Summary of "Queueing systems to study the energy consumption of a campus WLAN"

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***Abstract*— In this paper, simple queuing models was used to define the effectiveness of the approaches to save energy in wireless local area networks (WLANs), based on the activation of access points (APs) according to the user demand.**

I. Introduction

Mutation from wired to wireless happened in spite of the unavoidable loss in performance, just because of easiness. We prefer our laptops to our desktop, even if downloads are slower. To reduce this performance loss, large organizations have been consistently deploying more and more access points (APs) in their wireless local area networks (WLANs). Even if the individual power consumption of APs is small, the fact that their number is very high means a remarkable energy consumption and cost. And the most of this energy is wasted, beacuse the WLAN capacity is not necessary 24/7. Rather than, capacity should be modulated according to the number of active users, or the traffic they generate. These considerations has led several research groups to investigate the energy saving which is possible by switching on and off APs according to the required capacity.

II. Problem Statement

In this section,authors describe the system they focus on, including the considered customer management (CMN) and AP management algorithms, and they present a detailed queueing model to study the system.

Figure reports the traffic measured during one day in different locations of the Politecnico campus. Samples are taken every 5 min.

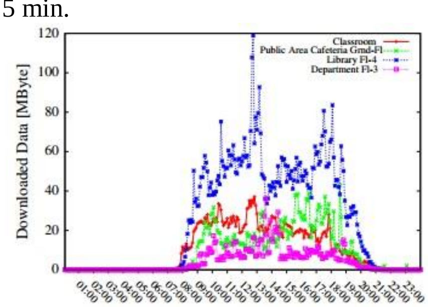

Figure reports the number of active MTs (network interface cards) and active sessions measured in an hour in the whole main campus of Politecnico. As you can see the day/night behavior is clear,so during no traffic periods (such as nights and holidays) energy can be saved by switcing off the unneeded APs.

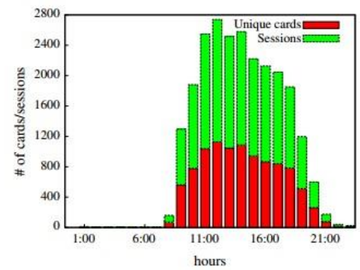

Fig. 5. Example of the number of active MTs (network interface cards) and active sessions measured in an hour in the whole main campus of Politecnico.

III. The Detailed Queuing Model

Authors model the portion of the dense WLAN with the queueing system shown in Figure. The queueing system is composed of two multiserver stations with no waiting room. Each station models a group of APs. The service corresponds to the MT association with an AP.

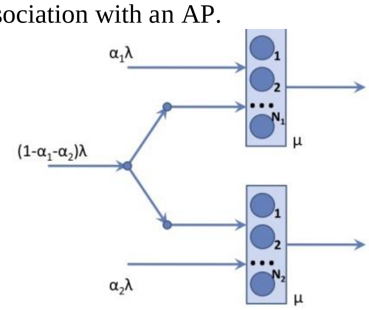

Fig. 6. Detailed queueing model of the system.

Each AP can be either active or inactive. Active servers can be either busy that serving a customer, or idle that ready to provide service to an incoming customer. We assume that as soon as K active servers are idle, their corresponding AP is deactivated, and that if all active servers are busy when a customer arrives, one inactive AP are activated, if available.

IV. THE APPROXIMATE QUEUING MODEL

In this section authors introduced approximate models that provide accurate estimates of the performance metrics.

V. NUMERICAL RESULTS

In this section numerical results from the solution of the approximate queueing model is discussed.

Authors consider the case of 3 APs per group, with the maximum number of associated MTs per AP, K = 8. They call AP1 the first AP to be switched on, the one which handles the first K MTs associated with APs in the group, AP2 the second AP to be switched on, the one which handles the K MTs in excess of the K handled by AP1, and AP3 the one that handles the MTs that are associated with the group in excess of 2K.

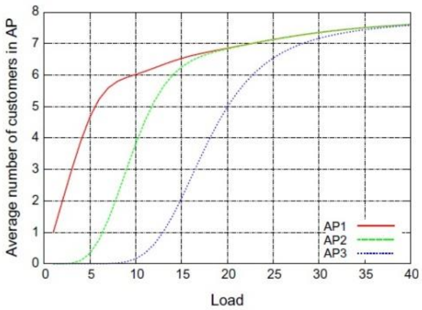

Fig. 8. Average number of MTs associated with each AP versus load.

Figure shows the average number of MTs associated with each APs versus the load. As you can see, the average number of MTs associated with AP1 is larger than AP2. The number of MTs associated with AP2 is negligible for load less than 3, and the number of MTs associated with AP3 is negligible for load less than 8.

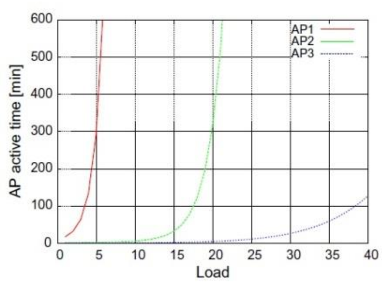

Fig. 10. Average active time for the three considered APs versus load.

Figure shows the average active time for each APs versus load. And you can see, when the load is low one active AP is enough.

VI. MODEL WITH AP1 ACTIVATION TIME

The model that is presented in the previous sections is based on the assumption that an AP can be switched on or off instantaneously.

In this section, the impact of the switch-on time of AP1 is investigated. This means to modifying the queueing model discussed in the previous sections by introducing a delay between the arrival of the customer that finds an empty queue, and the beginning of service. The results refer to the case in which the AP activation time is either exponentially distributed, with average between 0.5 and 2 min, or constant.

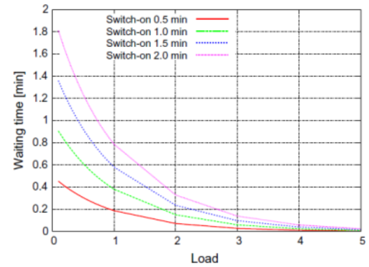

Fig. 13. Average time that a user has to wait that AP1 switches on, versus the AP group load, for variable average switch-on time.

Figure shows the average time that a user has to wait. Authors also note that the average time that a user has to wait is less than 10 s for all traffic load values larger than 3.

The next two figures, compare the cases of exponentially distributed and constant AP switch-on times. The waiting probabilities computed using the two models are almost same, while the average waiting times are slightly shorter in the case of constant switch-on times.

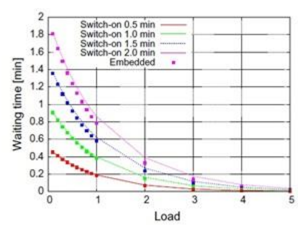

Fig. 15. Model with AP activation time, comparison between the MC and embedded MC model: average time that a user has to wait that AP1 switches on versus load.

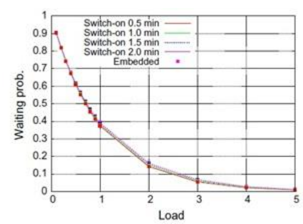

Fig. 14. Model with AP activation time, comparison between the CTMC and embedded MC model: average time that a user has to wait that AP1 switches on versus load.

VII. ENERGY SAVING

We can see in Figure that when the three APs are always on, the power consumption is constant, equal to 30 W. When AP1 is always on, but the other two APs are turned on only when necessary, the power consumption is 10W from 7 pm to 7 am.Finally, When all APs can be switched off when no MT requests, no power is consumed from midnight to 6 am.

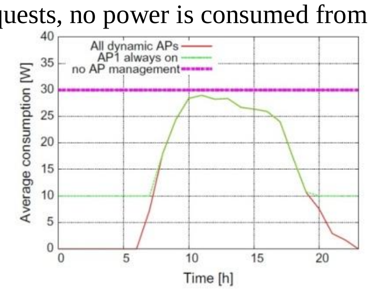

Fig. 17. Average total consumption in a typical day, with and without coverage continuity.

VIII. CONCLUSION

Authors showed that, even in new networking scenarios, queueing models remain a simple and effective tool for the investigation of the system behavior.