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ENERGY-EFFICIENT COMMUNICATION PROTOCOLS IN WIRELESS SENSOR NETWORK FOR VIDEO DATA TRANSMISSION

M.Sivaganapathi
Assistant Professor, Electronics and Communication Engg, JP College Of Engineering.

M.Paramaiyappan
Assistant Professor, Electronics and Communication Engg,JP College Of Engineering

ABSTRACT

Wireless sensor network (WSN) is a network of large *number of interconnected nodes that can independently sense, process and transmit data between themselves and to the base station. Video wireless sensor network (VWSN) is used for capturing and transmitting video data. In VWSN each node consists of camera, memory, processing unit, communication unit and battery. Due to the small size and limited battery life of the node, transmission of video data is a challenging task, as it requires larger bandwidth and more processing power. This paper primarily focuses on energy optimization which is achieved by compression of video at the first stage by using DCT lossless compression technique and then selection of the nodes for transmitting this video using 'Low Energy Adaptive Clustering Hierarchy' (LEACH) protocol. In LEACH protocol cluster head nodes are randomly selected in order to achieve even energy distribution.*

KEYWORDS—*Wireless Sensor Network (WSN); Video Wireless Sensor Networks (VWSN); Low Energy Adaptive Clustering Hierarchy (LEACH); Discrete Cosine Transform (DCT); Cluster Head (CH); Time Division Multiple Access (TDMA)*

I.INTRODUCTION

Wireless Sensor Network (WSN) is a dense network of sensor nodes, where each node can sense, process and transmit data. Sensed data can be transmitted among the different nodes and from node to base station in a single hop or multi-hop fashion. WSN has vast military and civil applications where once the network is laid down, it can function on its own without human intervention. Traditionally WSN were used to sense the scalar environmental data like temperature, humidity, pressure, wind direction etc. With the advancement in technology, video transmission over WSN started gaining importance for transmitting accurate real time information, thus Video Wireless Sensor Networks (VWSN) was formed. In VWSN each node consists of camera, memory, processing unit, communication unit and battery.

Video sensing is useful in various applications such as: military, environmental, healthcare, industries and surveillance of all its types. It can play a vital role in intelligent traffic transportation system which includes traffic surveillance, parking assist, accident avoidance, driverless vehicle etc [1]. Major challenges for VWSN are area coverage by camera nodes, increased network capacity and real time transmission [2].

Energy of the nodes is mostly consumed in processing and transmitting video data due to its huge size. As battery life of nodes is limited, lifetime of the network can be enhanced by energy optimization while processing and transmitting data for VWSN [3]. This paper proposes a method in which the video data is initially compressed using Discrete Cosine Transform (DCT) based lossless compression scheme. Lossless compression leads to perfect reconstruction of transmitted data at the receiver. For transmission of this compressed video data, the energy of each node is calculated and based upon Low Energy Adaptive Clustering Hierarchy (LEACH) protocol; an optimal route is formed to transmit data. LEACH protocol optimizes overall energy of the network, which improves network lifetime.

II.LOSSLESS VIDEO COMPRESSION

In lossless data compression algorithms, the compressed data is perfect reconstruction of original data. Whereas in lossy compression technique, compressed data is only the approximation of original data. The reduction in file size is more in lossy compression as compared to lossless compression but at the cost of data loss. DCT has excellent energy compaction properties and thus it is selected as a standard for JPEG image compression [4]. For transmitting the video over the network, initially it is converted into series of frames.

Lossless DCT is the transform coding technique applied on each of these frames in order to compress it. Due to lossless video compression, the quality of video data is maintained as it is and the size of data is drastically reduced, which makes it suitable for transmission over the network.

After obtaining the compressed video, simulation model of sensor network is created. This simulation model is created to calculate energy of nodes and for finding the optimal energy path for video data transmission

III.ENERGY OPTIMIZATION

In VWSN energy of each wireless node is limited due to battery life. The energy of the node is basically consumed for processing data and transmitting data. Processing of data is done before its transmission. If a node transmits data to another node which is not having sufficient energy to transmit it further, the data will be lost. In order to avoid such data loss, the energy of each node must be calculated before transmission and multi-hop routing [5] should be used for efficient data transmission and energy optimization. LEACH is efficient protocol based on clustering technique which evenly distributes the energy among the given nodes. LEACH is used for calculating energy of the nodes.

IV.LEACH PROTOCOL

LEACH is a hierarchical clustering and TDMA-based MAC layer protocol used for routing in WSNs. Hierarchical routing provides better energy efficiency and scalability due to its architecture. LEACH protocol improves the overall network lifetime as it lowers the energy consumption required to create as well as maintain clusters [6]. This protocol is robust and it distributes energy evenly among the nodes in a given WSN [7].In LEACH protocol, most nodes transmit data in single hop or multi-hop pattern. Clusters are formed out of all the nodes in the network. Each cluster is assigned one cluster head. Communication within a cluster that is from node to cluster head is generally in a single hop pattern, this is also known as intra cluster communication. And communication among various CHs and from CHs to sink is usually in multi-hop pattern, which is known as inter cluster communication.

The function of CH is to aggregate and compress the data before forwarding it to base station. LEACH protocol consists of several rounds. Residual energy of the node is calculated after each round [11]. Each round has two phases: (a) set-up phase and (b) steady state phase. During the setup phase, energy of all nodes is calculated and the nodes that are having highest energy are selected as cluster heads (CH), after the selection of CH, clusters are formed out of the remaining nodes [8]. Each cluster has one CH and all the nodes in a cluster transmit data to CH based on Time Division Multiple Access (TDMA).

Assignment of TDMA schedule is done by the CH for member nodes. In the steady state phase, the actual data transmission from nodes to CH and from CH to base station takes place.Nodes that have been CHs in previous rounds cannot become CHs again for P rounds, where P is the desired percentage of CHs. Thereafter, each node has a 1/P probability of becoming a cluster head again. At the end of each round, each node that was not a cluster head selects the closest CH and joins that cluster and becomes new CH for that cluster. The CH then creates a new schedule for each node in its cluster to transmit its data.

The main objective of LEACH is to increase the energy efficiency by rotation-based CH selection using a random number. In CH selection process, each node generates a random value between 0 and 1, in order to get elected as a cluster head. When the

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threshold value T (n) exceeds this random number generated, then that node becomes CH. The value of T (n) is calculated using the following formula given in Equation 1.

$$T(n) = \begin{cases} \dfrac{p}{1 - p\left(r \bmod \frac{1}{p}\right)}, & if\ n \in G \\ 0 & otherwise \end{cases}$$

Here P is the required percentage of sensor nodes that need to become CHs among all the other nodes, r represents the current round and G denotes the set of sensor nodes that have not participated in CH election in earlier 1/P rounds. If node becomes the CH in round r then it cannot participate again in the upcoming 1/P rounds. Thus each node gets equal chance to become the CH and it results in uniform distribution of energy dissipation among the sensor nodes. Once the node becomes CH, it broadcasts 'join' message to all other nodes in the network. Each node joins a particular cluster head depending upon the received signal strength. After the clusters are formed, CH assigns TDMA schedule to its cluster nodes. Based on this schedule, CH collects the data from nodes and transmits it further to other CHs or base station [9][10].

V.MATLAB SIMULATION

A. Data Compression

Initially the video is split into number of frames and then 8X8 block processing is used over each frame for compression. The output of DCT based compression is shown in the figures. It contains few frames from the original video and their counterparts from compressed video. Figure 1.1, 2.1 and 3.1 show the original frame with size 131KB, 134KB and 135KB respectively. Figure 1.2, 2.2 and 3.2 shows the corresponding compressed image frames which are having size of 15.1KB, 15.1KB and 15KB respectively. Thus the compression ratio of nearly 8.8 is achieved by DCT based lossless compression. The original video is having the size of 675KB and the corresponding compressed video is having the size of 76.4KB. This compressed video is the exact reconstruction of the original video. Percentage size reduction of an image [4] is given by the formula:

$$\frac{\text{Original file size} - \text{Compressed Size}}{\text{Original file size}} * 100\% \qquad (2)$$

From equation (2), it can be inferred that 88% to 90% reduction in size of the video is obtained after compression. Thus energy of each node consumed in processing as well as in transmitting the compressed video data, is reduced as compared to original video. Thus the network lifetime is also optimised. Trade-off between energy is needed for compression and transmission the video data is to be considered in order to enhance the functioning of VWSN.

Fig 1.1: Original frame1 size: 131 kb

Fig 1.2: Compressed frame1 size: 15.1 kb

Fig 2.1: Original frame 2 size: 134 kb

Fig 2.2: Compressed frame 2 size: 15.1 kb

Fig 3.1: Original frame 3 size: 135 kb

Fig 3.2: Compressed frame size: 15 kb

B. Optimal Energy Route

Sensor network simulation model is created. The total numbers of nodes specified by the user are randomly deployed in 1000 X 1000 mts area. There is a single base station located at the centre. The sensor nodes are homogeneous and have uniform energy. Initial energy of each node is taken as 0.5 Joules. Total numbers of rounds are taken as 50. The number of nodes can be entered at the run time. The nodes having the highest energy are selected as CH, based on the formula specified in equation 1. CH sends join message to all the other nodes in the network. Based upon the received signal strength of the message, nodes join CH and clusters are formed. These nodes transmit directly to their respective cluster heads within a particular cluster based on the TDMA schedule assigned by the CH to nodes. After completion of each round, energy per node is calculated Once a node is elected as CH in a particular round, it cannot become CH for the remaining rounds. Figure 4 displays the nodes communicating with CHs and CHs communicating with base station at the end of 50th round. Blue circle represents nodes and yellow circle represents CH. The communication between nodes to CH is shown by red lines. There are total five clusters in the figure.

Each cluster is having CH and the communication between various CHs and CH to base station located at centre is shown by using dotted lines. In each round, different clusters are formed and energy per node is calculated and then displayed after completion of that round. If the number of rounds is increased, the output will also display the dead nodes. Table 1 displays output of some rounds, out of total 50 rounds. The output energy of each node after completion of 5th round, 20th round and 50th round is shown in figure 5. After obtaining this output energy at the end of 50th round, an optimal energy route is found for video data transmission.

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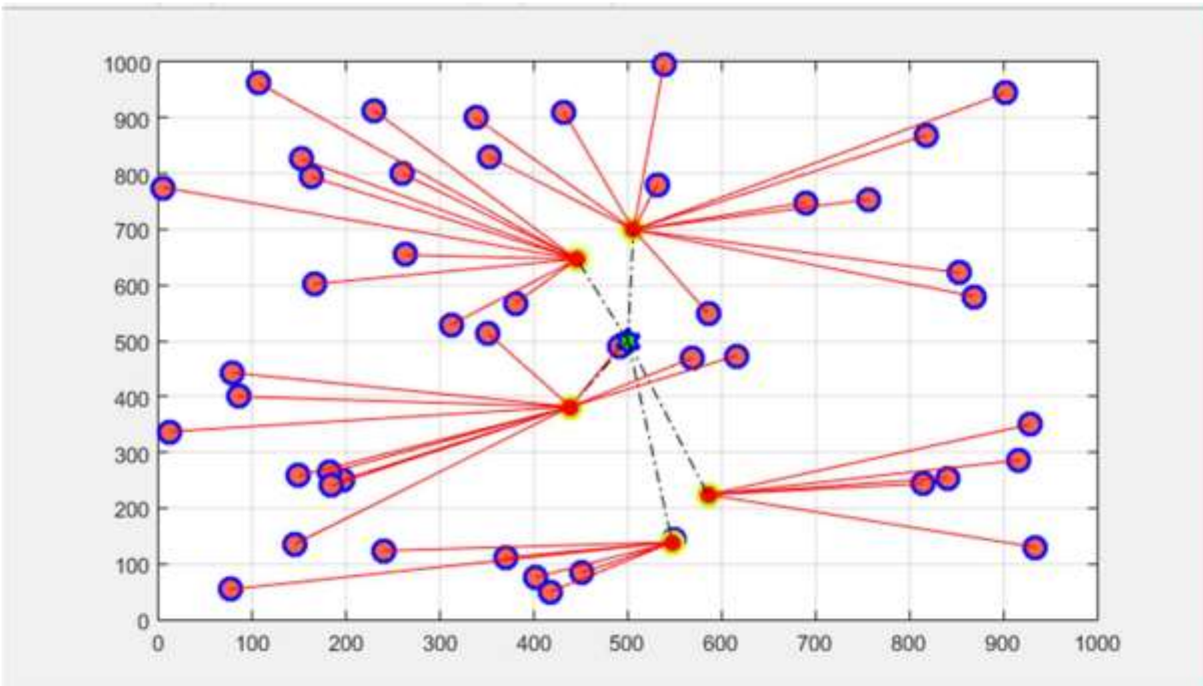

Fig 4: Simulation result for LEACH protocol

Table 1: Output showing energy per node at the end of 5th, 20th and 50th round;

ROUNDS 5	ROUNDS 20	ROUNDS 50
ENERGY PER NODE AND ROUND	ENERGY PER NODE AND ROUND	ENERGY PER NODE AND ROUND
0.418003	0.213011	0.424276
0.298681	0.0057010	0.370215
0.395939	0..022647	0.290925
0.269877	0.4773610	0.456379
0.421440	0.462919	0.455383

CONCLUSION

In order to overcome the limitations of VWSN, atwo-fold approach based on video compression and energy optimization is proposed in this paper. In the first part, DCT based lossless video compression is done and the compression ratio of 8.8 is obtained. After this a simulation model for sensor network is created and energy per node is calculated for each round by using LEACH protocol. Total number of rounds is chosen as 50. At the end of 50th round, an optimised route for video data transmission is obtained. As the battery life in sensor network is the main concern, energy optimization plays an important role. By compressing the video data, the overhead of data processing at each node is reduced. By choosing the least

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energy route for this compressed data transmission, an overall energy optimised VWSN is obtained.

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