For the last decade, wireless networking has become popular. Among various wireless technologies, the IEEE 802.11 has been very successful to attract users and nowadays it becomes a de facto standard in wireless networking. Since users expect better communication environment and most applications require wider bandwidth, the demand for higher throughput in wireless networking has been continuously increasing in recent years. This dissertation deals with designing wireless medium access control schemes, which can improve the throughput and fairness, in one-hop and multi-hop networks. Especially, the maximum end-to-end throughput in multi-hop wireless networks is investigated by using an optimization technique.

In the first part of this dissertation, TDM-based coordination function (TCF) is proposed to improve throughput in one-hop networks, i.e., WLAN, with fair resource sharing among senders. High throughput and fair resource sharing are two of the most important objectives in designing a medium access control (MAC) function in wireless networks. However, the IEEE 802.11 distributed coordinate function (DCF) MAC scheme is somewhat inefficient because of its header overhead, backoff mechanism, and waste of radio resource due to collisions among stations. TCF is a slightly modified version of DCF and inherits the simplicity of DCF. By separating the service period from the joining period, TCF eliminates the overhead resulting from the backoff mechanism and collisions among senders, and hence increases overall throughput. Each sender in TCF obtains an equal transmission opportunity scheduled by a distributed round robin mechanism, which helps in ensuring fairness among stations. The performance of TCF is investigated through intensive simulations, which show that TCF is superior to DCF, FCR, and Idle Sense in terms of aggregate throughput and fairness.

In the second part of the dissertation, the maximum end-to-end throughput in multi-hop wireless networks composed of IEEE 802.11 DCF nodes is investigated and SAFE (small buffer and adaptive freeze) MAC is presented. The analysis is performed by using the geometric programming technique under the assumptions of a static routing and a lossless channel condition. A normalized airtime of each node is used as a modeling parameter, and the analysis starts with modeling linear multi-hop topologies with one flow. Next, the throughput analysis is performed for networks with different attenuation factors and payload sizes, which demonstrates that the proposed analysis can be applied to diverse network environments. In order to show the possibility of extending the GP analysis to wireless networks of general topology, a 6-hop cross topology with two flows is studied by the GP. Extensive simulations show that the maximum throughput obtained by the GP matches well to the measured throughput by simulations. It is also noted that the throughput of multi-hop networks using the ad hoc on-demand distance vector (AODV) routing protocol is far below its optimal value due to frequent route breakages, which is caused by high contention among nodes.

SAFE MAC is proposed to improve throughput and fairness in multi-hop networks. Frequent route breakages is due to high contention level of the network, especially, severe interference from hidden nodes. SAFE MAC improves the throughput with a simple and hop-by-hop mechanism. In SAFE MAC, a small buffer is used at all wireless nodes to lower the contention level of the networks. By keeping the contention level of the network low, frequent routing failure will be mitigated and the network throughput will increase. In order to eliminate the buffer overflow problem which stems from a small buffer size, a freeze mechanism is adopted. When a node’s buffer is full and the buffer overflow is expected, the node notifies its queue status to its neighbors so that they can defer transmissions to the node. Performance evaluation through intensive simulations shows that SAFE MAC improves the throughput and fairness with significantly reduced packet losses.