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Sleep Scheduling Schemes Based on Location of Mobile User in Sensor-Cloud

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***Abstract*—**The mobile cloud computing (MCC) with wireless sensor networks (WSNs) technology gets more attraction by research scholars because its combines the sensors data gathering ability with the cloud data processing capacity. This approach overcomes the limitation of data storage capacity and computational ability of sensor nodes. Finally, the stored data are sent to the mobile users when the user sends the request. The most of the integrated sensor-cloud schemes fail to observe the following criteria: 1) The mobile users request the specific data to the cloud based on their present location. 2) Power consumption since most of them are equipped with non-rechargeable batteries. Mostly, the sensors are deployed in hazardous and remote areas. This paper focuses on above observations and introduces an approach known as collaborative location-based sleep scheduling (CLSS) scheme. Both awake and asleep status of each sensor node is dynamically devised by schedulers and the scheduling is done purely based on the of mobile users' current location; in this manner, large amount of energy consumption is minimized at WSN. CLSS work depends on two different methods; CLSS1 scheme provides lower energy consumption and CLSS2 provides the scalability and robustness of the integrated WSN.

***Keywords*—**Sleep scheduling, mobile cloud computing, wireless sensor network, integration, location, network lifetime.

I. Introduction

A. Wireless Sensor Networks (WSNs)

Wireless sensor network consists of a wide number of autonomous sensor nodes to cooperatively work together and gather various physical and environmental parameters such as humid, gas, light [1]. The deployments can be made either in uniform or random manner. The sensor has changed the traditional way of interacting with the real world. WSNs have been the research focus of both academic and industrial communities to explore their great potentials in the industrial and civilian applications (e.g., military, agriculture field, and forest area monitoring and fire detection). In smart agriculture, a WSN node can be utilized in the environmental detection system to detect the moisture level of soil as well as other changes in various parameters. It is possible to predict the health condition of a plant. In addition, with respect to sewer overflow detection, a number of distributed sensor nodes can be deployed at various points in a pipe, watershed or lakes to monitor the water quality, and accurate level of the water status can be created without using manual data retrieval, especially this methodology is most preferable were accessing point is very difficult to analysis. Basic units of the sensor are the processor, memory, radio transceiver, power source as shown in Fig. 1. The processor is application specific and Global Positioning System (GPS) is used for transmission purpose.

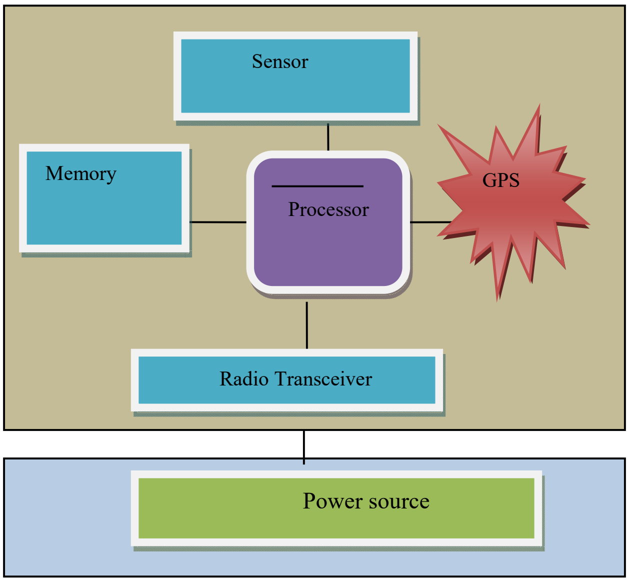

Fig. 1 Basic unit of WSN

B. MCC

The Cloud Computing is an innovative technology that provides shared computing resources instead of having private servers or personal devices while the Grid Computing includes multiple nodes from various locations which are connected together for common goal. In Cloud Computing, the word cloud is used as an analogy for "The internet'' [2]. It is used to connect the low-level consumers with minimum cost. Depending upon the user needs, they provide services. MCC supports both the data storage and the data process happening at an outer environment of the mobile device. Computing process and data storage will be done at the cloud in MCC applications. This application is applicable to a broader range of mobile subscribers [3], [4].

C. Integration of MCC and WSNs

The integration of WSN-MCC is an emerged technology that collaboratively combines the data gathering ability of sensor with the data processing capacity of the cloud as shown in Fig. 2. The cloud provides huge storage capacity with high computational ability. The sensed data from the sensor are

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decompressed at the sink and sent to cloud gateway [5], [6]. In cloud, data compression takes place and compressed data is stored there. The stored data is sent only to the mobile user, who sends the request message to the cloud.

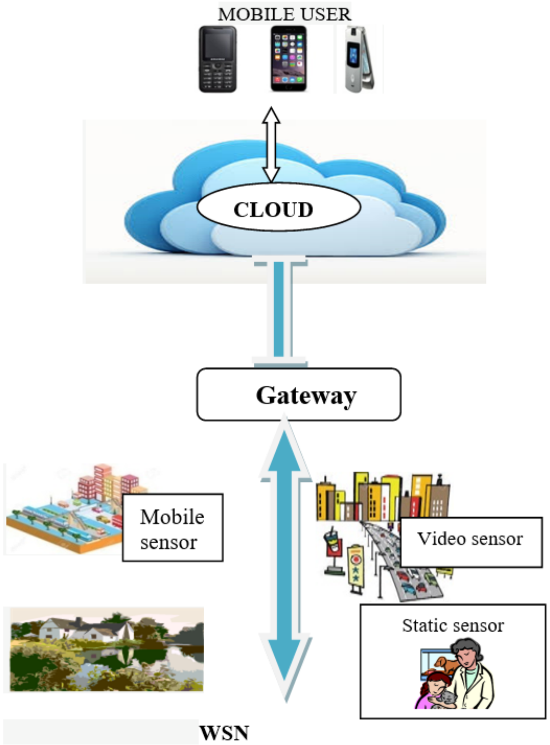

Fig. 2 Example of MCC-WSN Integration

II. Literature Review

In general, the scheduling is to arrange or plan things that take place within a particular time. The proper scheduling will reduce the power consumption and maintain the load in the network. Power management is vital because sensors are battery powered. Sleep scheduling reduces the power usage by implementing the idea that power sensor is in awaken stage at a particular instant of time (e.g. detection) and sleep at rest of time. Even at sleeping state, sensor consumes energy. But it is analogously lower than in other stages (i.e., an idle state, waiting for stage and transition stage). For instance, an adaptive partitioning scheme is used for reducing the energy consumption as presented in [7]. In this algorithm, a group of sensor is partitioned and connected to the backbone of the network. It can be managed by keeping only one willful node from each group in the active stage and the remaining nodes are maintained in sleep stage. This algorithm does not depend on nodes location.

In adaptive partitioning scheme, the designed node scheduling with topology control has NP-hard problem as a constrained optimal graph partition problem is formulated by Connectivity Partition Approach (CPA) where node connectivity is done by merging process. During the merging process, two adjacent nodes with the highest priority will be merged together. This merging process continues until paired data meets the energy constraint. The decision is made based on highest priority. In [8], another approach for sleep scheduling with Energy-Efficient algorithm is used for Data Collection and Aggregation. They have used the Time Division Multiple Access (TDMA) protocols for scheduling sensor nodes. The sensors consume energy for state transition. In such cases, MAC layer protocol is scheduled with TDMA and it reduces the number of state transitions through scheduling the sensor nodes with a consecutive time slot. This scheduling also optimizes the energy consumption of both homogeneous network and heterogeneous networks. Data gathering tree is used to construct the algorithm in order to maintain the power consumption level and delivering rate through the network. This scheduling also optimizes the energy consumption of both homogeneous network and heterogeneous networks. Data gathering tree is used to construct the algorithm in order to maintain the power consumption level and delivering rate through the network. In [9], new approach is discussed for a sleep scheduling based on distributed activity. In this algorithm, a major asset of partial coverage with Distributive Adaptive Sleep Scheduling Algorithm (DASSA) is maximizing the network lifetime. The DASSA algorithm target nodes, which are placed near to the base station or sink. The data transmitted through these nodes are placed near through the sink only. In this method, the sink nodes distributed the residual energy levels and feedback to neighboring nodes. This feedback methodology in DASSA scheduling reduces the randomness in scheduling because it occurs in the absence of location information. Through DASSA, network lifetimes can be achieved up to 92%.

The new scheme for Sleep Scheduling is introduced [10]. Generally, schedulers decide which node is to be in a power-saving mode to save network coverage and energy. Using this key idea, Range Based Sleep Scheduling (RBSS) is devised. It gathers only the distance information between the two sensors. RBSS approach demands the fewest working (awake) sensors and it takes only optimal selection pattern. It does not need any location information of the sensors nodes.

The Evolutionary Multi-objective Sleep-Scheduling Scheme is used for Coverage with the differentiated network in WSN [11]. It describes that nodes controlling can be done based on sleep scheduling using online density based on event detection probability. The node scheduling is done based on an optimization algorithm. The Decision maker is used for maintaining coverage and energy level at nodes. It also reschedules the nodes once a node failure occurs. From the survey, various sleep scheduling algorithms are discussed in terms of energy consumption, network lifetime, coverage and connectivity. The sleep scheduling algorithm is used to balance sensor node's energy consumption and a reasonable length towards energy saving while deploying WSNs for practical applications. It helps to maintain the required energy consumption and produces very high network lifetime than the traditional deployment schemes but, WSN is still lagging in storage capacity. This limitation can be rectified by the integration of WSN with MCC.

TABLE I
ANALYSIS OF SLEEP SCHEDULING

Ref.	Algorithm	Pros	Cons
[8]	Adaptive partitioning scheme	#Reducing energy consumption	#Connectivity problem
[9]	Energy-Efficient scheme	#Reduce the energy cost.	#Increased delay
[10]	Distributed activity scheduling	#Desired coverage without using any location information	#Gain is reduced, when randomness increased
[11]	Evolutionary multi-objective scheduling	#Optimized framework	#Rearrange the network when the network is failed
[12]	Range based scheduling	#Reduction in number of working sensor	#Effects of ranging errors

III. OVERALL SYSTEM MODEL

Consider, N number of sensors (i.e. wsn1 wsn2 wsn3 …wsn-1) deployed at the environment with multi-hopping along with N number of mobile users (i.e., U1, U2, U3 …. Un-1) at the receiving side. The cloud acts as a bridge between the mobile users and WSN. If any data request is issued to a cloud from a mobile user, the cloud sends the corresponding information to the requested mobile user, which is already gathered and stored by the cloud from WSN. The location of the mobile user is identified and stored at the cloud using a Star Track service [11]. The separate gateway or base station(s) is present between a WSN and the cloud. The base station is powered with unlimited energy supply. The scheduling is done based on the location of a mobile user list using time (T) and it is divided into time epochs with the interval (t).

A. WSN Energy Model

The energy used by a sensor to transmit and receive one byte, and the power required to amplify each transmitted byte to cover the distance of 1 m is used to calculate the WSN energy model. This includes the packet header and sensed data.

B. Overall WSN model

The multi-hop sensors are either uniformly or randomly deployed with N nodes in an area A. The hopping is existed between any two neighbors, only if a node present within the transmission range. Otherwise, they will look for another node for hopping. The energy consumed while transmit and receive a packet can be calculated using a length (h) of bytes over a distance (d).

- Transmitted energy (E_T):

$$E_T = e_t + e_a * h * d_2 \quad (1)$$

- Received energy (E_R):

$$E_R = e_r * h \quad (2)$$

where; e_a is energy consumption of power amplification; e_r is energy consumption of receiving a byte; e_t is energy consumption of transmitting a byte. [13]

IV. CLSS SCHEME

In this section, we initially show the mechanisms to obtain the location list of mobile user and later on CLSS schemes (Fig. 2). [13]

A. WSN Event Model

Characterizable distribution in space and time is used in the event model. The sensing is done at sensors node when a sensor node receives a signal with power above a predetermined level of threshold energy. For an instant, a Poisson process takes place for the temporal event behavior with an average event rate over the entire sensing region and the spatial distribution is used for independent probability distribution.

B. Mobile User Location List

In order to get the location list of the mobile user, the location history of a user is gathered by the cloud. The clouds do this work using Star Track service used by a mobile client application. It periodically captures the user's current location using GPS or some other source and then the captured information are transferred to the star track server which runs as a service in the cloud server [11]. Additionally, they process the collected location data and break down into various tracks (i.e., discrete tracks are operational and recoverable through a high-end application level of programming interface and they make up the location history list.

C. Mobile User Prediction Location List

Transition Graph is used to obtain the mobile user prediction location list. The locations of the mobile user would depend on their frequently visited locations based on this key idea prediction list is done. The future track of the mobile user will be aggregated by these frequently visited locations [12]. Finally, the location lists L of the mobile users are cumulatively formed from the mobile user location history list and mobile user prediction location list. [13]

D. Components of Sensor Networks

The major components of sensor networks consist of Task manager, Sink, Sensor field and the sensor node. In this scheme, they divided sensor nodes into two types based on Sleep Scheduling and they are named as CLSS1 and CLSS2. Always On node acts as a Sink. The description of the components will be discussed in the following section (Fig. 3).

E. CLSS1

The CLSS1 scheme, the mobile user current locations are first obtained by the cloud, then cloud decides either a Flag A or Z is sent to base station depends on the user location list L. If cloud sent flag A through the base station, then CLSS1 is maintained at the awakening state and then broadcasting the received flag to the remaining nodes. Otherwise, they go to the sleep state. [13]

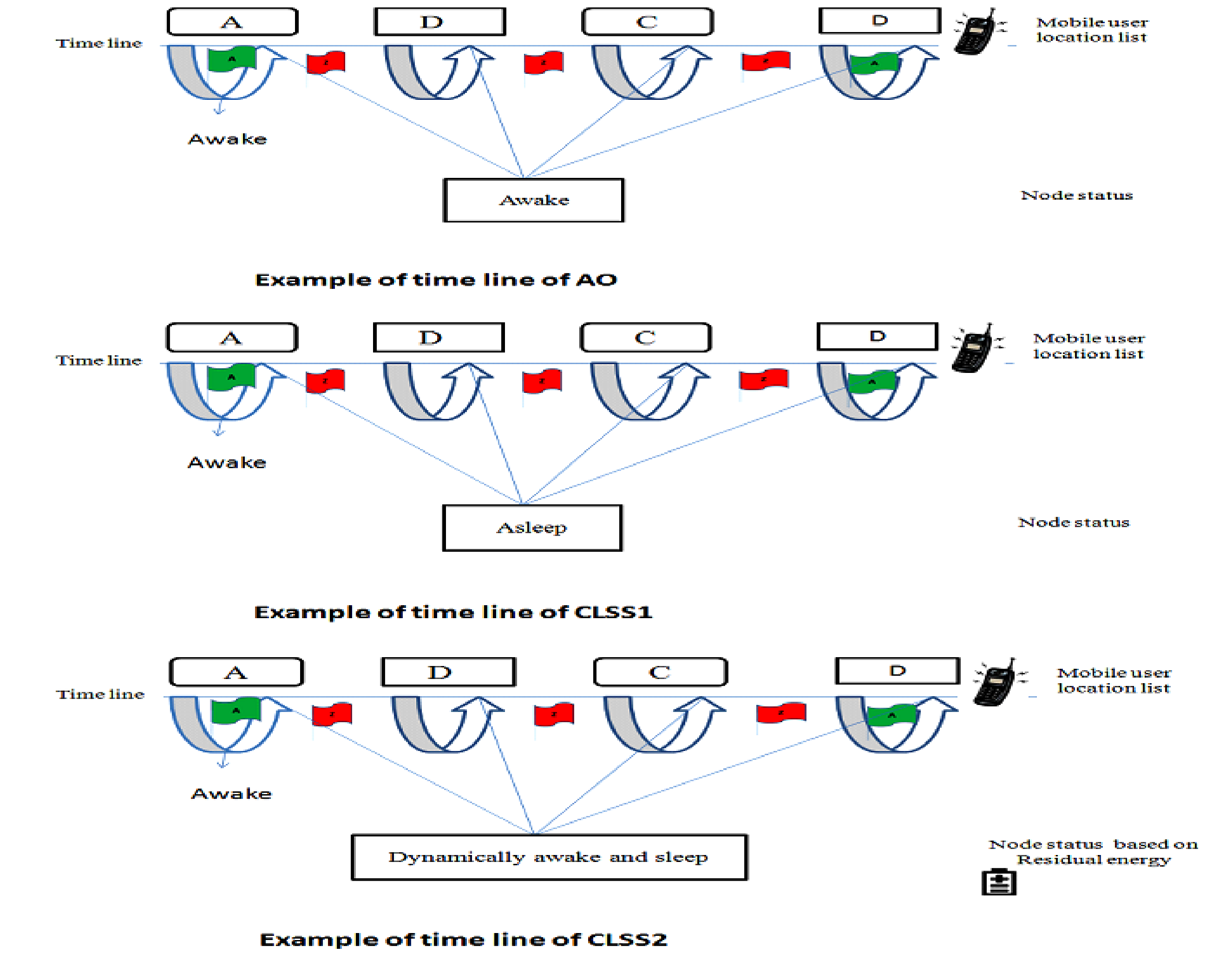

Fig. 2 Schematic Representation of AO, CLSS1, CLSS2

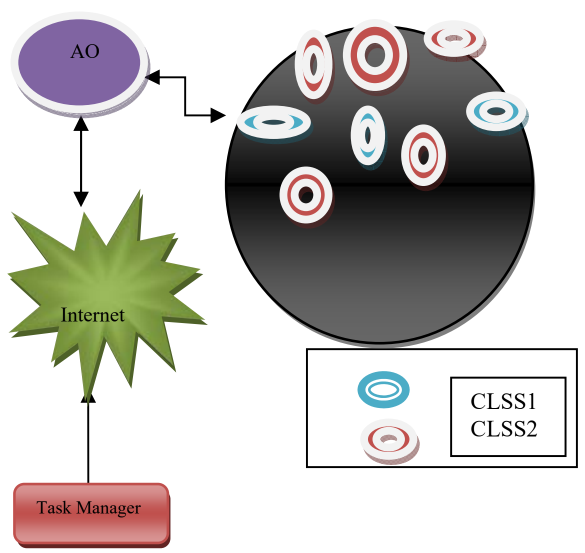

Fig. 3 Components of WSN

F. CLSS2

Both CLSS1 and CLSS2 scheme works the same if they receive flag A, but the difference occurs while they receiving flag Z. CLSS1 nodes are going to sleep state when they receive flag Z while at CLSS2 nodes will enter into a sleep state by using energy consumption based connected K-neighborhood (EC-CKN) sleep scheduling scheme. The EC-CKN scheme works based on the residual energy ($Erank_i$) of the sensor nodes. Before they enter into a sleep state, the sensor nodes broadcast their residual energy and receiving from others. After receiving the information from the neighbors, CLSS2 made their decision only if they satisfy the following conditions:

1. All nodes in the subset of currently awakening are connected by nodes with Erank > Eranki.
2. The node enters to the time epoch, at least, they have k neighbors from the subset of currently awakening node. [13]

G. Always On

AO nodes are always maintained to be in awakening state whatever the flag (flag A or Flag Z) they received. It acts as a sink and it transceivers the data from a cloud to the sensor networks and vice versa. In such case the nodes are maintained at awakening state, even the mobile users are not in the listed location. It also stores incoming data from all sensor nodes. [13]

H. Task Manager

Task Manager is also referred as a base station. It controls the entire function taking place at sensor networks. For instance, computer and mobile is the best example for Task Manager. The Internet plays a vital role in the sensor networks because it connects the virtual world with the cyber world.

V. Results and Discussion

The simulation analysis for network lifetime, throughput rate, residual energy and delay of CLSS1, CLSS2 as well as AO for mobile user1, mobile user2, and mobile user3 are shown below. From Fig. 5 and Table II, the network lifetime of a sensor is compared and obviously that CLSS1 has maximum lifetime when compared. This is because the AO nodes are maintained at awakening state, even the mobile user are not in the listed location. In Fig. 6 and Table III, the comparison is shown for throughput, the CLSS1 and the AO schemes have higher throughput when compared with CLSS2 scheme. Actually, the throughput calculation depends on the number of a successful packet sent through the sensor network to the number packet sends. From the analysis, it is clear that a throughput level of both CLSS is lower when compared with AO schemes and it has to be increased. Finally, Average residual energy is analyzed and compared with different schemes in Fig. 7 and Table IV. From that, CLSS1 has higher residual energy comparatively with other schemes. Among them AO has least residual energy, this is because of the CLSS1 maintaining at sleep state until they receive a response from the AO. However, this increases the energy level at CLSS1.

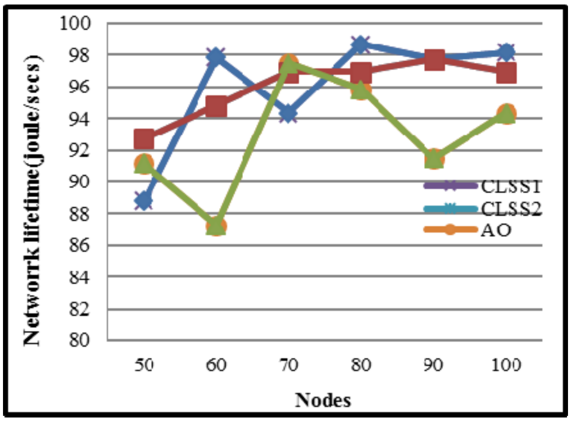

Fig. 5 Network lifetime Vs Nodes

TABLE II
Throughputs

Packet size	Throughput(bytes)		
	AO	MCCWSN1	MCCWSN2
100	15775	17456	20112.5
200	29325	27022.2	2990
300	21900	38488.9	37425
400	45600	43614.8	40400
500	31750	28074.1	48250
600	31950	42488.9	48750
700	54162.5	34533.3	56525
800	41700	45392.6	61100
900	42525	33600	58500
1000	35500	47555.6	63580

TABLE III
Network Lifetime

Node	Network Lifetime(joule/secs)		
	AO	MCCWSN1	MCCWSN2
50	91.147	88.7932	92.74
60	87.2629	97.836	94.8301
70	97.497	94.3545	96.9445
80	95.8494	98.6956	96.9379
90	91.494	97.7225	97.7286
100	94.337	98.1809	96.9409

TABLE IV
Average Residual Energy

Packet Size	Average Residual Energy(joule)		
	AO	MCCWSN	MCCWSN2
100	1.282400	0.674971	0.718941
200	0.844776	1.274890	0.534157
300	1.142870	1.126490	0.650900
400	0.974852	1.032520	0.540090
500	0.723543	0.874398	0.716454
600	1.382290	1.331330	0.6555824
700	1.010350	1.049320	0.446131
800	1.090540	0.960938	0.825451
900	1.065990	0.869495	0.549814
1000	0.822558	0.758364	0.5580107

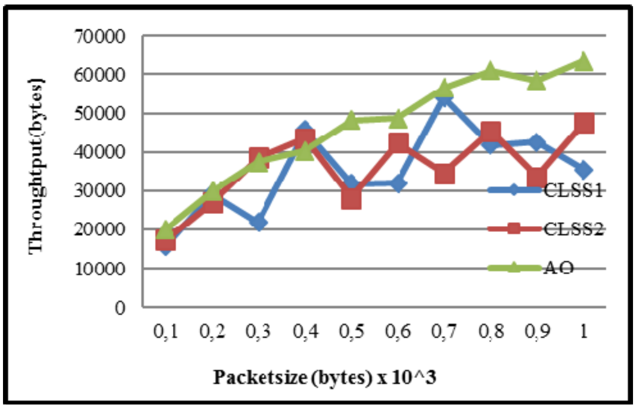

Fig. 6 Throughput Vs Packet size

VI. Conclusion

This paper presents an approach known as CLSS. This scheme is purely based on the current location of mobile users and scheduling. The sensor node has been dynamically devised by schedulers using these location lists. By doing this, a large amount of energy wastage can be reduced in sensor. The CLSS scheme provides reduced energy consumption and also they afforded the scalability and robustness of the integrated WSN. Finally, some interesting problems are chosen for our future work. First one is authentication Problems and another one is based on load management at sensor network.

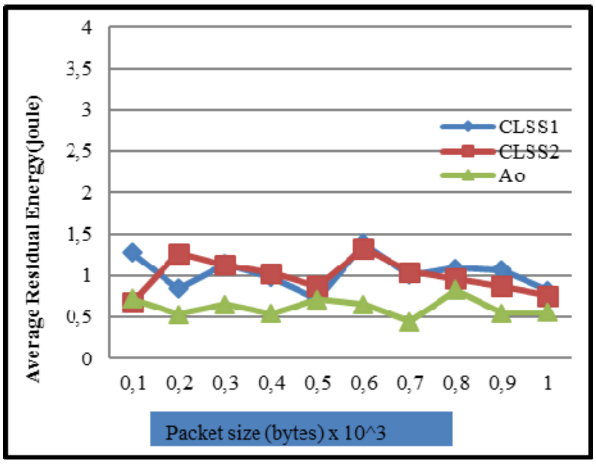

Fig. 7 Average Residual Energy

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