A Method for Access Point Selection in 802.11 Networks

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***Abstract*—Nowadays, since devices can find more than one access point (AP) in wireless local area networks (WLANs), we are supposed to choose the access point which tends to provide the best performance based on the kind of usage for which it is specified.**

Currently, in order to select the most appropriate AP, computers utilize the received signal strength which is referred to as the Signal Strength Strategy (SSS). But this leads to the concentration of many nodes on the nearest AP; as a consequence, the throughput of the network decreases. However, there may be some APs at a nearby location which were still in the idle mode.

In this paper, we have proposed a method for the access point selection by taking into account the throughput which is achieved from the specific servers over the Internet (not just the throughput of the node to an AP). This method was aimed at reducing the negative impact of the low throughput of one node on the others. Besides, to stabilize the wireless connection, the method benefited from the signal strength as well as the applied throughput based on the desired usage of the network and special QoS parameters, such as minimizing power consumption, UDP or TCP connection. Moreover, two different scenarios were simulated. In fact, the first one showed the importance of measuring the throughput of the Internet connection and the second one showed reduction of the negative influence.

***Index Terms*— Wireless LAN, Access Point, Access Point Selection, Signal Strength Strategy (SSS), Throughput**

I. Introduction

Over these years, the wireless network has been made quite popular owing to its ease of usage and installation. In fact, people prefer to use wireless networks instead of wired networks to connect to the Internet. With the development of wireless networks, many nearby access points can be found by the devices. At present, a reasonable question can be raised regarding the access point that should be selected. Currently, the AP selection mechanism is based on the strength of the received signal. Although selecting AP without transmitting any packets is a simple and quick method, it results in the concentration of many nodes on specific APs. In fact, several nodes are associated with the nearest AP due to its stronger signal strength. As a result, unbalanced traffic loads will be imposed on APs and thus the throughput of other clients will be decreased [1], while there may be some nearby APs in an idle mode.

Lately, several new mechanisms have been proposed to improve the access point selection. An adaptive access point selection method is shown in [1] that chooses an appropriate AP by calculating EoAP. In [2], "facilitating access point selection" method identifies a potential bandwidth based on the MAC layer, between AP and an end-host which is an important metric in the process of AP selection. Two algorithms which are presented in [3] measure the throughput performance by using the number of active stations sharing each AP. Virgil in [4] estimates the suitable AP by bandwidth and the round trip time to a set of referred servers. In fact, each of them has coped with the problem from a different perspective.

In our method, we have measured the throughput (which is achieved from specific servers on the Internet), instead of the signal strength to solve the defect of the signal strength strategy. We observed that when some mobile nodes used a throughput that was lower than the others, the performance of all nodes was considerably decreased [5]. Therefore, we tried to reduce the negative influence of the low throughput of a node on other nodes of associated AP. Besides, according to the desired usage of network and QoS parameters, such as minimizing power consumption, UDP or TCP connection, we benefited from the signal strength as well as applied throughput to improve the utilization of the connection. In what follows, we shall discuss some important issues about access point selection. In section III, we would try to identify these issues using our suggested method. Then, we shall describe our method in detail and two simulations are also included; The first one shows the importance of the measured throughput from node to specific servers on the Internet and the second one shows reduction of the negative influence of low throughput of a node in our method.

II. Important Issues in AP Selection

As mentioned earlier, due to the problem that the signal strength strategy has caused, recently some researchers have presented solutions from different aspects. SSS causes the concentration of many nodes on specific APs. This results in unbalanced traffic loads on APs and causes decreasing the throughput of clients, while there may be some nearby APs in an idle mode.

2.1) Therefore, [2] identifies the potential bandwidth

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between AP and an end host in MAC layer as a solution. They have suggested a methodology for estimating the potential bandwidth based on delays experienced by beacon frames from an AP. They also presented results from experiments conducted in a low noise environment. The final decision to choose the best AP in [2] is actually based on the bandwidth. So, we are supposed to measure the throughput instead of the signal strength in deciding on the best AP to select.

2.2) [3] measures the throughput performance by using the number of active stations sharing each AP. Therefore, the achieved throughput has an inverse relationship with the number of active stations: due to the following reasons.

--Packet loss due to network connection or bit errors.

--Packets may be dropped in switches and routers when the packet queues are full due to congestion.

So, when the number of active stations increases, the mass of packets as well as the packet loss shall increase; Therefore, the achieved throughput shall decrease .

2.3) In [5], it has been observed that when some mobile hosts use a lower bit rate than the others, the performance of all hosts shall be considerably degraded. Such a situation is a common case in wireless local area networks. To cope with this problem the host changes its modulation type which degrades its bit rate to some lower value. The throughput of all hosts transmitting the higher rate will also be degraded below the level of the lower rate [5].

2.4) In throughput-only method we do not consider the signal strength. Therefore, mobile nodes may be associated with an AP having a weak signal. This could lead to decreasing the stability of the wireless connection [1].

III. Resolving the Issues using our method

At this stage, it is expected that using our method would result in resolving the issues presented in section II. Some factors affect throughput including the signal strength which has a direct relationship with the throughput. In other words, when the signal strength decreases, the throughput shall also decrease, too. Due to this factor as well as 2.1, we are supposed to measure the throughput instead of the signal strength in an attempt at taking our decision regarding the selecting of the best AP. As a result, our method was based on the throughput.

As presented in 2.2, the achieved throughput has an inverse relationship with the number of active stations. Thus, to consider this issue, we had to measure the achieved throughput with transmitting packets. It means that the measured throughput was affected by the number of stations.

The purpose of most users in associating with an access point is connecting to the Internet network and transmitting data over it. In fact, the important point is achieving a better throughput from the Internet. Taking this point into consideration and according to 2.2, in our method we measured the throughput from the node to specific servers on the Internet. Therefore, the achieved throughput in as much as packets could pass all routers, switches, and reach the specific servers, influenced by all packet loss and delays which may exist between the node and specific servers. In this method, we could measure the achieved throughput not only from the AP to specific servers but also from the node to the AP. Therefore, this throughput was actually more real and useful. For instance, we can use Microsoft.com or Google.com, which has high bandwidth rate, or our specific server as our referred servers on the Internet. This issue is presented in simulation 5.1.

It needs to be mentioned that when the new node tries to associate with an access point, according to 2.3, it may decrease the throughput of other nodes, which have been connected before. Hence, we had better find out whether it was possible to associate with another AP in order to reduce its negative influence on other nodes. In our method, we had tried to decrease this negative influence by using the throughput of nodes (which were associated with the AP) when we were not connected yet. According to 2.3, it is obvious that before being associated with an AP, the throughputs of all clients of that AP are the same. Thus, we could measure the throughput of each node. Based on this strategy, we calculated the difference between the throughput of nodes before being associated as well as the achieved throughput of our node during the associating procedure. In fact, the decrement of the bit rate occurs when a host detects repeated unsuccessful frame transmissions [5], so in the associating procedure, the host does not change its modulation to decrease the bit rate. As a result, we could find the throughput of other nodes by transmitting some packets to other nodes which had already been connected to the AP. Actually such a difference had an inverse influence on our decision in selecting the best AP.

So far, we have not considered the signal strength in our method, but as pointed in 2.4, mobile nodes may select an AP with a weak signal. This could lead to a decrease in the stability of the wireless connection [1]. However, the stability of the wireless connection is an important parameter, depending on the user's desired usage of the network as well as QoS parameters such as minimization of power consumption, UDP or TCP connections. In fact, the received signal strength is an important parameter when the power consumption of a wireless node is being minimized; with stronger signals, the node needs a lower potency for transmitting data. Or when a UDP connection like VoIP is used, it is important to have a stable connection to have a better quality. Nevertheless, when a TCP connection is used the signal strength is not a major issue in comparison to the throughput. Therefore, depending on the user requirements, the signal strength would be applied in our method.

IV. Our Method for AP Selection

$$\frac{TP}{BTP - ATP} \times (SS\%)$$

The above formula is actually the result of section III. In fact, SS% is the received signal strength which is commonly calculated in percentage. It is an optional parameter. However,

it is used as a parameter in our method if:
1. The user asks the wireless node's power consumption be minimized.
2. The user requires using a UDP connection, or any other QoS parameters, they can be added later. However, in other modes, like a TCP connection, SS% is ignored. In fact, SS% can be found without transmitting any packets in association procedure [1].

TP refers to the achieved throughput of nodes from specific servers over the Internet. It is measured with transmitting packets. The Throughput is equal to the size of all packets that are transmitted, divided by time of transmission [1]. Hence, we define a function (F(t)) which demonstrate the throughput, and we will calculate our parameters using it. So,

$$F(t) = \frac{Size\ of\ (RTS + CTS + transmitted\ file + ACKs)}{t} \quad [1]$$

, and

$$TP = F(Tt)$$

RTS is actually a "Request To Send" packets and CTS stands for "Clear To Send Packets." These Packets are used in the handshaking procedure. ACKs are all acknowledgments of packets that the node has received. Tt refers to the Time of transmission from the node to specific servers on the Internet.

In the procedure of measuring the TP, in the previous part, we could also measure the transmission time from the node to AP (T1), by measuring the time of receiving the first ACK. Now, the same as calculating TP, we can calculate ATP (AP Throughput) which is the throughput between the node and the AP.

$$ATP = F(T1)$$

As pointed out in section III, we should measure the throughput that the nodes (which are already associated with the AP) can achieve, before we connect to the AP. We have shown this parameter with BTP (Before Throughput). Since the host decreases its bit rate after it detects repeated unsuccessful frame transmissions, we can measure BTP by transmitting data to the connected nodes during associating procedure.

In selecting the AP procedure, since our node was supposed to send and receive data in order to measure the throughput, at first, it took an IP address (IP) from the DHCP server. It is obvious that the previous IP address (IP-1) was still active because if it had not been active, the DHCP server would have given its IP address to our node. For instance, if our node takes 192.168.1.7, we know that 192.168.1.6 is an active node.

After measuring the TP and ATP, we also transmit some packets to a client that was already connected to the AP. Therefore, we only needed to measure the transmission time from our node to the IP-1(T2). As a result, we could calculate the BTP:

$$BTP = F(T2 - T1)$$

T2-T1 indicates the transmission time between the connected node and AP. If T2 is timed out, we can transmit data to IP-2.

All in all, we make our decision to choose the best AP with transmitting two small blocks of data to each AP; The first block is sent to the referred servers on the Internet, and we measure Tt (transmission time from our node to referred servers) and T1 (transmission time from our node to AP by measuring the time of receiving the first ACK in procedure of measuring Tt). The second block is sent to a connected client, and we measure T2 (transmission time from our node to the connected client). Finally, the node can measure $\frac{\text{TP}}{\text{BTP} - \text{ATP}} \times (\text{SS\%})$ for each AP and select one, which has the largest amount.

V. Performance Evaluation

5.1 The First Scenario

In the first scenario, we have two access points (802.11b) and one mobile node (802.11b). The node has the same distance to both of the APs. While AP1 is linked to the Internet router through one switch, AP2 is linked to the Internet router with one router and two switches. All of the wired links have 10 Mbit/s bandwidth. The latency of these links was set to 1μs. The topology is showed in Fig.1.

We simulated this topology with NCTUNS ver.5.0 [6] for 60 seconds. We noticed that, if the mobile node associates with AP1, which has a shorter path to the Internet, the node can achieve a higher throughput in comparison to the same node associating with AP2. As showed in Fig.2, the throughput of the mobile node when it is connected to AP1 is 720 KB/s. If the mobile node associates with AP2, due to AP2's packets having a longer path to reach the Internet and packets being obliged to pass through more routers and switches, the packet loss grows. So, the achieved throughput shall decreases. As showed in Fig.3, the throughput of the mobile node decreases to 712 KB/s.

This is very small scale of a network in comparison to the one we have in reality. It is just mentioned to emphasize the importance of measuring the throughput of the Internet as opposed to the throughput of AP. Therefore, in our method, we considered the achieved throughput of the node from specific servers on the Internet.

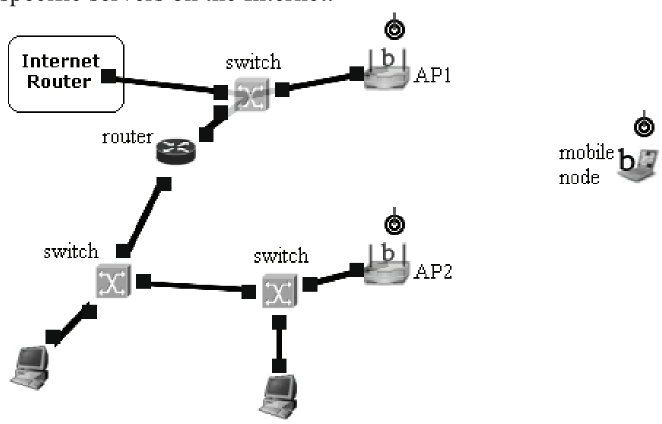

Fig. 1. Topology of the first scenario

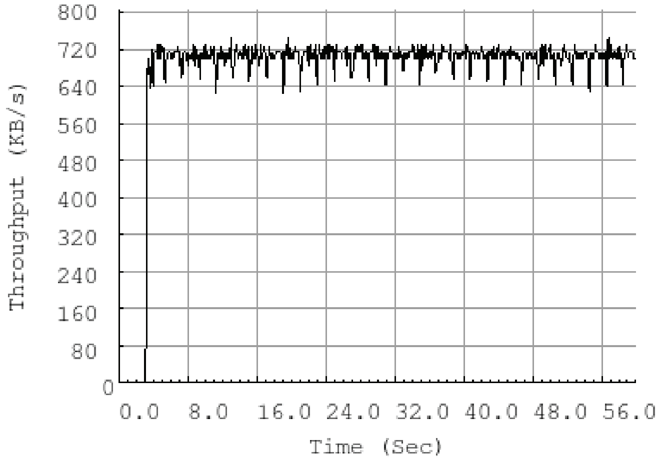

Fig. 2. Achieved throughput by mobile node, when connected to AP1

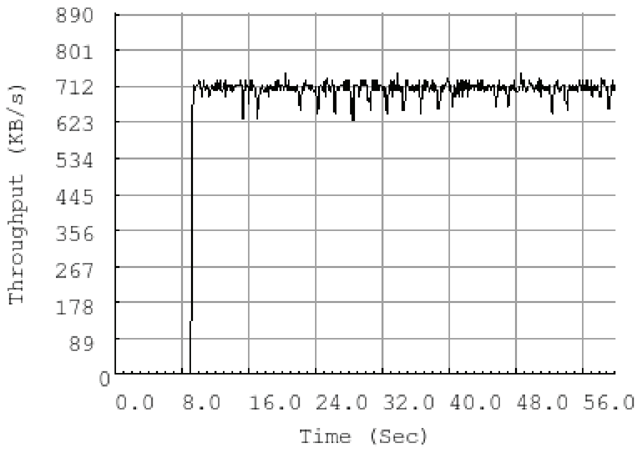

Fig. 3. Achieved throughput by mobile node, when connected to AP2

5.2 The Second Scenario

In the Second Scenario, we have two access points (802.11b) and one mobile node (802.11b). The mobile node has the same distance to both of the APs. Both of the APs are linked to the host through a switch. All of the wired links have 10 Mbit/s bandwidth. The latency of these links was set o 1μs. AP1 has three nodes that are already connected. All of these nodes have the same distance to AP1. AP2 like AP1 has three nodes that are already connected, yet we have changed the position of one node and placed it in a farther place. The topology is showed in Fig.4.

According to our method, before the mobile node is connected, because AP2 has a node in a farther distance, the achieved throughput of connected nodes is lower than AP1. Thus, the difference between BTP and ATP is lower for AP2. As a result, our method selects AP2 to reduce the negative influence of the mobile node's throughput on the nodes that are already connected.

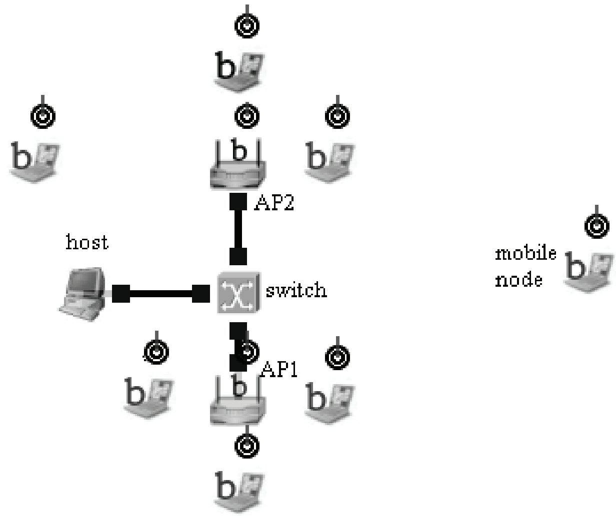

Fig. 4. Topology of the second scenario

We simulated this topology with NCTUNS ver.5.0 [6]. We measured the sustained throughput of nodes over 200 seconds. So, we calculated the average of the throughput over 200 seconds. Since we measure the throughput of nodes to the host, we can assume that ATP is equal to TP (just in this simulation). We gained these results:

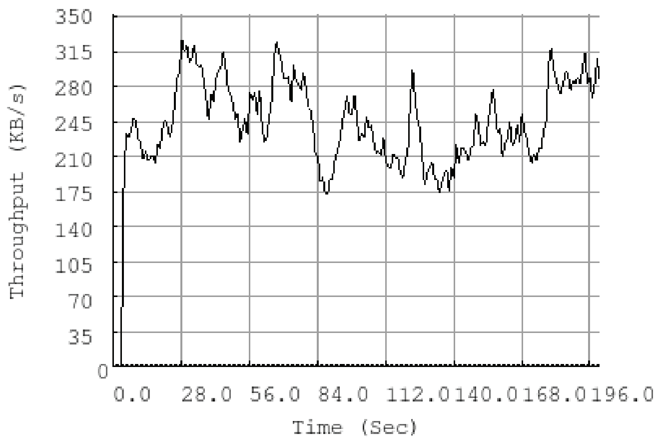

Fig. 5. Throughput of nodes of AP1 before connecting of mobile node

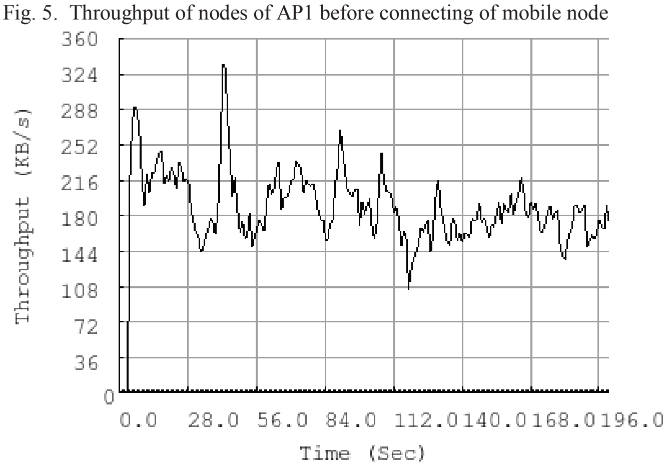

Fig. 6. Throughput of mobile node, when connected to AP1

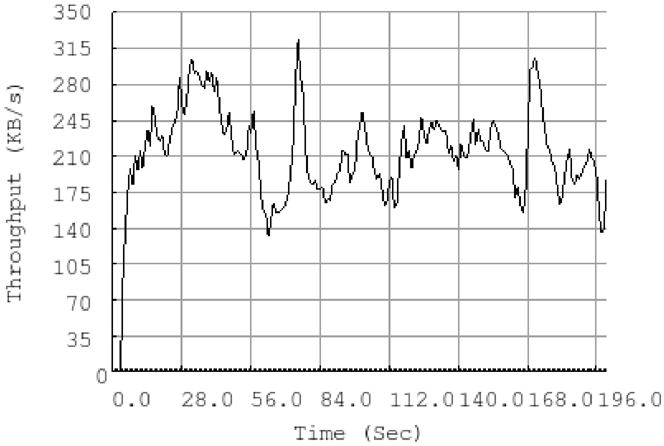

Fig. 6. Throughput of nodes of AP2 before connecting of mobile node

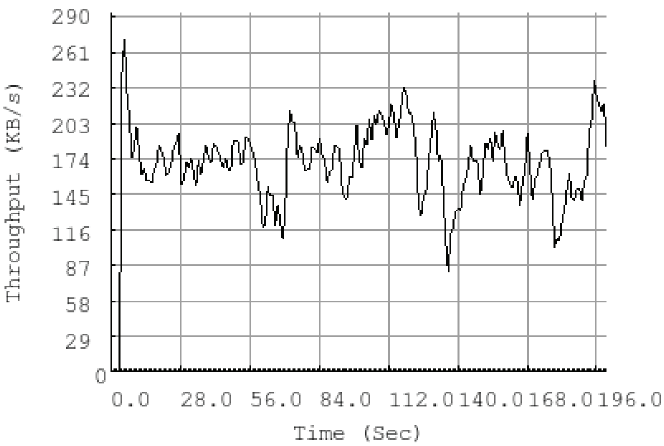

Fig. 6. Throughput of mobile node, when connected to AP2

TABLE 1
RESULTS OF THE SECOND SCENARIO

AP	Average TP (KB/s)	Average BTP (KB/s)	Result of Our Method
1	187.3755	242.4946	3.39
2	169.2258	211.6535	3.98

Our method selects an AP which has a higher amount. Therefore, in this scenario our method chooses AP2.

VI. CONCLUSION

In many situations, devices can find more than one nearby access point, so we should select an AP which meets our requirements. Currently, computers use the signal strength to select the appropriate AP. In this paper, we proposed a method which uses achieved throughput of the node from the Internet. This method tries to reduce the negative influence of low throughput of one node on the others. Our strategy uses the signal strength as well as the throughput depending on the applicant's requirements (minimizing power consumption, UDP or TCP connection) to stabilize the wireless connection.

The present study could show the importance of measuring achieved throughput from the Internet and the role of our method in reducing the negative influence of the device's low throughput on other nodes in two simulations.

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