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CONGESTION AVOIDANCE AND MITIGATION IN WSN

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Abstract: Multipath routing protocol always aims to achieve higher reliability and load balancing in Wireless Sensor Network. In the proposed framework of the project with various assumptions, constraints and dependencies of a heterogeneous wireless sensor network an efficient scheme of multipath congestion has been experimented. In this Project, it is propose about an efficient scheme to control multipath congestion so that the sink can get priority based throughput for heterogeneous data. It has used packet service ratio for detecting congestion as well as performed hop-by-hop multipath congestion control based on that metric.

Keywords: event reliability; congestion; mitigation; routing; wireless sensor network

1. Introduction

Multipath routing is a technique that exploits the underlying physical network resources by utilizing multiple source destination paths. It is used for a number of purposes, including bandwidth aggregation, minimizing end-to-end delay, increasing fault-tolerance, enhancing reliability, load balancing, and so on. The idea of using multiple paths has existed for some time and it has been explored in different areas of networking.

WSN generally consist of one or more sinks (or base stations) and perhaps tens or thousands of sensor nodes scattered in a physical space. With integration of information sensing, computation, and wireless communication, the sensor nodes can sense physical information, process crude information, and report them to the sink. The sink in turn queries the sensor nodes for information.

2. Theoretical Outline

In general, any load-balancing algorithm consists of two basic policies, a transfer policy and a location policy. The transfer policy decides if there is a need to initiate load balancing across the system. By using workload information, it determines when a node becomes eligible to act as a sender (transfer a job to another node) or as a receiver (retrieve a job from another node). The location policy determines a suitably underloaded processor. In other words, it locates complementary nodes to/from which a node can send/receive workload to improve the overall system performance. Location-based policies can be broadly classified as sender initiated, receiver initiated, or symmetrically initiated. Further, while balancing the load, certain types of information such as the number of jobs waiting in queue, job arrival rate, CPU processing rate, and so forth at each processor, as well as at neighbouring processors, may be exchanged among the processors for improving the overall performance. Based on the information that can be used, load-balancing algorithms are classified as static, dynamic, or adaptive. In a static algorithm, the scheduling is carried out according to a predetermined policy. The state of the system at the time of the scheduling is not taken into consideration. On the other hand, a dynamic algorithm adapts its decision to the state of the system. Adaptive algorithms are a special type of dynamic algorithms where the parameters of the algorithm and/or the scheduling policy itself is changed based on the global state of the system.

3. Existing System

Various research works has been carried out in past as well as ongoing project also, but the scenarios with multipath routing was never considered. It is not clear whether they can be directly applied to WSN’s with multipath routing enabled. Moreover, most of the protocols deal with homogeneous traffic. Sensor nodes may have multiple sensing devices e.g. temperature, light, pressure etc. and no other protocols except STCP considered multiple sensing devices in the same node.

But STCP has some problems:

It doesn't consider multipath routing even it doesn't state any explicit and detailed mechanism for single path congestion control.

The ACK/NACK based reliability mechanism is not suitable for wireless sensor networks in terms of delay and memory use.

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This is one of the recent works where a node priority based control mechanism PCCP has been proposed for WSN. It introduces an efficient congestion detection technique addressing both node level and link level for detecting congestion. Priority-based Congestion Control Protocol (PCCP) prioritizes both source and transit traffic but here the limitation of handling multiple sensed data within a node also remains considering as another flaw

4. Proposed System

The proposed system deploys multipath routing technique in order to achieve high reliability and load balancing in wireless sensor network. Multipath routing is a technique that exploits the underlying physical network resources by utilizing multiple source destination paths. It is used for a number of purposes, including bandwidth aggregation, minimizing end-to-end delay, increasing fault-tolerance, enhancing reliability, load balancing, and so on. The idea of using multiple paths has existed for some time and it has been explored in different areas of networking. The proposed work is designed with certain consideration that is taken into account when while constructing the congestion control algorithm.

5. Research Development Methods

The Waterfall lifecycle model is used for the development of this project. The Waterfall model is an activity centered lifecycle model first developed by Royce.

The approach of the Waterfall model is in a step-by-step way where all the requirements of one activity are completed before the design of the activity is started. The entire project design is broken down into several small tasks in order of precedence and these tasks are designed one by one making sure they work perfectly. Once one of these small tasks is completed another task, which is dependent on the completed task, can be started. Each step after being completed is verified to ensure the task is working, error-free and meeting all the requirements.

In this project work we chose this lifecycle model for the project primarily for two reasons. First reason being simplicity, by using the Waterfall model the entire project can be broken down into smaller activities which can be converted relatively easily into code and once the entire thing is combined, the code for the project can be derived. The second reason is because of the verification step required by the Waterfall model it would be ensured that a task is error free before other tasks that are dependent on it are developed. Thus chances of an error remaining somewhere high up in the task hierarchy are relatively low.

Some of the unique features of waterfall model are:

- It can be implemented for all size projects.
- It leads to a concrete and clear approach to software development.
- In this model testing is inherent in every phase.
- Documentation is produced at every stage of model which is very helpful for people who are involved.

Schematic illustration of waterfall model:

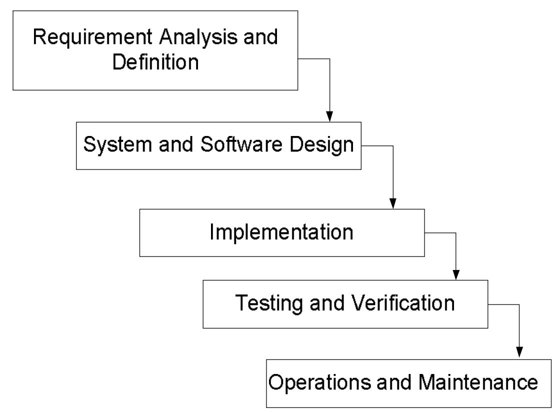

Figure 5.1 Waterfall Model

6.Congestion Avoidance

In routing protocol CAM (Congestion Avoidance and Mitigation) which has two parts:

(i) Congestion Avoidance and

(ii) Congestion Mitigation.

This subsection describes congestion avoidance part and energy dissipation issue (particularly, the maximum node energy spent) is an important factor in WSN.

If the routes are decided based on distances of nodes then there is a chance that the same routes in a static network will be used again and again, and as a result, a few particular nodes close to BS will die out of energy soon. If routes are randomly chosen then energy dissipation of nodes will be more uniform, although data success rate will be reduced. The values of *RSR* parameters of nodes vary time to time based on the current active congestion conditions of nodes. Therefore, routes will be

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random if they are chosen based on distances as well as *RSR* parameters of neighbours. As distances of neighbours are still a selection criterion, data success rate will be sufficiently high. So a utility function *f* that would be applied to each neighbour of a transmitter node *B*. When *B* forwards a packet, it chooses the highest *f*-valued node among its neighbours.

The function *f* has two components:

(i) "distance of next node" for ensuring high packet success rate,

(ii) Relative Success Rate (*RSR*) of each neighbour for avoiding congested nodes.

7. Congestion Control Algorithm

The algorithm used to avoid congestion in the proposed protocol:

procedure CAM_AVOIDANCE (Neighbour-list *NL*, Distance- list *DL*,Success-list *RSRL*)
local variables: Node *R*, Node *k*, real *f*
for each node *k* in *NL*

$$f = \alpha \times \frac{DL(k)}{D} + \beta \times RSRL(k)$$

Let, node *R* has the highest value of *f* among all nodes in *NL*
return *R*

The function *f has* two components:

(i) "distance of next node" for ensuring high packet success rate,

(ii) Relative Success Rate (*RSR*) of each neighbour for avoiding congested nodes.

$$f = \alpha \times \frac{D_k}{D} + \beta \times RSR_k$$

where D_k is the distance of next node *k* towards the BS from node *B*, *D* is the maximum distance that can be covered by the transmission power of each node, RSR_k is the relative success rate of node *k*.

7.1 End-to-end Data Success Rate

Each node knows its location as well as the locations of its neighbours and the static BS. Sensor nodes may be mobile.

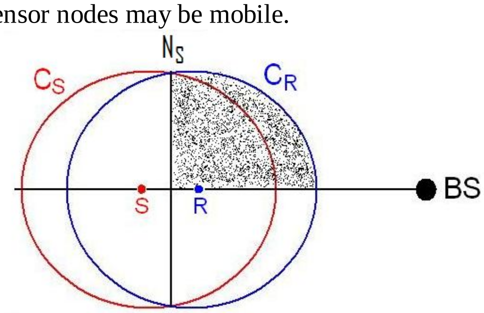

Figure7.1: Node S sends data towards the BS through node R

A node can forward its data to any neighbour that is closer to the BS than itself. Now Consider sensor nodes with a fixed transmission power and are interested to achieve high end-to-end success rate. Here it is assumed that all sensor nodes are uniformly distributed with a node-density of $\lambda 2$ per unit area. On an average, along a line of unit length, there will be λ number of nodes and two successive nodes will be 1/λ unit distance apart from each other. The transmission power of each node is fixed and can successfully reach another node that is at most *x* unit distance away from it. For simplicity, we assume $x = d/\lambda$ which means that when a node *A* transmits data, the farthest node *B* that can receive it is the d^{th} node from *A* on the way from node *A* to node *B*. Therefore, when a node transmits data, any other node which is located inside the circle centered at the transmitter node having a radius of d/λ unit can receive that data. In Fig. 1, node *S* sends its data directly to node *R* which is i^{th} node on the way from node *S* to the BS. The distance between *S* and *R* is i/λ where the maximum value of *i* may be *d*. Circles *CS* and *CR* are centered at nodes *S*and *R* respectively and the set *NS* contains any node residing inside of *CS* or *CR* or both. When *S* sends data to *R*, any member node of *NS* can cause collision to this transmission by sending data at the same time.

7.2 Congestion Mitigation

After calculating RSR, the network layer mitigates its own congestion. The network layer sends the value of *RSR* to the application layer. If the value of *RSR* is less than 1, the application layer reduces its data generation rate to *RSR* factor of the current rate. If the value of *RSR* is 1 (which is the maximum possible value) and the application layer has a lower data generation rate than its targeted rate, then it increases its data generation rate by a small factor (10% of current rate) and waits for the next value of *RSR* arriving from the network layer. In this way, the application layer always maintains its targeted data generation rate when there is no congestion. For packets coming from other nodes, network layer simply forwards *RSR* factor of the packets to MAC layer and drops the remaining ones. While dropping packets coming from other nodes, the network layer tries to forward as many critical packets (packets sent by nodes close to the event) as possible so that the

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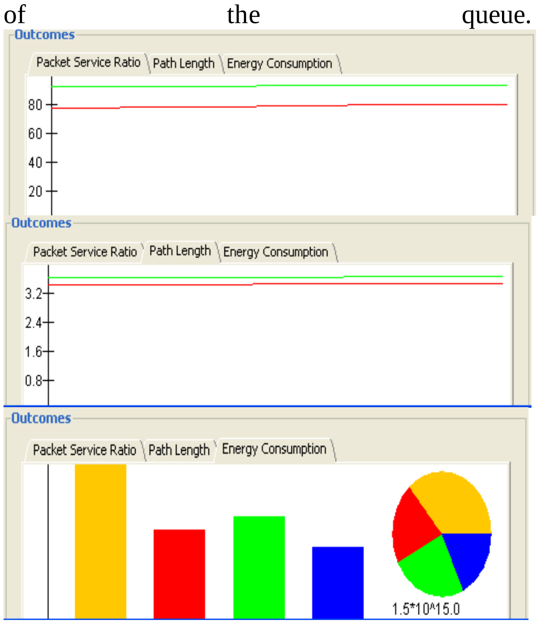
BS can get the maximum number of critical packets to be able to detect the event reliably and timely. (Each data packet has one control bit which is set to 1 if the packet is generated by a node close to the event; otherwise, it is set to 0. By inspecting this bit, a node can decide whether a packet received from other node is critical or not.) It may be noted that CAM utilizes an accurate rate adjustment in accordance to node's active congestion level.

7.3 MAC Layer Queue Management

CAM manages regular data as well as critical data and requires a minor modification in MAC layer queue management. The aim of CAM is to deliver high amount of critical data within an acceptable low amount of delay. In CAM, when a critical data packet comes to MAC layer from network layer, that packet is inserted in the front part of transmission queue where other critical packets reside. Each regular data packet is appended at the rear of the same queue. This technique will reduce the average delay of critical packets although it will increase the delay of regular packets at the same time. Each control packet (that includes location and *RSR* information of node is placed exactly at the front of the queue.



8.1 Conclusions

The main aim of the project work is to design protocol, where a queuing model for generating the heterogeneous traffic within each sensor node according to the priority specified by the sink. In this project work, a proposition is made for building an efficient scheme to perform multipath congestion control for heterogeneous traffic which avoids packet loss and thus enhances the probability of achieving the desired throughput of heterogeneous traffic. Our congestion detection mechanism is chosen based on packet service ratio and congestion notification is implicit. In this project, we have presented an efficient multipath congestion control mechanism for heterogeneous data originated from a single sensor node. we have demonstrated through the simulation that our scheme achieves:

i) Desired throughput for diverse data according to the priority specified by the sink,

ii) Moderate queue length to avoid packet loss and

iii) Lower packet drop rate.

Our design of this scheme points to some directions for future works to improve the fairness, analysis of the impact of other parameters on the proposed scheme's performance and implementing this scheme on a real sensor test-bed and compare the results with those obtained in the simulations.

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