Main Title: Enhanced AODV Protocol for Hybrid Wireless Network

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Abstract

Performance of algorithms in hybrid wireless network routing environments depends on end to end communication delay. Due to the fact that the end to end communication delay includes delay needed for finding the routing path & delay needed for actual routing. This delay increases exponentially as number of nodes increases, and can only be controlled till a certain network size, after which it is not optimum to use the underlying routing protocol, and change it in order to reduce the route computational delay. Thus, in order to provide improvement in Quality of Service (QoS) of hybrid wireless networks we need to off load this complex computational task to a high power and dedicated entity, which will be solely responsible for high speed route calculations. In this paper, we propose a cloud-based routing algorithm, which utilizes the compute layer of the cloud in order to optimize the end to end communication delay, reduce the energy consumption, improve the network throughput and reduce the end to end communication delay jitter of the wireless networks.

Introduction

The wireless network is normally divided into two mainly two categories: Networks with fixed infrastructure and Ad hoc wireless networks. Typical for networks with fixed infrastructure is using of access points. An access point (AP) can act as a router in the network, or as a bridge. Examples for such type of networks are GSM and UMTS cellular networks [1]. Access Points have more information about the network and they are able to route the packets the best way. In contrast, ad hoc networks have no fixed infrastructure or centralized administrative support, the topology of the network changes dynamically as mobile nodes join or leaves the network. In ad-hoc wireless networks the nodes them-selves use each other as routers, so these nodes should be more intelligent than the nodes in centralized networks with APs.

Routing protocols in mobile networks are subdivided into two different classes [12]. Proactive routing protocols and table-driven protocols. Link-state routing algorithms normally used to flood the link information. Link-state algorithms maintain a full or partial copy of the network topology and costs for all known links. The reactive routing protocols (e.g. AODV) create and maintain routes only if these are needed, on demand basis. They usually use distance-vector routing algorithms that keep only information about next hops to adjacent neighbors and costs for paths to all known destinations. Thus, link-state routing algorithms are more reliable, less bandwidth-intensive, but also more complex and compute- and memory-intensive.

Network and Service Models

In on-demand routing protocols a fundamental requirement for connectivity is to discover routes to a node via flooding of request messages. The AODV routing protocol is one of several published reactive routing protocols for mobile ad-hoc networks, and is currently extensively researched. Each routing table entry contains the following information [2] as destination, next hop, number of hops, destination sequence number, and active neighbors for this route and expiration time for this route table entry.

When a route is not available for the destination, a route request packet (RREQ) is broadcast throughout the network. The request ID is incremented each time the source node sends a new request message, so the pair (source address, request ID) identifies a request message uniquely. On receiving a RREQ message each node checks the source address and the request ID. If the node has already received a request message with the same pair of parameters the new RREQ packet will be discarded. Otherwise the request message will be either forwarded (broadcast) or replied (unicast) with a RREP message: if the node has no route entry for the destination, or it has one but this is no more an up-to-date route, the request messages will be rebroadcasted with incremented hop count and if the node has a route with a sequence number greater than or equal to that of request message, a RREP message will be generated and sent back to the source. The number of request messages that a node can send per second is limited.

Route discovery process starts when a source node does not have routing information for a node to be communicated with. Route discovery is initiated by broadcasting a request message. The route is generated when a request message is received. A source node may receive multiple request messages with different routes from nodes. It then updates its routing entries if and only if the request messages have a greater sequence number.

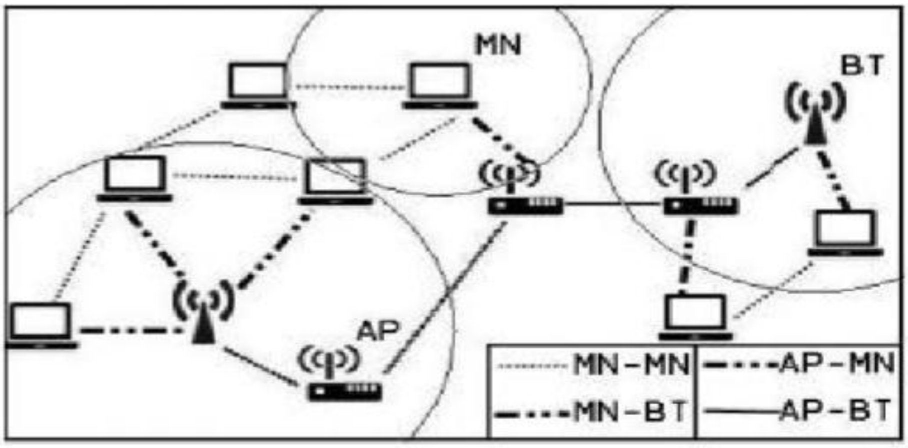

Fig.1.1. Basic MN & AP structure

The QoS specifications mainly consist of end-to-end delay bound, which is essential for many programs with stringent real-time need. While throughput guarantee is also essential, it is instantly assured by bounding the transmitting wait for a certain quantity of packets. The resource node performs entrance management to check whether there are enough sources to fulfil the requirements of QoS of the bundle flow. Fig. 1 reveals the network design of a multiple system. For example, when a source node n1 wants to publish information to an Online server through APs, it can select to deliver packages to the Apsdirectly by itself or need its next-door neighbour nodes n2, n3, or n4to support the bundle transmitting.

We believe that lining up happens only at the outcome ports of the cellular nodes. After a cellular node produces the packets, it first tries to deliver the packages to its nearby Aps that can assurance the QoS specifications. If it is not able (e.g., out of the transmitting variety of APs or in a hot/dead spot), it depends on its others who live close by that can assurance the QoS requirements for sending packages to APs. Relaying for apacket flow can be made as a procedure, in which packets from a resource node navigate a variety of queuing servers to some APs. In this design, the issue of how-to assurance QoS redirecting can be modified to the problem of how-to routine the next-door neighbour sources between nodes to make sure QoS of bundle redirecting.

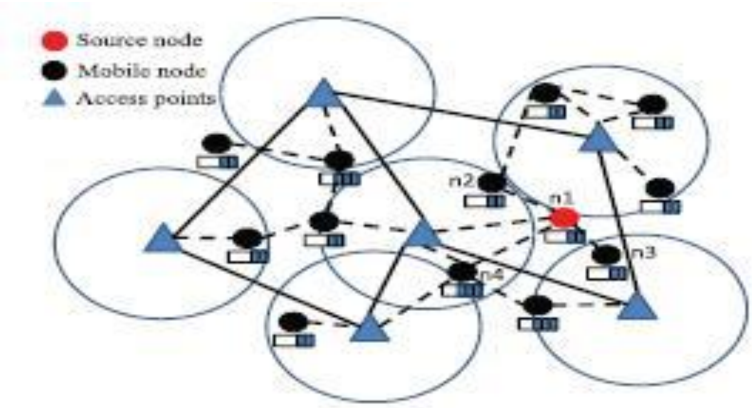

fig.1.2. Structure of Network Model

Literature Review

Wireless Routing Protocol Basics

There are several unicast routing algorithms that have been developed for MANETs that have their own unique characteristic strengths and weaknesses. A detailed description of all these protocols is beyond the scope of this thesis. We do describe in detail, however, all protocols that we felt were relevant to this work. Different algorithms may have benefits in different topologies and motion scenarios and for different application scales. For example, one protocol may work very well for 10 nodes in a small area but may work poorly (cause excessive delay or fail to deliver or drop most packets) for 100 nodes in a Proposed ge area or in certain mobility conditions.

The simplest wireless routing protocol is called flooding and as the name implies, a message is sent by a node to all its neighbors who send it out to all their neighbors and so on until it reaches the desired destination. This is one method known to guarantee delivery of packets provided at least one path exists between any two nodes. It has a great drawback, however, in that it wastes a lot of the limited bandwidth available, and if all nodes were to flood all other nodes, there would be too much interference, causing what is known as the Broadcast Storm problem [15]. Ideally, flooding should be avoided as much as possible or only done when absolutely necessary, such as in instances of very high mobility or to set up initial routes.

Classification of Routing Protocols

Most protocols can be classified in several ways. Some are classified as reactive or on- demand while others are proactive. In general, a proactive protocol finds routes in advance while a reactive protocol finds routes to the destination only when it absolutely must. For example, Ad hoc On demand Distance Vector routing (AODV) [16] is an on-demand protocol since no protocol information is transmitted before an application decides to send data and no data is sent until a route is formed, whereas Destination Sequenced Distance Vector protocol (DSDV) [17] is a more proactive protocol in which routes are discovered and stored even before they are needed.

Proactive protocols generally generate much more traffic than on-demand protocols. A third general category is a hybrid algorithm that effectively combines multiple characteristics in a unique and meaningful way. For example, the Zone Routing Protocol (ZRP) is a hybrid protocol that combines local proactive routing with a globally reactive routing strategy.

Geographic Routing

Another possible way of characterizing MANET routing protocol is whether they utilize position information or not. AODV for instance does not use position information whereas protocols like GPSR, GRID [9] and Proposed [10] do use position information. GPSR, GRID and Proposed and can be considered position based or geographic routing protocols since the position of each node is used as the basis for most routing decisions. It is assumed that individual nodes are aware of their own positions in absolute or relative terms as well as their velocity and the direction in which they are moving. This category is very relevant to this thesis since the protocols we propose lie in this category. At present there are already over thirty such position-based protocols, as can be seen in the taxonomy of position-based protocols by Ivan Stojmenovic and others [s1] and in [s2].

Some researchers have also proposed how computational intelligence can be applied to wireless sensor networks. A detailed description of this is given by Raghavendra V. Kulkarni and his team [5], wherein they have compared various algorithms for computational intelligence like neural networks, fuzzy logic, evolutionary algorithms like genetic algorithm, swarm intelligence techniques like particle swarm optimization, Artificial Immune Systems and Reinforcement Learning. Using this research, we evaluated that reinforcement learning which is a part of machine learning is one of the best choices for routing in wireless networks, and can be exploited further for increased network performance. Clique, Q-Routing, DRQ-Routing, Q-RC, RL-Flooding, TPOT-RL,SAMPLE,AdaR,Q-PR,Q-Fusion,RLGR are some of the examples of algorithms which are developed by various researchers over the globe to demonstrate how reinforcement learning can be used to optimize the network performance.

Another example of reinforcement learning is given by Anna Forster and Amy L. Murphy [6] in their paper on FORMS, wherein they are using reinforcement learning to optimize multiple sinks in the WSN networks. They have used Q-Routing technique to the multiple sink problem and obtained a low network overhead while maintaining an acceptable network QOS in practical WSNs. Their algorithm natively supports node failure and sink mobility and reduces the routing cost. Our work is inspired by these algorithms, and we thus developed a novel technique which is based on machine learning, for routing the data in the given wireless network environment. The next section describes our algorithm in details.

Proposed Methodology

Since short delay is the major real-time QoS requirement for traffic transmission features the Earliest Deadline First scheduling algorithm (EDF), which is a deadline driven scheduling algorithm for data traffic scheduling in intermediate nodes. In this algorithm, an intermediate node assigns the highest priority to the packet with the closest deadline and forwards the packet with the highest priority first. The source node needs to distribute its packets to nodes based on their available workload rate to make the scheduling feasible in each of the neighbor nodes the problem can be modelled as a linear programming process.

QoS optimization with multichannel data aggregation and lifetime aware routing

Our routing algorithm can be described as follows,

- Deploy a network of N nodes placed randomly in an area of X x Y sq. meters
- Select any source (S) and destination (D) from the network for routing process
- Let the euclidean distance between node S and D be dref
- Select all nodes from the network, where the following conditions are satisfied,

1. dsn+dnd > dref
2. dsn < dref

3. dnd < dref

where, dsn = Distance between source to selected node

dnd = Distance between selected node to destination

- This filters in only those nodes which are in the routing path, and removes all other nodes
- For each node in the path, evaluate the following metric,

Metric = di/Ei

where, di = Distance between the nodes

Ei = Energy of the source node

- Start the node selection from the source till the destination node is reached. Once reached, send the data on the selected path
- Before sending the data, apply data aggregation at the source node
- Split the aggregated data into k parts, where k is the number of channels available for routing
- Send the data on all the k channels from the source node to the destination
- Repeat this process for all communications

The above algorithm makes sure that the data is sent from the source to destination with minimum delay, and minimum energy due to data aggregation, multichannel communication and incorporation of d/E factor in the routing process. The throughput is optimized as well due to improvement in delay and reduced packet loss due to multichannel communication. This makes sure that the packet is transmitted in the almost same timing interval as the previous packets, thereby reducing the jitter of the network. The detailed result analysis is mentioned in the next section.

Implementation

As observed from the above we can see that there are multiple nodes present in a network the data is to be sent from sender to receiver. The modules of the system are as follows:

I. Input Data:

In this module, the data is selected by the system itself. As observed the red dot is the sender in the network it will select the data to be sent.

II. Priority:

Once the data is selected the system sends the data for processing. If the data is of high priority it is sent first similarly if the data is of low priority it is sent with a small delay. Due to which the efficiency of the network increases.

III. Routing Protocol:

We are going to use a hybrid algorithm using ASDV and DSDV protocols. According to the priority, the hybrid selects the algorithm to route the data from sender to receiver.

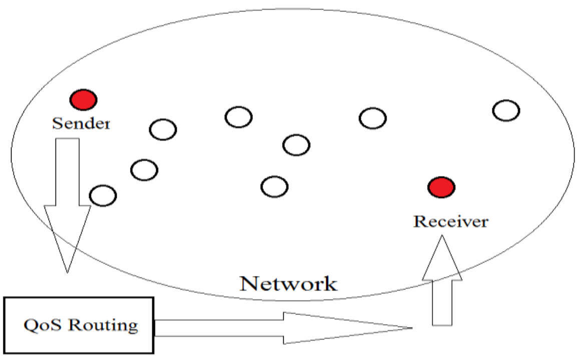

Fig.1.3. Structure of QoS Routing

We simulated our routing protocol in the network simulator version 2.3 environment, under the following network conditions,

Network parameter	Value
Network type	Wireless
Number of nodes	30 to 100
Network area	300m x 300m
Routing protocols	QoS aware
Packet size	1000 bits @ 0.001 packets per second
Number of communications	2 to 20
Initial node energies	Randomized, with maximum energy of 1000 mJ per node
Energy model	2 mJ per transmission 1 mJ per reception 0.1 mJ idle energy

Table 1.1. Network Parameters.

We compared our proposed protocol with the AODV routing for the wireless network, and the following parameters were obtained,

Nodes	Comms.	Delay AODV (ms)	Delay Proposed (ms)	% Improv.
20	2	0.31	0.24	21.74
20	3	0.35	0.27	22.78
20	4	0.38	0.26	31.10
20	5	0.41	0.33	18.45
50	5	0.37	0.32	12.49

50	6	0.39	0.28	27.31
50	8	0.52	0.41	20.32
50	12	0.63	0.49	23.00
Mean Improvement		0.42	0.32	22.15 %

Table 1.2. Results of AODV Protocl & Proposed Protocol

Similar comparisons were made for energy, packet delivery ratio, throughput and jitter. The following table shows the performance comparison:

Parameter	AODV	Proposed	% Improvement
Avg. Delay (ms)	0.477	0.362	23.61 %
Avg. Energy (mJ)	3.126	2.198	29 %

Table 1.1. Comparision Between Protocols.

From the above table we can observe that the network delay has been minimized, the energy consumption has been reduced by maintaining a constant average. Due to reduction in delay, the jitter is also reduced and thus it makes the network more reliable and consistent in terms of packet delivery times at the receiver. The PDR and throughput of AODV is already optimized, and thus there in minimal scope of improvement in that area. We recommend researchers to further evaluate this machine learning routing technique in order to check it's viability for the applications for which they would be designing the communication network.

Conclusion

The proposed approach when applied to the wireless network gives a significant improvement in network performance, when compared with the recent de-facto AODV routing algorithm. The performance improvement to network lifetime is more than 25%, while the delay minimization is more than 20% for a wide variety of network simulation parameters. This causes the network throughput to reduce by an infinitesimal percentage which is admissible by the wireless networks, due to the fact that our algorithm increases the energy consumption efficiency for the network, that can be used effectively by low power devices.

Future Scope

As a future work, we plan to realize the protocol using hardware implementation in a real time wireless based network, due to the low-cost nature of Arduino based wireless nodes, the hardware realization can be done in a closed lab environment. We also intend to research more into the QOS improvement of the wireless networks by incorporating more parameters into our machine learning protocol.

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