Simulation Modelling Practice and Theory 63 (2016) 1–22

Contents lists available at ScienceDirect

Simulation Modelling Practice and Theory

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

A new cross-layer routing with energy awareness in hybrid mobile ad hoc networks: A fuzzy-based mechanism

Tássio Carvalho*, José Jailton Júnior, Renato Francês

Federal University of Pará, Postgraduate Program in Electrical Engineering, Belém, Brazil

ARTICLE INFO

Article history:
Received 21 February 2015
Revised 11 January 2016
Accepted 11 February 2016
Available online 2 March 2016

Keywords:
MANET
Routing
Multimedia
QoS
QoE
Fuzzy
Energy awareness

ABSTRACT

The evolution of wireless technologies has led to the need to provide network support for data and video applications and thus foster the development of new types of network configurations. MANET is an important type of network operation that employs mechanisms that can enable a dynamic self-configuration to challenge the routing protocols. These protocols can also be challenged because energy failures are becoming more serious than the common network failures; in addition, the quality of the multimedia stream corresponds to a type of data flow that is increasingly prevalent in today's network. In light of this, a new cross-layer routing mechanism is set out to make an improvement in the main routing protocols. This involves adding decision metrics to all the network layers in a fuzzy-based mechanism with QoS and QoE guarantees, mobility indexes and energy parameters, by choosing the best path with an efficient way to use energy. The proposal has been evaluated in a network simulator which demonstrates the efficiency of increasing energy awareness and maximizing the life time of the network.

1. Introduction

The constant evolution of electric and electronic equipment for future computer networks and telecommunications, along with the demand for new multimedia applications, has led to both the creation and improvement of existing systems with the aim of achieving a better performance and more reliable technologies. This is becoming one of the main challenges of this third millennium, where new communications technologies must be sensitive to the need for a high-speed bandwidth in large coverage areas and provide services to a growing number of users. These must ensure support for the content of new multimedia applications by providing a better understanding of the concept of NGNs (next generations networks) and FI (future internet) where the users will be connected anytime, anyplace and always with the best service [20].

The evolution of new wireless network technologies is an effective way of overcoming physical barriers that impede the transmission of knowledge and reducing deployment costs. It also allows legal transactions to be carried out in many regions, especially in the "last-mile reach". One of the important modes of operation is the MANETs (mobile ad hoc networks), where all the nodes (mobile devices like smartphones, tablets, notebooks, etc.) function as routers, by forwarding communally the resulting communications of nearby terminals. This is a type of operating network that has many features like dynamic self-organization, self-configuration, self-optimization, etc. They are also employed in FANETs (flying ad hoc networks), VANETs (vehicular ad hoc networks) and WSNs (wireless sensor networks) for temporal, geological and marine prediction and in the following areas: DTNs (delay tolerant networks), Mesh, underwater networks, war scenarios, as well

* Corresponding author. Tel.: +55 91982578888.
E-mail address: tassiocarv@gmail.com, tassio@ufpa.br (T. Carvalho).

http://dx.doi.org/10.1016/j.simpat.2016.02.003
S1569-190X(16)00023-X/

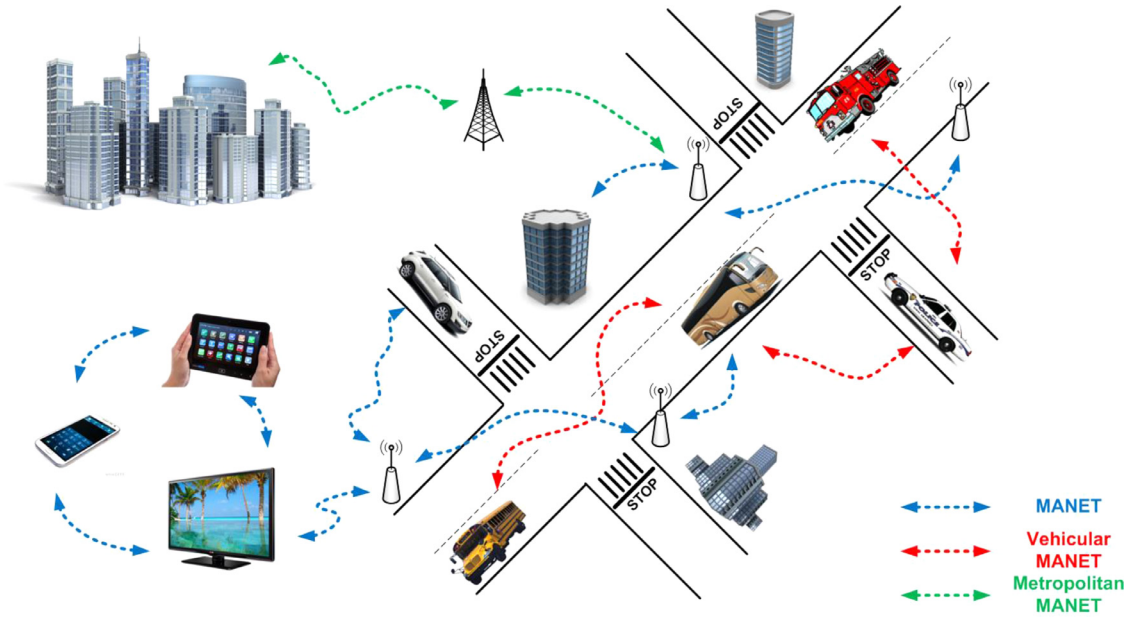

Fig. 1. Mobile ad hoc network.

as traditional scenarios and large urban centers. In addition, the routing mechanism is able to balance traffic and provide support when establishing connections for mobile clients [3,6,32], as shown in Fig. 1.

However, this type of network has unstable links, a limited energy capacity and a lack of a wired infrastructure that can provide certain problems. Furthermore, MANETs have no centralized nodes or controllers like other traditional wireless networks or cellular networks and WSNs. Owing to these limitations, MANETs raise a serious challenge. These networks are faced with one key issue—Routing. This matter is one of the main challenges raised by today's networks, especially MANET because the main routing protocols are limited in their choice of settings for the best routes. This can lead to it having a varied impact on the transmission data in the wireless link, especially when the application is a multimedia type [23].

The protocols and architecture for future routing must take into account other measures and be increasingly concerned with multimedia traffic and adopt more effective strategies to improve routing traffic for triple play (voice, data and video over a single communication). It must also take into account mobility factors and the need for energy consumption, which are based on the cross-layer paradigm so that it can provide improvements in performance and a longer lifetime for MANETs. In addition it should lead to the improvement of resources and services and be able to maximize customer satisfaction with NGNs [12].

There are currently a large number of routing protocols and groups in which the characteristics and peculiarities are classified by [15] and [18]. However, in the interests of brevity, in this paper, it has been decided to classify them into three groups on the basis of one of these divisions: proactive routing, reactive routing and hybrid routing protocols [4].

Proactive routing protocols determine a routing table in advance of all the possible paths where data traffic can be sent, regardless of the need for it and always search for new and best paths; the OLSR (optimized link state routing) protocol is one the most important known representatives of this group [37]; Reactive routing protocols only seek new paths when necessary, and when the previous path is broken and AODV (ad hoc on demand distance vector) is one of the most important known representatives of this group [22]; The third group represents both features, and enjoys the same resources in both groups; this is because it is proactive with routing tables kept at each neighbor node and reactive with other nodes of the network and HWMP (hybrid wireless mesh protocols) an important and well-known protocol for Mesh and Ad Hoc networks and chosen for this paper [38].

The cross-layer mechanism proposed here enables a new energy-aware decision-making process that takes into account a number of measures apart from the metrics already used by the main protocols. They also provide QoS and QoE for MANETs and maximize the lifetime of the network through a lower and realistic energy consumption model of the mobile devices in the architecture that is involved in network communication.

In Section 2, there will be a discussion of the key features needed for this paper and this will include a subsection devoted to examining related work. Section 3 describes the main objectives and features of the paper, as well as providing an overview of simulation modeling. Section 4 will analyze the findings of the experiments and evaluate the results. The last section summarizes the conclusions.