Fog-assisted Communication in Mobile Edge Computing-based Internet-of-Things (IoT) Networks

zzz ttt
National Mathematical Centre
Abuja, Nigeria
Email: yy@tcd.ie

ppp, and yyy
Trinity College Dublin
Ireland
Email: xx@tcd.ie

***Abstract*—Mobile edge computing (MEC) offers an information and communication technology environment with cloud computing capabilities within the radio access network (RAN). With increasing demand on real-time services, high-bandwidth, ultra-low latency, and minimal energy consumption from a massive number of devices, the fog-based Internet-of-things and MEC framework both have the potential to offer real-time, context-aware processing, and personalized services by leveraging proximity to end-users. However, mobility brings about several bottlenecks that hamper communication reliability within a network. This paper examines the uplink communication performance of an IoT end-device that leverages on a fog device, such as a 5G-enabled mobile device, to offload tasks to a remote MEC server situated at a macro base station. Putting into consideration the channel variations due to mobility of the fog device, we present a closed-form analytical expression for the achievable data rate. We then apply the stochastic gradient ascent optimization algorithm to the formulated problem in order to achieve convergence. Simulation results show an improved learning in the proposed algorithm.**

***Index Terms*—Mobile edge computing, fog, Internet-of-things, stochastic gradient ascent, optimization.**

1. Introduction

Mobile edge computing (MEC) has brought about immense potentials that could be derived from the 5G technology. Driven by diverse use cases such as the Internet of Things (IoT), public safety, explosive data usage, extreme video and gaming applications, and context-aware services, 5G brings about extreme requirements to the network. These requirements range from massive broadband to critical machine communication. As such, MEC will be a key building block in the evolution of mobile broadband and a fundamental technology and architectural concept. MEC entails hosting third-party authorized applications in the operator's network and allows for a synergy, where network providers and content providers can collaborate to provide an improved user experience. The MEC gives room for content developers to provide context-aware services by leveraging the real-time radio access network (RAN) information from MEC.

The emergence of MEC seems to have brought a lasting solution to imminent challenges such as high latency, slower application speed, and link failures, that often characterize the mobile cloud computing paradigm, however, distribution and allocation of computing resources, decisions on where and how to offload in cases of mobility and channel variations, remain a challenge in MEC [1]. Designing a resilient network involves more than the addition of redundant links, it entails minimizing the communication outage by countervailing the impact of the wireless channel. In energy and resource-constrained environment such as IoT, it is often necessary for the IoT end-devices to offload some computation-intensive task unto a remote device or server. This device may not necessarily be situated in the far-away cloud, rather, it could be at the edge of the network. Several researchers [2], [3] have highlighted the need to integrate the fog/edge computing paradigm with the IoT, in view of actualizing the IoT vision. The fog/edge computing based IoT (FECIoT) has the potential to meet the growing demands on real-time processing and data analytics.

The term "FECIoT" was first coined by Lin *et al.* in [2] with a motive to emphasize the immense potential that could be derived by integrating the fog/edge computing paradigm with the IoT architecture. The FECIoT framework consists of IoT end-devices, highly distributed and hierarchically-placed fog/edge devices, and the centralized cloud infrastructure [3]. Recently, the European Telecommunications Standards Institute (ETSI) MEC Industry Specification Group (ISG), was set up to find ways of standardizing the MEC to become an integral part of 5G systems driven by IoT. The ETSI MEC ISG was assigned the task of producing a set of specifications to allow third-party authorized applications to be hosted in a multi-vendor environment [4]. Questions may arise as to what roles MEC will play in the new FECIoT architectural framework. The MEC can readily be deployed in a distributed manner, leveraging on existing cellular infrastructures. Likewise, the FECIoT framework supports service provisioning at the edge of the network, with better prospects for small-to-medium-sized enterprises (SMEs).

In this paper, we consider an uplink communication sce-

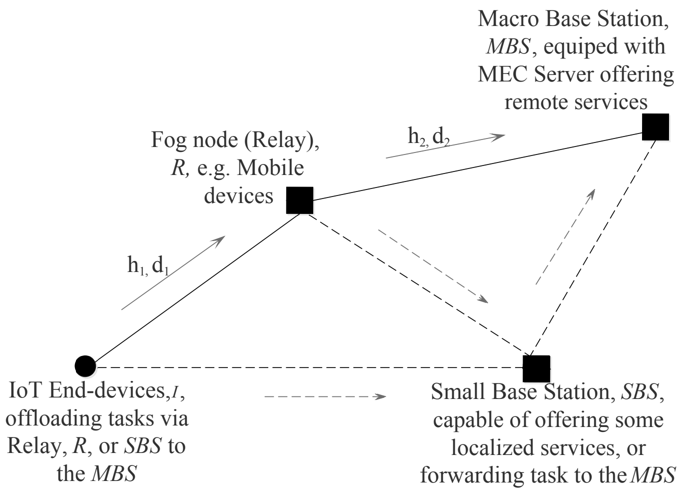

Figure 1. System model.

Table 1. SIMULATION PARAMETERS

Parameters	*Value*
Iterations	1000
Number of simulations	400
Maximum transmit power P_{max}	20 *dBm*
Noise power N_0	-99 *dBm*
Path-loss exponent α	3
Tolerance ϵ	-10^{-2}

nario between an IoT end-device and the MEC server via a 5G-enabled fog device, usually a smartphone. We formulate an optimization problem that maximizes the achievable data rate, and then applied a stochastic gradient ascent optimization algorithm to improve the communication performance of the proposed scenario.

2. System Model

In this paper, we consider an uplink communication scenario as shown in Figure 1, where an IoT end-device offloads data or service request to the MEC server via a 5G-enabled fog device, usually a smartphone.

3. Optimization

4. Results

Table 1 shows the simulation parameters used in our analysis.

This goes to show the vital role the MEC will play in

5. Conclusion

The conclusion goes here.

Appendix A. Proof of the First Zonklar Equation

Appendix one text goes here.

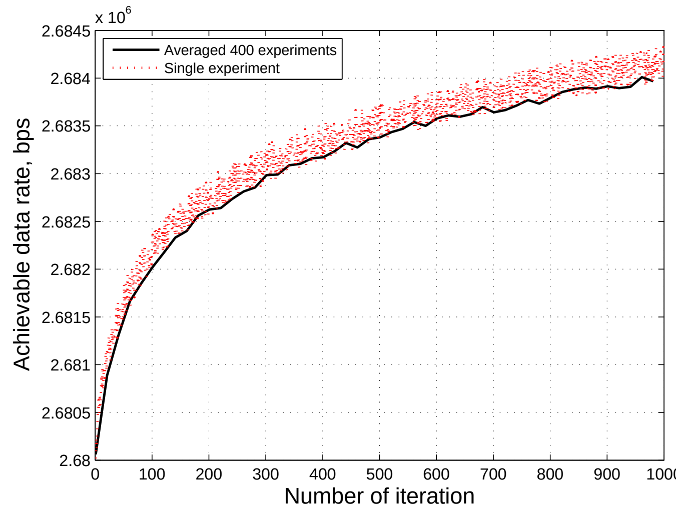

Figure 2. Achievable data rate vs. number of iterations for single stochastic instance and over 400 simulations.

Appendix B.

Appendix two text goes here.

Acknowledgment

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References

[1] Y. Yu, “Mobile edge computing towards 5G: Vision, recent progress, and open challenges,” *China Communications,* vol. 13, no. Supplement2, pp. 89-99, N/A 2016.

[2] J. Lin, W. Yu, N. Zhang, X. Yang, H. Zhang, and W. Zhao, “A Survey on Internet of Things: Architecture, Enabling Technologies, Security and Privacy, and Applications,” *IEEE Internet of Things,* vol. 4, no. 5, pp. 1125-1142, Oct. 2017.

[3] M. Chiang, and T. Zhang, “Fog and IoT: An Overview of Research Opportuinities,” *IEEE Internet of Things,* vol. 3, no. 6, pp. 854-864, Dec. 2016.

[4] D. Sabella, A. Vaillant, P. Kuure, U. Rauschenbach and F. Giust, “Mobile-Edge Computing Architecture: The role of MEC in the Internet of Things,” *IEEE Consumer Electronics Magazine,* vol. 5, no. 4, pp. 84-91, Oct. 2016.