Demonstrating On-Demand Cell Switching with a Two-Layer Mobile Network Testbed

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Abstract—Traditional cellular networks are forced to remain active regardless of the actual amount of traffic that is currently produced/requested, with a clear waste of energy. Two-layer mobile networks with separated signalling and data layers have been recently proposed for energy savings in future implementations. These networks are able to switch off unneeded data cells completely while maintaining full coverage with their signalling cells, thus saving energy. In this demonstration, we showcase a testbed that uses Wi-Fi access points to emulate small cells of the data layer and a publicly available cellular connection as the signalling layer. The testbed is used to demonstrate the general feasibility of this layered architecture and to facilitate experiments with network-wide resource optimization.

I. INTRODUCTION

The amount of mobile traffic that is delivered per month is predicted to exceed 15 exabytes in 2018 [1]. To handle this without a high increase in energy consumption, new mobile network architectures are needed.

Traditional mobile network architectures are founded on the concept of cellular layout, which provides full coverage in the service area anywhere, at any time, using a set of base stations. To ensure this continuous network accessibility, operators are forced to maintain most of the network active regardless of how many users are present and how much traffic they generate, wasting a lot of energy. Trivially, base stations cannot be switched off without causing connectivity issues to users that need to exchange data with the network.

To overcome this issue, a recently proposed heterogeneous architecture [2], [3], [4] tries to improve the energy efficiency of mobile networks by separating them into a signalling and data layer realized by macro cells and small cells, respectively. Such an approach has a twofold positive effect on the energy efficiency of the overall system: first, the use of small cells reduces the energy consumption required for data communication, due to the smaller distance towards the user terminals. Second, the separation of signalling and data functions allows to completely turn off data cells when needed with no impact on users’ connectivity. Clearly, such architecture requires the availability of context information (e.g., location and data requirements of users), which can be used to perform network-wide energy optimizations.

Fig. 1 shows this architecture and how active users can be connected to both layers at the same time. A resource management component which has a global view of the network and receives extended information about user devices via the signaling overlay optimizes the power management and decides which devices are assigned to the data layer. The global view on the network allows management strategies which minimize the total number of active small cells. This goes beyond classical energy saving techniques, like micro sleep modes, which operate on single base stations [2].

In this demonstration, we present a testbed that emulates such a layered network approach with a central management entity. The testbed can be used to (i) show the general feasibility of a layered network architecture with on-demand cell activation and (ii) evaluate different management strategies that decide which small cells should be activated and how to assign users to them.

II. SETUP

With reference to Fig. 2, the demonstrator is composed of the following components:

- **Signalling Layer**: we leverage the publicly available cellular connection (EDGE, 3G, or LTE) as a full-coverage signalling layer, totally decoupled from the data layer. The signalling layer is used to deliver context information (users location and traffic requirements) to the management software. User location is provided to the signalling layer through an ad-hoc indoor localization system based on low-power sensor nodes.

- **Data Layer**: we use a set of Wi-Fi access points to emulate the small cells data layer. The access points are based on Raspberry Pi hardware combined with a standard 802.11g Wi-Fi USB dongle running the latest version of hostapd. All access points are directly connected to the management backend through Ethernet connections.
The demonstration can be easily set up in an indoor space and does not have particular requirements except for:

- Good cellular coverage (3G, UMTS or LTE) in the area of the demo for emulating the signalling layer.

### III. Requirements

The demonstration can be easily set up in an indoor space and does not have particular requirements except for:

- Internet connection needed to connect the signalling layer to the backend controller. This connection can be a Wi-Fi connection (although an Ethernet cable would be preferred) and must allow outgoing traffic on at least one TCP port to setup an SSH tunnel for receiving signalling information from the cellular network.
- An external monitor for showing the Graphical User Interface (e.g., 23” LCD or similar).

The computer running the backend software and the access points composing the data network have standard power requirements. The set up time is about 2 hours.

### IV. Conclusions

The proposed testbed provides the minimal necessary environment to emulate a two-layer mobile network with separated signalling and data layer. From the perspective of the resource manager, status updates are received over a signalling layer (cellular connection) while data small cells (Wi-Fi access points) are available and can be activated on-demand for fast data transmissions. This testbed provides a cheap and flexible environment for further studies of two-layer mobile network management without the need to deploy specialized hardware, like LTE femto cells.

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### REFERENCES


