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A Survey on Query Response Time Optimization Approaches for Reliable Data Communication in Wireless Sensor Network

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ABSTRACT

Wireless sensor network is an application specific network. There are various factors which affects reliability in Wireless Sensor Network some of them are energy consumption, high packet loss, congestion, and large response time. There are different parameters, which affects query response time. Whenever Sink [Base Station] needs data, it sends query to source node and node response back to sink. In Wireless Sensor Networks (WSNs) query response time depends on number of parameters like data caching, routing algorithm, node deployment, topology, data availability, query aggregation, query processing, packet loss and congestion. This paper presents a survey of various approaches which help us to minimize query response time mainly for wireless sensor networks.

Keywords: Cooperative Caching, Node Placement, Query Aggregation, Query Processing.

1. INTRODUCTION

Wireless Sensor Network is an infrastructure comprised of sensing (measuring), computing, and communication elements that gives an administrator the ability to instrument, observe, and react to events and phenomena in a specified environment. It is very difficult task to make sensor network communication reliable because of its requirement parameters. Wireless Sensor Network (WSN) applications are health care, traffic control, environmental application, fire detection and military application. Sensor network consists of thousand or more number of nodes.

Query response time is a time between transmissions of query to first response from node including query processing time.

Query Response Time = Processing Time + Propagation Time + Transmission Time

Transmission time is greater than processing time. Processing time is negligible compared with transmission time and no queuing time. Generally there are two types of nodes used in wireless sensor network 1. Sink 2. Sensor nodes. Sensor node plays very important role in wireless sensor network. Sensor nodes sense environment and give query result back to sink. Sensor nodes are central heart of wireless sensor network .Sink stores data which is sense by sensor node. There may be one or more sink available to store data again it depends on application. If number of sink available it makes data communication reliable but cost increases accordingly. Cost of sensor network depends on resource requirement. Now a day's research main goals are increase lifetime of network and reduce query response time.

The resource constraints of wireless sensor network are packet loss, energy consumption, congestion, query response time. In military application it is very necessary to get response quickly otherwise we can say system is not friendly. Each author has different aspect to reduce query response time. Caching means store data at cache node .When sink send query deep in network it takes time to get query result back.

2. REASONS OF INCREASING QUERY RESPONSE TIME

1. Packet loss because of congestion.
2. Very less number of nodes available at data cached location.
3. No alternative path available.
4. If query processing takes more time to process.
5. High transmission and propagation time.
6. To find location of cached data.
7. Time given for query aggregation at every node.
8. Routing algorithm (more time complexity to find route).
9. Topology used
10. Filter the result.
11. Cached data at central location (depends on distance between node and sink)

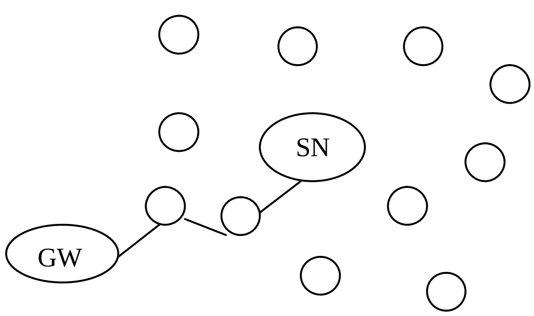
3. QUERY RESPONSE TIME PARAMETERS

Query Response time in wireless sensor network has been extensively studied. In this section, we describe query response time parameters briefly with advantages and disadvantages.

3.1 Dynamic Approximative Caching Scheme (DACS)

Query sends deep in network consumes more energy and reduce lifetime of network. Performance of wireless sensor network can be affected by caching [1]. Figure 1a. Dynamic Approximative Caching Scheme(DACS) ,in this does not necessary to send query deep in network , because cache placement done nearer to query source place at run time according to application requirement. There are number of gateway and sensor nodes. Gateway send query in network. Dynamic approximative caching scheme uses approximate cache coherence policy (not necessary to update all cache regularly). Update cache by using maximum deviation /error is exceeded [1]. GW is gateway node (It sends query in sensor networks), SN is source node and remaining are sensor nodes.

In this it is very easy to place cache at query source node at run time. It reduces intermediate node transmission help to reduce congestion and less energy consumption as well as response time. Dynamic Approximative Caching Scheme requires fewer resources to caching data. Network design complexity is less**.** It is very difficult to find location of cached data for query result. It is Difficult to keep network consistent.



GW: Gateway Node
SN: Source Node
Figure 1a: DACS Network Model

3.2 Node Placement for Congestion Control

Vasos Vassiliou et al [2] proposed node deployment in sensor network .Congestion in network results in packet loss. Retransmission of data after packet loss it consumes energy double every time result in shorten the lifetime of network and increase query response time .Congestion generally occurs because of number of packets send by sensor node at a time. Detect congestion and then try to avoid it takes time. Congestion control technique takes less time to control instead of congestion detection and avoidance [2]. The congestion control techniques are SenTCP (Its increases or decreases source data rate on behalf of congestion in network), Directed Diffusion (Select good or multiple path where congestion is less) and HTAP (use alternative path). There are three different topologies for placement of node like Simple Diffusion, Constant placement, random Placement and Grid placement. Figure 1b R-random Placement contains number of nodes around sink due to that finding alternate path get easy and it decreases query response time [2].

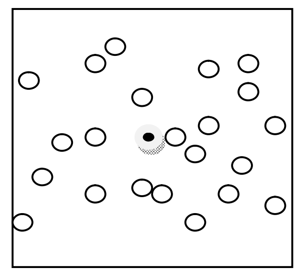


Figure 1b: Random Placement

Comparative to all congestion control algorithm Directed Diffusion is best because of less congestion. Directed Diffusion under R- random node placement strategy uses multiple path to travel query. More congestion at sink by using R- random node placement result in increase query response time.

3.3 Dual Radio Based Cooperative Caching

Dual Radio based cooperative caching is based on high and low power ranges. Figure 2. Network area is divided into number of cache zones [3]. The node within zone can be communicated with each other easily by using low power. Large Cumulative cache zone is created by all cache zones. Cache token based cache admission scheme is used in dual radio based cooperative caching. Only one token travels in different cache zone. Data can be store or retrieve by node whose holding token. It conserves lots of energy because of data availability and reduces response time .It is single hop caching .There are number of data dissemination node where we can cache data and retrieve it according to application need [3]. The node which is next to sink is called as immediate data dissemination node (IDN). In this data can be cached at many places .When query travel from sink it search first local cache .If query result does not found then transfer token to IDN. IDN first searches local cache if hit occurs means data find locally otherwise token cache transfer to next dissemination node. This process continue till data found.[3]Those nodes which hold token it acts as active control manager(ACM).This token travels form sink to other IDN if there is no space to store data in sink buffer. If after some time buffer empty then this message will be convey to all nodes. Now once again sink will be work as ACM.

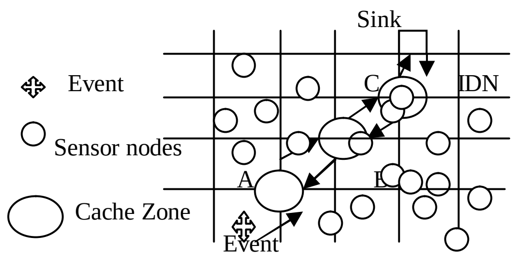


Figure 2: Query and Data Flow Path in DRDD

It reduces intermediate node transmission of packet. Cooperative caching conserves energy because of dual radio based cooperative caching. Data availability increases .It reduces query response time. Require cooperation among node. Cost increases because of extra resource requirement of data caching.

3.4 Query Aggregation

Fast and efficient query response is essential in WSN application [4]. When query travels from base station into deep network. The number of sensor nodes act as responder for query result. If all sensor node send data at time congestion will be generated. We can avoid congestion by using query aggregation. This waiting time may be fixed or it may be varied. In this upstream sensor node waits for downstream nodes response, nodes aggregate result with downstream query response then send to upstream node. Xiaoming Lu et al [4] propose soft line recursive response for query aggregation.

In this model waiting time calculated by using previous downstream query response time. If node is network edge then its waiting time is null. Figure 3, In this BS is base station and remaining are sensor nodes. Node 4 is on network edge, it does not wait for downstream node response. Node 3 waits for node 4 query result, aggregate result with downstream result then send to upstream means at node 2. Finally node 1 sends all aggregate data to base station. Each node wait according to past query result waiting time. If no new data available send to upstream then it send CANCEL-WAIT-ACK message to upstream [4].

It reduces congestion in networks because query result sends only in one packet and response time specially. Keep all record of past query response time. Apply sorting on all response time after new query response time added (time consuming). It takes time to maintain two buffers first to store all history wait time and second buffer is used to store sorting response wait times.

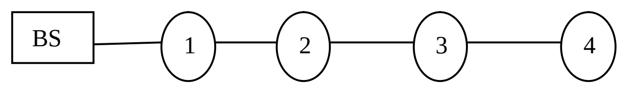


Figure 3 : Soft Line Query Aggregation

3.5 Replication of Data (Mirrors)

Replication is also one of the best solutions to reduce response time. Whole network are divided into number of sector .Each sector consist of number of sensor nodes. It require more resources to replicate data but increases data availability significantly [5].

Figure 4, in this model backup addresses strategy work very efficiently. Same data are distributed at number of places .This backup address knows to all neighboring node. Region of interest sends all up to date information about backup addresses to sink. The Address coding Strategy of making copies data at random locations throughout the network.
Data available easily because of replication. If one of the backup address node crash still sensor network will be in working state properly. It reduces inter node transmission. It controls congestion similarly. It requires more resources to cache data at different place. Cache localization is very difficult task.

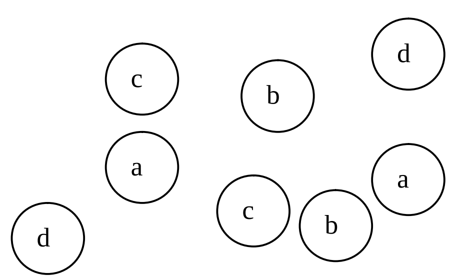


Figure 4: Backup addresses in Sensor Network

3.6 Similarity-Aware Query processing

Ping Xia et al [6] proposes Similarity-Aware Query processing model to reduce query processing time .We already know response time is time between submission of query to first response from node including query processing time. Time delay increases because of processing. If the same query was existed in past does not necessary to process it again .It reduces time complexity but increases space complexity. In this system model, three types of nodes are used. O-node is a original detect event node and store result of event. I- node is an index node, index is created by using hashing. Nodes are candidate set, which are responder to query. All past query result save in materialized view [6].

Figure 5 when query generates in sensor network ,it first transfers from query generate point (Q- Node) to I-node .I-node then checks materialized view ,whether there is any result which is similar to this query. If one or more same result found then retrieve it and make candidate set (responder to query) [6]. Suppose query injection point sends query with some temperature range like [10, 21] but result found with ranges [5, 12], [12, 21] in materialized view. In this [12, 14] range intersect with result then split query Q1: [12, 14] and Q2: [10, 12] or [14, 20]. It again checks materialized view to answer this query. In this model query split strategy and candidate selection algorithms are used to answer query but its too much time consuming.

It requires less queries processing time. It reduces energy consumption and increases lifetime of network significantly. It increases query response time accordingly. Maintain all past query result at centralized location in Materialized view.

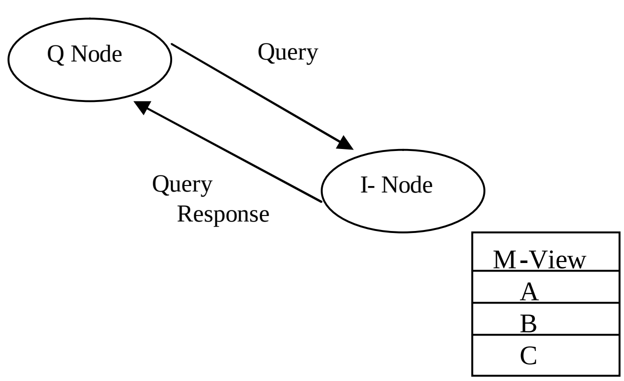


Figure 5: Query Processing Scheme

3.7 Bidirectional Congestion Control

Congestion can be affected by node deployment topology. It is very difficult task to address congestion [7] .Congestion can be increase when data transfer from sink to sensor node vice versa. There is no algorithm which control bidirectional congestion. In this paper authors have been presented learning based protocol for bidirectional control. Figure 6. Each node consists of learning automata. Learning automata is used to increase or decrease data rate at particular node to control congestion result in less packet drops and reliability increase probably [7]. Packet transfers smoothly either sink to source vice versa by using learning based automata.

It consumes less energy. It decreases packet loss. Network design is very simple. It is very costly.

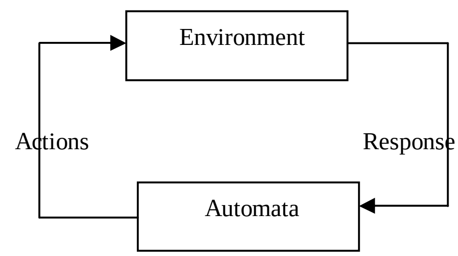


Figure 6: Learning Automata

4. COMPARISON

In previous section, we have studied all models of wireless sensor network. We have observed advantages and disadvantages of each model according to its behavior and application. All models have common objective to reduce query response time and energy consumption. Dynamic approximative caching scheme is more efficient than dual radio based cooperative caching scheme. In DACS caches place dynamically at a run time but in dual radio based cooperative caching caches place already. In DACS data caches generally at query injected point and in dual radio based if memory available, it first cache at sink otherwise it caches in next immediate node if space available.

Similarity aware query processing model keeps record of all previous and past queries in materialized view but this facility is not available in any other model. In other models previous all query result is not available at particular location, so that it takes more time if same query injected one again in future. Similarity aware query processing model reduces processing time if past query injected again in future. It reducing query processing time does not mean reducing query response time. Query response time vary because of transmission time. Query transmission time is more than query receiving time in any model.

Number of messages transmission in query aggregation model is very less comparative to all other models. In query aggregation query results aggregate when it transfer from one node to other, query result of different node aggregate in one packet but other model nodes transfer their individual packet without aggregation. Individual packet increases overhead of header. In bidirectional congestion control every node can increase or decrease data rate to reduce bidirectional congestion using learning automata but this facility is not available in other models. Table 1 shows comparison parameters which are affecting query response time.

Table 1: Comparison of Parameters which Are Affecting Query Response Time

	Caching	Packet Loss	Congestion	Data Availability	Resources Requirement	Design of Network	Performance	Response Time
Dynamic Approximative Caching	Yes	No	Reduce	Medium	Less	Simple	Good	Low
Node Placement for Congestion Control	Not Given	Less	Increase	Less	More	Simple	Good	--
Dual radio Based Cooperative caching	Yes	No	Reduce	More	Less	Simple	Good	Low
Query Aggregation	Not Given	Not Given	Reduce	More	Less	Less Complex	Good	Low
Mirrors	Yes	No	Increase	Very Large	More	Simple	Very Good	Very Large
Bidirectional Congestion Control	Not Given	No	No	Less	More	Complex	Good	Low
Similarity Aware Query Processing	Yes	Not Given	Increase	More	More	Very Complex	Not Good	Very Large

5. CONCLUSION

This paper presents a survey of various approaches which affect the response time of query. In this work first we elaborate the advantages and disadvantages of the approaches, on the basis of this we find out various factors that are directly or indirectly affect response time of query .These factors are congestion, data availability, and design of network, node placement, performance, packet loss, caching, and mirrors. This survey is useful for researchers undertaking the task of exploring reliable data communication issues in general wireless sensor network.

Our goal is to find out or measure the query response time required for wireless sensor network.

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