CHAPTER 5

EFFECTIVE QoS PROVISIONING FOR OPTIMAL ROUTING

5.1 NEED FOR QoS

Due to the inherent advantages of WMNs such as broadband capability, easy maintenance, low deployment cost, reliable service coverage, self configuration and improved capacity, they are commonly used for supporting real time services like streaming audio and video and voice over IP services besides data services. Hence, provisioning of QoS is foremost important in such type of networks to support next generation applications. In general, there exist two types of QoS models such as parameterized QoS and prioritized QoS used in networks. In parameterized QoS model, QoS requirements are specified as a set of parameters such as available bandwidth, delay, packet loss rate, delay jitter, etc. The traffic flows are allowed in the network based on the negotiation of these parameters. In prioritized QoS model, the data traffic is based on the priorities associated with the packets (Chu 2008). To support next generation applications with real time services, WMNs must provide improved parameterized QoS. In this chapter, we have proposed a protocol named Efficient Routing with QoS aware Reconfiguration (ER-QAR) protocol to support QoS for next generation applications by providing better QoS aware reconfiguration plans.

5.2 EFFICIENT ROUTING WITH QoS AWARE RECONFIGURATION PROTOCOL

Nowadays wireless technology enables very high data rate, which causes high demand for supporting real time applications over the wireless mesh networks. These networks experience frequent link failures due to various reasons such as channel interference, applications' bandwidth demands, etc during the network operation. Frequent link failures cause severe performance degradation. In this section, we present an Efficient Routing with QoS Aware Reconfiguration called ER-QAR protocol which includes route discovery algorithm, Self Reconfiguration System (SRS) and performance based routing metrics. Here we introduce hybrid routing metric during route discovery which establishes an efficient routing path by considering the link quality and enhanced routing metrics. Self Reconfiguration System (SRS) provides QoS aware reconfiguration plans during link failures.

5.2.1 Overview of ER-QAR

The proposed scheme combines Self Reconfiguration System (SRS) (Kim & Shin 2011) with an enhanced AODV that allows a multi-radio WMN to autonomously reconfigure its local network settings for recovery from link failures. SRS is equipped with a reconfiguration planning algorithm to identify local configuration changes for the recovery from link failures with minimal changes of healthy network settings. SRS first searches for feasible local configuration changes available around a faulty area by considering present channel and radio connections. By having these network settings as constraints, SRS generates better reconfiguration plans. The hop count metric which is commonly used for various existing routing protocols is not applicable for selecting the optimized path in WMNs. Hence, hybrid routing metrics (WCETT, ETT, ETX, Path Cost and Hop Count) are coupled in the route discovery process to improve the performance of routing.

5.2.2 Performance based Routing Metrics

Hybrid routing metrics namely ETX, ETT, WCETT, hop count and path cost metric implemented at each mesh router for discovering optimal routing path are derived as discussed in section 4.2.4.

5.2.3 Network Model and Functional Components

A network is assumed to consist of mesh clients and wireless mesh backbone. The set of mesh routers, IEEE 802.11-based wireless links and one control gateway form the backbone. Figure 5.1 shows the functional components implemented at each mesh router.

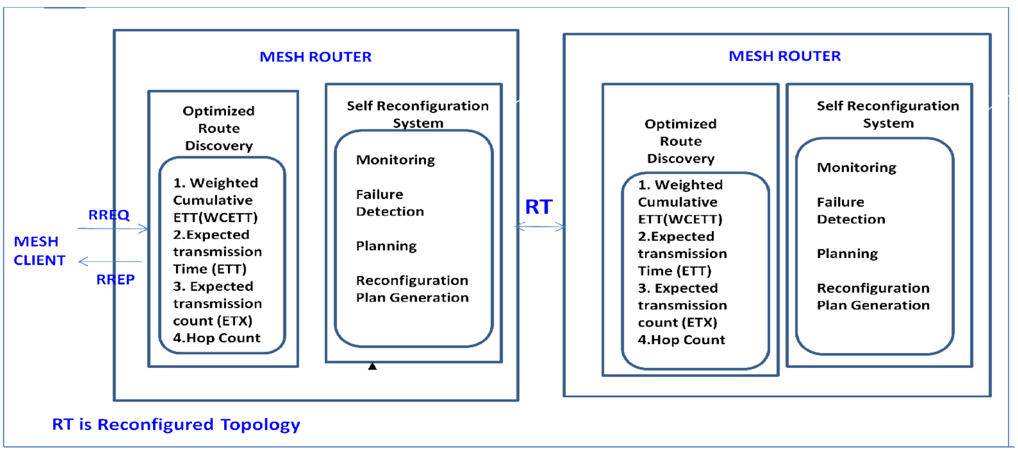

Figure 5.1 Functional Components of ER-QAR

The proposed design consists of two phases. First phase called optimized route discovery aims at finding an efficient path from the source to the destination by making use of the hybrid routing metrics. When link failure is detected, SRS is invoked to perform localized reconfiguration. Hence a reconfigured topology is obtained. The mesh routers on the path communicate this reconfigured topology to all other mesh routers in the path. To support QoS during the network operation, each mesh router periodically sends its local channel usage and the quality information to all outgoing links via control messages to the gateway. By having this information, gateway node controls the requests from various applications. For restricted flows, the required QoS resources are assigned to the nodes in the path.

5.2.4 Optimized Route Discovery

Whenever a mobile client (source) wants to send data to any other mobile client (destination) in the network and source doesn't have route entry in its routing table for destination, it needs to find route between them. We use AODV protocol for route discovery with slight changes. Initially, the source broadcasts the RREQ (Route Request) packets across the network. As the RREQ packet reaches each intermediate node, it calculates the following routing metrics. ETX, ETT, WCETT, hop count and path cost are computed and handled during the route discovery as discussed in the section 4.2.4. Destination node selects the path with the minimum path cost. Thus an efficient routing path is discovered and it unicasts RREP (Route Reply) packet through the selected path. The algorithm is described in Figure 5.2.

Step 1: The source S broadcasts the RREQ packets.
Step 2: Each intermediate node calculates ETX and ETT metrics
Step 3: ETT value is cumulatively added at each node and stored in the RREQ packet.
Step 4: Destination node receives RREQ packet through multiple paths.
Step 5: For each path, WCETT metric is calculated at the destination node.
Step 6: Destination node also calculates the path cost for all the paths.
Step 7: Destination node selects an optimal route with minimum path cost.

Figure 5.2 Optimized Route Discovery Algorithm

In case of any link failure, SRS is invoked. Instead of performing global configuration changes, SRS performs localized configuration changes. It effectively identifies the reconfiguration plans that satisfy the applications' QoS constraints.

5.2.5 Self Reconfiguration System

Self Reconfiguration System (SRS) is implemented at each mesh node according to the algorithm discussed in (Kim & Shin 2011) and it is called whenever link failure is detected. First, SRS in every mesh router monitors the quality of its outgoing wireless links at regular intervals and reports the results to a gateway via a control message. Second, once a link failure is detected, SRS in the detector node activates the formation of a group among local mesh routers which use a faulty channel. One of the group members is selected as a leader to coordinate the process of reconfiguration. Then the leader node sends a planning request message to a gateway node and the gateway node synchronizes the planning requests and generates reconfiguration plan for the request. At last, all nodes in the group perform the corresponding configuration changes.

5.2.6 Simulation Results and Performance Evaluation

We have implemented ER-QAR via NS2 simulation. The simulation parameters are shown in Table 5.1. Throughout the simulation we have used grid topology with 50 nodes and a simulation area of 1000m x 1000m. Each node is based on IEEE 802.11n standard and possesses Multiple Input Multiple Output (MIMO) transmission. Enhanced AODV routing protocol which includes a multi-radio-aware routing metric (WCETT) is implemented and used for routing. SRS is employed at each mesh router and it is implemented as an agent in both the MAC layer and routing layer. At regular intervals, SRS gathers channel information from MAC layer. It requests for channel switching or link-association changes based on the collected information. And also, it notifies the routing protocol about network failures or about routing table update operation.

Table 5.1 Simulation Parameters of ER-QAR

Parameters	Value
Simulation time	1000s
Routing protocol	AODV, ER-QAR
Wireless nodes	50
Length of queue	50
MAC protocol	802.11n
Simulated Area	1000m X 1000m
Antenna	Omni directional Antenna

The software design of SRS includes the modules namely network layer and device drivers (Kim & Shin 2011). The network layer comprises of the following components: (i) network planner- generating reconfiguration plans only at a gateway node; (ii) group organizer- initiates to form a group among mesh routers; (iii) failure detector- interacting with a network monitor in the device driver periodically and maintaining an up to date link-state table; and (iv) routing table manager-maintaining up to date states of a routing table. The device driver of SRS includes: (i) network monitor- to efficiently monitor link-quality and supports multiple radios and (ii) Network Interface Card (NIC) manager- to effectively reconfigure NIC's settings based on a reconfiguration plan from the group. Here we compare ER-QAR with AODV and have found that ER-QAR outperforms the traditional AODV in terms of

- Throughput
- Packet Delivery Ratio
- End-to-end Delay

Figure 5.3 shows the graph for the average throughput of the network. Since we have chosen the optimal path through link quality aware routing metrics along with self reconfiguration, the proposed scheme effectively increases the throughput than the traditional AODV routing protocol.

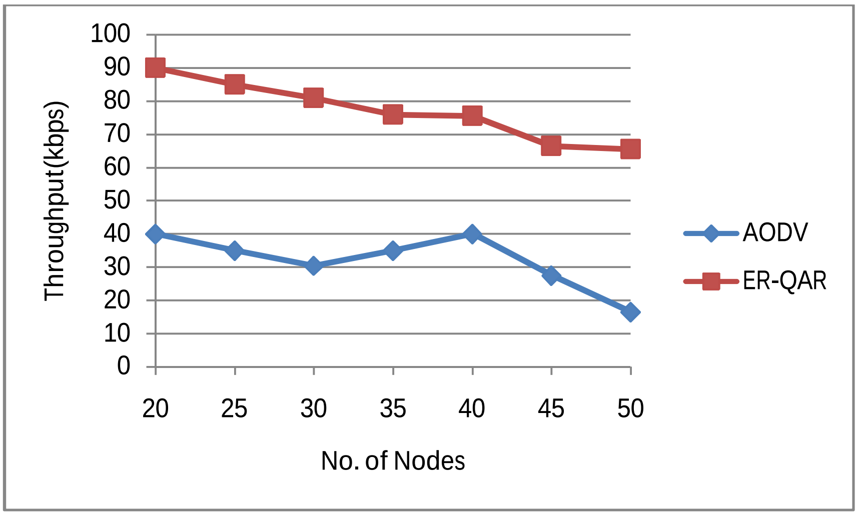

Figure 5.3 No. of Nodes Vs Throughput

Implementation of SRS scheme in the proposed protocol detects the link failures precisely by regular monitoring of links and completes the reconfiguration within a period of time. Hence packets are delivered successfully with reconfigured settings which in turn increase the throughput. On the other hand, AODV has obtained performance degradation for increase in number of nodes due to frequent link failures caused by node mobility.

The end to end delay is analyzed for both the protocols and it is shown in Figure 5.4. It can be observed that proposed scheme experiences less delay compared to AODV even when the number of nodes are increasing. The end to end delay is the average time required by a data packet to reach the destination. It also includes the delay caused by route discovery process and the queuing delay in data packet transmission. Since we have implemented QoS aware reconfiguration planning by incorporating SRS in the mesh routers, the on demand QoS requirements are satisfied and the delay incurred by the packets is also minimum. End-to-end delay is high in the case of AODV due to high mobility of the nodes and frequent link failures in the network. AODV initiates route rediscovery process whenever link failure is detected and thus increases end-to-end delay.

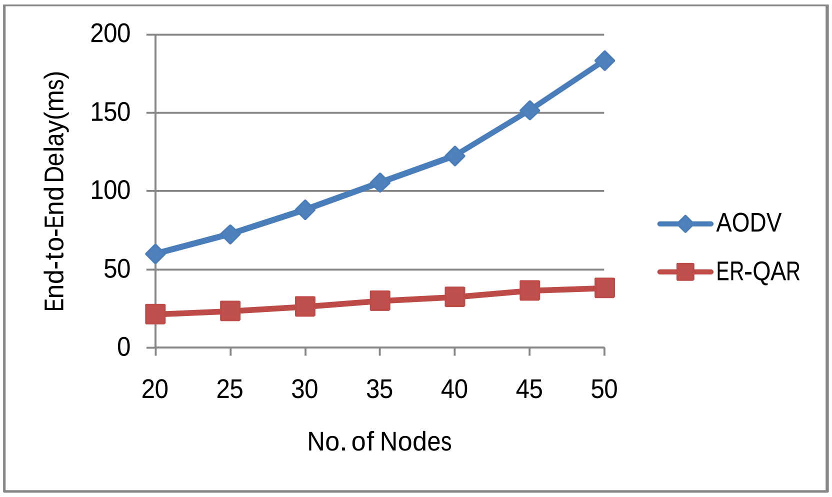

Figure 5.4 No. of Nodes Vs End-to-End Delay

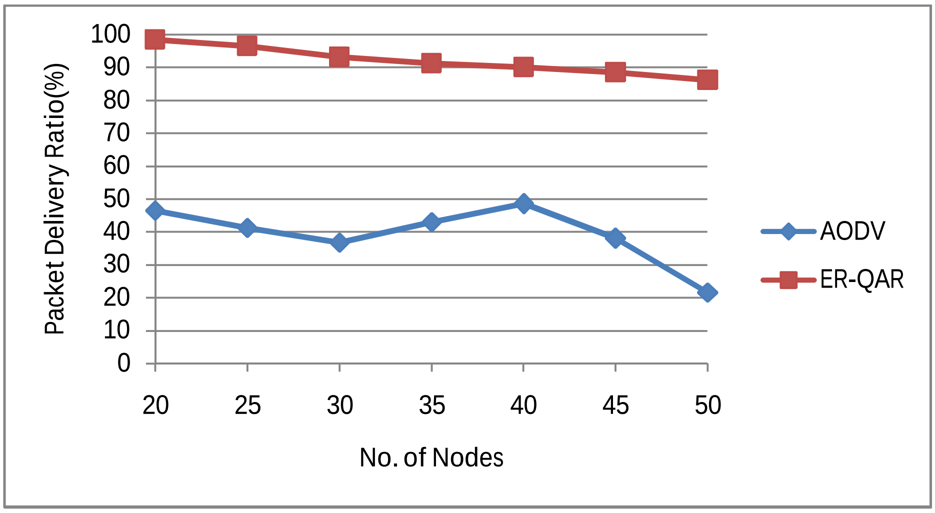

Figure 5.5 No. of Nodes Vs Packet Delivery Ratio

Figure 5.5 shows the packet delivery ratio analysis with respect to number of nodes present. This is the ratio of number of packets successfully received by the destination nodes to the number of packets sent by the source nodes. ER-QAR provides almost better performance when number of nodes is less and slightly drops when the number of nodes is increased. This has occurred due to more interference and traffic congestion. However, ER-QAR maintains the PDR above 85% for increase in number of nodes up to 50. AODV has less packet delivery ratio than the proposed protocol since it faces frequent link failures and route rediscovery due to high mobility. In the case of proposed protocol, whenever link failure is detected, SRS is invoked to provide better reconfiguration plans. Moreover, the proposed protocol has obtained optimal routing path by integrating link quality aware routing metrics. This shows that the proposed scheme gives better performance in delivering packets by having optimal routing path with better link quality.

5.3 THESIS CONTRIBUTIONS IN EFFECTIVE QoS PROVISIONING FOR OPTIMAL ROUTING

The major contributions of this chapter are designing an efficient routing protocol with QoS aware reconfigurations and ensuring better performance in WMNs by enforcing link quality aware hybrid routing metrics. The proposed scheme ER-QAR combines Self Reconfiguration System (SRS) with an enhanced AODV that allows a multiradio WMN to autonomously reconfigure its local network settings for recovery from link failures. SRS is provided with a reconfiguration planning algorithm to identify local configuration changes for the link failure recovery with minimal changes of healthy network settings. The proposed routing scheme is designed to effectively transmit the data and to recover from link failures. We have discussed the algorithm to determine an optimal route by making use of the hybrid routing metrics namely WCETT, ETT, ETX, Path cost and hop count. Furthermore, in case of link failures, it makes use of the SRS to autonomously recover from local link failures. Rather than performing global configuration changes, SRS helps to perform localized configuration changes. It effectively identifies the reconfiguration plans that satisfy the applications' QoS constraints. The simulation results also show that ER-QAR protocol performs better than AODV in terms of throughput, PDR and end-to-end delay. Thus, the proposed scheme ensures effective QoS support by providing better reconfiguration plans and helps to determine an optimal routing path for effective data communication.