Optimised Routing in Wireless Sensor Network for IoT

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Abstract— Wireless networks of battery-powered sensors with an event-driven wake-up function are becoming an increasingly important application area for Internet of Things (IoT).This paper analyzes the physical relation between the power consumption and the link utilization of wireless video sensor networks. We propose a multi-channel allocation and routing method for wireless multi-hop networks where each node generates event-driven video sensor data. Routing and channel allocation put a large impact on the battery life time of IoT sensors. We realistically analyze the power consumption model for a wireless link in terms of the distance and its utilization ratio. We then present an optimization formula of utilization-aware channel allocation and routing that minimizes the overall power consumption while transferring all the require data. We developed an efficient optimisation algorithm that accurately approximates the formula. A network simulator has been developed, which show that the proposed method can reduce the overall power consumption.

Key words: Wireless Video Sensor Network; Routing; Channel Allocation; Multi-Hop Path; Edges, Internet of Things

I. Introduction

The Internet of Things (IoT) is what happens when ordinary everyday objects contain inter-connected microchips. Smart sensors are the building block of the IoT vision. These sensors put intelligence into everyday object turning them into smart objects that not only can collect information from the environment and interact with/control the physical world, but also be connected to each other through the internet and exchange data and information. One of the most important elements in the IoT's paradigm is wireless video sensor networks (WVSN). The research work focus on the IoT applications based on wireless video sensors network where each node is consisting of battery powered video camera sensors. These camera sensors provide video coverage over monitored regions by developing portable wireless sensors with imaging signal processing and communication capabilities. With increase in demand of surveillance applications in remote areas, wireless video cameras on battery power are increasingly deployed to cover large areas, where power lines or Internet are limited. The power source for battery recharging, however, is often limited, and thus conserving the battery power is the most important issue in IoT long term vision.

A. Background

In the past, much of research has been done in the areas of WSNs. It is, how- ever, relatively recent that WVSN has received a lot of attention. WSNs are generally assumed to carry sensor data of very low bit rate, while WVSNs usually transfer video data that is high bit rate and often real time. The goal of most WSN is to maximize the life-time of the network, or to reduce the data delivery time. Such goal becomes more challenging for WVSN due to the network properties of high data rate and real time delivery. Most of today's commercial wireless cameras use wireless networks based on Wi-Fi (IEEE802.11 standards) with an access point system operating in the infrastructure mode [7][9]. However, such wireless networks have many restrictions in their data rate, wireless range, traffic congestion, and also battery lifetime. A wireless mesh network can provide a promising solution to these prob- lems, where each camera sensor operates as a node in a mesh network. Multi- channel routing schemes can be used to reduce the RF interference and traffic congestion, and to enhance the video data rate while minimizing the power consumption [4][5][6][7].

B. Motivation

WVSN provide great insight in applications like monitoring environmental conditions or industrial plants and machinery. Because they are simple to install, they can be deployed in a multitude of situations. In coming years, we will see an explosion of new uses for wireless sensors as the ―"Internet of Things" or "IoT" is widely deployed. But one of the factors that most limits the use of wireless sensors is their limited ability to do the job for a reasonable amount of time. When a wireless sensor‘s operation is fully dependent on a battery, and the battery is depleted, it becomes just a piece of junk.

Major constraint on sensor networks used for implementing IoT is that sensors employ batteries i.e. batteries are the driving force for the sensor nodes. Another limitation for sensors is that they are deployed unattended and in large numbers; so it becomes difficult to change or replace batteries frequently. This motivates developers and researchers to come up with such systems and communication protocols that are capable to drive these sensors for longer time with lesser power consumption.

The simplest way to increase the battery life is to use a bigger battery, a battery with higher capacity. Nevertheless, your customers are likely to expect their sensors to be small and to offer high performance (so they can send lots of data and have local intelligence/data crunching capability). Clearly, your customer expectations are diametrically opposed to the easiest way to solve the issue of short battery life.

This creates a need to find the balance between battery size and the wireless sensor‘s functionality to get the best performance from a small battery with a sufficiently long time interval between battery replacements. Thus, it becomes essential to look out for an optimized way of power-consumption in IoT sensors.

II. Related work

Navneet Kaur et al. "A Review on Reactive and Proactive Wireless Sensor Networks Protocols'' In this paper, HEER (Hybrid Energy Efficient Reactive) Protocol has been proposed in which the Cluster Head (CH) selection is based on the ratio of residual energy of node and average energy of network. But HEER does not use the inter cluster data aggregation. To overcome this problem a deterministic approach will be proposed to enhance the cluster head selection. In this selection criteria will have deterministic decisions because node with highest first energy will become cluster head than the probability. It will increase the overall network lifetime.

Quan Le et al. “RPL-based multipath Routing Protocols for Internet of Things on Wireless Sensor Networks”. This paper proposed three multipath schemes based on RPL (Energy Load Balancing-ELB, Fast Local Repair-FLR and theirs combination-ELB-FLR) and integrate them in a modified IPv6 communication stack for IoT. These schemes are implemented in OMNET++ simulator and the experiment outcomes show that the approaches have achieved better energy efficiency, better end-to-end delay, packet delivery rate and network load balance compared to traditional solution of RPL.

Sang-Hyun Park et al. “Energy-Efficient Probabilistic Routing Algorithm for Internet of Things” The EEPR algorithm has been proposed which employs both the residual energy of a node and the ETX value as the routing metrics, at the same time. The proposed EEPR algorithm stochastically controls the number of the RREQ packets using the residual energy and ETX value of a link on the path and thus facilitates energy-efficient route setup. Simulation results show that the proposed algorithm has longer network lifetime and consumes the residual energy of each node more evenly when compared with the typical AODV protocol while the routing setup delay is slightly increased and the routing success probability is slightly decreased.

HyungWon Kim et al. "Low power routing and channel allocation method of wireless video sensor networks for Internet of Things (IoT)" A new method of multichannel allocation and routing for wireless mesh networks is used where each node generates event-driven video sensor data. Battery powered video camera sensors are often connected wirelessly to cover a large area. Such wireless video sensor networks are considered as major applications of Internet of Things (IoT). Author analyzed the power consumption model for wireless video sensor network and proposed an algorithm to route the sensor nodes and allocate channels in a way that minimizes the overall power consumption while satisfying the required data transmission. A wireless video sensor network simulator is developed to prove the performance advantage of the proposed algorithm. Simulation results are provided with wireless sensor networks of various sizes Table 1: Technical counterpart of bio inspired variables

III. IMPLEMENTATION

We have tested our results with different number of active nodes and compare the results in term of effective distance and path loss component with aco algorithm. a total of six channels are used, each of 20 MHz bandwidth and as per IEEE 802.11 standard, these channels can be used multiple times for different edges. This channel allocation process is optimised with ACO algorithm. Figure 1 shows the random placement of different active nodes in a geographical region of 10810 square meters with transmission range of 5 meter. 6 different channels are allocated in the network for video transmission. In this work we haven’t considered the channel interference factor due to channel sharing and left for future work.

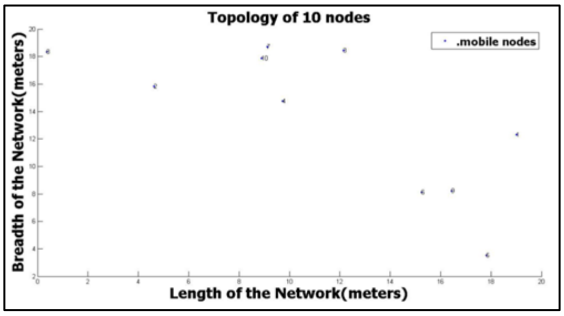


Fig. 1: Randomly allocated active nodes in a geographical region of 10*10 m^2

The nodes which are inside the circle can communicate with centre node. Using the method for searching the nodes in vicinity of source node, all nodes in range are plotted. These are all possible edges for each node and shown in figure 1 using the route search algorithm which sort the all available paths on the basis of total hops and paths and pick the shortest one, finalised routes for figure 1 is shown in figure 2. A final path table for each node to sink node is shown in table 1.

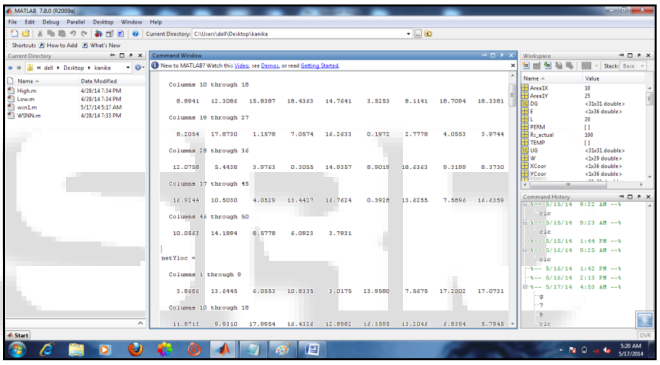


Fig. 2: all possible values for each node for nodes in figure

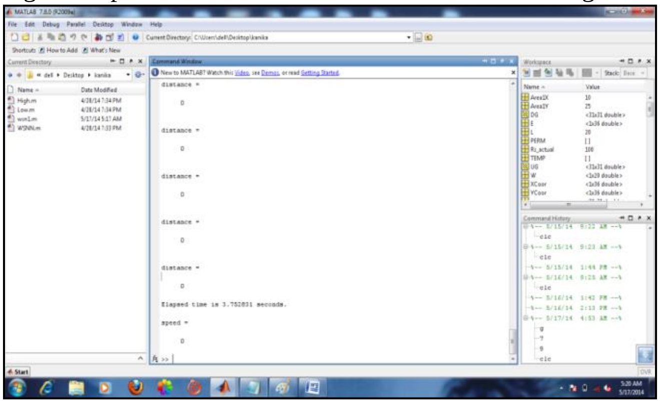


Fig. 3: Different values

No of Nodes	Elapsed time(seconds)
10	0.347175
20	1.333004
30	2.122022
40	2.991405
50	3.752831

Table 1: Final path table

For ACO optimisation we have used MATLAB’s optimization toolbox and provided the same searching space dimension and upper and lower bound for alocated channel bandwidth as FA.

IV. PROPOSED METHODOLOGY

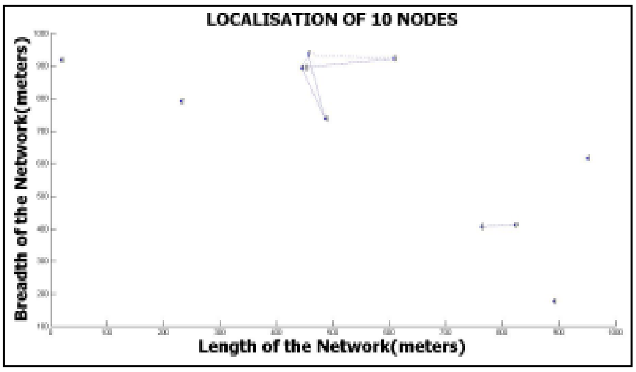
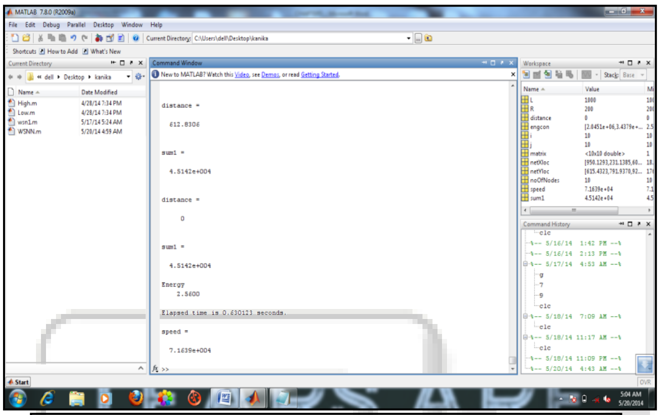


Fig. 4: Graph

A. *Localized pattern of WSN (10 Nodes)*



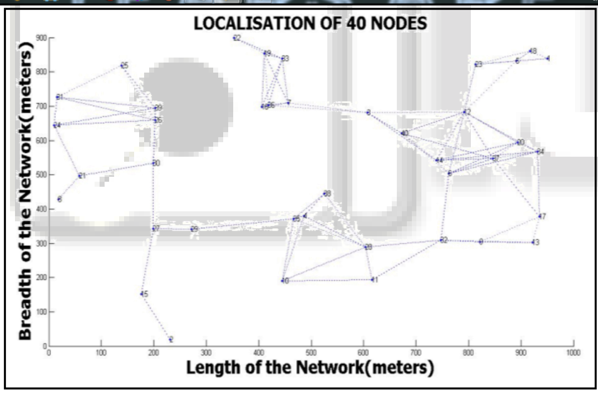


Fig. 5: Localized pattern of WSN (10 Nodes)

Now results are verified for different number of nodes and tabulated form.

No of Nodes	Sum of distances (meters)	Consumed Energy (joules)	Elapsed Time (sec)	Speed (m/s)
10	5.5142e+003	4.6600	0.630123 seconds	7.1639e+004
20	2.9699e+004	4.6600	0.273912 seconds	7.1915e+005
30	6.5491e+006	4.6600	0.657861 seconds	6.9149e+005
40	8.5731e+006	4.6600	0.739577 seconds	1.0240e+006
50	6.2490e+007	4.6600	1.204729 seconds	1.0368e+006

Table 2: Results

A plot for table is shown in figure below. This figure proved that with number of increase in active nodes, path loss and transmitted power consumption also increases but still with our proposed method it is still very less than genetic algorithm.

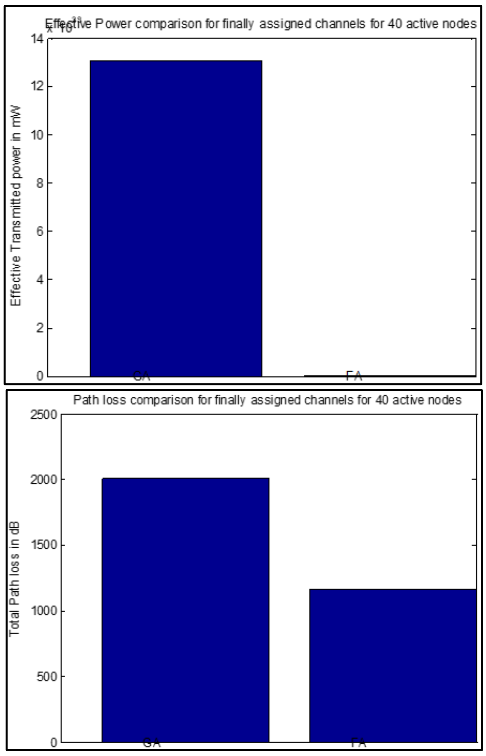


Fig. 6: Results

V. CONCLUSION

One of the main challenges to the IoT is the limitation of resources, including energy supply ,processing power, memory capacities, wireless communication range, and wireless communication bandwidth. This limitation affects routing in many ways. The short wireless communication range dictates that routing must be done in a multihop fashion, i.e., the data packets must be forwarded by multiple relay nodes in order to reach to their destination. In contrast to ACO, the genetic algorithm is quite old optimization technique and latest optimisation algorithm is better than GA in terms of convergence. So we have updated the work with this algorithm and compared it with others results. The target is to minimize the power-consumption in IoT sensors used for data transmission and connectivity. An improvement of 58.59% in path loss component is achieved by ACO for 20 active nodes with same input data and total bandwidth allocated. Results have been evaluated for different number of active nodes and improvement in between 50-65% is noted for those set of active nodes. So in each aspect of observation, ACO performs better than GA and giving a less power consumption and path loss component.

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