Chapter 21

Fuzzy-Controlled Energy-Conservation Technique (FET) for Mobile ad hoc Networks

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ABSTRACT

Nodes in ad hoc networks have limited battery power; hence, they require energy efficient techniques to improve average node lifetime and network performance. Maintaining energy efficiency in network communication is really challenging because highest energy efficiency is achieved if all the nodes are switched off and maximum network throughput is obtained if all the nodes are fully operational, i.e. always turned on. A promising energy conservation technique for the ad hoc networks must maintain effective packet forwarding capacity while turning off the network interface of very busy nodes for some time and redirecting the traffic through some comparatively idle nodes roaming around them. This also helps in fair load distribution in the network and maintenance of network connectivity by reducing the death rate (complete exhaustion of nodes). The present chapter proposes a fuzzy-controlled energy conservation technique (FET) that identifies the busy and idle nodes to canalize some traffic of busy nodes through the idle ones. In simulation section, the FET embedded versions of several state-of-the-art routing protocols in ad hoc networks are compared with their ordinary versions and the results quite emphatically establish the superiority of FET-embedded versions in terms of packet delivery ratio, message cost, and network energy consumption. End-to-end delay also reduces significantly.

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INTRODUCTION

In this section, Ad hoc networks are multi-hop wireless networks consisting of radio-equipped nodes that may be stationary or mobile. These are useful in emergency situations where temporary network connectivity is needed such as military exercises, disaster relief etc. (Maltz, 1999; Broch, October 1998; Corson, 1999). Routing in ad hoc networks faces extreme challenge due to node mobility / dynamics, potentially large number of nodes and limited communication resources. The classes of routing protocols can be mainly divided into two categories – proactive and reactive routing protocols.

Among proactive routing protocols, destination-sequenced distance vector (DSDV) (Perkins, 1994), wireless routing protocol (WRP) (Murthy, 1996), global state routing (GSR) (Chen, 1998) and cluster-based gateway switch routing (CGSR) (Chiang, 1997) are well known. In all proactive routing protocols the nodes proactively store route information to every other node in the network. In DSDV, routing information is distributed between nodes by sending full dumps of information infrequently and smaller incremental updates more frequently. DSDV requires a regular update of its routing tables which uses up battery power and a significant amount of bandwidth even when the network is idle. Whenever the topology of the network changes, a new sequence number is necessary before the network re-converges. Thus, this protocol is not suitable for highly dynamic networks. On the contrary, the wireless routing protocol (WRP) localizes its updates to immediate neighbors only. Similar technique is followed by global state routing (GSR) also. The CGSR protocol is more efficient from its predecessors from the perspective of propagation of routing information. It divides the network into clusters. A clusterhead is elected in each cluster among its members. Network-wide information is changed only among the clusterheads. In general, the proactive routing protocols suffer from extremely huge storage overhead because they store information both about active and non-active routes. This inculcates the unnecessary complexity of discovering routes to the destinations with which a node rarely communicates. Reactive or on-demand routing protocols are designed to reduce this overhead.

Dynamic source routing (DSR) (Broch, December 1998), ad hoc on-demand distance vector routing (AODV) (Perkins, 1999), adaptive communication aware routing (ACR) (Ueda, 2007), flow-oriented routing protocol (FORP) (Su, 1997) and associativity-based routing (ABR) (Toh, 1997) are well-known among the reactive routing protocols. AODV builds routes using a route-request, route-reply query cycle. When a source node desires to send packets to a destination for which it does not already have a route, it broadcasts a route-request (RREQ) packet across the network. Nodes receiving this packet update their information for the source node and set up pointers backward to the source node in their routing tables. A node receiving the route-request (RREQ) packet sends a route-reply (RREP) if it is either the destination or has a recently established route to the destination with. Dynamic source routing (DSR) is similar to AODV in that it forms a route on-demand when a source node requests one. However, it uses source routing instead of relaying on the routing table at each device. Determining source routes require accumulating the address of each router in the route-request message. Bin Hu and Hamid Gharavi (Hu, 2008) proposed a DSR based directional routing protocol (referred to as D-DSR) which uses directional antennas to reduce interference and packet loss during communication. In all the above mentioned protocols the path with minimum number of hops or minimum transmission delay is selected for communication.

The criterion for selecting the optimal path in FORP, is *Route Expiration Time* (RET). Computation of RET, on the other hand, is based on the *Link Expiration Time* (LET) that depends only on the relative velocities of consecutive nodes. Link breakages in FORP may occur frequently due to

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