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Fuzzy Load Balancing for IEEE 802.11 Wireless Networks

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Abstract

Wireless networks (WNs) are today used in many areas thanks to several benefits deriving from the ease of installation and maintenance and the high scalability. However, in large areas, the increasing number of nodes implies that Access Points (APs) are the main responsible of clients' connection. An overloaded access point may compromise requirements in terms of timeliness of data exchanged among the clients. This paper proposes a load balancing technique for IEEE 802.11 networks based on fuzzy logic in order to ensure the achievement of typical constraints that characterize a wireless scenario. To validate the goodness of the proposed approach several real test-bed scenarios were implemented and load distribution was evaluated.

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Keywords: IEEE 802.11; Load Balancing; Fuzzy Logic; Access Points

1. Introduction

WNs are increasingly used in real-time constrained environments. Researchers discussed a lot about problems that can arise from the use of wireless technology: what is the best protocol to use [1], how to better manage the life cycle and the energy consumption of each network entity [2] and network load balancing. Load balancing is a technique though which it is possible to equally distribute the network load, generated by

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connected clients, among all available access points based on predefined policies. Load balancing comes into play when different access points cover the same area or there is an overlapping zone in which clients can choose to connect to, at least, two access points. Load balancing techniques can be classified into two categories: centralized and distributed. The first one is characterized by policies implemented within a single network device. On the contrary, in distributed approaches load balancing policies are performed by all the access points of the network. Centralized approaches ensure the devices interoperability, but unlike distributed approaches, are not fault-tolerant, i.e., the malfunction of the device may determine the failure of the whole network. The association of a client to an access point can be regulated using the following different approaches: association management [3], admission control [4] or coverage adjustment. The technique described in [3] is based on the possibility that an access point can send a disassociation frame to a client; so, the client can be connected to another less overloaded access point, if it exists. In admission control [4] mechanism, an access point can reject the association of a new client in case there is an overload risk. Some access points, instead, provide specific policies based on the reduction, in case of overload risk, of the transmission power in order to avoid association requests. This technique is also known as coverage adjustment [9]. In standard approaches, the AP-client association is based on the Received Signal Strength Indication (RSSI) and consequently it is possible that all clients may choose only few overloaded access points leaving others idle. Moreover, as known, the IEEE 802.11 standard [5] uses the Carrier Sense Multiple Access with Collision Avoidance protocol (CSMA/CA) to regulate the medium access [6]. So, if many stations are connected to the same access point, the probability of collisions increases causing, at the same time, the reduction of network throughput (defined as the real use of the available bandwidth). For this reason, it is necessary to use an appropriate load balancing technique in order to make the associations to access points “load-aware”. The main contribution of this paper is represented by a new load balancing algorithm, based on fuzzy logic, that improves some approaches known in literature.

2. Related Works

In literature, several association metrics have been evaluated taking into account several factors like the packet loss [7], the access point RSSI [8] and the bandwidth utilization [9]. Load balancing definition is firstly analysed in [10] in order to prove the strong correlation between load balancing and max-min fair bandwidth allocation. Then, the authors describe an algorithm to achieve max-min fairness based on min-max load balancing. Using this algorithm and gathered information, the network can balance load and notify new ideal associations to connected clients. The authors of [11] present a load balancing algorithm that claims to find the best associations between access points and clients ensuring the best quality of service (QoS) level. This algorithm, that run within a load balancing server, uses several network information related to associated stations, traffic coursed by access points and users QoS requirements. This information has to be exchanged among WLAN entities and stored in an updated database. The load balancing server should periodically download a set of specific parameters from each access point. It executes the load balancing algorithm in order to find the best clients’ distribution among access points. The result will be then broadcasted in the system. In [12] the authors describe a dynamic load balancing approach used in real-time industrial contexts. Each access point, connected to the backbone, communicates with a network controller that performs corrective actions in case of performance degradation. However, this approach presents the same problems of centralized load balancing algorithms described previously. In [13], load balancing decisions are performed by each AP, in a distributed way, and not by a network controller only. The main aim is to provide a mechanism for load distribution in order to obtain less deadline miss possible considering that a deadline miss (DM) occurs when a packet misses its relative deadline. A station that measures a DM number exceeding a threshold value is characterized by performance degradation and will be managed.