Hierarchical Cluster-Based FIFO Asynchronous Data Transfer Technique for Reducing Congestion for Energy Efficient State Wireless Sensor Network-HAEEW

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Abstract— The applications of WSN can be quiet numerous. In applications like battlefield monitoring, grid power generation, health systems, sensors are deployed on large scale. During such deployment, energy efficiency must be proficient, which requires clustering, in the WSN architecture. Clustering architecture requires maintenance of sensor nodes due to malfunctioning of sensor which becomes depleted of energy. As some nodes leaves and some are being replaced, congestion is introduced in the network due the limited processing capability of memory, computations, and bandwidth condition.

This paper proposes one of the energy efficient clustering techniques (HAEEW), using asynchronous data transfer (ADT), which has been modeled from data transfer technique (EEHCR), and using hierarchical clustering. Our model uses synchronization in clock time queries in one and each iterations round time, to determine cluster head, and head-set member formation, using Ad hoc on-demand energy aware routing protocols (AOERP) to make decision. In each iteration, the head-set members receives message request from neighboring nodes to confirm their average distance estimation, in which to transmit aggregated data to the base station. In a sensor deployment, which is aimed for data collection, control and management of sensor nodes, play a vital role, where nodes can be adjusted to boost energy in the network life time. We used matlab for simulations analysis of our result.

Keywords—*WSN architecture, energy efficiency, clustering, asynchronous data transfer, base station, application*

1 Introduction

Recent emerging technology in Wireless Sensor Network (WSN) has become so ubiquitous such that, requirements in application delivery such as battlefield monitoring, smart power grid and health monitoring issues are critical. Based upon that, the application delivery design in data reliability practices must be robust. The WSN data transfer a technique which is deployed in multihop transfer, usually is not coped with time synchronization of clocks with the sensor data transmissions. Asynchronous data transfer, uses FIFO buffer techniques in the sensor nodes which use synchronized clocks for reducing congestion, as a result of node changes in clustering architecture. This does not depend on point-to-point address-based data transfer, which incurs a lot of overhead message and introduce congestion. Based upon this the need to reduce congestion for energy efficient sensor network due to the changes made to the data transfer, must be considered, especially from a particular sensor node distance to base station is required. Based upon the fact that sensor nodes must be deployed in larger scale, it is also an accepted fact that the sensor is a small device with limited memory, power and computational capabilities.

In order for more collaboration for efficient data delivery, energy efficient techniques using hierarchical clustering and asynchronous data transfer, is required, in clustered deployment of the sensors. This must have a significant impact in the design such that reliability in packet flow must overcome any congestion for a particular network deployment connection. Moreover, the wireless connection is envisaged as more prone to errors due to much vulnerability in the air [1]. Therefore, connectivity issues in the wireless multi-hop environment must not be underestimated. Sufficient number of packet generation must be constantly estimated. Sensor base station (sink) communication should be continuous in order to overcome any congestion encounter, that would constrain the limited memory resources due to limited bandwidth issues in the connection.

We propose Asynchronous Data Transfer phase model technique, in a clustered network, where the Wireless Sensor node deployment, is capable of transmitting data, based upon revised base station distance estimation technique, in transmitting data from the sensor, which enhances energy efficient and data control practices in clustered network architecture. In WSN congestion reducing must benefit the application to secure more data reliability for energy efficiency. Based upon this, the sensor memory must be pruned for more bandwidth resolution.

The rest of the work shall be observed as follows: Section I include introduction and the problem identification phase, Section II consist of the related work in various congestion mitigation algorithms in fast data transfer, and section III consist of the proposed system design, which include Section V as the description of hierarchical clustering architecture, section VI is the Asynchronous data transfer model description, section VII is result discussion, section VIII is conclusion, and section X is reference.

1.1 Problem Identification

Wireless Sensor Network (WSN) technology has become much ubiquitous, so that congestion control in a clustered architecture, using cluster head, head-set members in architecture deployment of large scale sensor node, is a widely accepted issue which must be reviewed. Therefore, a sensitive application such as battlefield surveillance, smart power grid systems, and health system deployments, requires sufficient bandwidth for efficient data transmissions. Random traffic generation improvement [2] over packet delivery, including intermediate sensor nodes should consequently enhance a packet delivery in all base station (sink) transactions [3].

A major cause of congestion in WSN can be attributed to the fact that the sensor node is smaller in size with corresponding limited memory, power, and computational capability [4]. The batteries which should be supplied to the sensor nodes usually run out so quickly that they are depleted in no time. This means they are not able to withstand long period of operations based on particular sensor deployment situation. Based upon this sensor deployment must adapt energy efficiency techniques, such as hierarchical clustering. In applications such as the battle field monitoring, smart grid power, etc. can be under threat if not well secured. Data reliability and delivery techniques are important for energy boost. Usually, in such situation, in order for more data reliability to be achieved, energy efficient techniques, using clustering architecture for sensor deployment for energy efficiency must be proficient and proactive. When this is achieved enough bandwidth will continuously occur in the memory of the sensor with enhanced computational capability, in order to sustain efficient energy state for the WSN.

2 RELATED WORK

In this section, we categorize the literature review under five aspect of wireless sensor data control techniques and algorithms. Our aim is to identify and investigate the issues relating to those proposed algorithms, and try to deal with any unresolved issues, that would not assist in achieving efficient and reliable fast packet delivery. The aim is also to provide loss data recovery in the network environment, that does not include estimation of average precision distance to the base station, regarding data transmissions. Therefore, it is important that fast data control techniques that we describe, in relation to those algorithms must address any congestion issue in the network, due to replacements of new nodes in clustering formation, which are depleted of their energy. Based upon this our related work can be reviewed as follows.

Retransmission timeout (RTO) [5] is one of the algorithms that can be used in data transfer in clustering network architecture. RTO is proposed for enhancement in packet delivery, and to increase the RTO value. Based upon this, Round Trip Time (RTT) for packets uses a timeout mechanism to trigger retransmission of packet which have not yet been acknowledged (ACK) in packet transmission, after an expired timer occurs. Based upon the standard de facto used, the transmission algorithm tracked average RTT in addition to m, and its product with RTT mean deviation which represent RTO value for subsequent packet derivation which has value 4 typically assigned to m.

If SRTT (k) is average smoothed RTT, then

$$SRTT(k) = (1 - \alpha_0)SRTT(k-1) + \alpha_0 RTT(k) \quad (1)$$

$$RTO(k) = SRTT(k) + mS(k) \quad (2)$$

(1) And (2) represents the smoothed average RTT and the RTT mean deviation, which is also used in determining the new RTO value.

2.1 RTO Determination:

Based upon the above description, in order for the next packet to be generated, the timeout value need to be set by the RTO. The RTT measurement should possibly be estimated afterwards, which subsequently update the RTO based on above two Eqns. (1) and (2).

This means, it is expected that timestamp must importantly be activated for RTT to be tracked for every packet that was transmitted. It was however

realized that only outstanding packet amongst the remaining tracked RTT at all times, whilst the remaining other packet could not be tracked. Based upon this, we ask an important question that, why should insignificant number of packet could only be used for tracking the RTO? This means, a timestamp issue occurs, which causes not all packets to be tracked by all RTT. This poses a conflicting design issue that need to be investigated. Although, equations (1) and (2) were proposed to resolve the issue, however the issue remains unresolved. We investigate about that and try to resolve the issue.

Fuzzy Based Algorithm for Congestion Control (FBACC) [2] was proposed for packet drop reduction, which occur over intermediate nodes. Moreover, at the same time, this also maximizes packets sent to the sink with source traffic rate regulation known as Fine tuning the Fuzzy Bucket Token [6]. Based upon this, the average packet delivery represents QoS which is an important metric factor that overcomes burst traffic. An important characteristic of FBACC is that it is very useful for applications that have limited memory, energy constraint, and with main objectives of performing very well in fast data transmission based on accepted packet level drop.

One important aim of this research is to investigate about fast reliable data, using effective hierarchical clustering congestion control technique, including asynchronous data transfer model. This also applies to time sensitive and fast data delivery application, such as battlefield monitoring of equipment and personnel. It can also be applicable in health system and smart power applications. This means that, an urgent requirement of our design is that, it must be capable to prevent occurrence of any congestion such as packet drop issue in clustered architecture. Moreover, in critical condition like health application situation, it would be unacceptable that a WSN application should transmit data that still incur appreciable level of congestion such as packet drop. This is because applications like battlefield health, and power systems, which are critical and time sensitive, require continuous data delivery from sensor to base station, in order to maintain the energy efficiency state using clustering architecture. In view of this, we deem it very urgent to investigate about the issue of packet drop in our WSN fast data transfer algorithm description.

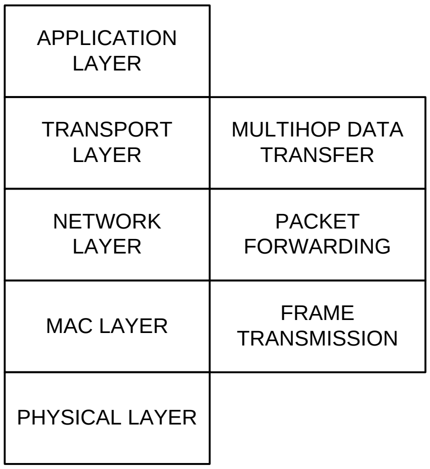

Fig.1 HAEEW Protocol

Distributed Control Algorithm (DCCA) [7] proposed for the WSN is congestion level detection based on queue detection scheme in the MAC layer. This adopts Hop-by-Hop (HBH) feedback notification scheme, with appreciable level of packet drop, which also gives high overhead. This also merges with the Transport Control Protocol Layer (TPL). Our fast data transfer, and congestion mitigation technique, which ensures a reliable data transmissions with energy efficiency design in mind, (Fig.1) has been designed such that, it is based on feedback congestion notification in a multihop WSN environment, and forward packet instantly without any congestion encounter such as packet drop from the Network Layer (NWL). Instantly, this is required to transmit fast data immediately to the remaining sensor nodes via the TPL. Meanwhile the NWL that is proposed in DCCA consist of packet forward and packet drop [7]. Packet drop issue is a severe congestion encounter in clustered network, are hostile to design environment such as our protocol design. We therefore seek to investigate about packet drop issue in our application that should be addressed in our protocol layer design.

Furthermore, due to limited memory and size of wireless sensor nodes, it must be carefully designed such that it protocol layered approach must be unique, compared to wired network layered approach. Based upon the description in WSN protocol layered approach used in [8], it was designed according to requirement of wired network layered protocol approach. Therefore, channel estimation for the WSN is not generated to suit the application. Since the reliable fast data application in the wired/traditional network is end-to-end [8], it does not include requirement in multihop feedback loss congestion notification and loss recovery for the WSN. We require that channel reliability in WSN must include use of multihop clustered architecture which is energy efficient compared to hop-by-hop, in order to solve the long distance latencies issue created in the end-to-end wired layered approach. Channel estimate for sending and receiving of control information must synchronize with same time clock, in order to serve its usefulness. Therefore, we find it urgent to investigate about any conflicting design issues, that would not to suit channel applicability situation in WSN transmissions.

In Energy Efficient Reliable Transport Protocol (EERT) Hadamard coding techniques is explored whereby a source node encodes a data packet. The packet encoded is finally delivered to the base station (sink) using Ad-hoc on Demand Distance Vector Routing Protocol (AODV) [9]. The technique of data encoding is that, Hadamard coding scheme maps a message length K-bits into 2K bits codeword, which is transmitted to the receiver node. At the receiver Cyclic Redundancy Check (CRC) is performed on the data with K-bits length in the transmitter and 2K-bit codeword in the receiver. Subsequently, it is detected that only few errors occurred [9], whiles in most occasion errors are rarely discovered in the transmission. Meanwhile, data encoding is done continuously, over and over. We consider using frame iterations time in clustered network, synchronized, should subsequently sent data to neighbors. We anticipate continuous delivery of such encoded data, without clustered architecture result in loss or inaccurate data transmission. We believe also this can give much data overhead which need to be investigated.

3 SYSTEM DESIGN

The system design comprises of description of various WSN energy efficiency, and data transfer clustering techniques, outlined below:

3.1 Sensor FIFO Buffer Queue Technique

FIFO [10] stands for first in, first out, and FIFO asynchronous data transfer (ADT) buffer queue, is a hardware component design that is capable of storing data, and also treat the data as part of exchange between a numbers of processors. FIFO ADT buffer queue can also be designed in queue block such that simulation in the buffers in software is possible. Based upon the requirement of the design, processors are required to be driven by a clock. The job of the clocks is required to provide synchronization between all processor hardware in the design, which intends to provide synchronization by all clocks and the sensor nodes, that are found in the design.

In Fig.2 is the model that represents two processors A and B. The processors are designed with their corresponding clock attached to the sensor FIFO ADT buffer. In the processors are found entities which have connections with the FIFO Queue blocks. Entity connections and entities are formed such that, implicitly, they move and unite along with each other, and also enforce blocking between blocks which occur in the design. Subsequently, FIFO queue blocks are developed which buffer and regulate the movement of data between Processors A and Processor B. For the purpose of our model design, processors represent sensor nodes.

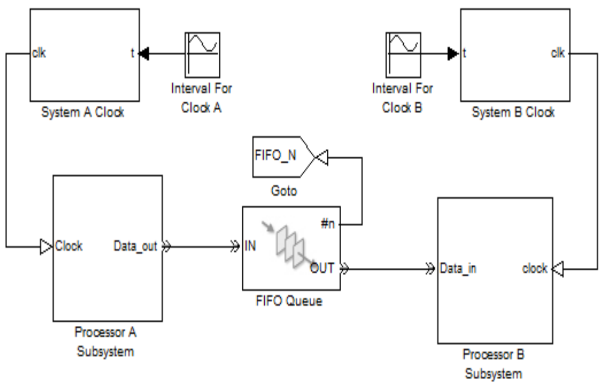

Fig2.Asynchronous Data Transfer Between Sensor Processors

One of the effective and commonly used backbones for organizing WSN is hierarchical clustering architecture [12]. As shown in Fig.3 below, hierarchical architecture for WSN for asynchronous data transfer is developed. This includes sensors transmitting data to the cluster head and subsequently transmit data to the base station (BS). Clustering architecture has been modeled from LEACH, but with a different concept in using head-set, rather that cluster head concept. By using clustering in our concept, election of head-set, in a large sensor nodes deployment in the network is developed, and divided into groups forming clusters, through partitioning. The head-set members, are required to transmit messages to distant BS. As the Wireless Sensor Network (WSN) is limited with bandwidth resources due to its limited memory and computation capability, and limited energy withholding capability, it is recommended that spatial reuse of bandwidth provision must be made continuously to sensor node. In addition, efficient energy-aware routing capability must be developed to aid in message transmission.

3.12 Reducing Congestion in Clustering Backbone

Constant clustering formation of the network consists of deployment in large scale sensor node in a multihop environment. As a result a lot of congestion is introduced in the network, due to replacements of new nodes that have sufficient energy that can replace nodes depleted out of energy. As such the network must be subdivided, with each given a separate base station. Due to congestion, there is contention for all data source, competing with each other, which access the sensor nodes from each cluster subdivision, reporting to the base station (sink). In energy efficient desiring protocol such us our model, contention of accessing the sensor nodes results in congestion, when each data reporting to the base station results in high energy depletion, and excessive energy holes. In order to introduce new batch sensor node in constant cluster formation, sensors must be capable of estimating twice as precision distance, in relation to data transmissions to the base station . The ADT FIFO buffer uses its synchronized clocks in each time iteration round, to determine the average distance between all the sensors due to implementation of block queuing in the deployment, in relation to the base station. New node with high enough energy should be successful to replace old sensor nodes, due to high connectivity protection developed in the asynchronous data transmission in the network.

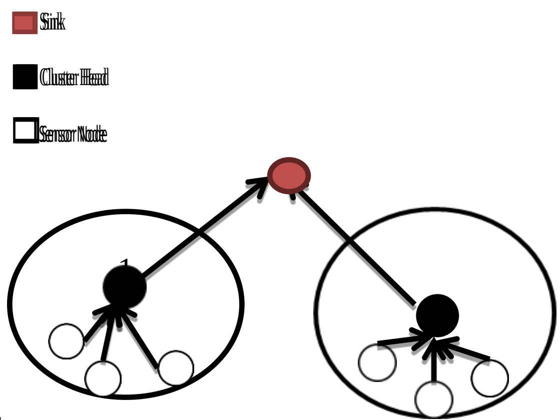

Fig. 3 Energy Efficiency Protocol

3.2 Radio Model Design

A new radio model design, synonymous to the one described in [13] is recommended in our model . However, the radio model in [13] uses only shorter transmissions distance in the clusters, which is not able to achieve synchronization of the sensor times. But in reference to our new proposed model, and for our purpose of attaining full synchronization in the sensor processors, we aim to design radio transmission that is capable of extending it scope, in order to achieve average precision sensor distance. The aim is to explore a diverse transmission range, based upon clustered network formation using energy consumption in transmit amplifier, proportional to $2r^2$. This means, irrespective of the nodes coverage distance, average distance estimation between long or short transmission ranges must be determined by the head-set formed, in relation to the transmissions of the base station; which is also capable of exploring the location of its position. Based upon this, we estimate the energy consumption to be $2r^4$. Estimating the energy consumed for 1-bit message transmit in this new radio model, which include estimating an average between short and long distance is necessary, which include obtaining average precision distance d with the corresponding energy as follows:

$$E_T = lE_A + 2l\epsilon_l d^4 \qquad (3)$$

Similarly, to transmit 1-bit message in shorter transmission range, the energy consumed is:

$$E_T = lE_e + 2l\epsilon_1 d^2 \qquad (4)$$

Furthermore, in order to receive 1-bit message, the energy consumed should be:

$$E_R = lE_e + 2lE_{BF} \qquad (5)$$

Eqn. 3, must incur a reduced cost assessment in our new sensor hardware design, that is capable of reducing energy consumption in the new receiver hardware . We show the constants in our new radio model as in Table 1 as below :

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Description	Symbol Representation	Cost
Amplifier energy consumption for Average distance data transfer	ϵ_l	0.0026pj/bit/m^4
Amplifier energy consumption for short distance data transfer	ϵ_s	20pJbit/m^2
Electronic circuit energy consumption in received signal	ϵ_e	50nJ/bit
Energy consumed for new sensor	ϵ_{BF}	2nJ/bit

Table 1: Parameter values in our radio model for quantitative measurement analysis

3.3 Cluster Head Election Phase

In our algorithm description of cluster head election phase, we determine optimal sensor cluster number k, required in our protocol for n sensor nodes. We anticipate that nodes have acquired average initial energy. The energy consumed is averagely estimated to be the same for all cluster formation. Before election phase begins, substantial amount of cluster head is randomly identified to the base station. A typical initial action is that, cluster head are required to disseminate message to all neighborhood sensors. After that, cluster heads sends message to sensors, and sensors depend on the received signal strength to choose their cluster head. Subsequently, sensors make decision and transmit to their corresponding cluster heads. Finally, cluster heads are able to identify messages that originate from their corresponding sensor nodes. These corresponding cluster head are capable of choosing m associate set, based on each cluster head, dependent on the signal well analyzed .

In order to maintain uniformity in cluster distribution, we anticipate that each cluster should have $\frac{n}{k}$ nodes. Eqns. 3 and 4 can be used in determining energy consumption in each cluster head as follows:

$$E_{CHelec} = \{\mathrm{lE_e} + 2\mathrm{l}\epsilon_\mathrm{s}\mathrm{d}^2\} + \left\{\left(\frac{n}{k} - 1\right) l(E_e + 2E_{BF})\right\} \quad (6)$$

In Eqn. (6), the first part $(\mathrm{lE_e} + 2\mathrm{l}\epsilon_\mathrm{s}\mathrm{d}^2)$ is used to show the advertisement of message transmit consumed energy, which typically represents average precision distance of sensor energy consumption dissipation model. Whilst in the second part, $\left(\frac{n}{k} - 1\right)$ represent received message energy consumption. Subsequently, we simplify Eqn. 6 as follows:

$$E_{CHelec} = lE_e\frac{n}{k} + 2lE_{BF}\left(\frac{n}{k} - 1\right) + 2\mathrm{l}\epsilon_\mathrm{s}\mathrm{d}^2 \quad (7)$$

The energy consumption of non-cluster head sensor nodes election, can be estimated by Eqns. 3 and 4 as follows:

$$E_{nonCHelec} = \{klE_e + 2klE_{BF}\} + \{lE_e + 2l\epsilon_s d^2\} \quad (8)$$

The first part of Eqn. 8, indicates the received k cluster head consumed energy message. Based upon this, we anticipate message is received by sensor node from all clusters. In the second part of Eqn. 8, the consumed energy for transmitting message decision to the corresponding cluster head is shown. Simplifying, Eqn. 8 is as follows:

$$E_{nonCHelec} = lE_e(1 + k) + 2klE_{BF} + l\epsilon_s d^2 \quad (9)$$

4 Asynchronous Data Transfer Model in WSN

We use asynchronous data transfer in our proposed model as outlined below. Asynchronous data transfer(ADT) in senor FIFO buffer queue phase in WSN is vital for storing data efficiently, and exchange data between corresponding numbers of sensors in a multihop clustered network environment. ADT is modeled according to data transfer phase model technique in [13]. With the data transfer phase model[13], hierarchical clustering technique is used in large scale sensor deployment, that enhances energy efficiency state of the clustered WSN. The technique further describes an algorithm for data transfers, which require that nodes must be capable of transmitting messages to their cluster head. Subsequently, aggregated message is transferred to a distant base station. With asynchronous data transfer, aggregate message transmission, which includes base station, and data gathering techniques, is not applicable in the data transfer phase. Therefore, we develop algorithm to fulfill that requirement, which fulfill deployment requirement in aggregated data transmission. This should include the energy consumed by each cluster head, in a multhop clustered network environment based on the new designed hardware transceiver.

Note, however that based upon description, already outlined in system design section III, ADT uses uniqueness attribute in sensor FIFO buffer queue software simulation attribute, that must be maintained. The software uniqueness emphasize on the capability of our algorithm, using blocking queue development within queuing block, to maintain constant connection. Subsequently, these form connections of data transfer protection, that should be capable to prevent occurrence of congestion in continuous clustered formation. Therefore, we model energy consumed based on each cluster head-set, as according to data transfer model in [13]. Reemphasizing, our simulation in software, which enables us use software simulation analysis development in our model is applicable in this new radio hardware data transmission test, and we compare our result to the data transfer phase mode[13]. However, our model uses energy efficient routing, such as ad-hoc on-demand energy-aware routing (AOER), for energy efficiency state, evaluated as follows:

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$$\{lE_e + 2l\epsilon_l d^2\} + \left\{\left(\frac{n}{k} - m\right) l(E_e + 2E_{BF})\right\} \quad (10)$$

From the foregoing analysis, energy development equations, which relate to average precision distance estimation of sensor nodes, in relation to base station, with cluster head formation, is given in Eqn. 10, which shows the energy consumed for transmitting message to distant base station. Based upon this energy requirement of our model can be satisfied. In the second part of the Eqn. 10, is energy consumed in order to receive message from the remaining sensor node is ($\frac{n}{k} - m$). Note that this does not form part of the head-set.
Simplifying Eqn. 10 is as follows:

$$E_{CH/frame} = 2l\epsilon_l d^4 + \left(\frac{n}{k} - m + 1\right) lE_e \left(\frac{n}{k} - m\right) lE_{BF}$$
(11)

In order to transmit sensor data to the cluster head, energy consumed by non-cluster head is determined as follows :

$$E_{nonCH/frame} = lE_e + 2l\epsilon_s d^2 \quad (12)$$

Determination of energy consumed is based on uniform distribution of circular clusters for sensor node, which uses network diameter M. Recalling, the average value distance measurement for $2d^2$, least cost energy requirement which is needed in our proposed model is given as:

$$E[2d^2] = 2\left(\frac{M^2}{2\pi k}\right) = \frac{M^2}{\pi k}$$
i.e. $E[2d^2] = \frac{M^2}{\pi k}$ (13)

Simplifying Eqn. 12 is given as below:

$$E_{nonCH/frame} = lE_c + l\epsilon_s \frac{M^2}{\pi k} \quad (14)$$

5 Circular Data Iteration

In circular data events for data distribution, N_f data frame transmission occurs in one iteration. Therefore, the transmitted frame by each cluster should be N_f/k. In all we estimate that uniform partition of N_f/k frame occur amongst n/k cluster nodes. In order for each cluster head frame transmission to occur, $\left(\frac{n}{k} - m\right)$ non-cluster head frame fraction determination is required.
We determine equations for frames transmissions fractions $f_1, and\ f_2$ as given below:

Now,

$$f_1 = \left(\frac{1}{\frac{n}{k} - m + 1}\right)\frac{1}{k} \quad (15)$$

$$f_2 = \left(\frac{\frac{n}{k} - m}{\frac{n}{k} - m + 1}\right)\frac{1}{k} \quad (16)$$

Therefore, we estimate that asynchronous data transfer (ADT) frame of each cluster energy consumption will be determined as:

$$E_{CHdata} = f_1 N_f E_{CH/frame} \quad (17)$$

$$E_{nonCHdata} = f_2 N_f E_{nonCH/frame} \quad (18)$$

6 Start Energy for Data Transfer Rounds

Start energy for data transfer round is denoted by E_{satart}. This is the initial energy of the sensor node, with initial start time. In order to successfully transfer data in rounds, E_{satart} should be sufficient for at least one round in transmitting data. During data transfer, it is required for a node to become head-set member for one time, in a data transfer round, and a non-cluster head for $\left(\frac{n}{km} - 1\right)$times.
E_{satart} is estimated finally to be:

$$E_{satart} = \frac{E_{CHelec} + E_{nonCHelec}}{m} + \frac{N_f}{m}\left(f_1 E_{CH} + f_2 E_{nonCH/frame}\right)$$
(19)

Hence, $N_f = \frac{mE_{start} - E_{CHelec} - E_{nonCHelec}}{f_1 E_{CH/frame} + f_2 E_{nonCH/frame}}$

7 Optimum Cluster Number Determination

Optimum cluster number k, used in minimum energy consumption, can be determined based on[13] as:

$$\epsilon_l d^4 - (2m-1)E_e - 2mE_{BF} - n\epsilon_s \frac{M}{\pi k^2}^2 \quad (20)$$

The optimum value of k is determined based on Eqns. used in [13] for minimum frame energy dissipation, evaluated and summarized as :

$$k = \sqrt{\frac{n}{\pi}}\sqrt{\frac{\epsilon_s}{\epsilon_l d^4 - (2m-1)E_e - 2mE_{BF}}} M \quad (21)$$

8 Description of Time Completion during One Round Data Transfer

In data transfer phase, message transmission has been specified in [13], which is based only on TDMA schedule. Asynchronous Data Transfer(ADT) phase message transmission is based on combination of message transfer in the network layer (NWL), transport layer (TPL), and MAC layer, shown in Fig.1. Furthermore, ADT FIFO buffer queue is specified with design requirement, that uses connections in sensor ad hoc behavior to maintain constant formation in queue. These queue are formed such that, implicitly, they move and unite along with each other, and also enforce blocking between blocks, which prevent occurrence in any irregular contention of access in the sensor buffer queue development medium. The design requirement also includes TDMA technique for data transfer in one round. In addition, this design need fulfill the requirement that address the need for finding a suitable protocol resolution for Wireless sensor network protocol layer transmissions.

Based upon this, frame time t_{frame}, which include different message transmission times for all sensor cluster nodes, should be determined. Consequently, sensor nodes should be giving equal time processing capability to synchronize their clock times

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due to routing in NWL, which uses ad-hoc on-demand energy-aware routing (AOER) protocol. During this stage, data transfer rate $R_b bits/seconds$ can be estimated and average precision message length of $2l\, bits$, is developed in time to transfer message t_{msg} time as follows:

$$t_{msg} = \frac{2l}{R_b} \qquad (22)$$

Note, here that message transmission in one frame, include non-cluster heads nodes and head-set active member. We estimate also that in one round time, appreciable number of sensor head-set members should be active. Therefore, as this requirement is fulfilled in our design, no additional requirement will be needed, in order for one to give account in overhead data transmission, that might occur as inactive head-set member in our design. Based upon this we estimate one frame time as below:

$$t_{frame} = \left\{ \sum_{i=1}^{\frac{n}{k}-m} t_{msg} \right\} + \{t_{msgcluster\_head}\}$$

(23)

Based upon the description in Eqn. 23 above, the first part uses $(\frac{n}{k} - m)$ messages from non-cluster head nodes. The second part, indicates sensor head-set active member message transmissions.

The justification of our model form [13] is based on estimating same frame time message transfer for all the sensors, based on uniform clock synchronization transmission of sensor device in our model. Therefore, Eqn. 23 can further be simplified as follows:

$$t_{frame} = \left(\frac{n}{k} - m + 1\right) t_{msg} \qquad (24)$$

Until now, we believe there should not be a concern, that should make one to misunderstand that, N_f frame have been used for data transmission in one iteration. Therefore, we determine one iteration time $t_{iteration}$ required as below:

$$t_{iteration} = t_{frame} \times N_f \qquad (25)$$

With Eqns. 23 and 24 combined, we summarize the time for iteration $t_{iteration}$ as:

$$t_{iteration} = \frac{1}{R_b}\left(\frac{n}{k} - m + 1\right) N_f \qquad (26)$$

Note here also that with $\frac{n}{km}$ iterations, occurring in one round in each data transmission, we estimate one round time t_{round} as below:

$$t_{round} = t_{iteration} \times \frac{n}{km}$$

$$t_{round} = \frac{1}{R_b}\frac{n}{k}\left(\frac{n}{k} - m + 1\right)\frac{N_f}{m} \qquad (27)$$

9 Results Discussion

We analyze our result discussion in our proposed Hierarchical Clustering based FIFO asynchronous data transfer technique, for Energy Efficient WSN (HAEEW). We also compare the result to the original model, Energy Efficient Hierarchical Cluster-based Routing (EEHCR) protocol- (which is modeled from LEACH) protocol, using quantitative measure, based on the radio communication model ,and software simulations parameter settings outlined in section V.

9.1 Optimum Cluster Setting Analysis

Based upon Eqn. 21, we analyze result in the optimum cluster number setting in the Asynchronous Data Transfer (ADT) technique (HAEEW), and compare the result to the original data transfer model technique (EEHCR). Fig.4 depicts the two graphs The graph for Energy Efficient Hierarchical Cluster-based Routing Protocol (EEHCR) and the graph for Hierarchical Clustering-based FIFO asynchronous data transfer technique for Energy efficient WSN (HAEEW)- our model. These two graphs are both evaluated based upon the optimum cluster number variation, and head-set size for sensor nodes in software simulation implementation in matlab, with parameters settings: sensor nodes number n=1200, with base station location at d=150m.

For improved result of our proposed model, even though, we varied the number of sensor node from n=1000 to n= 1200. The head-set was required not to exceed between 1 and 6 theoretically. We maintained that status (seeFig.4). Our algorithm HAEEW shows remarkable improvement in the head-set, and does not exceed the estimated theoretical setting range of 1 and 6, which does not also incur message overhead.

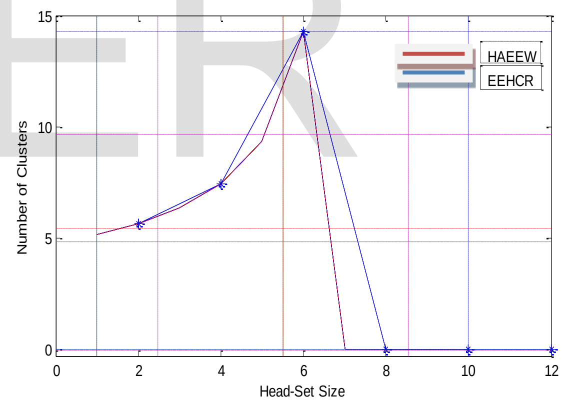

Fig.4

: Maximum optimum cluster number in Head - set

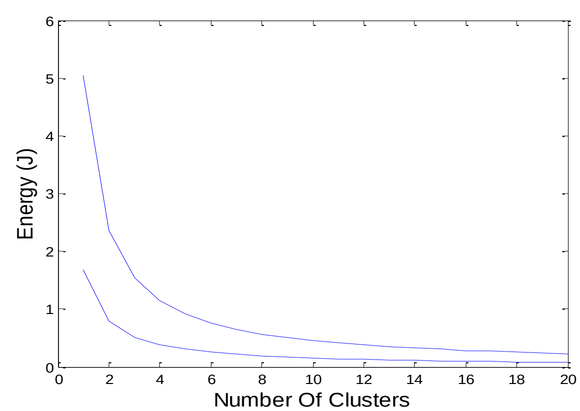

Fig. 5 Maximum optimum cluster number

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Fig.5 shows energy consumption, estimated in relation to the cluster number. Based upon this graph, the energy consumption is expected to reduce, with increased cluster number, using Hierarchical Clustering-based FIFO asynchronous data transfer technique for Energy Efficient WSN (HAEEW). However, based on our improved techniques in Asynchronous Data Transfer, the number of clusters used have been doubled, which also introduced average cluster number estimation. This include increased in cluster number as shown Fig.6, compared to that data transfer technique, in Energy Efficient Hierarchical Cluster-based Routing Protocol (EEHCR) shown in Fig.5. Therefore, it is expected that with more increased in the cluster number, due to perfect achievement in more clock synchronization, the difference in energy consumption reduction is huge with our technique, when more clusters are introduced in the network.

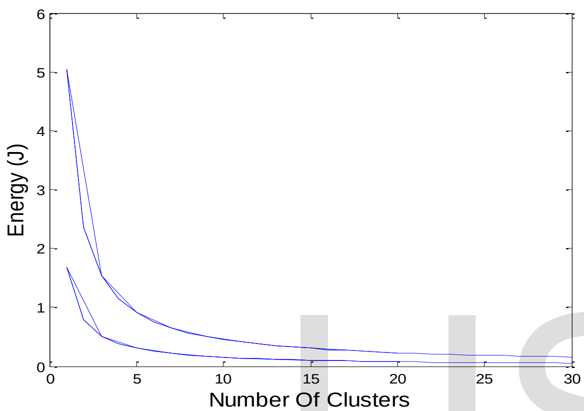

Fig. 6: Improved maximum optimum cluster number

9.2 Frame Iteration Synchronization Time

Frame iteration time is used for completing one iteration. This is averagely estimated based on the precision distance determination on sensor nodes transmissions, in relation to the base station; with respect to cluster head formation, which forms part of the head-set. Average time determination in one iteration is also estimated such that, each clock time for all sensor nodes becomes synchronized in relation to the network diameter estimation.

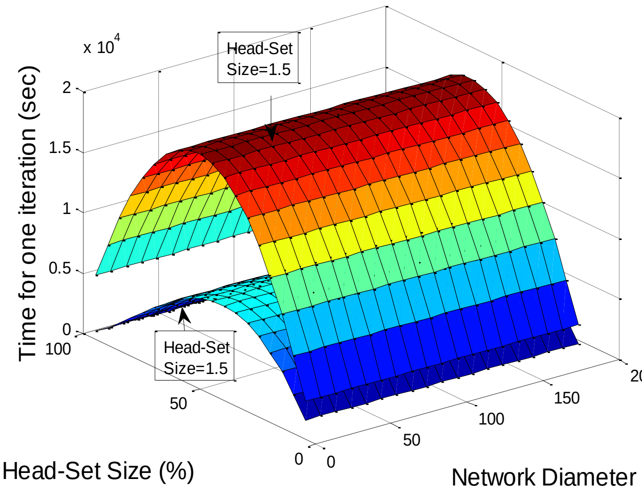

Fig.7:Iteration time for Head-set size on average diameter estimation

Fig.7 illustrate frame iteration time variation graph, based on synchronized clocks of the sensor, which has significant effect in cluster diameter, and head-set size estimation. In our model (HAEEW) improved diameter of 1.5m is estimated, which gives reduced cluster diameter, and correspondingly less one round iteration time, as compared to the diameter estimated in (EEHCR) which gives 3.0m. The three axes, are represented respectively by sensor cluster diameter, the head-set size, and synchronized clock time completion in one iteration. The sensor cluster percentage is used for determining the head-set size. Constant start energy E_{satart} is applied in all cases, and can be useful for long duration, with the head-set size estimated to be more than 50% of the cluster size. Based upon the increased percentage (>50%) in the head-size, sufficient data transmission is allowed in each iteration; this reduces overhead in the number of iteration in HAEEW; this would be impossible without improved time synchronization technique in Asynchronous Data Transfer, used for the percentage cluster size determination, and subsequently for estimating the head-set.

10 CONCLUSIONS

Our proposed model Hierarchical Clustering-based FIFO asynchronous data transfer technique for Energy efficient WSN (HAEEW) has been modeled in reference to, Energy Efficient Hierarchical Cluster-based Routing Protocol (EEHCR)-this is modeled from

LEACH algorithm. In EEHCR, quantitative analysis was used to indicate result for energy consumption, which decrease systematically; by inclusion of many sensor nodes in cluster head-set formation. In another development, with same number of data collecting sensor nodes, it was analyzed that, controlled number of nodes, and management number of nodes could possibly be adjusted, based upon the network prevailing condition. Our modeled technique, HAEEW, has even showed remarkable improved result in energy efficiency, with consistency in more energy consumption reduction. Thus when we consider using greater number of sensor nodes, in the cluster

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head-set formation, than that used in EEHCR (original model). Consequently, referring to our model, Asynchronous Data Transfer data collection of sensor nodes, shows much controlled number of sensor nodes, and management number of sensor nodes, which can be adjusted even more easier, irrespective of the prevailing network condition, example of which is greater number of sensor nodes that can be deployed for extended network life.

Future work will concentrate on estimating the cluster head-set size formation in mixed network environment of single-hop and multihop network, with non-uniform cluster distribution also taken into account.

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