Computers and Electrical Engineering 000 (2017) 1–18

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

Cell Permanence Time and mobility analysis in infrastructure networks: Analytical/statistical approaches and their applications☆

Peppino Fazio[a,*], Floriano De Rango[a], Mauro Tropea[a], Miroslav Voznak[b]

[a] D.I.M.E.S. Department, University of Calabria, 87036 Rende, Italy
[b] VSB Technical University of Ostrava, 17 Listopadu 15/2172, 70833 Ostrava-Poruba, Czech Republic

ARTICLE INFO

Article history:
Received 24 June 2016
Revised 26 December 2016
Accepted 26 December 2016
Available online xxx

Keywords:
Realistic mobility model
Data analysis
Mobility prediction
Cell Permanence Time
Trace analysis
Hand-over

ABSTRACT

Given the recent computation technologies and dedicated systems able to analyze huge amounts of “real-world” data and to extract information from it, the application possibilities reached in wireless mobile systems have significantly increased. The availability of mobile information, directly extracted from mobility traces, can be used to enhance the quality of the services offered, especially in a vehicular environment, where mobility is one of the main challenges. We present an in-depth study of mobility information management in infrastructure networks, where the covering devices can have a complete local visibility of what happens in terms of covered nodes. We focus our attention on the ways the gathered information can be used to set the coverage radius, to enhance a call admission control algorithm and to predict future movements. The paper introduces also a detailed description of how the obtained data can be statistically processed, and the obtained results confirm the benefits of the proposed scheme, especially in terms of call dropping probability (a minimum gain of 0.35 is obtained), which is a dominant parameter in infrastructure networks.

1. Introduction

In recent years, mobile computing has become one of the main ways of information dissemination, due to its numerous advantages: users can be located anywhere without needing cables and they can move around (on feet, by cars, by trains, etc.), while maintaining their active flows. Analyzing mobility traces generated by real measurements is becoming a notable advantage in the enhancement of services offered in wireless networks [1–3]. The access to real datasets is very important in modern systems, because it allows for the investigation of on movement components, snatching detailed information about user behaviors. On the basis of the analyzed data, it is also possible to derive some analytical/statistical models: for this aim, it is very important to analyze real measurements, in order to obtain realistic models. In this work, attention is focused on the ways that real trace-files can be analyzed to extract the required information about users' behaviors. In particular, as stated previously, we carried out an in-depth analysis of mobility traces of wireless nodes in infrastructure networks, gathering different data, both in a *qualitative* and a *quantitative* way. A better knowledge of how the mobile nodes act during their flow lifetimes is obtained. We show the importance of the Cell Permanence Time (CPT) (also called Cell Dwell

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Guest Editor Dr. R. Varatharajan.

* Corresponding author.
E-mail addresses: pfazio@dimes.unical.it (P. Fazio), derango@dimes.unical.it (F. De Rango), mtropea@dimes.unical.it (M. Tropea), miroslav.voznak@vsb.cz (M. Voznak).

http://dx.doi.org/10.1016/j.compeleceng.2016.12.027
0045-7906/

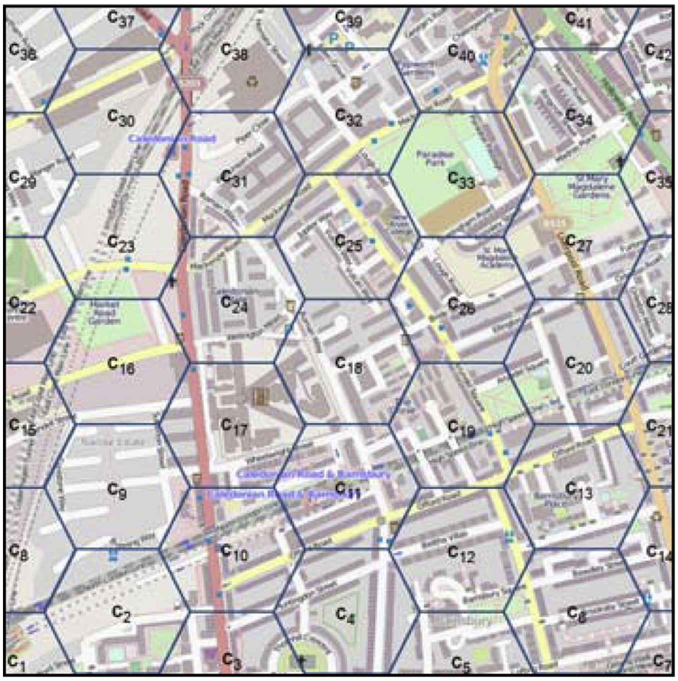

Fig. 1. The considered scenario, consisting of a mobility geographical region, covered by a certain number of service cells.

Time – CDT) for a mobile communication system, as well as the Hand-over Directional Probability matrix (HDP). We show how to build these structures and describe how they can be used in mobile systems to enhance the overall performance in terms of Quality of Service (QoS). Different additional features can be added to infrastructure wireless systems: mobility prediction (for in-advance reserving of future resources), bandwidth multiplexing (for increasing the number of admitted users, which can benefit from an enhanced transmission quality), enhanced coverage range and Signal-to-Noise Ratio (SNR, by detecting the most crowded places during the different moments of the day), discovering time-of-day periodicity and strong location preference, etc. The considered scenario, in this paper, regards a cellular infrastructure network, as illustrated in Fig. 1. As can be seen, a particular geographical region (a part of London city in Fig. 1) can be fully covered by the infrastructure network, which consists of a certain number of coverage cells (Access Points, Base Stations, LTE microcells, etc.), connected to a backbone, from which the service can be distributed. Each cell has a limited amount of resources (typically radio channels) which are used to satisfy mobile host requests.

In brief, the amount of “mobility regularity” extracted from real traces provides the opportunity to observe high predictability of the patterns [4]. Nowadays, the interest for these features is migrating also to new research fields, such as opportunistic networks [5]: many research activities have focused on inter-contact and contact durations, obtaining different trends for their probability density functions (power-law, exponential, etc.). In addition, in opportunistic ad-hoc networking it is important to understand the opportunities for user devices to interact when users pass close to each other. In general, mobility brings an excellent level of comfort to Mobile Hosts (MHs) but, at the same time, it could introduce serious service degradations if coverage cells are not planned adequately. One of the main issues for Mobile Cellular Networks (MCNs) is represented by the consequence of hand-overs: once an MH leaves a coverage area, bandwidth resources are not available “for sure” in the new cell, because it is dependent on the congestion level of the new location. When a user pays for the perceived service, it is not admissible to have call dropping events, as well as a low level of QoS, in terms of throughput, end-to-end delay and jitter. A detailed analysis of mobility traces can bring sufficient knowledge for predicting future movements and user habits to the system, even if with a certain error probability. The main aim of this work is to show a possible way of considering the content of mobility traces in order to extract some knowledge about user habits. In addition, through the deployment of such information, different additional features can be added to infrastructure wireless systems, such as:

- mobility prediction (for in-advance reserving of future resources);
- bandwidth multiplexing (for increasing the number of admitted users, which can benefit from an enhanced transmission quality);
- enhanced coverage range and Signal-to-Noise Ratio (SNR, by detecting the most crowded places during the different moments of the day);
- discovering time-of-day periodicity and strong location preference.