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Demo Abstract: Scaling Out srsRAN Through Interfacing Wirelessly srsENB With srsEPC

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***Abstract*—Software radio suite Radio Access Network (srsRAN) has been widely used in experimental research for 5G, 6G and their evolutions. However, in the current implementation of srsRAN, the Evolved Node B (srsENB) and Evolved Packet Core (srsEPC) are interfaced through wired connections, which makes it challenging to conduct experiments with mobile srsENBs and dynamic association between User Equipment (srsUE) and srsENB in future wireless networks. To address this challenge, we propose to interface srsENB and srsEPC by allowing srsENB to interface with srsEPC through wireless links and hence enabling easy integration of multiple possibly mobile srsENBs in experimental research. We show the effectiveness and scalability of the new srsRAN architecture through two demonstrations: (i) srsUE-srsENB connection establishment; (ii) srsUE handover between two srsENBs wirelessly interfaced with the same srsEPC.**

I. Introduction

In this demo, we focus on enhancing the scalability of srsRAN, which is an open-source 4G LTE/5G NR commercial-grade software radio suite developed by Software Radio Systems and has been widely used in experimental research for 5G, 6G and their future evolutions [1].

srsRAN: A Primer and Challenges. As illustrated in Fig. 1, the srsRAN framework consists of three major components, namely the User Equipment (srsUE), Evolved NodeB (srsENB) and Evolved Packet Core (srsEPC). The srsUE is a software based 4G LTE and 5G NR UE modem capable of connecting to any LTE or 5G NR network and providing high-speed mobile connectivity. The srsENB is the software based LTE eNodeB basestation that connects to srsEPC. The srsEPC is a lightweight implementation of the LTE core network that consists of Home Subscriber Service (HSS), Mobility Management Entity (MME), Service Gateway (S-GW) and Packet Data Network Gateway (P-GW) modules. The HSS module is the user database that stores user information such as user id, key and usage limits. It is also responsible for authorizing the user to connect to the network. The MME module is the main control element in the network that handles mobility. The S-GW module is responsible for setting up sessions between the srsENB and P-GW. Finally, the P-GW module acts as the point of contact with external networks.

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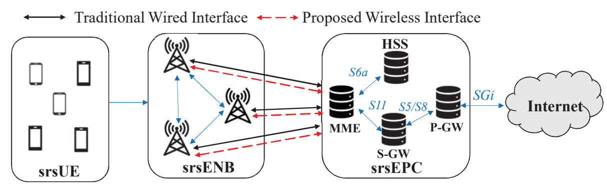

Fig. 1: Diagram of the traditional srsRAN architecture with wired interface (black solid lines) between srsENB and srsEPC and the architecture with wireless interface (red dashed lines).

In the current deployment of srsRAN, the srsENB and srsEPC are interfaced with each other through wired connections. As a result, it is hard to support experiments for wireless networks with mobile hotspots, where base stations can be carried on ground or flying vehicles [2], [3]. A natural question to ask is: *Can we interface srsENB with srsEPS through wireless links and hence enhance the scalability of srsRAN in experimental research for NextG networks with mobile hotspots?*

II. Interface Analysis and Adaptation

We first identify the modules and functionalities of srsRAN that will be affected by the adoption of a wireless interface between srsENB and srsEPC. In srsENB there are two layers connected to srsEPC. The S1 Application Protocol Layer (S1-AP) in srsENB is connected to MME in srsEPC to provide the control plane connection, and the GPRS Tunneling Protocol User Plane Layer (GTP-U) in srsENB is connected to S-GW to provide the data plane connection. The interface for these two connections are S1-AP and S1-U, respectively. To enable connecting srsEPC and srsENB wirelessly, the interfaces for both S1-AP and S1-U in srsEPC and srsENB need to be adapted properly. To this end, both hosts running srsEPC and srsENB need to establish a wireless link. In our prototyping, we consider commercial off-the-shelf Wi-Fi links as an example, while other wireless links can also be adopted, e.g., mmWave- and terahertz-band links.

Denote `wl_epc_addr` and `wl_enb_add` as the wireless IP address of hosts running srsEPC and srsENB, respectively.

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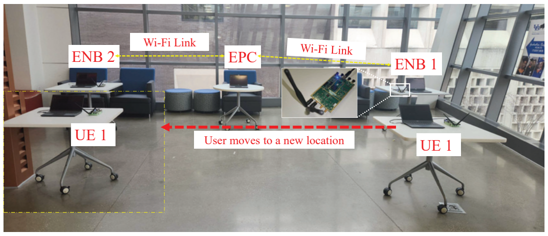
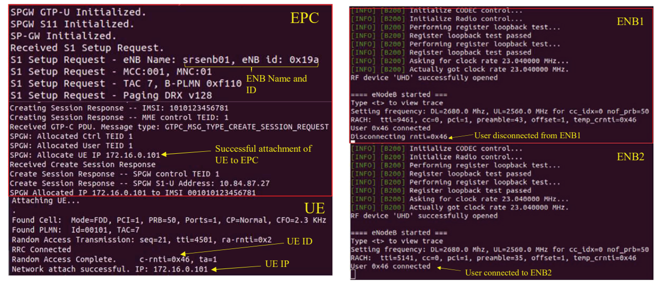


Fig. 2: Snapshot of the testbed deployed in *Salvador Lounge* in Davis Hall at University at Buffalo.



(a) (b)

Fig. 3: Terminal screenshots for (a) link establishment and (b) scalability and handover testing with a wireless interface between srsENB and srsEPC.

Then, we need to further modify the two interfaces based on the allocated wireless IP addresses in srsEPC configuration file. Specifically, we need to update MME Bind Address (`mme_addr`) and GTP-U bind address (`gtp_bind_addr`). The former specifies where the MME will listen for upcoming srsENB S1-AP connection and the latter specifies the tunnel address of S-GW for transmitting and receiving information to and from GTP-U at srsENB. Both of the two parameters need to be configured as `wl_epc_addr`. Furthermore, three bind addresses need to be modified for the two interfaces, that is GTP-U bind address (`gtp_bind_addr`), S1-C Bind Address (`s1c_bind_addr`) and MME Address (`mme_addr`), where `s1c_bind_addr` is used to for S1-AP connection. Both `gtp_bind_addr` and `s1c_bind_addr` need to be assigned with `wl_enb_add`, and `mme_addr` needs to be assigned with `wl_epc_addr`.

After establishing the wireless link between srsEPC and srsENB, the parameters stored in UE's USIM card should be added in the `user_db.csv`. This is a separate configuration file used by srsEPC to store the details of the users in HSS. The following parameters need to be updated in the `user_db.csv` file for each UE: ue_name (Human readable name to help distinguish UE's), algo (Authentication algorithm used by the UE like XOR and MILENAGE), imsi (UE's IMSI value), K (UE's key stored in hexadecimal), `OP_type` (Operator's code type, either OP or OPc), `OP_value` (Operator Code/Cyphered Operator Code), AMF (Authentication management field), SQN (UE's Sequence number for freshness of the authentication), QCI (QoS Class Identifier for the UE's default bearer), `IP_alloc` (IP allocation strategy for the SPGW). When `IP_alloc` parameter is set as "dynamic", SPGW automatically allocates IP address to UE. When `IP_alloc` parameter is set to a valid IPv4 (IP address must be in the same subnet as that of srsENB and srsEPC), SPGW statically assigns an IP address to UE.

III. Demonstration

To verify the effectiveness of the wireless interface between srsENB and srsEPC, we develop a software-defined radio based testbed. The testbed consists of three Universal Software Radio Peripheral (USRP) B210 for 2 srsENBs and 1 srsUE. Each USRP B210 is controlled by a dedicated Dell Latitude 3430 laptop. Another Dell laptop is used for srsEPC. All the hosts run Ubuntu 20.04 LTS. The Downlink E-UTRA Absolute Radio Frequency Channel Number (`dl_earfcn`) is set to 3350, corresponding to 2680 MHz for downlink and 2560 MHz for uplink. A snapshot of the SDR testbed is shown in Fig. 2. In the demonstration we will show the effectiveness and scalability of the new srsRAN architecture considering two scenarios: (i) srsUE-srsENB connection establishment; (ii) srsUE handover between two srsENBs wirelessly interfaced with the same srsEPC.

Connection Establishment: We first demonstrate the establishment of the wireless link between srsUE, srsENB and srsEPC. After the initial configuration, srsEPC and srsENB are started first by executing `sudo srsepc` and `sudo srsenb`, respectively. Then, srsUE is started with command `sudo srsue`. As shown in Fig. 3(a), the srsUE can be successfully attached to the network, verifying the effectiveness of the wireless interface between srsENB and srsEPC. *It is worth noting that in this experiment the srsENB first establishes a wireless link to the srsEPC (rather than wired connections in traditional srsRAN deployment).*

srsUE Handover: We further demonstrate the scalability of the new srsRAN architecture considering two srsENBs wirelessly connected to the same srsEPC. The second srsENB is configured similarly to the first. Additionally, the two srsENBs are deployed sufficiently far away from each other thereby creating no overlap in their coverage areas. In this scenario, we first let the srsUE connect to the first srsENB, i.e., ENB 1 in Fig. 2. The corresponding terminal output is shown in Fig. 3(b). We then move the srsUE from the coverage area of ENB 1 to ENB 2, as shown in Fig. 2 with a dashed red line. The corresponding terminal output is also shown in Fig. 3(b). It can be seen that the user with ID 0x46 is connected first to ENB 1. When it moves outside the coverage area of ENB 1, it first gets disconnected from ENB 1 and then connects to srsENB 2 automatically. *Notice again that the two srsENBs are wirelessly interfaced with the srsEPC, which makes it easier to deploy a large number of ENBs over possibly mobile hotspots.*

References

[1] "srsRAN Documentation: Release 21.10." [Online]. Available: https://docs.srsran.com/en/latest/

[2] Z. Guan, N. Cen, T. Melodia, and S. Pudlewski, "Joint Power, Association and Flight Control for Massive-MIMO Self-Organizing Flying Drones," *IEEE/ACM Trans. on Netw.*, vol. 28, no. 4, pp. 1491–1505, August 2020.

[3] J. Hu, S. K. Moorthy, A. Harindranath, Z. Guan, N. Mastronarde, E. S. Bentley, and S. Pudlewski, "SwarmShare: Mobility-Resilient Spectrum Sharing for Swarm UAV Networking in the 6 GHz Band," in *Proc. of IEEE SECON*, Virtual Conference, July 2021.