POTENTIAL SHORTCOMINGS OF SELECTED MEDIA ACCESS CONTROL PROTOCOLS FOR WIRELESS AD HOC NETWORKS

W. D. (Bill) Blair[1]

Abstract. An increasing desire for mobility for data users has encouraged wide-scale deployment of wireless networks, in particular using an approach of peer-to-peer multi-hop networks. In such networks, each node potentially acts as a data terminal as well as performing a relay function linking terminals that do not have a direct connection. This paper focuses on the Media Access Control (MAC) function of the Data Link Layer. It discusses the requirements of MAC in a wireless network and identifies four fundamental assumptions in many protocol designs that, if not true, may impact on protocol performance. A discussion of some well-known MAC protocols seeks to illustrate and clarify wireless ad hoc network MAC issues. Detailed examination, with particular attention on two of the assumptions, is then made of two attractive hybrid schemes called CATA and AGENT that have recently been proposed. The examination shows that the behaviour of AGENT is somewhat more robust.

INTRODUCTION

An increasing desire for mobility for data users has encouraged wide-scale deployment of wireless networks in the civilian domain as well as the military. In the civilian domain many such wireless networks are based on fixed infrastructure into which mobile users connect. Cellular mobile networks are examples of such networks. While such an approach has some application within the military, of potentially greater utility (and increasingly of interest in the civilian domain) is a concept of peer-to-peer multi-hop networks. In such networks, each node potentially acts as a data terminal as well as performing a relay function linking terminals that do not have a direct connection.

Radio frequency spectrum becomes the scarce resource that must be shared between the terminals in the network. In terms of the OSI communications stack, this sharing is carried out by Layer 2 (Data Link Layer) with its Media Access Control (MAC) function.

The rest of this paper is organised as follows. The first section discusses the requirements of MAC in a wireless network. It identifies four fundamental assumptions in many protocol designs that, if not true, may impact on protocol performance. Two contentionless MAC protocols are discussed in the second section followed by a discussion on contention based protocols—this seeks to illustrate and clarify wireless ad hoc network MAC issues. Detailed examination, with particular attention on two of the assumptions, is then made of two attractive hybrid schemes that have recently been proposed.

REQUIREMENTS ON A WIRELESS MAC

For most mobile wireless networks, radio nodes employ a single antenna for transmit and receive. Accordingly it is easier to implement half-duplex networks (that is, a node can transmit and receive, but not simultaneously). Thus a wireless node cannot simultaneously monitor the channel and transmit. Consequently, it is impossible for a transmitting node to detect collisions (that is, the presence of multiple nodes transmitting simultaneously). By contrast, in wired networks transmitters can monitor the medium and detect distortions to the transmitted data caused by collisions. A wireless system, typically at the MAC layer, needs to implement some mechanism to detect, or avoid, collisions.

Leaving aside the half-duplex constraint, for wireless systems the collisions may not be apparent at the transmitter location. In the end, it is reception at the receiver(s) that determines whether a transmission suffered collision. There will be occasions when two nodes that have no direct communications capability to/from each other have their transmissions colliding at the receiver(s). This is the so-called 'hidden station' problem. Regardless of whether the interferers are hidden or not, an ideal wireless MAC would not only detect such collisions, but also seek to prevent them from happening. This is the 'two-hop' challenge, in that nodes that are separated by two hops must be prevented from transmitting simultaneously if the intermediate node(s) are intended recipients of one or both of the transmissions.

Because wireless transmissions can potentially be received by multiple nodes there may be value in having a MAC approach that supports broadcast/multicast transmissions. One-to-one transmissions are called *unicast* and while unicast data transfer can be supported over a broadcast medium, sending data intended for multiple stations over a unicast transmission is inefficient (requiring broadcast traffic to be transmitted multiple times). Nevertheless, the issues of reliability of connection and collision avoidance might lead to MAC protocols based on unicast transmissions.

Mobile nodes make up the networks of interest. Thus the network topology is subject to continual change. The mobility of the nodes and the nature of the terrain dictate the rate of change in the topology. The MAC protocol of the network must be capable of coping with the rate of change in the topology.

An ideal MAC protocol ensures that all nodes receive a fair share of the transmission resource. The concept of fairness is open to interpretation in that a fair allocation may not be equal if nodes have differing traffic requirements, including in the military environment, differing precedences.

The concept of fairness leads on to the concept of Quality of Service (QoS). Different applications have different requirements on the network including source to destination delay (latency) and latency variation (jitter). These can be impacted strongly by the nature of the MAC and so it may be a requirement on the MAC to provide differentiated services for differing applications.

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[1] Defence Science and Technology Organisation, DSTO C3 Research Centre, Fernhill Park, Canberra, ACT, 2600, Australia.

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