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CBAODV: Effective Content-based QoS Routing Protocol with Redundant Path for Multimedia Applications in MANET

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Abstract

Mobile Ad-hoc Network (MANET) has a mobile self-organizing flat architecture which is composed of a number of wireless portable devices or nodes without depending on infrastructure or centralized management. Supporting the QoS routing in MANET is actually a challenging problem because of its unique characteristics such as limited battery power, limited range, limited bandwidth and its intensive mobility degree that pose several difficulties in provision QoS. Using the default parameters to find the QoS satisfied route for every application make the performance degrading and the packet delay for certain kind of applications. In this paper, to discover the path more efficiently in MANET, a QoS routing mechanism over AODV (Ad-hoc On-Demand) routing protocol for multimedia application is proposed. The parameters that are used to capture the quality of link are dynamic depending on the content of application. The criteria that are used in the route discovery are hop-count, end-to-end delay, packet loss and bandwidth. Each control message is added up the additional information field to ensure the required QoS in the application. All qualified paths including the primary path are maintain during the data transmission in order to provide the path as soon as possible when the network topology changes. Bandwidth reservation is accompanied with data transmission for throughput-demanded application. This system is proposed in order to improve the performance of AODV routing and to reduce the unnecessary computational complexity.

1. Introduction

Mobile Ad-hoc Network is a decentralized wireless network and does not rely on a pre-existing infrastructure such as router or access point. Instead, every mobile node in the network participates in routing by hopping from one to another for two nodes which are not connected directly as nodes in MANET can also perform like router. Therefore, routing plays the important part in this kind of network because it has a strong impact on the performance of network [1][2]. Generally, routing protocols in MANET can be classified as follow: Reactive routing protocol (On-demand), Proactive routing protocol (Table-driven) and Hybrid routing protocol [3]. Among them, on-demand routing protocols which performed well compared to table oriented are more suitable in such kind of network since maintaining up-to-date routing tables for the rapidly dynamic environment is a substantial difficulty for the network.

Among on-demand routing protocols [4], AODV is one of the most popular routing protocols for MANET. In AODV, the number of intermediate nodes (hop count) is used as a parameter to find the shortest path for the packet transmission. However, with the advancement in emerging technologies, wireless networks are also demand for the multimedia services which are provided by conventional wire networks [5]. These multimedia applications require to be provided the enough QoS to accomplish the task. As a result, using a single parameter for finding route is not sufficient for QoS-demanded application such as video and audio. To meet the necessary QoS in path, more than one parameter which are logically correlated, is considered in route discovery process for QoS-aware application for choosing an optimal path [6][7].

In this paper, the goal of the system is for choosing the most relevant path to satisfy the required QoS constraints of a particular application and improving routing mechanism more accurately. And to reduce the unnecessary processing overhead and complexity more efficiently, different parameters groups in term of hop count, end to end delay, packet loss and bandwidth are used for different application content.

This paper builds on AODV with the following key contributions:

- Application layer determines the relevant QoS parameters according to the application type
- Control message extension to collect information needed for QoS routing protocol
- Provide the secondary route to use when the primary routes disconnect

Although the dynamic nature of wireless network prevents to support the hard-guaranteed QoS support, this QoS mechanism can still increase the reliability of communication. The remainder of this paper is organized as follows: in Section II we describe the related work. Section III describes briefly the AODV routing protocol and mention some problems in adapting the protocol in mobile ad-hoc network. Section IV discusses about the proposed routing mechanism and Section V draw conclusion and future work.

2. Related Work

Original MANET routing protocols do not consider any level of Quality of Service for any kind of application. Supporting the required Quality of Service for delay sensitive and throughput-demanded application such as video conferencing is very important in an ad hoc network [8]. However, due to the dynamic nature of wireless environment, currently used QoS provision methods on the Internet, IntServ and DiffServ [9][10], cannot directly applied on wireless ad hoc networks. Therefore, many researchers have done a lot of research works in providing QoS in MANET. To provide a complete QoS solution for the ad hoc network, three aspects are needed to consider. They are QoS routing protocol, resource reservation scheme and QoS capable medium access control layer. While some researches only consider on individual aspect such as QoS routing protocol, some researches combine two or more aspects to offer the guaranteed QoS services.

Among the popular protocol in MANET routing scheme, a lot of modification and extension are applied on AODV for better performance since it development [11]. To avoid frequent route discovery and maintaining QoS in MANET, various multipath routing protocols has been proposed as a quality of service. In M-AODV [12], the node-disjoint secondary path is used to reduce the packet loss rate caused by frequent topology change and local repair procedure, and to provide the continuous availability of links between communication parties. According to [13], it provides backup path to primary route to decrease route discovery rate in single path routing based on bandwidth and delay. [14] Suggest a backup routing scheme using one-hop search method while guaranteeing the service quality for multimedia application. The author of [15] proposes a QoS routing solution based on a link available bandwidth monitoring. Notification mechanism is used to inform the source to make a route recovery. But, the drawback of this QoS routing is that the available bandwidth for a particular source may not be supported easily and readily because the available bandwidth is measured each time a RREQ or a data packet is received by node which results in a change in traffic load. In [16], it provides Quality of Service routing protocol support which based on the bandwidth estimation and delay constraints. [2] Proposed a new concept of QoS routing with using intelligence optimization techniques, e.g., Artificial Neural Network, Genetic Algorithms etc. M.M. Thaw et at [6] determines the optimal path for real-time traffic using hop-count, bandwidth and mobile speed by applying fuzzy-based routing protocol over AODV. In [17] uses GA with multi-objective function to find the QoS route in MANET considering node connectivity, delay and bandwidth. A QoS-aware routing protocol that incorporates an admission control scheme and a feedback scheme to meet the QoS requirement is proposed by using the approximate bandwidth estimation to react to network traffic [18]. In [19], an admission control mechanism for multi-rate wireless ad hoc network is presented. Nodes use the passive monitoring to measure the available channel bandwidth and it provides more accurate available bandwidth estimation by considering parallel transmissions.

3. Ad-Hoc On-Demand Routing Protocol

Ad-Hoc On-Demand Distance Vector Routing Protocol (AODV) is a routing protocol for mobile ad hoc networks. It is most popular routing protocol among others [20]. It is on-demand type routing protocol and its performance is better than other routing protocols in MANET environment [21]. AODV is a method of routing message in mobile nodes as shown in Fig (1). It allows the source node to pass message through its neighbour to the destination with which it cannot communicate directly. AODV does this by discovering the route. For route finding, route discovery cycle is used. Routes are only maintained just as long as they are needed by the sources. Whenever routes are not used, it will get expired and discarded. Therefore, it has the advantages of reducing stale routes and reducing the need for route maintenance.

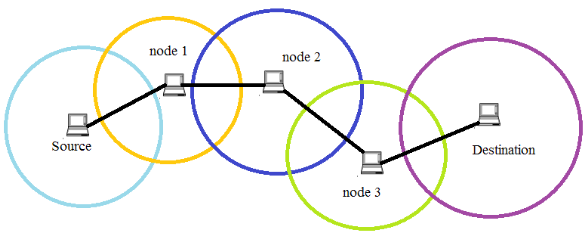

Figure 1. AODV routing from source to destination

3.1. AODV Route Discovery Phase

When a node wants to send the data to a destination, it checks its routing table to determine if it has a valid route to the destination. If it has the valid route, it will forward the data using the existing route. If not, it initiates the route discovery process by broadcasting the RREQ (Route Request) message in the networks. Each node receiving the

RREQ forwards this control message to its neighbours until it reaches the destination or the intermediate node which has a valid route to the destination that will reply with RREP (Route Reply) message. Each time a node receive a RREQ message, it makes a reverse route entry to source and each time a node receive a RREP message, it makes a forward route entry to destination. A routing table entry maintaining the reverse path is purged after the timeout interval and the routing table entry maintaining the forward path is purged after the active-route-timeout interval if no data is transmitted using a particular routing table entry.

3.2. AODV Route Discovery Phase

During this AODV route discovery phase, as soon as the RREP is received, the source can send the data to the destination. It maintains only path to the destination.

3.3. AODV Route Maintenance Phase

When the source node moves, a new route discovery process is initiated. If intermediate nodes or destination moves, it will result in link failure. Link failure detection is done by periodically exchanging Hello message among neighbour nodes. When the link failure is detected, routing table of upstream node is updated for the link failure and all active neighbours are informed by RRER (Route Error) message. RRER lists all the nodes affected by the link failure. When a node receives RRER, it marks its route to the destination as an invalid. When a source node is received RRER, it reinitiated the route discovery process. Later, local Repair method is used to make the optimization in AODV. In this method, upstream node locally repairs the break without notifying the source node. However, if first repair attempt is unsuccessful, it sends the RRER to the source.

3.4. AODV Overview

From the above discussion, a couple of major drawbacks of AODV can be identified:

- The original AODV does not provide the Quality of Service function.
- In an existing AODV, when the source node broadcasts RREQ messages to the neighbouring nodes, if an intermediate has a route in its routing table, then it will generate a RREP message to the source node. That will result in the stale RREP message.
- Local Repair Procedure also leads to packet loss problem.

Therefore, a method is proposed as an efficient and comprehensive scheme with the following distinct features:

- In order to capture the quality of link between two nodes in the case of QoS provision, more criteria are used in route selection.
- Application Layer determines the relevant QoS parameters according to the application type in order to generate the path with good quality
- Provide the secondary (backup) route to use when the primary routes disconnect
- Bandwidth Guarantee for Video application that requires high Throughput

4. Implementation of the Proposed System

In this proposed system, firstly, the application layer determines the content type of application and sends the content type to network layer to select the particular group of parameters. The layer architecture of the proposed system is shown in the Figure 2.

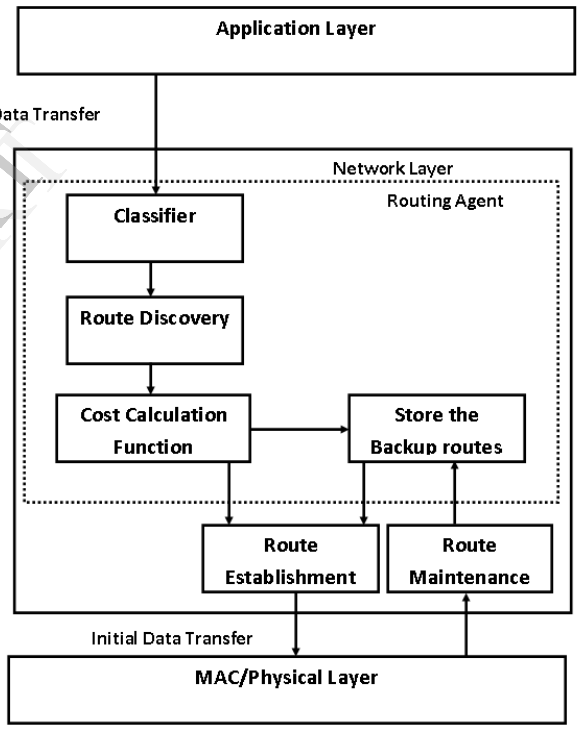

Figure 2. The layer architecture of the proposed system

4.1. AODV Route Maintenance Phase

Hop count, end-to-end delay and bandwidth are used for selecting the optimized route. Among these parameters, the appropriate parameters for a particular application contents are grouped together for finding the optimized routes as shown in Table 1. These parameters are:

- Hop count: It allows the routing protocols to find the routes having the shortest distance which means the least end-to-end delay between the source and the destination to some degree.

- End-to-End Delay: It is also vital parameter to consider for delay restricted application.
- Bandwidth: If bandwidth resource is insufficient, queuing delay will increase and congestion may appear.

Table 1. The relationship between the packet type and parameters

Content	Parameters for path optimization	Link constraint
Video	End-to-end delay, hop count	Bandwidth
Audio	End-to-end delay, hop count	No
Data	Hop count	No

4.2. System overview

In this QoS routing mechanism, when a station wants to transmit the data, firstly, the application layer will determine the QoS requirement based on application content, Delay-constraint application, Throughput-demanded application and no specific-constraint application to improve the routing mechanism more efficiently and accurately. Application layer will communicate directly to the network layer to characterize the relevant QoS metric according to content type.

Then, the system acquires the network state using RREQ (Route Request) control message. When the source receives the RREP (Route Reply message) from the destination, it will calculate the cost for each route. To be able to send the traffic along the path with high performance, the source will choose the best route which has the minimum cost value. As a result, the chosen route is appropriate for a particular type of traffic generated by applications.

The next point is about the link break. Since the nodes in the mobile ad hoc network are mobile, link breaks are frequently occurred. Frequent link breaks make the performance of the system decrease because of frequent route discovery again. However, this system will store all of the rest routes to support as backup while the data transmission. By using the redundant routes, the number of path computing in route discovery can also be reduced.

Finally, for the throughput demanding application, routing in conjunction with bandwidth reservation scheme provide the necessary bandwidth guarantee and improves the performance of the network. The overview of the system is shown in the Figure 3 and Figure 4.

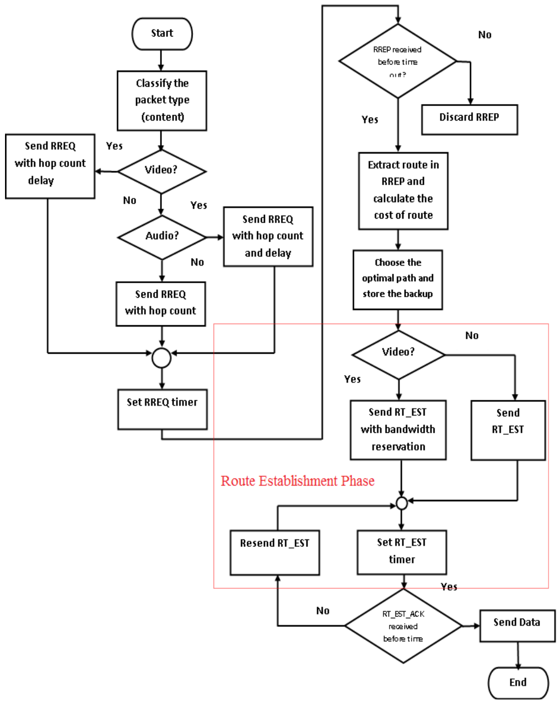

Figure 3. System flow of sender

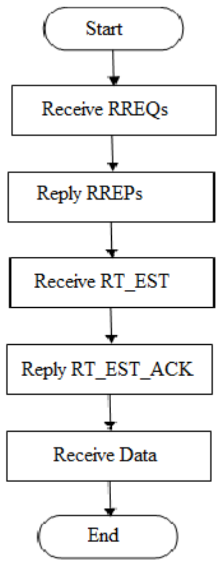

Figure 4. System flow of the receiver

4.3. CB-AODV: Content-Based Ad-Hoc On Demand Routing Protocol

To provide the QoS, some extension fields are added to the RREQ, RREP and RRER message. Application type (app_type) and requested bandwidth (rbw) fields are extended in RREQ control message. In RREP packet header, application type (app_type) and route fields are added. Similarly, RRER packet's header is modified to packet type(pk_type), upstream node (up_node) and downstream node (down_node). Moreover, the routing table is also extended with application type (app_type), previous hop and cost.

In this QoS routing protocol, two new message formats, route establish (RT_EST) and route establish acknowledgement (RT_EST_ACK) which is, are used for route establishment as shown in Figure 5 and Figure 6. This mechanism will allow the network to find the best route which is appropriate for the specific application content.

Type(5)	app_type	route
bandwidth		
src		Src_sequence
dst		Dst_sequence

Figure 5. Fields of RT_EST control message

Type(6)	Reverse

Figure 6. Fields of RT_EST_ACK control message

The role of the source node is written in the following algorithm 1.

```
IF application content is Video
    Source calculates the required bandwidth
    IF there is enough available bandwidth at the
    source node
        Broadcast the RREQ with bandwidth
        constraint for Video
    Else
        Exit
    END IF
ELSE IF the application's content is Audio class
    Broadcast RREQ for Audio
Else
    Broadcast the RREQ for Data
END IF
```

Then the source set the timer to accept the RREPs from the destination within the valid time interval. After the time out period, the source computes the cost of each route and chooses the most optimal route for establishing a route using RT_EST and RT_EST_ACK. At the same time, the source stores the rest routes to be used in case of link failure.

From the point of view of the destination, it accepts all the RREQ messages and stores the first route of RREQ message and then replies with the corresponding RREP routes using the stored route.

In MANET, the intermediate nodes behave as routers for forwarding data and control message. The intermediate node has two roles: one is for handling RREQ in source-to-destination direction and the other is for handling RREP in destination-to-source direction. When RREQ message is received, it performs as follows:

```
IF (packet-type is video )
    IF this node has the required bandwidth
        IF this node is destination
            Send RREP with relevant parameters
            and Exit
        END IF
        IF RREQ is New
            Set back the backwards pointer to the
            source node (Route-Request Table)
            Add the QoS state information to the
            RREQ
            Broadcast the RREQ message to
            neighbor nodes
        ELSE
            Discard and Exit
        END IF
    ELSE
        Exit
    END IF
END IF
```

The intermediate node will do the same operation for audio and data packet types with one exception. Bandwidth calculation will not involve in transmission of audio and data packet because these application types don't need the bandwidth assurance. For the reverse direction, whenever the intermediate node receives the RREP messages, it will just simply forward it to the source.

4.4. Route Maintenance Phase

In this phase, nodes detect the link status of next hops in active routes using Hello message. When a link break is detected, a RRER message with all affected destinations is sent to notify the source node. When the source node receives RRER message, it performs Backup Route Algorithm as follow:

```
IF there is remaining Data to send for that
destination
    Delete the route from the routing table
    Also delete the routes that contain link failure
    segments
    Extract the remaining routes and choose the
    optimal route
    Establish the new route and send the data to the
    destination
ELSE
    Delete the route from the routing table
END IF
```

5. Conclusion and Future Work

In this paper, a new mechanism is presented for content aware QoS routing protocol based on different selection of parameter which are hop count and end-to-end delay. The backup path is also set up for route reliability. Bandwidth guarantee is considered for the high throughput application. The proposed scheme is based on the AODV routing protocol. This mechanism will get the better performance the original AODV protocol.

6. Limitations

The proposed system assumes that the current network has the necessary quality of service that can offer the requested bandwidth indicated in the RREQ packets. However, if the network changes too fast, this QoS routing protocol cannot perform well. In addition to, the proposed system does not consider the link quality inferior which is the out of scope. At the present, we are still developing the system using NS2 (Network simulation tool). As a future work, we will analyze the proposed system with the original AODV protocol based on delivery ratio, packet delay and throughput using ns2. The experimental result and performance evaluation will indicate the effectiveness of this proposed system.

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