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SOLUTION FOR TCP-UNFAIRNESS IN IEEE802.11-BASED AD-HOC NETWORK BY ALLEVIATING EXPOSED TERMINAL PROBLEM USING CROSS LAYER APPROACH

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In this paper we proposed an algorithm to improve TCP fairness in IEEE802.11-based ad-hoc network. Proposed algorithm uses cross layer approach which involved the cooperation between MAC layer and network layer. The solution alleviates exposed terminal problem by allowing MAC layer to use the topology information available in network layer.

Key words: TCP, MAC, ad-hoc, cross layer, exposed terminal
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1 Introduction

Nowadays we see a rich and rapidly developed telecommunication terminal, which is equipped by wireless access capability. They come in a vary version such as notebook, PDS, hand phone etc and they used in almost every situation and location. This kind of technology drove by the needs to access the information anytime and anywhere.

In the situation when there is no telecommunication infrastructure, for instance in a natural disaster or battle field, while on the other hand there is a need to exchange the information among the users, it will be very helpful if the wireless nodes can talk to each other and forward the packets from a certain location to another ones without the help from centralized control such as a base station. This kind of communication can be established using the concept of wireless ad hoc networks.

Wireless ad hoc network is a distributed system consists of mobile as well as static wireless nodes that can form and maintain the network among each other without centralized control nor base stations. Wireless ad hoc network can perform self-organizing freely and dynamically (Hanbali et.al, 2005). IEEE802.11-based wireless local area network can be used as the platform for wireless ad hoc network.

Application services that can be deployed in wireless ad hoc network have a wide range from time-sensitive applications (such as voice) to time-insensitive (data) applications (such as e-mail). Data traffics are still dominated the information transfer in the internet (D.J.Leith et. al, 2005).

Data traffic uses the services provided by TCP. TCP provides an end-to-end reliable data transfer. All of the TCP versions have been tuned to perform well in wired environment. But when it comes to wireless environment, TCPs performances are not satisfactory (G. Holland and N. Vaidya, 2002; F. Wang and Y. Zhang, 2002; H. Lim et. Al 2003) because TCPs lack of capability to differentiate the losses caused by the congestion and the losses caused by certain characteristics of wireless channel (such as high bit error, path asymmetry, network partition, route failures, hidden terminal, and exposed terminals).

As mentioned before, IEEE802.11-based wireless LAN can be used as wireless ad hoc network platform. IEE802.11 standard specifies Medium Access Control (MAC) protocol as well as 3 physical layers protocols to support vary coverage and speed.

One of the major quality of service (QoS) problem in IEEE802.11-based network is TCP unfairness (Hanbali et.al, 2005; Marcelo G. Rubinstein and Jose Ferreira de Rezende, 2003). The basic definition of fairness is conditions where all of the nodes involved have equal access to network bandwidth (Nitin H. Vaidya, 2003).

According to G. Holland and N. Vaidya, 2003, the main cause of TCP unfairness is the BEB (Binary Exponential Back off) scheme in IEEE 802.11 MAC. The BEB do not count topology information so that it forces unnecessary back off process in hidden and exposed terminal problem.

Actually, DCF (Distributed Coordination Function) protocol implementation in IEEE802.11 standard supposed to be the solution for hidden terminal problem. But at least as in Kaixin Xu and Mario Gerla, (MINUTEMAN Project, year N.A.) for some scenarios the DCF still not effective. Some works also propose solutions for exposed terminal problem, but as reported in Al Hanbali et.al., 2005 none of them uses cross layer approach as.

In this work, we propose a new solution to overcome exposed terminal problem using cross layer approach in order to reduce TCP-unfairness (in other words to improve TCP-fairness) in IEEE802.11-based ad-hoc network.

2 Materials and methods

As mentioned before, the main cause of TCP unfairness is the BEB (Binary Exponential Back off) scheme in IEEE 802.11 MAC. The BEB does not count topology information so that it forces unnecessary back off process in hidden and exposed terminal situation. Repeatedly BEB will make data sending trial threshold is reached. When it is happen, MAC layer will declare that the link is broken and it makes routing protocol invoke route discovery to update the routes. The condition also sense by TCP layers. TCP sender won't get any TCP ACK from the receiver while MAC layer doing it's BEB and/or while routing protocol updating the routes. When it is happen, lack of TCP ACK, TCP sender invokes congestion protocol which narrowing TCP windows size which in turn lowering the throughputs. So some TCP flow in the network might suffer throughput unfairness, in fact in some conditions might happen channel capture where one TCP flow dominate the network.

In this work, we focus our research in exposed terminal situation as shown in Figure 1. Nodes with start-of-arrow attached to it are the senders.

Figure 1 Exposed terminal situation

For instance node 1 commence the transmission first. It invokes DCF protocol in MAC layer. First it must send and RTS (Request to Send) frame to node 2. RTS also contain duration information needed to send the frame which is called NAV (Network Allocation Vector) which is the time needed to send DATA and corresponding ACK. Node 2 must respond the corresponding RTS with CTS (Clear To Send) frame. CTS also contain NAV. The node 2's neighbouring nodes, in this case node 3, must silent for NAV period. After receiving CTS then node 1 will send DATA. Node 2 will send ACK to node 1 after successfully receive the DATA frame. We can see that if node 3 has frame to send to node 4 in that NAV period, it cannot start it's transmission even though node 4 is out of range from node 2 nor node 1. So actually, if node 3 aware of the situation it can start the transmission to node 4.

To make node 3 aware of the situation, we propose a new algorithm which is actually a modified version of DCF by considering network topology information from network layer which responsible in determination the whole picture of network.

3 Proposed algorithm

The proposed algorithm is shown in Figure 2. The notation is based on Figure 1 and the algorithm invokes by an exposed terminal's MAC layer (in this case node 3).

4 Discussion

In Figure 2 we can see that in exposed situation, a node has frame to send but NAV timer is ON, the MAC layer investigate first the information from network layer. It evaluates the number of hops of it's destination from detected signal's destination and source. If number of hop equal to 1, then node 3 invokes normal DCF. But when number of hops is more than 1, node 3 could start the transmission directly without DCF.

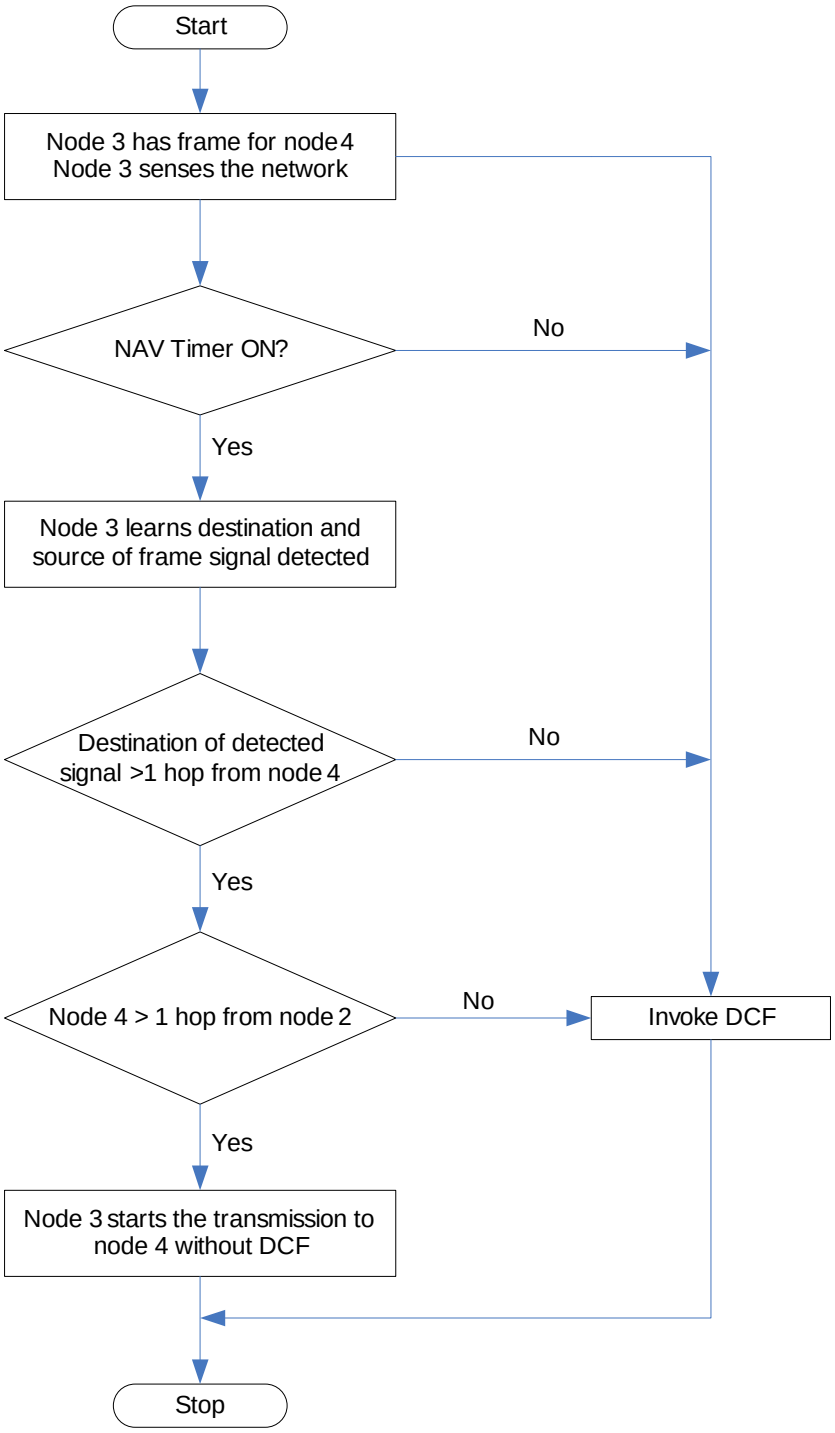

Figure 2 Proposed Algorithm

The proposed algorithm looks promising because the exposed terminal doesn't have to perform unnecessary BEB in the particular case. In the future we would like to derive mathematical analysis for the solution and evaluate the proposed algorithm using network simulator.

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