Analysis Method for Semantic Communication Based Automated Control Systems

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Abstract— In order to provide Ultra-Reliable Low Latency Communications (URLLC) services in 6G mobile communication, achieving high efficiency in the communication system is crucial. However, conventional information communication methods may have limitations in meeting these demands. As a result, interest in the paradigm of semantic communication (SemCom) is growing to surpass these limitations and offer more effective solutions. In this paper, the operation of the automated control system was modeled to propose a novel analysis method that incorporates service performance based on the performance of the mobile communication system. We can utilize performance metrics reflecting the performance of the automated control system in the communication layer from stochastic model. As a result, by optimizing the communication system based on service performance, we confirmed that more efficient service delivery is possible.

Keywords— URLLC, SemCom, Performance metric

Differ 5G mobile communication, where latency and reliability requirements were already stringent, the upcoming 6G mobile communication is expected to demand even stricter latency and reliability conditions, along with potentially larger packet sizes [1]. Consequently, traditional approaches based on Conventional Information Theory (CIT) in mobile communication systems are anticipated to face limitations in providing services. This has led to the emergence of research into a new paradigm called Semantic Communication (SemCom) [2]. In the next-generation mobile communication, discussions are underway about employing machine learning [3] to extract and utilize meaning at various stages, yet much of the current research focuses on semantic information for semantic en/decoding. However, in order to deliver low-latency, high-reliability services in 6G mobile communication, it's necessary to efficiently apply transmission techniques suitable for the communication scenario and the resulting service performance. To achieve this, there's a need for modeling the efficiency stages of the provided service, deriving additional information from the model, and devising methods to optimize the communication system based on this supplementary information. In this paper, to accomplish this, the operation of the automated control system was modeled as a state machine. A statistical model for execution time was derived, enabling the definition of performance metrics from the perspective of efficiency stages in semantic communication. As a result, the performance of services based on the air interface performance of different technological stages could be understood. With this insight, it was demonstrated through experimentation that by applying transmission and reception techniques suitable for the communication scenario, efficient service provision could be achieved.

In this paper, experiments were conducted utilizing a stochastic model derived from the operation of the control system. Performance metrics relevant to communication system design were employed, and these metrics were applied to resource allocation. As a result, we can compare between the distribution of actual latency when resources were uniformly allocated and the distribution of actual latency when resource allocation was conducted fairly, taking into account the probability of users' packet transmission failures based on actual latency. Additionally, a comparison of the averages of actual latency revealed a significant difference in efficiency relative to resource utilization when comparing the two allocation strategies.

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