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QUERY SCHEDULER FOR SECURE COLLISION-LESS TRANSMISSION IN WIRELESS SENSOR NETWORKS

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Abstract - The development of cyber physical frameworks that must support continuous queries of physical situations through wireless sensor systems has picked up thrust recently. Traditional embedded systems, contains standalone devices that can be replaced with a full-fledged Cyber Physical Systems that is designed as a wireless senor network with interacting elements both at the input and output.

The cyber-physical systems use query services at regular time intervals accumulate information from the sensor nodes to a centralized base station. Time Division Multiple Access (TDMA), Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), and Dynamic Conflict-free Query Scheduling (DCQS) etc. which are unsatisfactory for high information rate and continuous application in real time since they give exceedingly variable communication latencies because of their irregular back-off systems and accomplish low throughput under huge load because of intemperate channel discord. Subsequently, for clash free transmission scheduling for constant queries in Wireless Sensor Networks is proposed.

The proposed algorithm provides a characteristic tradeoff in the middle of in activity latency and real-time capacity that can adapt its transmission schedule in response to addition, removal and changes in queries dynamically. It provides the ability of adapting to workload changes more efficiently than Time Division Multiple Access with fixed transmissions schedules and it has limited storage requirements which makes it suitable for asset constrained devices. The analysis is validated through NS2 simulations.

Keywords- Cyber Physical Systems, CSMA/CA, DCQS, Query Services, TDMA, Wireless Sensor Networks

I. INTRODUCTION

Wireless cyber physical systems, which support real-time data collection over Wireless Sensor Networks at high data rates has attracted extensive attention in the present years. It co-operatively passes the data through the network to a main location or sink where the data can be monitored and analyzed. A sink node or base station performs like a gate between users and the network. Wireless Sensor Networks is a part of the Cyber-physical systems (CPSs) which are engineered systems with an integrated computing and communication core for monitoring, coordinating and controlling the physical systems in the network. Wireless Sensor Network may contain hundreds or thousands of scalar sensor nodes capable of measuring physical phenomenon such as temperature, pressure, light intensity, and humidity. The sensor nodes communicate among them using radio signals in the network. After the deployment of sensor nodes in the monitored area, they are accountable for self-organizing an acceptable network infrastructure often with multi-hop communication with each other's.

A convergence of computation, communication, and control in the system is required with storage capabilities for dependable, safe, secure and efficient architecture which consists of Wireless Sensor Networks, Distributed, Control and Real-Time Embedded Systems in the physical environments. The defining characteristics of CPS are it provides wired and wireless networking at multiple and extreme scales, coupling new demands and applications and actuations with higher degrees of automation can be achieved with the dynamic reorganization and configuration of ubiquity drives providing unprecedented security and privacy needs. With the help of above characteristics a system of collaborating computational elements can be used for controlling physical entities. Cyber-Physical Systems can be found in vast areas as diverse as aerospace, automotive, chemical processes, civil infrastructure, energy, healthcare, and manufacturing, entertainment, and consumer appliances with concepts of robotics and sensor networks.

The communication protocols used in wireless sensor networks for real-time communication often are Time Division Multiple Access based approaches which offer a probabilistic differentiation. It mainly adapts the back-off mechanism of the Carrier Sense Multiple Access with Collision Avoidance (CA). The above said approaches are unsuitable for high data rate and real-time application due to highly variable communication latencies with random back-off mechanisms and excessive channel contention which leads to low throughput under heavy loads.

Hence there must be proper scheduling of data for processing and transmission. The term scheduling refers to allocations of certain resources in the system for query services and coordinating all processes to satisfy uncertain and long-term average demands. One of the most important examples is packet scheduling in wireless networks, where the scarce wireless spectrum has to be allocated across all links in the network, to satisfy each link’s traffic demand.

The significant communication challenges for systems with high data rate applications like handling of multiple traffic classes by the system which have different deadlines. For example, the sensors deployed in a chemical plant detect a hazardous chemical spill the sensors present should sense and collect the data and send to the base station notifying the authorized personnel about the incident to take immediate safety precautions. Such traffic scenarios must be assigned highest priority of service than the other normal scenarios for production of chemicals.Hence, there should be constructive prioritization among traffic classes during multiple query service along with meeting their deadlines. Second, the system must provide high rate of throughput whenever the sensor generates a heavy workload in the network as the sensors should deliver data to the sink node within their deadlines.

II. LITERATURE SURVEY

Some of the communication protocols that were proposed to support constant information gathering at high information rates over wireless sensor systems.

In Wireless Sensor Networks (WSN) for multimedia data transmission, storage processing and bandwidth limitations of sensor nodes pose challenging issue for communication through the network. A two hop network test bed was setup to analyze the possibility of sending short voice commands over resource constrained WSNs. The data packets are transmitted over lossy wireless channels to a sink node where the success of transmission is measured in terms of Mean Opinion Score (MOS) and Signal-to-Noise Ratio (SNR) as proposed in Mangharam et al., [2].
For Structural Health Monitoring (SHM) a WSN is planned, actualized, set up and tried on the 4200ft long primary compass and the south tower of the Golden Gate Bridge (GGB). SHM is an innovation that permits the estimation of the auxiliary state and discovery of basic change that influences the execution of a structure. Ambient basic vibrations are dependably measured effortlessly and without meddling with the operation of the bridge. Necessities that SHM forces on WSN are recognized and new answers for meet these prerequisites are proposed and executed in Kim et al., [3].

WSN and the sensor nodes are rising as detecting standards that the basic building field has started to consider as substitutes for conventional fastened checking frameworks. An advantage of wireless structure observation frameworks is that they are reasonable to introduce in light of the fact that lengthy wiring is no more needed in the middle of sensors and the information securing framework. Lynch et al., [4] is expected to serve as an outline audit of the aggregate experience the structural designing group has picked up from the utilization of WSN and sensor nodes for observing structure execution plans and status appearance.

The solid conveyance of latency-sensitive voice and motion video streams orders the utilization of transport systems with less packet loss, jitter, and delay. The presentation of corporate Wi-Fi systems and wireless customers presents a troublesome new variable in the transportation of latency-sensitive streams, one that must be appropriately overseen and controlled to give an agreeable client experience. W. Pattara-Atikom et al., [5] have quickly analyzed Wi-Fi QoS norms, and see the part these play in conveying end-to-end QoS which guarantee the solid conveyance of inactivity delicate voice and feature streams.

Wireless sensor network integrate a number of sensing devices for varied applications such as for imaging, sound and temperature. The packet flow in the network is determined by the type of applications and requirements of bandwidth jitter towards the sink node. Traffic control and handling should be taken care in the network from the sensor nodes as interference result in congestion and result in packet loss and excessive delays. Hence K.Kraneos et al.,[6] proposed COBRA a distributed framework with cluster based mechanisms to avoid congestion by incorporating rate control. It estimates the traffic load collectively over regular intervals of time and it allocates and adjusts data rate to sources on pre-cluster bases with this significant improvements in performance can be seen in Wireless sensor network.

An clear administration separation model, relative administration separation, to the area of wireless network which focuses at giving corresponding delay separation in wireless LAN is proposed by Barry et al., [7], because of the dispersed medium sharing, the scheduling calculation utilized in wire line systems can't be connected straightforwardly to the setting of the remote system. To begin with, it presents an administration separation model, relative administration separation, to the area of wireless LAN. In the relative administration separation display, the execution of an administration class is corresponding to another as indicated by the proportion of their separation parameters. Such prescient and reliable separation conduct can incredibly encourage class determination for applications and give adaptability to class provisioning and administration.

A stateless real-time correspondence convention for sensor systems, called SPEED is proposed by Stankovic et al., [8]. It is particularly customized to be a stateless, restricted algorithm with insignificant control overhead. End-to-end delicate continuous correspondence is accomplished by keeping up a sought conveyance speed over the sensor network through a novel blend of input control and non-deterministic geographic transmission. This is a profoundly effective and adaptable convention for sensor systems where the assets of every node are rare.

For probabilistic Quality of Service ensure in wireless sensor systems, a novel packet transmission system called Multi-Path and Multi-SPEED Routing Protocol (MMSPEED) was executed by E. Felemban et al., [9]. The Quality of Service provisioning is performed in two quality areas, specifically timeliness and dependability. Different Quality of Service levels are given in the timeliness area by ensuring various packet conveyance speed alternatives. In the unwavering quality area, different dependability prerequisites are upheld by probabilistic multipath sending. Along these lines, MMSPEED can promise end-to-end necessities in a confined manner, which is attractive for versatility and flexibility to huge scale dynamic sensor systems.

Dynamic Conflict Free Transmission Scheduling for Sensor Network Queries (DCQS), a transmission planning system for WSN questions by Chipara et al., [10] was proposed. Rather than conventional TDMA conventions intended to support general workloads, DCQS is particularly intended to utilize communication examples and transient properties of queries in WSNs. This permits DCQS to accomplish high throughput and low inertness.

WirelessHART is a protected and TDMA- based wireless cross section organizing innovation operating in the 2.4 GHz ISM radio band. The execution of the building design of WirelessHART model for the particulars, for example, the outline of the clock, network wide synchronization, communication security, solid node organizing, and the central system supervisor was done by J. Song et al., [11]. This architecture design was fabricated for the execution of convention stacks in WirelessHART.

The striking elements of a WirelessHART system incorporate a centralized system administration structural engineering, multi-channel TDMA transmission, redundant courses, and shirking of spatial reuse of channels for upgraded dependability and performance in real time. A. Saifullah et al., [12] proposed a few key commitments to ongoing transmission planning in WirelessHART systems. Initially the detailing of the end-to-end continuous transmission scheduling issue in view of the attributes of WirelessHART and an ideal branch-and-bound planning calculation in light of a vital condition for schedulability. Second a proficient and common heuristic-based planning calculation called Conflict-aware Least Laxity First (C-LLF).
SWAN, a stateless system model which uses appropriated control calculations to convey administration separation in wireless sensor impromptu systems in a straightforward, adaptable and powerful way. The architectural planning was proposed by G.-S. Ahn et al., [13] and is intended to handle both continuous UDP activity, and best exertion UDP and TCP movement without the requirement for the presentation and administration of per-flow state data in the system. SWAN supports per-hop and end-to-end control calculations that basically depend on the proficient operation of TCP/IP conventions. Specifically, SWAN utilizes nearby rate control for best-effort activity, and sender-based confirmation control for ongoing UDP movement. It is utilized to powerfully control conceded ongoing sessions even with system elements brought on by portability or activity over-burden conditions.

Sensor nodes in WSN work together with each other to accomplish a typical objective to give occasional updates to the base station. In automated applications the information must be transmitted and prepared progressively to empower such cooperation among sensor nodes. Consequently scheduling of information transmission among sensors is exceptionally expected to process the information continuously. Consequently Huan Li et al., [14] proposed two heuristics for planning message transmission with legitimacy and preparing requirements in multi-hop automated wireless sensor system called channel Reuse-based smallest latest start time First(CR-SLF) and per-hop smallest LST First (PH-SLF). Most recent begin time in multi-hop system is the time by which the i^{th} jump must begin transmitting the message with the goal it should reach the destination by its successful due date. The strategies proposed endeavours to schedule parallel per hop transmission in order to meet the end-to-end successful due dates.

Wireless communication innovation encourages the advancement of generally ease groups of autonomous versatile units that participate to accomplish a typical objective. Giving constant correspondence among the group units is exceptionally alluring for ensuring an anticipated conduct while working independently in unstructured situations. A MAC convention for remote communication that supports dynamic asset scheduling for little groups of agreeable robots is actualized by T. Faccchinetti et al., [15]. The convention utilizes an opened time-activated medium access transmission control that is collision-free, even in the vicinity of concealed nodes. The

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transmissions are planned by Earliest Deadline First scheduling arrangement. A sufficient affirmation control ensures the timing imperatives of the group communication prerequisites, including when new nodes progressively join or leave the group.

Energy proficiency is generally viewed as one of the significant difficulties for wireless sensor systems. The issue is ordinarily tended to from the perspective of a particular convention layer or usefulness, for example, medium access control (MAC) or routing. S. Zhou et al., [16] examined the energy protection in wireless sensor networks and treated it with a comprehensive approach and inspected over all convention layers and functionalities including MAC, topology administration, routing and sensor conventions. In the MAC layer, the duty cycle control based conventions are more suitable for low information passive applications, for example, ecological observing. Correspondingly, arbitrary access conventions perform better when processing burdens are low in the systems. Hybrid conventions can be tailed for both low information rate and high information rate applications.

Real-time data flows between sensor and actuators must be analyzes in WirelessHART network for adjustments of devices and components present in the network. For this analysis A.Saifullah et al., [17] mapped the scheduling of real time data flows to the real-time multiprocessor scheduling. Based on this the schedulability of feedback control loops in WirelessHART network is analyzed under various fixed priority scheduling policies.

Convergecast is defined as a network for collecting data from multiple sources to a single sink. Thus an efficient scheduling strategy is needed for high data rate collection for convergecast application in industries. Hence H.Zhang et al., [18] proposed a novel technique that combines Time Division Multiple Access (TDMA) based multi-channel communication, channel hopping and packet transfer, which presents a time optimal solution for convergecast. This scheme is memory-efficient as each node buffers a packet in any time slot.

Wireless sensor network extracts data from the sensors periodically and data aggregation is used to collect it at the base station. As wireless sensor network are energy constrained networks, energy consumption at sensor node is a critical issue. Energy is consumed over idle or unwanted data collection at sensor nodes. Hence Madden et al., [19] proposed Tiny Aggregation service for data aggregation over sensor nodes is low power, distributed, wireless environments. It allows users to efficiently distribute and execute queries in a low power wireless sensor network.

The existing link and network protocols for wireless sensor network have different assumption about network stack composition and have limited network interoperability. But a unified abstraction of these stacks would make the link level closer than the network level. Hence J. Polastre et al., [20] implemented this principle and proposed a unifying sensor net protocol which provides shared neighbour management and a message pool. This protocol provides a greater efficiency by supporting link layer technologies over a wide range of network protocols.

In remote sensor system, presumption of impedance between two neighbouring nodes communication extent are done by numerous conventions. This impedance brings about impact of loss of packets. Consequently G.Zhou et al.,[21] proposed a convention called radio obstruction identification to distinguish run-time radio impedance connection among nodes which is outlined by utilizing TDMA conventions with this convention there is an increment in throughput and packet convey proportion in the framework generously.

Synchronization among sensor nodes for wireless sensor system application is obliged to give information consistency and co-appointment during inquiry administrations. Numerous conventions give synchronization however different calculates remote sensor system like energy protection, throughput provide poor execution. Hence forth Mikolas et al., [22] proposed a Flooding Time Synchronization Protocol (FTSP) gives strength by intermittent flooding of synchronization messages and element topology redesign. The convention uses a solitary show message to build up synchronization focuses between the sender and collector. It has negligible overhead than other synchronization conventions; henceforth the execution of the convention gives higher effectiveness and throughput.

Numerous transmission scheduling processes have been proposed to expand the spatial reuse and minimize the TDMA outline length in multi-hop packet radio systems. Every current algorithm accepts exact system topology data and don't adjust to diverse movement prerequisites. J.-H. Ju et al., [23] proposes a calculation which is ideal and it augments the base throughput contrasted with TDMA. It gives better execution as far as least throughput and least and most extreme delay times.
Ubiquitous computing with sensor nodes and actuators are connected over a wireless sensor node with cost constraints and the characteristic of dynamically changing topology of the network, the base station doesn't support a wired backbone. Hence a suitable network architecture with a medium access protocol based on Earliest Deadline First (EDF) is proposed by Marco Caccamo et al.,[24] cellular network architecture is adopted as it provides guaranteed bounded delay of messages as it uses the available bandwidth . It also uses implicit prioritization technique to prevent packet loss in the network. It provides lower latency and higher system throughput even under heavy load conditions.

WSN have restricted versatility and energy assets. It utilizes TDMA conventions for slot task yet crashes happen when two clashing nodes transmit in the system. This can be unravelled by allotting distinctive time slots to any two clashing nodes. Subsequently I. Rhee et al.,[25] proposed DRAND (disseminated randomized TDMA planning) for WSN. It gives a dispersed, strong and a unified TDMA planning calculation. It can deal with topology changes by performing confined operations. It gives a productive space assignment which brings about better channel use while expending less system assets and energy.

2.1 Motivation

There is seen a steady development of CPS that must support real time information accumulation at high information rates over WSNs. They utilize Real-time communication conventions which receive dispute based or Time Division Multiple Access (TDMA) based methodologies. Conflict based conventions support ongoing communication through probabilistic separation. This is generally accomplished by adjusting the discord window and/or the beginning back off of the Carrier Sense Multiple Access with Collision Avoidance (CA) instrument. Rate and confirmation control may be utilized with discord based conventions to handle clogging. These frameworks additionally utilize query administrations to occasionally gather information from sensors to a base station over multi-hop WSN.

The methodologies of TDMA and conflict based conventions are inadmissible for high information rate and continuous real time application on the grounds that they give profoundly variable communication latencies because of their arbitrary back-off instruments and accomplish low throughput under huge load because of unnecessary channel discord.
Hence there must be proper scheduling of data for processing and transmission. The term scheduling refers to applications where certain resources in the system are allocated by coordinating all users to satisfy uncertain and long-term average demands. One important example is packet scheduling in wireless networks, where the scarce wireless spectrum has to be allocated across all links in the network, to satisfy each link's traffic demand.

Frameworks with high information rate applications pose huge communication challenges. First and foremost, the framework must handle different traffic classes with distinctive due deadline dates. In case, amid a tremor, accelerated information from sensors sent on a building must be conveyed to the base station in a timely way to identify any structural harm. Such movement ought to have higher need than temperature information gathered for atmosphere control. Consequently, a WSN convention ought to give viable prioritization between traffic classes while meeting their individual due deadlines. Second, the framework must support high throughput in light of the fact that sensors may produce a high workload. For instance, structural observing requires various accelerometers to be inspected at high rates creating high system loads. Moreover, on the grounds that the framework must convey information to base stations inside of their due deadlines, it is essential for the framework to accomplish predictable and limited end-to-end latencies.

From the study of the past work said we are motivated to propose a Query Scheduling for secure collision less transmission in real-time WSN (QSRT), a transmission scheduling methodology for constant inquiries in WSNs. The proposed algorithm incorporates three ongoing query schedulers that endeavor the special attributes of WSN queries including numerous to-one communication and occasional inspecting. We give upper limits on the reaction times of continuous questions for every scheduler. A unique aspect of our methodology is that it bridges the barrier between WSN and schedulability investigation procedures, which have generally been connected to continuous processor scheduling.

III. METHODOLOGY

From related work, henceforth a Query Scheduler for secure collision less transmission for real-time WSN (QSRT) is proposed. A coordinated structure for transmission scheduling is concocted to suit the communication needs of high information rate applications. An information gathering application may express its accumulation intrigues as inquiries over subsets of nodes which may include information accumulation or data collection. Examples of these inquiries are executed intermittently to gather information at the base station. The utilization of routing trees in executing query occurrences presents priority requirements among packet transmissions.

At the point when information accumulation is utilized, a node must wait for its children information reports before registering an amassed information report and transferring it to its parent. Naturally, incorporating application layer data and routing layer data into the transmission scheduling procedure may prompt remarkable performance upgrades.

In this section the query services for which Query Scheduler for collision free transmission is designed and describe the network model. The entire project is divided into five modules. Each module concentrates on the part it is assigned and finally all the modules are integrated into one and the experimentation is conducted for expected results and analysis. The modules of the proposed algorithm are described as follows:

Topology Design: In the topology design the nodes n are deployed randomly in the networks. Different topologies are present but we prefer to place the nodes in a network at strategic locations, this can be done in a flat grid topology which is suitable for our purposes. The node which is in the centre of the network is chosen as the base station. The nodes around the base station are child nodes. In this module itself the communication and configuration parameters for each and every node is assigned. The parameters assigned to the node are propagation type, link states, type of links, buffer space , queue length , channel type to define whether wired or wireless, initial energy in joules, transmission power etc. And the communication range of the node is set to 250m.

Plan Request: In the plan request module, the base station initiates the PLAN REQUEST by flooding process and gets the PLAN FEEDBACK message from all the child nodes. With the help of the feedback message the base station perform the scheduling process and send the schedule plan to all nodes with PLAN SEND message and all the child nodes reply with the PLAN COMMIT message to the base station to acknowledge the scheduling process.

Plan scheduling: In the Plan schedule module, the scheduling process is done with the help of PLAN FEEDBACK message and Reversed plan is performed in the base station after that Actual plan is telecast to all the nodes in the network using PLAN SEND message.

Query Scheduling: In the Query scheduling module, the base station queries the sensor nodes and the sensor nodes send back the response to the base station with adjustable data rate in their scheduled time. When an end user issues a query to a sensor network through the base station, the description of the query issued is advertised to all the nodes present in the sensor network.

All the parameters of the queries issued from the base station are incorporated in the portrayal of the inquiry. As the query is promoted everywhere throughout the system, a routing tree is built which is established at the base station to empower information or data accumulation. At the point when a query occasion is executed, it brings about data or information aggregation in the sensor network. The non-leaf nodes in the system wait for the information reports from its children nodes and afterward create another information report by amassing its information with the children information reports and after that transmits it to its parent, which is done occasionally in the system. There are three scheduling methods to be specific:

- **Non pre-emptive Query Scheduler**: When a query is in the CPU under processing, it is permitted to finish processing with no intrusion regardless of the fact that an inquiry of higher priority arrives in the meanwhile. A different queue is kept up for every priority class. At the point when the processor turns out to be free, the first query of highest priority in the line enters the processor. It has diminished turnaround time and does not oblige unique equipment but rather the decision of scheduling algorithm is restricted. It supports high limit, however because of priority reversals the high-priority inquiries are not furnished with low reaction times.
- **Pre-emptive Query Scheduler:** Pre-emptive Query Scheduler: The noticeable element of non pre-emptive query scheduling is that the normal delay of a priority class relies on upon the arrival rate of lower priority classes. Because of this a high-priority query must wait for a lower-priority query in the processor. This reliance does not show up in the pre-emptive query scheduler. In this, the service of a query is interrupted when a higher-priority query arrives and it is resumed from the point of interruption once all queries of high-priority have been served. With reduced capacity in the system, the problem of priority inversions is completely eradicated.
- **Slack Stealing Query Scheduler (SQS):** This scheduler coordinates the upsides of the pre-emptive and non pre-emptive schedulers to fulfil the query deadline with expanded limit. SQS is set up on the examination that seizure brings down limit, and subsequently, it ought to be utilized just when important for meeting deadlines. We characterize the slack of an inquiry to be the most extreme number of openings that a case of a query permits a lower need occasion to execute before appropriating it. SQS has two parts, an affirmation calculation and a booking calculation. The confirmation calculation keeps running on the base station to focus the slack and schedulability of every inquiry when it is issued. The planning calculation executes conceded queries taking into account their slacks.

Performance analysis: In this module, we analyze the performance of the proposed system with throughput, energy consumption, delivery ratio and packet drops with basis of time in the network with the existing scheduling techniques.

IV. IMPLEMENTATION

We are motivated to propose a Query Scheduler for secure collision less transmission for WSN, to satisfy the needs of high data rate applications generating queries in real-time.

4.1System Requirements

To be used efficiently, all computer software needs certain hardware components or other software resources to be present on a computer. These prerequisites are known as system requirements and are often used as a guideline as opposed to an absolute rule. This includes the system level and functional requirements for the design and implementation of the algorithm:

- Pentium processor with dual core or higher architecture(core-2 duo, i3 etc)
- 2GB of RAM with 40GB available Hard disk space
- Inbuilt or an external graphics card.
- Operating system: LINUX, Ubuntu, Red Hat, Fedora, Windows (VMWARE or Cygwin). Most compatible is Ubuntu 13.04 edition.
- Software : Network Simulation Ver.2.35
- Pre-installed with Tool Command Language, AWK, C++ and necessary compilers for C/C++ executions and appropriate scripting compilers for compilation.

4.2 Data Flow Diagram

A Data Flow Diagram (DFD) is a graphical representation of the "flow" of data through an information system, modeling its process aspects. A DFD shows what kind of information will be input to and output from the system, where the data will come from and go to, and where the data will be stored. The data flow diagram shown in Fig. 1 consists of the five modules which are:

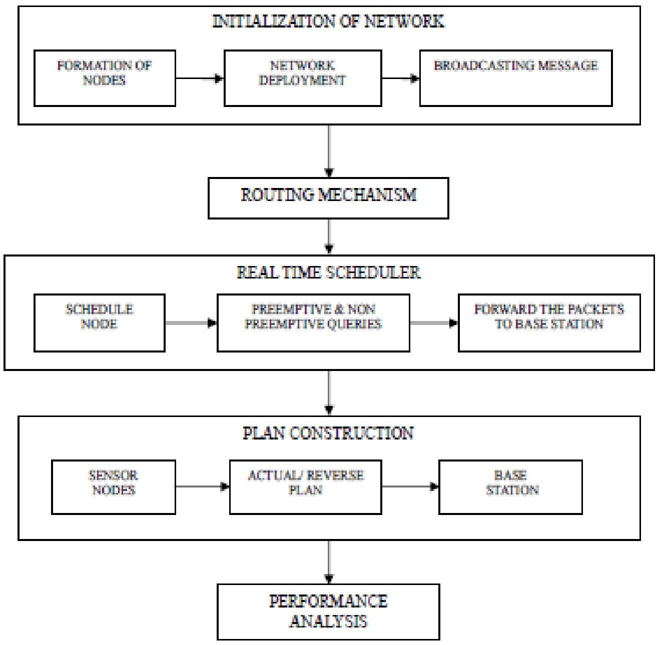

Figure 1. Data flow diagram for Least Latency Routing in WSN

Topology Design: In this module the deployment and positioning of the nodes takes place and respective configuration parameters are assigned to each and every node in the network. The node which is in the centre of the network is chosen as the base station. In this module the following steps take place:

- Sensor nodes are deployed into the network and placed in their positions
- The nodes broadcast control messages to find the neighbor nodes.
- With this even the local information of all the nodes present in the network are collected it may be link status of the node, type of links, residual energy etc.
- Packets are broadcast across the network for the nodes about the information collected and finally to the sink node.

Routing Mechanism: in this module the base station determines topology information of network and the routes in the network to the child nodes with help of broadcasting Route Request message (RREQ) and Route Reply message (RREP). Along with RREQ message the PLAN message is also sent for plan request from the base station to the child nodes. In this module the following steps take place:

- The base station broadcasts the RREQ message to all the nodes in the network and also obtains the necessary topology information.
- It obtains the routes to the nodes present in the network by broadcasting RREP message to the nodes.
- PLAN message is also broadcast in the network to obtain commit messages from the child nodes to acknowledge the process.

Real Time Scheduler: In this module the query scheduling of packets sent to the base station is done in real time. The base station queries the sensor nodes and the sensor nodes send back the response to the base station with adjustable data rate in their scheduled time. In this module the following steps take place:

- The scheduler node schedules the packets with the Slack Stealing Query Scheduler.
- The scheduling process from the node sending the data is sent to the sink node or the base station.

Plan Construction: in this module the scheduling process is done with the help of PLAN FEEDBACK message and Reversed plan is performed in the base station after that Actual plan is broadcast to all the nodes in the network using PLAN SEND message. In this module the following steps take place:

- The Reverse plan is determined by the base station with the help of PLAN FEEDBACK message from the child nodes.
- The sensor nodes receive Actual plan from the base station through PLAN SEND message.

Performance Analysis: In this module, we analyze the performance of the proposed system with throughput, energy consumption, delivery ratio and packet drops with basis of time in the network with the existing scheduling techniques.

V. SIMULATION RESULTS

The realization of the technical specifications or algorithm specified for the proposed methodology as a program and deployment was extensively carried out in Network Simulator version 2.35.

For execution the users use the ns command along with the file name holding the simulation parameters known as Tcl Scripting file which is an input argument. The creation of simulation trace file is done by the programming languages mentioned and after compiling and execution of the same, graphical plots of the results generated during simulation is displayed. The configuration parameters for the simulations are defined in Table1.

Parameter	Values
Number of nodes	20
Network Area	1500m * 1500m
Interface Queue	CMUPriQueue
Interface Queue length	500 packets
Antenna	Omni- Antenna
Initial Energy	100 Joules
Traffic Type	CBR
Transmission Rate	256 bps

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The node closest to the center of the topology is selected as the base station. The base station initiates the construction of the routing tree by flooding setup requests. A node may receive multiple setup requests from different nodes. The node selects as its parent the node that has the best link quality indicator among those with smaller depth than itself. In simulations, all queries are executed according to the same plan as every node sends its data report in a slot.

For comparison we consider the baseline as DRAND [22]. 802.11e is a representative contention-based protocol that supports prioritization in wireless networks. DRAND is a recently proposed TDMA protocol, which is a query scheduling algorithm that constructs TDMA schedules to execute queries. However DRAND support prioritization or real-time transmission scheduling.

We use response time to compare the performance of the protocols. The response time of a query instance is the time between its release time and completion time, i.e., when the base station receives the last data report for that instance. During the simulations, data reports may be dropped preventing some sources from contributing to the query result.

The following parameters are calculated and the performance of the proposed QSRT system is evaluated graphically with the previous work mentioned above. First with respect to Packet drops as it occurs when one or more packets of data travelling across the network fail to reach their destination. Packet Delivery Ratio it is the number of packets that are delivered to the destination in the network. Response Time is the average time taken by the algorithm to process the packets to the destination node from the source node. Throughput it is the rate of successful delivery of the packets in the network to the destination node from the source node. The amount of energy consumed by the nodes present in the network by the algorithm for the processing and delivery of packets in the network for determining energy consumption of the using the algorithms.

After the simulation of the proposed algorithm we obtain graphical representations of the algorithm with the baseline DRAND algorithm for the parameters defined. The figure 8.12 shows the graphical comparison of throughput between the proposed SQRT and DRAND systems. From the graph, we can concur that the throughput in QSRT is greater than DRAND systems. The throughput linearly increases in the proposed system. It is measured as the number of kilobits data transferred per second.

After the simulation of the QSRT algorithm we obtain graphical representations of the algorithm with the baseline DRAND algorithm for the parameters defined. The figure 2 shows the graphical comparison of throughput between the proposed QSRT and DRAND systems. From the graph, we can concur that the throughput in QSRT is greater than DRAND systems. The throughput linearly increases in QSRT. It is measured as the number of kilobits data transferred per second.

In Figure 3, the graphical representation of the Slack Stealing Query scheduling response times with respect to deadlines. These values for the response time are obtained by an iterative process and then mean values of the process is recorded and the graph is plotted. In figure 4, the graphical comparison of Packet Delivery Ratio is computed. The proposed system provides higher efficiency in the transfer of packets than the existing DRAND system.

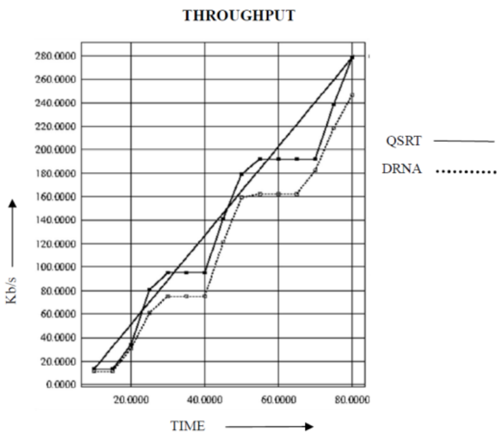

Figure 2. Graphical representation of Throughput

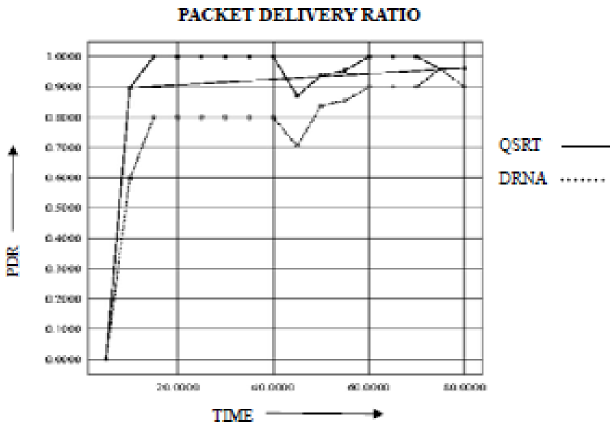

Figure 4. Graphical representation of PDR

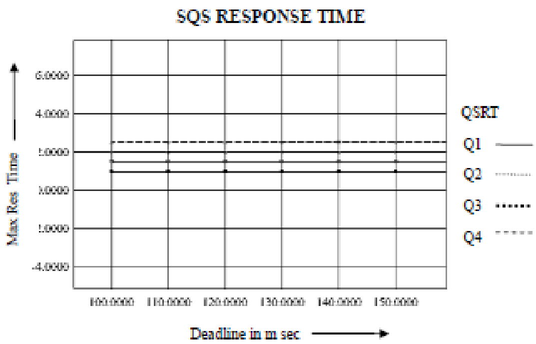

Figure 3. Graphical representation of SQS response time with respect to deadlines

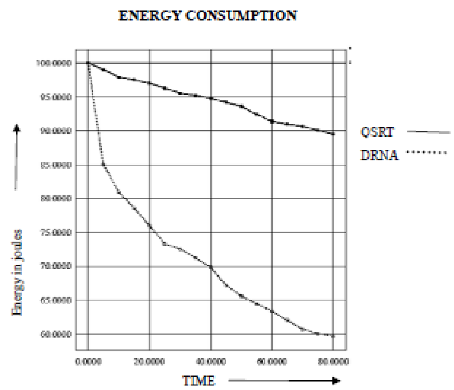

Figure 5.Graphical representation of Energy Consumption

The graph in figure 5 represents the energy consumption comparison of the proposed QSRT and existing DRAND system. The graph is a system of time in seconds with respect to energy in joules. From the graph, we concur that energy of the sensor nodes in the network is conserved by using the proposed SQRT scheduling strategy rather than the existing system DRAND during data transmission.

VI. CONCLUSIONS AND FUTURE WORK

Real-time information gathering at high speed rates of information for WSN with need for scheduling of query services in the network is reliably needed for cyber physical system applications. Present real-time communication protocols are built upon contention based MAC Protocols, it achieves expected communication patterns and provide higher throughput with heavy load. Hence to have conflict free data transmission in Wireless Sensor Network scheduling in real-time is required. The discussed algorithms and protocols proposed by research scholars discussed in Chapter II can be implemented practically but there are some restrictions.

A method that gives a schedulability investigation to every scheduler that empowers predictable ongoing inquiry benefits through online confirmation and rate control prompting high throughput and effectiveness in high information rate applications while meeting query deadlines. Henceforth a significant and coordinated Query Scheduling for collision-less information transmission in situations is needed as an effective methodology for servicing queries in a WSN.

A unique part of this methodology is that it conquers any hindrance between WSN and schedulability investigation methods, which have generally been connected to real-time processor scheduling. We show the advantages of the proposed algorithm over existing dispute based and TDMA-based conventions as far as constant execution through simulations.

It not only just provides preferable execution over conventional transmission scheduling methods intended for general workloads and systems, however it can adjust its transmission plan in light of the expansion/evacuation of queries and changes in inquiry rates without needing to re-register its transmission schedule alongside dynamically decides the transmissions to be executed in every slot and, subsequently, it may adjust to workload changes more adequately than customary TDMA conventions with fixed transmissions plans. It has low runtime overhead and restricted memory necessities making it suitable for asset constrained devices.

The proposed algorithm is enhanced with RSA Security protocols providing security to the data transmissions as they are in real-time. Hence sensitive data transmissions can be secured as malicious nodes may be present on the forwarding paths to the sink node or centralized base station. With this enhancement also the efficiency of the network does not degrade and achieves significant performance improvements.

As this proposed algorithm schedules queries for collision-less transmission with secure information transmissions, several avenues for future can be implemented with respect to reduce consumption of energy by incorporating the security algorithms in the MAC layer itself as it reduces memory allocations in the sensor node. Further for reducing energy consumption, sleep-wake mechanisms in the nodes can be implemented along with this algorithm for increasing the efficiency of energy utilization in the sensor network.

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