Guest Editorial

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THE PUBLICATION in 1970 by Abramson of his now famous paper on the ALOHA system marked the birth of random-access communications. This Special Issue begins appropriately with a lively anecdotal account by Abramson of the development of the ALOHA concept. It seems no accident that the cast of players consisted primarily of information theorists. Allowing data packets to be destroyed in "collisions" is an idea much more in tune with error-correcting codes than with classical multiplexing techniques.

Abramson's 1970 paper unleashed a torrent of activity in random-access techniques that reflected the pent-up demand for practical systems that could quickly service the multitude of sporadic data sources characteristic of computer communications. Yet, for almost a decade, the information theory of random-access systems hardly progressed beyond Abramson's original work. Feedback has always created difficulties in information theory; the particular way in which feedback was used in the ALOHA system to govern the retransmission of packets thwarted information-theoretic analysis. The theoretical logjam was broken in a 1977 MIT doctoral dissertation by John I. Capetanakis, under the supervision of Prof. R. G. Gallager, that treated collision feedback information in a way that "ensures a certain stability in behavior and allows, thereby, significant coding theorems" (to borrow a phrase from Shannon's 1961 paper, "Two-Way Communication Channels"). In his paper in this Special Issue, Gallager takes a penetrating look at this "collision resolution approach" to random-access communications and shows its relation to existing multi-user information theory. The graduate student looking for a doctoral thesis topic will find this paper a good source of interesting new problems. The "collision resolution approach" was independently formulated in the USSR by Tsybakov and Mihailov in 1978. Tsybakov's paper in this Special Issue reviews many important subsequent Soviet contributions to random-access communications. This Soviet work, which is in the best Russian tradition of precise mathematical reasoning, deserves a wide audience in the west.

Because the main objective of random-accessing is to reduce message delay from that incurred with multiplexing, queueing theory has played an important role in random-access system analysis. Kleinrock's paper in this Special Issue gives an overview of queueing problems in random-access systems, and challenges the reader with a tempting conjecture. The following paper by Hajek examines the use of stochastic approximation methods to obtain stable retransmission strategies in random-access systems. This is an alternative to the "collision resolution approach," which is more oriented toward queueing techniques and worthy of deeper study.

The paper by Wolf in this Special Issue traces the similarities between the "collision resolution approach" and the little-known subject of "group testing" that evolved, unlikely enough, from the mathematical analysis of tests for veneral disease used during World War II.

The next paper, by the Guest Editor and P. Mathys, considers random-accessing without feedback, and shows the sense in which $1/e$ is a true "capacity." This paper establishes the capacity region for the collision channel without feedback; the following paper by Post shows that the complement of this region, rather than the region itself, is convex—a reversal of the usual situation for multi-user channels. In the next paper, Hui and Humblet show, in general, that the capacity region of a multiple-access channel without feedback, in the case where the users have no common time reference, differs from that in the synchronized case only by the absence of the usual convex hull operator.

The "collision resolution approach" opened the possibility of an exact analysis of the stable steady-state behavior of a random-access system. The next four papers in this Special Issue are devoted to such exact analyses. The long paper by Mathys and Flajolet gives an in-depth treatment of the formulation and solution of the "functional equations" that arise in stable random-access systems. This paper is oriented particularly toward throughput calculations; the following paper by Fayolle, Flajolet, Hofri, and Jacquet complements the former by its emphasis on delay calculations. The paper by Kaplan and Gulko presents a simplified analysis for systems with blocked-access, and the following paper by Huang and Berger offers an alternative method of delay calculation based on an integral equation.

The paper by Panwar, Towsley, and Wolf in this Special Issue shows, among other things, that first-come first-served (FCFS) algorithms for Poisson traffic cannot achieve a stable throughput of more than 1/2 packet per slot–FCFS algorithms that achieve a stable throughput of 0.487 are known. The next paper by Georgiadis and Papantoni-Kazakos considers collision resolution algorithms in which stations need not continuously observe the channel feedback, and shows that surprising improvements result when stations defer their initial transmission. In the following paper, Sidi and Cidon show how to accommodate collision resolution algorithms to the situation where the "strongest" packet in a collision may be successfully received.

In the final paper in this Special Issue, Komlós and Greenberg show that there exist collision resolution algorithms that are nonadaptive (in the sense that, until correct reception, each station schedules its packet retransmissions independent of the feedback) and that resolve collisions of k stations out of n in time that depends on k and n in precisely the same way as for the best adaptive algorithms. Their proof is by a "random coding argument"; this paper may spur our readers to develop specific non-adaptive schemes with high performance.

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