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ENHANCEMENT OF QUALITY OF SERVICE BASED ON CROSS-LAYER APPROACHES IN WIRELESS SENSOR NETWORKS

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ABSTRACT

To improve the quality of services (QoS) based on service level agreements, wireless sensor networks (WSNs) are necessary in critical applications. It is difficult to ensure quality of service in wireless sensor networks due to the numerous constraints and demands placed on the resources available to sensors and the various applications that use these networks (WSNs). At the network level, the quality of service was assessed while taking routing, communication methods, scheduling delays, throughput, jitter, and other factors into consideration. In order to meet the requirements for latency and reliability in critical applications, we present an overview of the most recent cross-layer QoS approaches in wireless terrestrial sensor networks in this paper. For cross-layer QoS solutions, our study recommends using the RAS classification, which stands for reliability, availability, and serviceability. We outline many open issues and promising research directions with regard to achieving QoS in WSNs. Alternative middleware is also taken into account.

Keywords: *Wireless Sensor Network, RAS, Quality of Service, Cross Layer Scheduling.*

1. INTRODUCTION

A sensor, to put it simply, is a wireless sensor that consists of a transceiver radio, a sensor known as a transducer, a tiny CPU, and a small power source. The most typical kind of power source is a battery. Ad hoc networks might run with relatively little support from the infrastructure. According to [1] wireless sensor networks (WSN (limited)) all have data processing, short-range transmission, and ambient data sensing capabilities. The medical sector, the military, industrial process management, land seismicity monitoring, ghost monitoring, volcano monitoring, and many more fields employ it. an important A wireless sensor network has several sensor nodes. These nodes are impacted by limited power sources, limited computational power, and limited communication range.

Smaller, smarter, and more effective wireless sensor nodes are now possible thanks to the advancement of WSNs and new WSN technologies, among other uses in process control and industrial automation [2]. WSN is a substitute for wired sensors that provides the special benefits of wireless media.The latter may be summed up in three ways: deployment is simple, information is accessible, and installation is less expensive. Ad hoc networks are one kind of WSN in particular that mimics but varies from traditional wireless networks [3]. Think about the limitations that come with sensor nodes, such as their lack of processing power, limited memory, and lack of energy resources.

Quality-of-service (QoS) has become a serious issue as the use of wireless sensors in various applications increases [4]. Due to recent advancements in the technology of sensor hardware components, such as increased ROM and RAM capacities, improved energy capabilities, etc., the wireless sensor industry has been able to expand quickly [5]. The list of WSN definitions may include the following: An

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unsupervised network of tiny, battery-powered, low-resource devices containing a CPU, sensors, and transceivers are deployed in the real environment. Surprisingly few studies have focused on the quality of service in WSN, despite the fact that there has been a lot of study and development in the areas of architectural and protocol design, energy efficiency, and location [6]. Numerous QoS-related articles that concentrate on MAC and network protocols and procedures have been identified by us; nearly all of them have undergone simulation-based testing. These approaches to improving WSN QoS are all.

However, the concept of wireless sensor networks has a number of disadvantages. There are several issues that still need to be resolved since WSNs and traditional computer networks differ greatly from one another (such as wireless communications, dynamic topology, resource limitations, data redundancy, asymmetric traffic and a large number of hops routing)[7]. They nevertheless have computational and energy limitations in comparison to conventional computer networks [8]. The cheap production costs and broad adoption of wireless sensor nodes have recently allowed for the construction of very large wireless sensor networks that can contain up to 10,000 nodes[9].

Big networks may make even simple tasks like sending data from one source to another extremely complex [10] given how unpredictable radio communications are. In other words, WSN research and development is still continuing strong ten years after it began. Despite the fact that wireless technology has made significant advancements, there are still some applications where it does not provide enough quality of service (QoS), such as industrial plants where high reliability is required and where there are restrictions on the acceptable delay values in data transmission through the network[11]. The subsequent portions of the paper are structured as follows: Review of the literature is presented in Section 2. The concept of QOS for WSN is described in Section 3. A performance analysis is shown in Section 4. The conclusions and observations are presented in Section 5. The conclusion is presented in Section 6. After each of these subjects, there are further parts that provide the literature review.

2. LITERATURE REVIEW

The QoS control issue was addressed by Shenghong Li et al. [12]. Instead of being preset as a solution to the issue, the right number of sensors was initially determined through reinforcement learning interactions with higher level applications. The Estimator Goore Game (EGG) strategy was used to successfully adjust the number of active sensors. The recommended approach demonstrated a competitive performance and permitted a decrease in the aforementioned assumption. The technique can be used in stationary and non-stationary situations. The proposed approach worked as predicted, according to simulation findings on network life, convergence time, and the ability to track dynamic QoS.

Rob et. al [13] a procedure to check if WSN node configurations adhere to application-level QoS specifications. A novel algebraic Pareto analysis method that we created to look at trade-offs in QoS was used to construct the plan. It comprises an algorithm that narrows the range of feasible configurations by removing configurations that outperform others by analyzing various network components in modules. Furthermore, we offered models for target tracking and WSN mapping that specifically take QoS trade-offs into account. These two applications, as well as a heterogeneous WSN that integrated these two applications, were examined for the correctness of the models and the method's scalability, proving that it was practical for WSN even with a high number of nodes.

Akerele et.al. [14] a system that uses adaptive scheduling to facilitate collaboration between WSNs and optical network units (ONUs) in order to lower latency for high priority traffic. After then, end-to-end latency and dependability were taken into consideration while creating the quality of service (QoS) for time-sensitive smart grid monitoring applications. They demonstrated through simulations how the capabilities of the proposed QoS approach to lower end-to-end latency may benefit the Fi-WSN system and long-reach passive optical networks (LR-PONs). Additionally, they demonstrated that, in the same traffic and network conditions, our technique may exceed traditional knowledge. Jäger et al. [15] A highly scalable model for industrial embedded wireless networks was built to compare different system configurations. They then used it to create a system for setting up an avionic environment that used a framework for software architecture for simulation-based tools that were built for different industries. All major performance parameters for quality-of-service needs, including node lifespan, throughput, reliability, latency, and energy use, were incorporated in the overall model that was provided. The ability to customise hardware and take observed behaviour into account for fine-grained model and prototype validation was another significant development. This was made possible by the direct connection between the design tool and the test bed or prototype system. The use of a real-world system context served to illustrate the benefits of the integrated strategy.

Ibarra et.al [16] presented a three-module combined power-QoS (PEH-QoS) control strategy that would maximize energy savings and generate the optimum QoS. The suggested method makes sure that a sensor node can accurately identify medical occurrences and communicate the relevant data packets. Incorporating PEH-QoS into a medical node improves the system's energy effectiveness, throughput, and capacity to identify issues, according to several simulations for diverse human activities (such as relaxing, walking, running, and cycling). In their research from 2017 Rathee et al. [17], presented an ant colony optimization-based QoS aware energy balancing secure routing (QEBSR) solution for WSNs. It was proposed that more recent heuristics be utilized to evaluate the nodes in the routing path's trust factor and end-to-end transmission latency.The two current techniques, distributed energy balanced routing and energy-efficient routing with node compromised resistance, were contrasted with the suggested approach. The simulation results demonstrated that the suggested QEBSR approach outperformed the other two alternatives substantially.

3. PROPOSED QOS MODEL IN WSN

3.1 Qos in Wsn

Real-time applications have helped WSNs expand quickly, and WSN QoS has been the subject of extensive research. Dependability, timeliness, robustness, availability, and security are a few ways to characterise quality of service. Throughput, latency, jitter, and packet loss rate are examples of QoS metrics that may be used to gauge how satisfied customers are with these services. There are further Quality of Service factors to consider.

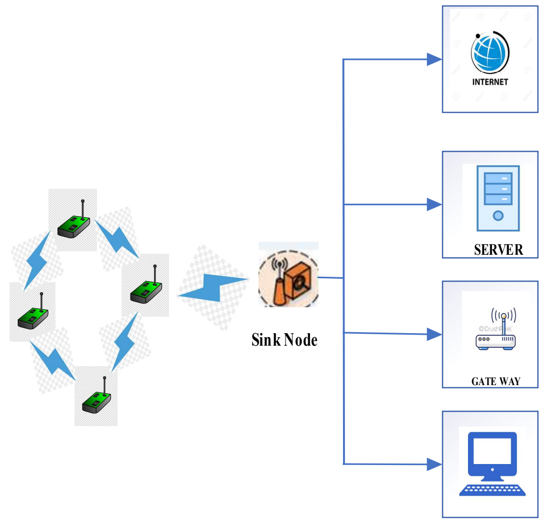

Figure 1: An example of Wireless Sensor Network

Priority should be given by the QoS management to a particular communication flow. Numerous QoS mechanisms are included in the WSNs protocol stack and may be used at each network tier to manage the prioritisation procedures.

A. Data compression techniques

Processing data requires less energy than transferring it. To minimize data size before transferring through wireless media, it is preferable to lower total power usage. The buffer size, however, is the main issue with algorithm implementation in WSNs. A few data compression techniques that might be utilized in WSNs are detailed in this section [5]. Some of these tactics were compiled into a list by Gonzalez, which is seen in table 1.

Network Layer	QOS Strategy	Improvement in QoS Metric
Link Layer	Channel Surfing	Reliability, Network Lifetime
	Modifying Signal Power	Network Lifetime
	Using Low interference channel	Reliability, Network Lifetime

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Physical Layer	Energy Aware MACs	Network Lifetime
	Selection of low interference channels	Reliability, Network Lifetime
	MAC that Avoids Collisions	Reliability, Network Lifetime
Network Layer	Routing Protocols	Reliability, Network Lifetime, Latency
	Packet Priority	Reliability, Network Lifetime, Latency
Application Layer	Compression	Latency, Available bandwidth
	Adjust sensing Rate	Network Lifetime, QoD
	Data reduction Technology	Latency, Available bandwidth

Table 1: Summary Of WSN Strategies That Improve Qos

B. Adjust sensing rate

In sensor networks, the sampling frequency determines the transmission rate, therefore choosing the right sampling frequency is essential for maximising wireless bandwidth and battery life. The answer to the optimum sample problem must take into account the potential for traffic congestion along each route. how to accurately pinpoint the correct frequencies. In order to dynamically establish the overall ideal sample frequencies in a large network and prevent bottlenecks, a distributed system must deliver balanced optimization traffic loads. In order to give nearly optimum global solutions at a cheaper cost, the solution must be incremental when the utility function at a few nodes changes.

C. Data reduction techniques

In sensor networks, continuous inquiry is widely used to collect ongoing data from the objects being viewed. This query has to be correctly constructed in order to use less power and last longer. Data reduction strategies are used to decrease the amount of data that each node delivers [10]. This approach, in contrast, employs an algorithm that does not require any prior modelling, allowing nodes to function independently and without the requirement for global model parameters. using real temperature data from an office setting and the adaptive Least-Mean-Square (LMS) approach.

D. Routing protocols

Despite the increasing growth of sensor networks, little study has been done on their routing. We provide a comprehensive evaluation of the suggested wireless sensor network routing techniques in the literature. The sensor network should be able to send data for a very long time, according to everyone. The three primary types of routing protocols are hierarchical,flat and place-based, as determined by the network topology.According to their operating modes, these protocols, as well as multipath, queries, negotiations, and QoS-based routing techniques, are categorized in Table 2.

Routing Protocols in WSNs	Network Structure	Hierarchical Network Routing
		Flat Network Routing
		Negotiation Based Routing
	Protocol Operation	Location Based Routing
		Query Based Routing
		Muti-Path Based Routing
		Coherent Based Routing
		QoS Based Routing

Table 2: Routing Protocols in WSNs

If the primary connection breaks, a backup route will link the source and the destination. Maintaining many routes available between the source and the destination may help with this, but it will increase energy consumption and traffic. These additional channels are still accessible as long as regular messages are sent.

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E. Packets priority

1) **Integrated services***:* For sensor networks, the concept of a flow may be understood in two different ways. In the data-centric interpretation, a single type

of data would be considered as a single flow. An interest expires when the monitor node stops updating it. The packet stream between a source and a monitor qualifies as a flow in the host-centric interpretation [14]. When utilising a sensor network model similar to IntServ, each sensor node is required to save per-flow states. Due to the limited memory at a sensor and the enormous number of sensors available in a field, it is difficult for sensor networks to maintain states for host-centric flows.The International Service model might only be appropriate for data-centric flows if a particular sensor market has few rivals. The only flows that can afford to handle packets from a particular flow differently are data-centric flows with a small number of interests. In this paradigm, the monitor node's interest refresh-message may contain the requested service for a specific interest.

2) **Differentiated services:** This is one method for controlling QoS traffic and guaranteeing dependable network packet transport[10]. There are no assurances for flows in the DiffServ paradigm. The per-hop behaviour (PHB) is instead recorded by the edge routers in the packet header. When deciding how to schedule packets, the core routers consult the PHB. The same treatment is given to packets with the same PHB from various flows. Actually, IntServ offers services based on individual flows, whereas DiffServ offers services based on individual aggregates. There are several approaches to differentiate services in sensor networks. For wired networks, there are two different strategies: IntServ and DiffServ. These service differentiation models give packets from a particular flow additional treatment.To manage the flow of packets being transferred, each router maintains track of a token bucket and has the ability to hold per-flow statuses. utilizing a forestall fire detection system as an example. In this context, a sensor reading of 60 degrees Fahrenheit is considered to be typical for a spring day; nevertheless, a result of 1000 degrees Fahrenheit in the same situation is rare and might be a sign of a forest fire. The packet with the 1000F temperature is unquestionably more important from the perspective of a monitor, hence the network must transmit it more rapidly. Contrarily, the Differentiated Services (DiffServ) model gives no guarantees regarding flows. The Per-Hop-Behavior (PHB) header can be added by the edge routers.The core routers use the PHB as a source of data when deciding how to schedule packets. If two flows deliver packets with the same PHB, they should be processed accordingly.

F. Energy aware macs

Idle When the sensor node keeps its radio in channels, listening uses the most energy for the energy-efficient sensory MAC protocols. Two NICs can communicate with one another if they are on the same channel and close enough for transmission. For such networks to perform well, the capacity to run many broadcasts simultaneously inside a neighbourhood is crucial. Due to competition for that channel among nearby wireless networks, a single channel wireless network can only support one broadcast at a time.However, as long as they operate on different channels, such concurrent broadcasts won't result in a collision in a multi-channel network. Due to broadcast interference, QoS routing in multi-hop wireless networks is quite difficult. Interference still happens in multichannel wireless networks due to the potential for interference from two broadcasts on the same channel.

G. Mac that avoid collisions

Medium Access Control (MAC), which regulates node communication and decreases collision, is crucial. The two protocols created for wireless sensor networks are S-MAC and IEEE 802.15.4. The carrier sense with control messages approach used by SMAC can be compared to the IEEE 802.11 standard. For the S-MAC protocol, carrier sense multiple access reduces collisions (CSMA). number of back offs (NB),Back off exponent (BE) and contention window are the three variables used by the Carrier sense multiple access with collision

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avoidance (CSMA-CA) technique in IEEE 802.15.4 to perform this (CW). Although there will be a decrease in throughput, the collision will now need more energy.

H. Channel surfing

The WSNs are prone to interference and jamming, which can hinder sensor communication. Utilizing traditional PHY-layer communication methods is a common solution to this issue. A helpful method for reducing the disturbance is channel surfing, in which the sensor nodes move to different channels when there is interference. Border nodes can reestablish network connectivity by using any of the two techniques described below:

1) **Coordinated channel switching:** when the entire sensor network's channel is changed. When a system node detects jamming, it switches channels and activates beacons to signal its presence on the new channel. They will notice their absence on the primary channel and search for them on the secondary channel if they are near to clogged border nodes. As a network expands, switching channels throughout the whole network necessitates a significant amount of latency. The network can then become unstable as some devices use the old channel while others wait for the new channel to be available. It can only have congested areas swap channels receiving mode repeatedly to reduce the latency issue.

2) Collisions between packets caused by simultaneous packet transmission.

3) **Control Packet Overhead**– It is necessary for synchronization. We had to implement certain energy-saving measures despite the fact that real-time wireless traffic didn't notably suffer since wireless sensor nodes had energy limitations.

I. Modifying signal power

The energy consumption of WSNs has a significant impact on their net lifespan, making it an important research parameter. A method for extending the life of a node and the network as a whole is to select the optimal power transfer in this sequence. The lowest transmit power that would satisfy the criterion may be calculated if the planned BER threshold is higher than the desired BER floor [20].The three different forms of CSIT listed below determine how average transmit power is lowered in line with average rate and BER restrictions: F-CSIT, where each sensor presumably has the ability to realise each channel; Individual (I-) CSIT, in which each sensor only has complete knowledge of its own channel but only quantized information on the channels of the other sensors, and Q-CSIT, in which the sensors only know how they are connected to the FC in quantized form.

4. PERFORMANCE ANALISYS

The bulk of the time, a variety of already developed apps for this kind of network are what determine the QoS in WSNs. The research's recommended fixes improve the different parameters utilised as QoS measurements by WSNs in the designated order. The advantages and disadvantages of the research approaches employed in this work are presented in Table 3.

Sr No	Strategy	Improvement	Challenges
1	Modifying Signal Power	Increased the Lifetime	Find the minimum transmit power for Application
2	Channel Surfing	Provide a Tool to against jamming	Improve channel Adaptability
3	MAC that avoids collisions	Improvement the throughput	Efficiently manage the transmission for Nodes
4	Selection of Low Interference Channels	Reliability and Lifetime	Interference between neighborhood channels
5	Energy aware MACs	Increased the Lifetime	Avoid degrading the performance of real time wireless traffic
6	Packet Priority	Reliability and Lifetime	Provide service level Agreement
7	Routing Protocol	Reduce power consumption	Balanced the bandwidth

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			and power requirement analysis
8	Data Reduction Techniques	Increased the Lifetime	Developed adaptive algorithm
9	Adjust Sensing Rate	Optimized bandwidth and Increased the Lifetime	Finding optimal Algorithm and sampling frequency
10	Data Compression	Avoid collision and Latency	Reduce the size of node buffer and Algorithm for data compression

Table 3: Challenges Faced By Various Techniques

The throughput gains and the admission area of flows with ensured QoS are used to gauge the efficiency of our SINR-EC scheduler. One-hop flows are taken into account since it is simple to analyse the admission region.

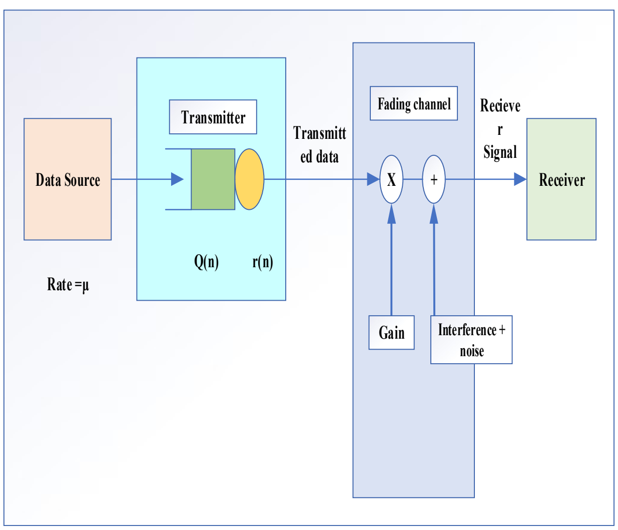

Figure 2: Queuing System Model Used In Our Simulation

Consider the admission control module of the system under assessment to ensure that the authorised one-hop flows obtain the appropriate QoS. Each point on the NI-TDMA channel utilisation and admission region is expected to be represented by one of the Pareto-optimal vectors [N1, NL]. Each of these flows should be managed simultaneously by the SINR-EC scheduler. $N_o$ne-hop flows for QoS class l (l = 1… L) and the percentage of channel use under our SINR-EC scheduler is $\sum_{k=1}^{S} w_k<1$. Then, $[N_1\times\lfloor 1 \ \sum_{k=1}^{S} wk],\ldots\ldots,[N_l\lfloor 1 \ \sum_{k=1}^{S} wk]\ ]$ is within the admission region under our SINR-EC scheduler, where $\lfloor x$ is the largest integer that is less than or equal to x.

5. RESULTS AND DISCUSSION

In the network setup shown below, the six nodes N1 through N6 that are connected to the sink node were used to carry out the desired operation.

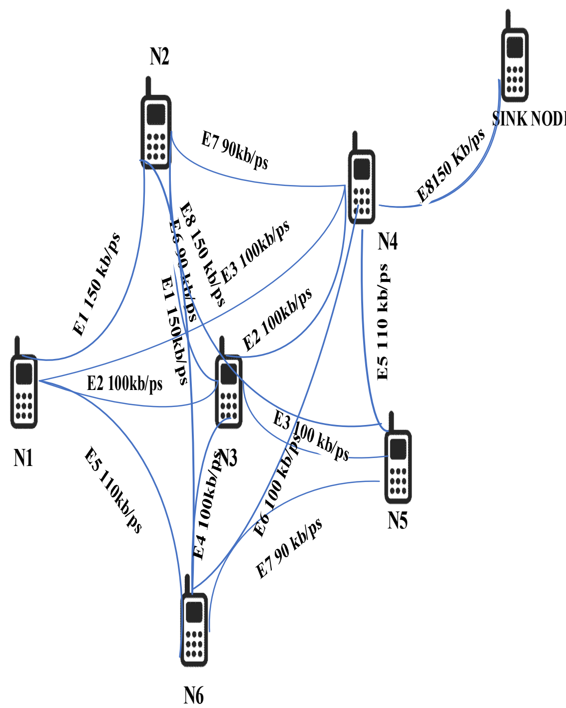

Figure 3: Topology And Traffic Load Of Six Node Network

The results of completing the listed activities will be discussed next. In this case, we are given 100 bytes of random data, which are distributed evenly across all TDMA and FDMA users.

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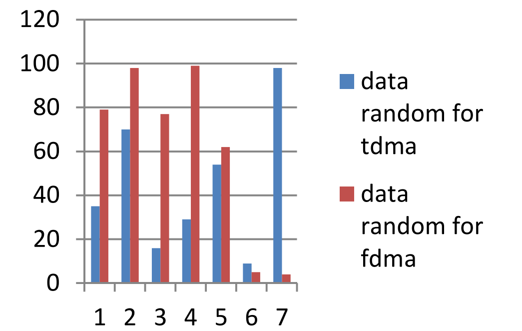

Figure 4: Graph User Vs Packets

In this study, we determine the average channel gain G in TDMA and FDMA modes utilising column generation and delay column generation techniques, with and without jitter. We estimated the average channel gain for FDMA and TDMA while taking into account the quality of service metrics of data rate, delay bound violation, latencyand jitter using source node N1 and destination node N5 with user 7 in the topology.

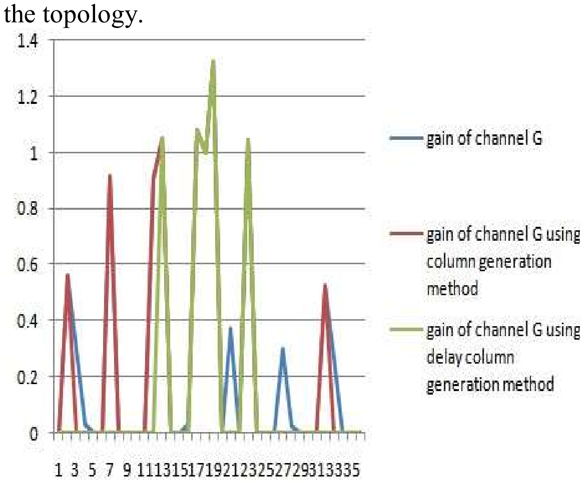

Figure 5: TDMA without Jitter

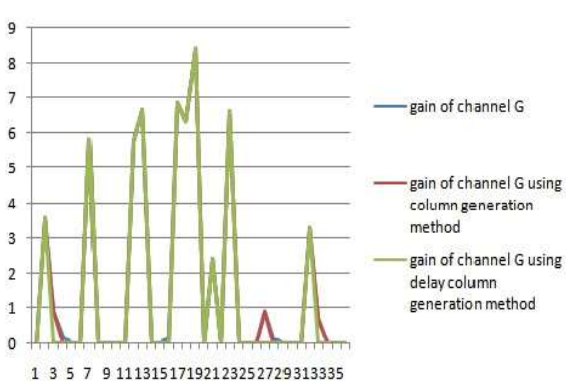

Figure 6: TDMA with jitter

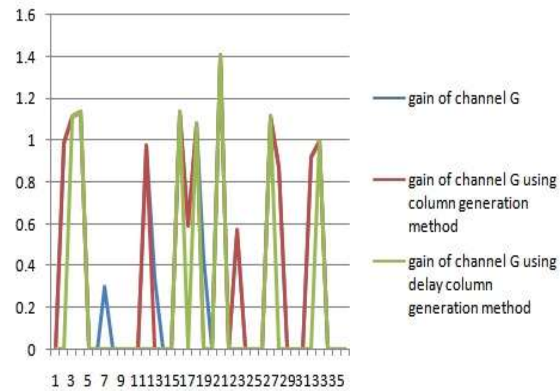

Figure 7: FDMA without jitter

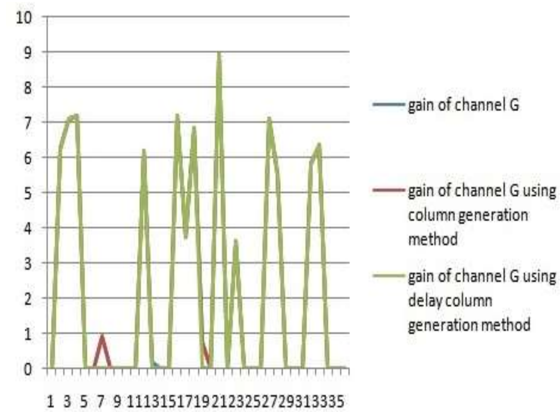

Figure 8: FDMA with Jitter

6. CONCLUSIONS

The QoS in wireless sensor networks is an extensive research field that provides a wide range of challenged that could be research lines to new developments in this important area. The used of several strategies can be improvement the main operation parameters of WSNs and its components considerate how metrics of QoS in function of each application. The trade-off required to use these technologies varies depending on the application and may or may not be deemed bearable. To find a less-than-ideal solution to the issue, we created an iterative approach based on the column generation and delay column technique using TDMA and FDMA.

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