An Intelligent Buffer Management For Packet Scheduling Algorithm in Multihop Wireless LANs

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Abstract

In this paper, an intelligent buffer management for packet scheduling algorithm in multihop wireless LANs has been proposed. In the recommended scheme, the mechanism of adaptive scheme will be integrated with a queue scheduler, as an effort to enhance the performance of the packet scheduling. The modus operandi of the strategy is intelligently identified the buffer and route based on the intended server's availability. By doing so, it has been shown that the problem of packet loss has been successfully avoided. When simulated, the proposed scheme has demonstrated better achievement in per-flow fairness compared to FIFO and max-min algorithm.

Keywords: *Packet Scheduling, Buffer Management, Multihop Wireless LANs, Throughput*

1. Introduction

Wireless network refers to any type of computer network that is wireless, and is commonly associated with a telecommunications network by which the interconnections between nodes are implemented without the use of wires. Wireless telecommunications networks are generally implemented with some type of remote information transmission system that uses electromagnetic waves, such as radio waves, for the carrier and this implementation usually takes place at the physical layer of the network.

Wireless network is normally be implemented using various of wireless technology, which include Communication Satellites, Infrared Communication, Wireless LANs and etc. This research will focus on the Wireless LANs, a Wireless Local Area Network that is using a high-frequency radio technology similar to digital cellular and a low-frequency radio technology. Wireless LANs use spread spectrum technology to enable communication between multiple devices in a limited area. An example of open-standards wireless radio-wave technology is IEEE. A wireless local area network links two or more devices using a wireless distribution method (typically spread-spectrum or OFDM radio), and usually provides a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network.

Currently, the most prevalent wireless LAN standard is IEEE 802.11[7] and recently, multihop wireless local area networks (LANs) have attracted considerable attention for next-generation networks supporting a large number of end users. The distributed coordination function (DCF) is the fundamental mechanism of the medium access control (MAC) protocol for IEEE 802.11, employing Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). The IEEE 802.11 DCF specifies random back off algorithm, with which each wireless node transmits data in an autonomous- decentralized manner. When the number of nodes increases, the overall throughput significantly degrades due to the hidden-node problem. To resolve this problem, the four-way handshake by using Request-To-Send/ Clear-To-Send (RTS/CTS) frames is available in IEEE 802.11. Because the four-way handshake was developed for single-hop communications, it does not work well for multihop communications [8].

Due to the problem, multihop wireless LANs has some issues to be resolved such as fairness, routing and the guarantee of quality of service (QoS). This research will focus on throughput unfairness, in which the end-to-end throughput of a packet flow degrades significantly with the increase in the number of its transmission hops. The efficiency buffer management of scheduling algorithms contributes to the effectiveness of the challenging networking environment nowadays. It is necessary to design an intelligent buffer management of scheduling algorithm with the correlation between a good scheduling discipline and packet discarding strategies with the best resource reservations scheme.

1.1. Packet Scheduling

Packet scheduling refers to the decision process used to choose which packets should be serviced or dropped. The main challenge of packet scheduling is designing fast yet clever algorithms to determine input-output matches that at any given time 1) maximize switch throughput utilization by matching as many input output pairs as possible. 2) Minimize the mean packet delay as well as jitter. 3) Minimize packet loss resulting from buffer overflow and 4) support strict QoS requirements in accordance with diverse data classes [3]. Packet scheduling has been a very popular paradigm to ensure minimum throughput and bounded delay access for packet flows [4].

1.2. Buffer In Multihop Wireless Lans

Many had referred queuing theory with buffer management in a packet switching networks. These observations made buffer handling and utilization a crucial factor in networking researches. This aspect need the buffer management scheme to be handled carefully for the performance boost up in the computer networks hence drove to the need of appropriate scheduling algorithm. The studies of buffer management need the reservation-oriented networks which are handled by switches. Therefore, several studies on the buffer handling were proposed and implemented by researchers. The goal of the buffer management algorithm is to maximize the total value of transmitted packets [5]. At the beginning of each time step, one packet can be sent, and afterwards an arbitrary number of new packets arrive. Packets that are not sent can be stored in a buffer. Each packet is attributed by a deadline, and a packet is automatically deleted from the buffer if it is still stored in the buffer by the end of its deadline. The differentiated service model is abstracted by attributing each packet with a value according to its service level. A buffer management strategy determines the packet to be sent in each time step.

Over the past decade, there has been great interest in the study of buffer management policies in the context of packet transmission for network switches. In a typical model, a switch receives packets on one or more input ports, with each packet having a designated output port through which it should be transmitted [6]. An online policy must consider bandwidth limits on the rate of transmission, memory constraints impacting the buffering of packets within a switch, and variations in packet properties used to differentiate quality of service.

2. Proposed Scheme

In this section, we present the details of the packet scheduling scheme improving per-flow throughput fairness for multihop wireless LANs. The proposed intelligent queue scheduler integrates the mechanisms of adaptive scheduling, as an effort to enhance the performance of the packet scheduling. The elements include buffer reservation strategy, packet discarding strategy and scheduling algorithms. The algorithm specifications are traced on packet arrival and departure. The strategy that uniquely defines in intelligent buffer management that is the packet discarding strategy which has the components that could intelligently manage to insert the packet into queue once the packet arrive at each node.

The implementations of intelligent buffer management for each event are discussed in this section. The buffer management algorithm constitutes of three interrelated event. The events are as follows: (1) when packet arrive at node 1 (2) when packet arrive at node 2 and (3) when packet arrive at node 3. In Figure 1, the flowcharts of buffer management process are described.

The flood of packets to be served need to be handled carefully so that important packets will not be missing on transmission. Therefore, the buffer is needed to be the transit for the packets on waiting for their turns to be served. When the packet arrives, it will check whether the server is idle or busy. If the server is idle it will automatically sent to server and service time is calculated. When another packet arrives, it will also check for the server availability. If the service time for the first packet is more than the arrival time of the second packet and so on, all the other packets that came earlier than time the server is ready to serve will be sent to buffer.

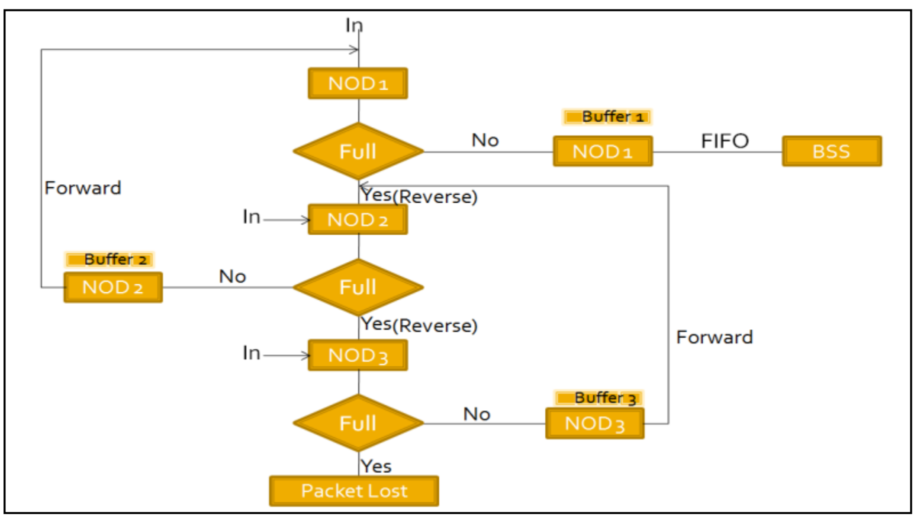

Figure 1. Flowchart of Buffer Management Process. Consider the case where the first wireless node to receive packets. If buffer in node 1 is empty, the packet is forwarded into the queue

Below, the pseudo-code of buffer management process is described:

1) When packet arrive at Nod1

If buffer1 $\neq$ FULL,
Insert packet into queue.

Capture time. (Waiting for process)

If buffer1 = FULL,
QM looks at buffer2 at nod2,
If buffer2 ≠ FULL,
Insert packet into queue.
Capture time.

If buffer2 ≠ FULL,
QM looks at buffer3 at nod3,
If buffer3 ≠ FULL, Insert packet into queue.
Capture time.
If buffer3 = FULL
Packet drop

2) When packet arrive at Nod2

If buffer2 at nod2 ≠ FULL,
Insert packet into queue.
Capture Time.

If buffer2 = FULL,
QM looks buffer1 at nod1,
If buffer1 ≠ FULL,
Insert packet into queue.
Capture Time.

If buffer1 also equal FULL,
QM looks at buffer3 at nod3,
If buffer3 ≠ FULL,
Insert packet into queue.
Capture Time.

If buffer3 = FULL,
Packet drop.

3) When packet arrive at Nod3

If buffer3 at nod3 ≠ FULL,
Insert packet into queue.
Capture Time.

If buffer3 = FULL,
QM looks buffer2 at nod2,
If buffer2 ≠ FULL,
Insert packet into queue.
Capture Time.

If buffer2 also equal FULL,

QM looks at buffer1 at nod1,
If buffer1 ≠ FULL,
Insert packet into queue.
Capture Time.

If buffer1 = FULL,
Packet drop.

4) Packets in Buffer3 at Nod3

If Queue Size Buffer3 greater than zero,
Check buffer 2 at nod2,
If buffer2 ≠ FULL,
Forward packet from buffer3 to buffer2 using FIFO Scheduler based on arrival time into queue. Capture time.

5) Packets in Buffer2 at Nod2

If Queue Size Buffer2 greater than zero,
Check buffer 1 at nod1 If buffer1 ≠ FULL,
Forward packet from buffer2 to buffer1 using FIFO Scheduler based on arrival time into queue. Capture time.

6) Packets in Buffer1 at Nod1

Scheduler will pick packet from queue (buffer1) for server process using packet scheduling algorithm base on arrival time (FIFO).
If Queue Size Buffer1 is greater than zero (there is packet in queue to process),

3. Performance Evaluation

The performance metric in this research is focused specifically on the fairness index [7] as a measurement to evaluate per-flow throughput fairness where the offered loads are the same, the average delay taken by the packets being scheduled to be serve and departed, packet lost ratio for the total numbers of packet being processed and execution time required by the program to run for the given total of load.

$$\text{Fairness Index} = 1 - \frac{\sum_{i=1}^{n}|x_i - \bar{x}|}{2(n-1)\bar{x}}$$

Where:
n is the number of flows,
x_i the end-to-end throughput of flow i (1 <= i <= n),
and $\bar{x}$ the average end-to-end throughput achieved by all n flows.

The input parameters used in the simulation experiments are outlined in Table 1.

Table 1. Input Parameter for the Simulation

Parameter	Value
Total Node	3
Buffer Size	50
Packet Size	1500[byte]
Bandwidth	11[Mbps]

3.1 Node Chain Topology

Figure 2 shows in our simulation, we assumed the topology being used is formed of 3 nodes and 1 base station (BS). All nodes are arranged in a multihop wireless LAN environment. When packet arrived at the first node which is the nearest nod to base station, the packet is sent directly to base station to be processed. When packet arrived in second node, the packet is sent to the first node before it is sent to base station. Similarly when packet arrived in third node, the packet is subsequently sent to the second node before it is sent to the first node and finally sent to base station. Figure 3 shows the illustration of arrival packet simulation.

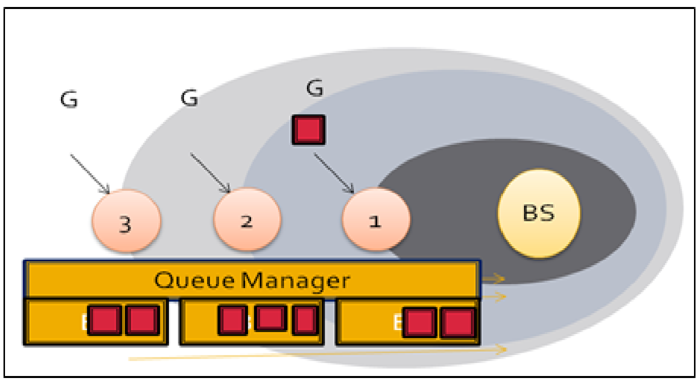

Figure 2. Node Chain Topology; Topology being used is formed of 3 nodes and 1 base station

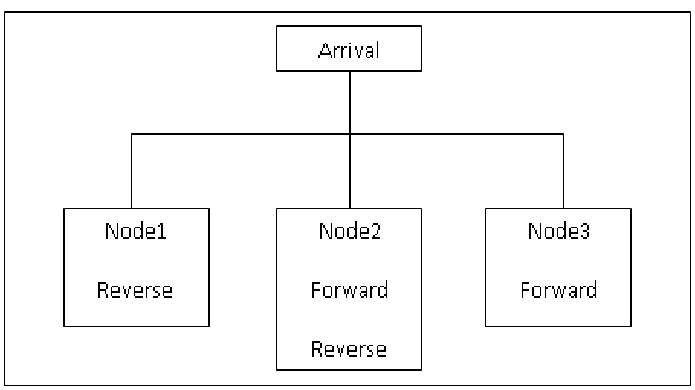

Figure 3. Illustrations of arrival packet simulation. If node 1 is full, node 1 will use reverse algorithm. If node 2 full, node 2 will use reverse algorithm, if node 1 is empty, forward algorithm used

3.2 Event List

The simulation maintains at least one list of simulation events. Table 2 show two events in this simulation. This is sometimes called the pending event set because it lists events that are pending as a result of previously simulated event but have yet to be simulated themselves. An event is described by the time at which it occurs and a type, indicating the code that will be used to simulate that event. It is common for the event code to be parameterised, in which case, the event description also contains parameters to the event code.

Table 2. Simulation Events and Functionalities

Events	**Function**
Packet Arrive	Packet arrival into queue at each node randomly.
Packet Departure	Packet departs from node to Base Station using packet scheduling algorithm.

3.3 Fairness

While comparing fairness indices for all scheme in Figure 4, we observe that the proposed scheme always keep high per-flow fairness, while FIFO scheme degrade fairness when load is greater than 700[kbps] and Max-Min Fairness[8] scheme degrade fairness when load is greater than 1100[kbps]. Obviously can be seen that proposed scheme shows a better behavior compared to previous work.

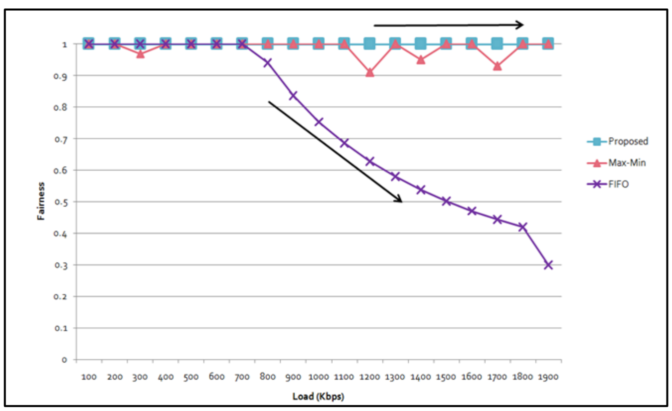

Figure 4. Fairness Index Graph Comparing Proposed Scheme with FIFO and Max-Min Scheme

3.4 Average Delay

The performance measure for average delay experiment in Figure 5, clearly and as expected the average delay for the proposed scheme lesser and much stable compare to FIFO scheme. FIFO scheme rising highly when the offer load reach to 500kbps and constantly increase with increasing load.

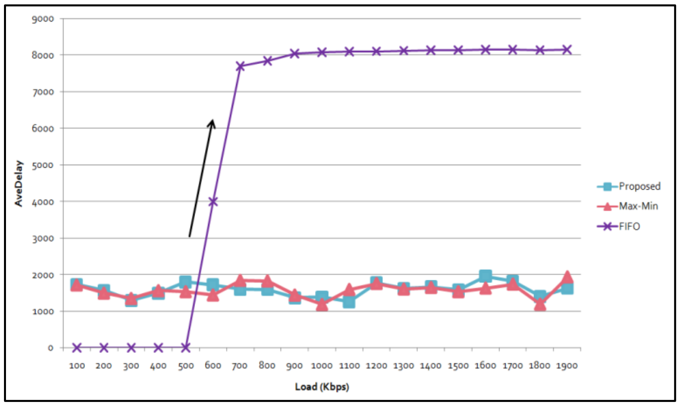

Figure 5. Average Delay Graph

4. Conclusion

In this research, an intelligent buffer management of packet scheduling algorithm proposed was the idea of managing the packet in the buffer to meet the better fairness, small packet loss, less delay and less execution time. From the simulation results, it was observed that the proposed scheme can achieve max-min fairness than the existing schemes. In addition, the proposed scheme can also reduce packet loss and execution time. The proposed scheme is a probabilistic packet scheduling scheme in which an autonomous traffic control mechanism is introduced without the modification of the MAC protocol. This study had contributed towards the idea of putting the best element to the best environment. There are needs for a dynamic resource reservation scheme to complement today's migration towards robust and adaptive network applications and the increase of communications among the increasing community. These finally can be fulfilled with the combination of an intelligent buffer management for packet scheduling algorithm as a good scheduler. The overloaded environment is common to happen nowadays because of the increasing community and infrastructures around the world.

References

[1] Demers A, Keshav S and Shenker S, "Analysis and Simulation of a Fair Queueing Algorithm", in Proceeding SIGCOMM '89 Symposium proceedings on Communications architectures & protocols, **(1989)**.
[2] Li Z, Das A, Gupta AK and Nandi S, "Performance Analysis of IEEE 802.11 DCF: Throughput, Delay, and Fairness", IEEE Journal on Selected Areas Communications, vol. 9, **(2004)**, pp. 1024-1039.
[3] Elhanany I, Kahane M and Sadot D, "Packet Scheduling in Next-Generation Multiterabit Networks**",** in Journal Computer, vol. 34 Issue 4, **(2001)** April.
[4] Luo H, Lu S, Bharghavan V, Cheng J and Zhong G, "A Packet Scheduling Approach to QoS Support in Multihop Wireless Networks", in ACM Journal of Mobile Networks and Applications (MONET), vol. 9, no. 3, **(2004)** June.
[5] Kobayashi K, Miyazaki S, Okabe Y, "Competitive Buffer Management for Multi-Queue Switches in QoS Networks Using Packet Buffering Algorithms", *SPAA'09,* Proceedings of the twenty-first annual symposium on Parallelism in algorithms and architectures, **(2009)**.
[6] Caminero A, Sulistio A, Caminero B, Carrion C and Buyya R, "Simulation of Buffer Management Policies in Networks for Grids", 41st Annual Simulation Symposium, **(2008)**.
[7] Gerla M and Kleinrock L, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications", IEEE Standard for Information technology, Telecommunications and information exchange between systems, Local and metropolitan area networks, Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, **(1999)**.

[8] Wakuda K, Kasahara S, Takahashi Y, Kure Y and Itakura E, "A packet scheduling algorithm for max–min fairness in multihop wireless LANs," in: Journal Computer Communications, vol. 32, Issue 13-14, **(2009)** August.

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