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Multiple Working Points and Multi-Slot Message Coding in Multichannel ALOHA with Deadlines

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Abstract

This work addresses the problem of maximizing the capacity of multichannel Slotted ALOHA networks subject to a deadline and a permissible probability of exceeding it. In a recent paper, two situations were considered. First, for single-slot messages, a nonstationary Multicopy policy that entails transmission of a nondecreasing number of copies of the message in successive rounds, up to the deadline, was proposed. This substantially increases capacity relative to classical ALOHA. Second, for multislot messages and a single permissible round, partitioning the message into several single-slot fragments, and using erasure codes, was proposed. In this work, we consider another approach for single-slot messages, and consider coding for multislot messages with multiple round deadlines.

For single-slot messages, this work proposes and studies the use of Multiple Working Points (MWP), whereby the channels are divided into groups, one per round, and later round groups are operated at "cleaner" working points. Compared with optimal non-stationary Single Working Point Multicopy policies, MWP policies transmitting a single copy per round have lower capacity, but Multicopy MWP policies are slightly better. By using a low offered load rather than transmitting multiple copies in order to increase the probability of success in late rounds, the MWP approach is advantageous when using single-transmitter stations. This is because a Multicopy transmission is carried out as a burst of transmissions in consecutive slots, prolonging transmission time and stretching the round. Therefore, as the trend from high orbit satellites to networks with lower propagation delays continues, resulting in shorter rounds, Multiple Working Point policies should become of more interest.

For multislot messages, this work proposes and studies multiple round coding schemes. For a K-slot message, redundant single-slot fragments are constructed using block erasure-correcting codes, such that any K fragments suffice for message reception. With the Multiround Coding scheme, an optimized number of fragments are transmitted in each round until K are received or the deadline is reached. Even with very strict constraints, capacities that approach the $1/e$ limit are attained. The Coding–Reservation scheme raises capacity above $1/e$ by also using the foregoing fragment transmissions to request contention-free channels, which are granted once some fragment(s) are received prior to the deadline, and are used for the remaining required fragments. Both schemes are adapted for use with single-transmitter stations at a small performance penalty in most cases. When compared with the optimal use of dedicated channels and shorter slots strictly for making reservations, the relative performance varies, with harsher requirements and longer headers favoring the new Coding–Reservation scheme.