

SUMMARY OF DOCTORAL THESIS

Thesis title: **Optimal Control of Multicast Video Streaming in 5G Ultra-dense Networks**

Major: Automation and Control Engineering

Code: 9520216

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1. Thesis summary

The mobile network explosion and the Internet development have played an important role in the realization of the Industrial Revolution 4.0 towards the Internet of Things (IoT) in various areas all over the world. In the automation and control industry, ubiquitous devices and control system components are easily connected thanks to the development of disruptive wireless networking technologies. In the networked control system (NCS), recently studies on increasing the flexibility, the ease of diagnose, and the system maintain capacity based on wireless connections have drawn significant attention from the control and automation community. Simultaneously, advanced services and applications have been rapidly developed leading to the requirement of extremely large communication traffic. It is estimated that by 2023 there will be about 5.3 billion mobile users (MUs) connected to the Internet to exchange data, especially video (accounting for 79%). This in turn requires not only the core network upgrades in a costly deployment but also the emerging wireless architectures, system models, techniques, and optimization designs in a much more cost-effective manner, so as to meet the upcoming surge of MUs' demand. In this context, the 5th generation ultra-dense networks (5G UDN) is considered as a promising architecture and also the key to the IoT era.

In this thesis, the author focuses on the 5G UDN architecture and related technologies, control techniques, and resource allocation and management solutions. Particularly, techniques such as cluster, multi-tier, multicast, and device-to-device communication; as well as storage and spectral resource allocation and management solutions are studied to improve the spectral efficiency, enlarge the bandwidth, and expand the network coverage/connectivity. Furthermore, caching and delivering control techniques for video streaming in 5G UDN are explored. These techniques enable the author to propose the joint optimal control of downlink resource sharing and caching selection for maximizing the capacity of multicast video streaming in 5G UDN. Then, the aforementioned control method is developed by considering the social relationship between the MUs and the capacity fluctuation constraint among the MUs to ensure the fairness of quality of service. Finally, one more tier for caching is added to the proposed solution for more flexibility in video source selection control. All the system models are formulated and simulated on computer with Matlab and Genetic Algorithms (GAs) to increase the processing speed while ensuring the exact or approximated optimal results of the optimization problems. The simulation results demonstrate the benefits of the proposed solutions compared to other conventional benchmarks.

2. The new contributions of the thesis

- In the networked control system (NCS): 1) communication between devices in control systems is the 5th generation mobile network; 2) the data in the system is video streaming ones (with large capacity).
- Propose the joint optimal control of downlink resource sharing and caching selection for maximizing the capacity of multicast video streaming in the 5th generation ultra-dense networks (5G UDN) in NCS.
- Optimal control solutions for multicast video streaming in 5G UDN through caching techniques, spectrum resources sharing, device-to-device communications, and clustering with social-aware relationships as well as ensuring the fairness of quality of services for device users (mobile users and IoT devices).

3. Achievable results, scientific and practical significance

The thesis focuses on researching and proposing an optimal control model for distribution of multicast video streaming in 5G ultra-dense network (5G UDN) in order

to improve the quality of service (QoS) and efficient use of caching resources as well as spectrum resources. The specific results obtained include : 1) the thesis has proposed an optimal control of multicast video streaming model to maximize capacity at the Requesting User (RU) with regard to QoS fairness of downlink resource Sharing User (SU) in 5G UDN; 2) improving the proposed model by: i) paying attention to the social relationships of the Caching Helper (CH) and RU; ii) more efficient utilization of SU's spectrum resources, i.e., one SU can share with more than one CH in many different clusters, as long as fairness of QoS is guarantee for SUs; iii) the capacity fluctuation constraint among RUs to assure the fairness of QoS for the RUs; 3) one more tier for caching is added to the proposed solution for more flexibility in video source selection control at the small-cell base station (SBS) to provide RU with maximum capacity and flexibility for video retrieval. From the proposed models, all the system models are formulated and simulated on computer with Matlab and Genetic Algorithms (GAs) to increase the processing speed while ensuring the exact or approximated optimal results of the optimization problems. Hence, the simulation results demonstrate the benefits of the proposed solutions compared to other conventional benchmarks as well as outstanding issues that need solving in the thesis.

The thesis results are a valuable reference contribution to the research community in the field of video streaming optimal control, i.e., the control of multi-tier caching and downlink resource sharing in 5G UDN to maximize capacity video streaming to device users. The scientific significance of the thesis is confirmed through research results published in one article in a prestigious national journal (Journal of Science and Technology: Issue on Information and Communications Technology), one article in the prestigious International journal with ISI index (IEEE Systems Journal, IF = 4.5), and one article presented and published at the International conference on INISCOM'20 (International Conference on Industrial Networks and Intelligent Systems).

4. Thesis structure

The layout of the dissertation consists of introduction, 5 chapters and conclusion as follows:

Introduction

Chapter 1: Overview of the Networked Control System

Chapter 2: Overview of Genetic Algorithms in the problem of video streaming optimal control

Chapter 3: Optimal Control of Downlink Resource Sharing and Caching Helper Selection of Multicast Video Streaming in 5G UDN

Chapter 4: Optimal Control of Social-Aware Spectrum Sharing and Caching Helper Selection of Multicast Video Streaming in 5G UDN.

Chapter 5: Optimal Control of Downlink Resource Sharing and Multi-tier Caching Selection of Multicast Video Streaming in 5G UDN.

Conclusion

Ho Chi Minh City, February 2nd, 2021

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