ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 10, October 2013

Adaptive Buffer size routing for Wireless Sensor Networks

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Abstract: In wireless networks IEEE 802.11 standard is used which determines physical layer and media access control. There are many issues with wireless networks which do not exist in wired networks. For instance buffer sizing is one such issue. In case of IEEE 802.11 networks fixed buffer size leads to higher delays, under-utilization of channels. To overcome this problem dynamic buffer sizing is the desired solution. Li et al. presented novel algorithms for dynamic buffer sizing in order to increase throughput and reduce delay in Wireless Sensor Networks under various network conditions. In this paper we built a prototype application to implement these buffer sizing algorithms. The experimental results revealed that the algorithms are effective.

Index Terms: IEEE 802.11 networks, WLANs, buffer sizing, medium access control

I. INTRODUCTION

Buffers and the size of them play an important role in network communications. Buffer size is essential to ensure communication effectiveness. This is because there might be burst of packets unexpectedly. This will cause problems when the buffer size does not support the dynamic packet flows at runtime. The packets are queued unnecessarily causing delay in communication. It also decreases throughput. For this reason buffer sizing in case of wired networks is an active research area for many researchers [1] [2] [3] [4] [5]. In case of wired networks buffer sizing is almost fixed as it depends on the bandwidth and average delay. In case of wireless networks buffer sizing has not attracted much research except the recent works as explored in [6], [7], [8] and [9]. In case of IEEE 802.11 networks buffers play an important role. The present solutions on buffer sizing provide poor performance.

In this paper we considered buffer sizing in IEEE 802.11 networks. WLAN topology as shown in fig. 1 is taken for experiments. The simulations reveal that the proposed algorithms for buffer sizing can improve performance wireless networks. When buffer sizing is not considered dynamically and given statically, it causes problems wireless networks. When traffic flows come dynamically with bursts now and then the network does not work in a predicted way. To overcome this problem in this paper we implement buffer sizing mechanisms that take care of dynamic allocation buffer sizes at runtime. The algorithms take care of buffer requirements so as to enable performance optimization in the network. The remainder of this paper is structured as follows. Section II reviews literature. Section III describes proposed buffer sizing algorithms. Section IV presents prototype implementation details. Section V presents experimental results. Section VI concludes the paper.

II. RELATED WORK

In [1] BDP rule is proposed for buffer sizing Internet routers. Later on in [2] it is argued that BDP is overlay conservative with respect to sharing huge number or network flows. For this reason TCP congestion windows are in tandem with it and the buffer requirement of BDP is less. The work in [2] is enhanced in [10], [11] and [12] where congestion of TCP is considered. The experiments are made with low, high and medium buffer sizes. However, many researchers opined that it is difficult to determine the buffer size in a realistic fashion. The analysis includes RTTs, connection sizes and they are time-varying as explored in [4] and [5]. Excessive loss rate is reported with less buffer size. With this motivation [13] and [3] focused on adaptive buffer sizing. However, it needed prior knowledge on line rate, link capacity and which is load dependent. In [14] another buffer sizing concept was introduced which is adaptive in nature. Later buffer sizing experiments are made with Internet core routers [15], [16].

With respect to wireless networks, almost no attention has been made. Buffer sizing in 802.11 networks was received little attention with exceptions in [7], [8], and [9]. The TCP and UDP related simulations are made in order to explore dynamic buffer sizing requirements of such networks.

III. PROPOSED APPROACH FOR BUFFER SIZING

We have made simulations with a prototype application that demonstrates how dynamic buffer sizing helps in wireless communications. The network architecture considered for simulations is as shown in figure 1.

ISSN (Print) : 2319-5940
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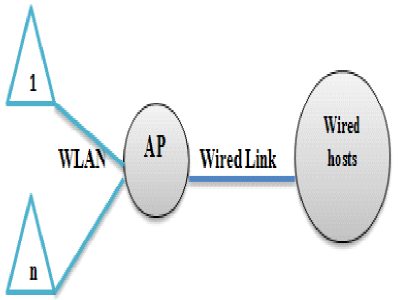

Fig. 1 – Topology of WLAN used for simulations

Preliminaries pertaining to IEEE 802.11 DCF, IEEE 802.11e EDCA, unfairness among TCP flows, BDP emulation are as explored in [17]. The algorithms used for drop tail operation and MAC operation of eBDP are presented here.

Algorithm 1: Drop tail operation of the eBDP algorithm.

Set the target queuing delay $T_{\max}$.
Set the overprovision parameter c.
for each incoming packet p **do**
  Calculate $Q_{\text{eBDP}} = \min(T_{\max}/T_{\text{serv}} + c, Q_{\max}^{\text{eBDP}})$,
  where T_{serv} is from MAC Algorithm 2.
  if current queue occupancy $< Q_{\text{eBDP}}$, **then**
    Put p into queue
  else
    Drop p.
  end if
end for

Fig. 2 – Drop tail operation of the eBDP (excerpt from [17])

As can be seen in fig. 2, the pseudo code for back tail operation of eBDP algorithm is presented. The dropping is based on a condition with respect to the current queue occupancy. In the same fashion, the MAC operation is presented in fig. 3.

Algorithm 2: MAC operation of the eBDP algorithm.

Set the averaging parameter W.
for each outgoing packet p **do**
  Record service start time t_s for p.
  Wait until receive MAC ACK for p, record service end time t_e.
  Calculate service time of p:
  $T_{\text{serv}} = (1 - W)T_{\text{serv}} + W(t_e - t_s)$.
end for

Fig. 3 – MAC operation of the eBDP (excerpt from [17])

As can be viewed in figure 3, the MAC operations are recorded and service time is calculated for each outgoing packet until MAC acknowledge is received.

IV. PROTOTYPE IMPLEMENTATION

We built a prototype application which is a custom simulator in Java platform. The simulator is built with graphical user interface that visualizes how buffer sizing can help improve communications in IEEE 802.11 networks. To simulate the network we built a server and nodes. The server program monitors the communications among the nodes and visualizes the way buffer sizing takes place dynamically at runtime. The design of server is as shown in fig. 1.

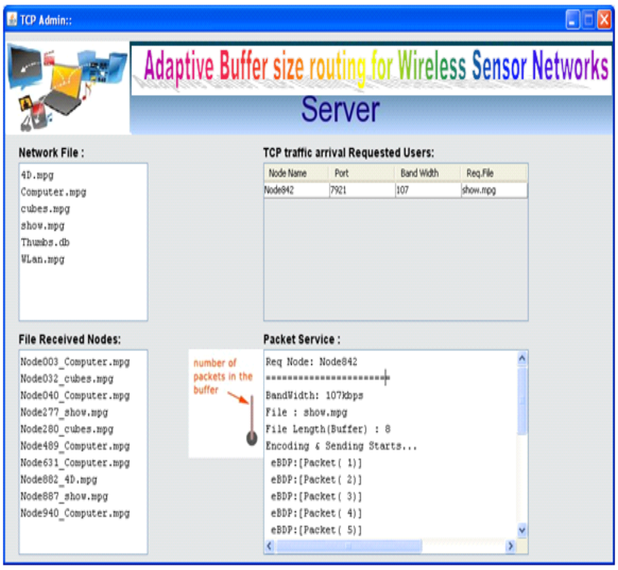

Fig. 4 – Visualizes communication process

As can be seen in fig. 4, the server program shows the packets received, bandwidth, nodes that receive files, the files available and the traffic arrival at users. As there is communication between the nodes, this program shows the details. A typical node that can make request for information is as shown in fig. 5.

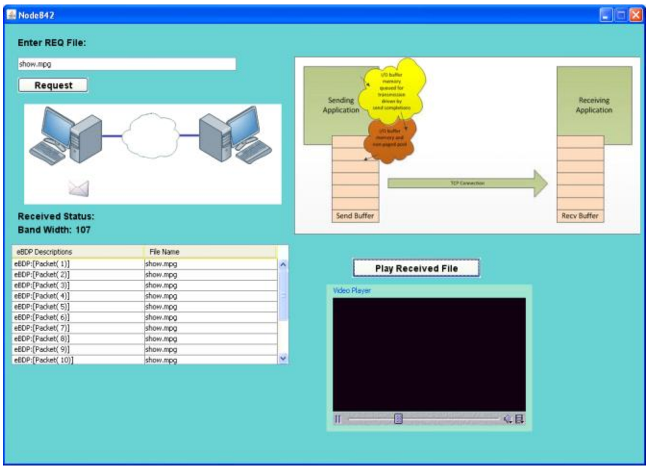

Fig. 5 – Typical node in the network

As shown in fig. 5, a typical node in the network is presented. It shows the list of received file and also the provision for playing file if that is a video file. Various

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
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kinds of traffic is alter visualized using graph as shown in fig. 6.

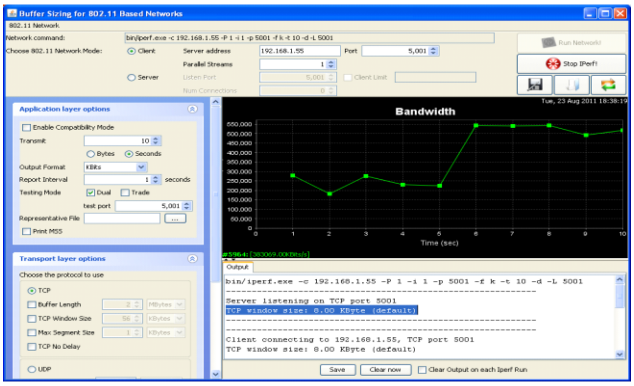

Fig. 6 – Buffer sizing visualization with TCP

As can be seen in fig. 6, it has provision for visualizing various parameters and corresponding simulated graphs. It shows the provision for application level options and transport layer options. End users can simulate the concept using various parameters. Fig. 7 shows the buffer sizing visualization with UDP protocol enabled.

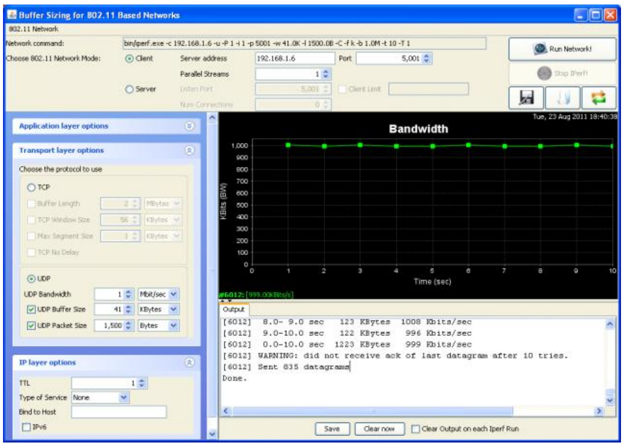

Fig. 7 – Buffer sizing visualization with UDP

As can be seen in fig. 7, it has provision for visualizing various parameters and corresponding simulated graphs. It shows the provision for application level options and transport layer options. End users can simulate the concept using various parameters. The results for UDP protocol are found in figure 7.

V. EXPERIMENTAL RESULTS

With the specified topology simulations are made and the results are as presented in this section. The experiments are made in terms of AP throughput percentage, max smoothed RTTI with number of downloads.

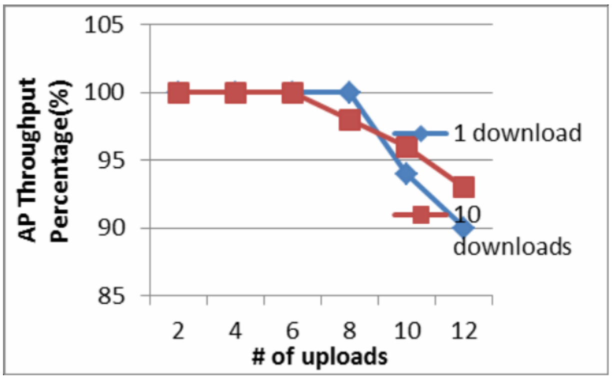

Fig 8 Performance of the eBDP algorithm as the number of upload flows is varied of throughput

As shown in the above figure represents the horizontal axis represents uploads while vertical axis represents AP Throughput percentage

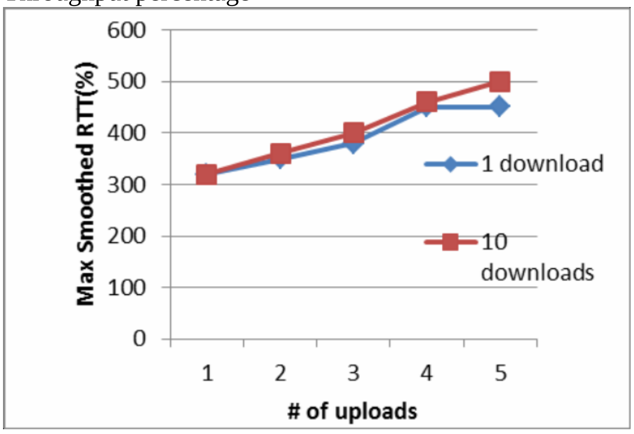

Fig 9 Performance of the eBDP algorithm as the number of upload flows is varied of Delay

As shown in the above figure represents the horizontal axis represents uploads while vertical axis represents Max smoothed RTT.

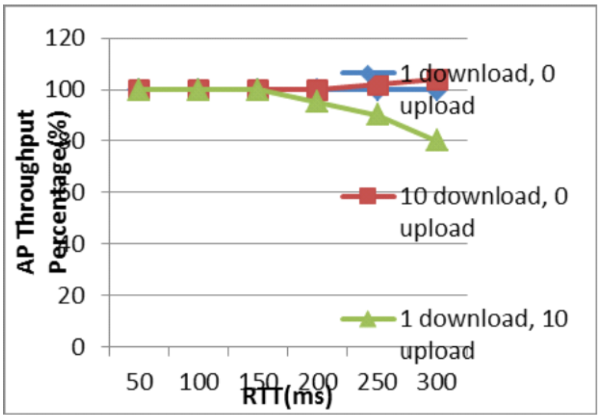

Fig 10 Performance of the eBDP algorithm as the RTT of wired backhaul is varied of Throughput

As shown in the above figure represents the horizontal axis represents RTT while vertical axis represents AP Throughput percentage.

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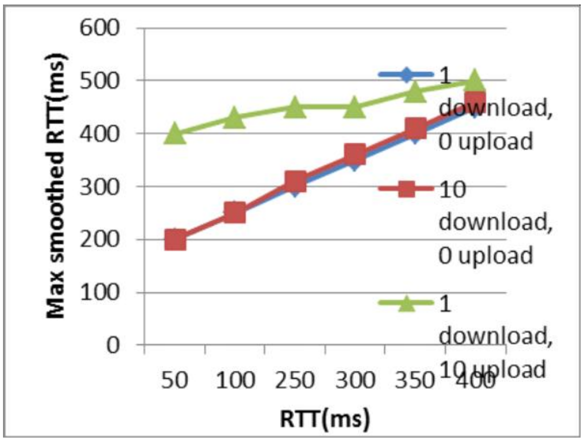

Fig 11 Performance of the eBDP algorithm as the RTT of wired backhaul is varied of Delay.

As shown in the above figure represents the horizontal axis represents RTT while vertical axis represents Max smoothed RTT.

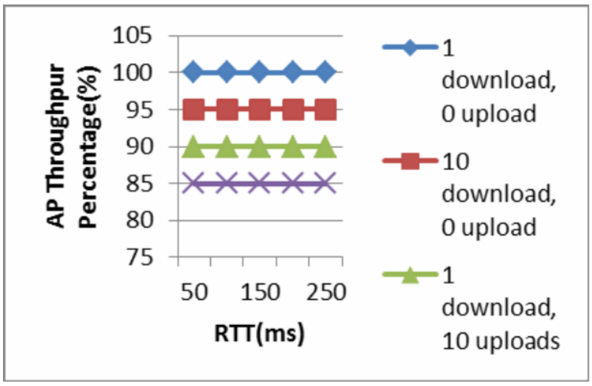

Fig 12 Performance of the A* algorithm as the wired RTT is varied of Throughput efficiency.

As shown in the above figure represents the horizontal axis represents RTT while vertical axis represents AP throughput percentage.

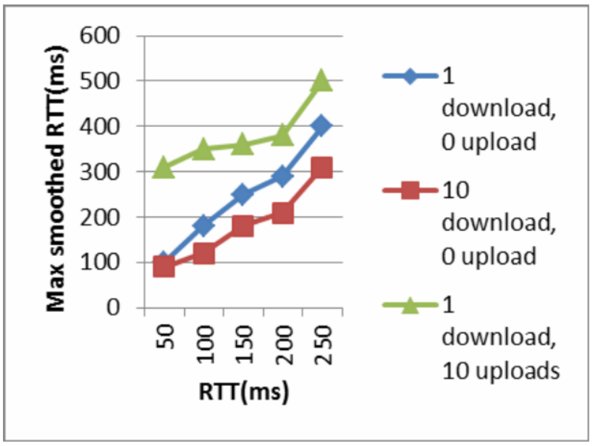

Fig 13 Performance of the A* algorithm as the wired RTT is varied of Delay

As shown in the above figure represents the horizontal axis represents RTT while vertical axis represents Max smoothed RTT.

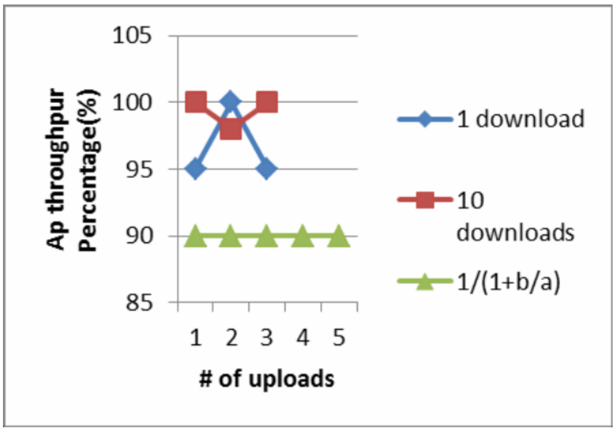

Fig 14 Performance of the A* algorithm for 802.11 DCF operation of Throughput

As shown in the above figure represents the horizontal axis represents uploads while vertical axis represents AP Throughput percentage.

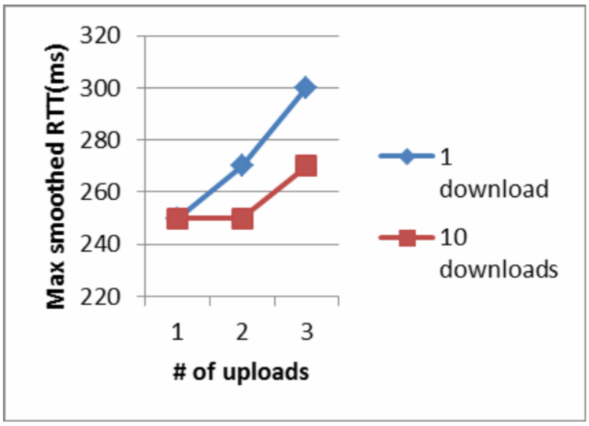

Fig 15 Performance of the A* algorithm for 802.11 DCF operation of Delay.

As shown in the above figure represents the horizontal axis represents uploads while vertical axis represents Max smoothed RTT.

VI. CONCLUSIONS

In this paper we consider buffer sizing problem in 802.11 networks. Fixed buffer sizing causes problems with wireless networks. Therefore it is inevitable to have dynamic buffer sizing algorithms to improve performance. In this paper we implement buffer sizing algorithms proposed by Li et al. [17]. The algorithms are implemented in wireless sensor network. The result of these algorithms is that they improve the throughput of network and reduce the delay in packet delivery. These two are the essential improvements that are achieved by changing buffer size dynamically. We built a prototype simulator which demonstrates the proof of concept. The empirical results revealed that the proposed solution is effective.

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BIOGRAPHIES

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