

Play, Innovate and Test: Open5GFusion Powers 5G Breakthroughs



Introduction

Fifth-generation (5G) mobile networks go beyond faster speeds, enabling key innovations such as autonomous vehicles, smart cities, and real-time industrial control. These distinct capabilities rest on three pillars: ultra-reliable low latency communication (URLLC), enhanced mobile broadband (eMBB), and massive machine-type communication (mMTC).



While experimentation with commercial 5G networks is often expensive and complex, Open5GFusion offers an affordable and flexible, open-source sandbox as an alternative [1]. Built on an open architecture using containerized core functions on commodity computer hardware and software-defined radios (SDRs), it is a 5G standalone (SA) network for students, researchers and developers. In contrast to commercial network equipment, Open5GFusion enables open exploration and optimization of advanced features like network slicing,

massive MIMO, and edge computing, and supports rapid application prototyping, deployment and testing.

Novelty

Open-source 5G frameworks such as OpenAirInterface (OAI), Open5GS, and srsRAN have enabled much academic exploration of 5G. However, each framework is typically used in isolation. Moreover, configuring and managing these systems require strong expertise in networking, virtualization, and

radio technologies. Filling these gaps, Open5GFusion is a reconfigurable, integrated, 3GPP-compliant 5G SA testbed combining multiple open-source frameworks. Being the first of its kind, it can combine different Core Network (CN) and Radio Access Network (RAN) components, to derive unique synergies in performance for different applications[1]. It drives open source testbeds beyond basic 5G network studies into deploying and testing real-world applications. Table 1 compares Open5GFusion with the above 5G frameworks.

The unified GUI of Open5GFusion simplifies complex deployments like Competitive VR Cycling (Fig. 2) by providing intuitive controls to start RAN, core, edge servers, and monitoring tools. This reduces setup time and configuration errors, enabling users to focus more on application behavior. It also supports rapid reconfiguration and real-time system health monitoring.

Architecture

Open5GFusion is built around a host computer running open-source software for the core network (CN) and radio access network (RAN), paired with a software defined radio (SDR) serving as the radio unit (RU). It supports different hardware versions—Pro for higher throughput and Lite for easy portability—compatible with various user equipment (UE). The sandbox environment integrates OpenAirInterface, srsRAN, and Open5GS within Linux using Docker containers to maintain stable and consistent performance across platforms. A custom GUI built with Flask and Node.js simplifies deployment, monitoring, and management of network components, providing users with an efficient and user-friendly system control interface. This architecture enables seamless multi-platform operation in a compact testbed setup. Fig. 1 shows the implemented testbed, and Table 2 lists its components.

Version	Host Computer	RU	Supported UEs
Pro	Dell Optiplex CPU: i7-10700 (2.9GHz) RAM: 16GB	<ul style="list-style-type: none"> • USRP N310 • USRP B210 	<ul style="list-style-type: none"> • Galaxy A15 5G • Galaxy Tab S8 Plus • Sim-Com Raspberry PiHAT • Quectel USB Modem • Seriallink SLK-R620
Lite	MSI Cyborg 15 CPU: i7-13620H RAM: 32GB	<ul style="list-style-type: none"> • USRP B210 	

Table 2. Hardware Components of Open5GFusion

A Tool for Education and Research

The Open5GFusion sandbox exposes learners to end-to-end 5G operations from radio transmission to core signaling and analytics. Deep insights and hands-on experience on the network - hitherto available only to a handful of telecom engineers - are now open to the student community, researchers and innovators.

While experimentation with channels, bandwidth and modulation schemes provides a good understanding of the basics of 5G's physical layer, Open5GFusion also provides a testing ground for advanced research, combining telecommunications, cloud computing, and data analytics.

Low-Latency Application Highlight: Competitive VR Cycling (CVC)

CVC[2], the flagship demonstration of Open5GFusion, is a study on low-latency performance and scalability. Multiple stationary bikes, a trainer replacing the rear wheel of each, are linked to a common virtual racing platform where riders race each other in real-time. The immersive virtual environment is created by a 360-degree video of a ride through a scenic route playing on the riders' VR display. Each bicycle is equipped with sensors that measure the pedaling speed of the rider. The playback speed of the video responds to the pedaling speed. The inclination of the route adjusts the pedaling resistance experienced by the riders. These

exchanges of data between the bicycles and the VR headsets occur via an edge server within the sandbox. Deployment of the CVC on Open5GFusion is illustrated in Fig. 2, and two competing riders in Fig. 3. The key challenge in this scenario is maintaining ultra-low latency and precise synchronization among multiple participants, ensuring that every movement and position update appears simultaneously across all riders' VR displays. A rider-to-edge latency of 25ms was achieved even under the most demanding network load conditions, well within the 50ms threshold required to prevent motion sickness in such applications. Through this, we provide opportunities for innovation in gaming, fitness, and interactive training platforms, combining 5G's low latency with immersive digital interaction.

Slicing Application Highlight: A Smart Warehouse Comes Alive

The smart warehouse is a novel paradigm of Industry 4.0, digitally connecting and managing physical assets. It extensively uses wireless sensors/actuators, and autonomous guided vehicles (AGVs). To meet the specific needs of these components, 5G uses network slicing, which divides a single physical network into multiple virtual networks, each optimized for a particular service.

Our warehouse application[3] on Open5GFusion creates a dual-slice network mimicking industrial telecom infrastructure, with one slice (URLLC) for real-time AGV navigation and another (mMTC) for connecting environmental sensors. Slicing ensure that sensor traffic does not disrupt critical

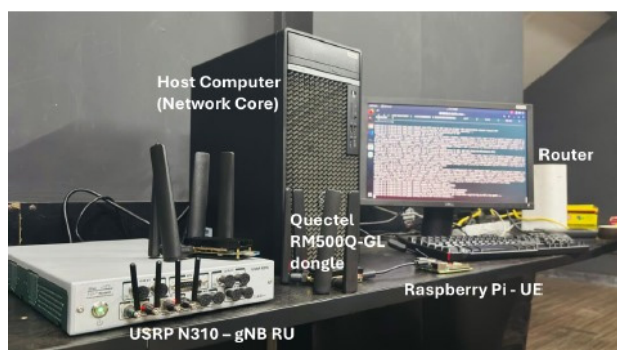


Fig. 1. The Open5GFusion Sandbox

AGV control. Experimental tests confirmed stable throughput for both slices under concurrent load as demonstrated in Fig. 4. Prototype AGVs successfully navigated the warehouse, sending location updates to a central server that triggers near-instant collision avoidance commands. The system achieved an average collision response delay of 134 ms, well below the 500 ms target of 3GPP, outperforming traditional Wi-Fi and 4G networks in reliability and latency.

Industry 4.0 envisages a broad spectrum of smart applications. Open5GFusion shows how affordable, research-grade 5G slicing can be deployed to support the development and testing of such applications.

Conclusion

Open5GFusion exemplifies the transformative potential of open-source 5G testbeds in bridging the gap between theoretical research and practical deployment. By integrating multiple open-source frameworks into a unified, accessible and cost-effective platform, it empowers students, researchers, and developers to deepen their understanding of 5G technologies and innovate advanced applications. This sandbox thus paves the way for rapid prototyping of applications that can drive the continued evolution and adoption of 5G-enabled Industry 4.0 and immersive digital services.

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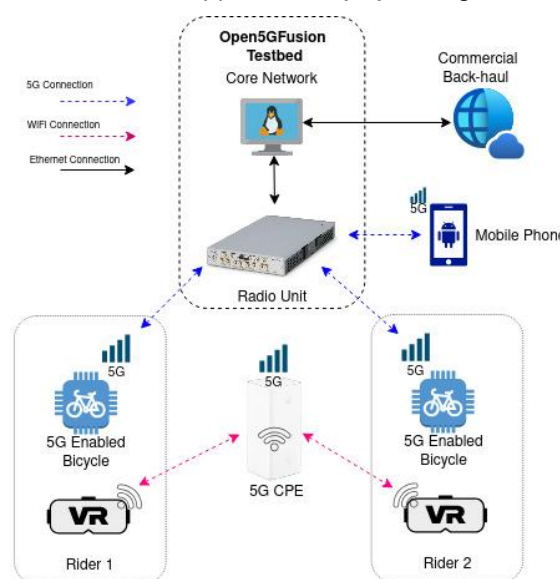


Fig. 2. Competitive virtual cycling is deployed on Open5GFusion



Fig.3. Two riders compete with each other in the virtual world.

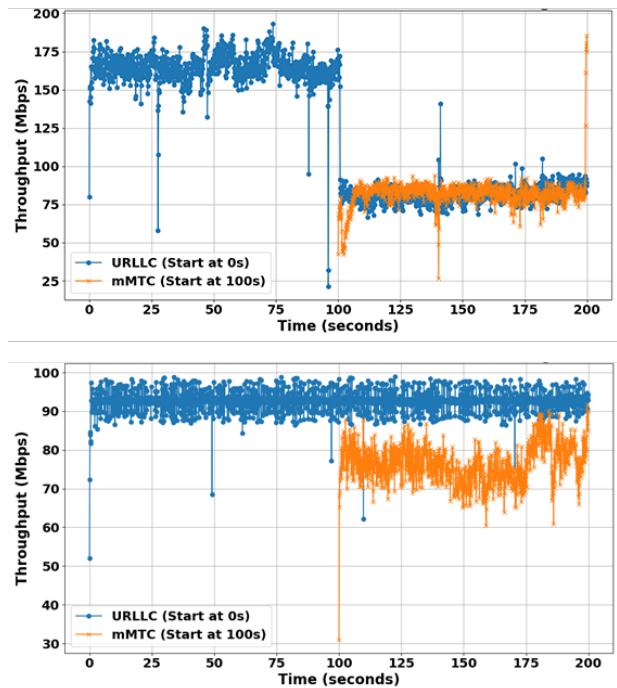


Fig. 4. Traffic Isolation works well. With slicing (bottom), without slicing (top). mMTC (sensor) traffic is injected at T=100s. The URLLC slice maintains stable throughput even under concurrent traffic conditions in the mMTC slice.

References:

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