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AN EFFICIENT CLUSTER BASED ALGORITHM FOR INFORMATION PROCESSING IN WIRELESS SENSOR NETWORKS

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ABSTRACT: - Wireless sensor networks are formed by small sensor nodes communicating over wireless links without using a fixed network infrastructure. Sensor nodes have a limited transmission range, and their processing and storage capabilities as well as their energy resources are also limited. Most current applications that consume energy can be customized or optimized in a process resulting less energy consumption. During the rise of wireless sensors field applications, and also, the critical situation of energy consumption, the optimization of energy dispatch becomes a critical and important field of research. Hence, the wireless sensor depends on its internal battery to work its total life time, extending the life time by minimizing the consumption of power is also very important field in current researches.

This research aims to optimize the energy consumption of wide scale wireless sensor networks by deploying a novel and adaptive improvement and modification on the traditional clustering of the cells of the network. In this thesis we work on load balancing of each cell in the network, introduce the “Potential” concept which is a measurement of node and cells overall availability and it is related to energy, distance and data transfer, deal with the nodes in between two clusters and finally make all nodes die almost at the same time by using an adaptive system for solving these problems.

Keywords: - Wireless, Sensor, Energy, Deployment, Nodes, Networks, Cluster.

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1. INTRODUCTION

Wireless networking and advanced sensing technology have enabled the development of low-cost and power-efficient Wireless Sensor Networks (WSNs) which can be used in various domains such as health care, military purposes, home intelligence, and Outdoor Environment Monitoring (OEM). Devices in WSNs, called sensor nodes (SNs), are used to sense certain properties of the surrounding environment, including physical/chemical properties, and transmit the sensed data to a central unit called Base Station (BS) either periodically or on-demand. According to different application requirements, a Wireless Sensor Network (WSN) may consist of just a few or as many as thousands of wireless nodes, operating in a collaborative and coherent manner for a few days or several years to fulfill a specific task.

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The wireless sensor networks are an emerging field that performs a comprehensive process of sensing and measurements, measurement logging, data transfer and management via a wireless data network. The wireless sensor is a tiny small device that combines all functions in special measurements and computation. A bulk or set of sensors connected though network in mesh form perfuming a networking protocol. The hopping data of the sensors from one sensor to another is a major protocol and technique, the sensors that hopping data from one to each other is so called “NODE”. The connection and cooperation of large number of nodes makes a rigid network with high capabilities and specifications.

The wireless sensor nodes also, don’t require communicating directly with the nearest control tower which is high power or even don’t require directly communicating to the base station. But it communicates with the nodes local peers only. Thus, this connection will be a pear-to-pear connection making a mesh network. The mesh architecture implies a flexible networking of hopping branches. And the system is very adaptive for node failure substitution and compensation.

Each sensor node in the wireless sensors networking can perform communication over a range of 50 meters. Thus, to communicate between sensors and transfer the data, no repeaters are needed and no huge number of sensors is required. A WSN is a network consisting of numerous sensor nodes with sensing, wireless communications and computing capabilities. These sensor nodes are scattered in an unattended environment (i.e. sensing field) to sense the physical world. The sensed data can be collected by a few sink nodes which have accesses to infrastructure networks like the Internet. Finally, an end user can remotely fetch the sensed data by accessing infrastructure networks. Fig. 1.1 shows the operation sketch map of WSNs.

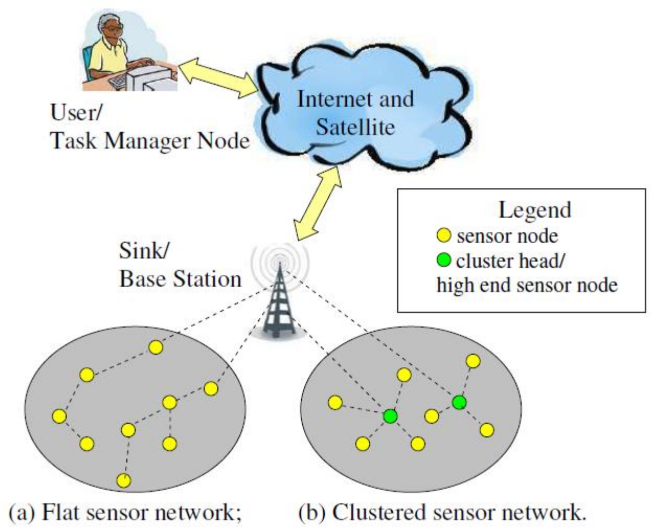


Fig 1.1: - Operations of WSNs

In Fig. 1.1, two kinds of network topologies are shown. The sensor nodes either form a flat network topology where sensor nodes also act as routers and transfer data to a sink through multi-hop routing, or a hierarchical network topology where more powerful fixed or mobile relays are used to collect and route the sensor data to a sink. Fig 1.1 shows an example of wireless sensor networks applied to a farm. It has a big important in agriculture fields, and such fields are active area for researchers and developers. It’s clear that, large number of nodes are distributed throughout the field and connected together. That is establishing what so called “Routing Topology” or “Network Topology”. The mount of sensors can be extended from tenth or hundreds to thousands in some cases.

The wireless sensor consumes energy from a battery depends on. The battery is internal structured in the sensors node, and has a specific power consumption period. Whoever, this period depends on the nature of the sensor and the running conditions. The running conditions represents the environmental conditions, data transfer packet, the sequence of transfer, measurement issues, etc. Hence, the wireless sensor depends on its internal battery; the sensors node life time is limited to battery energy and energy consumption scheme, what so called Power Dispatch or Power Consumption Flow. The computational limitations and also, storage limitations are main bounds of the wireless sensor networks and such systems. Unlike the cell phones or PDA’s, the power of the wireless sensor cannot be recharge during its running life. So, the sensor is almost being replaced after its battery died.

The communication of wireless sensors via a network is needs specified network to control, and manage the communication, data transfer, and also, measurement logging. Hence, such networks have wide range of applications, that makes developing universal or single protocol is difficult. Such network topology should provide a complete or enough support of application-specific protocols, that is proving the demands of the sensors and network, specially, power consumption and life time

2. PROBLEM DEFINITION

The sole purpose of this project is to find the method which is more energy efficient. Wireless sensor networks are battery operated. Sensor nodes collect the data and pass them on to the network for further use. This passing and receiving of data utilizes most of the energy of the network. So for better operation and increase the lifetime of the network, energy consumption must be the major factor of concern.

The wireless sensor depends on its battery to run along its life time, thus, the life time depends on the consumption of the power. This is related to many variables, including the distance between the sensor and the head of cluster, the transfer packet size, the energy slope of that sensor which is related to its physical measuring structure, and other effects.

In the wireless sensors network, once the first sensors battery consumed, the sensor is considered to be died. Not all sensors in the wireless network are being died in the same moment. So, once the first one died, the network and/or the cell will be unbalanced. In this case, if the network continues to running – collecting data, logging, and transferring the data to base station – the overall data will have a shortage. The dead sensor(s) couldn't send any data, so, the data is missing. From that, the problem of energy optimization in wireless sensor networks is important case for the modern researchers, and taken into place for all manufacturers and developers of such systems. Whereas, the main issue of this problem **-** from computer systems and information technology side – is the clustering of the wireless sensors network. By developing a good new adaptive clustering algorithm of the network, it can be save energy by 93% or more in large scale wireless sensors network.

Thus, this research developed a new methodology and technique of wireless sensor networks clustering. This clustering is fuzzy-clustering based. And comprise variable clusters every transfer process. Where, the clusters and also, the head of cluster, are being changed every transfer process. And this thesis also, introduces a new concept in distributing sensor (nodes) on the cells (clusters), depending on the potential of the cluster. The potential of the cluster is an introduced and adapted variable that included implicitly all physical variables those affect the energy dispatch and transfer of the network.

Finally, this research in determined concept, concentrate on deploying wireless sensor networks clustering procedure that ensures all nodes to be dead in a time limit approached to zero.

3. THE EXISTING METHOSDOLOGY FOR IP IN WSN

As a special purpose and new version of ad-hoc, the wireless sensor networks have many of applications in many areas, like agricultural, animal monitoring application and large factory area monitoring applications. All such networks are implemented in ad-hoc conditions and specifications. The wireless sensor networks consist of nodes and base station, each node is a representation of wireless sensor tag. The sensor's energy comes from internal battery that built in the sensors case, and thus, it has a limited life time depending on the battery used, sensor's design, and the applications. The criticality of power saving and energy consumption in wireless sensor networks make this field important and rich for modern researcher, weather software or hardware researchers.

3.1. Low Energy Adaptive Clustering Hierarchy

The hierarchal clustering was introduced by Heinzelman. It clusters all nodes of the network into clusters (cells) where each cell has center called "head of cluster". In such protocol, each node transmit its information to the head of cluster, and it collects the data from all cluster's nodes, then, it compress and format the data before sending it to the base mobile station. The cluster's head consumes more power than other sensors, because of the load on it. The load is subjected to collecting data from all nodes, formatting data, sending and receiving data from base station. This needs to make the CH to have max power or energy than other sensor nodes. The LEACH, uses random selection of the head of cluster, so, it may not be the maximum energy node. The LEACH protocol rotates the node that is selected as head of cluster when its energy becomes low after a threshold value.

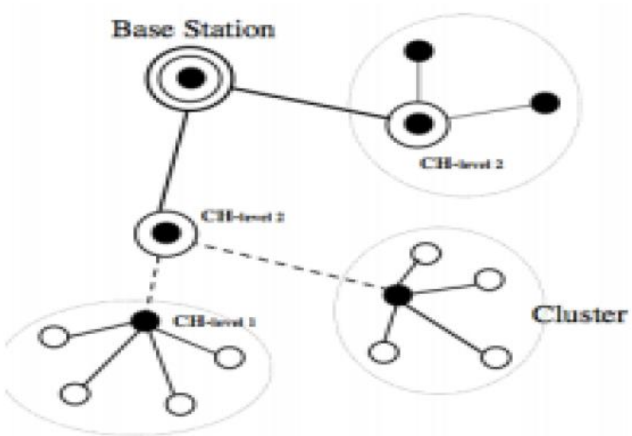


Fig 2.1: - Sample Hierarchically Clustered WSN

Heinzelman simulation results show that the nodes that can be considered the head of cluster is not exceed than 5% of the total wireless sensor networks nodes. Where the LEACH, uses a specified MAC protocol in order to minimize inter or intra cluster collision, such as DMAC. Also, this algorithm supposed the head of cluster to be centralized or semi-centralized node in the cluster. Fig 2.1 shows a sample hierarchically clustered network. The operation of LEACH consists of two stages; step stage and steady running phase. In the first stage, the networks are being clustered and select the cluster-head (CH) for each cluster. In the next stage, the sensing and measurement data transfer is being done. The data is transferred to the base station. The first stage is the configuration phase, while the steady running is the normal run phase.

The LEACH protocol attack is very difficult in comparison with the conventional protocols of multi-hope networks. The conventional protocols of multi-hop imply all nodes to be surrounding to the base station, so, this is attractive to compromise. But, in the LEACH protocol, the heads of clusters are communicates directly with the base station while the other nodes are not. The head of cluster can be located anywhere in network irrespective of the mobile base station. Also, the heads of clusters (CH) can be changed randomly. This makes head cluster to be difficult to be spotted. Hence, the wireless sensor networks based on a negligible memory sensors and low computational power, thus, the security of the network is a key management of improving the networks.

The following problems and difficulties occur in when using the LEACH for wireless sensor network, such as,

- If needed, all nodes can transmit to the base station with enough power.
- Each node can supports different MAC protocols, so it should have enough computational power.
- The nodes always have data that is waiting to be sent.
- The nodes that are located close to each other have data correlation.
- Since the first node dies, the system becomes unbalanced.

As for the system lifetime, it is the most challenging problem in any OEM deployment as the utilized nodes are energy constrained, and deployed networks are required sometimes to work for long time intervals measured in years. In addition, it is undesirable to revisit harsh environments such as those targeted by the OEM applications simply for node replacement or recharging. Accordingly, accurate lifetime prediction in the early deployment planning stages is required. There are two types of lifetime predictions in the literature: node and network lifetime prediction. Node lifetime can be measured in several ways. For example it can be measured based on the number of cycles over which the data is collected, it can be measured based on the cumulative active time of the node before it is depleted, or it can be measured based on the cumulative traffic volume of the node before its energy is depleted.

4. PROPOSESD ALGORITHM AND ITS CONTRIBUTIONS

The deployments targeting network properties mentioned above are mainly classified into two categories: random versus deterministic deployments.

In random deployments, nodes can be placed purely random to reduce the deployment cost, or based on a weighted random deployment planning, where the distributed nodes' density is not uniform in the monitored areas. For instance, K. Xu *et al.* studied the random RN deployment in a 2 Dimensional (2D) plane. The authors proposed an efficient network lifetime maximization deployment when the RNs are directly communicating with the BS. In this study, it was established that different energy consumption rates at different distances from the BS render uniform RN deployment a poor candidate for network lifetime extension. Alternatively, a weighted random deployment is proposed. In this random deployment, the density of RNs deployment increases as the distance to the BS increases, and thus, distant RNs can split the traffic amongst themselves. This in turn extends the average RN lifetime. We remark that some attempts have been made towards the 3D deployment, as well.

4.1. Deterministic Deployment

Proposals described above are suitable for applications which are not interested in the exact node positioning. In contrast, some proposals have advocated deploying nodes exactly on specific predefined locations, called grid vertices. These locations are optimized in terms of the aforementioned network properties and the feasibility of the location itself in reality (e.g. non-reachable locations are not feasible for node deployment). Due to the interest posed by OEM applications in the exact physical positioning of sensor and relay nodes, this type of deployment (i.e. grid-based deployment) serves this purpose more appropriately, and hence, is adopted in our work. Moreover, coupling this type of deployment with guaranteed multi-path routing can significantly enhance the network lifetime and fault-tolerance chances, in addition to repairing network connectivity problems.

4.2. Proposed Methodology

Fig 3.1. shows the general mode of the Energy Efficient Clustering Algorithm “EECA” adaptive software system. Starting by network data collection, it includes the calculation, determining the energy of each sensor and the initial nodes clustering (distributing on the cells) over the measurement space and initialization.

The initialization is plotting the location of each sensor in measurement space and applying (FCM) traditional clustering algorithm to get the starting location of the head of each cluster. That done after receiving the number of clusters that is needed to be used for cells from the base station. The next is to start the EECA clustering procedure, which is continue overall running period of the network. During this mode, the network is re-clustered every transfer time and re-localizes a new head of cluster and new distribution of nodes (sensors) in the cells (clusters). When the nodes start to die, the base station should stop collecting data from the network and generates the decision and command to replace the sensors.

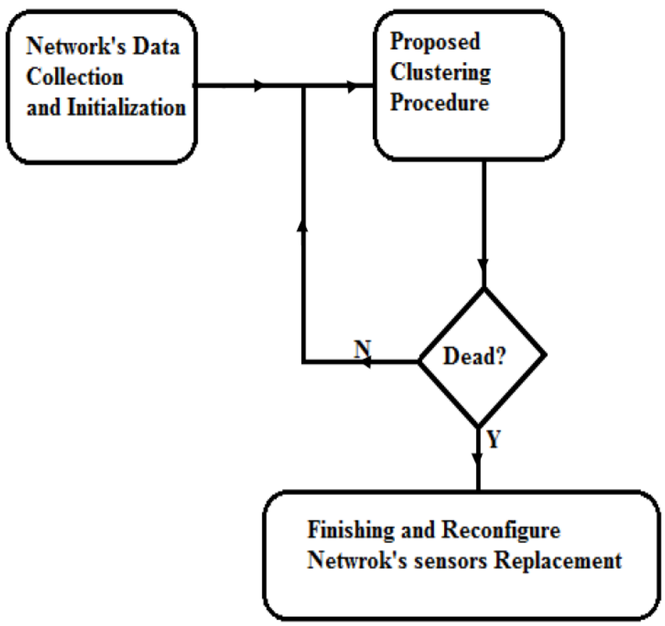


Fig 3.1: - The Proposed Cluster Algorithm

General scheme of the adaptive EECA is being illustrated in Figure 3.1.b and the details will be described as following; the process starts by data collection from the network. Then, the initial fuzzy clustering algorithm FCM is applied. After that, the normal running mode is entered, it consists of two phases those are consequent. The first is adaptive clustering which is described in details in Section 3.6, and the second is data transfer. This is still running until the network becomes idle, either by nodes death or by the base station commands.

While Figure 3.1.c illustrates the original LEACH algorithm flow. It is summarized as following; the process starts by data collection from the network. Then traditional clustering is applied at startup which means that the cluster head is going to be fixed forever. A normal running mode is entered, it consists of only data transfer and this is still running until the network becomes idle, either by nodes death or by the base station commands.

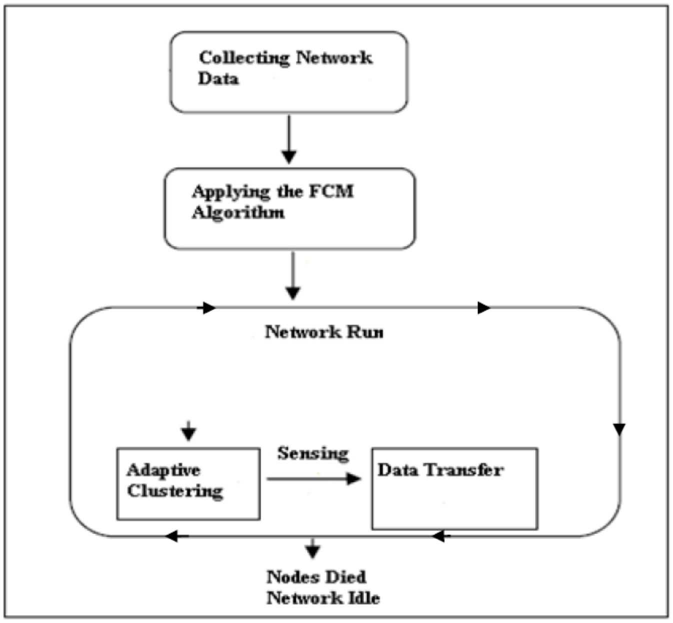


Fig 3.2: - The Block Diagram of Proposed Algorithm

The power consumption of any device can be represented in many ways. Actually, the energy is being measured in "Joules" and has the "J" abbreviation. The power consumption is measured in "Watts" and is abbreviated as "W". Watt is the energy consumed in one time unit. Usually, the system's power is represented by the manipulated variables – not direct variable – like voltage and current. The voltage is not changes depending on the load, the manipulated variable of batteries become the current and time.

In wireless sensors network, the battery is fixed and wouldn't be replaced until the sensor is replaced. The sensors are designated for a long time operation of its internal battery. The life time of battery may extend to 5 or more years. This thesis aims to optimize the energy consumption of the wireless sensors nodes by optimizing the protocol of LEACH introducing a new terms and algorithms of nodes clustering in order to make the network to be adapted to the work conditions.

5. IMPLEMENTATION

The EECA is an adaptive developed structural algorithm that locates the head of cluster by cluster centroid localization of data set that consists of geometric distribution of sensor-nodes in x-y plan or even capable to be used in 3-D space of sensing. EECA is based on the original Fuzzy C-mean algorithm of clustering data in 2-D plan, and improving it that by the use of "Potential" concept of the networks nodes and clusters. When calculating the overall sensor-nodes potential to the centroid that is being obtained from FCM, the nodes will be distributed into clusters easily by the mean of its potential not Euclidean distance.

The proposed methodology of the thesis consists of three phases. The bulk network of sensors should be divided into clusters and that process is so called "Clustering". The thesis assumed to use the fuzzy logic approach of clustering by what is called C-mean. The phase one distribute the sensor points into separate clusters, each cluster has its own head.

The data transfer (protocol data, measurement physical variables data, and status) will proceed starting from each node in the cell or cluster to communicate with the base station. This communication doesn't pass directly, the node communicates with CH (cluster head), and all heads will transfer data directly to/from the main unit (base station). After each single transmission round, the sensor loses a part of its energy. The power consumption is named above to be named as (slope of the energy). Many researchers performed experiments and researches to save network energy, specially the energy between the first and final node death. This thesis, implements a very effective and adaptive approach, that minimizes significantly the energy lose and cost.

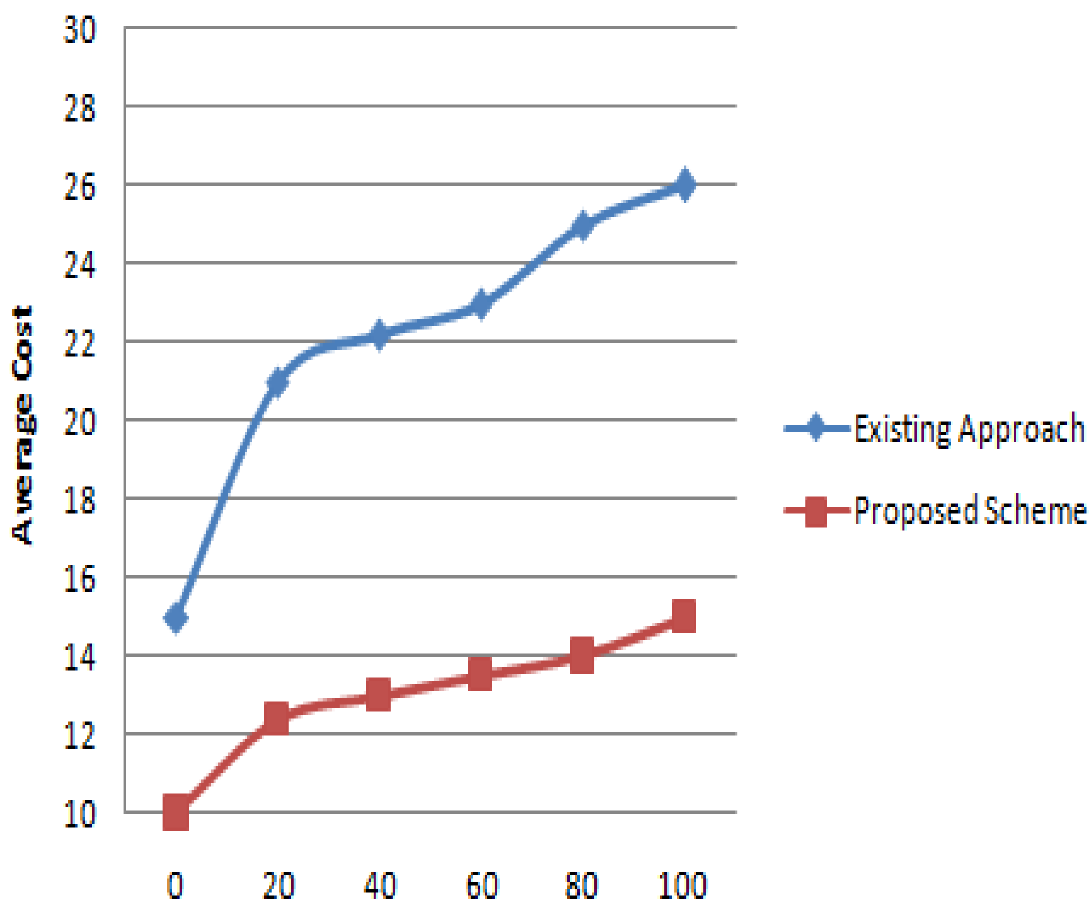
The best algorithm that saves the energy in interval of nodes death is LEACH-L before testing the EECA approach. It increases the balancing in the nodes, thus, the use of low power nodes converted to high power nodes. This contributed thesis increase the efficiency to 90% rather than LEACH-L.

The evaluation metrics is the measurements and criteria that are being used to evaluate and test the wireless sensor networks quality and operation. It implies a high level criteria and network aimed functionality in addition to long time running period. These metrics will be met at optimal value to ensure the benefits of the wireless sensor networks in comparison with other technologies. The evaluation metrics includes a key variables that should be monitored and recode its validity. Those variables describe the capabilities of the wireless sensor networks and include

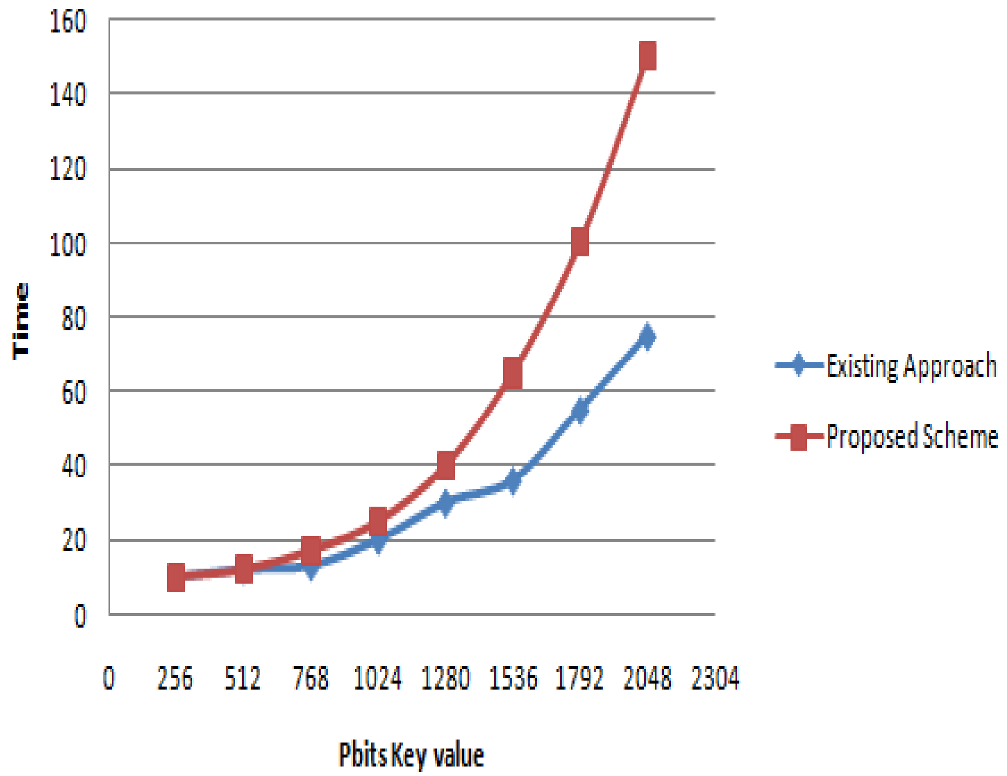
- Cost.
- Power dissipation.
- Coverage.
- The ease to use and deploy.
- Life time.
- Security.
- Accuracy.
- Effective sampling rate.
- Response time.

Sometimes, those metrics are dependent to other, so, in order to increase one metric variable, another variable should be changed. For example: in order to increase the life time, the power dissipation should be minimized.

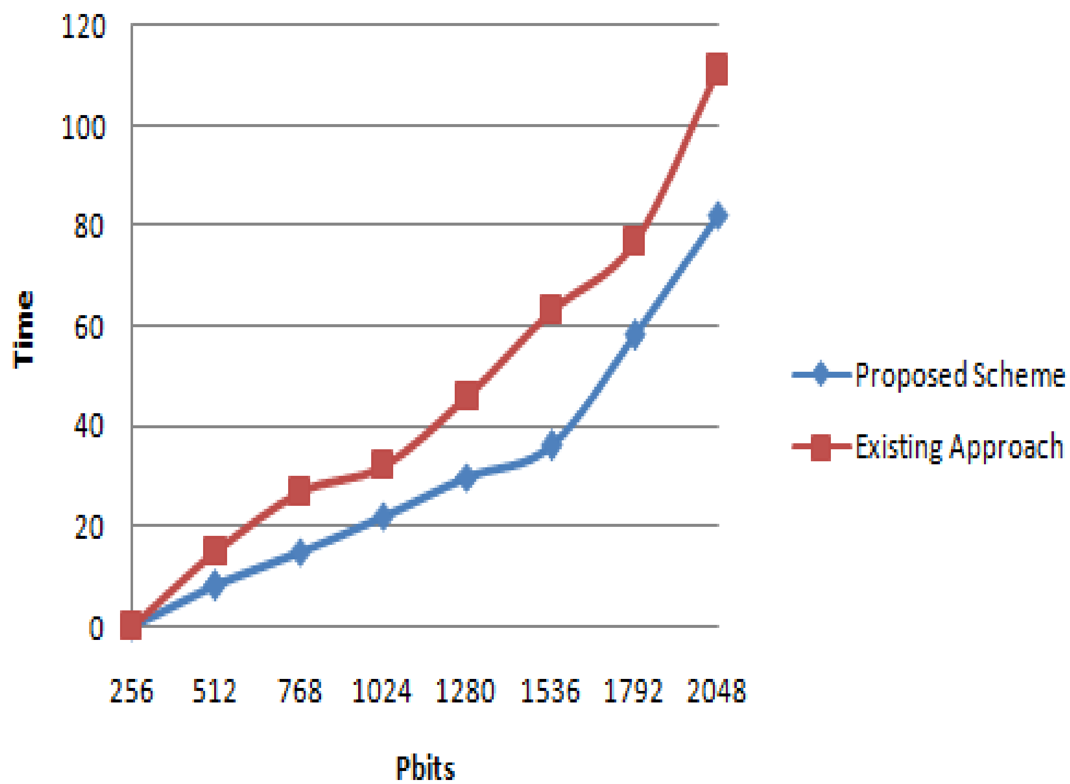
i) Cost Analysis



ii) Received Packets



iii) Energy Consumption



6. CONCLUSIONS

This research concerns to implement a new methodology for wireless sensors adaptive clustering in order to optimize energy and power consumption in the network. Many researches in past and current information systems world are concerning in the energy optimization. The optimization of wireless network energy researches either concerns on hardware modification and optimization or either software management.

The past researches on clustering of wireless sensor networks got a result of saving an interesting amount of energy and sensor's life. This research added a value of saving more energy and power, and building adaptive algorithm. This algorithm as shown in chapter four, was been tested on different scopes of wireless sensors networks in different conditions.

Also the proposed scheme gives the better performance in terms of throughput. Our scheme basically considers the energy of the node as well as the position of the node, it helps to produce best cluster. Our scheme does not consider the From this we can conclude that our proposed algorithm achieves best results in terms of energy required, throughput of the network and number of dropped packets.

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