Tutorial T-17: Cloud Radio Access Networks: Principles, Challenges, and Technologies

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Tutorial Overview

The proposed tutorial will be a collections of background, state-of-the-art, and open research topics in the area of cloud radio access networks (C-RAN) in view of 5G systems. The tutorial is organized in 6 parts as follows:

1) **Principles (45 minutes):** In this part, we will describe the main concept and features, architecture (from centralized to cloud), current activities (including NGMN RAN evolution project, MCN and iJoin EU projects, and ETSI), and example use-cases of C-RAN. We will provide a comparative table to highlight the pros and cons of C-RAN with respect to the standard cellular architecture, distributed antenna system, and HetNet.

2) **Challenges (45 minutes):** The main challenges toward a cloudifcation of LTE/LTE-A will be presented in this part. We start by presenting the realtime constraints imposed by an LTE base station. Then we present the real-world cloud-RAN processing budget in view of the HARQ deadlines and OS induced delay (scheduling/interrupt delay, and virtualization delay). Implication and feasibility of different family of the front-haul will be examined. Finally, we elaborate on the power-performance-flexibility trade-offs of a full-GPP vs a hardware accelerated LTE base station, and present their respective reference software architectures.

3) **Technologies (45 minutes):** In this part, we will highlight a set of selected techniques that can benefit from C-RAN, namely cooperative resource allocation and scheduling, CoMP, load balancing, energy-harvesting, caching and mobile edge computing (MEC). We will further elaborate the achievable gain for a subset of enabling techniques. Finally, we analyze the potentials of C-RAN for the 5G systems.

4) **Testbeds and Field Trials (45 minutes):** Recent efforts have shown the feasibility of full software implementation of LTE RAN functions over General Purpose Processors (GPPs), namely OpenAirInterface LTE softmodem (http://www.openairinterface.org). In particular, we highlight a set of DSP optimization techniques for x86 architecture to meet the realtime requirement of a LTE modem applied to the OpenAirInterface prototype. In this part, we presents the methodology of C-RAN testbed design as well as the main on-going efforts toward building proof-of-concept C-RAN prototypes and highlight their main features and objective. In addition, several sets of PoCs from other operators and vendors will be introduced. Furthermore, field trials on C-RAN centralization from a representative operators network will be presented. The purpose is to demonstrate the benefits that centralization could bring to operators in its basic form. In addition, the performance and potential impact by different fronthaul technologies, including CPRI compression, WDM, and OTN will be demonstrated through the trials.

5) **Conclusion (10 minutes):** In this part we summarize the efforts in C-RAN, present the main conclusions and recent achievements and open issues in C-RAN.

6) **References:** we provide an extensive list of publications and efforts in the area of C-RAN from the research communities as well as industries.

Presenter Biographies

Navid Nikaein is an assistant professor in the Mobile Communication Department at Eurecom. He received his Ph.D. degree in communication systems from the Swiss Federal Institute of Technology EPFL in 2003. He is leading a research group focusing on experimental system research related to radio access network (RAN) (L1.5/L2/L3) in cellular, adhoc/mesh, and cloud settings with realistic use-cases. Broadly, his research contributions are in the areas of wireless access layer techniques and networking protocols, programmable and virtualizable RAN, machine type communication, cooperative Layer 2 relaying, software define radio networking architecture, and OpenAirInterface.org wireless technology platform. Related to C-RAN, he is involved in the EU Mobile Cloud Network project where he is building a true C-RAN proof-of-concept based on the OpenAirInterface LTE softmodem and OpenStack cloud platform. He also acts as an advisory member for the NGMN Alliance of behalf of Eurecom.

Raymond Knopp is professor in the Mobile Communications Department at EURECOM. He received the B.Eng. (Honours) and the M.Eng. degrees in Electrical Engineering from McGill University, Montreal, Canada, in 1992 and 1993, respectively. From 1993-1997 he was a research assistant in the Mobile Communications Department at EURECOM working towards the PhD degree in Communication Systems from the Swiss Federal Institute of Technology (EPFL), Lausanne. From 1997-2000 he was a research associate in the Mobile Communications Laboratory (LCM) of the Communication Systems Department of EPFL. His current research and teaching interests are in the area of digital communications, software radio architectures, and implementation aspects of signal processing systems and real-time wireless networking protocols. He has a proven track record in managing both fundamental and experimental research projects at an international level and is also technical coordinator of the OpenAirInterface.org opensource wireless radio platform initiative which aims to bridge the gap between cutting-edge theoretical advances in wireless communications and practical designs.

Chih-Lin I is the China Mobile Chief Scientist of Wireless Technologies, in charge of advanced wireless communication R&D effort of China Mobile Research Institute (CMRI). She established the Green Communications Research Center of China Mobile, spearheading major initiatives including 5G Key Technologies R&D; high energy efficiency system architecture, technologies, and devices; green energy; C-RAN and soft base station. Dr. I received her Ph.D. degree in Electrical Engineering from Stanford University, has almost 30 years experience in wireless communication area. She has worked in various world-class companies and research institutes, including wireless communication fundamental research department of AT&T Bell Labs; Headquarter of AT&T, as Director of Wireless Communications Infrastructure and Access Technology; ITRI of Taiwan, as Director of Wireless Communication Technology; Hong Kong ASTRI, as VP and the Founding GD of Communications Technology Domain. Dr. I received the Trans. COM Stephen Rice Best Paper Award, and is a winner of CCCP "National 1000 talent" program. She was an elected Board Member of IEEE ComSoc, Chair of ComSoc Meeting and Conference Board, and the Founding Chair of IEEE WCNC Steering Committee. She is currently the Chair of Fu-TURE Forum 5G SIG, an Executive Board Member of GreenTouch, a Network Operator Council Member of ETSI NFV, a Steering Board Member of WWRF

(Wireless World Research Forum), and an adjunct Professor of BUPT (Beijing University of Posts and Telecommunications).