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Scheduling Based Wireless Sensor Networks Integrated with IoT Environment

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ABSTRACT

Wireless Sensor networks are widely adopt in military, target tracking, signal processing and monitoring applications like traffic and structural, the small and low cost unreliable sensor nodes in these applications uses batteries as the sole energy source. The energy efficiency becomes difficult task as the tiny and less weight battery act as source of each node. Scheduling the different category of data packets is a way to reduce the power consumption and increasing the lifetime of sensor nodes. The existing scheduling algorithms are not adapted to the environment changes. The basic FCFS (First Come First Serve) suffered by long delay while transmit the real time data packets. In DMP (Dynamic Multilevel Priority) real time data packets occupies highest priority, the remaining non real time data packets sent to lower priority level queues. Some real time task holds the resources for longer time, the other task have to wait, it makes the deadlock condition. The NJN (Nearest Job Next) will select the nearest requesting sensor node for service, real time packets have to wait long time. The proposed Adaptive weighted scheduling scheme changes the behavior of the network queue by adaptively changes the weights based on network traffic. Simulation results proof that, adaptive weighted scheduling algorithm works better than the FCFS and DMP data scheduling in terms of energy consumption and lifetime. Our future scheme to integrate Internet of Things (IoT) with the WSN to increase the performance of the wireless networks.

Keywords**:** Data Scheduling Schemes, Energy Efficient, Network lifetime, Sensor Network, IoT

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1. INTRODUCTION

Wireless Sensor Networks (WSNs) have small size, less cost and low battery powered device which able to collect sensing data and process the data and to generate the needed information which is forwarded to the base station. Each sensor node consists of a limited power source, radio through which sensor node can communicate with other nodes within its communication range. Normally all the sensor nodes contain four important units such as sensing area- which sense the data in the deployed region, memory- it used to store the data for future application and analysis, processor- aggregate the data for reducing the power and power unit- provide supply to the entire system [1-2].

In recent decades WSNs have applied in wide range of applications, from military surveillance to environmental monitoring, disaster relief, and home automation [3-4]. For instance, sensors are collaboratively detects, process, deliver and receive the sensed data continuously, also estimate the accurate location of moving targets and also classify the targets which are nearby distance under the limited energy consumption. Nowadays, video sensor networks are one of the challenging applications. Since multimedia processing generally involves computationally intensive operations, computation power emerges as a highly demanding resource in video sensor networks [5-6].

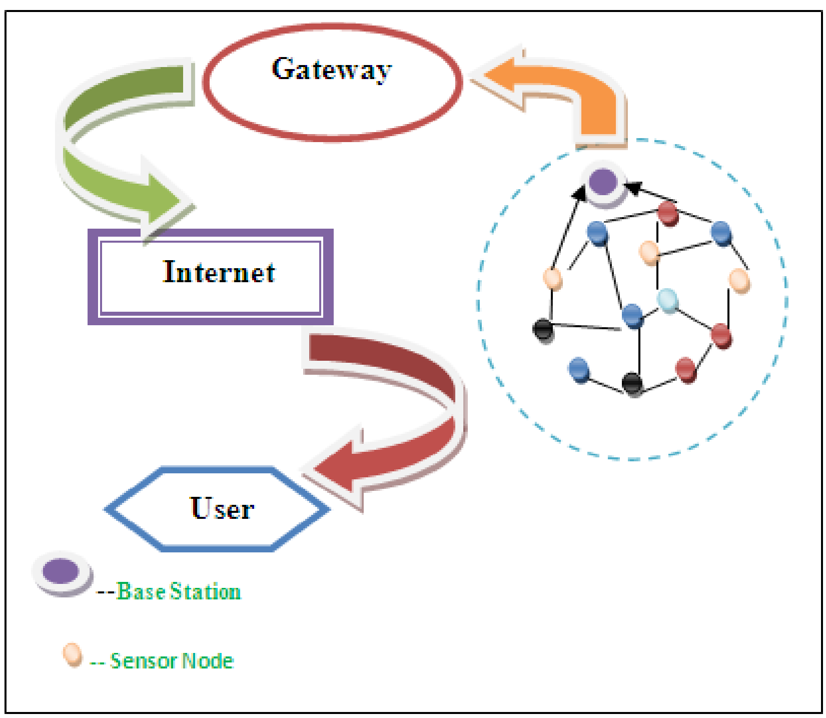

Fig. 1. Wireless sensor network

Only the limited studies and research papers published in the data scheduling and its performance in wireless sensor networks [7-8]

The IoT is developing network technologies in academia and industry. The IoT enabled devices have less expensive, less power consumption, scalability and resource constraints.

The applications area of IoT includes smart city, health monitoring, smart homes, environmental monitoring…

The most existing algorithm First Come First Serve (FCFS) process the data in the arrival order, it makes the real time packets to wait long time than the other non real time data's [9]. The next scheduling scheme named as Earliest Deadline First (EDF) process the packets based on their deadline assigned, it gives highest priority to low deadline packets leads high memory consumption [10-12].

The recent algorithm called Dynamic Multilevel Priority (DMP) scheduling works based on Time Division Multiple Access (TDMA) scheme, it provide three level of priority levels. The real time packets stay in first high priority level and remaining two levels occupied by other non real time packets. The main limitation in DMP is that, the real time packets holds resources more time than the non real time packets makes deadlock [8, 23, 24]. The proposed Adaptive Weighted Packet (AWP) Scheduling adjusts the weights according to the dynamic which is based on nature of average queue size and priority which could results low loss rate, low delay and delay jitter of premium services.

The remaining of the paper scheduled as following order. The section II discuss about existing scheduling schemes in WSN and their pros and cons. The proposed AWP detailed at section III. The performance of FCFS, DMP, NJN and AWP schemes evaluated in the section IV. Finally the paper concluded with some research issues in future at section V.

2. RELATED WORK

This section deals about existing packet scheduling algorithms based on arrivals, priority and deadline in wireless sensor networks.

2. 1. FCFS (First Come First Serve)

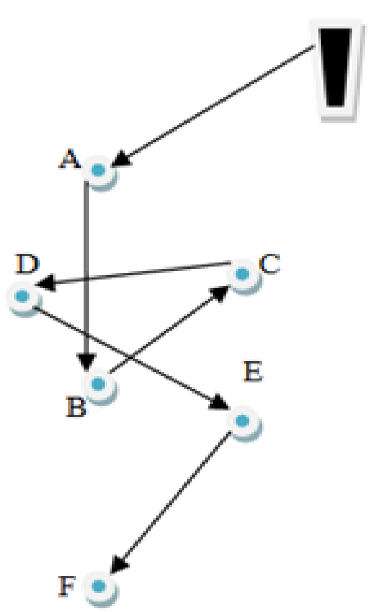

Fig. 2. FCFS Scheduling Scheme

FCFS scheduler act as basic and most existing algorithm used in WSNs applications in early days, which process the data packets in the same order as it's received from the input queue. FCFS does not differentiate real time and non real time data packets as shown in Figure 2. In some real time applications like healthcare monitoring, disaster management, that data should process first than the temperature, pressure monitoring applications data's. FCFS will provide long delay for real time data's makes inefficient in many places. The next version of fair queuing as weighted fair queuing (WFQ), it distribute the available resources to the different member sessions with a set of pre- defined weights. WFQ overcome the starvation problem faced by low priority queues [14-18].

2. 2. Nearest Job Next (NJN)

The data collection requests in the online scenario can be captured by a Poisson arrival process and the travel distance (and time) distribution between any two sensor nodes in the sensing field, the collection process can be modeled as an M=G=1=C-NJN queuing system, which accommodates at most C requests at the same time. The approach is to model the on-demand data collection process as a queuing system an M=G=1=C queuing system.

When talking about service disciplines, the first one come to our mind would be the first-come-first-serve discipline, whose performance has been extensively explored by the queuing theory society. However, FCFS discipline schedules requests based on their temporal features, which may make the ME unnecessarily move back-and forth, as shown in Figure 3. This is clearly undesirable since usually the travel time of the ME dominates the data collection latency. Furthermore, with wireless communications, it is possible for the ME to collect data from multiple sensor nodes at a single collection site [22].

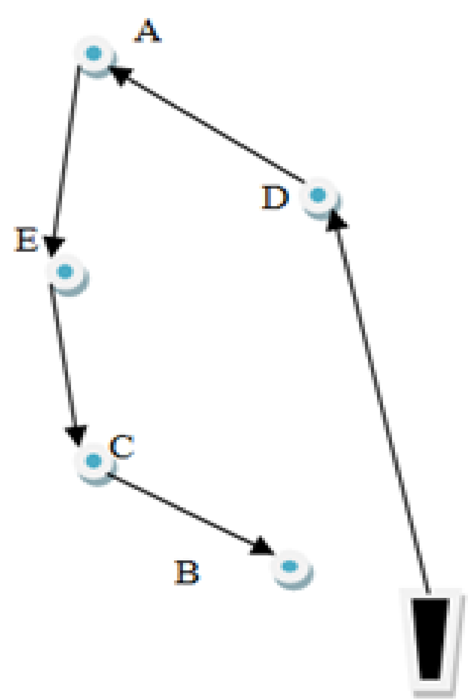

Fig. 3. NJN-Discipline

The ultimate metric to evaluate the data collection performance is the response time R of requests, i.e., from the time the request is sent to the time it is served. With the expected system size and by Little's Law,

$$E[R] = E[L]/(\lambda(1 - \omega_C)) \text{ ----------------- } (1)$$

For a given request, its response time R consists of three parts, the residual service time Sr of the request under service upon its arrival, the waiting time from the first departure after its arrival to the time it enters service W, and its service time S

$$R = S_r + W + S \text{ ------------------------ } (2)$$

2. 3. Dynamic Multilevel Priority (DMP) packet scheduling

The existing data scheduling schemes named as FCFS, real time and non real time scheduling are suffered by high processing overhead and not adaptable to wireless changing environment. FCFS will make high end to end delay for real time sensitive data due to process in the order as it receives the data from the source. The priority data scheduling are affected by starvation of non real time packets. The zone based topology in DMP having three level of hierarchy, the delay sensitive packets are occupied in first priority and processed by FCFS and remaining packets are in next highest priority levels to reduce the waiting time and delay shown in Figure 4. The TDMA scheme used to access the data's at different level in the queues. In DMP the high priority queues holds more bandwidth for longer time, it affects the non real time packets have to wait leads to deadlock condition [8].

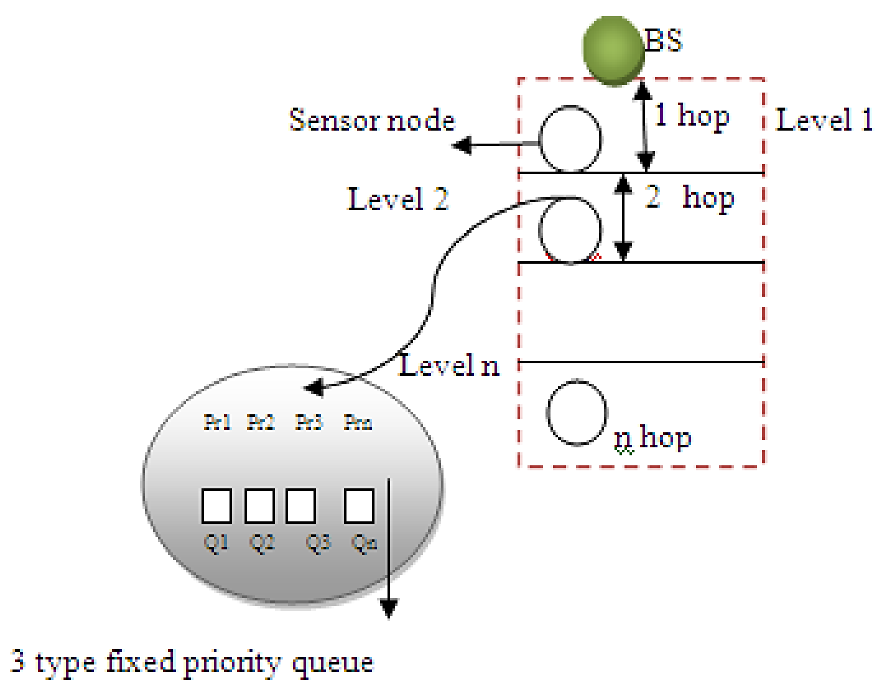

Fig. 4. DMP Scheduling Scheme

3. ADAPTIVE WEIGHTED PACKET SCHEDULING SCHEME (AWP)

The proposed scheme performs efficient in terms of low loss rate, queuing delay, and jitter than the existing scheduling schemes in WSN. It combines the features of round robin and weighted fair queuing. The average queue size and buffer space increases the bandwidth in DMP; it overcome by adaptively changing the weights leads smaller buffer size and low delay. The EWMA (Exponential Weight Moving Average) is used to calculate the average queue size which used in weight calculation.

Based on the data arrival, it adaptively varies the queue size by assigning weights which is used to achieve the premium service. The weights are classified based on threshold which is maximum and minimum. The low delay is achieved by minimum value and acceptable delay by maximum threshold value. When the average queue size increased than the minimum threshold, delay will increase, it overcome by providing more weights makes should not exceed upper limit.

Assuming avg as average queue size, Q is the instantaneous queue size and f_1 is the low-pass filter, the average queue size of premium service is estimated as,

$$avg \rightarrow (1\text{-}f_1)\ avg + f_1 \times Q \quad \text{----------------} \ (3)$$

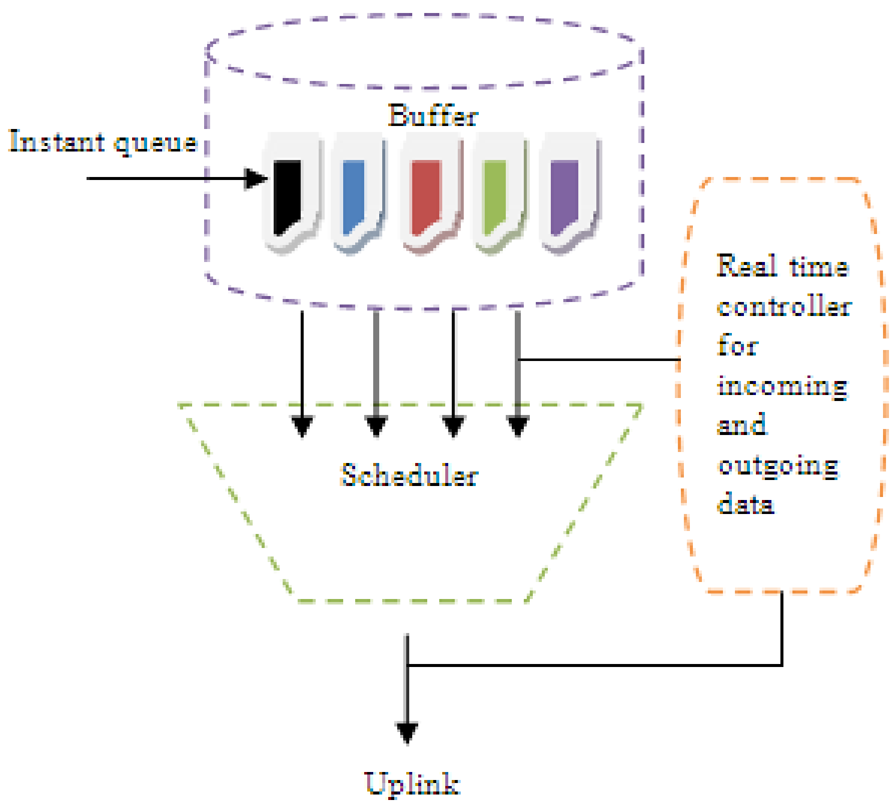

Fig. 5. Adaptive Scheduler

4. RESULTS AND DISCUSSION

In this section, we illustrated the effectiveness of our proposed scheduling schemes through Network Simulator (NS2) simulation. The Simulator configured according to the 802.11 wireless channels setting with packet size of 64 bytes. The simulation model consists of 101 nodes and 5-10 zones, the nodes are distributed randomly by selecting the (x, y) locations over the zones. The values are taken by varying the zone size from 5 to 10 as shown in Figure 6, as the size of zone increases AWP perform better and less delay than the FCFS and DMP due to the dynamic adjusting weight and queue size characteristics.

Table 1. Parameter and Values

Parameter	Value
Channel	Wireless Channel
Propagation	Two Ray Ground
Antenna	Omni Directional Antenna
MAC Address	802.11
Network Interface	PHY/Wireless
Number of nodes	101
Initial Energy	100 J
Sensing Period	1.0ms
Packet Size	64 bytes
Receiver Power	0.01
Transmitter Power	0.02

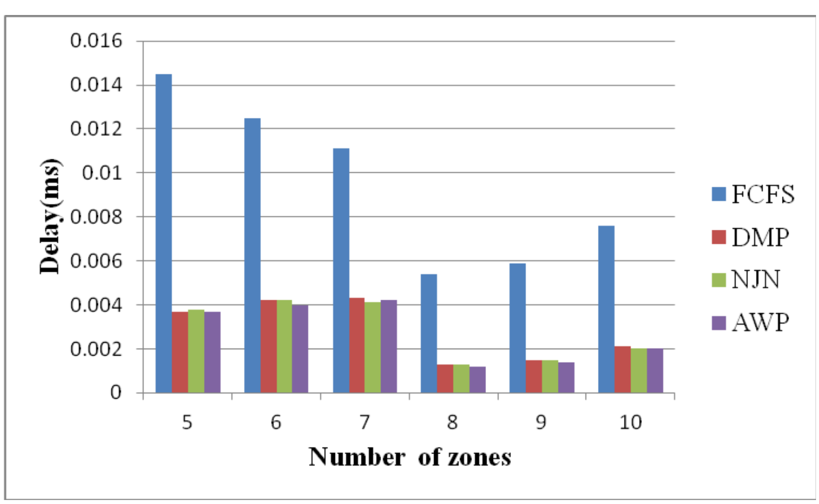

Fig. 6. Zone Size Vs End to End Delay

Due to unavailability of dynamic and adaptive property FCFS gives higher delay, it makes unsuitable for real time data applications like health monitoring and military applications.

Table 2. End to End Delay (micro second)

Number of Zones	FCFS	DMP	NJN	AWP
5	0.0145	0.0037	0.0038	0.0037
6	0.0125	0.0042	0.0042	0.0040
7	0.01110	0.0043	0.0041	0.0042
8	0.0054	0.0013	0.0013	0.0012
9	0.0059	0.0015	0.0015	0.0014
10	0.0076	0.0021	0.0020	0.0020

Table 3. Energy Consumption (Joules)

Number of Zones	FCFS	DMP	NJN	AWP
5	0.9583	0.3958	0.3858	0.3457
6	0.8810	0.3094	0.3091	0.2932
7	0.8438	0.3291	0.3022	0.3166
8	0.7036	0.2013	0.2000	0.1979
9	0.5693	0.1751	0.1711	0.1757
10	0.5859	0.1639	0.1700	0.1639

The energy consumption is a measure of energy spent for transmitting or forwarding a packet from node to another anode or to base station. In Figure 7 the zone size plotted on x axis and energy consumption plotted on Y axis. The AWP gives slightly improved performance than the DMP due to its behavior of queue size and adaptive weight characteristics. The network lifetime depends on the energy consumption and battery source. The node consumes less energy makes increased lifetime. In FCFS packets have to wait long time when the queue filled, it leads high energy consumption. Another DMP scheduling, the queue size are fixed, it does not support changes in the environment makes waste of energy.

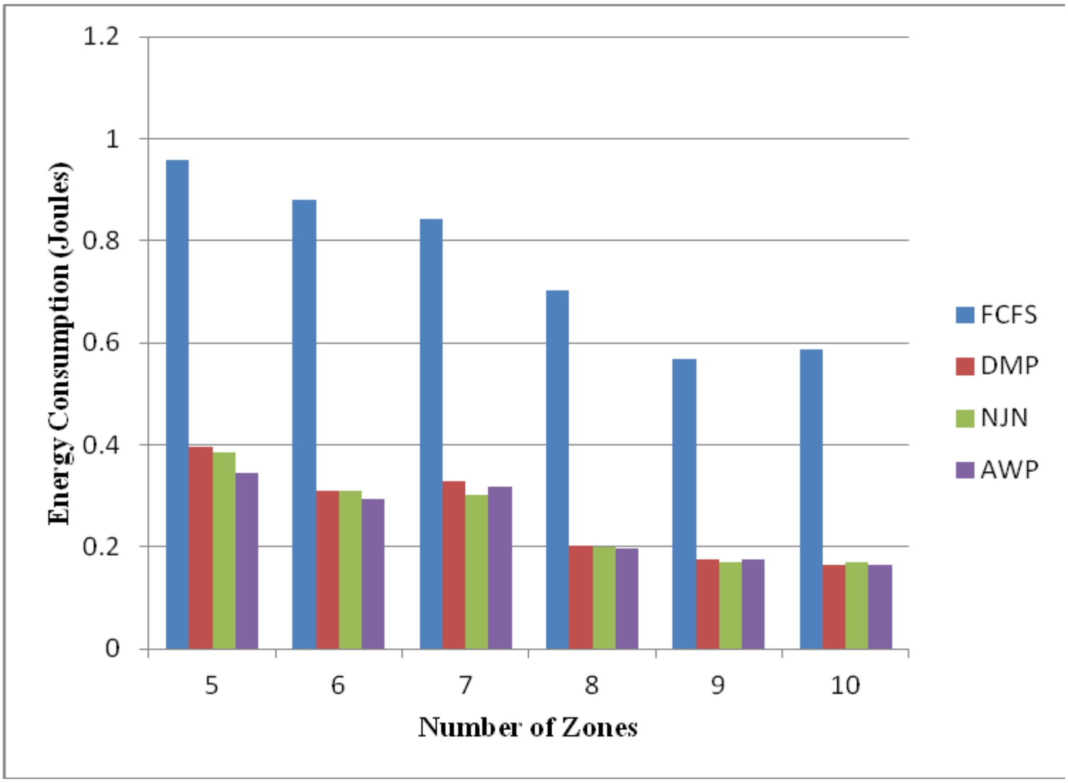

Fig. 7. Zone Size Vs Energy Consumption

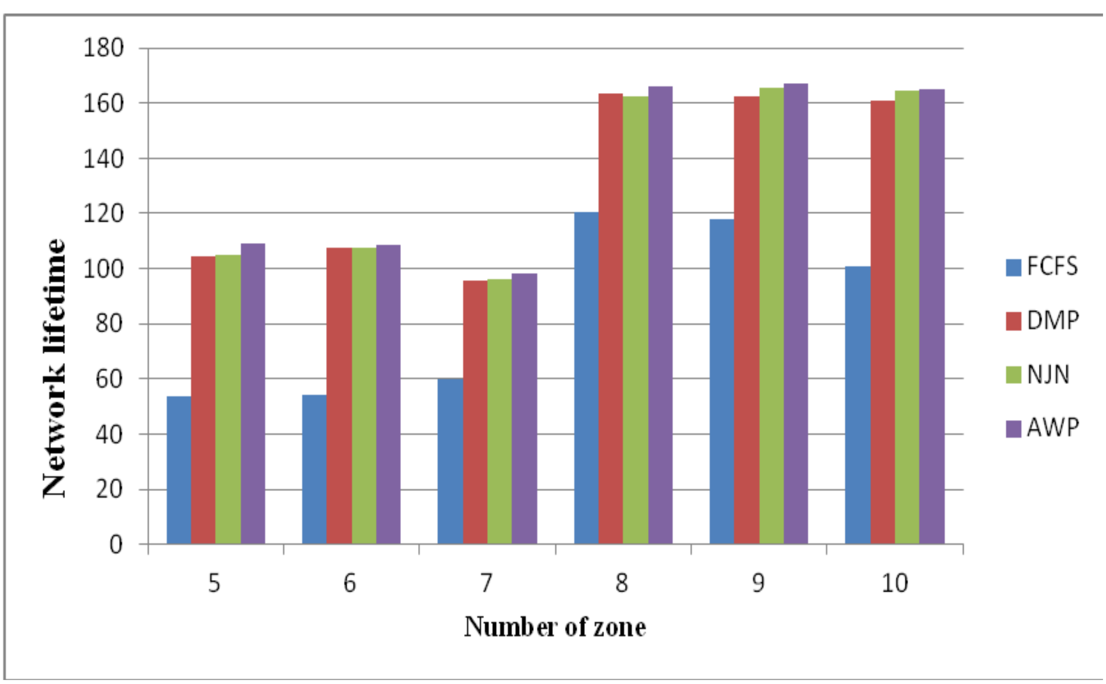

Fig. 8. Zone Size Vs Network Lifetime

The queue size and priority are adaptively changing according to dynamic nature in AWP, so it provide better lifetime for sensor nodes than the FCFS and DMP.

5. CONCLUSION AND FUTURE WORK

We evaluated the effectiveness of data scheduling algorithms in wireless sensor networks. The Simulation result demonstrated that, When compare to the FCFS and DMP scheduling, the adaptive weighted packet scheduling outperforms in terms of energy consumption, end to end delay and network lifetime. In FCFS, the packets are forwarded how it arrives to the queue, no priority assigned to packets; it leads that real time data's have to wait long time named as static weight delay problem. The DMP scheme contains three different levels of priority, the real time data's occupies high priority, when the absence of real time data's, the occupied resources are not shared by non real time data's, it makes the high energy consumption and low life time. NJN gives highest priority to the neighboring task only. The AWP scheme achieve good performance by schedules the weights by adaptively changing behavior of queue size and priority, that performs makes AWP suitable for real time sensor applications with high QoS performance.

The performance of data scheduling schemes can be increased by integrating with IoT environment and applying suitable optimization techniques and sensor scheduling schemes as the future scope.

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