

Perfectly Periodic Scheduling for Fault Avoidance in IEEE 802.11e in the Context of Home Networks

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Abstract – In the upcoming new standard IEEE 802.11e to support Quality of Service (QoS) in WLAN, we present perfectly periodic scheduling based on usage probability u_i to provide fault avoidance. We address Medium Access Control (MAC) enhancements found in the current 802.11e specification by emphasizing perfectly periodic scheduling over the proposed round robin polling.

I. INTRODUCTION

We are now witnessing a new wireless revolution in short range radio networks with QoS like IEEE 802.11e [3] and Bluetooth. Such networks are easily deployable and combine the power of wireless access with mobile computing, delivering high data rates on unlicensed radio spectrum for office, home and hot spots. In this paper we restrict our discussion on the applicability of 802.11e in the context of Home Networks. Home network is a network of intelligent wireless devices in home that process, manage, transport and store information, enabling integration of computing, control, monitoring, security, communication and entertainment devices in the home. Using IEEE 802.11e standard in home networking requires special care, based on the type of services provided. Some example service scenarios are:

- Emergency services like intrusion detection and fire alerts
- Real-Time services of media like voice and video

To justify our reliance on the applicability of 802.11e for home networking, fault tolerance must be provided. Moreover, fault tolerance must be provided efficiently.

A. QOS SUPPORT MECHANISMS OF 802.11E

Traffic Category (TC) based priority schemes to support QoS in 802.11 are currently under discussion. 802.11e defines two new MAC modes, Enhanced Distributed Coordination Function (EDCF) and Hybrid Coordination Function (HCF) and supports up to eight traffic categories. One important feature of 802.11e MAC is Transmission Opportunity (TXOP). A TXOP is defined as an interval of time when a station has the right to initiate transmissions, defined by a starting time and a maximum duration. TXOPs are allotted in Contention Period (CP) or in Contention Free Period (CFP). During CP, each TXOP

begins either when the medium is determined to be available (EDCF) or when the station (STA) receives a QoS CF-Poll frame from HC (Hybrid Coordinator). During CFP HC allocates TXOP by polling (HCF) and stations will not access the medium on their own.

II. PROBLEM DEFINITION

Polling of TXOP in 802.11e is by round robin. The polling frequency p_i for all STA_i is same, irrespective of the critical data that they transmit and their access frequency i.e., $p_1 = p_2 = \dots = p_n$. STA maintains eight TC queues and transmits the TC with highest priority during its polled-TXOP. As a result, no priority consideration is made for the service requirement of the STA. Instead, priority consideration is made in STA based on TC. This might lead to excessive delay or even a denial of Service (DoS) for emergency and real-time traffic waiting for TXOP. For example, low priority bursty traffic in STA_1 may block out a long-running critical video feed on STA_2 before STA_2 gets the TXOP on the round robin basis. We call such type of a situation as *fault*. Fault can occur in any of the following situations –

- Station constantly waiting for connectivity
- Failure to maintain connectivity
- Loss of connectivity
- AP association is full

A. PROPOSED APPROACH

We propose to handle such faults in two ways: *fault avoidance* and *fault tolerance* [2]. *Fault Avoidance* situation is addressed by *perfectly periodic scheduling* algorithm. The proposed scheme assigns polling frequency p_i to STA_i based on its associated *usage probability* u_i i.e., p_i is no more the same for all STA's. *Fault tolerance* is by having Replication Access Points (RAP), which is a part of future work.

B. PERFECTLY PERIODIC SCHEDULING

In a perfectly periodic schedule, time is divided into time-slots and each client gets a time-slot precisely after a pre-determined number of time-slots. The task is to construct

a schedule that matches the request as closely as possible. However finding an optimal periodic schedule is NP-hard in general [1]. In this paper, we study the problem of perfectly scheduling a set of 'n' STA's based on its associated *usage probability* u_i . The usage probability u_i can be obtained by prediction algorithms, that are able to predict the mobility patterns and device usages of the inhabitants in a smart home architecture [4]. The polling frequency p_i is also a function of b_i and TC_i . Where, b_i is the bandwidth required for Traffic Category TC_i . $TC_i=0$, represents the traffic with lowest priority.

ALGORITHM

Goal: The goal is to minimize the average waiting time in general by matching the request time as close as possible by using u_i and p_i . This scheme also reduces the critical power consumption in wireless devices by reducing the waiting time.

Input: A set $\{1, 2, \dots, n\}$ STA_i with each i associated with u_i , b_i and TC_i

Output: $\{p_1, p_2, \dots, p_n\}$ such that, $1/p_1 + 1/p_2 + \dots + 1/p_n \approx 1$
 (1) Define TXOPLimit based on b_i and TC_i . Number of frames to be transmitted in one TXOP is, $f_i = \text{TXOPLimit}_i / \text{one frame period}$.

(2) Given u_i , f_i and TC_i define weight w_i for STA_i

$$w_i = \{u_i * f_i * TC_i\}$$

$$0 \leq u_i \leq 1, 0 \leq TC_i \leq 7 \text{ and } 1 \leq f_i \leq x$$

$$\Rightarrow 0 \leq w_i \leq 7x$$

(3) Quantize the weight into a k -bit quantizer. Where, $2^k = 7x$. $0 \leq k \leq \ln(7x-2)$

Quantization: The weighed instantaneous samples w_i , are rounded off to the nearest of several specific, predetermined levels. The number of levels is always a power of 2. This makes p_i , harmonic, whose frequency is an integral multiple of fundamental frequency p_0 .

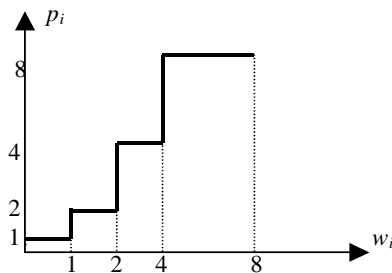


Figure1: Quantization Levels for w_i

Example: Quantizer Input: $w_i\{1.21, 2.34, 3.91\}$

Quantizer Output: $p_i\{2, 4, 4\}$

(4) The quantized output represents the polling frequency p_i , with which the STA_i is polled.

III. IMPLEMENTATION

We are using Berkley NS2 v2.1b6 to implement HCF and EDCF with a minimum bandwidth of 11 Mbps. We are

also adding new packet types based on the home network traffic [4]. For the HC scheduler we are implementing the perfect periodic scheduling. The HC allocates TXOP based on the algorithm presented in this paper. In the first phase we intend to simulate three basic traffic categories namely, entertainment (Video, Audio), communication (Voice) and background (FTP) traffic. The simulation environment is as shown in figure2.

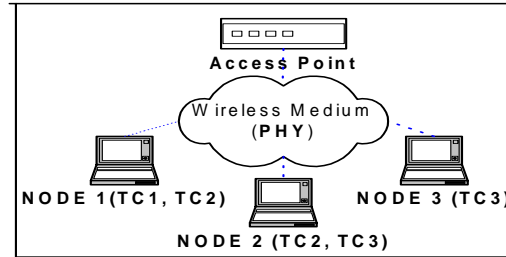


Figure 2: Phase I Simulation Scenario

Window Period: 5:30 – 7:30 PM

TC1: Video Stream; 6 Mbps; u_i (0.6)

TC2: Audio Stream; 8/32 Kbps; u_i (0.3)

TC3: Background; 1/2 Mbps; u_i (0.1)

In the above scenario, we will be varying u_i , x_i and TC_i for different traffic loads to analyze the critical performance issues like access grant time and jitter in video and audio streams.

IV. CONCLUSION AND FUTURE WORK

In this paper we presented an approach for fault avoidance in 802.11e using perfectly periodic scheduling. The approach provides an efficient way to reduce the access waiting time based on usage probability. We will be implementing the algorithm to evaluate the performance over round robin. As a part of future work, we intend to extend the proposed idea by handling faults in two ways: fault avoidance by perfect periodic scheduling and fault tolerance by having Replication Access Points (RAP).

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