

Demo Abstract: Practical Cross-technology Radio Resource Management between LTE-U and WiFi

Piotr Gawłowicz and Anatolij Zubow
 {gawlowicz, zubow}@tkn.tu-berlin.de
 Technische Universität Berlin, Germany

Abstract—For efficient usage of the unlicensed spectrum being shared by heterogeneous wireless technologies like LTE unlicensed and IEEE 802.11 (WiFi), a cross-technology communication (CTC) is needed. We present LtFi, a system that enables set-up such a CTC channel between co-located LTE-U and WiFi networks for the purpose of cross-technology collaboration.

We demonstrate a running prototype of LtFi implemented using USRP SDR platform running srsLTE and commodity WiFi hardware. During the demo, we show how to set-up the LtFi CTC channel and use it to transmit data from LTE-U BS to WiFi nodes. We display all the relevant performance metrics in real-time. In the second part, we showcase a simple RRM scheme, where neighboring WiFi BSS and LTE-U cells periodically negotiate the fair usage of the available air-time on the shared unlicensed channel. Specifically, depending on the actual traffic load in both networks the LTE-U's duty cycle is adapted in real-time.

Index terms— Cross-technology communication, LTE-U, WiFi, coexistence, radio resource management

I. INTRODUCTION

Meeting the expected rapid growth of wireless traffic is a key challenge for mobile network operators. Fortunately, a significant fraction of the mobile traffic is already being offloaded to IEEE 802.11 (WiFi) networks. However, recently, LTE operators have started to explore the possibility, known as *unlicensed LTE*, to use the unlicensed spectrum directly by performing carrier aggregation at the modem-level.

However, the proliferation of a particular technology like LTE-U [1] together with the predicted exponential growth in the usage of WiFi is expected to result in severe mutual interference and hence performance degradation [2], [3] unless coexistence is considered seriously. Although LTE-U and WiFi technologies have similar physical layers they are unable to decode each other's packets and have to rely on simple but inefficient uncoordinated co-existence schemes. Efficient coordination assuring better performance requires, however, enabling direct cross-technology communication (CTC) between those heterogeneous systems.

Recently we presented LtFi [4] a system which enables to set-up a CTC between co-located LTE-U and WiFi networks. Such communication channel can be used for realization of efficient radio resource management (RRM) schemes (e.g. negotiation of channel assignment, adaptation of LTE-U's duty cycle or even cross-technology TDMA [5]) between the interfering wireless nodes.

In this paper, we demonstrate a running prototype of LtFi. Moreover, we showcase a simple RRM scheme, where a

neighboring WiFi BSS and LTE-U cell periodically negotiate usage of the air-time of the shared unlicensed channel taking into account their actual load in both networks.

II. LtFi IN A NUTSHELL

The architecture of LtFi [4] and its integration into LTE network architecture is shown in Fig. 1. LtFi consists of two parts, namely the LtFi-Air-Interface and the LtFi-X2a/b-Interfaces. The first is used for over-the-air broadcast transmission of configuration parameters (i.e. IP address) from LTE-U BSs to co-located WiFi APs which decode this information by utilizing their existing sensing capabilities. This configuration data is needed to set-up the over-the-wire bi-directional control channel between WiFi nodes and the corresponding LtFi Management Unit (LtFiMU) over the Internet. The LtFiMU being deployed in the LTE network controls all the BSs and is responsible for the configuration of LtFi and the execution of actual RRM applications.

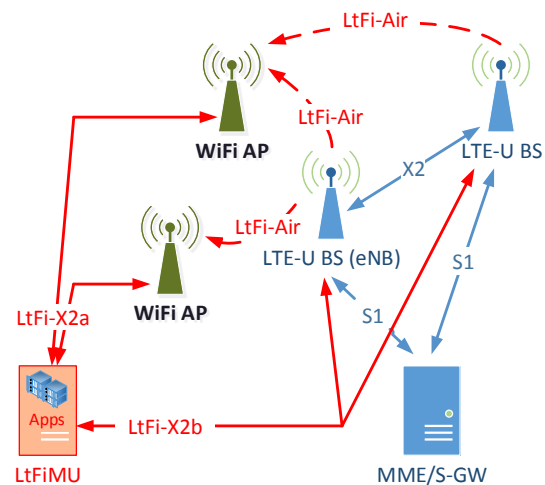


Fig. 1. Architecture of LtFi and its integration into an LTE network.

LtFi is of low complexity and fully compliant with LTE-U technology. On WiFi side, it works with commodity hardware by utilizing the possibility to monitor the signal detection logic of modern WiFi NICs (e.g. Atheros 802.11n/ac). It can be easily integrated into LTE and WiFi stacks as it is only a software add-on. A detailed description of LtFi can be found in this year INFOCOM paper [4].

III. DEMONSTRATOR DESCRIPTION

The demo setup consists of an LTE-U network, i.e. eNB (BS) with associated UE, and a WiFi Basic Service Set, i.e. AP with associated STA, both operating on the same RF channel in the unlicensed 5 GHz band (Fig. 2).

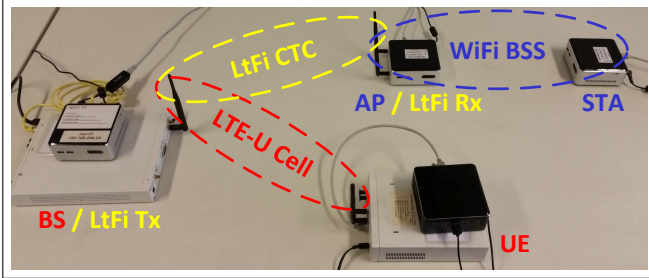


Fig. 2. Demonstrator setup consisting of an LTE-U and a WiFi network.

In the *first part* of our demo, we will demonstrate the uncoordinated coexistence of LTE-U and WiFi. For this purpose the LTE-U BS transmits downlink data to the UE with a fixed CSAT duty cycle of 25%, cycle duration of 40 ms and without additional puncturing, while the WiFi AP sends backlogged TCP/IP traffic towards its STA using the *iperf* application. During that step of the demo, we will change the LTE-U parameters to show how it impacts the WiFi throughput and packet error rate performance. To verify that, in parallel, we will display in real-time the throughput in both networks.

In the *second part* we demonstrate the feasibility of LtFi to set-up a CTC communication channel between the two networks. Moreover, we show that LtFi does not degrade the performance of the LTE-U network. For this purpose, in addition to the DL data traffic, we program the LTE-U BS (eNB) to transmit messages over the LtFi CTC channel. Again, we display the aforementioned performance metrics as well as frame and symbol error rate statistics of the LtFi air-interface in real-time. The entire setup will be controlled using the interactive web-based GUI (Fig. 3). Here we can vary the RF gain of the LTE-U BS (USRP), what allows us to emulate different distance between eNB and AP. While the higher path-loss causes higher BER on the CTC channel, we can counteract it by raising the sensitivity level of LtFi receiver at the WiFi AP, i.e. lowering energy detection threshold.

In the *third part* of our demo, we present a simple cross-technology collaboration scheme between the LTE-U cell and WiFi BSS with the goal to negotiate the fair share of radio resources (i.e. air-time) to be used by both networks. Therefore, we program the LTE-U BS to broadcast IP address of LtFiMU over the LtFi-Air-Interface, which is used by the WiFi Access Point Management Unit (APMU) to establish the bidirectional LtFi-X2-Interface. Then, we start the LTE-U CSAT adaptation application in the LtFiMU which consists of two parts. First, it gets periodic information from the APMU about the network load and the number of active STAs (the value is forged using random numbers, as we only use a single STA) in its cell. Second, based on the load and number

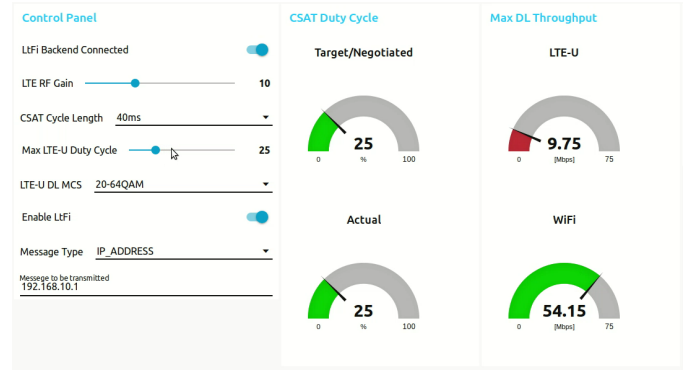


Fig. 3. Web-based control panel GUI.

of active clients observed in both networks, the fair air-time share is computed and the LTE-U duty cycle in the BS is adapted. The objective is to achieve the per-client fairness in the usage of the wireless resources. The individual steps of the collaboration procedure are shown in Fig. 4. The audience can observe in real-time how the allocation of air-time between LTE-U and WiFi changes and verify those values with the throughput values achieved in both networks.

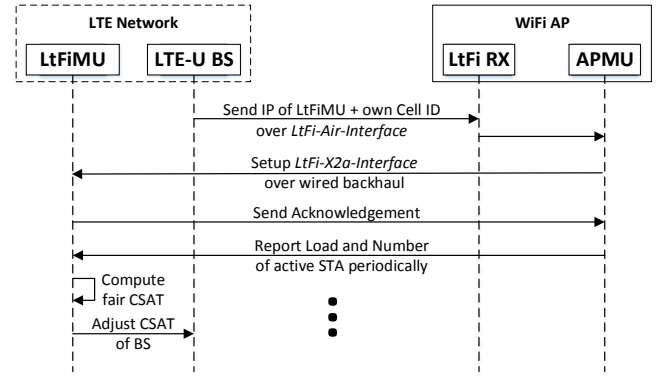


Fig. 4. Sequence diagram of the envisioned collaboration procedure.

ACKNOWLEDGMENT

This work has been supported by the EU's H2020 program grant agreement No. 645274 (WiSHFUL project).

REFERENCES

- [1] "LTE-U Forum." [Online]. Available: <http://www.lteuforum.org>
- [2] N. Jindal, D. Breslin, and A. Norman, "LTE-U and Wi-Fi: A coexistence study by Google, Wi-Fi LTE-U coexistence test workshop," <https://goo.gl/x6r0Ac>, March 2015, online; accessed 30 Sept. 2017.
- [3] S. Bayhan, A. Zubow, and A. Wolisz, "Coexistence gaps in space: Cross-technology interference-nulling for improving lte-u/wifi coexistence," *arXiv preprint arXiv:1710.07927*, 2017.
- [4] P. Gawłowicz, A. Zubow, and A. Wolisz, "Enabling Cross-technology Communication between LTE Unlicensed and Wi-Fi," in *INFOCOM 2018*.
- [5] M. Olbrich, A. Zubow, S. Zehl, and A. Wolisz, "WiPLUS: Towards LTE-U Interference Detection, Assessment and Mitigation in 802.11 Networks," in *European Wireless Conference*, 2017.