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Analyzing Small-Cells and Distributed Antenna Systems from Techno-Economic Perspective

Christos Bouras, Computer Technology Institute and Press "Diophantus", Patras, Greece & Computer Engineering and Informatics Dept., University of Patras, Patras, Greece

Vasileios Kokkinos, University of Patras, Patras, Greece

Anastasia Kollia, University of Patras, Patras, Greece

Andreas Papazois, University of Patras, Patras, Greece

ABSTRACT

The new generations of mobile networks will require economical and viable solutions in order to meet the promises raised by scientists. In this article, the authors overview the available research activities and present an architecture for DAS and femtocells and a mathematical model analyzing their costs, as they are considered technologies, that offer great advantages for mobile networks. The authors present a wide research in the solutions' parameters and prices. There are thorough experiments including several different types of costs. In particular, Capital (CAPEX), Operational (OPEX) expenditures and Total Cost of Ownership (TCO) are examined for both technologies in terms of the backhauling technologies, of the size of buildings that they are implemented in and the years of investment from a telecommunication company. The main results are that femtocells are a more appealing solution when it comes to small places, while the alternative is more favorable for big infrastructures.

KEYWORDS

5G, DAS, Femtocells, Small-Cells, Techno-Economic Analysis, Ultra-Dense

1. INTRODUCTION

Next-generation of mobile technologies is expected to largely augment the system's peak data rates and cut down on the round-trip delays. The main idea of using ultra-density or DAS (Distributed Antenna Systems) based on their properties, is that they are able to increase efficiency and expand network capacity without the need for more spectrum resources by redistributing the existing ones, depict them as the key solutions for the future mobile networks. Small cells and DAS were launched mainly for addressing the issue of limited connectivity indoors.

There are several other important benefits of these technologies, which constitute them as bases for future generations of mobile networks, such as 5G (5G-PPP, 2014). Femtocells' benefit is that they provide ultra-density, which is expected to be one of the essential features of 5G. Ultra-dense networks coexist with the existing macrocellular ones forming altogether heterogeneous networks and fulfill the requirements and the network's future demands. Scientists and researchers have decided to move towards this direction by conducting research activity in the area (Networld2020 ETP, 2014; IWPC, 2014).

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The future mobile networks are going to demand a large network coverage. DAS would be an ideal solution to deal with the limited spectrum, because it provides repeaters, that are connected to the antenna system. It also serves the augmenting numbers of the smart devices, that in the future will be connected to the Internet or the smart home devices of the owner's home network as we move dynamically to the Internet of Things.

This paper studies the techno-economic aspects of ultra-dense and DAS deployments. It presents the characteristics and advantages for all their parts, as well as a techno-economic modeling of these deployment types. The defined models are used for the investigation of the upper technologies from an economic point of view. They provide an insight in the future financial and pricing aspects of these solutions and consist a useful tool for the definition of financing and pricing policies towards economically viable deployments. The authors define models for selecting the most appropriate network architectural solution for public buildings' indoor coverage. Cost, investment, materials, coverage and capacity are the parameters that are taken into account for the definition of their models. The main scientific contribution of this paper is that it includes multiple case-study examples of the techno-economic models as well as results of conducted experiments. It also analyzes and presents a techno-economic model and summarizes the main research activity in the particular field.

The remaining part of this paper is structured as follows: the second section refers to the related research that has been conducted so far. The third section presents the architectures of ultra-dense and DAS deployments used in the models. In the following section we describe cost models for ultra-dense and DAS deployments. In the next section we define the parameterization of the cost models. In the sixth section we conduce some experimental scenarios and analyze the corresponding results. Finally, in the seventh section we conclude our paper with the most fundamental conclusions realized in the experimental procedure and in the final section we list some ideas for future research work in the field of mobile network technologies.

2. RELATED WORK

In this section, it is of major importance to present the most valuable studies that have been conducted in the field. The record of the most valuable past research activity is going to indicate the paths that future scientific research should follow describing mobile network deployments.

In literature, the DAS system's most valuable studies are (Liu, 2013; Liu et al., 2012), that examine technological and economic aspects of the technology and compare the Total Cost of Ownership (TCO) between DAS and femtocells, leading to the fact that femtocell deployments are cheaper than the DAS ones. There are not any other vital studies in the field of DAS deployments, so it is important to point out the need of investigating it.

There exists substantial activity in the field of small cells. Scientists have already studied the technological aspects, such as cognitive radio, self-organized networks, and radio resource management leading to a significant technological background. Literature review is indicating that techno-economic aspects of small cells have not been fully researched, although there are fundamental works that have been published so far, like (Shetty et al., 2009) that refers to the economic advantages that stem from the combination of the macrocells and the femtocells for the operator and (Claussen et al., 2007) that adequately investigates the cost of the network for the predecessor of femtocell, the picocell. Scientists, but mostly the telecommunication and network operators are interested in the techno-economic aspects. Similar works like the one described in (Nikolikj et al., 2014) examine several deployment strategies from a cost perspective.

The authors of this paper have also presented an introduction to the present work in (Bouras et al., 2014), where they analyze models for financing and pricing small cell and macrocell service and compare which case is the most favorable from the perspectives of users and operators. (Markendahl et al., 2010) compares the two main technologies macrocells and femtocells conducting important conclusions for the costs whether or not a new base station is formed. According to this research, if