The Ergodic Rate Density of Slotted and Unslotted CSMA Ad-Hoc Networks

The performance of random Wireless Ad-hoc Networks (WANETs) is primarily limited by their self-interference. The utilization of a decentralized Carrier Sensing Multiple Access (CSMA) protocol protects the participating receivers from the presence of strong interferers and enhances the performance compared to the simpler ALOHA protocol. In this work we analyze the Ergodic Rate Density (ERD) of slotted and unslotted CSMA WANETs in the small back-off probability regime. Our main result is the derivation of simple expressions which describe the ERD of CSMA WANETs as a function of the back-off probability, the path-loss exponent and the ERD of the same WANET when applying the ALOHA protocol. The ERD expressions for both the slotted and the unslotted variants are shown to grow with the back-off probability. For the slotted variant the gain of CSMA over ALOHA is equal to the back-off probability. On the other hand, for the unslotted variant this gain is smaller by a constant factor, which is within the range of 0.57 to 0.67 for all cases of practical interest. Simulation results validate the precision of the derived expressions and demonstrate their capability to predict the optimal system parameters with very good accuracy.