Study on Simplified Test Bench for QoS Analysis using Traffic Models of Pre-5G Service

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***Abstract*—The present paper analyzes the establishment of an overall network, necessary bandwidth, estimated performance and capacity, and the requirements of unit network factors and thereafter proposes the direction for testing/verification of products, for the purpose of developing a new network structure and a new method of service provision to support 5G mobile communications that pursues convergence between different industries.**

Keywords—5G systems; testing; quality of service; quality of experience; business network applications

I. Introduction

Competition to dominate the 5G mobile communications market in advance is becoming fiercer around the world. With emphasis on the emergence of 5G mobile communications technology and changes in industries, Europe's 5GPPP has published a brochure titled "5G empowering vertical industries" and a vertical-industry-related white paper about automobile, medicine, factory, energy, and entertainment industries in 2015 and 2016. In these publications, 5GPPP concentrated on the next-generation mobile communications eco-system, where existing industries (conventional industries) and 5G technology are combined. 5G is an outstanding technology in terms of transmission time latency and the capacity for accommodating terminals, and is much superior to long-term evolution (LTE) technology. The maximum target rate is 20 Gbps in a stationary condition, which is 20 times faster than that of LTE, which enables only 1 Gbps. 5G technology can efficiently process services that cause large-volume data traffic, such as video contents, VR, or hologram. Therefore, services that require high-level reliability such as autonomous driving, remote operation, and remote surgery could be offered by using 5G technology [1].

Hence, countries around the world are making efforts to provide an interface between different industries and to offer an environment where new services and business models can be freely proposed, developed, and thereafter tested and verified. To conduct testing for each network requirement for 5G mobile communications systems, testing each service is necessary.

This study analyzes and examines the development of an environment that enables a hardware-connected multi-purpose integrated 5G standard model that can support verification of the core technologies and service of 5G, in addition to new communications structure and parts, and the requirements of a test platform with structure, reconstructability, flexibility, applicability, and operability, which are the technologies unique to a network for the purpose of supporting vertical industry (other industries) and a system for testing. It is intended to identify and research diverse requirements for vertical industry by conducting verification and interlock testing of core network and vertical industries (medical, autonomous driving, healthcare, etc.) on the pre-5G test platform, to reflect standardization [2]. This study introduces studies about 5G test bench based on hardware developed by Korean industry–university–institute collaboration projects and about testing verification.

II. Requirements for 5G Mobile Communications System

The current form of LTE network will not be able to satisfy such requirements for future service, which is represented by large-volume data and low latency, ultimately to catalyze evolution into a next-generation network, which has properties different from the current network, i.e., the 5G network. The following three properties are believed to be the factors most essential for the adoption of such rapid changes in the mobile environment: first, a large-capacity pipeline that can cope with an explosive increase in traffic should be offered; second, massive connectivity that can enable a smooth connection to the network from numerous mobile devices and IoT devices should be offered; and third, near-zero latency E2E connectivity that can allow a smooth augmented-reality service and mission-critical M2M should be provided.

Approximately 100 services that are currently offered or have a high likelihood of commercialization in the future in the four areas of home, industry, public, and personal including services suggested by "Next Generation Mobile Networks" (NGMN), which is an organization composed of major mobile communications companies, device manufacturers, and research institutions around the world, IEEE papers, and similar services were analyzed. Subsequently, call attempt numbers per subscriber of each service, data rate per call, and call maintenance time were materialized into a traffic model to calculate data volume.

Service bandwidth R×Number of devices subscribing service × simultaneous connection rate Q_τ× traffic model T = Data volume (1)

There are diverse 5G service use scenarios and traffic patterns, but when based on the number of call attempts per subscriber, rate per call, and call maintenance time, 5G service can be categorized into monitoring type, reading type, and tangible and immersive service. The traffic volume for the year 2020 was calculated by applying the average traffic volume per cell of LG U Plus as of 2015, traffic model of each service type, and call attempt number per subscriber, and was estimated to rise to 2,230 PB, which is 17.8 times larger than the current level. In terms of proportion of traffic generation, out of LTE (VoLTE, web portal, video service), home, public, industry, and personal areas, the traffic generation volume of personal (tangible/immersive service) area was the highest at 65%. [3]

As the range of 5G applications is wide as such, diverse services and new business models are expected to emerge. Mobile carriers will introduce network slicing technology in order to raise the efficiency of use in establishing the 5G network. In addition, the volume of traffic to be generated in 5G should be estimated in order to predict the basic structure of 5G infrastructure, overall network design, necessary bandwidth, and the performance and capacity required for unit network factors of 5G. For the prediction, the traffic trends of the current 4G network traffic should be analyzed.

A. Current Status of 4G Traffic and Issues of Mobile Communications Network

Technologies including CoMP and CA were applied for LTE to expand the traffic accommodation capacity and for 5G, technologies such as massive MIMO, in-band full duplex, millimeter wave, and UDN are being developed. However, these technologies only target the expansion of traffic accommodation capacity in the mobile connection section and have undergone no technological/structural advancement other than capacity expansion through installation of more facility in the packet core area. Notably, in 4G EPC, the data after base station should pass through PGW without fail through GTP tunnel to materialize communications, which aggravates the concentration of user traffic on a specific node. It is evident that a serious problem would occur if the 5G network expected to experience a 1,000-fold increase in traffic volume succeeds the existing methodology [2].

The 5G network should economically and stably accommodate a wide variety of IoT devices with diverse characteristics, including devices that require regular connection even though the frequency of connection is low; devices that are connected around the clock and transmit data continuously at over a certain rate; devices that require high connection frequency and high rate when connected, etc. Therefore, the introduction of an efficient IoT control technology for the prevention of network overloading, which could be caused by controlling many devices with one signal and by simultaneous connection of many devices to the network, is necessary. As the current system allocates the same resources while not distinguishing between devices with different traffic, some devices could have relatively more idle resources, causing loss in terms of service production cost. Notably, this functions as a factor for reducing the operation efficiency, as the idle resources existing sufficiently for some service facility cannot be used as substitute resources in case of system failure or functional aggravation.

B. 5G Network Slicing Structure and Major Technologies

In 5G technology, a network structure that enables provision of service to diverse devices with different properties is required. 5G service can largely be divided into eMBB, mission critical, and massive IoT service, and additionally, in the perspective of network operation. First, as for eMBB service, which requires a bandwidth of 20 Gbps or over per cell, significant backhaul of the network is required and various connection methods should be accommodated. Second, in contrast to eMBB, mission critical service requires low latency within 10 ms and stability (e.g. autonomous driving or remote-controlled industrial robot, etc.). Third, massive IoT service requires massive connectivity. These services must use not all recourses of network according to the characteristics of each service. They can provide service by using only specific resources [4][5].

In network slicing, the 5G core network can be separated into the control tier and data tier, which can be materialized into a virtual environment and efficiently support diverse services. An increase in traffic can be handled by installing an additional data-tier facility and an increase in signaling can be dealt with by selectively expanding control-tier facility only, which enables efficient investment. In addition, the efficiency of operation and management such as a change in traffic route and bandwidth adjustment can be improved [6][7].

III. ENVIRONMENT FOR PERFORMANCE ANALYSIS OF 5G COMMUNICATIONS SYSTEM

For an efficient 5G infrastructure and service operation, a definition of the network system and specification of the requirements of the actual operation are required [8][9]. From a physically singular network, an individual network logically separated end-to-end can be created to support a specific service/use case, and thus, this study proposes a testing and research methodology using a traffic model.

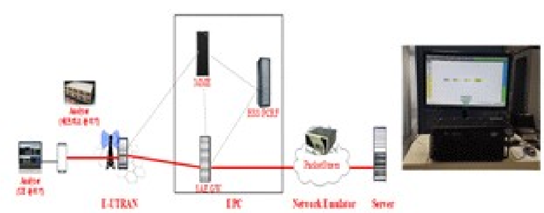

Fig. 1. Network structure of the proposed testing environment

This study can perform measurement by grouping network traffic and service by their type and analyzing them. In some cases, an awareness function that recognizes the analytics facility and application can accompany the analysis. After the analysis, testing of traffic processing function is also expected to be necessary.

The following table lists the examples of test items for supporting the development and verification of Gumi Test Bed 5G convergence service technologies and products.

TABLE I. TESTING SCENARIO

No.	Content of Test
1	Device network (EPC) initial connection test
2	Protocol verification test between device network (EPC)
3	Device bandwidth adjustment test through network (EPC)
4	Device delay adjustment test through network (EPC)
5	Device network (EPC) detach test

For system performance verification of next-generation mobile communications, the feasibility of using RF (millimeter wave) technology should be verified. To propose the guidelines for service development, various service qualities including service coverage, transmission speed, latency, and signal performance index should be measured and analyzed by conducting indoor and outdoor tests with test devices. For this study, traffic analysis was performed by connecting to the actual network in the Lab unit, before conducting outdoor tests.

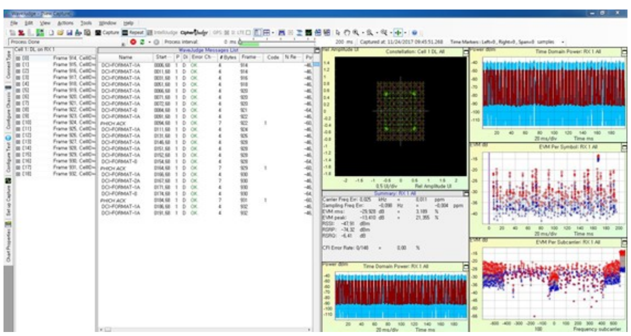

Fig. 2. Analysis of mobile network environment

The test suggests a traffic analysis method based on a wider concept of core network reference model including use case and business model. The model is divided into the infrastructure resource layer composed of physical resources, the business enabler layer to provide specific network functions and performances, and the business application layer to offer specific applications and services of business owners or third parties. In addition, supports such as E2E management to manage these layers and orchestration for the purpose of offering network slicing are necessary. Generally, device framework is a term used to comprehensively refer to the OS, library, API, service agent, and components, and UI widget components required for developing and executing applications and services. The device framework should be defined and optimized in order to offer stable quality and differentiated service. Moreover, performance analysis is required to examine the feasibility of accommodating an extraordinarily large number of devices in a mobile network for the connection of IoT devices, which will continue to increase.

Fig. 3. Example of device analysis

Accordingly, testing and verification of local ISP service and connectivity provision to users in the Lab unit are required before conducting an outdoor test for the measurement and analysis of various service qualities including service coverage, transmission speed, latency, signal performance index, etc., which are the requirements for a mobile network system. According to the test result of this study, the network requirements are satisfied.

IV. CONCLUSION

Network slicing technology has emerged as the leader of today's technological paradigm when the focus of technology is moving toward service-oriented network virtualization technology based on maturing SDN/NFV. Around the world, PoC based on diverse technology and service scenarios is under full-fledged development. Network selection technology is evaluated as the core technology to support a smooth and effective 5G service and the International Organization for Standardization is making many efforts in this regard. This study reviewed the network slice selection technology for supporting 5G service and described challenges according to the characteristics of the service required in the future. As for the section, eMTC should be applied to reduce power consumption by using a narrow bandwidth and expanding the report cycle and to expand coverage by performing repeated transmission function. By selecting a separate IoT server optimized for IoT resource allocation and management independently from a smart phone server, the operating efficiency of the core network is expected to be increased. To minimize signaling load caused by a large number of devices, IoT devices should be grouped into service units and controlled with a singular message.

The current form of LTE network will not be able to satisfy the requirements for future service represented by large-volume data and low latency. Ultimately, evolution into a next-generation network with properties different from the current network, i.e., 5G network, will be promoted. As each tier uses diverse facilities and multiple protocols to satisfy the quality required for the service, a long-time verification is required when launching a new service or applying a new facility, to guarantee mutual compatibility with the existing facility or protocol and the operator must be fully aware of the operation method of the new service or facility. Therefore, in the era of 5G, large-volume user traffic far higher the current level and numerous control signals expected to be mostly generated by IoT devices should be processed in an efficient manner and research for the improvement of network operation through simplified control and management is necessary.

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