Introduction

Network operators running many 5GHz PTP links may notice that the throughput over the link degrades significantly as a function of distance. This White Paper explains the protocol design responsible for such a behavior in a typical TDD PTP link and how Solectek resolves the issue by enhancing the MAC protocol to neutralize the negative effect of long distance packet transfers.

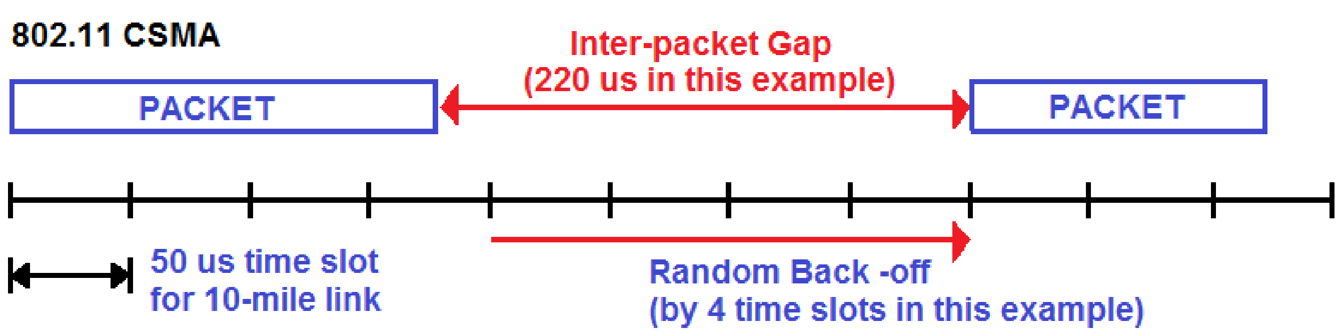
The "Time Slot" Problem with CSMA

The IEEE 802.11n and 11ac standards have some improvements over distance by eliminating the requirement for an acknowledgement frame for each packet transfer. The new "bulk ACK" scheme requires an ACK frame for a bundle of a large number of frames.

However, the CSMA protocol inherent to any 802.11 standards is hampered by protocol inefficiency that plagues long distance links. The reason is the following:

The CSMA protocol employs a "listen before talk" method to avoid packet collisions. This means a station cannot send a packet until it senses that the channel is cleared, i.e. packets cannot be sent while packets from other stations are in the middle of being transferred. For long distance links, the packet transfer time is longer and thus the waiting time is correspondingly longer as well. Further, each transmission is designed to wait a random number of time slots ("backoff") to insure that no two stations are sending packets at the same time. The number of back-off time slots depends on QoS settings, e.g. 3 -5 for real time traffic and more than 10 for data traffic.

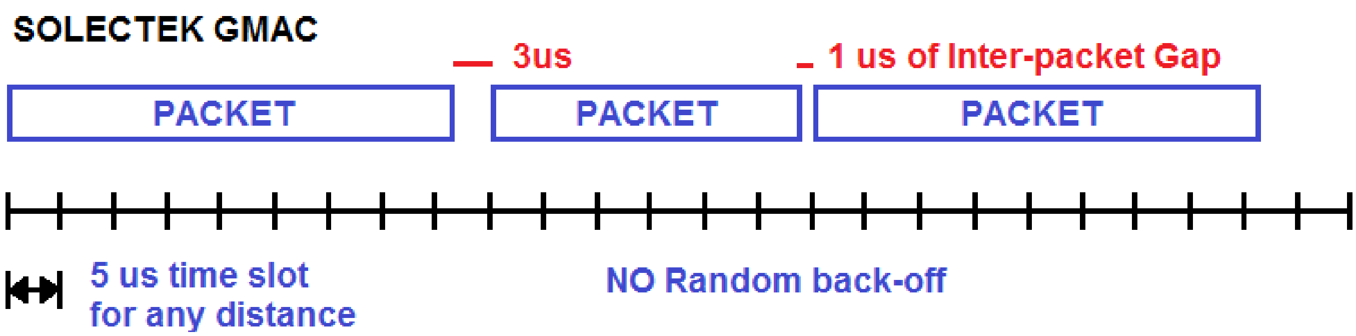
Each time slot must be set to be long enough to complete the packet transfer to the remote receiver. Given that time of flight delay is ~ 5µs per mile, time windows between two data packets can be fairly large for long distances. For example, a 10 miles link will have a time slot of 60µs and a back-off of three time slots will waste a 150µs tine window between two packet transfers.



Solution for minimum Inter-Packet Gap — Solectek GMAC

In contrast to the case of running CSMA, Solectek GMAC (GPS MAC) protocol does not need to worry about time-of-flight delays and thus does not suffer from long-distance related problems. GMAC frame (5, 10 or 20ms) is divided into uplink and downlink sub-frames. In each sub-frame, packets are sent in one-direction only, as opposed to a regular TDD where packets can be sent in either direction after insuring that the channel is clear. This means that GMAC packets can be sent in rapid succession without “back-off” waiting periods, which are required in the case of CSMA. In addition, even for long distances, time slots in GMAC do not need to correspond to time of flight delays. GMAC time slots can be set, for example, to be 9μs regardless of distances, as opposed to 60μs for CSMA for 10 miles. The difference for a 10-mile link then is at most 5μs inter-packet gap for Solectek GMAC vs. more than 100μs for CSMA. In this regard, GMAC represent a significant improvement in throughput efficiency over CSMA.

In a typical 802.11ac link based on CSMA, the throughput loss is estimated to be 2.5% per mile (25% for 10 miles). Using Solectek GMAC will reduce the loss rate to less than 1% per mile (less than 10% for 10 miles), representing a net gain of 15% throughput in a Solectek GMAC-based link.



For more details on how Solectek GMAC works or how it can be used for GPS synchronization, please refer to other Solectek GMAC white papers found at www.solectek.com/techlib-main.php.