Adaptive Control Scheme in Wireless Ad Hoc Networks

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ABSTRACT

We consider a wireless ad hoc network and propose an adaptive control scheme with a single backoff stage. The proposed scheme achieves both higher short-term fairness and higher throughput than the IEEE 802.11. Moreover, the proposed scheme is quite simple to implement, operates in a distributive manner, and needs no priori information about the network.

PRELIMINARY AND NETWORK MODELING

We consider a wireless ad hoc network with 1 IBSS (independent basic service set). All nodes are assumed to sense each other's transmissions, so any simultaneous transmissions are considered as collisions. We assume that there are no other causes of transmission failure such as channel error except collisions. All nodes are assumed to have packets to transmit and we do not consider the capture effect.

Assume that a network has N nodes and has no hidden nodes. All nodes use the IEEE 802.11 DCF but they have a single backoff stage. When N is fixed, the network throughput is a function of the contention window size W. Let $\tau^*_{(N)}$ be the transmission probability of a node when the network throughput of the network with N nodes is maximized. According to [1], the network throughput is maximized when the transmission probability $\tau^*_{(N)}$ is approximately given by $\frac{c^*}{N}$ where c^* is the unique solution of $(1-c)e^c - \frac{E[T_c]-1}{E[T_c]} = 0$. Here, $E[T_c]$ is the average length of time period for a collided packet transmission. Moreover, when N goes to ∞, it can be shown that the collision probability converges to $p^* = 1 - e^{-c^*}$. We use p^* as a benchmark to reach the maximum network throughput without using any complex analytical model.

ADAPTIVE CONTROL SCHEME

The proposed adaptive control scheme tries to adjust the window size W according to the packet transmission results. For instance, if the estimated collision probability is greater than the optimal collision probability p^*, then the window size is increased. On the other hand, if the collision probability is smaller than the optimal collision probability p^*, then the window size is decreased. The updated window size is broadcasted through a beacon frame. The detailed scheme is omitted. The performance results are provided in Figure 1 which shows the network throughputs when the number of nodes changes from 4 to 100 in basic access (above) and RTS/CTS mode (below). For comparison purpose we consider IEEE 802.11 DCF [2], EIED [3], and QB [4]. As seen in the figure the proposed scheme (denoted by ACWC in the figure) provides higher throughput than all other schemes when the number of nodes is larger than 40. Even when the

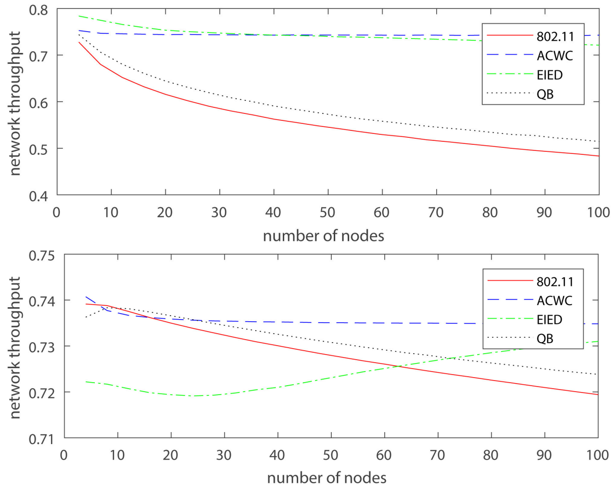

Figure 1. the network throughputs of various schemes in networks with $4 \sim 100$ nodes in basic access mode (above) and in RTS/CTS mode (below).

number of nodes is smaller than 40, some other schemes provides a little higher throughputs than the proposed scheme, and the differences are not significant. One important observation from the figure is that the proposed scheme provides almost constant network throughput regardless of the number of nodes while the other schemes provide different network throughputs in both basic access mode and RTS/CTS mode as the number of nodes changes.

REFERENCES

1. Kim, Yunbae, et al., "Throughput Performance Optimization of Super Dense Wireless Networks With the Renewal Access Protocol", *IEEE Transactions on Wireless Communications*, Vol. 15, No. 5, 2016, pp. 3440-3452.
2. 802.11-2016 - IEEE Standard for Information technology–Telecommunications and information exchange between systems Local and metropolitan area networks–Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
3. Song, Nah-Oak, et al., "Enhancement of IEEE 802.11 distributed coordination function with exponential increase exponential decrease backoff algorithm", *Vehicular Technology Conference*, 2003. VTC 2003-Spring. The 57th IEEE Semiannual. Vol. 4. IEEE, 2003.
4. Sun, Xinghua, and Lin Dai., "Backoff design for IEEE 802.11 DCF networks: Fundamental tradeoff and design criterion", *IEEE/ACM Transactions on Networking*, Vol. 23, No. 1, 2015, pp. 300-316.