Mobile Network Offloading: Deployment and Energy Aspects

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ABSTRACT

The mobile data traffic growth and the high fraction of indoor-generated traffic push mobile operators to devise new deployment strategies such as mobile network offloading. The purpose of this paper is to evaluate the energy consumption and the deployment cost, based on the demanded traffic level, for a joint macro-femtocell network which enables mobile network offloading in Helsinki Metropolitan Area by 2015. This deployment is compared to an optimized only macro cellular network. The study tries to resolve under what conditions, in terms of demanded traffic, deployment cost and energy consumption, a mobile operator should deploy femtocells. Assuming that only the new network infrastructure is installed by 2015, the results show that wide-to-local area offloading is beneficial for a mobile operator to handle the mobile data traffic growth, reduce the deployment costs and the energy consumption of the radio access network.

Keywords: *Deployment Cost, Energy Consumption, Mobile Data Traffic, Offloading, Radio Access Networks*

INTRODUCTION

The usage of smart terminals and laptops as well as the proliferation of mobile applications create an enormous amount of data traffic in the mobile networks. Ericsson (2011) predicts that within the next five years (2011-2016), mobile data traffic will grow 10 times as the number of mobile broadband subscriptions increases from 900 Million to almost 5 Billion globally. In fact, people spend most of the time at home and office and the majority of smartphone usage takes place while people are indoors (Smura, 2008). Around 70-80% of the mobile data traffic is generated indoors (Chowdhury & Noll, 2010). However, the radio signals incur significant additional attenuation when they are transmitted from outdoor to indoor environment, due to the building penetration losses. The signal degradation results in poor quality of service in indoor places, and subsequently, macrocell needs to dedicate more radio resources for an indoor connection to compensate the degradation.

Mobile operators have to address the challenges for achieving sufficient coverage, capacity and quality targets under the aforementioned conditions. The traditional macrocell deployment strategy with the installation of more dense cellular sites might meet the requirements, however such deployment is not a cost and energy efficient solution (Katsigiannis & Hämmäinen, 2011). It requires large number of base stations which is accompanied by high investments and operating costs. The latter is further increased due to the power consumption of the radio access network which creates huge

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energy bills for mobile operators. Besides the economic impact, the increasing power consumption of radio access network has a strong environmental effect due to the growing carbon dioxide (C02) emissions (Fehske, Fettweis, Malmodin, & Biczók, 2011). Consequently, different deployment strategies have to be investigated by mobile operators (Webb, 2009).

Mobile network offloading as a deployment strategy, especially in densely populated areas such as metropolitan areas, might provide a good solution to mobile operators. Mobile network offloading, also referred to as mobile data offloading, is the use of complementary network technologies to deliver mobile data traffic originally planned for transmission over cellular networks (Han, Hui, Kumar, Marathe, Shao, & Srinivasan, 2011). This article focuses on local area networks as a complementary network technology, defining the so-called wide-to-local area offloading. The main technologies for wide-to-local area offloading are 3GPP femtocells and IEEE WiFi. Fuxjager, Fischer, Gojmerac, and Reichl (2010) provide a comparison of licensed-band femtocell versus unlicensed WiFi technologies. Other studies show that deploying multiple wireless networks including WiFi in metropolitan and city areas is an effective way of traffic offloading (Dimatteo, Hui, Han, & Li, 2011; Fuxjager, Gojmerac, Fischer, & Reichl 2011; Han, Hui, & Srinivasan, 2010; Lee, Rhee, Lee, Chong, & Yi, 2010; Yongmin, Hyun Wook, Jae-yoon, Hyun-chul, & Silvester, 2011).

This study examines only femtocells because the functionalities and wireless interface are identical to the cellular network. Femtocells are low-cost, low-power cellular base stations that are designed to provide high quality cellular service. They operate in licensed spectrum and utilize the user's existing broadband internet access as backhaul. The deployment of femtocells can reduce the number of indoor users that need to be served by the macro cellular network with high power links (Chandrasekhar, Andrews, & Gatherer, 2008; Di Zenobio, Celidonio, Pulcini, & Rufini, 2011). Claussen and Calin (2009) and Calin, Claussen, and Uzunalioglu (2010) investigate the macrocell offloading achievable benefits in joint macro-femtocell deployments using system level simulations. They define the macrocell offloading capacity gain as the equivalent number of outdoor users that can be supported by the macrocell network for each offloaded indoor user to femtocells. It is shown that the potential increase in the number of supported users per macrocell in joint macro-femtocell deployments depends on the macro cellular network configuration and can range from no gain for a system which is only interference limited to more than 30% in cases where noise is the limiting factor for indoor users at the macrocell edge. Wide-to-local area offloading could result in macrocell resource savings. By serving users at homes, offices and public places, through femtocells, might have a positive impact on cost. Less installation of wide area radio equipment is needed, causing capital (CAPEX) and operational expenditures (OPEX) reduction. The potential energy savings, because femtocells consume less power than macrocells, can reduce further the OPEX via the lower energy bills. Hence, cost reduction can create larger profit margin for the mobile operator. The co-existence of femtocells and macro cellular network would be beneficial not only for mobile operators but also for end-users. Firstly, the service pricing can be low and affordable to all end-users. Furthermore, the better coverage and capacity cause customer satisfaction which results in less churn rate. Mobile operators can offer new value-added services and applications to the end-users via femtocells which could increase the user's utility and eventually the average revenue per user (ARPU) for mobile operator. Consequently, through their right integration with the wide area radio access network, femtocells could improve the capabilities of the radio access network as well as its power consumption and increase quality of user experience. However, to motivate wireless usage through femtocells, developers and designers of this future wireless technology do not need to overwhelm end-users with technical details (Saluja, Mahatanankoon, & Gyires, 2010).

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