Multi-rate aware Partition and Cooperation in WLANs

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1. INTRODUCTION

Recently the prominent growing of smartphone users accelerates the demand of Wireless Local Area Network (WLAN) services more. In a large scale WLAN, the IEEE 802.11 Distributed Coordination Function (DCF) protocol has two problems; one is performance anomaly in multi-rate 802.11 environments [1]. The other is performance degradation due to frequent collision by a large number of stations [2].

If a mobile node transmits data with a low data rate, other nodes present similar throughput regardless of their data rate, because IEEE 802.11 provides equal channel access to every node. This phenomenon has been called performance anomaly. To address performance anomaly, the time fairness have been proposed in previous studies. In [3], baseline property has been proposed, and it guarantees time fairness if every node achieves its target throughput. In [4], for achieving the time fairness, the packet release rate from the network layer to MAC layer is adjusted based on the queue length.

Aside from the time fairness, cooperative communication is another approach to improve the performance. Cooperative transmission exploits packet forwarding via a relay node with a higher data rate instead of direct transmission with a lower data rate. Since it is able to enhance the throughput of nodes with a low data rate, cooperation improves the throughput of a WLAN. In CoopMAC proposed in [5], a source node selects a relay node based on the monitored information, and data is transmitted via the relay node.

In Fig. 1(a), it is observed that air time overhead such as idle time and collision time increases as the number of nodes increases, because a large number of nodes cause a lot of collisions, and it also increases the backoff counter. To reduce the number of contending nodes temporally, several researches have proposed grouping schemes to improve the throughput of a WLAN under crowded. In [6], each group is configured randomly.

Table 1: Performance Measurement in WLAN

location	AP	signal strength	throughput
Cafe 3	AP 1	-65 dBm	0.4 Mbps
	AP 2	-65 dBm	0.16 Mbps
	AP 3	-66 dBm	7.14 Mbps

To observe high contention in a large WLAN, we measure the throughput and the signal strength of WLANs in five cafes near Gangnam subway station, Seoul, Korea. Due to the space limitation, we present one result in Table 1. There are three APs in Cafe 3, and similar signal strength is measured from each AP. However, actual throughput with AP 3 is much higher than that of AP 1 and AP 2. We do not know the number of nodes attached to each AP, but it is obvious that the actual throughput is not just depending on the signal strength and transmission rate.

Existing approaches for cooperation and time fairness do not deal with frequent collisions, and previous studies on partitioning do not consider performance anomaly. In this paper, we propose a scheme to cope with both performance anomaly and collision. In the proposed scheme, we partition nodes into several groups based on their transmission rate. Then, we can easily find a relay node for cooperative communication, and through group-based channel access, we can reduce the collision rate.

2. METHODOLOGY

We propose a scheme to consider both partition and cooperation in multi-rate environment. In the existing researches, partitioning is effective to reduce collisions in a high node density environment, but they still do

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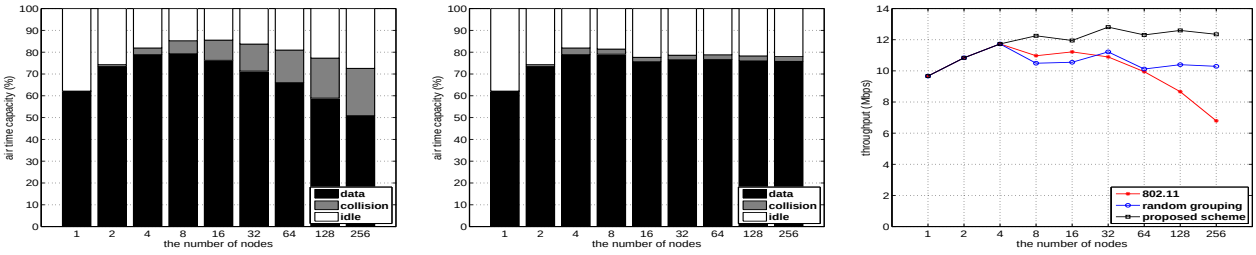

(a) Air time in IEEE 802.11 (b) Air time in proposed scheme (c) Aggregate throughput

Figure 1: The air time capacity and aggregate throughput in IEEE 802.11

not handle performance anomaly. We divide nodes into several groups based on the transmission rate. This rate based partitioning is beneficial for achieving time fairness without adjusting contention window or release rate. Each group consists of nodes with similar data rates, and we assign the equal transmission time to each group for time fairness. Since contention occurs in each group, we can reduce the collision rate also.

We also suggest a cooperation scheme utilizing the rate based partitioning. In previous studies on cooperation, before transmitting data, a source node should know a relay node to utilize cooperative communication. It takes overhead such as message exchange or monitoring medium for selecting a relay node. To reduce the overhead, in the proposed scheme, a source node sends data to a group consisted of high data rates instead of a relay node. After receiving the data, one node in the partition forwards data to a destination. A node which uses cooperative transmission joins to a partition of which data rate is similar to the data rate achieved by cooperation. Through this method, data is transmitted via a relay node with high data rate and less searching overhead.

In future work, we need to optimize the number of nodes per a partition for maximizing data air time, and we develop the detail algorithm for cooperation. We also provide the configuring method for rate based partition. Through future work, the scheme proposed in this paper, improves the throughput and decreases collisions and performance anomaly, simultaneously.

3. PERFORMANCE EVALUATION

We evaluate the proposed scheme using ns-2 simulator, and compare the results with the IEEE 802.11 standard and random grouping in [6]. The random grouping uses random modulation and does not consider multi-rate. For rate adaptation in multi-rate environment, we employ RBAR (Receiver Based Auto Rate). The transmission range of the basic data rate is 250 meters. Nodes are placed randomly in the transmission range of the AP. The proposed scheme is used when the number of nodes is more than four nodes, and the average number of nodes per a partition is four.

As shown in Fig. 1(b), the proposed scheme reduces the air time overhead such as idle time and collision time. Fig. 1(c) shows the aggregate throughput in the same WLAN topology. As the number of nodes increases, the throughput of 802.11 decreases by high collision rate and by consuming more air time of low data rate. In contrast, the proposed scheme shows the higher throughput than 802.11 and random grouping due to utilizing cooperation and reducing performance anomaly, when the number of nodes is more than four nodes.

4. CONCLUSIONS

In this paper, we have proposed the multi-rate aware partition and cooperation scheme to simultaneously utilize cooperative communications, time fairness and partitioning method. In the proposed scheme, cooperation enhances the throughput of low data rate, time fairness is used to reduce the bad effect in performance anomaly, and partitioning method is utilized to minimize air time overhead. The proposed protocol is evaluated through simulation. It has been shown that the proposed scheme has a potential to be able to achieve significant throughput gain in WLAN.

5. REFERENCES

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