors to detect the presence of vehicles for vehicles detection. Wireless sensor networks are also used to control the temperature and humidity levels inside commercial greenhouses.

1. Overview of MAC Protocol

The MAC protocol simply determines when a node is allowed to transmit its packets, and typically controls all access to the physical layer. The specific functions associated with a MAC protocol vary according to the system requirements and application.[5] Design goals of Mac Protocols are Operation of the protocol should be distributed, Should support real-time traffic, The access delay must be minimized, Available bandwidth must be utilized efficiently, fair band width allocation to competing nodes, Control overhead must be minimized, The effects of hidden/exposed terminals must be minimized, Must be scalable, Should minimize power consumption, Should provide synchronization between nodes.[6]

Classification of MAC protocols:

a) S-MAC

Locally managed synchronizations and periodic sleep listen schedules based on these synchronizations form the basic idea behind the Sensor-MAC (S-MAC) protocol [7]. Neighboring nodes form virtual clusters to set up a common sleep schedule. If two neighboring nodes reside in two different virtual clusters, they wake-up at listen periods of both clusters. The main advantage is the energy reduction by sleep schedules. In addition to its implementation simplicity, time synchronization overhead may be prevented with sleep schedule announcements. Main disadvantage is that broadcast data packets do not use RTS/CTS which increase collision probability. Adaptive listening incurs overhearing or idle listening if the packet is not destined to the listening node. Sleep and listen periods are predefined and constant, which decreases the efficiency of the algorithm under variable traffic load.

b) Wise MAC

Wise MAC is a medium access control protocol developed by CSEM and designed for the Wise NET™ wireless sensor network (WSN). Wise Stack is a complete communication stack based on Wise MAC that also includes a self-configuring cluster-tree routing protocol and a host controller interface (HCI) for interacting with the communication module. Clock synchronization is also available. Wise MAC is a low power MAC protocol specially developed for WSN [8] in combination with the Wise NET SoC.

c) TRAMA

TRAMA [9] is a TDMA-based algorithm and proposed to increase the utilization of classical TDMA in an energy efficient manner. It is similar to Node Activation Multiple Access (NAMA) [10], where for each time slot a distributed election algorithm is used to select one transmitter within two-hop neighborhood. This kind of election eliminates the hidden terminal problem and hence, ensures all nodes in the one-hop neighborhood of the transmitter will receive data without any collision.

2. OLS-MAC

Medium Access Control with Overlapped Schedules (OLS-MAC) for wireless sensor networks has been proposed [11]. The algorithm aims to prolong wireless sensor network lifetime using the duty cycle technique where sensors are alternate between sleeping and awaking period. During the sleeping period, there is no energy consumption due to communication. However, the OLS-MAC algorithm has to ensure the awaking period of sensors sufficiently overlaps in order to allow nodes to communicate with each other. Saving energy using duty cycle concept requires fulfill number of concerns.

The algorithm aims to prolong wireless sensor network lifetime using the duty cycle technique where sensors are alternate between sleeping and awaking period. During the sleeping period, there is no energy consumption due to communication. However, the OLS-MAC algorithm has to ensure the awaking period of sensors sufficiently overlaps in order to allow nodes to communicate with each other. Saving energy using duty cycle concept requires fulfill number of concerns.

A) The OLS-MAC Core Components

a) **Starter node (S):** This node assigned to one of the sink nodes. S node initiates the creation of the first cluster by generates a schedule and sends it with its neighbors. Also the schedules of the forthcoming clusters are relative to S node schedule in order to produce overlapped schedules. Configures the clusters synchronization according to the direction of the data traffic improves the system delay. Thus choosing the sink node for this purpose would serve the desired synchronization.

b) **Cluster size (h):** one of the tools that used for producing approximately equal-sized clusters is the cluster radius. An equal-sized cluster is a desired property because it enables load balancing. Also the depths of the cluster affect the network performance directly in terms of energy efficacy, low over head, communication reliability, etc. In addition to it is relative to the clock drift error. It is hard to find a general optimal value representing the cluster size where it depends on different parameters, like the network application, communication, routing overhead and number of nodes, etc.

c) **Overlap shift ratio (k):** This value represents the time shift between the schedules of the adjacent clusters. Making schedules sufficiently overlapped and allowing for a small shift between them can be beneficial for numerous reasons i.e. maintain the clock drift and boost the resilience of the routing. Also the over lapped schedules may provide multiple paths between communicated clusters, in addition to avoid the boundary nodes failures.

Existing sensor network can be presented as graph G=(V,L) where V is the set of nodes and L is the links between nodes.

a) There is a link $L_{u,v}$ between any two nodes u and v if node v lies in the transmission range of u and vice versa.
b) The immediate nodes of node u are the set of nodes $L(u)=\{v|(u,v)\in L\}$.
c) The number of hops between node u and node v $h_{u,v}$ is the minimum number of links in the u-v path.
d) Cluster i is defined as Πi, a set of nodes that have a common schedule Υi. Any cluster Πi has starter node(s)$\{u^i{}_j,0\}$where j is the indexes of the starter nodes in cluster i.
e) Node $\{u^i{}_j,1\}$is defined with respect to the starter node of cluster i as the set of nodes,such that $H_{u,v}=l$, where u is the starter node and v is the node $\{u^i{}_j,1\}$.

B) The OLS-MAC Architecture

The first step of the algorithm is assigning the start node (S) as root for the network. This phase runs only once at the network deployment time. At this time all nodes of the network are in initial mode after being deployed, they are fully awake and keep listening for SYNC

packets which is broadcasts by the S node first. The SYNC packet is very short, and includes the address of the sender, the time of its next sleep and counter for the travelled hops. OLS-MAC follows the steps below to choose the first schedule and broadcasted to the remaining nodes

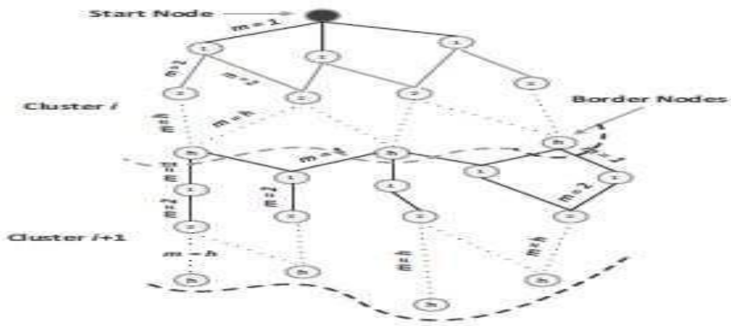

Figure 1: Clusters with Overlap Schedules

The root node $u^1{}_{1,}$ 0 creates the first cluster Π_i by choosing a schedule Υ_i and broadcast to its immediate neighbors $u^i{}_j$, 1. The process is repeated for each node ($u^i{}_{j,}$ m)level i where m<h and h is the maximum number of hops per cluster. Nodesin level h are called the edge nodes $u^i{}_j$, h of the cluster Πi.

a) The edge nodes generate the new schedule Υi+1 for the cluster Πi +1 such that $\Upsilon_{(i+1)} = \Upsilon_i - k$, where *k* is given desired shift time. The edge nodes broadcast the schedule $\Upsilon_{(i+1)}$ to the immediate neighbors $u^{(i+1)}{}_j$,1.The process is repeated for each node $u^{(i+1)}{}_j$,min level m where m<h.
b) Step 2 is repeated until the whole nodes are grouped into clusters. Fig.3.2 above illustrates the steps followed by OLS-MAC algorithm.

C) Performance and Evaluation

This section studies the performance of the OLS- MAC algorithm and the effect of k and h parameters on the clustering process of OLS-MAC. Our goals are

1) Finding out the proper selection of the input parameters (k and h) that OLS-MAC algorithm based on.
2) Study the effect of k and h with respect the duty cycle varied from 10% to 30 on the network performance in terms of system throughput, power consumption, packet loss and communication overhead.

a) Simulation Environment

The OLS-MAC algorithm was implemented using NS2 simulator [12]. Nodes are spread uniformly over a square area of 2000 X 2000 unit area. All experiments were performed over tandem and random topologies representing different network sizes (*N*) ranging from 11 to 200 sensor nodes. For each topology, the transmission range of each node (*Tr*) kept at 250 meter. The energy consumption in transmission, reception, idle and sleep modes are

36.0 14.4 14.4 .015 respectively. The packets inter- arrival time fixedat1packet/second with size of 50 byte. The average of five independent tests for each protocol with 95 percent confidence level.

b) Packet Loss Rate

The evaluation of the system behavior under different utilization states can be represented by the packet loss probability. It is clear from the dropped packets probability that OLS-MAC has higher ability for delivering data than the other studied protocols. The synchronization technique used in OLS-MAC make nodes know their schedules at very beginning time of the simulation which make the routing process more easy and robust for passing the data. Also no border nodes were used in OLS-MAC.

The area of these boarder nodes will suffer from high contentions. This because of all the traffic between clusters has to go through this area. Analyzing the simulation trace file shows that very small percentage of packet loss happen because of the collisions. Also increasing the queue size for each node does not affect the probability of the packet loss. To prove that the routing has impact on the packet loss probability there is a toggle between static (NOAH) and dynamic (DSR) routing protocols. It is found that the number of dropped packets in static protocol is higher than that of the dynamic protocol. The number of dropped packets in dynamic routing protocol is reduced by over 12% per cent.

c) Power Consumption

The primary concern of designing a good protocol for WSNs is the energy efficiency. Minimizing the idle listening by adopting the scheme of periodic listen and sleep so far is the dominating scheme for power saving in synchronized WSNs. OLS-MAC consumes less power compare to the other protocols for many reasons.

1. OLSMAC uses less control packets for synchronizing the nodes.
2. The network under OLS-MAC protocol requires much less time to be fully synchronized while for example Global S-MAC needsabout450 second to reach the global stage as stated by the Global S- MAC author in [13].

3. There are no boarder nodes in OLS-MAC which reduces the energy consumption of these nodes by at least the half. Despite that power consumption of tandem topology is less than that of the random topology still changing the duty cycle value plays the same influence for all the studied protocols whilst varying the duty cycle value. The delivered packets increase as long as the duty cycle increased and the energy consumption per load in turn decreased smoothly for all analyzed protocols.

CONCLUSION

The OLS-MAC in its design takes in consideration low-duty-cycle, network clustering and maintains the nodes synchronization. With the aim of achieving energy efficiency to maximize the lifetime of entire system, scalability which is particularly important for sensor networks due to the needs of large number of nodes in WSNs and reducing packet loss probability to enhance the Network performance further. In future, the existing MAC protocol can be modified with the target of making sensor nodes more energy efficient, to enhanced the packet data rate and to reduce the delay.

REFERENCES

[1] I. Akyildiz, W. Su, Y. Sankara subramaniam, and E. Cayirci. Wireless sensor networks: A survey. Computer Networks, 38:393–422, December 2001.
[2] J. N. Al-Karaki and A. Kamal, “Routing techniques in wireless sensor networks: A survey”, IEEE Wireless Communications, 11(5):6–28, December 2004.
[3] R. Cristescu, B. Beferull-Lozano, and M. Vetterli, “On Network Correlated Data Gathering,” in *IEEE INFOCOM*, March 2004, pp. 2571–2582.
[4] Rohit Vaish, “Application of Wireless Sensor Networks for Environmental Monitoring & Development of an Energy Efficient Hierarchical Cluster based Routing” electrical engineering department, Kurukshetra University.
[5] ANDREWD. MYERS and STEFANO BASAGNI, “Wireless Media Access Control” published in book “Handbook of wireless network and mobile computing” page119-143. (2002) http://www.cs.tut._/kurssit/TLT-2616/
[6] W. Ye, J. Heidemann, D. Estrin, “Medium Access Control With Coordinated Adaptive Sleeping for Wireless Sensor Networks”, *IEEE/ACM Transactions on Networking*, Volume:12,Issue:3,Pages:493-506,June 2004.
[7] A. El-Hoiydi et al., Wise MAC: An Ultra Low Power MAC Protocol for Multi-hop Wireless Sensor Networks. ALGOSENSORS 2004: 18-31
[8] V. Rajendran, K. Obraczka, J.J. Garcia-Luna- Aceves, “Energy- Efficient, Collision-Free Medium Access Control for Wireless Sensor Networks”,*Proc.ACMSenSys03*,Pages:181- 192,LosAngeles,California,5-7November 2003.
[9] L. Bao and J.J. Garcia-Luna-Aceves, “A New Approach To Channel Access Scheduling For Ad Hoc Networks”,

Seventh Annual International Conference on Mobile Computing and Networking, pp. 210–221, 2001.

[10] Ibrahim Ammar, Guzlan Miskeen, Irfan Awan' "Overlapped Schedules with Centralized Clustering for Wireless Sensor Networks", published in 2013 IEEE 27th International Conference on Advanced Information Networking and Applications

[11] The Network Simulator NS-2. Available: http://www.isi.edu/nsnam/ns/, Y. Li, W. Ye, and J. Heidemann, "Energy and latency control in low duty cycle MAC protocols," 2005, pp. 676-682 Vol. 2.