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Multiround coding and coding-reservation for multislot messages in multi-channel ALOHA with deadlines

D. Baron and Y. Birk

ABSTRACT

Slotted multichannel ALOHA is the access scheme of choice for short messages and for reserving channels for longer ones in many satellite-based networks. This paper proposes schemes for increasing the capacity (maximum attainable throughput) of multichannel Slotted ALOHA subject to meeting a user-specified deadline with a (high) required probability, thereby jointly capturing the users' requirements and the system owner's desires. The focus is on short yet multislot messages. A key idea is to achieve a low probability of missing the deadline by permitting a large maximum resource expenditure per message, while holding the mean expenditure low in order to minimize ``pollution''. 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 Multiround Coding, 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 allowing the hub, upon receipt of any message fragment(s), to grant contention-free slots for the remaining required fragments. Both schemes are also adapted for use with single-transmitter stations at a small performance penalty in most cases. Finally, because capacity is maximized by minimizing the mean per-message transmission resources, the transmission scheme is also energy-efficient.