

Realistic Traffic Generation Orchestrator for 5G Networks

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Abstract—The evolution of Fifth Generation (5G) networks demands experimental platforms that can replicate the stochastic nature of real-world traffic. However, traditional benchmarking tools often rely on stationary models that fail to capture the burst behavior of modern applications. This paper presents a novel orchestration framework for generating realistic, non-stationary traffic for 5G testbeds. The solution automates heterogeneous application profiles, including interactive browsing, Dynamic Adaptive Streaming over HTTP (MPEG-DASH) streaming, and Cloud gaming simulation across multiple User Equipments (UEs) without human intervention. Experimental results demonstrate that the orchestrator effectively mimics unpredictable load fluctuations, providing a high-fidelity environment for network performance evaluation that significantly surpasses conventional synthetic traffic models.

Keywords—Traffic modeling, Network orchestration, 5G testbeds, Non-stationary traffic, Automation.

I. INTRODUCTION

The advent of Fifth Generation (5G) technology has introduced a transformative paradigm in telecommunications, characterized by Ultra-Reliable Low-Latency Communication (URLLC), Enhanced Mobile Broadband (eMBB), and Massive Machine-Type Communications (mMTC) [1]. These advancements provide the backbone for emerging technologies such as autonomous vehicles, Industry 4.0, and immersive multimedia services. However, as network architectures become increasingly complex, accurately emulating network traffic on experimental platforms remains a significant challenge. Recent efforts in the field have focused on evaluating open-source 5G core platforms [2] and on developing programmable, Multi-Vendor O-RAN testbeds [3], [4]. While these studies provide rigorous performance evaluations of network stability and peak throughput, they predominantly rely on traditional benchmarking tools, such as *iperf*, for network stress testing. Such tools are limited by their inability to replicate the nuances

of real-world usage, as they typically generate stationary traffic based on constant bitrates and average values that fail to capture the stochastic and bursty nature of actual data consumption in a live 5G environment.

To address the gap between stationary benchmarking and real-world behavior, recent literature has explored alternative traffic-generation methodologies, particularly by virtualizing user equipment. For instance, frameworks have demonstrated the feasibility of automating specific user tasks, such as video streaming and Web browsing, mapping client devices to virtualized User Equipments (UEs) for large-scale data collection and security profiling [5]. While such approaches successfully demonstrate the need for application-aware traffic and automated task execution, they are largely tailored for offline dataset generation or rely on static experimental scripts run in virtualized environments. Consequently, a critical challenge remains combining realistic session-based application behavior with dynamic lifecycle management and orchestration of physical hardware endpoints on a live testbed.

To address this need, we propose a remote-access orchestration framework that generates realistic, non-stationary traffic for 5G experimental environments. The proposed solution employs a scalable architecture capable of managing a variable number of N physical UEs simultaneously, each executing distinct real application profiles without direct human intervention. Within each application, the framework implements automated sequences that simulate human interaction by executing programmatic inputs, such as navigation commands and interface interactions. By dynamically coordinating and swapping these behaviors across multiple physical devices distributed throughout the network, the orchestrator produces traffic patterns that accurately reflect the unpredictable fluctuations of daily internet usage. Moving beyond static synthetic data to a high-fidelity environment, this framework provides a solid foundation for researchers to evaluate 5G infrastructures under authentic dynamic loads.

II. PROPOSED METHOD

This work proposes a realistic UE traffic generator-centered orchestration for 5G networks to generate, capture, and measure network traffic. This proposed architecture offers a self-sufficient model that does not require human intervention to generate network traffic. Each UE executes tasks that simulate human traffic and generate inputs. This approach results in non-stationary traffic patterns that fluctuate according to the nature of the application, providing a more realistic representation of network demand.

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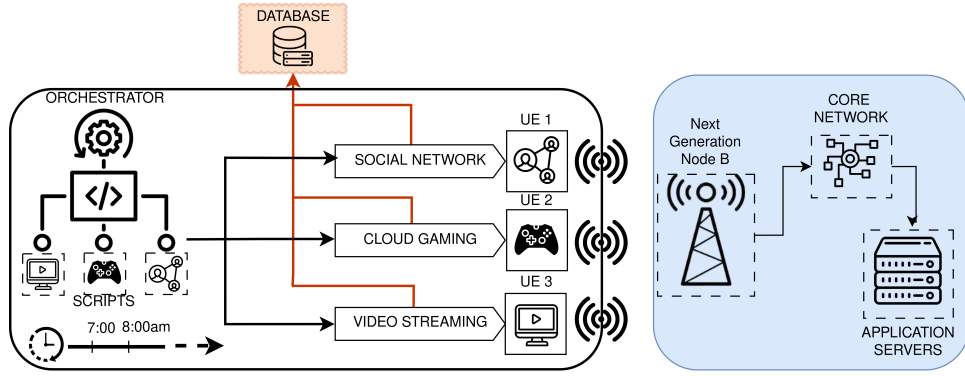


Fig. 1. Proposed orchestration framework and 5G testbed architecture, illustrating the communication flow between the central orchestrator and multiple UEs to automate traffic profiles.

Figure 1 illustrates the proposed architecture of the 5G network, comprising the central orchestration framework and the base station infrastructure. The network comprises a Next-Generation NodeB (gNB) and N UEs, each represented by a hardware module providing 5G connectivity to a dedicated Linux computer. The system features an orchestrator that dynamically controls network traffic for a variable number N of UEs in the network. Within the proposed framework, each UE is assigned to execute a specific network activity from a predefined set: Video Streaming, Cloud Gaming, or Social Networking. These processes are managed by the central orchestrator, which dynamically schedules the workloads. Consequently, at a given timestamp, each UE performs a specific task, while in the subsequent interval, the orchestrator reconfigures the UEs to execute a different activity in sequence.

Figure 2 offers a detailed representation of the internal functional blocks within both the orchestrator and each UE, illustrating how task execution is handled in conjunction with the systematic generation of experimental results. To establish terminal communication across the architecture, a Python 3-based remote access orchestration framework is employed. This framework enables the central orchestrator to manage a variable number of N UEs by dispatching terminal-based instructions to multiple devices distributed across the same network. These commands trigger specific scripts for each unit, simulating human interactions within an emulation environment tailored for predefined tasks. Such environments are essential for generating realistic traffic. For instance, a Social Network profile automates sequences of accessing social media platforms followed by transitions to news websites. By systematically alternating among distinct web services, the system generates network traffic that closely replicates typical daily internet usage.

To test the network with different tasks, a task scheduler runs distinct commands and scripts concurrently on the UEs, enabling automated communication between the orchestrator and these units. To ensure accurate network measurements, it is essential to collect metrics from those devices and applications simultaneously. To facilitate subsequent analysis within the database, a synchronization manager synchronizes the internal clocks of each node, using the Orchestrator as a

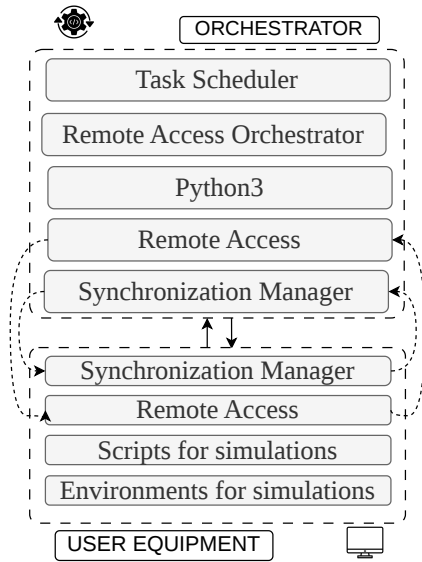


Fig. 2. Internal modules of the Orchestrator and UE, illustrating the communication workflow and synchronization interfaces between components.

common time reference. Specifically, this manager leverages Network Time Protocol (NTP) to synchronize clocks across all machines, ensuring temporal consistency throughout the environment. By eliminating clock drifts, the system ensures that metrics arriving from various UEs are accurately ordered and compared, which is vital for identifying simultaneous network behaviors and transient performance bottlenecks.

As the orchestrator and UEs are synchronized via the synchronization manager, Chrony, which establishes the architecture's timestamp, the communication process follows a structured hierarchy. Once synchronization is stable, the Task Scheduler triggers the automation workflow by invoking the remote access orchestrator. This component manages the dispatch of terminal commands across the network. These instructions flow through the remote access module to each UE, where they initiate simulation scripts. Finally, these scripts run in dedicated simulation environments to generate the required network traffic, ensuring that all activities are accurately timed

and coordinated across the experimental testbed.

III. RESULTS

The distributed 5G testbed comprises three UEs, each a Ubuntu 24.04 computer equipped with a Fibocom module, each module has a four-antenna array. These units are connected to a 5G radio access network powered by a USRP B210 transceiver, where the gNB is also executed by the OpenAirInterface (OAI) framework. The network core is similarly implemented using OAI, deployed via Helm charts within a Kubernetes (K8S) cluster. Furthermore, the transport layer is emulated via Mininet, with one node dedicated to the 5G Core orchestration and the other responsible for the transport network, ensuring an environment for real-time telemetry and data consistency.

Regarding the software stack, each UE is equipped with specific frameworks to replicate real-world service consumption. For cloud gaming, the Moonlight¹ and Sunshine² tools are integrated with automated scripts to simulate interactive sessions, with performance data, such as throughput and latency, sent to an InfluxDB instance via collectors based on Python. Social media interactions, such as browsing Pinterest, are replicated using the Robot Framework to automate navigation tasks. Additionally, video streaming sessions are implemented through an HTML/JavaScript interface, delivering segmented content via the Dynamic Adaptive Streaming over HTTP (MPEG-DASH) protocol to ensure a realistic representation of modern multimedia traffic.

Task execution is governed by a Crontab scheduler that periodically triggers Ansible via SSH. This orchestrator ensures each UE initiates its assigned application profile at specific timestamps by executing shell scripts that concurrently launch the simulation environments and Python collectors.

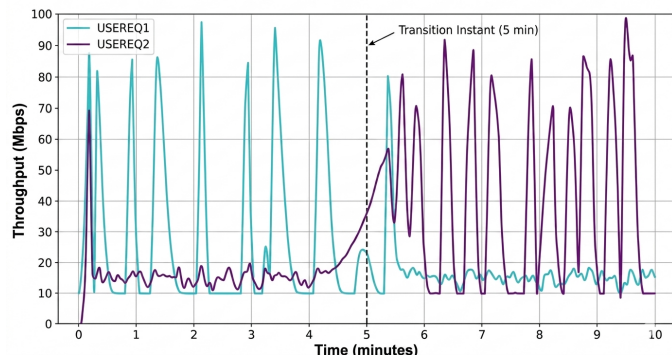


Fig. 3. Throughput behavior of two UEs during the taskswap.

Fig. 3 illustrates the throughput dynamics of two UEs throughout a 10 minute experimental window, characterized by a task swap event at the 5 minute mark. Initially, one UE executes the social media and news browsing profile. Conversely, the other UE handles the video streaming task, which uses MPEG-DASH protocol. At the 5 minute transition

¹<https://github.com/moonlight-stream/moonlight-gt.git>

²<https://github.com/LizardByte/Sunshine>

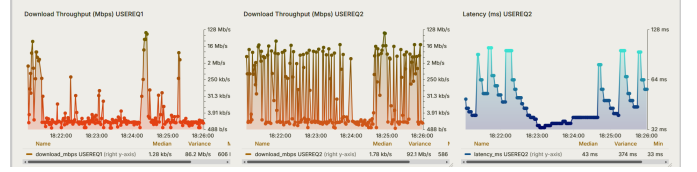


Fig. 4. Real-time telemetry dashboard in Grafana displaying the performance metrics for each UE task.

instant, the orchestrator triggers a remote command that forces both units to exchange their application profiles. Following this swap, a sudden shift in traffic behavior is observed: the first UE adopts the high-frequency burst pattern of the web browsing application, while the second UE shifts to the video streaming profile. These transitions show the different types of traffic consumption.

Fig. 4 presents a real-time telemetry dashboard developed using the Grafana visualization platform. The entire data collection pipeline is fully automated, ensuring continuous monitoring. As depicted, the system captures distinct performance profiles. The UE handles the video streaming service and is monitored for both throughput and latency. This dual metric tracking is crucial for the streaming application, as the continuous and correct delivery of multimedia packets is highly sensitive to network delays.

IV. CONCLUSIONS

This work presented a scalable orchestration framework for 5G experimental testbeds designed to overcome the limitations of traditional stationary traffic generators. By automating heterogeneous application profiles across multiple UEs, experimental results validated the system's ability to replicate dynamic, non-stationary traffic patterns without human intervention, providing a high-fidelity environment for performance evaluation. Ultimately, this framework establishes a reliable foundation for future research into complex network scenarios, enabling evaluations under realistic conditions and in the presence of potential network anomalies.

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