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Improving throughput in Wireless LAN using Load Balancing Approach

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Abstract - In recent years, network bandwidth and quality has been drastically improved in a speed even much faster than the enhancement of computer performance. Various communication and computing tasks in the fields can be integrated and applied in a distributed system in now a days. However, those resources are heterogeneous and dynamic in distributed systems connecting a broad range of resources. This study proposed a hybrid load balancing policy to maintain performance and stability of distributed system. Load balancing is found to reduce significantly the mean and standard deviation of job response times, especially under heavy and/or unbalanced workload. Network overload is one of the key challenges in wireless LANs (WLANs). This goal is classically achieved when the load of access points (APs) is balanced. Recent studies on operational WLAN have shown that AP load is often uneven allocation. To rectify such overload, more than a few load balancing schemes have been proposed. These methods are commonly required proprietary software or hardware at the end side for calculating the user-AP association. In this paper we present a new load balancing method by controlling the size of WLAN cells (i.e., AP's coverage range), which is conceptually similar to cell breathing in cellular networks. This method does not require any modification to the users neither the wireless standard. It only requires the ability of dynamically changing the transmission power of the AP beacon messages. We build up a set of polynomial time algorithms that locate the optimal beacon power settings which minimize the load of the most congested AP. We also consider the problem of network-wide min-max load balancing.

Index Term - WLAN IEEE 802.11 Network, Cell Breathing, Load Balancing, faireness, FTP Server, TCP protocol, RSSI

I. INTRODUCTION

RECENT studies, on operational IEEE 802.11 wireless LANs (WLANs) have shown that traffic load is often unevenly distributed among the access points (APs). In WLANs, by default, a user scans all available channels and associates itself with an AP that has the strongest received signal strength indicator (RSSI), while being oblivious to the load of APs. As users are, typically, not evenly distributed, some APs tend to suffer from heavy load, while their adjacent APs may carry only light load. Such load imbalance among APs is undesirable as it hampers the network from fully utilizing its capacity and providing fair services to users.

In this paper, we present a novel load balancing scheme that reduces the load of congested APs by forcing the users near the boundaries of congested cells to move to neighboring less congested cells. We achieve this via cell size dimensioning by controlling the transmission power of the AP beacon messages. In this paper, a WLAN cell is defined as a region in which the AP beacon signal has the strongest RSSI. Our approach is conceptually similar to cell breathing in cellular networks. We present an optimal algorithm that finds deterministic min-max load balancing solutions. Informally, a WLAN is called min-max load balanced, if it is impossible to reduce the load of any AP without increasing the load of other APs with equal or higher load. Our approach is practical since it does not require either user assistance or standard modification.

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WLAN fairness needs to be considered in two aspects, intra-AP fairness and inter-AP fairness. Intra-AP fairness requires each AP to provide fairness to its associated users based on a given objective or metric. The scope of this task is locally confined to each AP cell and it can be obtained relatively easily, e.g., by controlling the traffic. Inter-AP fairness addresses a task of determining user association for ensuring fairness across all APs, assuming that each AP provides intra-AP fairness. Inter-AP fairness is obtained when the load of APs is balanced. Since the load of APs frequently changes as a result of varying channel conditions and the burstiness of user traffic, short-term load balancing causes instability of the system as users will be constantly shifted between APs. To prevent system instability, it is desirable to consider only the long-term channel condition and user traffic. In this paper, we target at the long-term inter- AP fairness assuming that intra-AP fairness is provided. Our scheme provides inter-AP fairness by adjusting the cell sizes. The WLAN cell size is changed by controlling the transmission power of the AP beacons. Note that we do not change the transmission power of the data traffic messages. The proposed algorithms are not tied to a particular load definition, but support a broad range of load definitions. We treat the load of an AP as the aggregation of the load contributions of its associated users. The load contribution may be as simple as the number of users associated with an AP or can be more sophisticated to consider factors like transmission bit rates and traffic demands. Consequently, various load balancing and max-min fairness objectives can be achieved, such as bandwidth fairness, time fairness, and weighted fairness.1 Our scheme does neither require any special assistance from users nor any change in the 802.11 standard. It only requires the ability of dynamically changing the transmission power of the AP beacons. Today, commercial AP products already support multiple transmission power levels, so we believe that this requirement can be relatively easily achieved. Depending on the extent of available information, we consider two knowledge models. The first model assumes complete knowledge, in which user-AP association and AP load are known a priori for all possible beacon power settings. Since such information may not be readily available, we also consider the limited knowledge model, in which only information on the user-AP association and AP load for the current beacon power setting is available.

A wireless local area network (WLAN) links two or more devices using some wireless distribution method (typically spread-spectrum or OFDM radio), and usually providing a connection through an access point to the wider Internet. This gives users the mobility to move around within a local coverage area and still be connected to the network. Most modern WLANs are based on IEEE 802.11 standards, marketed under the Wi-Fi brand name.

Fig.2. Wireless LAN

Wireless LANs have become popular in the home due to ease of installation, and in commercial complexes offering wireless access to their customers; often for free. Large wireless network projects are being put up in many major cities.

Problem Statement

Finding the suitable power assignment at APs to routinely achieve the load balancing is a stimulating problem. Setting the powers of all APs. Choosing the best power configuration.

AP's capacity to accommodate the demands assigned to it.

- The more subscribers logged on to the cell, the lower the power available for an individual subscriber and hence the lower its range. Clients continue to associate with an AP with the strongest "Beacons". APs manage their load by adjusting the beacon packets Transmission power.
- In this way, the AP's coverage area is shrunk or expanded transparently, adapting to client demands and balancing the traffic load across the network. In this way we are achieving the load balancing approach.

Goals

1. Finding the suitable power assignment at APs to routinely achieve load balancing is a stimulating problem.
2. When client demands are same we can always calculate such a power assignment, we can set the powers of all APs in such a way that, after all the clients choose their AP.
3. We only assume that the received power is proportional to the transmission power, but do not assume any relationship between the received power and the distance.
4. We start by setting the powers of all APs to the highest value and then we choose the best power configuration resulting from iteratively decreasing the power of overloaded APs. This approach is intuitive and easy to implement.
5. It only requires knowledge of APs' Load, which is easy to obtain. We show that if there exists a power assignment such that each AP has capacity to accommodate the demands assigned to it, our algorithm can find solution in a polynomial time.

Contributions

WLAN fairness needs to be considered in two aspects, intra-AP fairness and inter-AP fairness. Intra-AP fairness requires each AP to provide fairness to its associated users based on a given objective or metric. The scope of this task is locally confined to each AP cell and it can be obtained relatively easily, e.g., by controlling the traffic. Inter-AP fairness addresses a task of determining user association for ensuring fairness across all APs, assuming that each AP provides intra-AP fairness. Inter-AP fairness is obtained when the load of APs is balanced. Since the load of APs frequently changes as a result of varying channel conditions and the burstiness of user traffic, short-term load balancing causes instability of the system as users will be constantly shifted between APs. To prevent system instability, it is desirable to consider only the long-term channel condition and user traffic. In this paper, we target at the long-term inter-AP fairness assuming that an intra-AP fairness is provided. Our scheme provides an inter-AP fairness by adjusting the cell sizes. The WLAN cell size is changed by controlling the transmission power of the AP beacons.

Note that we do not change the transmission power of the data traffic messages. The proposed algorithms are not tied to a particular load definition, but support a broad range of load definitions.

II. Related Works

At present, the IEEE 802.11 standard does not provide any mechanism to resolve load imbalance. To overcome this deficiency, various load balancing schemes have been proposed. These methods commonly take the approach of directly controlling the user-AP association by deploying proprietary client software or hardware. For instance, vendors can incorporate certain load balancing features in their device drivers, AP firmwares, and WLAN cards. In these proprietary solutions, APs broadcast their load levels to users via modified beacon messages and each user chooses the least-loaded AP.

Several studies have proposed a variety of association metrics instead of using the RSSI as the sole criterion. These metrics typically take into account such factors as the number of users currently associated with an AP, the mean RSSI of users currently associated with an AP, and the bandwidth that a new user can get if it is associated with an AP, e.g.Balachandran et al. proposed to associate a user with an AP that can provide a minimal bandwidth required by the user. In, Velayos et al. introduced a distributed load balancing architecture where the AP load is defined as the aggregated downlink and uplink traffic through the AP.

In Kumar and coworkers proposed association selection algorithms which are based on the concept of proportional fairness to balance between throughput and fairness. In Kauffmann et al. provided a mathematical foundation for distributed frequency allocation and user association for efficient resource sharing. Recently, in Shakkottai al. considered a no cooperative multihoming approach and showed that under appropriate pricing, the system throughput is maximized. In a strong relation between fairness and load balancing is shown. Most of these works determine only the association of newly arrived users.

Tsai et al is an exception, in which Tsai and Lien proposed to reassociate users when the total load exceeds a certain threshold or the bandwidth allocated to user's drops below a certain threshold. While the existing load balancing schemes achieved considerable improvement in terms of throughput and fairness, they require certain support from the client side. In contrast, the proposed scheme does not require any proprietary client support.

Cell breathing has been studied mostly in the context of CDMA cellular networks. The coverage and capacity of a CDMA cell are inversely related with each other .The increase of the number of active users in a cell causes the increase of the total interference sensed at the base station. Therefore, in congested cells, users need to transmit with higher power to maintain a certain signal-to-interference ratio at the receiving base station. As the users in a congested cell increase their transmission power, they also increase their interference to the neighboring cells since all cells use the same frequency in CDMA networks. As a result, the overall network capacity may decrease.

III. NEED AND IMPORTANCE OF THE STUDY

A commonly used approach to evaluate the quality of a load balancing method is whether it generates a min-max load balanced solution. Informally, we say that a network state is min-max load balanced if there is no way to reduce the load of any AP without increasing the load of another AP with same or higher load. We define the load vector Y = {y1 . . . . y|A|} of a state S to be the |A|-tuple consisting of the load of each AP sorted in decreasing order.

Definition 1 (min-max load balanced network state). A feasible network state s is called min-max load balanced if its corresponding load vector y = {y1 . . . y|a|} has the same or lower lexicographical value than any other load vector y^1={y0 1 . . . y0 |a|} of any other feasible state s0. In other words, if ~y 6¼ ~y 0, where ~y is the load vector of a min-max load balanced state, there exists an index j such that yj < y0 j and for every index i < j, it follows that yi ¼ y0.

We can show that the problem of finding a min-max load balanced state is NP-hard. Furthermore, we can prove that even a simpler problem, i.e., the problem of identifying the minimal set of congested APs for a known minimal congestion load, is by itself NP-hard.

IV. METHODOLOGY

Cell Breathing Approach

In this section, we present the basic concept that underlies our approach and also address the algorithmic challenge.

Basic Concept

We reduce the load of congested APs by reducing the size of the corresponding cells. Such cell dimensioning can be obtained, for instance, by reducing the transmission power of the congested APs. This forces users near the congested cells' boundaries to shift to adjacent (less congested) APs.

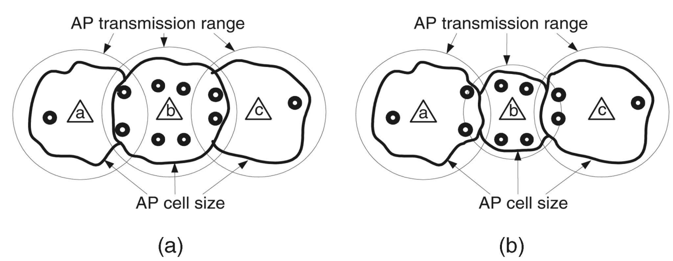


Fig. 1. Balancing AP load by adjusting transmission power (a) All APs transmit with the same power level. (b) AP b transmit with lower power level than APs a and c.

Example 1: Consider a WLAN with three APs, a, b, and c that transmit with maximal power Pmax and let us assume that they are associated with 1, 8, and 1 users, respectively, as depicted in Fig. 1a. In this example, we define the load of an AP to be the number of its associated users. Clearly, b has much higher load than the other two APs. Now, by reducing the transmission power of b, the cell size of b is also reduced and four of the users associated with b suffer from low signal quality. These users initiate scanning operations that cause them to shift to adjacent APs. As a result, the number of users Associated with the three APs are now 3, 4, and 3, respectively, as illustrated in Fig. 1b, and the AP load becomes more evenly distributed.

Reducing the transmission power of an AP affects the channel quality of all of its associated users, and this effect is not limited to those users that we intend to shift. The users who remain associated with the considered AP also experience lower channel quality and may have to communicate at a lower bit rate than before. This may result in longer transmission time of user traffic, which effectively increases the user load contributions on the AP, if the AP load is determined by considering not by the number of users but by the effective user throughput. Thus, we may end up with increasing the load of APs. The transmission bit rate for a user-AP pair is determined by the Signal to-Noise Ratio (SNR). Users associated with the same AP may transmit at different bit rates, and each user may contribute a different amount of load to its serving AP.

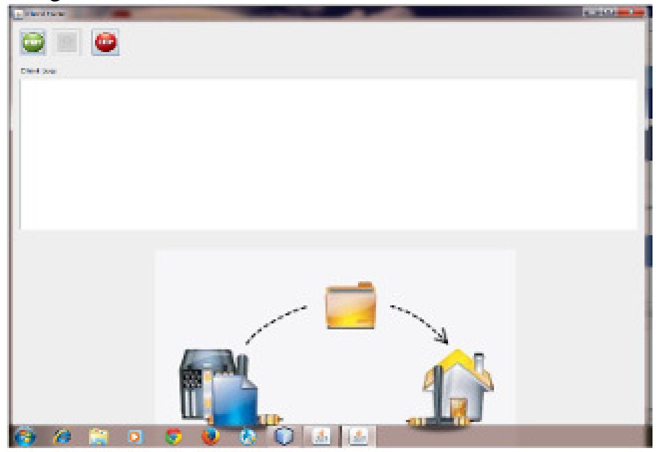
We overcome this problem by the separation between the transmission power of the data traffic and that of the AP beacon messages. On one hand, the transmission bit rate between a user and its associated AP is determined by the quality of the data traffic channel. Transmitting the data traffic with maximal power3 maximizes the AP-user SNR and the bit rate. On the other hand, each user determines its association by performing a scanning operation, in which it evaluates the quality of the beacon messages of the APs in its vicinity. By reducing the beacon messages' power level of congested APs, we practically shrink the size of their cells, and consequently discourage user association. This concept of controlling the cells' dimensions by adapting power levels of the beacon messages is termed cell breathing. The separation between the power levels of the data traffic and the beacon messages is the only modification that we require from APs. In the remainder of this paper, when we say transmission power, we mean only the transmission power of beacon messages.

V. RESULT & DISCUSSION

File Transfer Protocol (FTP) is a standard network protocol used to transfer files from one host to another host over a TCP-based network, such as the Internet.FTP is built on client-server architecture and uses separate control and data connections between the client and the server.

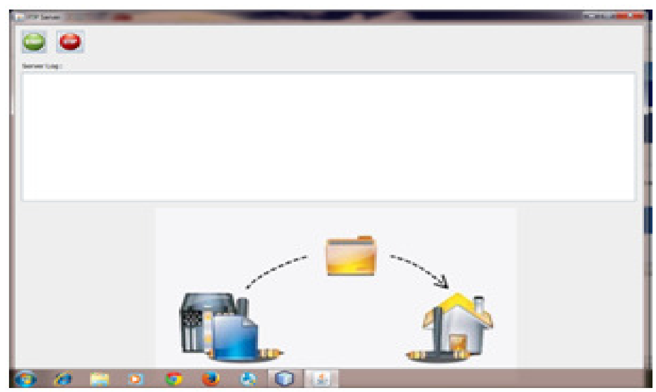
- FTP users may authenticate themselves using a clear-text sign-in protocol, normally in the form of a username and password, but can connect anonymously if the server is configured to allow it.
- FTP may run in active or passive mode, which determines how the data connection is established. In active mode, the client creates a TCP control connection to the server and sends the server the client's IP address and an arbitrary client port number, and then waits until the server initiates the data connection over TCP to that client IP address and client port number. In situations where client is behind a firewall and unable to accept incoming TCP connections, passive mode may be used.

In this way we have created FTP server and snapshot is given below:



Similarly for showing the communication in between server and client we have created the client, scenario will look as shown below:

- **Creating a FTP client**



a) Formatting: Insert one hard return immediately after the last character of the last affiliation line. Then paste down the copy of affiliation 1. Repeat as necessary for each additional affiliation.

b) Reassign number of columns: Place your cursor to the right of the last character of the last affiliation line of an even numbered affiliation (e.g., if there are five affiliations, place your cursor at end of fourth affiliation). Drag the cursor up to highlight all of the above author and affiliation lines. Go to Column icon and select "2 Columns". If you have an odd number of affiliations, the final affiliation will be centered on the page; all previous will be in two columns.

Algorithms:

1. Min-Max Algorithm

The algorithms presented in this project minimize the load of the congested AP, but they do not necessarily balance the load of the non-congested APs. In this section, we consider min-max load balancing approach that not only minimizes the network congestion load but also balances the load of the non-congested APs. As mentioned earlier, the proposed approach can be used for obtaining various max-min fairness objectives by associating each user with appropriate load contributions. Unfortunately, min-max load balancing is NP-hard problem and it is hard to find even an approximated solution. In this paper, we solve a variant of the min-max problem, termed min-max priority-load balancing problem, whose optimal solution can be found in polynomial time.

The algorithm iteratively finds a min max priority-load-balanced state that yields the optimal load vector Y. At any iteration m, m ε [1…|A|], we call a routine to calculate a network state that minimizes the priority load of the m^{th} coordinate of the load vector.

Priority-load-balanced state:

Load balancing pool: A load balancing pool is a logical set of devices, such as web servers, that you group together to receive and process traffic. Instead of sending client traffic to destination IP address specified in client request, Local Traffic Manager sends request to any of the servers that are members of that pool. This helps to efficiently distribute the load on your server resources. With the Priority Group Activation feature, you can specify the minimum number of members that must remain available in each priority group in order for traffic to remain confined to that group. This feature is used in tandem with the Priority Group feature for individual pool members. If number of available members assigned to the highest priority group drops below the number that you specify, The Local Traffic Manager distributes traffic to the next highest priority group, and so on.

When you create a pool, you assign pool members to the pool. A **pool member** is a logical object that represents a physical node (server), on the network. You then associate the pool with a virtual server on the BIG-IP system. Once you have assigned a pool to a virtual server, Local Traffic Manager directs traffic coming into the virtual server to a member of that pool. An individual pool member can belong to one or multiple pools, depending on how you want to manage your network traffic.

The specific pool member to which Local Traffic Manager chooses to send the request is determined by the load balancing method that you have assigned to that pool. A **load balancing method** is an algorithm that Local Traffic Manager uses to select a pool member for processing a request.

The routine needs to satisfy two requirements:

Requirement 1: The initial state of each iteration, m, must dominate the optimal state.

Consider a car traveling on a straight line through a hilly road. The question is, how should the driver press the accelerator pedal in order to minimize total traveling time? Clearly in this example, the term control law refers specifically to the way in which the driver presses accelerator and shifts the gears. The "system" consists of both the car and the road, and the optimality criterion is the minimization of total traveling time. Control problems usually include ancillary constraints. For example amount of available fuel might be limited; the accelerator pedal cannot be pushed through floor of the car, speed limits, etc.

The same thing we need to achieve in our proposed project work is that if any server is becoming overloaded then immediately as its load is exceeding beyond the set capacity will be diverted or handled by other backup server.

Requirement 2: The calculated network state at the m^{th} iteration should not affect (increase) load of APs that their load have already been determined by previous iterations.

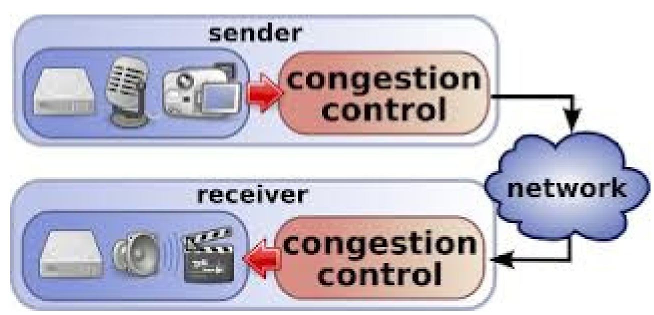
To meet Requirement 1, the algorithm starts with the maximal power state in the first iteration and we need to ensure that each iteration ends with dominating state of the optimal solution. Moreover, to meet Requirement 2, we define a set of fixed APs, F, whose load have already been determined by previous iterations. Initially, the set F is the empty and at each iteration, a new AP is added to it, until F contains all the APs. We refine the definition of the congestion load Y as the maximal load on any no fixed AP.

2. Minimum Congestion Algorithm

The Minimum Congestion algorithm based on dynamic alternative solution in which idea is to go for effective utilization of resources so that congestion can be avoided at an node.

In networking **network congestion** occurs when a link or node is carrying so much data that its quality of service deteriorates. Typical effects include queuing delay, packet loss or the blocking of new connections.

Network protocols which use aggressive retransmissions to compensate for packet loss tend to keep systems in a state of network congestion even after the initial load has been reduced to a level which would not normally have induced network congestion. Thus, networks using these protocols can exhibit two stable states under the same level of load.



The objective of minimum congestion algorithm is reducing the Congestion Probability from the source to the destination therefore we can say that performance criteria can be focused which is very important. Here what we can do is utilize the node at it's peak level so that transaction throughput can be

increased and we will achieve the maximum utilization factor by minimizing the congestion.
So set S= {S1, S2, S3…..Sn} will be the nodes in the network. Set R = {R1, R2, R3…Rn} will represent the resources at every node.
Similarly few things need to be analyzed and those are if we are implementing such type of system then there is need to identify number of nodes present, capacity of each node i.e. we need to know peak level at which that node can handle the load, a list in which we will hold all idle resources (nodes) so that if any process is arising towards busy node then it will be automatically transferred to node which is idle. After transferring the process or load to specific node then the actual load need to be re- calculated in real time fashion. Here we can maintain access transparency and the final result will be returned to the requested node. Whenever any process or processes will be initiated at the node if it is free then only will be handled by that node else that process will be diverted to the next free node. Hence this type of solution will avoid congestion as no process will wait for the execution on certain node only.

VI. CONCLUSION

We presented a novel scheme for optimal load balancing in IEEE 802.11 WLANs. We provided rigorous analysis of the problem and presented two algorithms that find deterministic optimal solutions. The first algorithm minimizes the load of the congested AP(s) in the network, and the second algorithm produces an optimal min-max (priority) load balanced solution. These optimal solutions are obtained only with the minimal information which is readily available without any special assistance from the users or modification of the standard. We assume only the control on the transmission power of the AP beacon messages. The simulations show that even a small number of power levels, e.g., between 5 and 10, is enough to achieve near optimal results.

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