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Service Quality Dimensions and Customer Satisfaction with Online Services of Nigerian Banks

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Abstract

Wireless Local Area Networks (WLANs) have been deployed rapidly in enterprises in order to satisfy user demands for high bandwidth and mobility. For this reason WLANs consist of several Access Points (APs). As a consequence, to this spread of APs, there has been also a substantial increase in energy consumption and economic costs. In order to address this problem, this paper introduces a solution for an energy-aware management of WLANs in enterprises. The proposed solution considers the instantaneous traffic intensity and switches on and off the APs according to the distance value of the client with respect to the AP. The results of real test-bed scenarios reveal that the proposed approach obtains promising performance.

Keywords: **Wireless Local Area Network (WLAN); Access Point (AP); Energy efficiency; Power consumption costs**

INTRODUCTION

In recent years' wireless solutions are changing the world of computer networks. Businesses around the world are deploying independent wireless networks or in addition to those wired in order to increase employee productivity, to reduce costs and to overcome the obstacles of connectivity such as network expansion, deployment, responsiveness, expandability, mobility, convenience and costs. Several protocols have been implemented, such as ieee 802.11 [1], ieee 802.15.4 [2] and bluetooth [3]. They found applications in home [4] and industrial automation [5], intelligent systems [6-8] and wireless sensor networks [9].

Arrived on the market in the early 1990s, the wireless local area networks (wlans) had the final turn with the approval of the ieee 802.11 standard [1]. The ieee 802.11 is today one of the most popular standard for wlans. One of the advantages of wlans is undoubtedly the flexibility. There is a huge increase in efficiency compared to a wired network [10]. In this way it is possible to overcome several problems; for instance, the implementation of a lan that connects two buildings separated by several or large obstacles or the development of the same within a historic structure.

Wlans have become mainly indispensable for flexible internet connectivity in enterprises, universities, campuses, and municipal down-towns. Moreover, with increasing budgets, enterprises have now shifted their deployment objective from providing just basic complete coverage to designing dense wlans with several redundant layers of access points (aps). The objective of these redundant layers is to provide very high bandwidth in situations where hundreds of enterprise clients simultaneously run bandwidth-intensive and delay-sensitive applications. It is necessary to highlight that recent studies have shown that peak demand rarely occurs [11] as the aps are utilized during the day, and even fewer during nights and weekends. As a consequence, the majority of the aps frequently remain idle, which means they serve no users in the network.

The issue of the increase in energy consumption over time has become the subject of attention in several research works. Even wireless communication, however, raised several concerns, including that of power consumption. In recent years there have been some efforts to try to solve this problem by introducing wireless communication systems with low energy consumption [12]. The average power consumption of the network equipment has been estimated to be 25 gw during operation worldwide (yearly average in 2008) [13] and a single corporate wlan may feature more than 5000 aps [14]. But, as shown by lannoo [15], these values have risen over the past few years. In wlans, the three main consumers of energy are aps, switches, and controllers. Each ap typically draws up to 10w power from power over ethernet (poe) ports on poe-compatible switches, from the 15.4w allocated per port by poe specifications. Each wlan switch, with 24 to 72 poe ports, consumes up to 350w each per hour. This consumption of 350w is in addition to the power the switches supply to the aps connected to them.

Commercial central controllers of centralized wlans provided by worldwide manufacturers of network devices, that can manage up to 512 aps and 8192 users, consume up to 466w. Based on these numbers alone, 100 aps consume about 8.76 mwh of energy per year. Such energy consumption in tens of thousands of aps is far from negligible even today and will continue to increase as wlan densities increase.

The existing network design approaches developed in enterprises lack several key elements. Traffic demand and user density are not considered. For this reason, the coverage based optimization approaches may appear insufficient for networks where user density and traffic load is high. As a consequence, in the near future, wlan environments in enterprises will have both higher user concentration and applications demanding increased data rates. Furthermore, other approaches to design of wireless networks do not take into account the energy consumption, which is a fundamental feature nowadays.

Considering the problems described above, the objective of this paper is to develop a network design model for enterprises based on an efficient solution in order to manage wlan resources and, at the same time, to save energy. The proposed solution is focused on access networks since access devices are the main energy consumers in ieee 802.11 [1] wlans. This paper proposes a novel approach for an energy aware management of access networks and consists in a dynamic network planning that, based on the instantaneous traffic intensity, reduces the number of active access devices when they are underutilized. The turning on/off of devices is considered as a decision parameter that is dynamically set according to the distance value of the client with respect to the access point. The distance value is calculated by using the receiving signal strength indicator (rssi). In this way, the wlan coverage is still maintained and only redundant coverage is reduced.

This paper is organized as follows. Section 2 introduces existing approaches in the literature. Section 3 presents the network architecture and describes in detail the proposed algorithm. Section 4 shows the performance obtained with proposed solution and, finally, in section 5 the paper is summarized, reporting the conclusions and future works.

POWER CONSUMPTION REDUCTION IN WLANS

Several works in the field of wlans that aim to reduce the power consumption efficiently have been proposed in the literature at various levels, such as core [16], edge [17] and data center networks [18]. The reduction of energy consumption can be achieved on a larger scale by introducing intelligence into the network infrastructure at various levels by employing, for instance, different kinds of algorithms [19] or mac access protocols [20]. This issue is addressed by morelli [21] where a comparative study of the energy consumption of several wireless network access points is shown. The authors compare the energy consumption of different brands and models, for several operation scenarios and operating modes. The obtained results indicate the guidelines to be followed for the development and implementation of energy efficient wireless networks.

The authors proposed an approach to reduce the energy consumption in wlans, but they mainly focused on the user side, in order to preserve battery lifetime [22]. On the contrary, considering the internal architecture of the aps normally deployed in wlans, by shaddad [23], it is observed that the largest amount of power consumption is due to base components, rather than transmission circuits, so that an ap consumes approximately the same amount of power, independently from the traffic that is flowing through it. For this reason, the shut-down of unused aps can be a viable solution in order to save energy.

A simple analytical model that provides the average power consumption of a wlan device is introduced by levy [24], while marsan and meo [25] introduced a simple approximate queuing model in order to assess the effectiveness of other approaches, proposed to save energy in dense wlans, based on the activation of aps according to the user demand. The authors consider a portion of a dense wlan, where several aps are deployed in order to provide sufficient capacity in order to serve a large number of active users during peak traffic hours. Due to daily variations of the number of active users accessing the wlan, some aps can be switched off to save energy when not all the capacity is needed. The results of a a real experimental scenario show that the energy saving achievable with the proposed model is quite substantial, from 40% to almost 60% if all aps can be switched off at night, using a separate technology to activate an ap when the first user requests association in the morning.

In order to reduce the power consumption of aps the main aim of bhola [26] is to study the power consumption of wlans and propose a new technique. The authors introduce a centralized network in which a controller node is capable of taking appropriate power saving decisions. Thanks to this controller, the approach proposed by the authors has a significant impact in term of power saving and cost of communication network.

The authors note that several solutions have been presented in order to reduce the power consumption in wlans [27]. However, most of them are expensive to install and to manage especially for large legacy deployments. For this reason, in order to overcome this limitation, they propose a virtual power consumption monitoring solution capable of estimating in real-time the actual power consumption of wi-fi ap. The results of a real experimental scenario show that that the proposed approach can provide a precise estimation of the power consumed by a typical ieee 802.11 ap.

The author has shown in this section that in the literature there are several approaches that aim to enhance the energy efficiency of wlans. However, it is necessary to note that most of them did not focus on access networks considering that access devices are the main energy consumers in ieee 802.11-based wlans. For this reason, the approach proposed in this paper for the energy-aware management of access networks may be a viable solution in order to solve the energy efficiency problem in enterprises.

THE PROPOSED SOLUTION

First of all, it is necessary to present the proposed network architecture. A dense deployed network, where the coverage areas of neighboring cells overlap each other, is considered in this paper. This network consists of several cells that have the same coverage radius and a traffic load that has a periodic day/night pattern. In figure 1 the architecture of the wireless access network, on which the proposed approach is developed, is depicted. The controller, placed appropriately by the network administrator, receives information from each ap, such as a mean of received signal strength indicator (rssi) of probe requests from user devices (uds), a list of neighbor aps and the number of connected uds. Using these information, the controller is able to determine whether each ap should be powered on or off through an appropriate request.

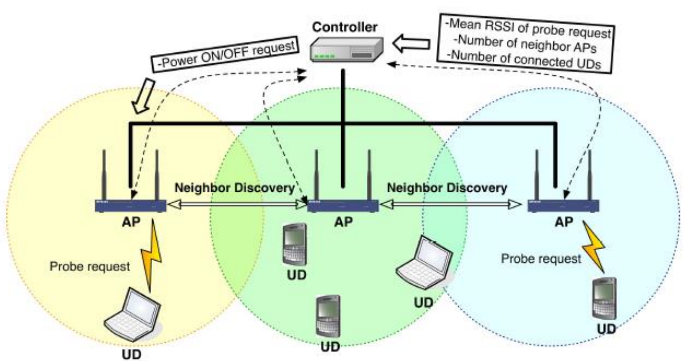

Figure 1: The Proposed Network Architecture.

The proposed power saving solution turns off the redundant aps not according to traffic load, but according to the average distance of their users. Each ap must estimate the distance of its uds as well as that of neighboring aps up to the coverage region. As a consequence, the ap calculates the average of the estimated distances. However, a greater average distance implies a higher use of transmission power.

The proposed algorithm, shown in figure 2, aims to turn off the aps with the maximum average distance value because these would increase their transmission power to a greater value if they were switched on. The algorithm works as follows. In the first step, neighbor discovery, it is determined whether two aps that belong to the same wlan can be neighbor of each other. It is useful to note that in a wlan two aps can be neighbor if they are in close physical proximity of each other. In the solution proposed in this work each ap transmits a beacon message periodically and neighboring aps use it in order to update their "neighbor table" after receiving k beacons. Furthermore, an ap is removed from the table after w missed beacons. The values of k and w are established in the design phase of the network. It is easy to deduce that according to the chosen values network performance change significantly.

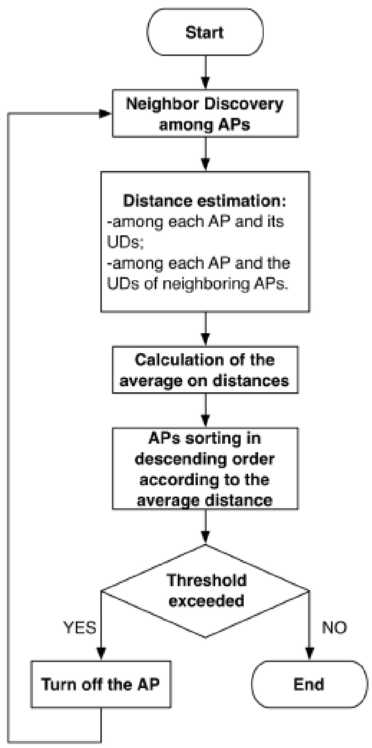

FIGURE 2: Power Saving Flowchart Of The Proposed Algorithm.

At the second step, distance estimation, the uds send a probe request to all channels in order to localize the ap. As a consequence, each ap can estimate the rssi (distance). Subsequently, in the third step, the aps calculate the average distance of the traffic load based on the results of the second step. In this way, in the fourth step, the aps are ranked based on the estimated average because they will be examined from the first one with the maximum average distance value, which is less average rssi probe power, to the last.

Finally, the first ap is powered off if it exceeds the threshold value of the neighboring aps in its neighboring table and the number of connected user. Even in this case, the threshold value is established in the design phase of the network. In this way it is possible to differentiate the settings for each ap. For example, an ap may have both more neighboring ap and more connected users compared to others, while another ap can have less. As it is possible to note in figure 2, the algorithm continues with subsequent aps in the list, until less than the half of aps are switched off.

Anyhow, it is necessary to note that once the aps to be switched off have been identified it is not possible to just turn-off them, since, even if the traffic is low, a number of users may be accessing the candidate ap with their devices for several services. To overcome this problem, in this paper is taken into account the approach proposed by collotta [28]. As a consequence, immediately after the switch-off decision is taken, the users are forced to implement the handover from the ap that is going to be switched off to one of the aps that remain active. Although this approach is the most invasive for users it is even true that forced handovers are foreseen by wlan standards.

EXPERIMENTAL RESULTS

In order to demonstrate the efficiency of the proposed algorithm, several test campaigns have been realized. In the test campaigns the cisco/linksys wrt54gl [29] routers/aps have been used. These devices are based on a linux os and it is therefore possible to execute tasks on them through openwrt firmware [30]. This characteristic makes these devices suitable for the development of an energy saving system, in which it’s necessary to run a specific module on each ap. It is necessary to note that these devices can be programmed to act both as ap and ud.

In each iteration of the test campaigns, uds are placed in the system area based on an uniform deployment and the aps generate traffic according to a poisson distribution [31]. The packet size has been set to 100 kb and the data rate varies from 5 kbps to 1000 kbps. Moreover, the duration of the test campaigns has been 90 seconds. In order to obtain the power consumption, the power that is consumed in the aps for the downlink transmission is considered. For neighborhood discovery, the aps transmit a beacon signal every 0.02 seconds so that neighborhood aps can detect the signal and add it to the neighborhood aps table for further processing. An active scanning process, where the all clients start scanning the channel, has been implemented. It is done through sending multiple probe requests and recording the probe responses (containing bssid and wlan ssid).

Three different network conditions have been tested for exactly same traffic pattern and node positions. In the first condition all aps are powered on with full power. In the second condition, the aps are powered off randomly while in the third condition the aps radio is turned off on the basis of the proposed algorithm. In all three conditions the power consumption, that is the total power required to transmit, receive and process of the signal by the device, and the ratio of throughput (t h) to workload (w l) have been calculated for performance analysis of the network, where t h is the sum of packets sent by the device and w l is the total number of packets that the device has to send.

In figure 3 the network topology, composed of 9 aps (ap 0, ap 1, ap 2, ap 3, ap 4, ap 5, ap 6, ap 7, ap 8, ap 9) and ten uds (u d1, u d2, u d3, u d4, u d5, u d6, u d7, u d8, u d9, u d10) is shown. The ap0, ap3, ap4, and ap8 are switched off randomly when the random switch on/off scheme is applied. On the contrary, using the proposed algorithm the ap1, ap3, ap5, and ap7 have been switched off according to the result of the rssi power calculation.

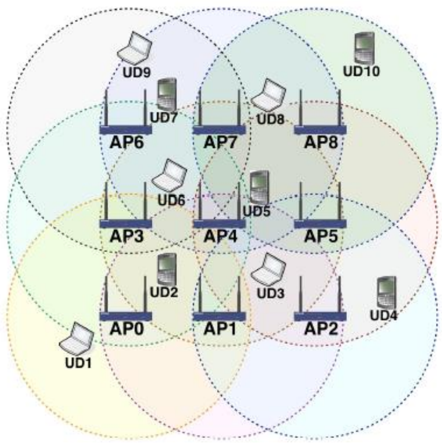

Figure 3: APs Deployment Structure.

Analyzing the results shown in figure 4, it is possible to note that using a distance aware switch off mechanism (the proposed algorithm) an energy consumption reduction, about 40%, of the whole network is obtained by turning off less than half of the aps. The solution proposed in this work obtained better performance even to the case where the aps are switched off randomly. These results are closely related to network topology taken into account in the experimental scenario and the number of devices (aps and uds) placed in it. It is clear that the most substantial benefits could be obtained in network topologies in which there are numerous ap, as for example in enterprises. In this case it could be possible to get an energy consumption reduction also exceeding 40%.

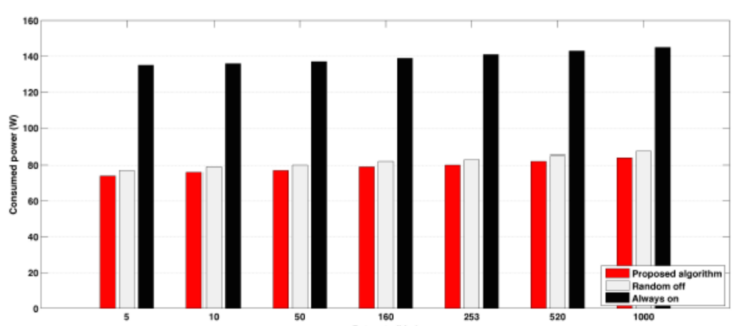

Figure 4: Power Consumption.

As depicted in figure 5, a very small drop in th/wl percentage was obtained. The drop in th/wl percentage was just 3%. In this case, the performance of the proposed algorithm is better. The turning off of the aps and the use of the handover mechanism did not degrade network performance. Anyhow, it is obvious that in the scenario taken into account in this paper the value of th/wl can be acceptable because there are no constraints regarding the data transmission within the network. However, if classes of service that can be used by uds, such as audio/ video streaming, web surfing or the implementation and the use of visual wireless networks, would be taken into account, then the value of th/wl which was obtained might not be appropriate depending on the context. This is an interesting topic that can be analyzed in future extensions of the solution presented in this paper.

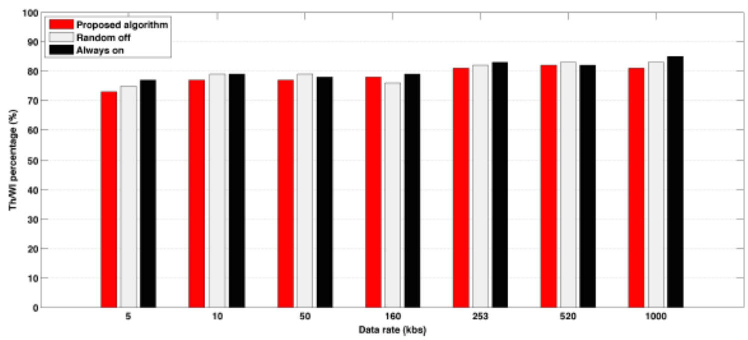

Figure 5: Th/Wl behaviour.

Considering the result obtained with the proposed solution, it is clear that a substantial reduction of power consumption can be achieved. The benefits can be even more substantial in enterprises with dense wlans, in which there are a lot of aps. This can lead to a concrete reduction of economic costs due to power consumption savings.

CONCLUSIONS

A novel solution that turns off unnecessary aps for wireless access networks in enterprises has been presented in this paper. The considered network architecture is composed of several aps, each of which provides a full coverage and services during peak traffic time, but offering redundant resources when traffic load is low. As a consequence, this implies a waste of electricity. For this reason, a distance-aware algorithm, in order to achieve a significant reduction in power consumption without compromising the performance of the network, has been introduced in this work.

The results obtained in an experimental scenario have shown the efficiency of the proposed solution. Using the proposed algorithm, it is possible to save up to 40% of power consumed in the network by decreasing the number of active aps during low traffic periods. The solution proposed in this work has been compared with other 2 techniques, in which aps are turned off randomly or are always on.

At the end, the results showed that the proposed solution would obtain better performance in terms of power consumption.

In the future, the approach proposed in this paper will be tested on networks with higher density in order to make the scenario closer to that of a real enterprise. Furthermore, the algorithm will be optimized, for instance through a soft computing technique, and it will be evaluated its complexity. The possibility to introduce additional distance metrics will be analyzed in order to improve the power consumption management, and how these impact to the quality of service of the network.

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