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Traffic scheduling for Green city through energy efficient Wireless sensor Networks

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ABSTRACT

Due to the exponential growth in the vehicle population it become very much challenging to control the pollution in the green city. As the vehicle waiting time in a traffic signal is diagonally proportional to the increase in pollution the traffic scheduling become essential. The IOT based wireless sensor based monitoring and traffic scheduling is an effective method but it always suffer from the energy efficiency of sensor network which ultimately aversively affect the environment of Green city. A fuzzy logic based traffic scheduling improves the system as the expert knowledge of a traffic police and environment specialist can be incorporated in the control algorithm. Genetic algorithm based or particle swarm optimization based approach will be able to improve the energy efficiency of the network as optimize the performance by considering multiple parameters which affect the environment.

Key words: Traffic, Wireless, Sensor, Networks, Fuzzification

1. INTRODUCTION

Green city is a demanding environment where planned eco-friendly activities are executed with monitoring as shown in figure 1. Due to the heavy increase in population of vehicle or transport system in a city the pollution in air, water, soil etc will increase beyond the affordable limit and it will lead to unexpected results. In the present century where people lead modern life does not have a solution for reducing the vehicle count. The emission of modern vehicle and high The power vehicle also high due its fuel consumption is more as power requirement also high. efficient traffic management through traffic light controller will reduce the average waiting time of the vehicle in the city, which will ultimately lead to reduce the pollution in terms of emission and sound. As this is a situation where effective decision making is important fuzzy logic is used as control logic. In order have a good decision making multiple parameters need to be considered and so only the monitoring of each parameter also important. The decision making algorithm can perform well only if the input data or traffic monitoring data and other environment monitoring data is perfect. The improved monitoring of the green city can be done through IOT enabled wireless sensor networks. Since the whole city is need to be monitored for different parameters, the sensor network will be huge and the energy usage of the same will be a overhead. Hence it is important to have a energy efficient sensor network through proper scheduling but without compromising on coverage.

Wireless Sensor Networks (WSNs) are constructed by a number of sensor nodes that are operated with restricted battery power. Sensor nodes help for sensing the data from a physical area and then send the sensed data to destination with the help of intermediate sensor nodes. One of the major problems to be addressed in WSN is improving the network coverage and lifetime. Network lifetime is affected when there is a presence of collision and interference across sensor nodes. Collision is said to be occurred in the network where two nodes try to transmit data at same time. Interference refers to the affection of data when it is transmitted from source to destination through a wireless medium. Collisions and interferences are avoided by performing load balancing among the sensor nodes in WSN. Load balancing is achieved by separating the amount of data to be transmitted in order to reduce the overload of any single sensor node.

Figure 1: Greencity

2. BACKGROUND WORK

Time Division Multiple Access (TDMA) is considered in [1] to perform Data Aggregation Scheduling (DAS) and hence providing fault-tolerant network. Data aggregation scheduling is a basic communication pattern in WSN such that, sensor nodes collect and forward the information to a sink node. In order to address the problems associated with the crash failures, the following steps are considered. The essential conditions are determined in order to solve the DAS problem. Strong and weak version of the DAS problem are considered. In addition, impossibility results obtained because of the crash failures are taken into account. A modular local algorithm is also developed for stabilizing the weak DAS. However, network lifetime was not enhanced by performing load balancing among sensor nodes in WSN.

Energy efficient routing [2] was performed in WSN through relay selection and load balancing around connectivity holes. Route discovery and routing among connectivity holes (Rainbow) are also performed by considering the problems associated with connectivity holes in a connected topology. Topology planarization is performed in order to solve the above problems. A cross-layer protocol, known as Adaptive Load-Balancing Algorithm (ALBA) is utilized to carry out geographic routing, load balancing and relay selection in WSN. Integration of ALBA and Rainbow protocols is an important task to be achieved in effective converge casting of WSNs with connectivity holes. Though, collisions among sensor nodes are not eliminated effectively in ALBA and Rainbow protocols.

With the aim of achieving better network performance, it is necessary to consider network lifetime, coverage and connectivity of WSN simultaneously. Multi objective optimization [3] was performed in WSN for improving network lifetime and coverage with maintained network connectivity. Transmission range Adjustment, Scheduling, Coverage and Connectivity control (TASCC) algorithm is implemented in WSN based on Non Dominated Sorting Genetic Algorithm-II (NSGA-II) in order to achieve the above objectives. Although, transmission range adjustment is taken in to account, collision nodes removal is not carried out earlier.

In [4], sensor nodes are scheduled for improving their spatial-temporal coverage for a specific lifetime of a sensor network. A distributed Parallel Optimization Protocol (POP) was developed with the aim of improving spatial-temporal network coverage of WSN by scheduling the sensor nodes. By utilizing POP, the sensor nodes in WSN are ensured that they are converged to local optimum with no conflicts. POP also considers the problems associated with network lifetime and coverage optimization between static sensor deployment and the changes in requirements. A novel spatial-temporal coverage metric is employed in place of traditional area coverage. Spatial-temporal coverage of each small area is computed which depends on area size and length of the period through which an area is covered. However, network connectivity for effective data delivery is not considered.

Network coverage and network lifetime in WSN are optimized with the help of a cluster-based routing protocol [5] known as Non-Dominated Sorting Genetic Algorithm-II. Here, coverage optimization problem is solved by re-deciding the location of a given mobile sensors with the condition that, sensed data about detected targets are routed more efficiently to the sink to improve the network lifetime. However, there is a lack of providing effective collision detection in sensor network. A distributed, coordinate-free algorithm was employed in [6] for enhancing the network lifetime of WSN where distances between adjacent nodes in its transmission range is considered for lifetime improvement. Though, collision detection among sensor nodes in WSN was not achieved to achieve higher network lifetime.

In [7], mobility aware and energy efficient congestion control protocol was developed with the aim of saving energy in sensor nodes. A hybrid system is obtained with Time Division Multiple Access (TDMA) protocol and Statistical Time Division Multiple Access (STDMA) protocol for the sensor nodes when to wake up to conserve energy. Congestion in the sensor network is minimized by using this hybrid scheme. Although energy consumption is minimized and packet deliver ratio is improved, network lifetime is not improved effectively. The problems associated with slot assignment optimization in WSN are addressed in [8] with different traffic loads. Average time delay for scheduling is reduced, but collisions are not removed earlier to provide better results on slot assignment.

TDMA scheduling mechanism [9] was developed where the time slots are reused for WSN to minimize the interference nodes during transmission. TDMA protocols helps for achieving the energy conservation among sensor nodes by avoiding needless idle listening and communication collision. Because of the sensor nodes are implemented with limited resource supply, TDMA scheduling is utilized in order to improve network capacity and energy efficiency. However, fault tolerance was not considered while transmitting data among sensor nodes.

An energy efficient load balancing technique [10] was employed to improve network lifetime in WSN by considering sub-network management. However, collisions among nodes are not effectively removed. In WSN, coverage aware scheduling [11] was implemented by utilizing an optimal placement method. A distributed scheduling algorithm was implemented such that each node is able to decide when to make its sensor on or off based on its location and node density over the target area. Based on the measured location, the area is divided into several sub-areas where each sub-area is coverable by only one sensor. After that, a local scheduling is performed on the activation of sensor in each sub-area. However, scheduling based on the sensor density and location information is difficult.

3. FUZZY BASED TRAFFIC CONTROL AND OPTIMIZATION OF SENSOR NETWORK

Air Pollution due vehicle emission is very serious issue in metro cities and the case creates lot of impacts in green cities. The multiple parameters like air pollution measurement, sound pollution parameter, water pollution, soli condition etc can be measured using IOT based sensor networks. The pollution due to emission is controlled by government through various rules and regulation which creates lot of inconvenience to the society due to multiple reasons which involve cost also. An efficient traffic control system in the city will reduce the traffic block in the junction, which will reduce the waiting time of vehicles in the signal junction, which reduces the emission inside the city.

Figure 2 shows the overall system where the traffic system uses fuzzy based controlling algorithm which incorporate human procedure knowledge in the decision making. The fuzzy based decision making system also uses input parameter like traffic density, road condition, weather condition etc. The sensor network based monitoring system always suffer from energy efficiency and load balancing related issues as it directly depend on coverage of the network which we need maximum always. The genetic based optimization technique will optimize the over all system performance and load balancing with out compromising the energy efficiency of the network, the network scheduling will operate accordingly.

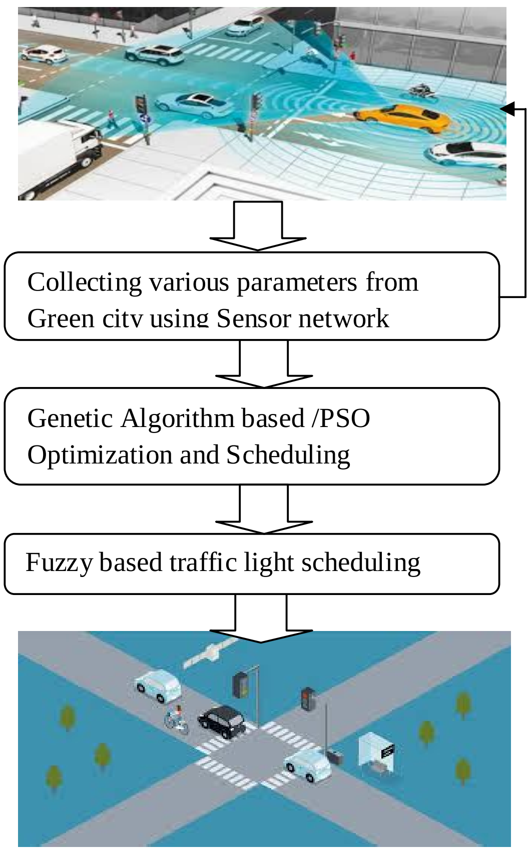

Figure 2: Over all system

3.1 Fuzzy based Decision making system

The fuzzy based decision making system contains procedure like fuzzificztion, inference, defuzzification. The traffic control is done by consideration multiple parameter like 1. Traffic density 2. Road condition 3. Weather condition etc.

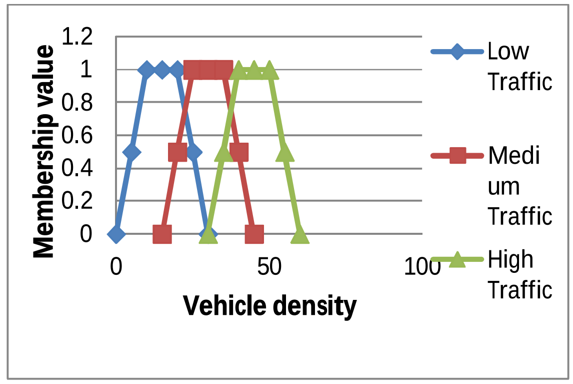

Figure 3: Membership function for traffic density

Figure 3 shows the membership function of traffic density where linguistic variable like Low traffic, Medium traffic and High traffic are used. Decision making can be further inproved by increasing the number of linguistic variable. The shape of the membership function also another factor which affect the decision. Similarly the Figure 4 shows the linguistic variables and corresponding membership function for road condition.

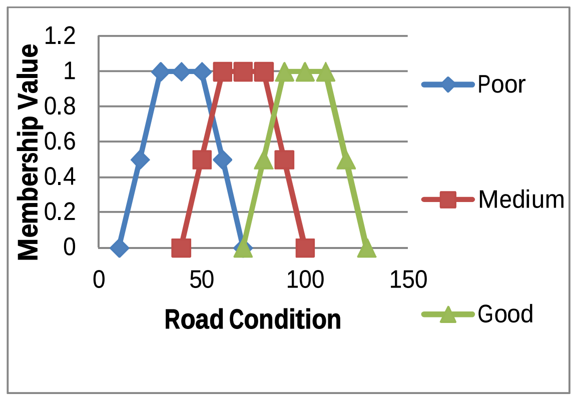

Figure 4: Membership function for Road Condition

3.2 GA based load balancing in WSN

Genetic Algorithm (GA) is applied on network parameters to perform genetic operations like initial population, selection, crossover and mutation. Genetic operations are performed based on weighted variance (i.e., difference between attained load value and specified value) to optimize the load factor in WSN. GA is employed in proposed method with the objective of achieving load balancing on the network structure that is free from collisions or interferences. Genetic optimization is applied in the network, which helps for scheduling and load balancing at an earlier stage. Hence packet delivery ratio is improved in WSN by utilizing GA.

Crossover operation in GA helps for exchanging information between two parent chromosomes to create new child chromosomes. After crossover operation, mutation is performed on the obtained child chromosome with a given probability in order to achieve optimal solutions on load balancing.

3.3 PSO Based load balancing

In order to further enhance the packet delivery ratio and network lifetime, Particle Swarm Optimization (PSO) is implemented in proposed method. PSO is utilized among sensor nodes in WSN at later stages of scheduling because of its optimal memory usage to achieve efficient load balancing. Once all particles are initialized, an iterative optimization process is started in proposed method. Process of PSO algorithm is shown in figure 3.

Input: An array of the population of particles from D dimensions in a problem space
Output: Improved load balancing among sensor nodes in WSN
Step 1: Begin **Step 2: For** each particle **Step 3:** Evaluate fitness function in D variables **Step 4:** Compare each particle's fitness evaluation with its '*pbest*' **Step 5:** **If** current fitness value is better than '*pbest*' **Step 6:** Save the current value as '*pbest*' **Step 7:** **End If** **Step 8: End For** **Step 9:** Compare fitness evaluation with population's overall previous best **Step 10:** **If** current value is better than '*gbest*' **Step 11:** Save current value as '*gbest*' to current particle's array index and value **Step 12:** **End If** **Step 13:** Modify velocity and position of each particle. **Step 14:** Repeat until stop condition is met **Step 15: End**

Figure 5: Process of PSO algorithm

Figure 5 illustrates the PSO algorithm to offer better load balancing among sensor nodes in WSN. In PSO algorithm, fitness evaluation, speed and velocity updates are continued until there is a satisfaction of stop condition. Therefore, proposed PSO based method achieves effective load balancing for transmitting data packets from source to destination based on the neighbor nodes' fitness value. Therefore, network lifetime is significantly improved in WSN.

4. SIMULATIONS AND PERFORMANCE METRIC ANALYSIS

Proposed GA based and PSO methods are compared with the existing methods such as Transmission range Adjustment, Scheduling, Coverage and Connectivity control (TASCC) algorithm [3] and Non-Dominated Sorting Genetic Algorithm-II (NSGA-II) [5]. NS-2 simulator is utilized for conducting experiments on these methods in order to analyze the performance. Network area size is considered as 1500 m ×1500 m where 500 sensor nodes are randomly deployed.

Number of packets is considered from 10 to 100 for experimental purpose. Random Waypoint Model (RWM) is employed to provide sensor movement with a random speed of 5.0 m/s. in addition, Dynamic Source Routing (DSR) protocol is utilized for achieving data transmission among sensor nodes in WSN. Experiments are conducted on the parameters such as load balancing efficiency, search time for identifying collisions in the network and network lifetime as follows.

4.1 Impact of load balancing efficiency

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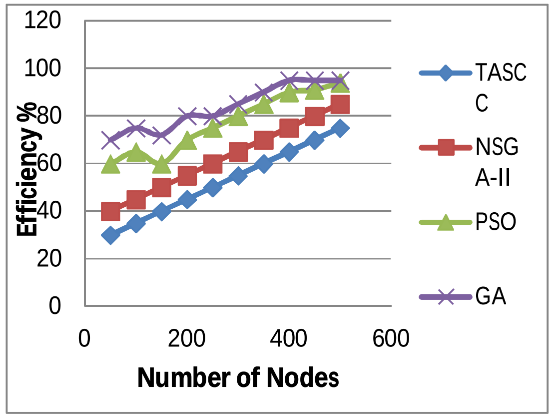

Figure 6: Measure of load balancing efficiency

Load balancing efficiency is measured while balancing the load among neighboring sensor nodes in order to achieve effective transmission of data packets. If a method has higher load balancing efficiency, then it ensures the effectiveness of that method

Figure 6 demonstrates load balancing efficiency for the proposed GA based, PSO based methods which are compared with existing methods namely TASCC [3] and NSGA-II [5]. Figure 4 clearly shows that, load balancing efficiency gets improved for the respective increase in number of sensor nodes for all methods. But, proposed GA method achieves maximum load balancing efficiency by utilizing genetic optimization procedure on a collision free network to balance the load. As shown in figure, load balancing efficiency in proposed GA method is improved by 15% than the existing methods [3] and [5]. Load balancing efficiency in proposed CNNA-NG method is increased by 6% than existing methods [3] and [5]. Load balancing efficiency in proposed PSO method is increased by 10% than existing methods [3] and [5]. As a result, proposed GA method improves load balancing efficiency in a significant manner as compared with other methods.

4.2 Impact of network lifetime

Network lifetime is calculated based on the number of required sensor nodes that are addressed for data transmission with respect to total number of sensor nodes in WSN. A method is said to be more effective when its network lifetime is higher.

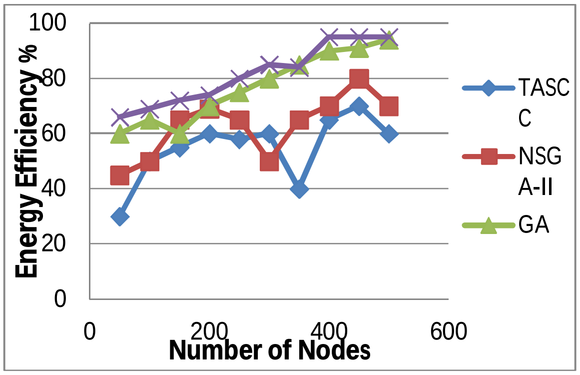

Figure 7: Measure of network lifetime

Above figure 7 shows the measure of network lifetime for different methods such as proposed GA, PSO based, existing TASCC [3] and NSGA-II [5]. As shown in figure 6, for the particular increase in number of sensor nodes, network lifetime also gets increased using all methods. But, sensor network lifetime is comparatively improved in proposed PSO method when compared to other methods. Higher network lifetime is achieved by implementing PSO algorithm to balance the load among sensor nodes. Proposed PSO method achieves 14% improvement on network lifetime when compared with existing methods [3] and [5]. By using proposed GA based method, network lifetime is improved by 7% than the existing methods [3] and [5]. Hence, proposed PSO based method achieves better performance on improving network lifetime in WSN.

5.CONCLUSION

The fuzzy based traffic scheduling in a greencity reduces the average waiting time of vehicles in a traffic signal as this technique uses human procedure knowledge in control algorithm , the system reduces the overall emission in a green city. The GA or PSO based optimization and scheduling improves the network lifetime by balancing the load. Genetic optimized procedure is employed for balancing the load with maximum load balancing efficiency .GA and PSO based load balancing is performed with the objective of enhancing the network lifetime.

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