Quality of Service-aware Routing for Static Mesh Networks with Mobile Nodes

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Abstract- This paper describes work in progress to explore a quality of service based routing protocol suitable for a hybrid wireless mesh network. A hybrid network has both static and mobile wireless mesh routers. The combination of static and mobile routers can increase the reach and redundancy of an ad hoc network. Such networks ideally suite a rural environment where constant management and maintenance is unaffordedable. The network would therefore be extremely dynamic and require optimization of the routing protocol to adapt to frequent topological changes. The latest smart mobile phones, such as those running Android, can act as routers to support mesh protocols. We believe the use of these high end mobile handsets amongst the rural populace may become common place on village telco-type networks. However, adding mobile phones to a mesh network complicates the link structure and the stability of the network. The routing protocol should therefore know the topological situation, and the quality of its links, before making a routing decision. We will use statistical methods to monitor the stability of links and use the media access control layer to measure link signal strength to compute a situation-aware next-hop.

Index Terms TCP/IP & Layer 3 Protocols, Mobile/wireless protocols, Wireless mesh networks, Quality of service, Situation-aware routing.

I. INTRODUCTION

Quality-aware routing in mesh networks is about making routing decisions based on link quality. This paper discusses work in progress to study quality-aware routing on static wireless mesh networks with mobile nodes for quality of service (QoS) optimization. We call such a network a hybrid mesh network, as shown in Fig. 1.

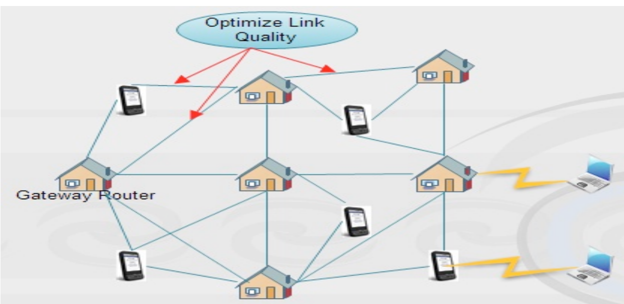

Fig. 1: A hybrid mesh network, applicable to a rural area, with static mesh routers inside homes, and mobile routers on cell phones. The goal is to optimize link quality within such dynamic topologies.

Wireless mesh networks (WMNs) have recently gained much popularity, as well as research attention, due to their inexpensive deployment and interesting characteristics. A wireless mesh network is a distributed network that can self-discover and self-heal [1]. WMNs offer an ideal infrastructure for providing affordable wireless Internet access to the less privileged. Such end-users still rely on 'push' type information such as newspapers, television news and radio. In our view, all people should have access to on-demand information such as the Internet, and mesh networks offer an affordable way to provide that access.

Routing protocols are at the centre of ongoing research on WMNs. This paper describes an aim to optimize BATMAN, a mesh routing protocol, to be feasible for a hybrid mesh network. Due to the participation of mobile nodes/routers, the protocol should be able to adapt to rapid topological changes. Situation-aware methods are proposed to improve the routing decisions in the hybrid mesh network to optimize the link quality for better throughput. BATMAN's routing algorithm checks for the existence of a link and increases the probability of delivering a packet through that link [7].

We propose two methods to optimize BATMAN's routing algorithm: statistical situation monitoring and MAC layer situation monitoring. The first uses standard deviation and average calculations to estimate the stability of a link, and the second method queries the MAC layer of the WMN to check the strength and congestion rate of a link. The investigation will test a situation-aware modification of BATMAN through simulation as well as on an actual network. CPU cycles will be taken into consideration for the examination of the computation complexity.

The rest of this paper is organized as follows: Section II previews the related literature, Section III discusses the methods and Section IV highlights conclusions and future work.

II. RELATED WORK

Routing is a process of delivering data packets from a source (sender) node to destination (receiver) node on a network. Routing protocols deal with the maintenance, creation, establishment and discovery of such routes [2]. Routing protocols are based on three protocol classification categories: proactive, reactive and hybrid. In proactive protocols, each node in the network maintains a table containing routing information of the entire network, which is updated periodically. Reactive protocols, also referred to as on-demand protocols, create a route from source to destination only when needed, e.g. when there is data to be sent. Hybrid protocols exhibit behavioural design aspects of both approaches.

Ad-hoc on demand distance vector (AODV) is one of the popular reactive protocols and hence creates routes on demand. AODV is a single path routing that is based on hop-by-hop routing [3]. Ad-hoc on-demand multipath distance vector (AOMDV) routing is based on AODV. Unlike AODV, AOMDV utilizes multipath routing alleviating link failures and link breakage suffered in AODV [3][4]. MeshDv is a hybrid protocol that uses a combination of proactive route computation for the routers and on-demand path request for clients [2] [5]. Optimized link state routing (OLSR) protocol is a proactive protocol that is based on a link state algorithm and uses hop-by-hop routing [6]. OLSR's objective is to reduce the size of control packets as well as the overhead cost by broadcasting control packets. Multipoint relays (MPR) are key to OLSR [7], and are subsets of the neighbours that a node uses to forward broadcast messages. A 'better approach to mobile ad-hoc networks' (BATMAN) is another proactive protocol that only maintains information about the best next-hop towards the destination [1][2] and thus reduces signal overhead. The objective of this protocol is to enhance the probability of delivering a packet [8]. The protocol maintains information about the existence of a node and thus does not check the quality of the packet [8]. BATMAN protocol stack has been successfully ported on an Android platform by the village-telco team (www.villageteco.org).

Routing protocols use metrics to decide how to select the best path to the next hop. Hop count routing metrics count the number of hops between the sender and the destination. This metric is simple to compute but does not consider packet loss or bandwidth. Expected transmission count (ETX) is a quality-aware metric that considers the number of MAC layer transmissions needed to successfully deliver a packet through a link [9][10]. An expected transmission time (ETT) metric was developed to overcome the shortcomings of ETX and hence it is an optimization of ETX [9]. Weighted cumulative ETT was designed to overcome the shortcomings of both ETX and ETT in order to reduce interference [9].

III. METHODS

We now turn attention solely on how to optimize BATMAN based on the related work. BATMAN uses control packets called originator messages (OGMs) in routing decisions. The proposed methods adopt the same criterion with some added QoS-oriented features. Each node in BATMAN periodically broadcasts OGMs to its neighbours who further rebroadcast the packets. The best link is measured by the highest number of OGMs received from the destination over a current sliding window. Given the mobility of mobile nodes, rapid topological changes to the hybrid mesh network are inevitable and thus the ideal approach is to take the current network situation into consideration before making routing decisions.

The first proposed method uses statistical methods to ensure the stability and reliability of the link. By computing statistical standard deviation of the number of OGMS recorded in the current sliding window, the variability of the link will be evaluated. Depending on the network's behavioural data, we will consider the top ranked links by BATMAN and apply statistical quality to check on them.

The second proposed method uses OSI Layer 2 information to estimate the signal strength and the congestion rate of the links. The Received Signal Strength Indicator (RSSI) obtained from the MAC layer will be used in this regard. The signal-to-noise ratio (SNR) will also be used to check the quantity of signal affected by noise. Again the top ranked links by BATMAN will be considered together with RSSI and SNR in to make routing decisions.

IV. CONCLUSIONS AND FUTURE WORK

According to the literature reviewed, BATMAN outperforms many other WMN protocols. However BATMAN does not check the quality of the link to make routing decisions. Considering the rapid topological changes in hybrid WMNs with mobile routers, quality-aware methods based on the network situation at any given time were proposed. These methods look at link stability and reliability to optimize routing decisions.

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