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Communication and Interference Aware Query Scheduling in a Wireless Sensor Networks

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Abstract— ***Wireless sensor network systems that must support high data rate and real time queries of physical environments. For distributed real-time systems, we face the critical challenge of meeting the end-to-end deadlines of real-time flows. This paper proposes Real-Time Query Scheduling (RTQS), a novel approach to conflict-free transmission scheduling for real-time queries in wireless sensor networks. First, we show that there is an inherent trade-off between prioritization and throughput in conflict-free query scheduling. We then present three new real-time scheduling algorithms. The non-preemptive query scheduling algorithm achieves high throughput while introducing priority inversions. The preemptive query scheduling algorithm eliminates priority inversion at the cost of reduced throughput. The slack stealing query scheduling algorithm combines the benefits of preemptive and non-preemptive scheduling by improving the throughput while meeting query deadlines. Furthermore, we provide schedulability analysis for each scheduling algorithm. and advantages of our scheduling algorithms are validated using ns2. That analysis is called slack stealing. Here we introduce additionally RFS that can reduce the flow latency.***

Keywords— ***Query scheduling, Schedulability analysis, Energy efficiency,RFS.***

I. INTRODUCTION

A Wireless Sensor Network (WSN) consists of spatially distributed are deployed to monitor the sensing field and gather information from physical or environmental condition, such as temperature, sound, vibration, pressure, motion or pollutants and to co-operatively pass their data through the network to a main location. Traditionally, two approaches can be adopted to accomplish the data collection task: Direct communication, and Multi-hop forwarding. In the sensor nodes upload data directly to the sink through one-hop wireless communication, which may result in long communication distances and degrade the energy efficiency of sensor nodes. On the other hand, with multi-hop forwarding, data are reported to the sink through multiple relays, and the communication distance is reduced. However, since nodes near the sink generally have a much heavier forwarding load, their energy may be depleted very fast, which degrades the network performance.

The applications of WSNs can be found in diverse areas such as military (e.g., battle field surveillance), environmental protection (e.g., habitat monitoring), healthcare (e.g., telemonitoring of human physiological data), and home automation. Sensor nodes in a WSN constitute a wireless ad-hoc network, with one or a few sink nodes as the collection point(s) and bridge(s) to the base station(s). Every node in the network may create data periodically, on demand of base stations, or triggered by events. At the same time, every node may forward data that it receives toward sink nodes, which are often multiple hops away. Sensing units are usually composed of two subunits: sensors and analog to digital converters (ADCs).

Scheduling takes place in a base station or between the nodes. Basic notations are task, resources, scheduling events. Scheduler ensures the processes to meet deadline. Scheduled task can be distributed to devices and managed at backend. The system must handle various types of traffic with different deadlines which should provide effective prioritization. And the system must support high throughput. The system has to achieve predictable, end to end boundaries.

RFS is optimized for scheduling flows by taking an advantage of their temporal properties and precedence constraints. Temporal properties carries the workload changes. Precedence constraint corresponds multihop forwarding between source and destination.

II. EXISTING WORK

Real-time communication protocols are categorized into contention-based and TDMA-based protocols.

A: Protocols used for real time communication

Contention-based protocols to handle overload conditions. However, contention-based approaches have two inherent drawbacks that make them unsuitable for high data rate and real-time applications. Since their packet latencies are highly variable and maximum throughput is low.

TDMA protocols can provide predictable packet latencies and achieve higher throughput than contention-based protocols under heavy load. The protocol supports multi-hop communication and does not provide prioritization.

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III. MODELLING

We characterize the query services using query and network modelling.

A. query

RTQS assumes a common query model in which source nodes produce data reports periodically. This model fits many applications that gather data from the environment. A new query instance is released in the beginning of each period to gather data from the WSN. The priority of instances depends on the priority of its query. If two instances have the same query priority, the instance with the earliest release time has higher priority.

A query service works as follows: a user issues a query to a sensor network through a base station, which disseminates the query parameters to all nodes. The query service maintains a routing tree rooted at the base station. The query service supports in-network data aggregation. Accordingly, each non-leaf node waits to receive the data reports from its children, produces a new data report by aggregating its data with the children's data reports, and then sends it to its parent. During the lifetime of the application the user may issue new queries, delete queries, or change the period or priority of existing queries. RTQS is designed to support such workload dynamics efficiently

B. Network

RTQS models a WSN as an Interference- Communication (IC) graph. The IC graph, IC(E,V), has all nodes as vertices and has two types of directed edges: communication and interference edges. Communication indicates packet transmission, interference indicates transmission of interferences. These two transmissions can be scheduled concurrently. IC graph is used to compute and store in a distributed fashion: a node needs to know only its incoming/outgoing communication and interference edges.

C. Flow

Flow established between source and destination. Packets are transmitted periodically with start time, deadline, period. A static priority is associated with each flow and used to provide differentiated service. We do not require the programmer to specify all flows when the system is started. The workload may be changed by adding new flows, removing existing flows, or changing the priority and the temporal properties of existing flows. RFS is designed to handle these operations efficiently.

REAL TIME QUERY SCHEDULING

Real time query scheduling achieves predictable and differentiated query latencies through prioritized conflict-free transmission scheduling. It has two components: planner and a scheduler. The planner constructs a plan for executing all the instances of a query. The scheduler that runs on every node determines the time slot in which each step in a plan is executed which is used to improve the throughput.

Planner is classified as centralized and distributed planner. When the query involves aggregation, the plan must respect the constraints introduced by aggregation in a centralized planner. A distributed planner uses only neighbourhood information. A node knows only its adjacent communication and interference edges

A plan in three stages: plan formulation, plan dissemination, and plan reversal. The formulation stage starts when a node n becomes the highest priority eligible node in its one-hop neighbourhood. Node n disseminates its local plan to its one-hop neighbours via a Plan Send. If neighbour is lost, n assumes that a higher priority node has not yet been scheduled and retransmits the Plan Request until it has received Plan Feedback from each neighbour or reached the maximum number of retransmissions.

RTQS works as follows: (1) When a query is submitted, RTQS identifies a plan for its execution. Multiple queries be executed using the same plan. Therefore, RTQS may reuse a previously constructed plan for the new query. When no plan may be reused, the planner constructs a new one. (2) RTQS determines if a query meets its deadline using our schedulability analysis. The schedulability analysis is performed on the base station. If the query is schedulable, the parameters of the query are disseminated; otherwise, the query is rejected.(3) At run-time the scheduler running on each node executes all admitted queries in a localized fashion.

It has three scheduling algorithms which are preemptive, non-preemptive, slack stealing. Each scheduling algorithm achieves a different tradeoff between query prioritization and throughput. The Non-preemptive Query Scheduling (NQS) algorithm achieves high throughput at the cost of priority inversion, while the Preemptive Query Scheduling (PQS) algorithm eliminates priority inversion at the cost of lower throughput. The Slack-stealing Query Scheduling (SQS) algorithm combines the benefits of NQS and PQS by improving the throughput while meeting all deadlines.

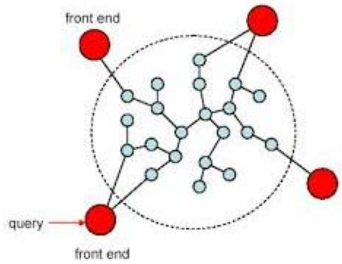

Fig 1.query service in a sensor network

1) Pre-emptive query scheduling:

NQS maintains two queues: a run queue and a release queue. The release queue is a priority queue containing all instances that have been released but are not being executed. The run queue is a FIFO queue. A drawback of NQS is that it introduces priority inversions.

2) Non pre-emptive query scheduling:

The query throughput is lower because it allows less overlap in the execution of instances. This exemplifies the trade-off between prioritization and throughput in query scheduling.

3) *Slack stealing query scheduling:*

SQS combines the benefits of NQS and PQS in that it improves query throughput while meeting all deadlines. The design of SQS is based on the observation that preemption lowers throughput, and hence it should be used only when necessary for meeting deadlines. This algorithm runs on the base station and determines the slack and schedulability of each query when it is issued. It has TDMA protocol to schedule the queries. So that it support prioritization and real time transmission scheduling.

We use response time and data fidelity 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 maybe dropped preventing some sources from contributing to the query result. The data fidelity of a query instance is the ratio of the number of sources that contributed to the aggregated data reports received by the base station and the total number of sources.

ENERGY EFFICIENCY IN RTQS:

The emergence of high data rate sensor network applications has resulted in an increasing demand for high-performance query service. The key challenge was to provide a high throughput query service that can collect data from large networks and adapt to workload changes. A data collection application may express its collection interests as queries over subset of nodes, which may involve data aggregation. These queries have to be executed periodically to collect data at the base station. Sensor nodes consists of one or more microcontrollers, CPUs or DSP chips, a memory and a RF transceiver, a power source such as batteries and accommodates various sensors and actuators. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and bandwidth.

The constraints of energies are follows. Energy consumption occurs in three aspects: sensing, communication, and data processing. Algorithmic modifications can often result in significant energy savings. And key features of energy efficiency are to maximize the life time of nodes, self-configuration and robustness of node/network.

IV. SIMULATIONS

Energy conservation of real time query scheduling methods are follows:

1.When a new query is submitted by the user, it identifies a plan for its execution. Normally many queries can be executed using the same plan. If no plan is reused then the planner constructs a new plan for executing the query.

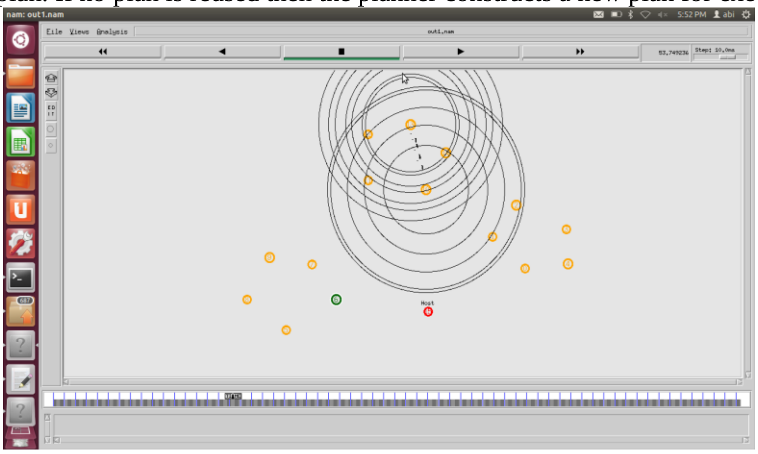

Fig.2 Scheduling in-between a network and base station

2. The base station performs rate control to ensure that the total query rate remain within the maximum query rate under RTQS. If not the query rate is decreased proportionally, not to exceed the maximum query rate.
3. The phase, period and the aggregation function of the query are disseminated to all nodes.
4. At runtime, the scheduler executes all query instances

Response time is directly proportional to data fidelity in an energy model of real time query scheduling. Query processing involves through put, bandwidth, overhead, query latency and efficiency.

HEALTH MONITORING OF CIVIL INFRASTRUCTURE

It uses a single purpose processor and application based system. Monitoring the structure of bridge and detecting the structural damage through wireless that leads to low cost installation and equipment. Factors of health monitoring is Time scale of state change(how quickly it changes from each state),Severity of state change(response of changed state)

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Functionalities of several nodes are continuous health monitoring and alarm warning. The detection of structural damage will be direct(visual and x-ray) or indirect(system behaviour). Nodes gets charge by collecting ambient vibrations synchronously at 1 kHz. Its applicable for large scale system resources. And heavy traffic increases noise level so that link estimator gets confused. In a heavy traffic the routing layer can be broken and routing tree frozen in that collision.

DYNAMIC CONFLICT FREE QUERY SCHEDULING

Application for high data rate network there is a demand for high performance. TDMA protocols are designed for general purpose network. DCQS is designed for query services that should support data aggregation. First it optimizes query performance and energy efficiency. Then it adapt to dynamic workload. It must analyse in terms of query completion. It is efficient for query latency and throughput, energy efficiency. DCQS integrated with Tiny DB and allows submitting their queries periodically and collecting data from number of sources in a network. Protocol consists of planner and scheduler which has to plan for its execution and schedule their process. Planner reduces their query latency. And scheduler improve throughput by overlapping transmissions. Scheduler maintains queue for their queries. It provides different scalability for single and multiple queries.

END TO END DELAY ANALYSIS FOR FIXED PRIORITY SCHEDULING

Real time communication between sensors and actuators in a network is applicable for measuring a delay between two endpoints. Here scheduling is based on fixed priority scheduling algorithm. Hart is responsible for highway addressable remote transducer. And Hart is designed for monitoring and control application s. for each periodic flow the delay can be analysed between two ends. Wireless Hart is used for interoperation.

SCHEDULING THE MESSAGES WITH DIFFERENT DEADLINE

Group of sensors equipped with robots. Sensors on robots produce periodic updates that must be transmitted to other robots and processed in a real time. Robots communicate one to another via ad-hoc wireless network. It provides multi-hop message transmission. Clustering of robotic actions to be carried using following technique.

DATA VALIDITY: define the time interval for each data value produced by a sensor is valid.

SENSOR PERIOD: sensor produce data periodically is known as sensor period.

The leader takes out the current position of followers, overall goal and important of sensor readings have to reported. It follows CSMA/CA.

FLOODING TIME SYNCHRONIZATION PROTOCOL

FTSP uses low communication bandwidth and robust against node and link failure. This protocol achieves precision performance and enabling the data consistency. In a complex network FTSP involves monitoring the applications, node management, and military applications.

Time synchronization protocol consist of reference broadcast synchronization. In RBS messages are broadcasted. And timing sync protocol for sensor networks. In TPSN node gets synchronized by exchanging synchronization messages. It provides two times better performance than RBS. FTSP depends on send, access, transmission, receive, reception, propagation, interrupt handling time.

V. CONCLUSIONS

High data rate real-time queries are important to many sensor network applications. This paper proposes RTQS, a novel transmission scheduling approach designed real-time queries in WSNs. We observe that there exists a tradeoff between throughput and prioritization under conflict-free query scheduling. We then present the design and schedulability analysis of three new real-time scheduling algorithms for prioritized transmission scheduling. NQS achieves high throughput at the cost of priority inversion, while PQS eliminates priority inversion at the cost of query throughput. SQS combines the advantages of NQS and PQS to achieve high query throughput while meeting query deadlines. NS2 simulations results demonstrate that both NQS and PQS achieve significantly better real-time performance than representative contention-based and TDMA protocols. SQS can maintain desirable real-time performance by adapting to deadlines.

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