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# Hybrid Typed Graphs on Finite Rings from Conditions C1–C3


## Communication Info

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## Abstract

Background. Graphs built from ring operations link algebra and combinatorics, yet most studies fix a single adjacency rule. Goal. We introduce a single, typed hybrid graph H123(R) that only merges three classical mechanisms: (C1) $xy = 0$ (zero-divisors), (C2) $x + y \in U(R)$ (unit-sum), and (C3) $x \sim y \Leftrightarrow x = uy$ for some u∈U(R) (associates), and study how these layers interact across finite/Artinian rings. This unifies and extends viewpoints from zero-divisor and unit graphs Anderson–Livingston (1999), Beck (1988), Ashrafi et al. (2010). Framework. For V=R\{0}, H123(R) carries C1/C2/C3-typed edges. Canonical equitable partitions arise from annihilator classes (C1), residue classes modulo J(R) (C2), and U(R)-orbits of associates (C3). With adjacency AH and quotient matrix B induced by any equitable partition (incidence matrix S), we have AHS=SB, giving spectral interlacing and sharp bounds on the spectral radius and independence/covering parameters; see Brouwer–Haemers (2011, Ch. 2.5). Main results. (i) Structure: On principal ideal rings and CRT products R ≃ ∏i Ri, each typed layer decomposes into cliques and complete bipartite bands determined by primary components and unit groups; the hybrid inherits succinct degree/component formulae. (ii) Metrics: Classical bounds for zero-divisor graphs (e.g. diameter ≤3 when nonempty) transfer to H123(R) via typed geodesics Anderson–Livingston (1999); unit-graph constraints control C2-connectivity on Artinian rings Ashrafi et al. (2010). (iii) Spectra: Explicit quotient blocks on chain rings R=Zpk yield lower bounds on ρ(AH) and practical expansion proxies. (iv) Positioning: We clarify what the typed design preserves/forbids compared with total/annihilator constructions Anderson–Badawi (2008). Significance. Restricting strictly to (C1)–(C3) with explicit typing provides a clean vehicle to transfer tools between algebra (annihilators, units, associates, CRT idempotents) and graph theory (equitable partitions, interlacing, extremal metrics), enabling scalable analyses of hybrid ring graphs with standard linear-time generation for broad families.




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