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MOMENTUM Data Scenarios for Radio Network Planning and Simulation

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MOMENTUM Data Scenarios for Radio Network Planning and Simulation†

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1 Introduction

Third generation (3G) telecommunication networks based on UMTS technology are currently being deployed across Europe. Within the EU-project MOMENTUM a detailed and realistic collection of data concerning UMTS network design was assembled in several scenarios. Some of these scenarios and their common format are publicly available [5]. The wide scope of the data collections and their modular structure allows a use beyond UMTS technology, for several research activities in the field of mobile communications.

We present the content of these data collections and demonstrate how they can be used for different network planning and evaluation methods. The data is available in XML [7] and described with XML Schema technology [8]. Format details are not covered here, a documentation can be found at [5].

To our knowledge, there is no similarly comprehensive, integrated, well-described and detailed data collection on radio network planning that is publicly available. Instances of optimisation and configuration problems that are closely related to the MOMENTUM automatic design task are available at [1].

2 Outline of the Datasets

The MOMENTUM data sets were created with two application fields in mind: *automatic network design* and *network simulation*. The combination of these two different tasks led to a data collection that offers a broad view on mobile networks. An overview of the data contents can be found in Table 1. Three scenarios are publicly available: Berlin,

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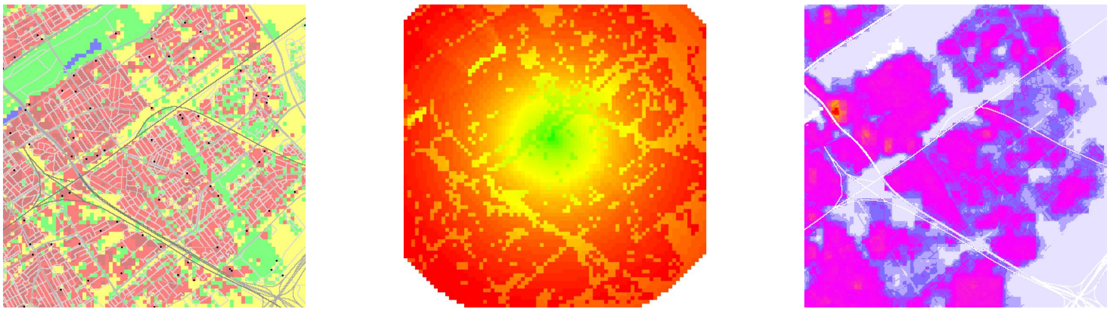
Lisbon, and The Hague. The public data sets differ from the project-internal ones only in the resolution of the raster data and in the additional use of building data.

Environment. The first section of the data deals with the "world" in which the scenario is located. This includes terrain information such as *clutter types*. Clutter types are matched to a meta-layer called *operational environments*, see Fig. 1(a). *Radio propagation* data is present in form of isotropic propagation grids at different heights for each antenna location. The grids (assuming an ideal isotropic radiator) contain no effects of antenna diagrams, these can be found in the paragraph on UMTS specific information. An example of such a grid is shown in Fig. 1(b). In the pixel based *mobility model*, there is one mobility map for each *mobility type* (such as pedestrian, street, highway, railway). For each pixel, the transition probabilities to its four direct neighbours are specified in dependence of the direction of origin. This enables, among others, the modelling of corners, street crossings, highways with bidirectional traffic, or railway bridges over streets.



(a) (b) (c)

Figure 1: Data contents (The Hague): (a) Operational environments and potential sites (b) Isotropic prediction (c) Traffic (average load for video telephony service)

Service and Traffic Related Data. Different *services* are distinguished; there are circuit switched and packet switched services that allow for asymmetric traffic. Services differ in possible data rates and link quality demand, i. e., block error rate (BLER) requirements. Users of different types use the services differently. For example, a vehicular user may not access video telephony, or a body loss applies for a pedestrian. For each service, there is a stochastic data source model specified, that is, a stochastic description of the data flow during one session. For each service, there is a *call arrival* map giving the arrival-rate of a Poisson process for each pixel. This can be used together with the mobility model for dynamic user simulation. On the other hand, *average load* grids specify the number of users per pixel at a specific instance in time, they can be used for generating static user snapshots. An example non-homogeneous traffic intensity is shown in Fig. 1(c); these grids are computed by combining the call arrival rates with the mobility model. The pixel size varies between $20\,\mathrm{m}\times 20\,\mathrm{m}$ and $50\,\mathrm{m}\times 50\,\mathrm{m}$ in the public scenarios.

Network Configuration. For describing configured radio networks, several elements are provided. The hierarchical network *structure* from sites over NodeB to cells is specified together with *radio resource management* (RRM) settings. The radio propagation features of different cells are stored as *propagation grids* containing the effect of antenna diagrams and installation parameters.

UMTS Specific Information. The data specific to UMTS systems concerns mainly the *hardware*: base station controllers (Node B), user equipment, and antennas. All relevant properties such as gains and losses, antenna diagram are described. For the UMTS radio bearers, block error rate (BLER) vs. CIR tables are given. This category also contains *offsets* that allow taking into account highly dynamic effects, such as fast fading, on the system in static methods.

As an example for resolution of the data, we calculate the system's end-to-end attenuation between the NodeB's output power and the mobile's RX unit for a given user. This attenuation is used to determine the relation between transmitted power and received power on a link. The following calculation can be carried out with individual parameters for each site and user; uplink and downlink are distinguished:

$$\begin{aligned}\text{Attenuation} &= \text{Feeder Loss} - \text{Directional Antenna Gain} + \text{Path Loss} \\ &\quad + \text{Mobile Equipment Loss/Gain} + \text{Usage Loss (e. g. body)}\end{aligned}$$

3 Usage of the Data

The main tasks within MOMENTUM, *automatic network design* and *simulation*, use the data presented above differently, as is illustrated in Table 1.

Automatic Design. The task is to design cells, specified by configured antennas, that deliver good performance for the given traffic in a cost-efficient way. Fig. 2 shows a resulting network. Since network planning has many degrees of freedom (site selection, determine azimuth, tilt, height, antenna type, ...) automatic approaches operate on a simplified model of the network. Within MOMENTUM, network design is based on snapshots created from the average load maps. Detailed information on services and user mobility allow to calculate realistic CIR targets and attenuation coefficients.

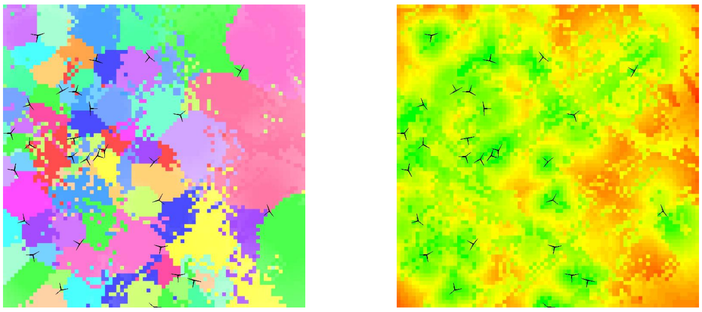
		Automatic Design	Simulation	
			Static	Dynamic
Environment	Clutter Type/Operational Env.	●	●	●
	Mobility			●
	Radio Propagation (isotropic)	●		
	Potential Sites	●		
Traffic/Services	Traffic: Average Load	●	●	
	Traffic: Call Arrivals			●
	Services	○	●	●
	Source Models	○	○	●
	Velocity	○	○	●
Configuration	Network	(result)	●	●
	Cell Predictions	(result)	●	●
	Radio Resource Management		●	●
UMTS Specific	Bearer	○	●	●
	NodeB	○	○	○
	User Equipment	●	●	●
	Antenna Diagrams	●		

Table 1: Data usage in network planning tasks: ○ considered, • fully modelled

For each (potential) site, candidate antenna configurations are determined based on the isotropic prediction, taking into account possible antenna diagrams and traffic. The decision problem of determining active sites and assigning users to cells while obeying capacity and CIR constraints is modelled as a mixed integer linear program (MIP) [4]. Solution approaches are presented in [2, 3].

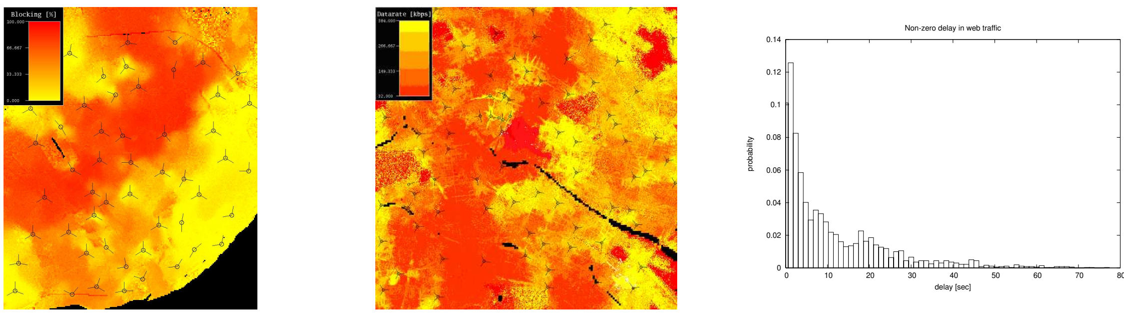
Static Simulation. Network simulations aim at a detailed analysis of the network performance indicators. Static snapshot simulations [6] are a common trade-off between level of detail and computational effort. Both static simulations and automatic design utilise similar inputs from the data scenarios. The main difference is that static simulations consider a configured network (as opposed to potential configurations in network design), but with more details on RRM and source parameters. In this way, a realistic estimation of the resource scheduling and network performance is carried out. In Figs. 3(a)–(b) typical results that can be obtained from static simulations are presented.

Dynamic Simulation. While allowing to obtain most detailed results, dynamic simulations are usually considered to be too time consuming for an application in network planning. However, it has been proposed in MOMENTUM to supplement results obtained from static simulations for the whole planning area with results from dynamic simulations carried out for sub-areas of special interest, e. g. high traffic areas or down-



(a) (b)

Figure 2: Planning result, The Hague: (a) Cell map (b) Coverage map



(a) (b) (c)

Figure 3: Results of network simulation: (a) Total blocking probability: Lisbon scenario (b) DL throughput (web browsing): Berlin scenario © Digital Building Model Berlin (2002), E-Plus Mobilfunk GmbH & Co. KG (c) Delay statistic for web-browsing traffic in a sub-area of the Berlin scenario

town districts [9]. Fig. 3(c) shows a simulation result that can only be obtained using dynamic simulations. The MOMENTUM data scenarios include all parameters relevant for dynamic simulations, such as for the modelling of the users' mobility and source models. For the first aspect, the call arrival rate is considered for each pixel. Once a user appears, it can be assigned a velocity according to its mobility type. The user then moves along the pixel grid according to random choices that are distributed as described in the mobility model. Dynamic models can also capture fast fading and realistic power control mechanisms. Further information can be found in [9].

4 Conclusions

We presented publicly available data sets that contain a wide range of data related to research on wireless networks and is yet detailed in all aspects. To our knowledge, this is the most realistic, comprehensive, and detailed *public* data collection on mobile networking. We have shown some usage of this data in applications related to UMTS. However, only a part of it is actually specific to UMTS, many modules may prove useful for other research topics related to wireless networks.

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