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Secrecy-ensured NOMA-based cooperative D2D-aided fog computing under imperfect CSI

Rajesh Gupta [a], Sudeep Tanwar [a,*], Neeraj Kumar [b,c,d]

[a] Department of Computer Science and Engineering, Institute of Technology, Nirma University, Ahmedabad, Gujarat, India
[b] Department of Computer Science Engineering, Thapar Institute of Engineering and Technology, Deemed to be University, Patiala, Punjab, India
[c] Department of Computer Science and Information Engineering, Asia University, Taiwan
[d] King Abdul Aziz University, Jeddah, Saudi Arabia

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ABSTRACT

Fog Computing (FC) is a paradigm that offers centralized cloud computing services to the proximity of a device, i.e., at the edge for fast, secure, efficient, and reliable processing. Although FC offers many benefits, but it is not ideally suitable for various mission-critical applications such as healthcare, autonomous vehicle, connected cars, and unmanned aerial vehicles. To overcome the aforementioned issue, this paper integrates the concept of Device-to-Device (D2D) communication with the traditional FC. D2D offers faster processing due to the local processing of data at the device itself. But, D2D communication is potentially affected by interferences (from the cellular user and other devices) and noises (additive-white Gaussian noise). This can be mitigated if the Orthogonal Frequency Division Multiple Access (OFDMA) is replaced with Non-Orthogonal Multiple Access (NOMA) scheme. The Successive Interference Cancellation (SIC) technique of NOMA minimizes the interference effect. To improve the secrecy capacity of the network and spectral efficiency, we used a coalition game theory. Simulation results scrutinize the superiority of the proposed NOMA-based D2D-aided FC system over sum rate, secrecy capacity, and processing delay parameters.

1. Introduction

Nowadays (by 2020), the number of Internet of Things (IoT) connections and devices are approx. 11.7 billion and 21.7 billion, respectively. However, it is foreseen by the end of 2025, the number of IoT connections would be more than 30 billion with an average of almost three to four IoT devices per person [1]. Currently, these devices have already been an indispensable part of human lives for gaming, education, business, healthcare, etc. It generates a prodigious amount of data that demands gigantic infrastructure, which is very much costly and hard to afford for everyone. To overcome this, centralized cloud computing is the best solution, which offers various computing resources, services, platforms, and intelligence on pay per use basis [2]. Although, it saves the organization's infrastructure setup cost (i.e., operational cost), but can have many other issues such as single point of failure, delay in data store/access, security, and privacy even in Fifth-Generation (5G) communication networks. The above-mentioned issues are not acceptable for mission-critical applications (AI-based and highly compute-intensive) such as healthcare, connected cars, and industry automation [3,4].

The probable solution to the aforementioned issues is a new paradigm called Fog Computing (FC), which brings computing resources and intelligence in the proximity (or edge) of the mobile user (with minimal storage and processing capabilities) [5]. It eradicates the need for data offloading to the cloud server for further processing and computation. So, it helps users in getting prompt execution and flexible computation that somewhere sort the latency, reliability, and traffic congestion issues for mission-critical applications. So, the entire research community has started working on the prototype of FC to resolve various issues associated with CCS [6]. FC comprises of many fog nodes which extend ubiquitous communication among the huge number of heterogeneous mobile devices to communicate for some purpose [7,8]. FC increases the performance and overall efficiency of data access wirelessly. As the 5G network offers massive connectivity that generates a huge volume of heterogeneous data, which questions the processing and computing capabilities of fog nodes. This forestalls the implementation of FC.

The 5G communication system has an influential technology known as Device-to-Device (D2D) communication, which permits nearby or proximity devices to communicate directly using Bluetooth and WiFi

* Corresponding author.
E-mail addresses: 18ftvphde31@nirmauni.ac.in (R. Gupta), sudeep.tanwar@nirmauni.ac.in (S. Tanwar), neeraj.kumar@thapar.edu (N. Kumar).

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