On Designing a Performance-Guaranteed Interface for 6G Cellular Networks

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***Abstract*—In cellular networks, performance guarantees at the application layer are essential to realize time-sensitive services such as extended reality (XR), digital twin, and holographic telepresence. To guarantee performances in 5G, cellular systems provide radio resources passively depending on the sender's request. However, how passive resource management can immediately respond to time-varying natures of performance requirements and network delays remains an open question. In this paper, to deal with the time-varying natures, We discuss a new logical interface architecture with guaranteed performance for 6G.**

I. Introduction

Next-generation cellular networks (6G) are expected to support promising services such as extended reality (XR), digital twin, and holographic telepresence [1] by enabling mobile devices to offload heavy computation of the services to edge servers. This offloading works by sending a computation request and receiving its response via RPC (remote procedure call), which is designed to execute the necessary processing from the remote server. To run an RPC operation in a timely manner, it is essential to deliver the entire bits of an RPC message such as an RPC request or response, which we call an application data unit (ADU), within the desired time (i.e., ADU latency guarantees).

In a cellular network, ADU latency is determined by baseline delay that occurs while traversing the network and transmission delay which is the time taken to transmit all of the ADU's data bits [2]. The baseline delay heavily depends on network states such as how far apart the client and server are physically, how congested the network is, and how quickly radio signaling is performed. The transmission delay is decided by dividing the ADU size by the network data rate. By the definition, to guarantee ADU latency, the baseline delay is estimated, and based on this, the transmission delay target needs to be set appropriately so as not to exceed the ADU delay requirement. The cellular system then should allocate radio resources to guarantee the data rate determined to keep the transmission delay within the target. In addition, it is crucial to respond immediately to an increase in network delay due to uncertainties such as network congestion, radio channel errors, and ADU size growth. To this end, cellular systems need to actively manage radio resources in order to keep network delay at an appropriate level based on host application information and network state information, while responding immediately to delay changes, which we call *active networking*. However, traditional cellular systems that passively adjust radio resources depending on the sender's requests are limited in their ability to implement active networking, even with 5G network slicing [3]. In this paper, we discuss a performance-guaranteed interface for 6G enabling active networking.

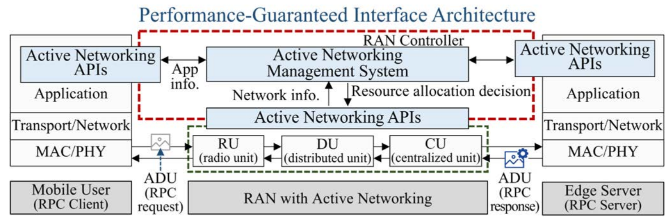

Fig. 1. The proposed interface architecture to actively manage radio resources based on ADU and network status information.

II. Performance-Guaranteed Interface

To implement active networking, we introduce a new management system that actively allocates radio resources based on essential information obtained using our APIs (application programming interfaces), as shown in Fig. 1.

Active Networking Management System: The management system first determines the transmission delay target by estimating the baseline delay from network state information. Then, for transmission delay bounds, the required radio data rate is calculated using the ADU size information. To provide the guaranteed data rate, the management system assigns radio resources within the transmission delay target depending on the spectral efficiency. In addition, upon detecting variations in network congestion, channel errors, and ADU size, resource reallocation is conducted to compensate for the delay growth.

Active Networking APIs: Our APIs are designed to request information about the network topology, congestion, and radio signaling in order to estimate baseline delay. To set transmission delay targets, information about ADU latency requirements, available resources, and spectral efficiency can be queried through the APIs. Moreover, ADU size information is used to allocate radio resources to guarantee the transmission delay. This information is collected periodically so that the management system can react promptly to changes in delay.

III. Conclusion

In this paper, we discussed a new logical interface architecture for 6G that is designed to provide guaranteed performance by actively managing radio resources.

References

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