Modeling Resource Fluctuations for Adaptive Communications in Mobile Environments

– Extended Abstract –

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Abstract

Resource adaptability is induced by upcoming mobile communications in heterogeneous environments. For evaluating adaptation control algorithms and adaptation control architectures, models of resource fluctuations are a prerequisite. To model this, it is suggest with this work to deduce such models from well-known random mobility models in combination with cell and hot-spot topologies. With this talk, evaluations of statistical properties of such models are presented and influences from mobility model parameterizations on derived resource models are discussed.

Keywords: Mobile communications, adaptive communications, mobility modeling, resource modeling

1 Introduction

The notion of *adaptation* in communications means choosing a setup of components and their parameterization that is adequate to a current environment. Either to fix cross-layer issues in a self-healing way or to meet resource consumption limits. For both topics, many examples can be found in current literature, e. g., [1, 2]. Depending on the grade of adaptation, either configuration at service start or periodic or event driven reconfiguration at runtime is meant. The first case is relevant for nomadic usage scenarios with static conditions during service usage. The latter applies to fully mobile scenarios in a heterogeneous environment as depicted in the scenario at top of Fig. 1. In both cases, adaptation mechanisms as well as control algorithms are essential. In the following, methods for evaluating adaptation control mechanisms in the fully mobile case are considered.

Resource availabilities are time-dependent and can be modeled

- as individual patterns for state transition evaluations, e. g. [3]
- as random patterns for statistical analyses, e. g. [4]

Random patterns, e. g., as depicted by the Gantt-diagram at the bottom of Fig. 1 for simple on/off-resources, can (a) either be specified straightforward by distribution functions for inter-arrival times and durations of resource availability phases, or (b) be derived from random walk mobility models and cell and hot-spot topologies as proposed in this work. The link between the walk scenario (top) and the Gantt-diagram (bottom) is depicted in the middle part of Fig. 1.

2 Metrics and Properties

Before using these models for evaluating adaptation control systems, an in-depth evaluation of their properties and the influences of cell topologies and mobility model parameterizations to these proper-

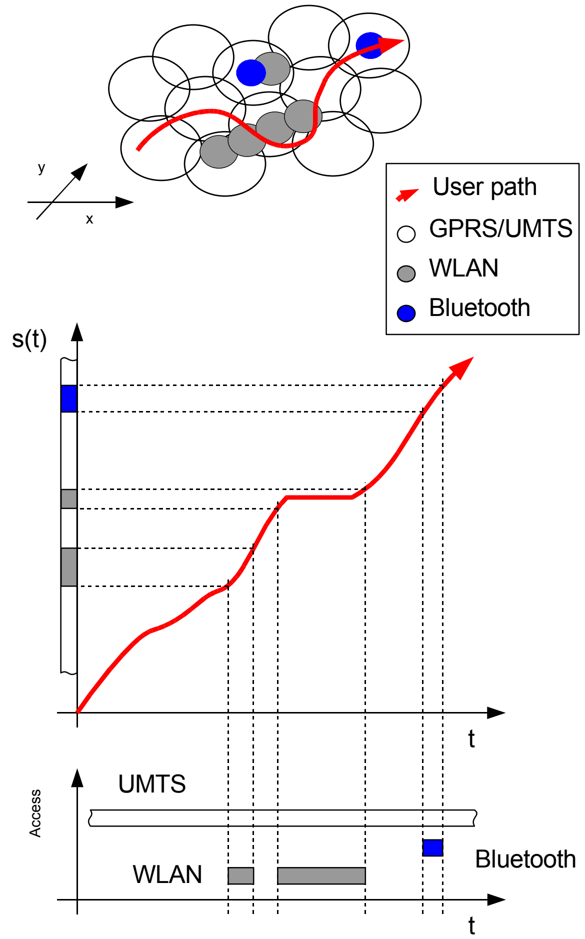

Figure 1: Link between user mobility, cell and hot-spot topologies, and resource availabilities

ties is desirable. For this, metrics describing the resource mix available to a mobile user are introduced. These metrics are either directly derived from the base-models or indirectly defined as measurements at test systems influenced by resource fluctuations. Among others, direct metrics are the hot-spot inter-arrival time distribution and dwell time distribution, and, as defined in Eqn. 1, the mean bitrate available to the mobile user for an *Always Best Connected (ABC)* scenario with one access system active at a time out of a set of S possible access systems.

$$\overline{r} = \lim_{T\to\infty} \frac{1}{T} \int_{t_1}^{t_1+T} max(r_n(t))dt \quad \forall \quad n \in S \qquad (1)$$

An indirect metric used in this talk is the mean waiting time[1] of data generated by a continuous flow source in a queue just before the wireless link as defined by Eqn. 2.

$$\overline{t}_w = \lim_{T\to\infty} \frac{1}{T} \int_{t_1}^{t_1+T} l(t)dt \qquad (2)$$

This metric covers the correlation of hot-spot visits since a penalty is given to long but rare visits in comparison to frequent but short ones.

3 Parameter Studies

As mobility models the well known *Random Direction* and *Random Waypoint* models are chosen and weighted against each other. They are used in combination with selected hot-spot topologies. Direct metrics like the hot-spot dwell time distributions as depicted in Fig. 2 are related to typical walk model parameterizations.

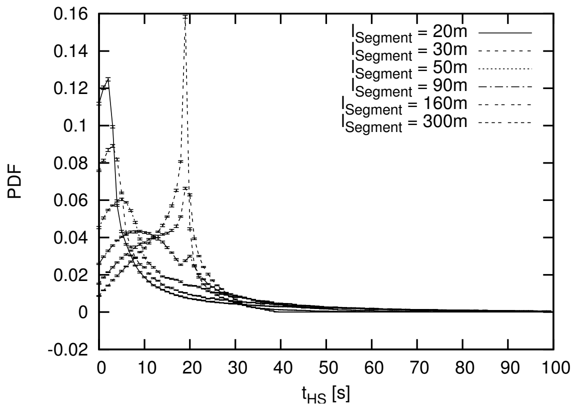

Figure 2: Hot-spot dwell time distribution of a Random Direction walker in a scenario with one hot-spot in dependence to the walk segment length $l_{min} = l_{max} = l$

A result from this comparison is that the Random Direction mobility model with parameters for the

[1]The mean waiting time equals the mean queue length of the access link and is a well known metric for evaluating communication systems

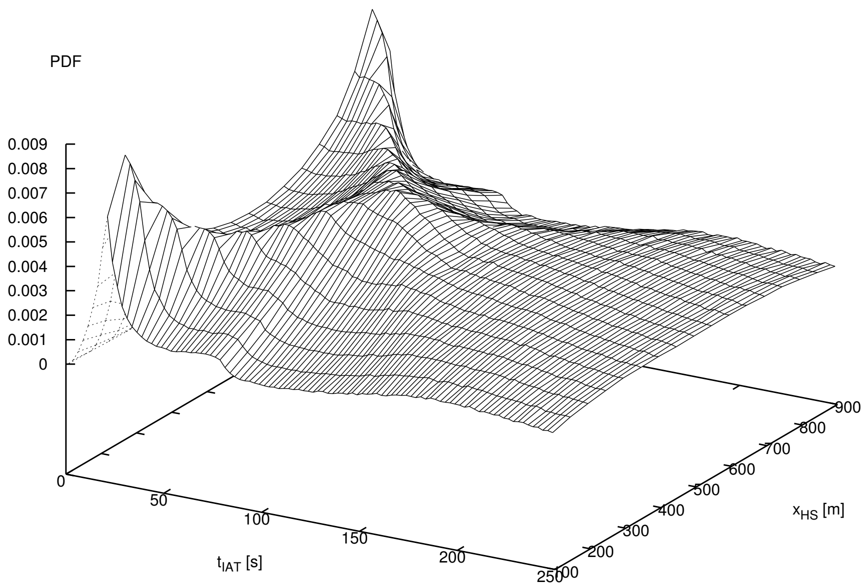

Figure 3: Visit inter-arrival time distribution of a Random Waypoint walker visiting a circular hot-spot with $r = 100\,\mathrm{m}$ depending on the hot-spot location $\vec{p} = (x_{HS}, 400m)$. The walk area is $1000\,\mathrm{m} \times 800\,\mathrm{m}$.

walk segment length distribution, absolute or relative angle distribution, and speed distribution offers a promising parameterization while the Random Waypoint model appears to be a bit stiff. Furthermore, the Random Waypoint model suffers from a location dependency of hot-spots within the walk area as illustrated in Fig. 3. This study evaluates the visit inter arrival time distribution in relation to the hot-spot position.

4 Summary

With this talk, resource models that are derived from mobility models and cell and hot-spot topologies are motivated and some example cases are evaluated. Especially the adjustable randomness of the Random Direction mobility model as one basis for this kind of resource model is shown to be a promising approach.

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