Abstract

Cover-Free Families and Topology-Transparent Communication

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Imagine that tens or hundreds of thousands of sensors are deployed in a person's circulatory system to monitor blood chemistry, travelling on currents in the blood stream. Our task is to enable these sensors to communicate with one another effectively, to provide multihop paths to fixed monitoring stations, and to provide clinical personnel with the critical data needed to respond. The sensors can move rapidly and unpredictably. They must operate at very low transmission power to avoid tissue damage. In this extreme case any knowledge of the network topology is at best severely limited. Indeed, topology discovery has limited value in the face of such rapid changes. Protocols are needed that do not require a sensor to know the identity of its neighbours — *topology-transparent communication*. With Violet Syrotiuk and others, we have recently shown that topology-transparent communication can be achieved using cover-free families of sets. These have a deep mathematical history in group testing.

Combinatorial group testing has been the main tool to isolate defectives, by identifying pools of members with one or more defectives. Uses include disease screening, identifying clones in DNA libraries, and communications. In satellite communications, group testing is used to schedule polling of ground stations in groups. Instead our goal is to schedule transmissions so that every node pair has a collision-free transmission opportunity. Such topology-transparency has been, until now, a theoretical curiosity. We have made major inroads in changing this, by establishing that the substantial theory of cover-free families provides the necessary mathematical basis, and by overcoming many of the obstacles to implementation. The basic research to bring these into application in the large sensor networks to come requires generalization of the mathematical foundations from cover-free families, and their experimentation in practical scenarios.

In this talk, an introduction to cover-free families and to topology-tranparency is given. Then we describe a three-state generalization of cover-free families for application in sensor networks. Since sensors are energy-limited, any transmission schedule must address energy savings. This requires the scheduling not only of times for transmission and reception, but also for sleep. The resulting combinatorial problem yields a new, and largely unexplored, extension of cover-free families to permit three states rather than two. While focussing on the combinatorial problem, experimental results from simulations in ad hoc and sensor networks will also be presented.