Adaptive and Resilient Solutions for Energy Savings of Mobile Access Networks

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ABSTRACT

Continuous development and evolution of mobile communications toward end user expectations has led to heterogeneous mobile networks in the most general sense of the word. The mixture of core network infrastructures and radio access technologies, due to the arrival of new technologies while older ones are still used and not fully exploited, brings mobile operators to a complex business environment. Such a situation threatens future profit margins since the cost of running mobile networks rises with greater pace than total profit. A significant share in the total costs of running a mobile network belongs to energy consumption. Decreasing energy costs by designing hardware with low-energy consumption characteristics and site collocation is already under way, but additional sparing could be achieved through soft solutions or adaptive networks. To reduce operational costs, the crucial role will be played by the self-organizing network paradigm, featured by network management systems and operations/business support systems. In this paper, the authors provide an overview of adaptive and resilient concepts appropriate for improving the energy efficiency of mobile access networks. More precisely, they present the most promising self-organizing network solutions in the radio access and backhaul part of mobile networks, the implementation of which can bring a synergetic effect in terms of significant energy savings.

Keywords: Base Station, Cellular, Energy Efficiency, Heterogeneous Network, Self-Organizing Networks, Wireless

INTRODUCTION

The development of mobile networks, across all phases and generations, is a race to fulfill end users’ expectations. Definitions of mobile network generations are preceding real implementations. Such definitions mostly rely on state of the art radio communications and strongly push further development. Today, the main development drivers are, on one side, mobile broadband services, and on the other
one, reducing operational (OPEX) expenditure and capital expenditure (CAPEX).

Users expect mobile broadband services to be comparable with those provided by fixed networks. With proliferation of mobile smart phones followed by mobile applications and services, conservative estimations predict that network traffic will grow 20 to 30 times over the next five years (Marshall, 2012). Improving existing networks by introducing advanced technology such as long-term evolution (LTE) and utilization of new spectrum resources, however, will not be enough (Marshall, 2012; Landstrom, 2011). A promising expansion strategy is to create a heterogeneous network consisting of low-power nodes to complement the macro mobile network layer. Generally, this means complex mobile networks with different Radio Access Technologies (RAT), including Wireless Local Area Networks (WLANs) and a mixture of macro cells with micro, pico and femto cells.

Growing demand for data services does not necessarily translate to an increase in profits due to commoditization, operating complexity, and operational/capital investment. Therefore, the cost of running these mobile networks becomes a very important issue. Further development and evolution toward high-quality services, as well as public availability, could be jeopardized by the overall expenditure of running these communications networks.

With rising energy prices, base stations (BSs) are the most significant energy consumers in the wide area cellular networks and contribute up to 50 percent of the total operational expenditure (OPEX) of an operator (Correia, 2010). This is because the off-grid BSs in remote areas generally use diesel powered generators, which can cost ten times more in comparison with BSs connected to the electrical grid—they are also estimated to have an average yearly OPEX equal to $3,000 (Hasan, 2011). Hence, improving the energy efficiency of wide area wireless networks turns out to be an important economic issue since reducing energy consumption translates into the lowering of an operator’s OPEX.

With such an “all heterogeneous approach” and foreseen dynamic optimization, the overall complexity of mobile telecommunications is growing. Complexity in the information technology (IT) industry was recognized as the main challenge by IBM research at the turn of the century. As a solution, they came up with autonomic computing: a computing system that can manage itself according to high-level policies defined by administrators. Self-management with its four self-x aspects, namely self-configuration, self-optimization, self-healing and self-protection, is the essence of autonomic computing systems (Horn, 2001; Kephart, 2003). The name, idea and principles behind autonomic computing are borrowed from the human autonomic nervous system.

The communications industry or newly integrated information and communications technology (ICT) industry are experiencing the same complexity problems, but on a bigger scale. These issues are similar to autonomic computing, but are more focused on the foundational rethinking of communication and networking in autonomic communications research. While autonomic computing is directly oriented towards application software and the management of computing resources, autonomic communication is focused on distributed systems and the management of network elements. Both research areas recognize the need for decentralized algorithms and control, context-awareness, and self-x properties (configuration, monitoring, adaptation, and healing) (Dobson, 2006).

Envisioned paramount tools for reducing complexity and growing operational costs of mobile communication networks are self-organizing networks (SONs). The main concept of SONs is that the network should self-organize and manage its elements in order to achieve optimal network quality and performance. The SON is defined around broadly agreed cases grouped into functional domains (NGMN, 2008). Such functional domains cover all aspects of network operations, but more specifically include: self-planning, self-configuration, self-optimization and self-healing (NGMN,
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