Computers and Electrical Engineering 48 (2015) 77–85

Contents lists available at ScienceDirect

Computers and Electrical Engineering

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

A new routing protocol for energy efficient mobile applications for ad hoc networks ☆

G. Ravi *, K.R. Kashwan

Department of Electronics and Communication Engineering, Sona College of Technology (Autonomous Institution), Salem 636005, Tamil Nadu, India

ARTICLE INFO

Article history:
Received 12 August 2014
Received in revised form 16 March 2015
Accepted 18 March 2015
Available online 6 April 2015

Keywords:
MANET
Energy conservation
Span
AFECA
Remote Activated Switch
Zone Routing Protocol

ABSTRACT

A Mobile Ad hoc Network (MANET) is an infrastructure-less collection of nodes that are powered by portable batteries. Consumption of energy is the major constraint in a wireless network. This paper presents a new algorithm called Energy-Aware Span Routing Protocol (EASRP) that uses energy-saving approaches such as Span and the Adaptive Fidelity Energy Conservation Algorithm (AFECA). Energy consumption is further optimized by using a hardware circuit called the Remote Activated Switch (RAS) to wake up sleeping nodes. These energy-saving approaches are well-established in reactive protocols. However, there are certain issues to be addressed when using EASRP in a hybrid protocol, especially a proactive protocol. Simulation results for the EASRP protocol show an increase in energy efficiency of 12.2% and 17.45% compared with EAZRP and ZRP, respectively. The EASRP protocol also proves to be effective in by producing a better packet delivery ratio for low- and high-density networks as measured by the NS-2 simulation tool.

1. Introduction

MANET [1] is a collection of nodes that act independently but depend on each other for their operation in the network. The process of route discovery, route maintenance and error reporting happens collectively rather than centrally. The importance of MANET is increasing with the increased dependence on personal devices, such as Personal Digital Assistants (PDAs), smartphones and laptops for information exchange. These devices can be linked into a network at any time without any infrastructure using MANET. They are mainly being used in the defence field, where the possibility of setting up infrastructure in hostile areas is not feasible. However, MANET is also used for civilian applications, such as for transferring data during a meeting that was arranged in a short time [2]. MANET has some unique features: (1) absence of centralized control, (2) time-varying wireless link characteristics, (3) route changes occur due to mobility, (4) the limited range of wireless transmission and (5) packet losses due to the hidden terminal problem [3]. In addition to these unique features, they have the common features of wireless communication systems, such as unreliable links and restricted bandwidth resources.

The process of routing is complex in MANET due to its unique features. Thus, the routing protocol of MANET plays a crucial role in determining the performance of the network. It controls the route establishment time, throughput, Packet Delivery Ratio (PDR) and the energy consumption of the entire network. Energy is consumed due to the route discovery

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Guest Editor Dr. H.A. Shabeer.

* Corresponding author.
E-mail addresses: raviraj.govind@yahoo.com (G. Ravi), kashwan.kr@gmail.com (K.R. Kashwan).

http://dx.doi.org/10.1016/j.compeleceng.2015.03.023
0045-7906/

process, which involves the transmission of overheads. The number of overheads is proportional to the rate of change of the network topology.

Depending upon the route discovery process, the routing protocols [4,5] are divided into three types:

1. Reactive protocol (or "on demand"), where the route discovery is carried out when the node has some data to transmit. The nodes do not periodically update the topology information. Thus, the route establishment time is high, but the overheads are minimal. Examples are Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR).
2. Proactive protocols (or "table driven"), in which the nodes periodically update the changes in network topology, regardless of whether they have data to send. At any time, each node knows the route to all other nodes. Thus, the route discovery time is minimal, but more overheads are needed. Examples of proactive protocols are Hierarchical State Routing (HSR) and Destination Sequenced Distance Vector (DSDV).
3. Hybrid protocols combine the pros and cons of the previous two types of routing protocols. Examples of such protocols are the Zone Routing Protocol (ZRP) and the Hybrid Ad hoc Routing Protocol (HARP).

Energy saving [6,7] can be achieved in MANET in three ways:

1. *The Power Save Approach* – The nodes are designed to sleep for a particular period by use of an efficient scheduling technique.
2. *The Power Control Approach* – Transmission power is controlled and the least energy is used to route the data packets. It utilizes the power based on-distance rule: a short-distance transmission [8] expends less energy than a long-distance transmission.
3. *The Power Management Control Approach* – In the ad hoc power saving mode of IEEE 802.11 [9], nodes are placed into sleep state using the Adaptive Ad-hoc Traffic Indication Message (ATIM) window and beacon interval at the Medium Access Control (MAC) layer. Thus, they increase the network lifetime [10]. Power management faces three challenges: beacon contention, timing synchronization and neighbour maintenance. Based on the traffic announcement message, the node awakens until the end of the beacon interval and the other nodes remain in the sleep state to save power until the ATIM interval is over. The total energy saving depends on the time spent in sleep state and the number of nodes. Thus, the overall lifetime of the network is enhanced.

This paper focuses on the first issue, namely, an energy efficient scheduling technique. In this paper, we combine the energy-saving approaches of AFECA and Span with Zone Routing Protocol and finally incorporate the hardware circuit Remote Activated Switch to wake up the sleeping nodes in the network. The EASRP is a promising solution for the energy efficiency of the network and for increasing the network's lifetime. It is possible to reduce energy consumption and increase the PDR by optimizing the Span coordination algorithm for a high-density network.

The rest of the paper is organised as follows. In Section 2, we present recent developments in routing protocol systems. In Section 3, we describe the proposed protocol. In Sections 4 and 5, the simulation setup and results are discussed with supporting graphs. In the last section, the advantages of EASRP are presented, and the scope for further research to improve its performance is put forth.

2. Related works

AFECA [11] is a power-save approach used with the routing protocols. It provides a procedure to select the idle nodes and rotate nodes into the sleep, listen and active states. AFECA is the enhanced form of Basic Energy-Conserving Algorithm (BECA) with a new sleep interval based on neighbours. Energy saving is achieved by changing the states of the nodes periodically.

Span [12] adaptively selects coordinators from the network from amongst all nodes. It rotates the coordinator role amongst nodes to balance the energy savings. Thus, coordinators act as backbone routers for the whole network and provide guaranteed connectivity by ensuring that at least one active node is in the coordinator's range. The coordinators are selected based on their remaining energy and the utilization of the node [13]. If two nodes cannot reach each other, those nodes become a coordinator node, which produces better throughput and energy efficiency.

An algorithm named Energy-Aware Geo-location-aided Routing (EAGER) [14] is based on a hybrid routing protocol, which belongs to a topology-based technique. The routing protocol divides the network into different proactive cells based on self-location information. It reduces the number of nodes participating in the route discovery process and transmission range [15]. It uses RAS to wake up a sleeping node to active communication. The performance of EAGER shows better energy efficiency than that of ZRP.

Genetic algorithms based upon heuristic approaches provide methods to reduce the energy consumption in MANETs. An example of such an approach is Ant Colony Optimization (ACO) [16] in routing protocols. ACO is based upon the natural behaviour of ants; it finds the shortest route by depositing pheromones in their food. These approaches are rugged with respect to the dynamic topological changes, which are characteristic of MANETs.