Detach CTS for active load balancing in 802.11 networks

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Abstract. Transmit power reduction is the most common algorithm to achieve load balancing in either 802.11 or cellular networks. The method does not require changes in the user terminal; however, the method requires access point (AP) to have a multi-level front-end power amplifier so that transmission power can be adjusted accordingly. Transmit power reduction also removes the quality of services that may be applied to some users. Such flaws may contradict the value-added services offered by certain access points or cellular base stations. This paper proposes a simple method to avoid power reduction in 802.11 networks. Load balancing is achieved by ordering disconnection for unwanted users by sending a detach clear to send (CTS) signal in response to a request to transmit (CTS) sent by users. Although it violates the standard Ethernet algorithm, it may be applicable in the future standard. By receiving detect CTS, the user is simply disconnected to existing AP and finding the alternative AP. Simulation evaluations show that the method successfully maintains the average throughput as well as maintains the possible prioritized users.

1. Introduction

The 802.11 network allows users to migrate from one access point (AP) to other APs as in cellular networks \cite{1}. Users may be affected by several reasons in choosing preferred AP, such as the comfort seat, electric power availability or signal strength. Particular AP could be overloaded. The load balancing algorithm is the solution for user distribution among 802.11 APs so that network performances are optimum \cite{2}.

Hojiev \cite{3} and Shafi \cite{4} proposed decentralized load balancing to maximize throughput and to minimize transmission delay. Load balancing control is distributed among AP. Velayos et al \cite{5} proposed centralized load balancing using a specialized server to determine network utility. This server then distributed an average value to APs. Each AP checks its load, if it is larger than the average value, it means the AP experiencing overload. It can decide either to receive or to reject the incoming connection. The work of Velayos et al was improved by Josua \cite{6} by enabling AP with different speeds to implement load balancing.

Bahl \cite{7} proposed cell breathing for the cellular network than decreased network coverage when overload occurred. However, a current connection may disturb as the signal decreases suddenly. Wang \cite{8} applied cell breathing and enhanced the performance by applying signal decrement for the beacon signal only. However, both methods cause nodes without alternative AP lost connection permanently. This weakness was repaired by Suherman \cite{9} by introducing a clustered cell breathing.

Methods proposed in [3 - 9] were performed in the medium access layer by introducing new hardware and software. This is actually unnecessary as the Ethernet frame may be adjustable for implementing load balancing. Of course, adjustment changes the 802.11 standards. But it is possible as...
standards keep improved in its variants, so that load balancing may be applied in upcoming standards. This paper proposes to detach Clear-to-Sense (CTS) for a simple load balancing algorithm. In order to discuss the proposed method, the carrier sense multiple access (CSMA) frame should be explained in the first place.

2. CSMA and CTS Frame
Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) is a contention protocol to enable multiple stations sending a packet with less collision in the wireless network. It is used for the 802.11 standards. One of the ways to avoid a collision is by using a Request to Send (RTS) for transmission requests, and clear-to-send to denote the right of the transmission process. Figure 1 shows how CSMA/CA works. After creating an Ethernet frame to encapsulate the transmitted data, the transmitter senses network either it is busy or not. If not, it sends the RTS frame defining a request for some bytes of data transmission. If RTS is successfully accepted, CTS will be sent by the receiver, telling all nodes that a transmitter is given the right to transmit data. Other stations will defer transmission.

![CSMA Algorithm](a)

![CTS frame](b)

Figure 1. CSMA and CTS.
Clear to Send (CTS) signal is part of Ethernet software (CSMA/CA) which is a reply of the client request (request to send, RTS), informing a client when and how many bytes to send. The frame is shown in Figure 1b. CTS frame contains four fields, which are frame control, duration, a receiver address (RA), and frame check sequence (FCS).

3. The proposed method
The existing load balancers are mainly aimed at one objective, to reduce clients when overloaded. By taking a look at the 802.11 standards, CSMA/CA is able to perform load balancing tasks easily. However, as the standard has been applied in widely spread computers, changes are not preferred. However, new 802.11 standards are kept coming. Active load balancers may be applied in the revised standard. This work proposes changes in CSMA signal slightly to accommodate a simple load balancing task.

Since overloaded AP is mainly caused by active traffic, detachment for load balancing is preferred applied to CTS rather than RTS. The proposed method works as follows: CSMA/CA within the access point should monitor network congestion. In the case network is overload, the proposed method referred to as “detach CTS” is applied to some clients. The chosen nodes may be randomized or selected based on some criteria. This paper chose a random method.

Detach CTS modifies CTS octets within the duration field. The duration field may be set as 00 or FF to indicate the detachment order. The client who reads this CTS frame will disconnect itself from AP by erasing SSID from its list, and automatically finding an alternative AP.

4. Research method
In order to evaluate the proposed method, simulation is set up following steps in Figure 2. The program was written in Java. AP and MN generations were performed randomly, while AP-MN connections were set based on the strongest signal. The evaluated load balancing methods were the existing cell breathing and the proposed one. Average throughput and un-served clients were evaluated.

Figure 2. Research steps.
In order to evaluate the 802.11 network performance, Pamvotis java files [10] were extracted. The simulation was repeated using 2 APs with a maximum capacity of 2 Mbps and several iterations with a various number of users with constant traffic of 8 packets per second with a packet length of 16000 bits.

5. Evaluation results
Figure 3 shows the average throughput. The proposed method consistently keeps the performance in the highest threshold when network overloaded as detach CTS easily orders clients to disconnect. It works 0.08% better than existing cell breathing in terms of average throughput.

![Figure 3. Throughput performance.](image)

The method is also stable in maintaining AP to be always avoiding overload. The proposed method is also able to maintain the unserved nodes as low as possible (Figure 4).
6. Conclusions
This paper has proposed to detach CTS to resolve overloaded access points. CSMA/CA modification to allow CTS informing user disconnection makes load balancing is easier to perform. Whenever non-prioritized nodes requested transmission by using RTS, AP is easily removing the clients by replying to detach CTS, so that probability collision increment is avoided and only active nodes that cause overload are removed.

The simulation shows that the proposed method is better than existing cell breathing in terms of throughput and un-served mobile nodes with the cost of CSMA/CA modification.

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References
[1] Krishnanjali M A, Patankar A. 2014. Techniques for Load Balancing in Wireless LAN’s. Int. Conf. on Communication and Signal Processing, p1831–36.
[2] Long H, Shen H Y, Guo M, Tang F. 2013. LABERIO: Dynamic Load-Balanced Routing in OpenFlow-Enabled Networks. Int. Conf. on Advanced Information Networking and Applications, AINA, 290–97. https://doi.org/10.1109/AINA.2013.7.
[3] Hojiev Q, D-S Kim. 2015. Dynamic Load Balancing Algorithm Based on Users Immigration in Wireless LANs. Journal of Advances in Computer Networks 3 (2).
[4] Shafi U, Zeeshan M, Iqbal N, Kalsoom N, Mumtaz R. 2018. An Optimal Distributed Algorithm for Best AP Selection and Load Balancing in WiFi. 15th Int. Conf. on Smart Cities: Improving Quality of Life Using ICT & IoT, 65–69.
[5] Velayos H, Aleo V, Karlsson G. 2004. Load Balancing in Overlapping Wireless LAN Cells. IEEE Int. Conf. on Communications, 3833–36. https://doi.org/10.1109/ICC.2004.1313270.
[6] Napitupulu C J, Sihombing P, Suherman S. 2018. Optimizing the 802.11 hotspot performances by using load and resource balancing method. IOP Materials Science and Engineering 420(1).
[7] Bahl P, Mohammad T H, Kamal J, Sayyed V M, Lili Q, Amin S. 2007. Cell Breathing in Wireless LANs: Algorithms and Evaluation. IEEE Trans. on Mobile Computing 6 (2), 164–77.
[8] Wang S-L, Huang J-H, Cheng X-Z, Chen B. 2014. Coverage Adjustment for Load Balancing with an AP Service Availability Guarantee in WLANs. Wireless Networks 20 (3), 475–91
[9] Suherman S, Sandi A, Ali H. 2019. Clustered cell breathing for load balancing in mobile and wireless networks, ELTICOM.
[10] Vassis D, Zafeiris V. Pamvotis—IEEE 802.11 WLAN simulator. http://www.pamvotis.org.