IEEE 802.11 INTRA-WLAN Load Balancing Algorithm for Network Performance Improvement

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***Abstract* – The present work focuses on creating a QoS mechanism (throughput oriented) which will optimally allow integrating applications and traffic parameters in general. This mechanism adapts an organizational model to a technical load balancing model based on Controller "intelligence". Physical parameters (Antenna Gain, Transmitted Power, RSSI, Bandwidth, and Load) are inputs used for triggering the balancing mechanism which will increase the WLAN throughput value. The experimental results show the proposed algorithm can improve the network throughput up to 50% compared to algorithms using number of users as "triggering" factor.**

***Keywords* – WLAN, QoS, Access Point, Controller, Throughput**

I. INTRODUCTION

The "load balancing" concept is often used in wireless broadband communications and it represents one of the viable solutions when it involves QoS concept. From this perspective, the most used criteria in order to trigger load balancing mechanism is the number of users [3, 5, 6] associated with an Access Point AP. They are embedded in proprietary solutions. There are currently recent solutions [4, 7] to improve these criteria.

This paper analyses the possibility to use physical (e.g. SNR, EIRP) or traffic parameters (e.g. Bandwidth, Throughput) based on a multidisciplinary approach represented by these papers [1, 2]. The clustering concept was successfully implemented from the organizational management perspective. We show via experimental evaluation that our balancing scheme increases the overall wireless network throughput.

II. ALGORITHM OVERVIEW: INTRA-AP (AP AND ASSOCIATED CLIENTS) AND INTER-AP (ACCESS POINTS AND CONTROLLER)

The architecture and the overview of the proposed load balanced mechanism is explained in figure 1.

Steps 1 and 2 are used by AP for collecting essential data parameters (e.g. Bandwidth, throughput, SNR) and calculating gains and losses according to Intra-AP algorithm (described in 3.). Step 3 is used for transmitting those data for processing to the Controller.

In step 4, the Controller compares the received data from Access Controllers (AP) and in step 5 the client to be balanced is selected. In step 6, the client is disconnected from the AP and encouraged to connect to other AP (it will receive "busy" message and it will be able to choose another AP from the same SSID).

In step 7, the load recalculation process will start. This is trigger based event. By comparison, HP Patent maintains a "real time database" [4] so that the wireless terminal knows where to connect to. However, the algorithm from this paper involves AP's for recalculating the load, so the analysis effort is distributed between AP's and the Controller; therefore it doesn't maintain a complex database.

III. INTRA-AP ALGORITHM (AP AND ASSOCIATED CLIENTS) DESCRIPTION FOR GAIN/LOSSES CALCULATION

The below algorithm describes the essence of calculating the gains and losses for the intra AP part:

```
if ( m(i,j))  >= mdest(j)
        g(i,j)=m(i,j);
        losses(i,j)=alfa*(m(i,j)-mdest(j));%the losses are averaged by alfa processing capacity
      else
        if m(i,j)<mdest(j)
        g(i,j)=m(i,j);
        losses(i,j)=mdest(j)-m(i,j);
        end
      end
```

where:

m(i,j)- is the processing capacity of the channel for a client associated to an AP; j competencies for i clients associated to an AP. The values are normalized.

Mdest(j)- is the minimum accepted capacity by the Controller(minimum values for the accepted competences by the Controller). The values are normalized.

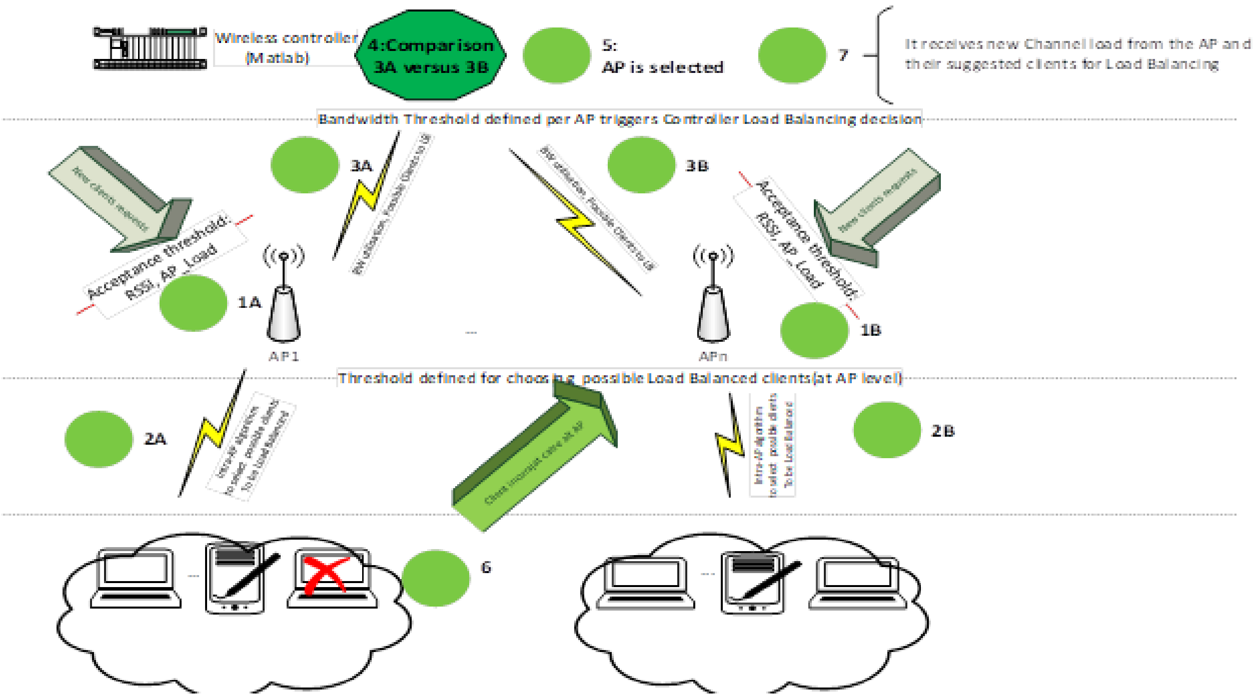

Fig. 1: Overview of the proposed Load Balancing algorithm

Alfa- is the processing capacity which indicates the relationship between AP and the Controller; it can have values between 0 and 1; used value was 0.5.

In both cases (1. m>:=mdest, 2.m<mdest), the gain remains the same and is the value reported by the AP. The only difference is the value of the losses. If the minimum quality threshold is reached then the losses are minimum; however, if the threshold is not reached then the value for losses is increasing. Therefore, information processing (e.g. SNR, EIRP, Throughput) is the AP attribute and the Controller must be able to receive/"understand" that information. This is important for the load redistribution from one cluster to another.

$$AP\_Load = \frac{BW}{Sum(ABSGain\_Client1 + \ldots + ABSGain\_Client\ N)} \quad (1)$$

where:

BW-is the bandwidth value according to the used standard (e.g. for 802.11g this is 54)

Abs_Gain_Client: is the absolute gain value per client obtained as a difference between gain and losses ("g"-"losses").

The associated value for the gain per Access Point was averaged as a simple average:

$$AverageGain\_AP = SUM(AverageGain\_Client1 + \cdots + AverageGain\_ClientN)/n \quad (2)$$

where :

- *AverageGain _AP*: is the average gain per AP

-*n*: is the number of clients.

IV. SCENARIO IMPLEMENTATION FOR TESTING THE ALGORITHM

The following initial scenario was considered:

- ✓ AP1:8 clients, AP2:8 clients
- ✓ Modified competencies values: Antenna Gain, Tx, Channel Width

For the above scenario, the following settings were considered:

-2 Access Points: AP1 and AP2 both subordinate to the controller (the computer running Matlab and the FTP server);

- AP2 initially assigned 8 clients will generate FTP traffic limited to 100 kbps per client by simultaneously downloading a file on the laptop containing the Matlab software;

-AP1 initial clients have no throughput limitation on the FTP download;

- Each AP has an open source DD-WRT type firmware installed;

- All wireless clients were HP Laptops with similar physical features (Intel Core I5 processor, 4GB RAM);

The above mentioned scenarios will not trigger any load balance for the compared commercial algorithms (e.g. "Cisco aggressive load balancing", "Juniper") which have clients number as load balancing triggering factor.

V. RESULTS

Variation of bandwidth:

Bandwidth=20 MHZ:

Total throughput (AP1+AP2) before load balancing is 17.104 Mbps (AP1=16.304 Mbps, AP2=0.8 Mbps). Total throughput (AP1+AP2) after load balancing is 19.511 Mbps (AP1=11.231 Mbps, AP2=8.28 Mbps). The new allocation of clients is: AP1:3 clients, AP2:13 clients. The total throughput before balancing is 17.104 Mbps and after balancing it becomes 19.511 Mbps. This means an improvement in the throughput of 13%. By comparison, before the balancing, the throughput for AP2 associated customers was 0.5% of the value associated with AP1. After load balance it becomes 73%.

Bandwidth=5 MHZ:

The total throughput (AP1 + AP2) before balancing is 16.368 Mbps and after balancing it is 17.572 Mbps. This means an improvement in the throughput of 10%. The new allocation of clients is: AP1:6 clients, AP2:10 clients.

Antenna Gain Variation

Antenna gain = 0 dBi

The total throughput (AP1 + AP2) before balancing is 9.4 Mbps and after balancing it becomes 14.77. This means an improvement in the throughput of 57%. The new allocation of clients is: AP1:3 clients, AP2:13 clients.

Antenna gain = 2 dBi

The total throughput (AP1 + AP2) before balancing is 17.104 and after balancing it becomes 19.511. This means an improvement in the throughput of 13%. By comparison, prior to balancing, the throughput for AP2 associated customers was 10% of the value associated with AP1. After balancing it becomes 95%. The new allocation of clients is: AP1:3 clients, AP2:13 clients.

Tx power variation

Tx= 15 dBm

The total throughput (AP1 + AP2) before balancing is 15.68 and after balancing it becomes 17.4. This means an improvement in the throughput of 10%. The new allocation of clients is: AP1:7 clients, AP2:9 clients.

Tx= 20 dBm

The total throughput (AP1 + AP2) before balancing is 15.68 and after balancing it becomes 17.45. This means an improvement in the throughput of 11.3%. By comparison, before the balancing, the throughput for AP2 associated customers was 0.5% of the value associated with AP1. After balancing it becomes 60%. The new allocation of clients is: AP1:6 clients, AP2:10 clients.

VI. CONCLUSION

Compared with the wireless commercial load balancing algorithms, having number of users as triggering criteria, the proposed algorithm shows an improvement in the throughput WLAN performance ranging from 5% to 52%. The studied parameters were: Antenna gain, Tx, Channel Width. Better load distribution between AP's up to 90% (with the proposed algorithm) translates into better application functionality. The new redistribution of the clients, shows that number of clients doesn't play a major role. However, this can be relevant only if the throughput values are similar for the allocated clients.

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