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Packing designs with large block size

Given positive integers v, k, t and λ with $v \geq k \geq t$, a packing design $\mathsf{PD}_\lambda(v,k,t)$ is a pair $(V,\mathcal{B})$, where V is a v-set and $\mathcal{B}$ is a collection of k-subsets of V such that each t-subset of V appears in at most λ elements of $\mathcal{B}$. When $\lambda = 1$, a $\mathsf{PD}_1(v,k,t)$ is equivalent to a binary code with length v, minimum distance $2(k-t+1)$ and constant weight k. The maximum size of a $\mathsf{PD}_\lambda(v,k,t)$ is called the packing number, denoted $\mathsf{PDN}_\lambda(v,k,t)$.

We consider packing designs with k large relative to v. In this case, we extend the second Johnson bound to arbitrary λ and show that this bound is tight. Specifically, we prove that for a positive integer n, $\mathsf{PDN}_\lambda(v,k,t) = n$ whenever $nk - (t-1)\binom{n}{\lambda+1} \leq \lambda v < (n+1)k - (t-1)\binom{n+1}{\lambda+1}$. For fixed t and λ, this determines the value of $\mathsf{PDN}_\lambda(v,k,t)$ when k is large with respect to v. We also extend this result to directed packings, by showing that if no point appears in more than three blocks, then the blocks of a $\mathsf{PD}_2(v,k,2)$ can be directed so that no ordered pair occurs more than once.

Joint work with Andrea Burgess, Daniel Horsley and Muhammad Tariq Javed