3G 셀룰러 네트워크에서의 성능 평가를 위한 펨토셀 기반 테스트베드 설계

*정하경, *임영빈, *이지훈, *박철현, **권태경, **최양희

서울대학교

*{hkjung, ybim, jhlee, chpark}mmlab.snu.ac.kr, **{tkkwon, yhchoi}@snu.ac.kr

A Femtocell-based Testbed Design for Evaluating 3G Cellular Networks

Hakyung Jung, Youngbin Im, Ji Hoon Lee, Chulhyun Park, Ted "Taekyoung" Kwon, Yanghee Choi

Seoul National Univ.

요 약

While the demand for the performance evaluation of proposals using real hardware is ever increasing, the lineup of wireless testbeds focuses on IEEE 802.11-based WLAN, and lacks cellular communication environments despite of their popularity. We argue that research community needs a wireless testbed targeted on cellular technologies. To this end, this paper proposes a novel wireless testbed, dubbed Cell-Lab, which is developed to evaluate a wide spectrum of proposals in cellular environments. Cell-Lab resolves a cost problem, which is a decisive barrier to the deployment of cellular network testbed, by adopting a low-cost femtocell base station instead of conventional one. To support both virtualization and programmability as basic features, we integrate all the cellular network entities into a femtocell base station, and introduce a separate controller that performs virtualization and controls a femtocell base station. By means of Cell-Lab, researchers will be able to experiment their proposals under realistic cellular network conditions.

Ⅰ. INTRODUCTION

A recent trend in the networking research area is the increasing demand on the performance evaluation of proposals by real prototypes or testbeds. That is, we need to run proposals on network testbeds for realistic evaluation. There have been proposed numerous network testbeds that are operating to facilitate the evaluation [1-3].

We notice that an important piece is missing in the lineup of research testbeds for wireless networks, which are cellular communication environments. Today, the major wireless data networks are IEEE 802.11 based WLANs and the cellular networks (e.g., 3G or WiMAX), which have significantly different characteristics at the physical and MAC layer because of their inherent design principles. However, to the best of our knowledge, all the current wireless testbeds are based on IEEE 802.11 radio networks.

The overwhelming popularity of 802.11-based testbeds comes from two reasons: (i) wireless LAN devices are flat and relatively inexpensive, and (ii) open source device drivers are available that help run diverse experiments. A cellular network, on the other hand, is hierarchically comprised of a number of equipments that perform different functions, most of which are expensive and often proprietary.

To this end, we propose a new cellular network testbed, dubbed Cell-Lab, which is developed to evaluate a wide spectrum of proposals in cellular radio networking environments. To resolve the cost problem, Cell-Lab adopts the user-deployable femtocell base stations instead of conventional larger scale (e.g. microcells or macrocells) base stations in commercial cellular networks.

Ⅱ. TESTBED DESIGN

We describe the overall architecture of Cell-Lab and its design principles.

First, our goal is to build multiple virtual cellular networks over a real UMTS cellular network, so that multiple researchers

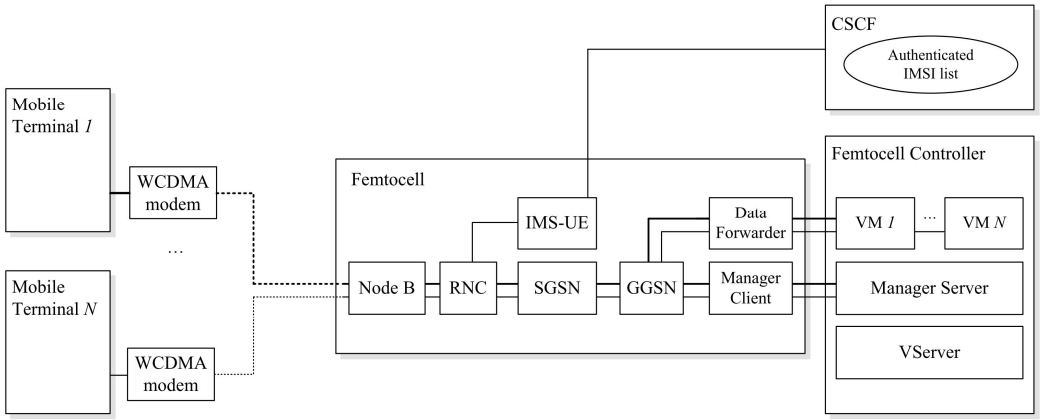

Fig. 1. Overall testbed architecture

can run their own experiments. Many components in the cellular network infrastructure (such as the Node B, the RNC, the SGSN, and the GGSN) becomes an obstacle to construct a cellular network testbed at a low cost. Moreover, it makes the network virtualization harder since every component may have to be virtualized separately, which should be avoided. To overcome this hurdle, it is advantageous to collapse all of the functionalities in the UMTS infrastructure into a single device. To this end, we first modify a femtocell device to accommodate all the functional entities in the UMTS network, except for the mobile terminal. Then, we simply virtualize the femtocell device. This allows to provide researchers with multiple virtual UMTS networks from a single miniaturized physical UMTS network.

Second, our testbed should provide programmability that enables researchers to program and evaluate a new proposal. For this purpose, the testbed should be a high end system to run multiple simultaneous experiments. Moreover, in general, running a virtualization software itself requires a lot of CPU and memory resources. If we make a single device that performs all the functionalities of a UMTS network and also carries out virtualization functionalities, it may be infeasible or at least require an extremely high end device. Therefore, we propose to use two separate devices: one for the UMTS networking functionalities and the other for the virtualization functionalities. The former is the femtocell and the latter is names as a femtocell controller. As a result, the femtocell controller can provide each mobile terminal with a virtual cellular network through the femtocell which prototypes a cellular network in reality.

Finally, we design Cell-Lab as shown in Fig. 1. Both mobile terminals and the femtocell controller serve as primary platforms on which researchers can run their proposals. Mobile terminals are labtop computers with Linux, and the femtocell controller is a Linux-based high end server. Researchers can access these two devices and execute their new protocols or applications. Since we have equipped our testbed with multiple mobile terminals, the mobile terminal need not be virtualized normally; each mobile terminal can be dedicated to a single experiment. We attach a WCDMA modem to a mobile terminal with a USB interface, and the Ethernet is used between the femtocell and femtocell controller.

Ⅲ. CONCLUDING REMARK

In this paper, we point out that network community needs a cellular network testbed. To fill this gap, we introduce a new cellular network testbed using a femtocell, which is not only a real hardware in the field but also a low cost material for a testbed. Especially, Cell-Lab provides programmability and supports virtualization. We expect that it can be used to evaluate a wide spectrum of proposals in cellular radio networking environment.

REFERENCES

[1] Raychaudhuri, D., Seskar, I., Ott, M., Ganu, S., Ramachandran, K., Kremo, H., Siracusa, R., Liu, H., Singh, M., "Overview of the orbit radio grid testbed for evaluation of next-generation wireless network protocols", in Proceedings of IEEE WCNC 2005

[2] Bicket, J., Aguayo, D., Biswas, S., Morris, R., "Architecture and evaluation of an unplanned 802.11b mesh network.", in Proceedings of ACM MobiCom 2005,

[3] M. Kropff, T. Krop, M .Hollick, P.S. Mogre, R. Steinmetz, "A survey on real world and emulation testbeds for mobile ad hoc networks", in Proceedings of TRIDENTCOM 2006.