

# Abstract

The physical properties of the wireless communication channel imply a sharing of the limited frequency spectrum among its users. Hence, the available transportation capacity of wireless links is typically several orders of magnitude below the capacity of comparable fixed wire connections. In consequence, mobile users, accessing information by means of a hypertext system, such as the world wide web, experience undesirable long waiting times for requested documents.

This thesis' primary objective is the improvement of information access for mobile users. The approach proposed and discussed in this thesis is partly based on the assumption that mobile devices are increasingly equipped with multiple wireless access technologies which facilitate the use of heterogeneous wireless access networks, differing in parameters such as range, data-rate and costs. Since some of these networks are deployed with partial coverage, a user's mobility causes changes of the actual network conditions. Furthermore, it is assumed that a particular user's scope of interest in information is time-variant and depending on this user's actual situation. Advances in the fields of ubiquitous and pervasive computing, particularly the work on context sensors and observation of user interaction, render it feasible to derive information on the user's context. In this thesis it is therefore proposed to employ knowledge about the user's context and behavior, to pro-actively transmit documents' data, especially during favorable network conditions, over the wireless communication link, before the user requests the documents.

Human behavior, as observed from outside, is inherently probabilistic, despite advances in sensor technology. Therefore a probabilistic model for the user context is formulated. In order to distinguish this model from non-probabilistic context models and context awareness, the terms "situation model" and "situation awareness" are introduced. Since the concept of situation awareness may as well be utilized for other applications, such as handover decisions, pro-active computing or future user interfaces to search engines, the situation model and its discussion is intentionally kept as general as possible, in order to enable its application to various domains. The properties of a situation model are analyzed from an information theoretic viewpoint. This perspective is used later on to illustrate the selection of suitable sensor data, based on metrics such as conditional entropy and mutual information.

The task of obtaining and continuously adjusting suitable probabilities for the model is formally treated as an estimation problem. Several estimators, such as maximum likelihood (ML), minimum mean square error (MMSE), and maximum

a posteriori (MAP) are discussed and related to Bayesian estimation. Particularly, the temporal development of the estimation is investigated and illustrated.

The concept of situation awareness is then applied to the prefetching of documents in hypertext systems. A thorough analysis yields qualitative and quantitative insights into the effects of situation aware prefetching on the average waiting time and transported data volume. The necessity for the assumption of a user policy is discussed and an optimum probability threshold is derived.

The investigation of situation-aware prefetching is further extended by means of simulations towards various mobile networking scenarios. For this purpose a novel mobility model is developed and used in conjunction with models for network topology and traffic to obtain insight into the influence of situation aware prefetching in both heterogeneous and hybrid wireless networking scenarios. Results of several simulations are discussed, showing the influence of parameters such as document probabilities, probability thresholds or level of network deployment. Simulation results show that significant reductions in average waiting time are obtainable with the proposed concept.

Finally, implementation aspects of the proposed concept are addressed. A system architecture for realizing situation-aware mobile information access in a heterogeneous wireless access infrastructure is proposed. Integration aspects as well as operational experiences obtained in an experimental testbed are discussed.

The thesis concludes with a short summary of the achieved results and a brief outlook to further research inspired by this work.