Physical Communication 18 (2016) 85–94

Contents lists available at ScienceDirect

Physical Communication

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

Full length article

What will interference be like in 5G HetNets?

Janne Riihijärvi *, Petri Mähönen, Marina Petrova

Institute for Networked Systems, RWTH Aachen University, Germany

ARTICLE INFO

Article history:
Received 30 September 2015
Accepted 9 October 2015
Available online 23 October 2015

Keywords:
5G
Heterogeneous networks
Interference modeling and analysis
Point processes
Spatial statistics

ABSTRACT

In this paper we discuss challenges in interference modeling for performance analysis of future wireless networks. We show through detailed numerical and simulation case studies as well as through measurements that many of the commonly used models result in potentially highly inaccurate predictions of interference and performance. In particular, we identify *correlations in node locations*, *three-dimensional structure of future network deployments*, and *complexity of in-building and inter-building radio propagation* as key domains where further research is needed. We also discuss in detail potential approaches to be taken as starting points for new research in these domains.

1. Introduction

Interference plays a critical role in the performance of dense wireless networks. Thus understanding the behavior of interference in future 5G heterogeneous networks (HetNets for short) is very important for performance analysis as well as for effective system design especially regarding resource management [1–3]. Vast amount of work has been conducted towards detailed modeling of interference in macrocellular and currently deployed heterogeneous cellular networks both using simulations as well as analytical calculations [4–6]. These results have provided detailed estimates for the statistics of interference as well as desired signal powers under various simplifying assumptions, such as power-law propagation models and uniform spatial distributions of transmitters and receivers. However, the very approximations used to enable these estimates and the calculations involved should be evaluated critically in the context of future 5G HetNets before these results can be applied there.

In this paper we argue that major changes in the system models used for interference and SINR statistic estimation are needed in the context of future wireless networks. In particular, we argue that the currently almost universally used assumptions such as independence of base station and client locations are perhaps valid for macrocellular systems and large-scale wireless deployments well approximated as such, but can result in significant approximation errors when numerous user or operator deployed small cells are introduced. Further, we show through detailed simulations that the currently employed 2.5D homogeneous urban propagation models can yield highly optimistic estimates for the magnitude of interference future HetNet access points and base stations must be able to cope with. We also show through the use of measurement data from extensive indoor propagation measurements than commonly used models such as the multi-wall model can result in significant inaccuracies in path loss predictions, directly causing similarly large errors in predicted network performance.

The rest of this paper is structured as follows. In Section 2 we discuss in more detail the changes we expect the deployment of small cells to bring to the interference statistics experienced by a 'typical' user terminal. Sections 3–5 then present several case studies demonstrating these effects and studying them in detail. These examples vary from stylized semi-analytical computations through detailed propagation simulations using highly realistic

* Corresponding author. Tel.: +49 241 80 20921; fax: +49 241 80 620900.

E-mail address: jar@inets.rwth-aachen.de (J. Riihijärvi).

http://dx.doi.org/10.1016/j.phycom.2015.10.003
1874-4907/

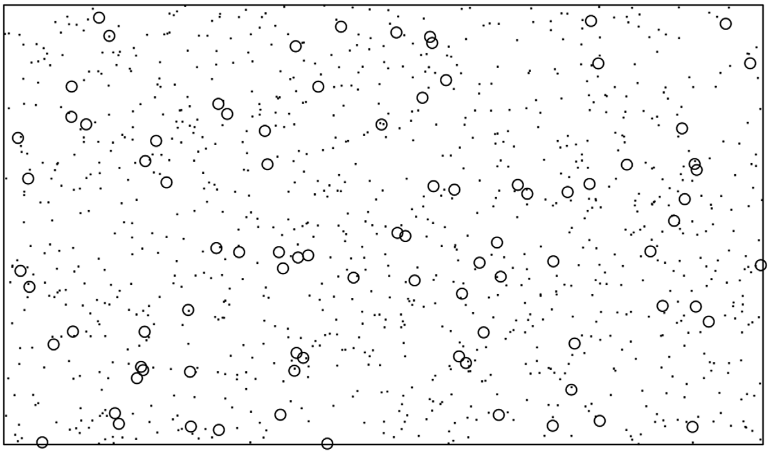

Fig. 1. Typical scenario used especially for macrocellular interference studies, with uniformly distributed transmitters (circles) and receivers (dots).

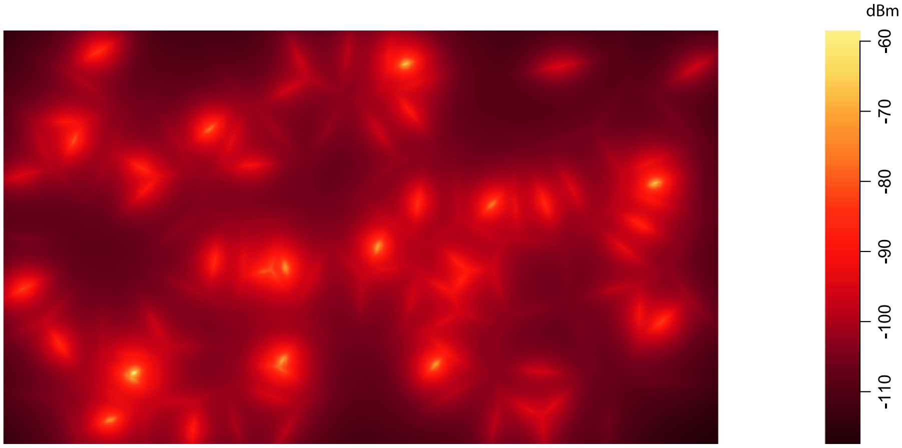

Fig. 2. Interference map for the scenario depicted in Fig. 1.

building models all the way to results from extensive measurement campaigns. In Section 6 we further discuss avenues for future research based on our case studies and experiences from our ongoing research work. Finally, we conclude the paper in Section 7.

2. What will change?

Fig. 1 illustrates the system model used explicitly or implicitly in vast majority of simulation and analytical studies of interference and SINR statistics. Base stations with one or more tiers are assumed to be uniformly randomly distributed over an area, and the studied clients are likewise assumed to be uniformly randomly distributed over the same chosen region. Transmit powers, antenna configurations, chosen transmit powers, scheduling decisions, and similar parameters are assumed to be equal or be governed by random processes that have the same distributions across the network, and the locations of clients and base stations are all assumed to be independent of each other. In such a setting elegant analytical results can be derived for numerous statistical aspects of interference as well as for SINR. Recent work has started to incorporate different base station location models in order to model planned networks (through the use of so-called 'regular' point process models [7,8]) or, in few cases, user-deployed networks modeled through the use of 'clustered' point process[1] models [11,12]. The rest of the system model are typically kept the same, in particular relating to the assumptions on the propagation environment. Assuming a simple association rule where client or the network chooses the base station with strongest received signal strength for each client, the resulting interference field can be visualized as an 'interference map' shown in Fig. 2. Structure of this map together with the statistics of the received signal strength from the serving base station are key to understanding the performance of the network for all interference limited wireless communication systems.

[1] A *point process* is a probabilistic description of locations often used to model base station and client locations in wireless network analysis, see [9] for a general introduction, and [10] for an exposition specifically in the wireless networking context.