Traffic Balancing with Dynamic Access Point Selection in WLANs

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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 use 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, unbalanced traffic load will be imposed on WLAN. However, there may be some APs at a nearby location which were still in the idle mode.

In this paper, we have tried to balance the traffic of WLANs with a dynamic 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). Therefore, we have specified some servers on the Internet as our reference servers for measuring the Internet bit rate. This method was aimed at reducing the negative impact of the low throughput of one node on the others, without transmitting extra packets. 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.

Keywords: Wireless LAN, Access Point, Access Point Selection, Traffic Balancing, Signal Strength Strategy (SSS), Throughput

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1. Introduction

Wireless networks has been made quite popular owing to its ease of usage and installation. The family of IEEE 802.11 Wireless LANs are pervading diverse places such as hotels and airports as well as offices and home in recent years because they can provide a great deal of flexibility and high bandwidth. In consequence, they actually provide convenient and important ways to access the Internet [3].

As the widespread 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.

Recently, 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. In order to measure the Internet bit rate, we use some DNS root zone servers as our reference servers for transmitting data to them and measuring the throughput. 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, without transmitting extra packets. Furthermore, we proposed an alternative method to get the information which is used to reduce the negative effect. 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 related work. In section III, we describe our dynamic method for AP selection. 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.

2. Related Work

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.

Therefore, [2] identifies the potential bandwidth 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. Another research [3] also considers throughput as its main parameter in choosing the best AP. However, they measure the throughput performance by using the number of active stations sharing each AP. Furthermore, an adaptive access point selection method is shown in [1] that chooses an appropriate AP by calculating EoAP which choose the AP by measuring the throughput from AP to node, and also signal strength. Virgil in [4] estimates the suitable AP by bandwidth and the round trip time to a set of referred servers.

We are also supposed to measure the throughput instead of the signal strength in deciding on the best AP to select. However, 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, in our method we measured the throughput from the node to specific servers on the Internet, instead of the throughput between AP and an end host. This issue was neglected in [1,2,3].

Furthermore, the method [2,3,4], which just aimed at throughput, does 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]. Thus, according to the desired usage of network and QoS parameters, we benefited from the signal strength as well as applied throughput to improve the utilization of the connection.

Moreover, 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 [5]. Therefore, we tried to reduce the negative influence of the low throughput of a node on other nodes of associated AP. This is an important issue which is not considered in [1,2,3,4].

Finally, we have improved our method by choosing the best AP among the available APs by transmitting just one block of data, instead of two blocks.

3. Dynamic Access Point Selection

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

At this stage, it is expected that using our method would result in resolving the issues presented in section II. We use throughput which is achieved from Internet as our main parameter in choosing the best AP. Besides, we try to decrease the mentioned negative influence with calculating the square root of difference between two measured throughput (BTP and ATP). Furthermore, we benefited from signal strength as an optional parameter. In following subsections, we shall describe above formula in detail.

3.1 Throughput (TP)

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, 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.

Besides, The achieved throughput has an inverse relationship with the number of active stations: due to the following reasons [3].

--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. 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, in our method we measured the throughput from the node to Reference Servers on the Internet. Therefore, the achieved throughput inasmuch 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. This issue is presented in simulation IV.A.

3.2 Reference Servers on Internet

The Domain Name System (DNS) is a fundamental component of the modern Internet, providing a critical link between human users and Internet routing infrastructure by mapping host names to IP addresses [7]. In practice, full host names will frequently consist of just three segments: ahost.inadomain.example. For querying purposes, software interprets the name segment by segment, from right to left. At each step along the way, the program queries a corresponding DNS server to provide a pointer to the next server which it should consult.

If the application does not know about the desired zone, it queries the “root zone.” The DNS root zone is served by 13 name servers, distributed across the globe. Ten root servers are located in the U.S., two are in Europe, and one is in Asia. The root zone and the root name servers are vital because they are the starting points for locating anything in the DNS. Without them, the DNS and hence almost every application we use (the Web, ssh, email) would be rendered unusable [7].

Therefore, we use DNS root zone servers as our reference servers to measure the Internet throughput. Depending, on geographical region, we choose the specified DNS root zone server. However, we can use DNS root zone servers which distributed using anycast. Anycast is a network addressing and routing scheme whereby data is routed to the nearest or best destination. Fore instance, we can use 192.33.4.12 as our reference server.

3.3 Measuring TP

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 our specific servers on the Internet.

3.4 Reducing the negative effect

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]. 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 dynamic 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. 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. Actually such a difference had an inverse influence on our decision in selecting the best AP. Besides, inasmuch as our main parameter in making the decision is throughput (TP), we calculate the square root of the difference.

3.5 Measuring ATP

In the procedure of measuring the TP, in III.A.2, 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.

$$ATP = F(T1)$$

3.6 Measuring BTP

As pointed out above, 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). As we know the IEEE 802.11 protocol has specific manage frames, which called beacons. These frames are being sent periodically by each AP in order to announce its presence and provide relevant information, such as timestamp, SSID, supported rates and other parameters regarding the access point to stations that are within range. The mobile nodes continuously scan all 802.11 radio channels and listen for beacon frames, which will be the basis for selecting an AP. The period that these frames are being transmitted is basically 100ms [8].

Each beacon conveys some information. One of them, Supported rates, describes data rates that particular wireless LAN supports. For instance, a beacon frame may expose information which shows that the particular AP supports 1.1 and 2.2 Mbps in an 802.11b wireless network. Thus, we can infer that the AP is limited and does not support 5.5 and 11 Mbps. Moreover, this indicates that the maximum bit rate of connected nodes is 2.2 Mbps.

In conclusion, we find the throughput of nodes which already connected to the AP (BTP) by logging the maximum supported rate which is included in beacon frames. Consequently, we are able to find BTP without transmitting any extra packet to AP, and before associating procedure.

3.7 An Alternative Approach

Besides, we also able to add an extra field to beacon frames which convey the BTP information on these frames. In this case, AP measures the average bit rate over each minute. Therefore, the throughput information will be included in an extra field of beacon frames, which periodically is sent.

Thus, our nodes can find the BTP from beacon frames.

3.8 Signal Strength

So far, we have not considered the signal strength in our method, 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.

3.9 Measuring SS%

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].

All in all, we make our decision to choose the best AP with transmitting a small block of data to each AP; Before the associating procedure, we log the BTP and received signal strength from beacon frames. Besides, a block is sent to the reference 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). Finally, the node can measure $\frac{TP}{\sqrt{BTP - ATP}} \times (SS\%)$ for each AP and select one, which has the largest amount.

4. Performance Evaluation

4.1 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.

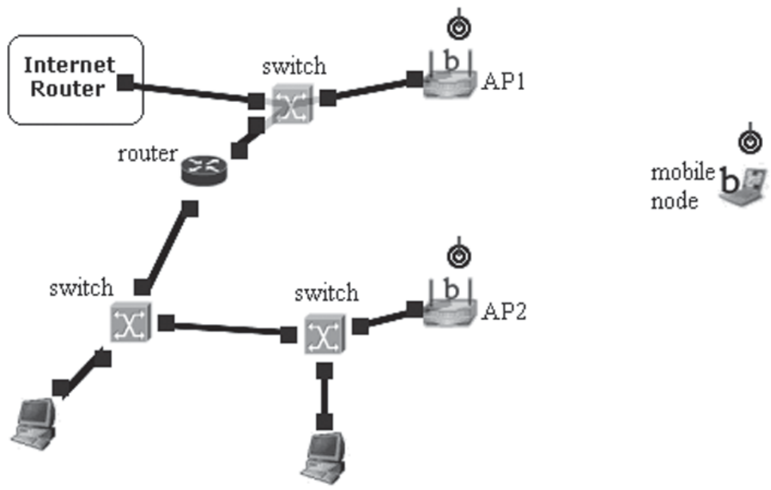

Figure 1. Topology of the first scenario

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.

4.2 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.

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:

AP	Average TP (KB/s)	Average BTP (KB/s)	Result of Our Method
1	187.3755	242.4946	25.23
2	169.2258	211.6535	25.98

Table 1. Results of the Second Scenario

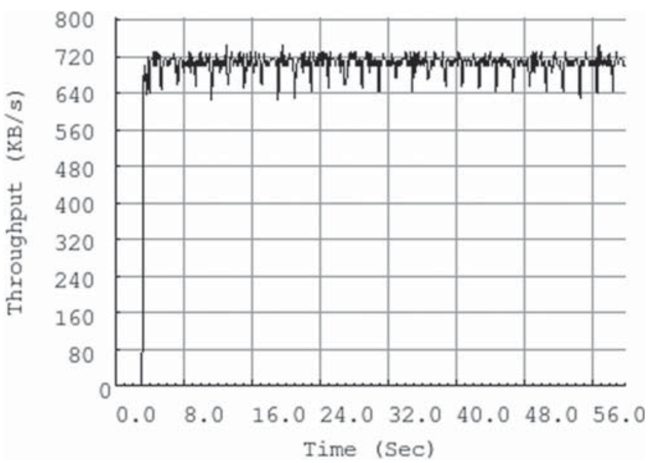

Figure 2. Achieved throughput by mobile node, when connected to AP1

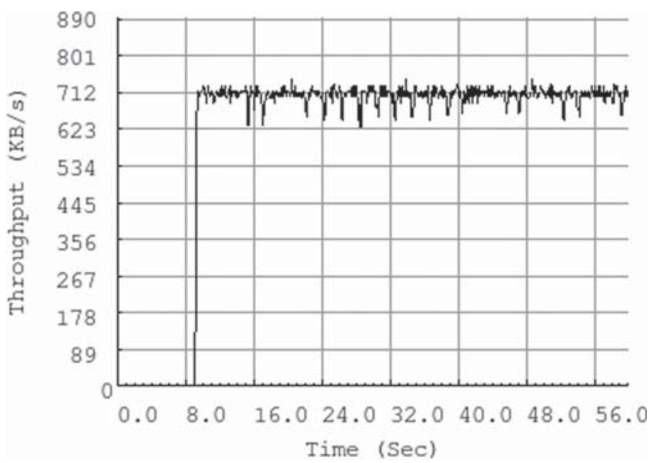

Figure 3. Achieved throughput by mobile node, when connected to AP2

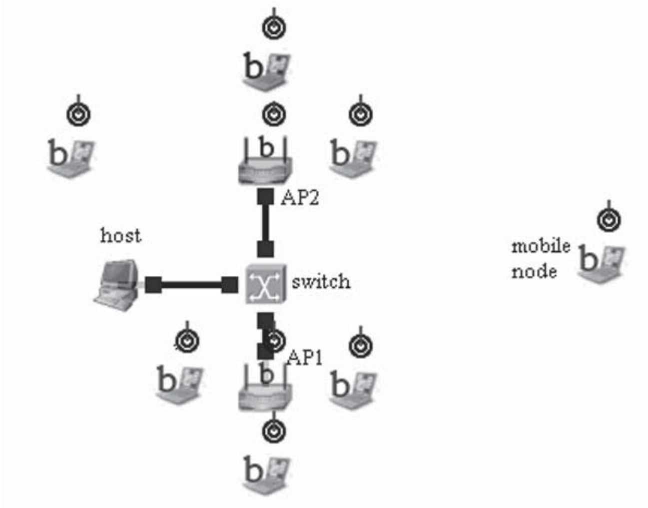

Figure 4. Topology of the second scenario

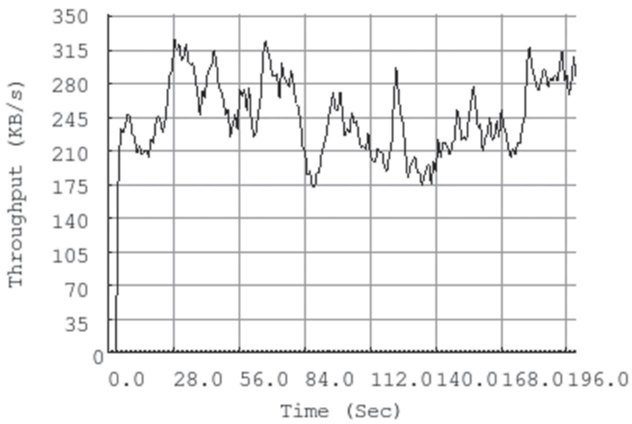

Figure 5. Throughput of nodes of AP1 before connecting of mobile node

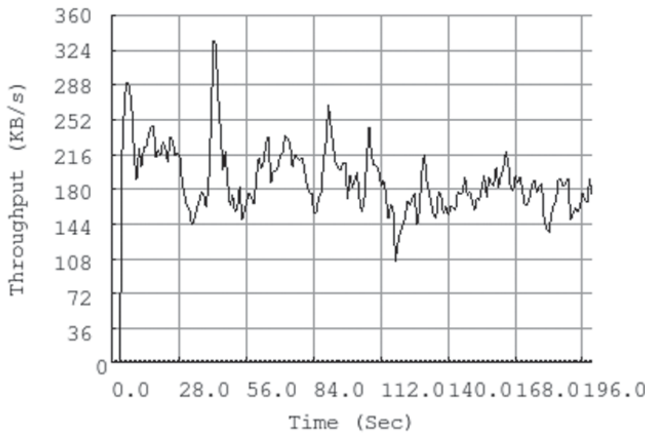

Figure 6. Throughput of mobile node, when connected to AP1

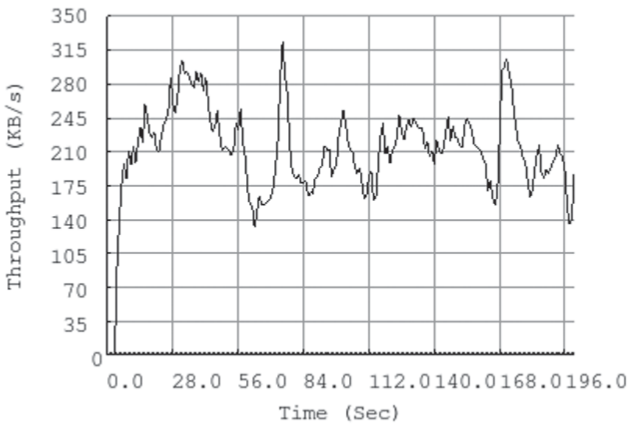

Figure 7. Throughput of nodes of AP2 before connecting of mobile node

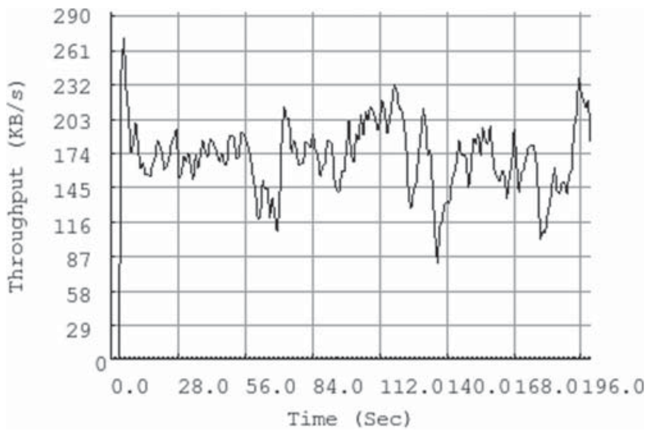

Figure 8. Throughput of mobile node, when connected to AP2

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

5. 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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