QoS Aware Distributed Routing Protocol Based on Energy Efficiency for Hybrid Wireless Networks

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***Abstract*— Mobile hosts and wireless networks are becoming increasingly popular. The rapid development of wireless networks has motivated many wireless applications that are used in various areas such as commercial applications, medical emergency services, industrial environment etc. The emergence of real time and multimedia applications has stimulated the need of high Quality of Service (QoS) support in wireless and mobile networking environments. Emerging next generation hybrid wireless networks could provide high flexibility and reliability. Hybrid wireless networks combine the advantages of both infrastructure networks and adhoc wireless networks. But QoS support for routing in hybrid wireless networks is a challenging process because of their dynamic topology and varying bandwidth. For ensuring QoS support in hybrid wireless networks, the proposed idea is to implement energy aware QoS Oriented Distributed routing protocol. This protocol ensures QoS parameters such as high energy efficiency, improved throughput and reduction in transmission delay. The energy aware concept is an important concern in hybrid wireless networks due to the fact that the mobile nodes are run by limited battery power and by reducing their power consumption the network lifetime can be increased.**

Index Terms*— Hybrid Wireless Networks, Adhoc Wireless Networks, Quality of Service, Routing Protocol.

I. INTRODUCTION

The tremendous expansion of wireless communication technologies such as cellular networks and wireless local area networks has enabled the support of global network connectivity for mobile computers. Wireless technology is anywhere and everywhere, and that fact alone makes it a very efficient tool. The remote capability of wireless technology itself enables the introduction of applications and services to reach people and places in extreme terrestrial conditions. In general, the more convenient the technology, the more extensively users will accept it.More people using wireless technology means the services become more robust and reliable, and thus more socially impactful. Emerging next generation hybrid wireless networks could provide high flexibility and reliability. Hybrid wireless networks are networks in which any mobile node in a wireless network may have connectivity, either directly or via a gateway node, to an infrastructure network. The latter network may be an IP network as the Internet, a 3G wide area wireless network, or an 802.11 local area wireless network. A hybrid wireless network can provide higher throughput and switch between different types of networks, having an endless access to integrated or distributed services. Thus various benefits to both users and service providers/network operators are expected. Providing Quality of Service (QoS) for real time applications such as voice, data, and multimedia services is an important objective in the design of hybrid wireless networks. Quality of Service (QoS) can be defined as the performance level of a service offered by the network to the user. Different applications possess diverse QoS requirements in terms of data rates, transmission delay bounds and bandwidth requirements.

In the infrastructure wireless networks and adhoc wireless networks there are many existing protocols which guarantee QoS. Intserv, RSVP etc. are some of the different protocols which guarantee QoS in infrastructure networks. These protocols are based on principles like node negotiation, resource reservation etc. Similarly in adhoc networks, many QoS routing protocols are proposed for ensuring QoS. QoS Adhoc On demand Distance Vector (QoS AODV), Core Extraction Distributed Ad Hoc Routing (CEDAR) etc. are some of the existing QoS routing protocols for Mobile Adhoc Networks (MANET).

In hybrid wireless networks, hardly any efforts have been made for supporting QoS. The protocols for infrastructure networks and MANETs would not be suitable for hybrid networks for a number of reasons such as invalid reservation problems, race condition etc. The aim of this paper is to propose a new distributed routing protocol for ensuring QoS in hybrid wireless networks namely Energy Aware QoS Oriented Distributed Routing Protocol. The proposed system mainly focuses on how to minimize power consumption of the nodes during routing. The other QoS metrics considered are increasing throughput and minimizing the transmission delay [1].

Usually a hybrid wireless network consists of a number of a base stations (BS) and a set of mobile nodes/hosts (MH) under the control of every base station. Transmissions can be either in the infrastructure mode or in adhoc mode. In the infrastructure mode, base stations are involved in packet routing wherein adhoc mode nodes directly communicate among themselves. The number of hops between a source node and destination node is limited to two. The destination node could be a BS as well. The two hop limit would help in reducing the power consumption involved in multi hop routing. The power aware concept minimizes the power consumption of the nodes during routing and thus increases the network lifetime. The energy aware concept mainly focuses on how to reduce the power consumption during routing among mobile nodes. There could not be any specific steps that could be initiated for reducing the the power consumption in the case of a BS to BS/MH communication .The rest of the paper is organized as follows.

II. RELATED WORK

Hybrid wireless networks combine the advantages of Base Station oriented networks and Adhoc wireless networks [2]. They have been proven an alternative for the next generation wireless networks. The hybrid routing protocols are far more flexible, reliable and have better performance than the traditional wireless network protocols. A source node directly communicates with the destination node if the hop count distance is one, without seeking the help of the base station. If there is a suitable neighboring node between the two nodes, then two hop communication is used by the system. Existing hybrid routing protocols are mainly focused on improving the reliability and network capacity. But the aim of the new Energy Aware QOD (E-QOD) protocol is to provide QoS guaranteed routing.

An adhoc network may be defined as any set of networks where all devices have equal status on a network Adhoc network often refers to a mode of operation of IEEE 802.11 wireless networks. The decentralized nature of wireless adhoc networks makes them suitable for a variety of applications where central nodes can't be relied on and may improve the scalability of networks compared to wireless managed networks. Energy optimization is an important factor in case of adhoc wireless networks because the nodes which are mobile in nature are run by limited battery power. Due to factors such as their dynamic topology, mobility and routing by multiple hops may result in draining of battery power at a faster rate. In order to meet QoS constraints such as reduced power consumption and improved throughput, the power aware protocols consider factors such as the shortest path, node lifetime, and minimum drain rate etc. are considered in an Adhoc network. [3]

In case of wireless sensor networks (WSN), depletion of battery power takes place even much faster because the sensor nodes are featured by their constant sensing rate and data aggregation. Hence there are algorithms followed for the purpose of energy management in case of WSN also [4].

Infrastructure networks need a central access point to which all devices are connected. Most of the Wi-Fi networks function in infrastructure mode. Devices on the network communicate through a single access point, which is usually a wireless router. Consider a situation where two laptops are connected to the same wireless network. These devices would not be communicating directly. Instead, they communicate indirectly via the common access point. A variety of approaches have been adopted for guarantying QoS for infrastructure networks. There are mainly two models namely Intserv and DiffServ [5]. In computer networking, IntServ or integrated services is an architecture that specifies the elements to guarantee QoS on networks. IntServ can be used to allow video and sound to reach the receiver without any interruption. The idea of IntServ is that every router in the system implements IntServ and every application that requires some kind of guarantees has to make an individual reservation.

In recent years, there are several studies on routing related parameters like connectivity related parameters and density of the distributed nodes, in wireless networks [6]. Previous works studied the connectivity probability of two certain nodes versus the entire network. Other works investigated on uniformly and independently distribution under the assumption that the transmission range is fixed among the mobile nodes [7]. Some energy-efficient approaches have been explored in the literature [8]. As transmitting data consumes much more energy than other tasks of mobile nodes, energy savings optimization is realized by finding the minimum energy path between the source and base station in MANETs and WSNs. The unreliable wireless links makes routing in wireless networks a challenging problem. In order to overcome this problem, the concept of opportunistic routing was proposed [9]. Opportunistic routing take advantage of the broadcast nature of the wireless medium, and allow multiple neighbors that can overhear the transmission to participate in forwarding packets. To improve the energy efficiency for transmitting data, most of the existing energy efficient routing protocols attempt to find the minimum energy path between a source and a sink to achieve optimal energy consumption in WSNs [10].Mao et al. [11] introduced an energy efficient opportunistic routing strategy called energy efficient opportunistic (EEOR) which selects a forwarder set and prioritizes them using energy savings optimization solution of forwarding data to the sink node in WSNs.

III. SYSTEM MODEL

A. Network Model

Consider a hybrid wireless network with an arbitrary number of base stations spanning over the network. Consider a set of mobile nodes which are moving around in the network. In this architecture, when two nodes which are not in direct transmission range but belongs under the control of a single base station, the connection is routed through multiple wireless hops over the intermediate nodes. The base station maintains the topology information of the network for efficient routing. The base station need not be involved for this kind of routing. Thus hybrid wireless networks can provide high capacity resulting in lowering the cost of communication. The architecture of a hybrid wireless network is shown in fig 1.Our scheme is targeted for relatively dense network, i.e., each relay node has plenty of neighboring nodes. Nodes have some knowledge of the location information of their direct neighboring nodes and the position of the source node and the

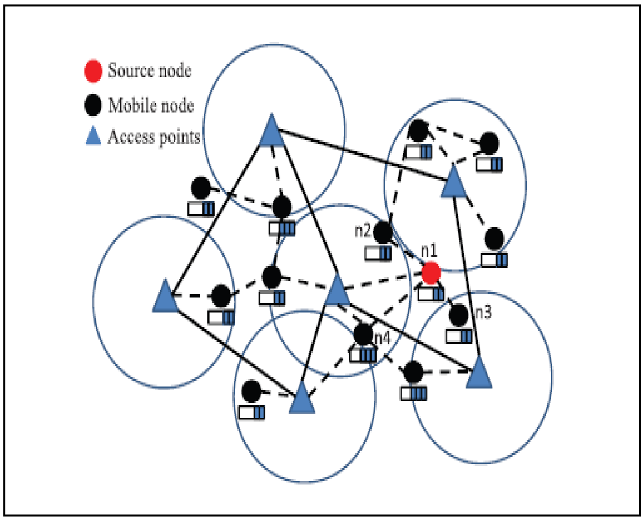

Fig. 1.The network model of hybrid wireless networks

BS. Every wireless node has fixed maximum transmission range R and a minimal transmission ranged_{min}. The network is then constructed by a connected graph G = (V, E), where V is a set of mobile nodes and E is a set of links between these nodes. Let N (n) represents as the neighbor set of a node n, i.e., i ϵ N (n). Each directed link (n, i) has a nonnegative weight w (n,i), which denotes the total energy dissipation in transmission and reception required by node n to its neighboring node i.

B. *Energy Model*

Consider a hybrid wireless network as shown in fig 1.A simplified model of radio communication is considered to analyze the energy model. The energy consumption can be expressed as follows:

$$E_T = (E_{elec} + \varepsilon_{amp} d^t)\, B \qquad (1)$$

where E_{elec} is the basic energy consumption of a wireless node to run the transmitter or receiver circuitry, and ε_{amp} is its energy dissipated in the transmit amplifier and d is the distance between transmitter and receiver, τ is the channel path loss exponent, which is affected by the radio frequency (RF) environment. E_T denotes the energy consumption to transmit a B-bit message in a distance d. On the other hand, the energy consumption of receiver ER can be calculated as follows:

$$E_R = E_{elec} B \qquad (2)$$

Here we are concerned with energy optimization during transmission. The energy optimization that could be done in the circuitry, noise interference etc. are not considered.

IV. OVERVIEW

A. *Energy Aware QOD Protocol*

Energy management is defined as the process of managing the sources and consumers of energy in a node or in the network as a whole for enhancing the lifetime of the network. Shaping the energy discharge pattern of a node's battery to enhance the battery life, finding routes that result in minimum total energy consumption in the network etc. are some of the functions of energy management. Energy management schemes are highly important in hybrid wireless networks as such networks are designed to serve large number of power constrained mobile nodes. Based on the topology of the network formed by the mobile nodes, a BS estimates the minimum necessary power to achieve connectivity. The maximum achievable throughput is a function of the transmission power used. The higher the transmission power, the lower the throughput achieved.

B. *Energy Aware QoS Oriented Routing Algorithm*

In this section we further analyze the energy consumption of hybrid wireless networks under the Energy Aware QoS Oriented Routing Algorithm. In order to acquire the minimum energy consumption during data transmission in whole network, we introduce the concept of energy optimal strategy at the position based on the optimal transmission distance d_{op}. We can achieve optimal energy strategy by choosing optimal hops n_{op} to determine optimal transmission distance d_{op}. In addition, factors such as energy balanced of a network and the residual energy of nodes are also considered while selecting the available next hop forwarder. We assume that node 'n' is sending a data packet to the BS and 'n + i' is one of neighbors of node n. If the neighboring node is having more residual energy, the node 'n+ i' can be a forwarding candidate, then the network can obtain better energy usage. Moreover, these eligible candidates rank themselves according to their distances from the access point or destination node and the residual energy of each node is calculated as

$$P(n+i) = \begin{cases} (d_{n+i} - d_n)\left[\frac{1}{|d_{n+i} - d_{op}|} + (E_{n+i} - \zeta)\right] \\ (n+i) \in F(n), -R \le i \le R \end{cases} \qquad (3)$$

where $d_{n+i} - d_n$ is the distance between node n and neighbor node n + i, E_{n+i}denotes the residual energy of node n + i, and ζ denotes the value of energy threshold. F(n) ,(F(n) ⊆ N(n)) is the selected forwarding candidate set of node n. The larger the value of P(n + i) is, the higher priority of the node will be. Only the forwarder candidate with the highest priority is selected as the next forwarder. We use above forwarding candidate set to decide corresponding energy saving strategy, which is specifically achieved through the following opportunistic routing algorithm, called Energy Aware QoS Oriented Algorithm.

Algorithm 1. Energy Aware QoS Oriented Algorithm

Require:

d_i, d_n, d_{op}, E_i, where i ε F(n).

Event:

Node n has a data packet to send to the BS or to a destination node.

1: start a retransmission timer
2: select the forwarder set F (n) from neighboring nodes N (n)

3: for each node i ∈ N (n) do
4: if ((d (i,d_{op}) < d(n, d_{op})) ∪ (E_i>ζ)) then
5: add i to F(n);
6: end if
7: end for
8: prioritize the forwarder set using Optimal Energy Strategy;
9: for each node i ∈ F (n) do
10: P (i) = ($d_i - d_n$) [1/ ($d_i - d_{op}$) +(Ei −ζ)]
11. end for
12: send the data packet through the selected neighbors.
13: for each node i ∈ F (n) do
14: receive the data packet;
15: checks the sender ID and start a timer.
17: if node n which has the highest-priority receives the data packet successfully then
18: reply an ACK to notify the sender;
19: for each node i ∈ F (n) except n do
20: discard the data packet and close timer to avoid duplication;
21: end for
22: if no forwarding candidate has successfully received the packets then send via BS.

IV. PERFORMANCE EVALUATION

This section demonstrates the distinguishing properties of E-QOD compared to that of adhoc networks and QOD.The proposed protocol provides a better performance for hybrid wireless networks .The energy consumption of hybrid wireless networks is much lesser than adhoc networks because of avoiding multhop paths. Besides this, base station service is not used for one hop and two hop transmissions. The energy consumption during transmissions in adhoc wireless networks and hybrid wireless networks is shown in fig.2.

This algorithm improves the network lifetime to a greater extend. This means that the proposed routing algorithm makes the network perform in an efficient manner. The graph in fig 3. plots the residual energy of the nodes in the network to that of the time of simulation. The nodes having more residual energy would increase the network lifetime.

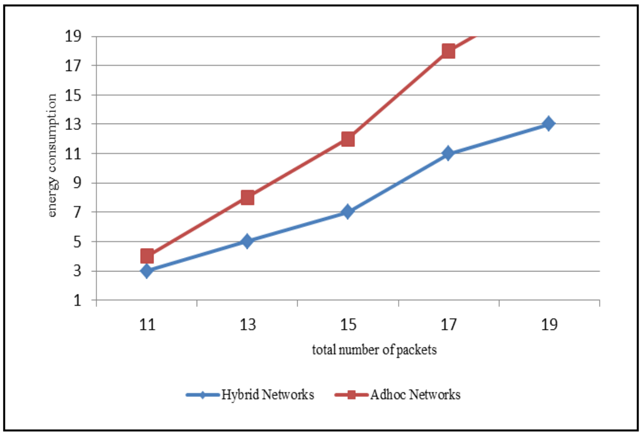

Fig. 2. Energy consumption versus number of packets

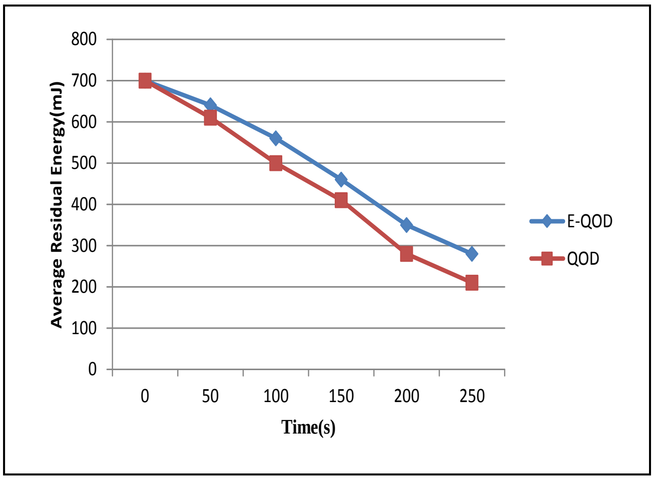

Fig. 3.Average Residual Energy versus time of transmission.

V. CONCLUSION

Hybrid wireless networks combine the advantages of infrastructure networks and adhoc wireless networks. They have proven to be a better alternative for the next generation networks. Still hardly any works have been initiated been for guaranteeing QoS routing in hybrid networks. The protocols for infrastructure networks and MANETs would not be suitable for hybrid networks for a number of reasons such as invalid reservation problems, race condition etc. In this paper, we propose an Energy Aware QoS Oriented Distributed Routing Protocol (E-QOD) for hybrid wireless networks to satisfy QoS requirements. We know that the mobile nodes are equipped with the limited battery power. Energy savings optimization, therefore, becomes one of major concerns in the HWN routing protocol design. In this paper, we focus on minimizing energy consumption and maximizing network lifetime of hybrid wireless network. The network energy efficiency is optimized by considering the differences among mobile nodes in terms of both their distance to base station and their residual energy .The simulation results show that the proposed solution makes significant improvement as compared with other routing algorithms.

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