Soft-LTE: A Software Radio Implementation of 3GPP Long Term Evolution Based on Sora Platform

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1. INTRODUCTION

This demo shows an implementation of 3GPP LTE (Long Term Evolution) [2] Uplink, using Sora high performance software radio platform [5]. LTE is the state-of-the-art wide-area wireless technology and employs many cutting-edge physical layer designs, including Turbo Coding, MIMO, SC-FDMA and OFDMA [3, 4]. This demo shows a LTE Uplink implementation based on Release 8 3GPP 36 Series specifications in LTE-TDD (Time Division Duplex) system. Specifically, we implement the PUSCH (Physical Uplink Shared Channel) physical layer in single user environment, which provides a peak rate of 43.8Mbps with 20MHz channel band. The whole implementation contains around 5,000 lines of C code and runs in real-time in a commodity general purpose PC.

This demo works as another example of the flexibility and capability of Sora as a high-speed software radio platform, beside the SoftWiFi implementation as described in [5]. By using multi-core CPUs, Sora allows all PHY and MAC of modern wireless system (*e.g.* WiFi and LTE) completely in software on commodity PC. As a result, it provides a convenient and effective environment for the implementation and experimental evaluation of various sophisticated wireless technologies.

2. BACKGROUND

2.1 Sora high performance software radio platform

Sora is a fully programmable software radio platform based on commodity general-purpose PC architectures. Sora includes a Radio Control Board (RCB), as shown in Figure 1, which can connect to various radio front-ends, and interfaces with the PC using the high-speed, low-latency PCIe bus. The current Sora RCB implements PCIe-x8 and achieves 12Gbps throughput, sufficient for transferring high-speed, wide-band digital samples between the RF front-end and PC memory. All PHY and MAC processing is done in software on the host CPU.

We have previously implemented SoftWiFi, a full-featured IEEE 802.11a/b/g PHY and CSMA MAC, entirely in software on Sora. SoftWiFi seamlessly inter-operates with commercial 802.11 NICs in all modulation rates, and also achieves the equivalent performance. In this demo, we show an implementation of a future 4G wireless standard, LTE, using the same Sora platform.

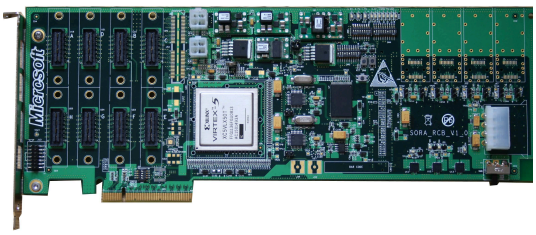

Figure 1: Sora radio control board.

2.2 3GPP LTE Uplink

3GPP LTE holds the promise to be the converged 4th generation wireless standards [2]. Compared to existing wireless technologies, LTE has higher efficiency, lower costs, better services, more spectrum opportunities, and easier integration with other open standards. LTE has obtained the wide support from a collaborative group of international standard organizations and mobile technology companies.

We has implemented PUSCH (Physical Uplink Shared Channel) for LTE TDD system. Currently, we only demo the single-input-single-output (SISO) uplink with SD-FDMA.

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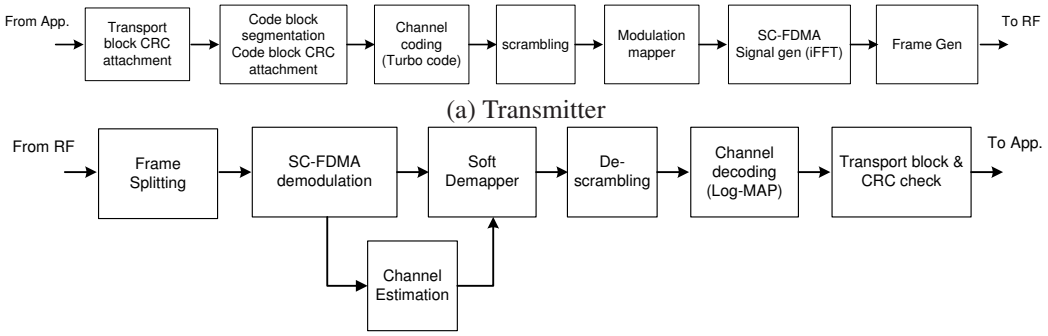
[†]This work is done when Ji Fang is a research intern in Microsoft Research Asia.



(a) Transmitter

(b) Receiver

Figure 2: Illustration of LTE PUSCH transceiver.

The peak rate is 43.816Mbps at 20MHz channel band. Figure. 2 shows the physical layer processing diagrams of LTE PUSCH. Table 2.2 summarizes the detailed parameter configuration of our implementation.

Parameter	Value (in 20MHz BW)
Subcarrier spacing	15kHz
Sampling frequency	30.72MHz
FFT size	2048
CP size	160(1st symbol), 144(2–7th symbol)
Frame length	10ms
Subframe length	1ms
Slot length	0.5ms
Channel Coding Rate	3/4
Modulation	16QAM
Peak data rate	43.816Mbps

Table 1: Parameter configuration of LTE PUSCH.

3. DEMO SETUP

The demo setup is shown in Figure 3. It takes one regular desk and around 15mins to setup. We use two Shuttle XPS small form-factor PCs, each of which is equipped with a Sora Radio Control Board (RCB) and a 700M/2.4GHz Radio Front-end. One machine works as a LTE terminal and the other one works as a base station. We show the terminal can communicate with the base station over air using LTE Uplink PHY. To support existing application, we emulate an Ethernet interface over LTE link. Thus, we can support various network applications, including simple "ping", and high-definition video streaming

We also deploy a protocol analyzer from Agilent Technologies [1] to validate the correctness of our LTE PHY implementation. We input our generated LTE frame into the analyzer and we can see the demodulated signals using Agilent's commercial analyzer.

We further show a simple LTE analyzer with our own decoder on Sora. It can graphically display the waveform and modulation points in a constellation graph, as well as the demodulated results. It has the basic functions of a commercial spectrum/protocol analyzer, but it is much cheaper.

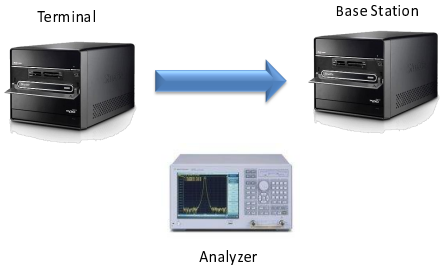


Figure 3: Demo setup.

4. SUMMARY

In the demo, we show the flexibility and capability of Sora as a high-speed software radio research platform, by implementing LTE Uplink, a cutting-edge wireless technology with advanced physical layer like Turbo coding and SC-FDMA. The implementation takes one student for about three months and it can run in real-time in a commodity PC architecture. In the next step, we will continue our implementation to the LTE Down-link standard and MIMO support. Our plan is to have a complete software radio LTE system based on Sora platform.

5. REFERENCES

[1] Agilent technologies. *http://www.agilent.com*.

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