Simulation Modelling Practice and Theory 77 (2017) 245–271

Contents lists available at ScienceDirect

Simulation Modelling Practice and Theory

journal homepage: www.elsevier.com/locate/simpat

# Energy and mobility conscious multipath routing scheme for route stability and load balancing in MANETs

Waheb A. Jabbar[a,*], Mahamod Ismail[b], Rosdiadee Nordin[b]

[a] *Faculty of Engineering Technology, Universiti Malaysia Pahang (UMP), Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang, Malaysia*

[b] *Department of Electrical, Electronic and Systems Engineering, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia*

ARTICLE INFO

*Article history:*
Received 2 April 2016
Revised 5 July 2017
Accepted 7 July 2017

*Keywords:*
MANET
Energy-Efficient
Mobility-Aware
MP-OLSRv2
MBMA-OLSR

ABSTRACT

Mobility and limited energy resources of nodes are the most critical attributes of Mobile Ad hoc Networks (MANETs). The mobility of the nodes changes the network's topology in an unpredictable manner, which in turn, affects the stability of connected paths. In addition, it causes an excessive overhead traffic that leads to a higher energy consumption and degrades the performance of routing protocols. Therefore, a routing scheme in MANETs should comprise techniques that cope with challenges incurred by both the energy failures and node's mobility. In this paper, we proposed Multipath Battery and Mobility-Aware routing scheme (MBMA-OLSR) based on MP-OLSRv2. Specifically, the study exploits a Multi-Criteria Node Rank (MCNR) metric that comprises the residual battery energy and the speed of nodes. It aims to rank the stability of the links using a link assessment function and to select the most efficient and stable paths to the destination. Moreover, an Energy and Mobility Aware Multi-Point Relay (EMA-MPR) selection mechanism is introduced and utilized by the MBMA-OLSR to set the willingness of nodes to contribute as MPRs, for flooding topological information. We implemented the proposed scheme as an extension to the EXata network simulator. Benefits of the innovative scheme have been demonstrated and validated under various simulation scenarios based on different mobility parameters. The simulation results provided evidence of the effectiveness of our scheme, especially during the high mobility scenarios with heavy traffic load where it outperformed the conventional MP-OLSRv2 routing protocol in terms of QoS and energy related metrics.


## 1. Introduction

Mobile Ad hoc Network (MANET) is identified as the pure general purpose networking paradigm of multi-hop ad hoc networks [1]. General purpose denotes that these networks are designed without any specific applications in mind, but rather to support any legacy TCP/IP applications as shown in Fig. 1. In such networks, people with smart devices (mobile nodes) which are battery-powered can freely and dynamically form a self-configuring MANET to send, receive and share data in a restricted zone. Hence, the connection between the mobile nodes and the topology of the network will change frequently. There is a variety of applications for MANET paradigm, especially in places where there are difficulties in the

* Corresponding author.
*E-mail addresses:* waheb@ump.edu.my, waheb@ieee.org (W.A. Jabbar), mahamod@ukm.edu.my (M. Ismail), adee@ukm.edu.my (R. Nordin).

http://dx.doi.org/10.1016/j.simpat.2017.07.001
1569-190X/

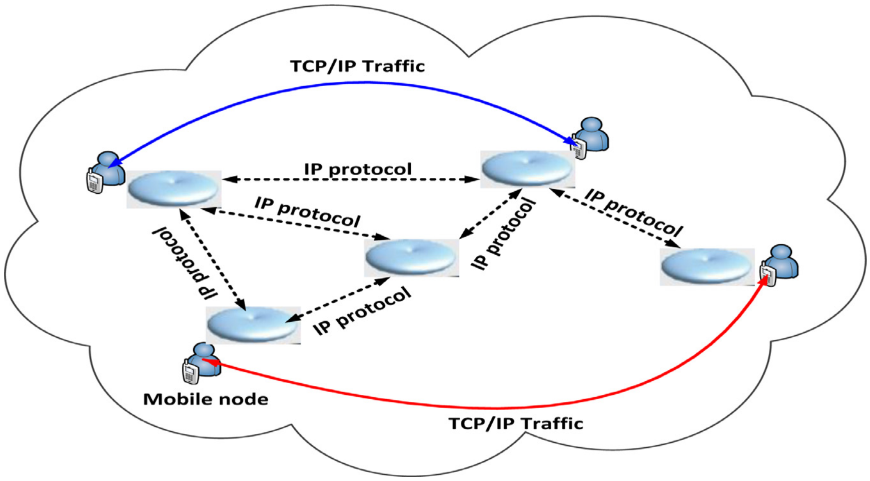


**Fig. 1.** The pure general purpose MANET paradigm (modified from [6]).

deployment of network infrastructures such as in battlefield communications, disaster recovery, crisis management services and health care.

The limited battery capacity and the mobility of nodes are key features in MANETs which render routing in such mobile environments a challenging issue [2,3]. In MANETs, energy failures are becoming more serious than common network failures [4]. Moreover, the changes of topology due to the mobility of nodes also affect the consumed energy for data transmission. Therefore, routing schemes in MANETs need to comprise mechanisms that cope with the challenges incurred by the mobility of nodes, the changes of topology and the limitations of energy resources. Furthermore, the routing protocols should be efficient in terms of the quality of service (QoS) and energy consumption to guarantee the data transmission over the wireless medium [5].

Although energy constraints during routing in MANETs have been extensively investigated by previous studies, most earlier investigation is exclusive to the single path energy efficient routing protocols while ignoring multipath which is advantageous over single path routing. One of the main limitations often imputed to single path routing schemes is the quick depletion of the battery of nodes in the selected path [7]. Such limitation is due to the fact that some nodes are not involved in the routing, while others are highly congested and they carry most of the network traffic. Thus, these approaches continue to suffer from issues related to energy balancing among all nodes. These effects can lead to a considerable degradation of network performance. Moreover, the dynamic topology of MANETs due to the mobility of nodes may obstruct the obtaining accurate state information about the energy levels of mobile nodes and consequently, it may make selecting the most efficient path between source-destinations pairs difficult. In this regard, there is no simultaneous consideration of energy balancing and mobility of nodes while selecting energy efficient path in the existing routing schemes.

The conventional multipath optimized link state routing protocol (MP-OLSRv2) [8,9] is a hybrid multipath routing scheme which is based on OLSRv2 [10]. It attempts to provide a reliable communication and to ensure the high traffic load distribution into multiple paths, thus leading to a balance of the loads among mobile nodes. The MP-OLSRv2 does not always keep a routing table to all the possible destinations rather it only calculates the routes when there are data packets needed to be sent out. However, the Multi-Point Relays (MPR) selection mechanism of MP-OLSRv2, which is used for MPR nodes for flooding topological information, is still inefficient in terms of the energy because it ignores the status of the selected MPRs in relation to the available energy resources and mobility. As a result of this, the MPR's energy is quickly depleted [11].This situation is often attributed to the continuous selection of MPRs in the routes from a source to a destination. If the MPRs are not stable and do not have an adequate energy level, they will be exhausted earlier. Moreover, the MP-OLSRv2 does not consider the status of nodes; neither the energy nor the mobility to measure the quality of links to make routing decisions. This may lead to degrading its performance in high mobility and heavy traffic load scenarios [12,13]. From the perspective of energy consumption, the shortest path is not always the optimal and stable path.

Based on the above-mentioned issues and challenges, we propose a hybrid routing scheme that combines energy and mobility awareness metrics by taking the advantages of the multipath concept. The aim of the proposed scheme is to balance energy among multiple paths, and to select the most efficient paths to forward data to the destination. To achieve this, we present multiple contributions in this paper starting from the implementation of the MP-OLSRv2 [8,9] in EXata Network Simulator [14]. Then, we revise and modify the MP-OLSRv2 by proposing a Multipath Battery and Mobility-Aware routing scheme (MBMA-OLSR) for energy efficient routing with mobility awareness to deal with the frequent topological changes of the network. The current study utilizes the advantages of the conventional MP-OLSRv2 by thoroughly improving and upgrading it for a simultaneous consideration of the battery energy level and the speed of the nodes move during both MPR selection and routes computation. The MBMA-OLSR routing scheme introduces two new features. The first feature is