optimUMTS

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1 Brief Description

optimUMTS is a simulation prototype for an optimized site selection of base stations in UMTS mobile networks.
optimUMTS has been developed in collaboration with the University of Madrid ("Universidad Politécnica de Madrid, Dpto. de Señales, Sistemas y Radiocomunicaciones") and the University of Vigo ("Universidade de Vigo, Dpto. de Telecomunicaciones").
optimUMTS uses sophisticated optimization algorithms (heuristic branch-and-bound as well as genetic algorithms) to compute a "good subset" of base stations among a set of possible locations for base stations given certain service quality parameters and expected mobile user distributions. optimUMTS is a valuable tool in the planning process of cellular wireless UMTS networks, especially for the migration of GSM ("second generation") to UMTS ("third generation") networks.
optimUMTS considers both the uplink and the downlink direction of the connection between mobile user and base station. The service quality and other UMTS system parameters are handled individually per mobile and base station, respectively. The underlying propagation prediction is based on the Xia-Bertoni model over digital elevation data with building clutters. Any other prediction model can be incorporated easily into optimUMTS.

2 Input Data

2.1 Geometric Data

base stations:
set of base stations with 3D coordinates, a subset of the base stations can be fixed such that they always will appear in the site selection

mobile user:
set of mobile user equipments given as a distribution of 3D coordinates in an area, or
mobile user distribution and activation factor

Terrain:
digital elevation data and corresponding building clutter in any resolution

2.2 UMTS system parameters

- objective $Eb/N0$ for uplink and downlink direction, optimUMTS handles the parameter independently for all Rx-Tx combinations
- parameters for the Xia-Bertoni propagation model currently integrated into the simulation tool
- base frequency, noise parameters, and antenna gains
- activity factor of the uplink connection and orthogonality factor of the downlink connection
- maximum transmitting power of mobile and base station, pilot power and maximum channel power of the base station
- service quality (bit rate) and validation percentage, i.e. percentage of user distributions to which the service quality should be guaranteed

2.3 Simulation and Optimization Parameters

There is a set of parameters which allows to select certain optimization parameters and to finetune the simulation runs. These parameters guide the heuristic respectively genetic optimization algorithm.

3 Output Data

The principal output data include the set of base stations being sufficient to guarantee the desired service quality to the given percentage of mobile users.

4 Software Aspects

- optimUMTS has no restrictions in the number of base stations or in the number of user locations (besides the memory restrictions and affordable run times on the simulation platform).
- optimUMTS is an interactive tool with graphical user interface for Windows and Unix-like operating systems.
- The core routines are available as C/C++-run-time-libraries both for Unix and Windows systems.
- optimUMTS is based on deterministic and heuristic/randomized optimization techniques (branch-and-bound, MonteCarlo, genetic algorithms). The main optimization criterion is the reduction of the number of base stations while guaranteeing the service quality to the mobile users. The assignment of mobiles to base stations is based on minimum power requirements. The second optimization criterion reduces either the overall power sum of the mobiles or the maximum power necessary among all mobiles.

5 Developments

Currently the following extensions are in development state:

- integration of more sophisticated propagation models (e.g. UTD (RadioTracer))
- automatic generation of parameterized distributions of mobile users
- automatic generation of parameterized distributions of service quality
- extension of the assignment to handle soft-handoff in the downlink connection
- extension of the optimization to handle different optimization criteria, e.g. service quality
- integration of sectorized antennae and their radiation patterns
- optimization of inner loops to speed-up certain parts of the computation

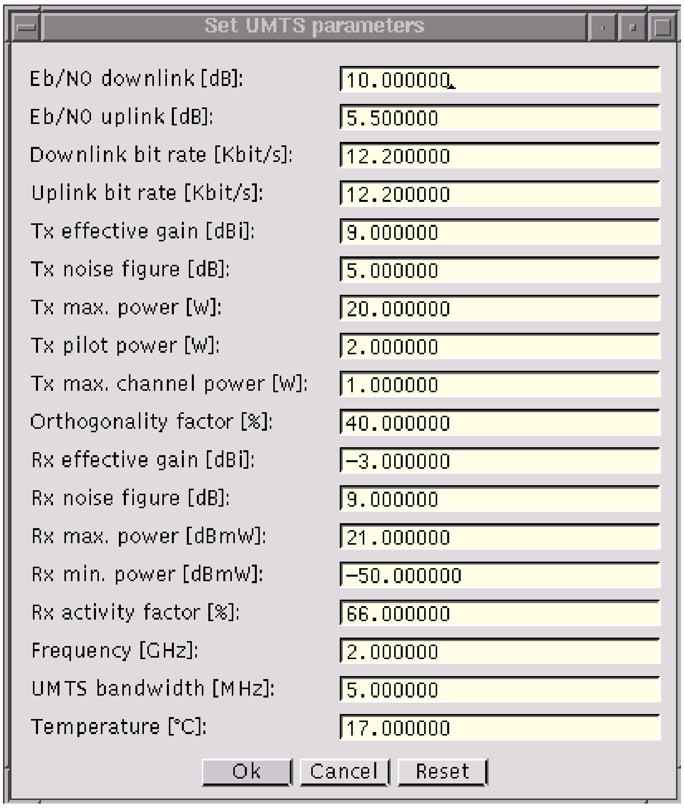
6 Examples

optimUMTS will be available as a demonstration version on the internet

`http://www.mobile-connect.de`

The following screen shots show some window contents obtained in simulation runs of the demonstration version.

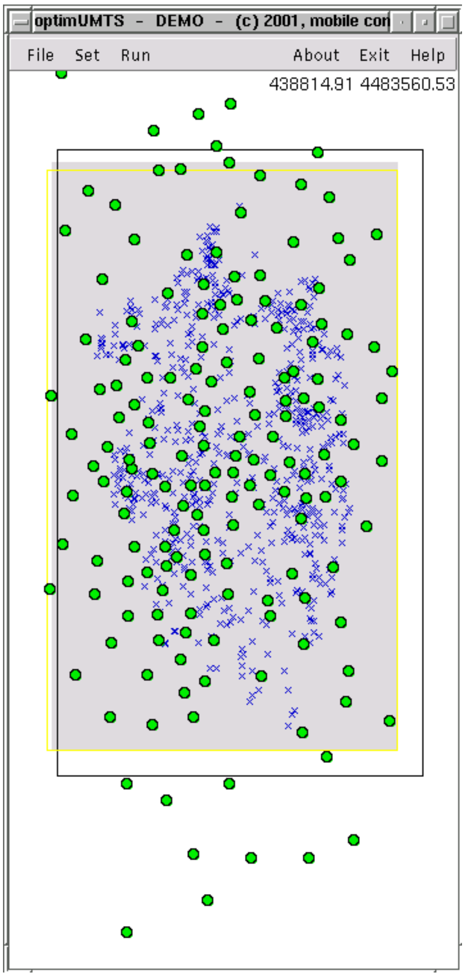
The following figure shows the settings of the UMTS parameters. In the demonstration version, the parameters cannot be set individually per mobile user and base station connection, however, the algorithm is designed to deal with individual parameter sets per connection.



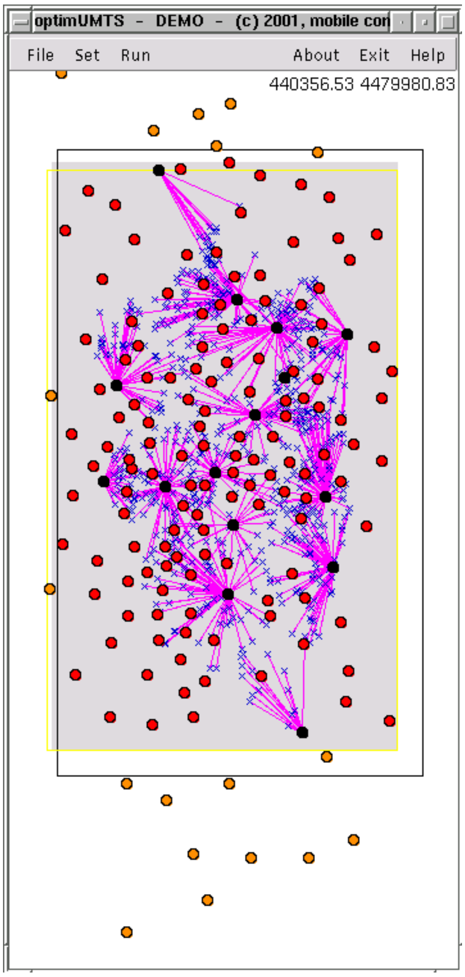
optimUMTS visualizes the current base station and mobile user distributions, the terrain area, the area of the building clutter, and the area of the distribution parameters for the generation of mobile users in the main window. Various sets of output data are presented in different subwindows.
The terrain data defines an area of approximately 12 km height and 7 km width which have been sampled with 1 m spacing.

6.1 Optimization Results

Before starting the search algorithm, the main window looks like the figure on the left hand side. The figure on the right hand side shows the result of the optimization run.



before simulation run

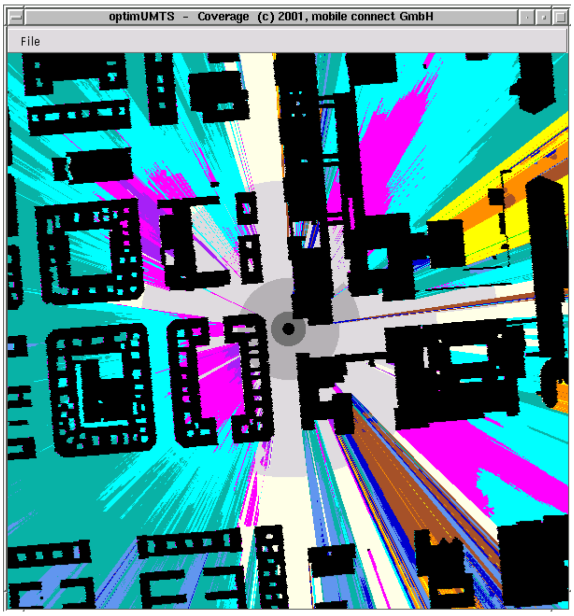


after simulation run

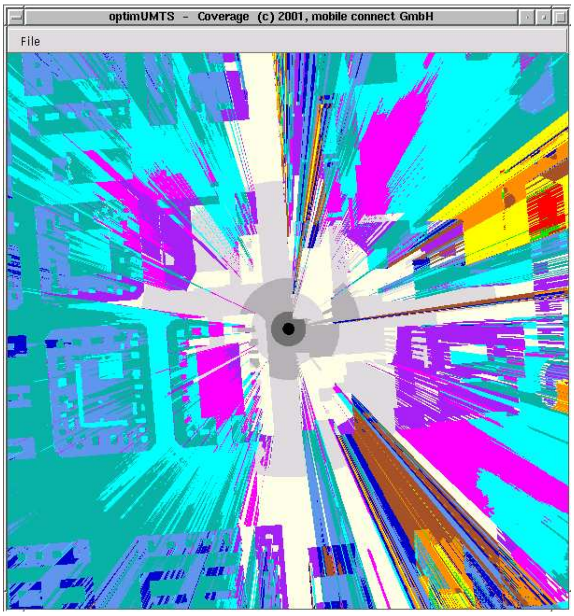
The base stations belonging to the optimized system are drawn in black, the unused base stations are drawn in red. The connection established between a mobile user and a base station is drawn with a pink line.

6.2 Pathloss Coverage Map

The pathloss coverage map shows the pathloss at the user locations respective to a base station applying the simplified Xia-Bertoni propagation model. The data is visualized in an area of 600×600 meter around a base station. The following figure shows examples of pathloss coverage maps, (on the left hand side, no values are calculated within building blocks):



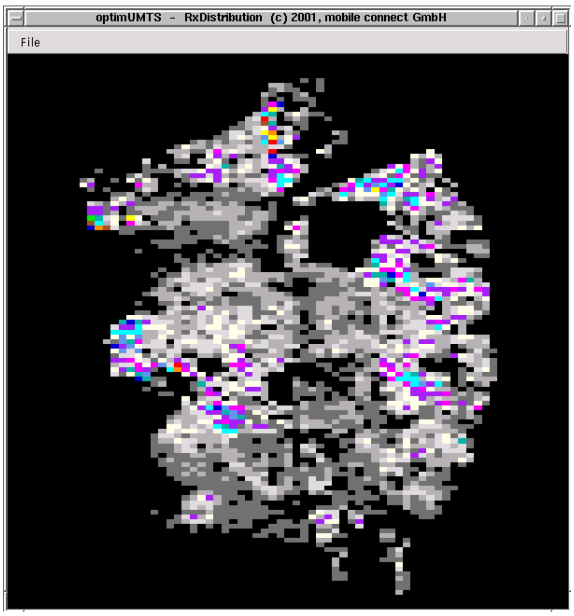
pathloss (no inside)



pathloss (+12 dB inside)

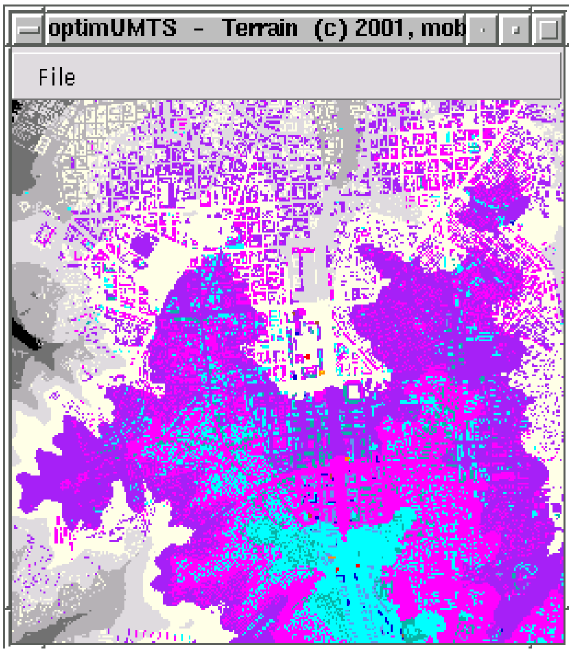
6.3 Mobile User Distribution Parameter Map

The mobile user distribution parameter map shows the number of mobile users being present in a certain region. The following figure shows the example mobile user distribution parameter map:

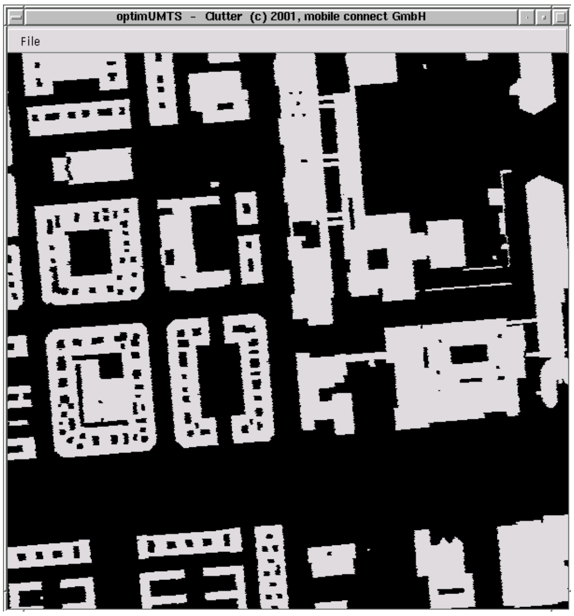


6.4 Terrain Map and Building Clutter

The terrain map (on the left hand side) shows the terrain heights according to the underlying grid. The corresponding building clutter is shown on the right hand side. The data is visualized in an area of 600×600 meter around a base station.



digital elevation data



building clutter

7 Performance

optimUMTS is a high performance tool which uses special data structures both to reduce the run time and to work with large data files.
For instance, calculating a pathloss coverage map for a 2×2 km region of a 12×7 km urban terrain data base with 1 m sampling (i.e., a large UMTS cell) takes approximately 3 minutes on a 800 MHz PC-based platform.