Hans-Florian Geerdes

UMTS Radio Network Planning: Mastering Cell Coupling for Capacity Optimization

VIEWEG+TEUBNER RESEARCH

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Abstract

This thesis deals with UMTS radio network planning, which aims at achieving maximum coverage and capacity in third-generation cellular systems at low cost. UMTS uses W-CDMA technology on the radio interface. More traffic can be served than in previous systems, but the precise capacity of a cell depends on the current user positions, traffic demands, and channel conditions. Furthermore, cells are coupled through interference and need to be considered jointly. Static system models include all these factors and support network planning decisions in practice. They contain thousands of users in typical city-wide scenarios and model each link explicitly. Until now, only time-consuming simulation methods are known for accurately evaluating expected network capacity under random variations of the input data. Known optimization schemes either rely on a simplified capacity model, or they use complex models, which are hard to analyze theoretically.

These problems are addressed with new models and methods for UMTS capacity evaluation and planning. Interference-coupling complementarity systems are first introduced as a concise static system model. They extend known models by including the new concept of perfect load control. This allows to treat individual users implicitly even if some traffic cannot be served, so the model dimension depends only on the number of cells. Subsequently, expected-coupling estimates provide a first-order approximation of expected cell load and user blocking. Their computation requires no simulation, but only a single evaluation of the complementarity system. Experiments on realistic data validate the new system model and confirm that the performance estimates are informative for planning.

The expected-coupling estimates are the basis of a new challenging optimization model that maximizes expected capacity via a deterministic objective. The model contains an accurate notion of cell coupling and is stated in closed form. It admits structural analysis, which leads to new mixed integer programming formulations, lower bounds, and heuristic solution algorithms. Four case studies on large realistic datasets demonstrate that the planning heuristics run efficiently and produce highly efficient configurations.

The results establish a top-level perspective on the relations between cells in UMTS radio networks. This paradigm allows new insights into capacity optimization and makes effective radio network planning with an accurate notion of capacity computationally feasible in practice.

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