An Adaptive Backoff Algorithm for Mobile Ad-Hoc Networks

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ABSTRACT

Collision is a common problem in Mobile Ad Hoc Networks (MANETs). There are several backoff algorithms that have been proposed to avoid this problem. This paper proposes a new backoff algorithm called the Square Root Backoff (SRB). Moreover, it identifies that no algorithm can perform the best in all cases. Therefore, an adaptive strategy is proposed to choose the best backoff mechanism from a set of mechanisms based on network density and mobility parameters. The proposed adaptive algorithm is implemented in two phases, the offline phase and the online phase. Such design aims at reducing the time complexity of the algorithm by performing some of the computations prior to the actual deployment and of the network. Results from simulations demonstrate that the SRB algorithm achieved better performance than BEB and LB. Moreover, the adaptive backoff algorithm obtains the best throughput and end-to-end delay performance over the other backoff algorithms.

Keywords: Adaptive, Ad Hoc Networks, Backoff Algorithm, Offline Analysis, Square Root

INTRODUCTION

In the last few decades, studies in networking were concentrated on wireless networks. This is due to the success of wireless networks in many life applications. Wireless Networks can be used by devices such as cell phones, laptops, PDAs. Many features discriminate wireless networks over wired networks. Wireless network is less expensive because it eliminates the need to connect nodes by cables which also can help make connecting to the internet much more convenient, and it provides the ability of anytime, anywhere, and unlimited access to the Internet. Two main types of wireless networks have been introduced, infrastructure based and infrastructure-less (ad hoc) wireless networks (Kurose & Ross, 2007). Infrastructure based wireless network has a base station that is connected to a larger wired network such as the Internet. While in infrastructure-less wireless network there is no base station. An example of such infrastructure-less wireless network is Mobile Ad Hoc Network (MANET). MANETs consist of a set of nodes that communicate with

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each other wirelessly and without the existence of infrastructure, which means that there is not a base station to control the communication between the mobile hosts, so each node will act as both a host and a router (Kurose & Ross, 2007). These networks have many distinguishing features such as self healing, self organizing, multi-hop routing, neighborhood awareness, scarce resources specially bandwidth and batteries, and changing network topology due to the mobility of the nodes in the network (Sun, 2001).

Without the existence of base stations, routers, or any infrastructure, nodes use peer-to-peer communication to interact with each other. Nodes’ communication will be direct if the nodes that need to communicate are within the coverage area of each other. But, if they are not within the coverage area of each other then they must communicate via a multi hop route with the cooperation of other nodes in the network (Yi, Gerla, & Kwon, 2002). To find such multi-hop paths between nodes, there must be a method that allows nodes to collect information. This method is known in MANETs as flooding, in which each node receives the message will retransmit it to all its neighbors (Bani Yassein, Ould Khaoua, Mackenzie, & Papanastasiou, 2005, 2006; Bani Yassein & Ould Khaoua, 2007; Sasson, Cavin, & Schiper, 2003). The need to flooding comes from the changing topology of the network in MANETs where the nodes move and may change their location frequently. Many operations in MANETs depend on flooding such as routing protocols, multicast schemes, or service discovery programs. But there is a drawback of using flooding that is redundant transmissions may generate great overhead on the network and cause frequent contentions and collisions which leads to what is called the broadcast storm problem (Tseng, Ni, Chen, & Sheu, 2002).

Wireless links suffer from serious problems such as the shared bandwidth, signal weakening, noise, and interference. With shared medium where we have multiple sending and receiving nodes all connected to the same single shared channel, it is essential to have an efficient and effective Medium Access Control (MAC) mechanism, which is a set of rules or procedures by which a frame is transmitted onto the link, to allow the efficient use of a shared medium, to manage the scarce bandwidth resources among active users, and as a result to avoid collisions (Manaseer, Ould-Khaoua, & Mackenzie, 2006). According to the seven layer Open System Interconnection (OSI) model, IEEE 802.11 MAC represents a sub-layer of the Data Link Control (DLC) layer in that model (Bani Yassein, Manaseer, & Al-Turani, 2009). MAC protocols are essential to control channel access especially multiple-access to the shared medium by multiple nodes at the same time. Another function of MAC protocols is to provide MAC addressing. A mechanism called Carrier Sense Multiple Access with collision Avoidance (CSMA/CA) is used for controlling the channel access in IEEE 802.11 (Bani Yassein, Manaseer, & Al-Turani, 2009).

The IEEE 802.11 standard can be used in either an ad hoc infrastructure less networks or in base station based networks. In this standard, either a distributed coordination function (DCF) or a point coordination function (PCF) is used for achieving the medium sharing (Pang, Liew, Lee, & Leung, 2004). In Ad Hoc Networks, the MAC protocol includes backoff algorithm to avoid collisions. Such collisions occur when multiple nodes try to access the shared medium at the same time (Manaseer & Ould-Khaoua, 2006; IEEE, 1999; Song, Kwak, Song, Miller, 2004; Manaseer & Masadeh, 2008). At any time, only one of the nodes can access the channel, while other nodes must wait for some random period of time that is called backoff time which is uniformly selected from the Contention Window (CW).

Many Backoff algorithms have been proposed. But most of the proposed algorithms suffer from increasing the CW in case of failure to transmit rapidly to large sizes like the Binary Exponential Backoff (BEB) algorithm (Manaseer, Ould-Khaoua, & Mackenzie, 2006). This leads to long delays and increases the wasted time for which the channel will be idle. On the other hand, other algorithms like the Linear Backoff (LB) don’t give the node sufficient
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