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True-Data Testbed for 5G/B5G Intelligent Network

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Abstract: *Future mobile communications will shift from supporting the internet of everything (IoE) to facilitating interpersonal communications beyond fifth-generation (B5G) and sixth-generation (6G) mobile communications. Intelligent communications with full integration of big data and artificial intelligence (AI) will play a key role in improving network efficiency and providing high-quality service. The AI-powered mobile communications require vast volumes of data to be collected from a real network environment for systematic testing and verification because it is a rapidly growing paradigm. As a result, we create the first true-data testbed for 5G/B5G intelligent networks (TTIN), which includes on-site experimental 5G/B5G networks, data collection and storage, and an AI engine and network optimization. True network data collecting, storage, standardisation, and analysis are possible in the TTIN, allowing for data-driven networks and system-level online verification of important B5G/6G technologies.*

Keywords: True-Data Testbed; Wireless Communication Networks; Artificial Intelligence (AI); Big Data; Internet of Everything (IoE).

I. INTRODUCTION

The widespread adoption and commercial use of fifth-generation (5G) mobile communication are currently accelerating. In the meantime, since 2018, a number of upcoming technologies, such as terahertz communication, six-generation (6G), and beyond 5G (B5G), have been considered and explored. Artificial intelligence (AI) has been envisioned as having satellite-territorial-integrated networks as potential key enablers[1--3]. Future B5G and 6G are anticipated to offer not only a noticeably higher network intelligence than current 5G, but also a wider frequency range, higher transmission rate, shorter delay, and wider coverage. In order for the B5G and 6G to be significantly more intelligent in their self-learning, self-optimizing, and self-managing capacities, data-driven AI technologies will play a crucial role. Numerous data-driven advancements in network management, optimization, and automation have been made during the last several years, significantly raising the degree of intelligence of wireless communication networks.

II. SYSTEM ARCHITECTURE

We have created the first true-data testbed in the world for real-time large datagathering, storage, analysis, and intelligent closed-loop control in order to enable true-data experimentation with techniques and schemes for intelligent mobile networks. the TTIN is made up of on-site 5G/B5G experimental networks, a data warehouse and data collecting system, and an AI engine and network optimization system. Commercially available instruments and equipment have been used in the TTIN. The NE20E-S routers, the Huawei AAU5613, the Huawei BBU5900, the Huawei NE20E-S servers, the Huawei disc arrays, and the Huawei optical transceivers are the main components of the on-site experimental 5G/B5G networks. Additionally, the data collection platform and the wireless big data platform, respectively, utilise commercial servers and the industrial Hadoop platform. The robust computer cluster of the intelligent computing platform is made up of Xeon servers with Tesla V100 GPUs and NVIDIA T4 GPUs. The unified network management platform uses Huawei's U2020 network management technology to provide sophisticated network management capabilities. Additionally, other terminal devices such as the Dingli pilot RCU, Huawei Mate30 smartphones, DH X1100 unmanned aerial aircraft, commercial robots, and automobiles are also available. Following a quick introduction of each essential module, Section 3 will provide further information.

III. 5G/B5G ON-SITE EXPERIMENTAL NETWORKS

The experimental 5G/B5G network uses the 3GPP R15 SA architecture, which includes a full set of core networks, transmission networks, macro base stations, active antenna units (AAUs), small stations, base band units (BBUs), and a

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network management system. The operating frequency lies between 3:5 and 3:6 GHz. With the data interfaces of the core network and transmission network all opened to offer thorough network state data in real time, TTIN may be utilised as a commercial network to support a variety of 5G services.

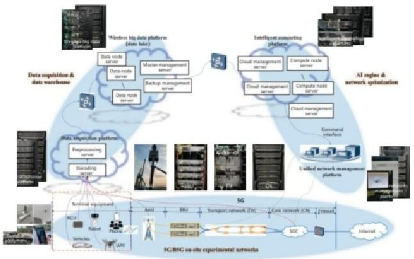


Fig. 2 System architecture of TTIN.

III. FLEXIBLE NUMEROLOGY

By increasing the spacing between the subcarriers in the OFDM waveform, 5G NR offers scalable numerology. The depending on the situation, spacing can range from 15 kHz to 240 kHz. the carrier, deployment circumstance, and service demand frequency. Table 2 included several frequency bands and supported port spacing for subcarriers (SCS). frequency below 2 GHz band can accommodate the 15 kHz SCS. more than 2 GHz and The SCS will range from 15/30/60 kHz below 6GHz, depending on the offering. The frequency range above 6 GHz will make use of 60, 120, 240, and 480 kHz SCS. In accordance with each SCS, Durations of the OFDM symbol, the Cyclic Prefix (CP), and the slot Variations in duration are depicted in Table 4.

TABLE 4. Subcarrier spacing with corresponding sub frame and symbol duration.

Subcarrier spacing (kHz) Δf_s	OFDM symbol duration (µs)	CP duration (µs)	Total symbol duration (µs)	Slot duration (µs)
15	66.67	4.69	71.35	1000
30	33.33	2.34	35.68	500
60	16.67	1.17	17.84	250
120	8.34	0.585	8.92	125
240	4.17	0.293	4.46	62.5
480	2.08	0.146	2.23	31.25
2^n *15kHz (n=0,1,2,…5)	$66.67/2^n$	$4.69/2^n$	$71.35/2^n$	$1000/2^n$

The SCS in 5G NR is scaled by multiplying the factor 2n to 15 kHz. The 15 kHz is the SCS used in the LTE system, and n will be any integer whether positive, negative or zero. In 5G systems, n e[0, 1, 2, 3, 4, 5]. Thus the available spacing will be 15kHz, 30kHz, 60 kHz, 120kHz, 240 kHz and 480 kHz (for example, 15 × 20 = 15 kHz with n = 0 and 15 × 21 = 30 kHz for n = 1). This spacing leads to the formation of mini-slots which provides an additional feature to the NR functionalities. The availability of mini-slots will result in the successful transmission of a very small packet. Mini-slots are the smallest Resource Blocks (RBs) that can be allocated to the user. It carries a control signal with it and used for enabling the low latency communication. The frame structure of 5G NR is highly flexible and sup-ports both FDD and TDD. In the time domain, the basic time unit Tb of NR is given by:

$$T_b = \frac{1}{\Delta f_s \times N_f}$$

Here 1fs is subcarrier spacing which is scalable as the factor of 15× 2n kHz, Nf is the FFT size of 5G NR, which is always assumed to be 4096. Each frame of 5G NR will last for frame duration of Tfd sec, which is calculated by using equation, such that:

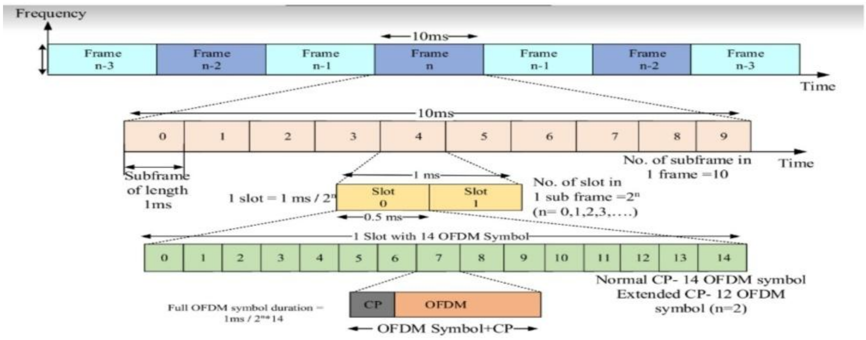
$$T_{fd} = \frac{\Delta f_s \times N_f}{100} \times T_b = 10\text{ms}$$

The frame is then divided into 10 subframes of duration Tsb sec given as under:

$$T_{sb} = \frac{\Delta f_s \times N_f}{1000} \times T_b = 1\text{ms}$$

Thus each frame of 10ms duration is divided into 10 sub-frames of 1ms duration. 5 subframes together combine to form two equal size half frames. These subframes are self-contained, which means the information in one slot can be decoded without dependency on any other slot. Each sub-frame is then divided into flexible number of slots based on Tsb 2n .

For n = 0, the slot duration will be 1ms, and the number of the slot will also be 1 and for n = 1, the slot duration will be 0.5 ms and the number of slots will be 2.



Recently, THz communication is emerging as the tempting technology of 6Gnetwork that will extend the capacity of the system by providing more spectrum ranges. However, these frequencies are susceptible to blockages and high absorption losses, which may limit its deployment to short-range communications only. Moreover, for supporting such high frequencies advance devices, miniature circuitry and small-sized transceivers design with low noise and reduced inter-component interferences are required [93]. Therefore, researchers should focus on investigating the abilities of devices to operate at such high frequencies and modify it accordingly so that high-performance gain can be obtained.

IV. CONCLUSION

The launch of TTIN marks a milestone in the development of 5G/B5G intelligent networks, for it overcomes the mutual isolation of on-site networks, big data, and AI techniques in the current 5G/5G research. The open interfaces and the closed-loop control in this platform enable comprehensive true network data collection, standard dataset production, and intelligent data analysis, which facilitate in situ inspection of AI algorithms and in turn improve the self-learning, self-optimizing, and self-managing capabilities of the networks. Additionally, the established experimental platform is open-source and ever-evolving, where open architecture and white-box hardware are utilized to provide extensible ecosystems.

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