A Green Small Cells Deployment in 5G - Switch ON/OFF via IoT Networks & Energy Efficient Mesh Backhauling

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***Abstract*—**
The densification of the network based on a large scale deployment of small cells represents a promising solution that meets the requirements of the 5th generation wireless systems (*5G*) in terms of network capacity and throughput. This densification via small cells with different sizes in addition to macro base stations constitute an heterogeneous network (HetNet) with a high level of performance and service quality. However, it introduces several important technical challenges. On one hand, even if the small cells are low power consumption base stations, a large scale deployment of them increases the energy consumption of the radio access network. On the other hand, this large deployment creates new challenges related to the insuring of a reliable and flexible backhaul links for all the small cell base stations.

In this paper, we address the topic of the deployment of small cells in the future radio access network 5G. We propose our new and original switch ON/OFF mechanism for small cells base stations based on Low Power Wide Area Networks (*LPWAN*). Our proposal aims to completely shutdown the small cells in heterogeneous networks during low traffic periods. We carry out the wake-up process using a connected Internet of Things (*IoT*) object based on a Long Range (*LoRa*) system dedicated for Internet of Things applications. Furthermore, we present our proposal of providing an energy efficient backhaul for the small cell based on the deployment of Mesh routers. These routers are based on our original mechanism that we called *start and stop* which also allows a reducing of the energy consumed requested to insure the backhauling.

Keywords - Switch ON/OFF, Small cells, HetNets, 5G, LoRa, Open Air Interface, Mesh routers, Energy Efficiency, Backhaul

INTRODUCTION

Setting Small Cells (*SC*) into a standby mode during low traffic periods is one of the mostly used technique in the literature that aim to reduce their energy consumption. In order to insure the functionality of this standby mode and thus be able to receive & execute the wake-up messages during peak traffic periods, some reception interfaces in the *SC* should still be in an active state. By consequence, the *SC* continues to consume a quantity of energy even within this standby mode. This quantity represents a significant percentage of the total amount of the energy consumed by the *SC* during a day. According to [1], a Femto base station[1], consumes between 8 and 9 Watts when it is activated (mode ON), while it consumes around 3 Watts in standby mode (Sleep mode). In other words, the Femto base station continues to consume around 35% of the amount of energy that it consumes when it is activated.

Another way to greatly reduce the energy consumption of small cells is to completely shut it down during low traffic periods [2]. From a technical point of view, it is possible to completely shutdown today's *SC* (by sending a system shutdown message), but the question is rather: How to wake-up the *SC* once it's completely shutdown? In fact, to carry out a complete shutdown of the *SC*, all the components should be turned *OFF* and no *Rx* (reception interface) will be able to receive and execute the message to wake-up the small cell base station.

One more way that helps to reduce significantly the energy consumption of small cells deployment is to switch OFF not only of the *SC*, but also its backhaul. To do so, it is necessary to provide self-organization and flexible backhaul links.

OUR PROPOSAL

The coexistence of the "traditional" wireless cellular networks (2G, 3G and 4G) and the new networks dedicated to *IoT* applications such as *LoRa* (Long Range)[2] and *Sigfox*[3], led us to think about the possible interaction between them. From where our idea to carry out a switch ON/OFF for small cells based on a Low-Power Wide-Area Network in order to be able to completely shutdown the *SC*, and thus reduces at maximum its energy consumption. The choice of using *IoT* networks is motivated by their low power consumption, ease of deployment and low cost. *LPWAN* are dedicated for *IoT* applications and with the explosion of *IoT* systems deployment, they will be widely deployed. Hence, it will be possible to use

[1]A femto base station (also called an Access Point Base Station, femtocell, femto base station) is an in-home small cell base station
[2]https://www.lora-alliance.org/
[3]http://www.sigfox.com/

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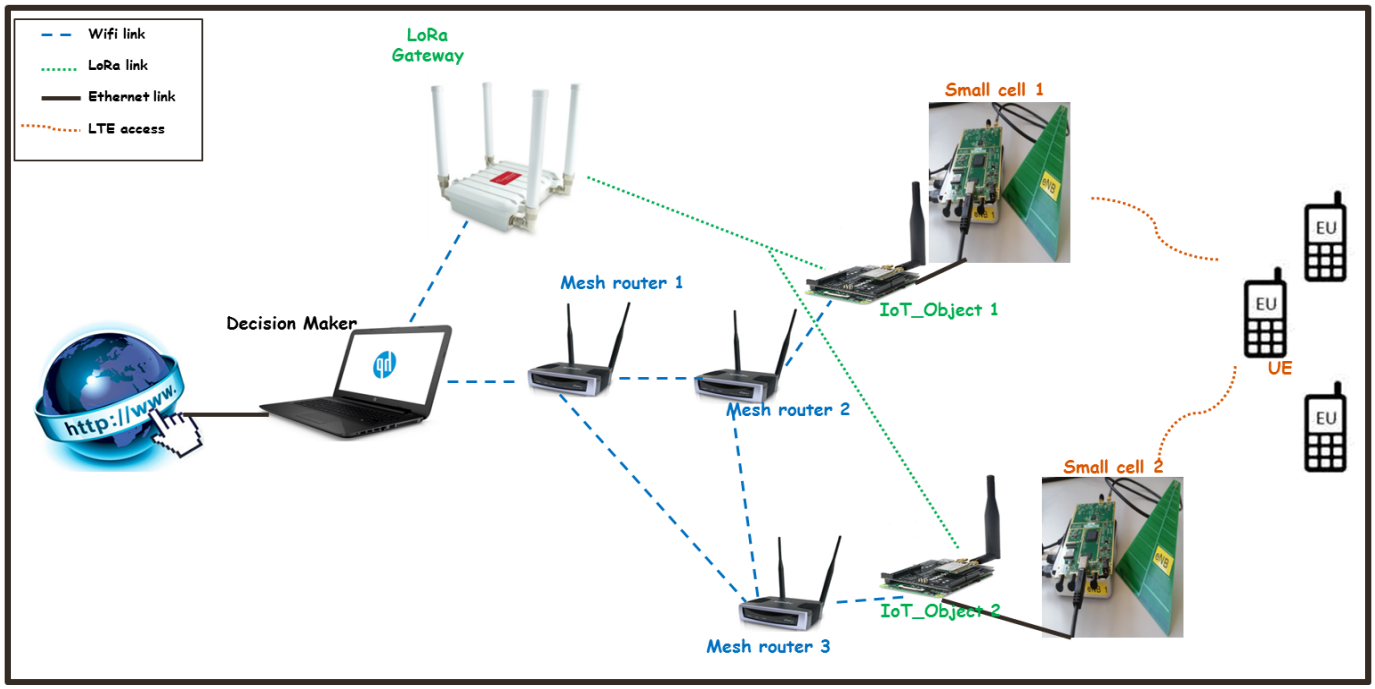

Fig. 1: Demo description

them to insure our mechanism of small cells switch ON/OFF without additional cost. Fig .1 illustrates the architecture of our proposal.

Our idea is to associate a connected object (*IoT Object* in Fig. 1) to each small cell base station (small cell 1 and small cell 2 in Fig. 1) via an *Ethernet* cable. This object will serve to receive the wake-up message sent through the *IoT* gateway (LorRa Gateway in Fig. 1) when the *SC* is completely shutdown. Then, the *IoT Object* will wake-up the *SC* by sending to it a Magic Packet in order to carry out a Wake-On-Lan[4]. Furthermore, in our proposal we provide a flexible and energy efficient small cells backhauling via our green mesh routers. This allows also a reducing of the energy consumption based on our original mechanism of switch ON/OFF (*Start and Stop*) [3].

In order to carry out our demo, we used *LoRa* technology as a *LPWAN* with a *Meshlium Libelium LoRa* gateway [5] for the *IoT* gateway, and a *Raspberry Pi* with a *Cooking hack* and a *LoRa* antenna [6] to realize the *IoT Object*. In order to implement the small cell base station, we used a *Mini PC Intel* with the *Open Air Interface* software [7] and a *B200* card as shown in Fig. 1. We implemented the core network using *Nokia Bell Labs* software *ePC* and *Centreon* open source software[8]. Furthermore, we developed an application that we called (*Decision Maker*) which takes the decision to switch ON/OFF the small cells according to the traffic load and the requests send by the users. For the small cells backhauling, we used our energy efficient Mesh routers called *Green-box*[9].

In the scenario of our demo, we show : (i) how we completely shutdown the small cell during low traffic period, (ii) our mechanism to wake-up the *SC* via *LoRa* and the time requested to carry out this process, (iii) how to shutdown the backhaul link, (iv) the performance of our mesh routers with our *Start and Stop* mechanism, and (v) the gain in terms of energy consumption.

Conclusions and Future Works

In this paper, we propose a new and original mechanism to switch ON/OFF small cell base stations based on Low Power Wide Area Networks. Our proposal can be implemented without a lot of modification for the existing small cell base station. This allows a significant reduction of small cells energy consumption. Furthermore, thanks to our mesh routers, it is possible to provide a flexible and energy efficiency backhauling for the small cells. In our future works, we aim to carry out a trial for our proposal in order to study the performance of our solution with large number of small cells.

References

[1] M. Ali Imran et al. "energy efficiency analysis of the reference systems, areas of improvements and target breakdown". In *INFSO-ICT-247733 EARTH Deliverable D2.3, January 2012*.

[2] I. Allal et al. "a new sustainable mechanism to wake-up base stations in mobile networks". In *The Global Information Infrastructure and Networking Symposium (GIIS), 19-21 Oct. 2016, Porto, Portugal*, 2016.

[3] K. Al Agha. "method for extending routers in a communications network and router implementing this method", January 3 2013. WO Patent App. PCT/EP2012/062,550.

[4] Wake-On-LAN (WOL) : is hardware and software technology that wake-up stopped systems by sending specially coded network packets, called Magic packets, to machines equipped and enabled to respond to the packets

[5] http://www.libelium.com/development/meshlium

[6] https://www.cooking-hacks.com/documentation/tutorials/extreme-range-lora-sx1272-module-shield-arduino-raspberry-pi-intel-galileo/

[7] http://www.openairinterface.org/

[8] https://documentation.centreon.com/

[9] http://www.green-communications.fr/