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Demonstration of Queue Management with Differentiated Services in Wireless Sensor Networks (WSN)

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Abstract: Determining the optimal arrival rate to the microcontroller to balance the trade-off between arrival rate and blocking Probability is one of the fundamental issues in WSN. Due to that fact, the bigger the data, the more computation and energy required to deliver the data packets.In an attempt to overcome this challenge, we have extended the model to determine the optimal arrival rate to the Microcontroller with both real time and non- real time traffic to balance the trade-off between arrival rate and blocking probability.Numerical results conducted for various loads, Average arrival rates, service rate of server, Average waiting time and probability of blocking show that real time traffic class experiences lower blocking Probability than non- real time, also results showed that Real time traffic experiences lower average waiting time than non- real time traffic.

Keywords: WSN, Differentiated Services, Blocking Probability, Real & Non-Real Time Traffics.

I. INTRODUCTION

A wireless sensor network is a network with a quite large number of nodes that have both processing and sensing capabilities. Of recent, this technology has emerged in terms of applications from transportation and logistics to Smart grids and energy control systems as well as security and surveillance.

InWirelesssensor networks, nodes are deployed in a distant environment and normally data is collected from sources and transferred to a common node known as the sink. The presence of a sink node has an influential impact on the energy consumption and lifetime of WSNs.

Wireless sensor networks had been crucial in different areas [1], however a number of issues raised and these include limited bandwidth, computing capacity, data delivery and severe energy constraints. Not only these but limited availability of energy within WSN, hence this has to be optimized. Additionally, it is still challenging to investigate the optimal arrival rate and balance the trade-offs between arrival rate and blocking probability in wireless multimedia sensor networks.

This research work aims at determining the optimal arrival rate to the microcontroller to balance the trade-off between arrival rates and blocking probability.

Multimedia data in WSN is transmitted in Megabytes, hence data transfer becomes a bigchallenge [1, 2]. The bigger the data, the more computation energy required to deliver the data packets. In this study, all multimedia traffic were regarded as a single class without differentiating their requirements such as delay jitter, latency, throughput & reliability.We propose a model to determine the optimal arrival rate to the microcontroller with both real time and non-real time traffic to balance the trade-off between arrival rate and blocking probability.A threshold value is employed to ensure that real time traffics are not starved under their high arrival rate.The purpose is to differentiate the service of traffic to the microcontroller while minimizing blocking probability and energy consumption.

There to develop a model that provides differentiated service amongst arriving packets based on the times sensitivity of the application. And to demonstrate the performance of the proposed model against the single class model with regard to the arrival rate, load and service rate. This study will include real time and non-real time data traffic in wireless sensor networks.

This work is bound to the sensors employed in weather monitoring, surveillance as these represent both non-real time and real time respectively. The significance of this research is to determine an optimal arrival rate to the microcontroller so as to ensure the least blocking probability with energy consumption reduction. Cost-effective architecture is among the desired advantages of sensor networks, like all other resources, computing resources in nodes spread in the coverage area are severely limited. The two most in common include processor bandwidth and memory constraints [1]. As a matter of fact this explains why nodes are only able to carry out low tasks that need less computation. As a major issue energy Consumption should be minded about in various research works in the discipline of WSNs.

Traditionally, the size of packets deliveredfrom source node to destinationwas a bit small. In the case of multimedia data which is transmitted in megabytes becomes more challenging. The bigger the data, the more

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computation and energy parameters are needed for packets delivery [2].
In that context wireless multimedia sensor networks require special routing protocols and sensor nodes with high speed processors which would withstand the big data transfer. However, energy consumption remains the key issue to be addressed. One of the ways to make the life of sensing nodes long is to provide additional power supply such as solar power.

II. RELATED WORK

Of the recent WSN existed as a rich technology due its popular important applications. WSN are normally distributed in wide area and consists of independent sensing nodes connected according to set algorithms they can work together to measure some physical quantities such as temperature, humidity, pressure, vibrations and others. In this regard, WSN ever experienced some designing issues and some of them are highlighted below.

A. Key issues to address in WSN

A number of issues are to be addressed in the area of WSN and differentiated services to ensure that the intended implementation is technically possible and cost-effective. Sensing coverage had always been very cardinal in this area and this should include a desired sensing coverage with the power saving criteria in mind. Additional to the blocking probability as our target in this study, energy balancing problem in WSN is an important approach.

B. Sensing node structure

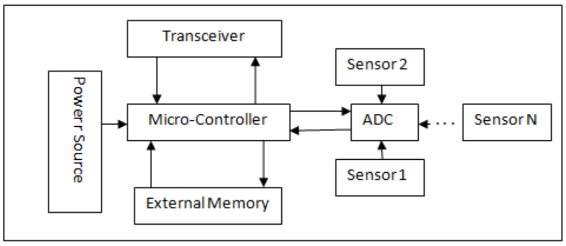

Fig. 1. A typical structure of a sensor node

A sensing node in WSN consists of the components indicated in the diagram above. Each of these has a special function, for instance, the controller performs tasks according to the programs, processes data and controls the functionality. But all together contribute to the entire working of the sensing node. Essentially, sensor nodes connect to each other in a multi-hop topology [7].

C. Wireless sensor networks with web service

The below figure represents multiple sensors delivering data from a monitored environment via a common gate way to the web server. The role of sensors in this case is to collect data from the monitored environment, the gateway transmits data from sensors to the database server via a TCP connection.

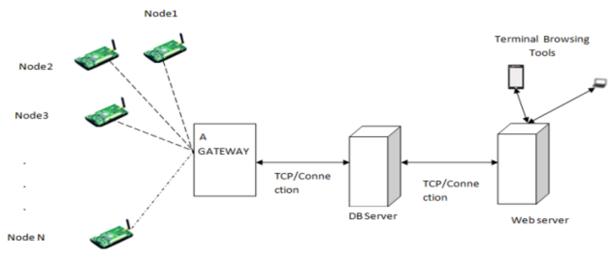

Fig. 2. A WSN with a web service

WSN with such service is very important as it can supports both real/live data as well as historical data demonstrations.

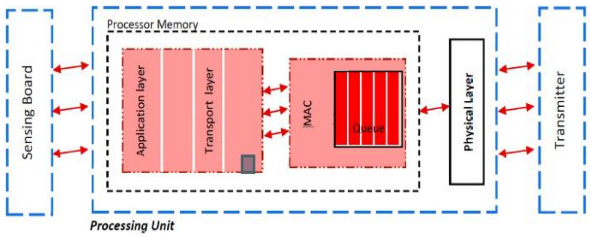

Fig. 3. Queuing process in the processor memory adopted in [1]

In their research on Queuing management for QoS, authors in [1] partitioned the queuing process into three parts, Sensing board, Processing unit and the transmitter.The arrival packets enter the sub layer through the physical layer and keep waiting if the system is busy.

D. Security in Wireless & wireless multimedia sensor networks

WMSN have sensitive and confidential applications for instance in medical care and military. This forces WMSN to take into account the security issues to ensure data authenticity, integrity and privacy in general. Researches demonstrated the ease of wireless sensor networks attacks compared to their counterparts/wired networks [3, 4]. And this explains why security is an issue to be addressed. In their research authors in [3] proposed a privacy paradigm called HoLiSTiC that ensures routing and topology information for WMSNs against outside attacks. Their study considers a clustered network with some nodes having free-space optical capabilities. In the same context, authors in [4] proposed a secure data converter architecture for WMSN that assumes fingerprinting and encryption capabilities for concurrent digitise and authenticate sensor readings [4]. The architecture in their study involved hardware modifications to the data converter with a purpose of decreasing the computational complexity of the security algorithms. Among other WSN security techniques includes Digital watermarking techniques. This method is utilized to verify data authenticity and reliability in WSNs. Digital watermarking techniques normally employs a digital watermarking embedding and extraction algorithms [5, 6]. Data is watermarked at the source sensor node and watermarking

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extraction is performed at the base station side.In [5], FaridLalemet al., proposed a method that uses semi-blind watermarking technique, in their research they presented an embedding process with a linear expression shown below.

$$v' = (1-\alpha)\cdot w + \alpha \cdot v$$

Where v = Original dataand v' =Watermarked data, whereas w stands for the original watermarking

Information

Employment of multimedia equipment allows the existence of Wireless Sensor Network (WMSN).The use of satellites, broadband wireless network and mobile Ad hoc networks allowed the shoot-up in WMSN [8, 9].

D. Wireless Multimedia Sensor Networks Design Needs

Due to their complexity in the design of routing protocols for Wireless Multimedia Sensor Networks. A number of issues raised. Some factors need to be taken into account for a good WMSN design [10].

i. Quality of Service (QoS) needs

The Quality of service need for WMSNs is a cardinal factor as far as their design is concerned. Like other sensor networks the QoS need changes in regard to their characteristics such as latency, jitter, reliability and bandwidth.

ii. Energy Efficiency

Like described before, Energy consumption in WSN and WMSN is among the major issues. In their applications WMSNs are set in remote and hardly walkable areas, such as big forests, high volcanic mountains. Etc. This forces designers to equip WMSN with durable batteries. As a matter of fact, energy efficiency should be a major issue to address in WMSN protocol design.

iii. Architectural issues

In designing WMSNs routing protocol, the network architecture is also a major factor. A number of architecture issues are revised before designing the routing protocol and these include: Network Dynamics, Data delivery Models, Channel Capacity and Hole Detection and Bypassing [10].

III. SYSTEM MODEL, TOOLS & MODEL METRICS

A. Tools used

Matlab application was used which allowed fast numerical performance evaluation under varying workloads; it provides a flexible environment for advanced computation, simulation and mathematical modelling.

B. Model Metrics

The model metrics are Blocking Probability, Average waiting time in the system and Average load on the server.

i. Blocking Probability denotes the probability that the arriving packet finds its particular queue full and has to be dropped. The general blocking probability P_{real} is expressed as follows:

$$P_{real}(R,0) = (1-\rho_1)\,\rho_1^R.(1-\rho_2),$$

Where R in this scenario represents the buffer capacity of the server. For non-real time data, the blocking probability $P_{non-real}(R,0)$ is given below:

$$P_{non-real}(R,0) = (1-\rho_1)\,\rho_1^R.(1-\rho_2)^+(1-\rho_1)\,\rho_1^R.(1-\rho_2)$$

ii.Average waiting time in the system signifies the time spent waiting in the buffer and time spent receiving service from both servers.

$$E[T] = \frac{1}{(\mu_1-\lambda)} + \frac{1}{(\mu_2-\lambda)}$$

iii.Average load in the server demonstrates the amount of packets reaching the server at a particular time ρ:

μ : Service rate of the server

λ : Utilization of node/load

iv. Continuous Markov Chain. This is used to derive the performance of the metrics presented above.

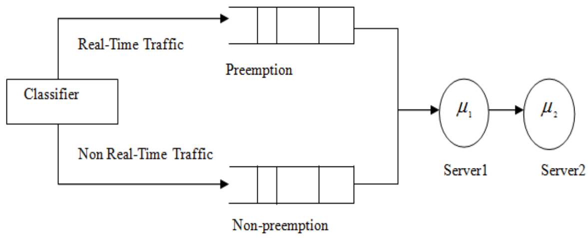

Fig. 3. System model

IV. NUMERICAL RESULTS

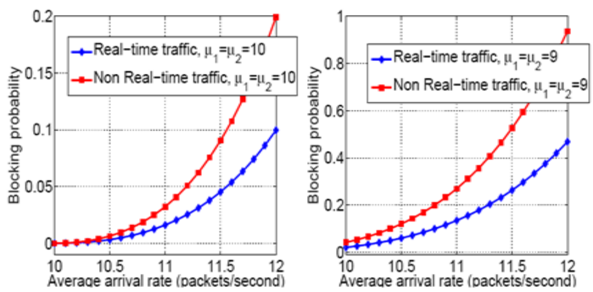

Fig. 4. Blocking probability versus average arrival rate for both real-time and non real-time

Figure.4 shows that probability of blocking is increasing as average arrival rate increase, it also shows that non – real time traffics and real time traffics are the same at the beginning but non real time is always above real traffics at different values of μ .

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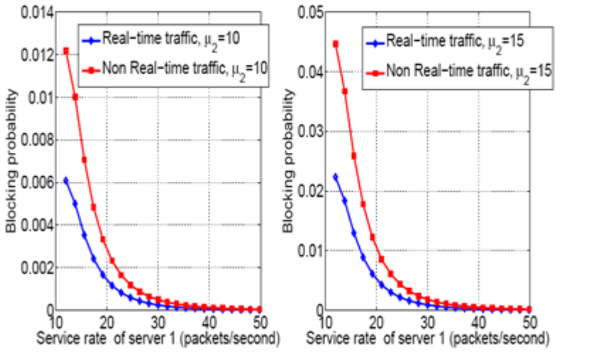

Fig. 5.Blocking probability versus Service rate of server 1 for both real-time and Nonreal-time

The figure.5 shows that the probability of blocking is decreasing as service rate of server 1(packet/second) increases and this common for both real-time traffic and non-real-time traffic when the load is increased from $\mu_1 = 10$ and $\mu_2 = 15$

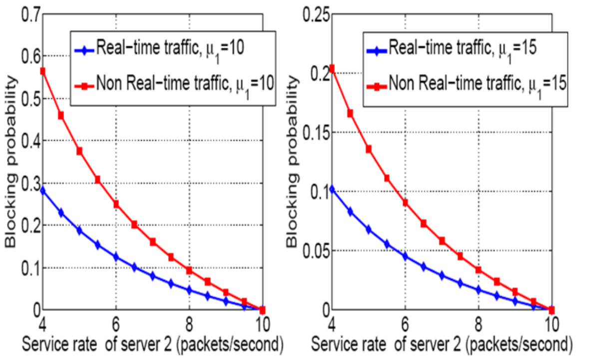

Fig. 6. Blocking probability versus Service rate of server 2 for both real-time and Non real-time

The figure.6 shows that the probability of blocking is decreasing as service rate of server 2(packet/second) increases and this common for both real-time traffic and non-real-time traffic when the load is increased from $\mu_1 = 10$ and $\mu_2 = 15$

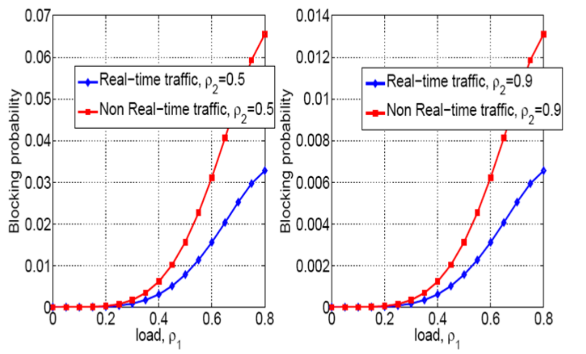

Fig. 7. Blocking probability versus load (ρ) of server 1 for both real-time and Non real-time

The results shows that the probability of blocking is increasing for both real time and non-real time but non – real time traffic is always high for different values of load with respect to server 1.

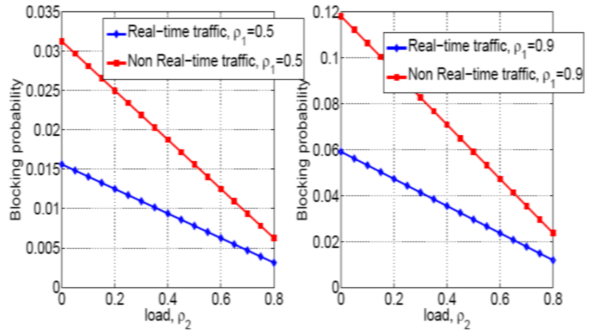

Fig. 8. Blocking probability versus load (ρ) of server 2 for both real-time and Non real-time

The results show that the probability of blocking is decreasing for both real time and non-real time but non – real time traffic is high for different values of load with respect to server 2.

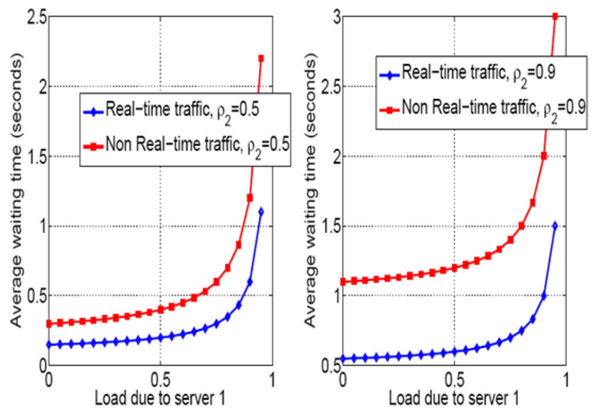

Fig. 9. Average waiting time (s) versus load (ρ) due to server 1 for both real-time and Non real-time traffics

The shows that the average waiting time increases as the load due to server1 also increases, it is noted from the figure that real-time traffic and non-real time traffic increases with respect to $\rho = 0.5$ and $\rho = 0.9$,the results alsoshows that non-real time traffic is high compared to real-time traffic.

V. CONCLUSION

An analytical modelof aqueue management mechanism that differentiates the services of traffic based on the time sensitivity of the traffic classes are presented with Markov chain to model the blocking Probability and average waiting time of the traffic classes.Numerical results show that real time traffic class experiences lower blocking Probability than non-real time. In the future, the model

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will be optimized to simulate the behavior of Queue management mechanism and would be extended to situations that involves multiple traffic like video, Voice and texts in WMSN

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BIOGRAPHIES

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