A Hypergraph Model for Combinatorial Testing: The Qualitative Independence (QI) Framework

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Combinatorial testing is a black-box technique that tests software by creating cost-efficient test suites from all possible input parameter combinations to identify interaction faults. Covering arrays are fundamental mathematical structures used for generating such test suites. A natural hypergraph model for studying these objects arises through *qualitative independence (QI) hypergraphs*, which connect combinatorial testing, extremal set theory, and hypergraph homomorphisms.

In this talk, we provide a brief overview of qualitatively independent families and then discuss qualitative independence hypergraphs t-$QI(n, g)$ and their importance in determining covering array numbers of hypergraphs via homomorphism techniques. Focusing on the binary case ($g = 2$) and strength $t = 3$, we study structural properties of uniform and almost-uniform QI hypergraphs and their connection with merged Johnson graphs. In particular, we present a complete analysis of 3-$QI(8, 2)$ and show that it is a core. We also discuss applications of these structural results to covering array numbers of certain classes of hypergraphs. This talk is based in part on joint work with Raina M. Thomas.