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Determination of the Required Data Type and Position in the EDG Algorithm in Wireless Sensor Networks

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Abstract: *The wireless sensor networks can be used for a number of military purposes such as monitoring the activities of the forces and protecting them. Initially, through equipping this network with proper sensors, the friendly forces can be distinguished from the enemy forces and the status of enemy's movements can be analyzed. The current study has aimed to, by the use of Emergency Data GTS (EDG) algorithm features and improving it, identify the data required for a region and determine the position and the scope of the data, so that the best decisions in time period can be made. Therefore, the current study will be most usable for military purposes. At the end of the article, the results of the simulation along with the latitude and longitude, will be provided.*

Keywords: *Wireless Sensor Network, Required Data, Emergency Data GTS Algorithm, Geographical Coordinates.*

INTRODUCTION

During the last decades, numerous studies have been conducted on the field of wireless sensor network (wireless receiver network), and significant progress has been achieved in this regard.
These networks may have non-military use, such as: monitoring the environmental tasks, the factories, and etc. However, in the current study, the main purpose is the military use. Based on these assumptions, it can be understood that they have been used based on the requirements of this network (military). In the current study, through provision of the scope and the method of the data type identification, the type of the important data of the region can be identified, and then, by determination of the type of these data required for that purpose, it can be generalized to the whole network (Akyildiz et al., 2010).

Wireless Sensor Networks

A wireless sensor network is a wireless network consists of a large number of very small devices, which are called sensor nodes. The sensor nodes are usually capable of sensory, processing, and communicating capabilities. The sensor nodes are spatially distributed and measure the adjacent conditions. The main duty of the sensor is to gather the data points in regular time intervals and changing them to an electronic signal, and then distributing it to the sink node and base station, through trusted wireless communication media.

The Applications of Wireless Sensor Networks

The emergence of the wireless sensor network has led to the extensive research in different aspects. A wireless sensor network may include different types of sensors such as seismic, magnetic, thermal, imaging, infrared, audio, and radar sensors which can monitor a wide range of environmental conditions such as temperature, humidity, pressure, speed, direction, motion, light, soil type, noise level, existence or absence of object, and level of mechanical pressure on the object. As a result, a wide range of applications is possible. It includes monitoring the waters and soil, gathering information for defense, monitoring the environment, urban warfare, analyzing and forecasting the weather conditions, monitoring and protecting the battlefields, discovery of the solar system, monitoring the intensity of the earthquakes, pressure, temperature, wind speed, and location information. These ever increasing applications can be classified under five categories as military, environmental, health and hygiene, domestic, and industrial applications.

- **Surveillance and Military Applications**

The WSN (Wireless Sensor Network) can be an inseparable part of Military command, control, communication, computing, intelligence, surveillance, identification and targeting systems. The quick establishment, self-organization, and error tolerance are among the important features of the WSN's, which have led to the use of networks for military purposes. Since the WSN's are based on the dense and low-cost deployment of the sensor nodes, the destruction of some nodes due to the enemy's actions, would not affect the performance of the network to the extent of the sensor's destruction, and it has led to a better approach towards the concept of WSN's for the battlefield. Some of the military applications of the WSN's include the monitoring of the own forces, equipment, and ammunition, monitoring the battlefield, identification of the enemy forces and attacking them, evaluation of the war damage, and the nuclear, biological, and chemical warfare detection. Among the conducted projects, the Smart Dust, identify archer, and Monitoring or Tracking, can be named.

IEEE 802.15.4 Standard

IEEE 802.15.4 is a LR-WPAN standard, designed for applications such as low data-rate and low power consumption. This standard supports the physical and MAC layers. The physical layer is responsible for low-level operations such as data expansion, bits transmission, and receiving based on the interference factors, and so on. On the other hand, the MAC layer creates the information packets and determines the data destination in transmission mode. Therefore, in the receiving mode, it determines the transmission source and analyzes the received data. Also, this layer enables the channel's access control, and runs its multiple access protocols. The lower layers are responsible for provision of the data for the upper layers (Aqili, 2011).

Allocation of GTS in IEEE 802.15.4 Standard

The issue of data transmission gets more complicated with the FCFS (First Come, First Service) solution of GTS allocation, due to lack of flexibility and scheduling for meeting the functional requirements and density of the network's work in delivery of the data with low latency. For the devices with low data transmission frequencies, due to the presence of a fixed timer, set at 802.15.4 for obtaining the GTS, the data transmission reduction is possible. How to make the GTS allocation scheme work properly and sufficiently, is itself a challenging issue. Among the measures taken for solving this problem, the study done by Zheng et al. is a feasible one for 802.15.4 for the pervasive networks. Timmons et al. have provided the performance analysis of the group-based regional networks for the surveillance sensors.

In terms of performance analysis of 802.15.4, numerous studies have been conducted and the GTS allocations problems have been partially addressed. It should be noted that due to low energy consumption of the wireless devices in 802.15.4 standard, and its low bandwidth, the current sampling algorithms (query, polling) cannot be used for GTS allocation.

- **AGA-Type GTS Allocation Algorithm**

The researchers have proposed the AGA (Adaptive GTS Allocation Algorithm) scheme for the 802.15.4 which has a low latency and idle time. This scheme estimates the applied and future behaviors of each device's GTS. With such estimation, the coordinator allocates the GTS sources to the applicant devices and takes back the pre-allocated GTS which have not been used. In figure 1, the structure of AGA algorithm is shown. The prioritization in AGA algorithm is done through the following methods (Huang et al., 2006):

- GTS Classification Phase
- GTS Scheduling Phase

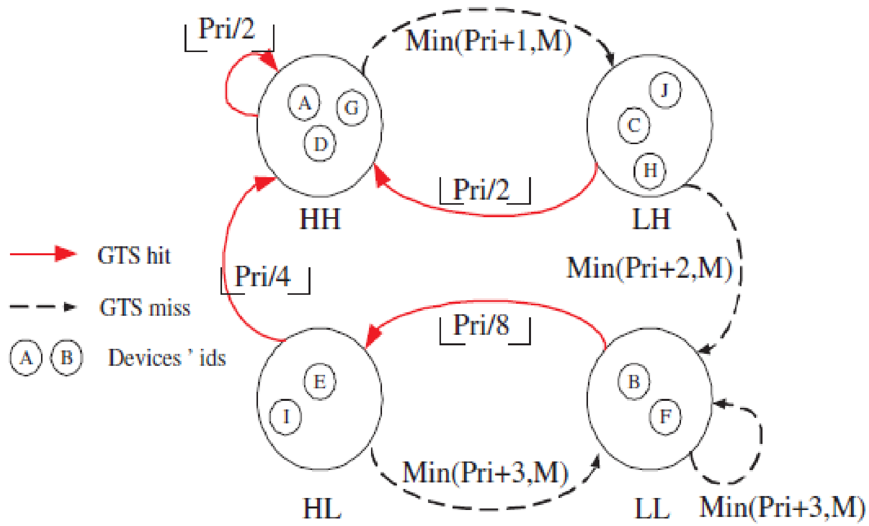

Figure 1: AGA Algorithm Structure

- **The GTS Scheme for Emergency Data Transmission in Tree-based and Cluster-Based WSN's**

Hyeopgeon Lee et al,. proposed the GTS scheduling pre-allocation mechanism for reducing the number of control packets resulted from CSMA/CA. In this algorithm, the GTS allocation scheme has been proposed for emergency transmission in the cluster-tree topology networks. This proposed scheme improves the transmission delay rate and output of the emergency data packet. For emergency data transmission, the EDG is allocated to the GTS slot. If the nodes send the emergency data to the coordinator, the emergency type in the framework of GTS demand, is represented y 1, and the node request must be answered in the shortest time. In case the data is normal, the EDG field will be 0 (Der-Chen et al., 2012).

- **The 802.15.4 Standard's EDG Algorithm Pitfalls**

In short, the above algorithm is planned in a way that if the field is 1, the emergency data will be sent non-stop and with low delay, to the coordinator for evaluation, and the answer will be provided. However, in spite of existence of delay and energy reduction methods, some matters have not been predicted in this algorithm, which are as follows (Rao et al., 2013):

- Failure in determination of emergency data location
- Failure in expression of accurate features of emergency data

- **The Proposed Algorithm**

If it is presumed that the implemented sensor network structure is cluster-based like figure 2:

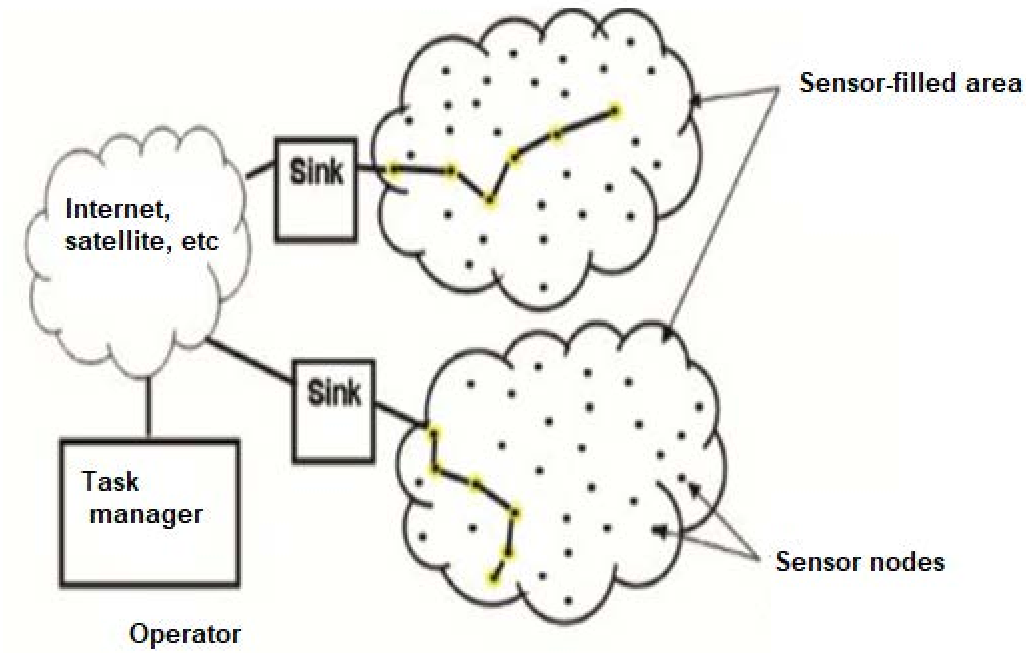

Figure 2: A sample of a cluster wireless network

Like the above figure, the network will be administered by a main coordinator, and this coordinator is connected to a sink node, and from the sink node. It is connected to the level 1 cluster heads, and then, to the level 2 cluster heads, and then, to the network environment of the node which consists of a number of sensors or nodes. In the EDG algorithm, the data transmission to the upper level nodes is done in two ways. If the data collected from the environment are normal, the data transmission to the main coordinator of the network is done in the normal form, with higher distribution delay, and followed by a normal network answer. When the data is of emergency type, regarding the features of EDG algorithm, the data transmission to the upper clusters is done quickly and answered with lowest delay. Therefore, in case of existence of the normal data in answering queue, first, the emergency data is answered and then, the normal data are answered. In EDG algorithm, the method of data type determination has not been assigned and also, it is not expressed that how the sensors should consider a data as emergency. Also, the location and scope of the highest cluster heads that contain emergency data, have not been determined. Moreover, each sensor can arbitrarily consider a data as emergency in order to fulfill its tasks faster. It causes difficulty for determination of the type of data and the network traffic, which should be increased for the emergency data. In the current study, through provision of a prioritization method in level 1 cluster heads on a network surface, has led to the identification of the most important network's data type and selection of it as the emergency data, through evaluation of an earlier background of the network and the type of data sent to the coordinator. Besides, through identification of the emergency data, it can be generalized to the whole network, so that after a certain time, the emergency data of the network is determined. Also, the scope and the cluster heads with the highest emergency data exchange are determined and reported to the system administrator. In this case, the decision needed for that sensitive geographical coordinates can be made. Through determination of the emergency data by prioritization of the cluster heads, the excessive emergency and normal data transmission of cluster heads with lower priority, can be avoided and it would lead to a proper reduction in network traffic in critical situations. In this method, the cluster heads with higher priority, would have higher bandwidth for sending and receiving of data, and the cluster heads with lower priority would have lower bandwidth, which is among the advantages of the proposed algorithm.

The code network in the proposed method for determination of the cluster heads with highest priority of emergency data transmission to the sink nodes, is presented in figure 3.

```
AN = 0;
          AN = find (Mem == S(CH). IONMS);
          tflag = 0;
          if(AN)
            tflag = 1;
          end
            if (tflag == 1)
               [minx, id] = min(S(CH). NONM);
               if (minx < S(CH). NONM(AN) && S(CH). IONMS(id) ~= Mem)
                 S(CH). NONM(AN) = S(CH). NONM(AN) + 1;
                 for kk=1:1: Q
                   if(S(CH). AFIOM(kk) == S(CH). IONMS(id))
                     S(CH). AFIOM(kk) = Mem;
                   end
                 end
```

Figure 3: the network of proposed algorithm codes

- **Different Modes of Prioritization**

The messages in the level 1 cluster heads are sent to the sink immediately after reception. They are queued in the sink based on entrance order. If the cluster head i sends a message, and the sink k's queue is empty, the message will not be queued. But if the queue is full, three conditions may pose:

1- The transmitted message is of normal type in which case, the message will be deleted.
2- The transmitted message is of emergency type and the queue contains a normal message, in which case, the emergency message will replace the normal one.
3- The transmitted message is of emergency type and the queue does not contains a normal message, in which case, the number of the emergency messages transmitted to this level 1 cluster head will be compared to the other cluster heads in sink k. if the number of messages is higher, the message of the cluster head that had transmitted lower emergency data, would be omitted, and the emergency data of cluster head i, would replace it. Otherwise, the message of the cluster head i will be omitted.

- **Evaluation of the Simulation Results**

The results of the algorithm were applied in MATLAB Software with geographical area of 200*200, for evaluation of the results. Therefore, firstly, the volume of the normal and emergency data transmitted to the network's sink was evaluated, and then, regarding the results of the data volume and the network record, the prioritized scope is determined:

- **Simulation Results**

The Comparison between the Number of Emergency and Normal Packets Transmitted to the Sink Nodes

In the graph 4, the comparison between the number of the emergency and normal packets transmitted to the level 1 cluster heads of sink nodes, is represented:

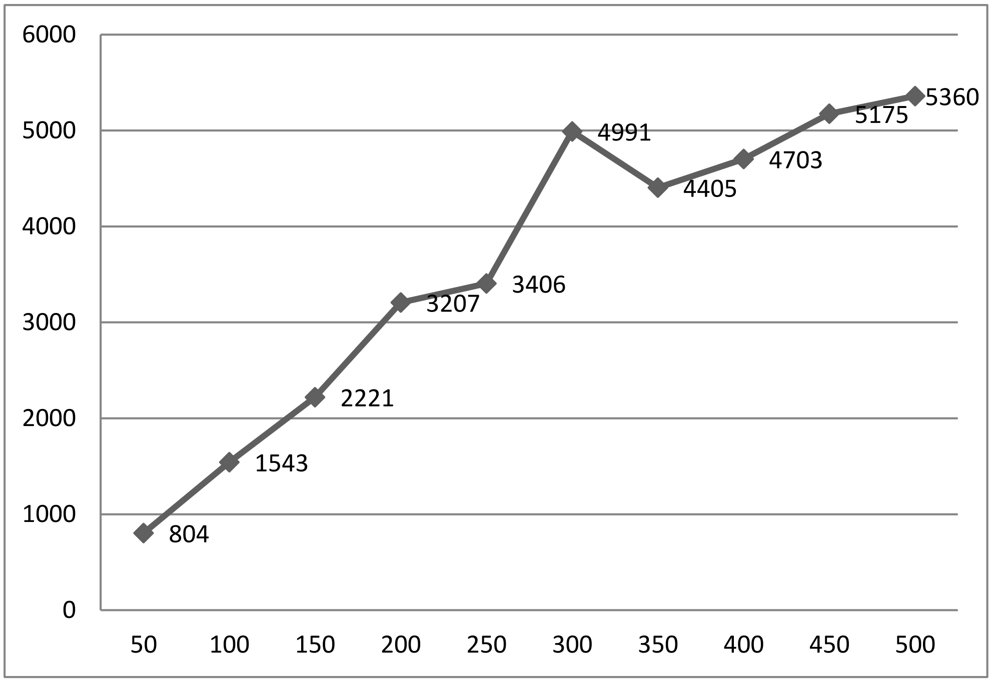

Figure 4: the comparison between the results of packets sent to the sink nodes

Graph 4 shows the comparison between the number of the emergency and normal packets transmitted to the level 1 cluster heads of sink nodes. In the above figure, the vertical axis represents the number of the emergency and normal packets transmitted to the sink nodes, and the horizontal axis represents the number of rounds or nodes collection from the physical environment. In transmission of the packets to the sink nodes, it should be noted that the EDG algorithm, includes the emergency and normal data, but the improved algorithm, due to the prioritization, only includes the emergency data. Therefore, by evaluation of the emergency data of the network, the higher scope of the emergency data can be determined. This process is shown in figure 5. It should be noted that at the beginning of network's operation, a period of time would be calculated as the interval for gathering of the data from environment, and then the emergency data would be determined and it is generalized to the whole network.

Determination of the Coordinates and the Scope of the Emergency Data in the Network

In the graph of figure 5, the scope and coordinates of the prioritized cluster head data in the emergency data is represented:

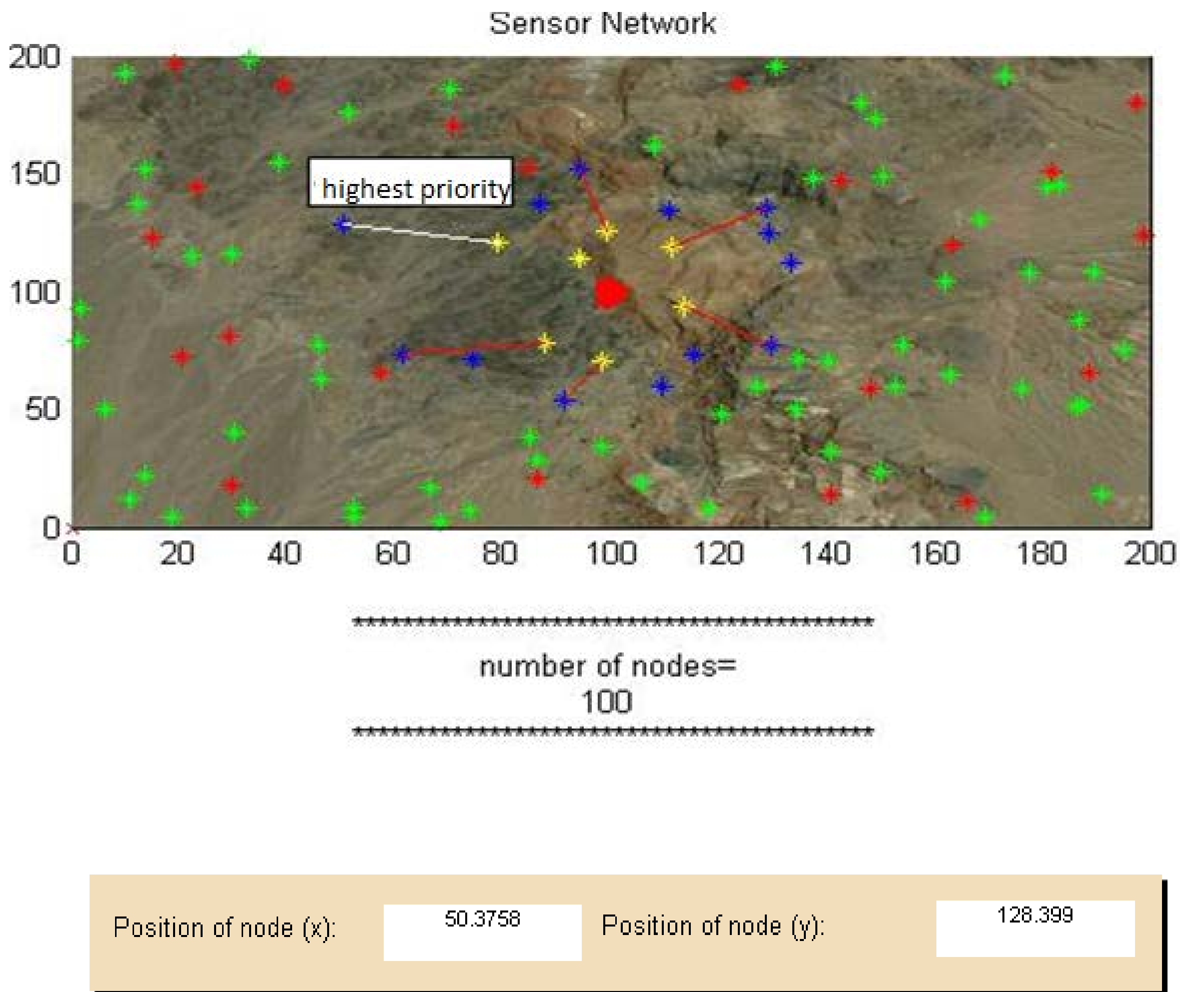

Figure 5: determination of the geographical location and the first priority of cluster head

As it is seen in the figure 5, firstly, with beginning of the network's operation, and normal gathering from the environment, and then, through evaluation of the received data, the type of the data important for the network operator, would be obtained, and then, the type of the emergency data will be determined. Through the conducted simulation, the scope of the cluster head with highest priority can be determined based on the type of the emergency data. The highest priority in the network for a level 1 cluster head, which has the highest bandwidth allocation for sending and receiving of data, compared to other cluster heads, is highlighted in white, in the figure 5. Its coordinates are also shown in the lower part of the image. Through this graphical figure, the decisions for the sensitive scope of the network can be easily made with a proper approach. The cluster heads with lower priority are shown in red, in the center of the main coordinator of the network. Therefore, in military decision-makings, the important regions can be easily processed.

Conclusion

As was mentioned in results evaluation, through prioritization in scope of cluster heads of a sensor network surface, and by gathering of earlier information, the high-traffic scopes of the network can be obtained and the emergency data needed for it, can be determined, and by generalizing it to the whole network, a proper processing for the whole network can be adopted. In the current study, the methodology can be implemented for military purposes, since in military applications, the intended and important targets are firstly determined in a geographical area with the earlier gatherings, and then, based on these information, the planning is done.

In the algorithm proposed in the current study, for unfamiliar regions, the information of the region can be gathered by the aid of earlier records, and the data important for the network administrator can be determined, in order to make decisions based on them.

In terms of the proposed algorithm, the below case can be evaluated as the recommendation for further studies:

1) In the proposed algorithm, all the results are based on the emergency data, thus the conditions for consideration of normal data can also be predicted in the algorithm.

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