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Review of Resource Allocation using Fog-IoT NOMA Technique for 5G Communication

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***Abstract*— This review paper explores resource allocation in 5G communication networks using Fog-IoT with Non-Orthogonal Multiple Access (NOMA) techniques. As 5G strives to meet massive connectivity, low latency, and high data rate demands, Fog-IoT enables processing closer to end devices, minimizing latency and enhancing real-time data handling. Integrating NOMA further improves spectral efficiency by allowing simultaneous transmission for multiple users within the same bandwidth. This review analyzes the effectiveness of Fog-IoT NOMA in optimizing resource allocation, addressing challenges such as interference, energy efficiency, and user fairness. By examining recent research, it provides insights into advanced resource management strategies crucial for next-generation communication systems.**

***Keywords*— 5G, IOT, LoRa, Fog, Cloud, Datacenter.**

I. INTRODUCTION

The 5th generation mobile communication technology (5G) is at the forefront of supporting the emerging AI-enabled IoT applications and has evoked technology competitions among different organizations and countries. With the mature of 5G technologies, every "thing" in the world will be connected to the Internet [1]. It is predicted that more than 50 billion of terminals and devices, such as smartphones, tablets, wearable devices, etc., will be connected to the Internet in 2020, which will generate as much as two Exabytes daily IoT data with features of volume, velocity, and variety [2].

Personal safety of mine professionals in open-cast (OC) mines is a critical concern in mines management and administrative agencies. Miners are required to perform many mining activities and hence are prone to unexpected calamities such as slope failure which is a frequently occurring catastrophe in OC mines. With emerging technologies like wireless sensor network (WSN), fog computing (FC), Internet of Things (IoT), and low-power technologies like long-range (LoRa), the task of monitoring OC mines has become more feasible, cost-effective, and efficient [3]. Traditional cloud computing becomes short of handling such a huge amount of IoT data that requests ultra-low latency (i.e., real-time) and services with mobility, due to its centralized management relying on the distant enterprise datacenters belonging to some leading IT companies, such as Cisco, Google, Amazon, Facebook, etc [4].

To make up for the above shortcomings of cloud computing and provide real-time IoT services in the vicinity of where IoT data are generated, fog computing was coined in 2012 by Cisco, aiming at making use of the leisure devices that are distributed in the network edge mostly with one-hop distance from the IoT end devices. These leisure devices can provide rich computing and storage resources after being appropriately organized as fogs [5]. Fog Computing (FC) and Conditional Deep Neural Networks (CDDNs) with early exits are two emerging paradigms which, up to now, are evolving in a standing-alone fashion. However, their integration is expected to be valuable in IoT applications in which resource-poor devices must mine large volume of sensed data in real-time [6]. Motivated by this consideration, this article focuses on the optimized design and performance validation of *Learning-in-the-Fog* (LiFo), a novel virtualized technological platform for the minimum-energy and delay-constrained execution of the inference-phase of CDDNs with early exits atop multi-tier networked computing infrastructures composed by multiple hierarchically-organized wireless Fog nodes [7].

Nonetheless, to efficiently provision IoT services by resorting to fog computing, a lot of significant issues should be

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addressed first. Amongst them, the most important one might be fog planning, in which fogs should be wisely constructed before they become available to provide effective services [8]. The major reason lies in that the edge network devices may be wired or wireless, which differs significantly from each other in many aspects, such as computing/storage resources, capability of supporting the real-time and mobile IoT tasks, communication bandwidth, etc [9]. How to effectively select the most appropriate candidate fog nodes (i.e., network edge devices) to form appropriate fog networks (fogs) so as to provision the diverse IoT services needs to be explored at the first stage. To the best of our knowledge, most of the existing research is conducted under the assumption of pre-designed fogs. Very few works have addressed the fog planning issue [10], [11] and none of them have taken into consideration various IoT data requirements.

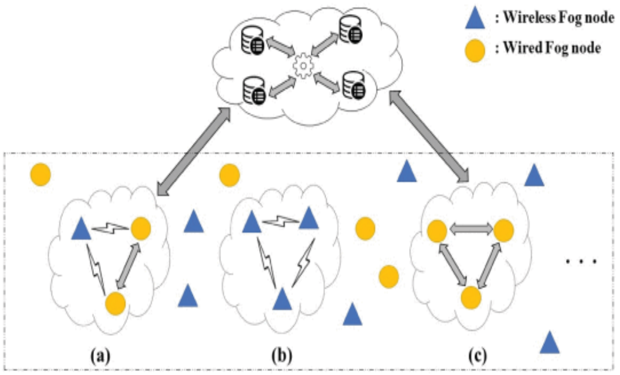

Figure 1: Fog node

The iCloudFog framework is shown in Fig 1. It consists of three layers, i.e., IoT end layer, fog layer and cloud layer from bottom to top. The bottom IoT layer consists of various types IoT devices, such as sensors, smartphones, wearable devices, tablets, etc [12]. These tremendous IoT devices generate a large volume of heavyweight or lightweight IoT tasks that would require services from fogs and/or cloud. Note that we assume there is no direct connection from the IoT end layer to the cloud. Any IoT task must bypass some wired fog node in the fog layer to access the resources in the cloud, if needed.

II. LITERATURE SURVEY

J. D. K. Yadav et al.,[1] presents novel real-time fog-IoT slope monitoring (FIoTSM) system is developed to monitor OC mines. Performance of LoRa coverage is assessed in line of sight (LoS) and no line of sight (NLoS) scenarios. Due to an uncertain condition of mine, where slope failure can occur anytime, latency-free data transmission and processing are required. Thus, IoT is applied to deploy LoRa modules for wireless communication under FC, boosting the monitoring system with the power of LoRa and FC. The data transmitted are permanently stored in cloud servers making it ubiquitously available to users for analytics. The experimental outcome projects the system to be up-and-coming for smart real-time monitoring of slope of OC mines and thereby alert the miners of any failure.

E. Baccarelli et al.,[2] The main research contributions of this article are threefold, namely: (i) we design the main building blocks and supporting services of the LiFo architecture by explicitly accounting for the multiple constraints on the per-exit maximum inference delays of the supported CDNN; (ii) we develop an adaptive algorithm for the minimum-energy distributed joint allocation and reconfiguration of the available computing-plus-networking resources of the LiFo platform. Interestingly enough, the designed algorithm is capable to self-detect (typically, unpredictable) environmental changes and quickly self-react them by properly re-configuring the available computing and networking resources; and, (iii) we design the main building blocks and related virtualized functionalities of an Information Centric-based networking architecture, which enables the LiFo platform to perform the aggregation of spatially-distributed IoT sensed data. The energy-vs.-inference delay LiFo performance is numerically tested under a number of IoT scenarios and compared against the corresponding ones of some state-of-the-art benchmark solutions that do not rely on the Fog support.

H. Tran-Dang et al.,[3] FRATO is based on the fog resource to select flexibly the optimal offloading policy, which in particular includes a collaborative task offloading solution based on the data fragment concept. In addition, two distributed fog resource allocation algorithms, namely TPRA and MaxRU are developed to deploy the optimized offloading solutions efficiently in cases of resource competition. Through the extensive simulation analysis, the FRATO-based service provisioning approaches show potential advantages in reducing the average delay significantly in the systems with high rate of service requests and heterogeneous fog environment compared with the existing solutions.

H. Tran-Dang and D. -S. Kim et al.,[4] In the IoT-based systems, the integration of fog computing allows the fog nodes to offload and process tasks requested from IoT-enabled devices in a distributed manner to reduce the response delay. However, achieving such a benefit is still challenging in the heterogeneous fog systems in which long task queues of powerful fogs can contribute to an average long delay of task execution. To handle the conflict of resource request for task processing this work proposes a distributed fog resource allocation algorithm, namely MaxRU (Maximum Resource Allocation). Through the simulation analysis, MaxRU show potential advantages in reducing the average delay in the heterogeneous fog environment compared with the existing solutions.

M. Whaiduzzaman et al.,[5] Fog computing complements cloud computing by removing several limitations, such as delays and network bandwidth. It emerged to support Internet of Things (IoT) applications wherein its computations and tasks are carried out at the network's edge. Heterogeneous IoT devices interact with different users throughout a network. However, data security is a crucial concern for IoT, fog and cloud network ecosystems. Since the number of anonymous users increases and new identity disclosures occur within the IoTs, it is becoming challenging to grow mesh networks to deliver end to end communications, as the extended IoT networks resemble a mesh architecture. To reinforce data security over IoTs, we deploy a microservice-based blockchain mechanism for fogs, which works as a decentralized client-server network medium (i.e., secured end device-based communication).

R. Marini et al.,[6] The performance of CA-ADR is characterized and benchmarked against the standard solution as well as another proposal presented in the literature. An integrated simulation-experimental approach is used to assess results for large-scale networks and to compare two architectures based on cloud and fog computing. Results show that CA-ADR outperforms standard solutions when connectivity is good, whereas it behaves similarly in large areas. It is also shown that the improvement with respect to the benchmark solutions does not depend on the channel model considered (no shadowing, uncorrelated, and correlated shadowing). Finally, a fog-based architecture is proved to be feasible, with the advantage of reducing the end-to-end latency.

V. -D. Gavra et al.,[7] IoT systems are based sensors and actuators to enable ubiquitous sensing to measure environment parameters from delicate ecologies and natural environments to urban environments. By connecting these sensors and actuators to a big network, like internet, an automatization can be performed, and repetitive actions can be done in background by the IoT ecosystem and save a lot of time. IoT can do such things in Home Automation, Smart Cities and even in Air Quality analysis. IoT solution are dependent on the way sensors are transmitting data to cloud or up to the internet. This work will present the benefits of using Zig Bee instead of using traditional Wi-Fi sensor and present some of the characteristics of LoRa sensors. Cloud computing contributed to the expansion of the IoT systems by offloading local IoT devices of computation intensive tasks. Fog computing brings Cloud closer to the sensors and by doing this minimize communication latencies.

S. S. Vedaei et al.,[8] In the early months of the COVID-19 pandemic with no designated cure or vaccine, the only way to break the infection chain is self-isolation and maintaining the physical distancing. In this article, we present a potential application of the Internet of Things (IoT) in healthcare and physical distance monitoring for pandemic situations. The proposed framework consists of three parts: a lightweight and low-cost IoT node, a smartphone application (app), and fog-based Machine Learning (ML) tools for data analysis and diagnosis. The IoT node tracks health parameters, including body temperature, cough rate, respiratory rate, and blood oxygen saturation, then updates the smartphone app to display the user health conditions. The app notifies the user to maintain a physical distance of 2 m (or 6 ft), which is a key factor in controlling virus spread. In addition, a Fuzzy Mamdani system (running at the fog server) considers the environmental risk and user health conditions to predict the risk of spreading infection in real time. The environmental risk conveys from the virtual zone concept and provides updated information for different places.

R. Tiwari et al., [9] presented a coordinated multipoint JT technique as a part of a CR system in this study. An analytical model for the received signal-to-noise ratio at a CR is developed in order to determine the energy detection threshold and the smallest number of samples required for energy detection-based spectrum sensing in a CR network (CRN) with the CoMP JT technique. This is done in order to determine the energy detection threshold. The received signal-to-noise ratio at a CR can be calculated with the help of this model. The reliability of energy detection-based spectrum sensing was assessed using simulation, and it was determined to be effective. The analytical model is created using the MATLAB software with using communication tool box. With the aim of maximising the users' least throughput, setting the channel allocation and user scheduling with a coordinated multipoint JT approach is presented as an optimization problem.

M. Patel et al., [10] An analysis on numerous researches on MIMO STBC system so as to achieve the higher system performance is standard that the performance of the wireless communication systems can be enhanced by utilization multiple transmit and receive antennas (MIMO), that is typically supposed because the MIMO technique, and has been included. The reference system cryptography (STBC) may be a promising thanks to notice the gain within the wireless communications system exploitation MIMO. To extend the code rate and also the output of the orthogonal area time block code for over 2 transmit antennas is analyzed. The designed system is outperformed once imposed with 16-PSK modulation. The system organized and tested for 4×M and 2×M, wherever M is variety of receiver antennas.

III. CHALLENGES

Challenge 1: data security

With increasing awareness of user data privacy, data security has become a critical element in every communication protocol. Companies including Microchip and STMicro have developed encrypted Integrated Circuit for LoRa products, to lower the risks of data being decrypted. LoRaWAN network service providers, at the same time, have also built much safer connections through IPSec and MQTTS technologies, to protect data transmission between base stations and network servers.

Considering data privacy, consumers won't be willing to join the data flow ecosystem of enterprises. As a result, more data transmitting technologies are going to avoid big name data servers, such as MQTT, CoAP and LWM2M, are appearing in the market. "How to free the whole LoRaWAN ecosystem in order to allow companies to work independently under the alliance's agreement will be urgent issues for LoRaWAN," said Andy Lin, Senior Manager, Advantech.

Challenge 2: competitors

"From the perspective of a LoRa-enabled device maker, how to stand out from several LPWA technologies will be the first challenge, especially from SigFox and NB-IoT," said Jesse Chen, Director of LoRa & Wi-Fi Business Division, Browan Communication. Chen gave an example of the NB-IoT development in China. Its government has subsidized NB-IoT modules, increasing adoption of the technology. Furthermore, NB-IoT can be rolled out with slight adjustments on operators' current base stations. While LoRaWAN needs operators to invest in building base stations from the ground up. "If more operators are willing to invest and to increase the coverage of the LoRa network, there will be more clients offering IoT services based on LoRaWAN," said Chen.

Due to its license-free characteristics, LoRaWAN operates on open frequencies that might incur interference issues, making it unsuitable for large data payloads. Also, the definition of Unicast or Multicast on LoRaWAN hasn't had mature development, making it difficult to serve remote-control applications. "However, each of the LPWA variants plays a major role in the IoT space depending upon the specific use case and connectivity requirements," said Preeti Wadhwani, Assistant Manager, ICT at Global Market Insights.

IV. CONCLUSION

The recent expansion of the Internet of Things (IoT) and the consequent explosion in the volume of data produced by smart devices have led to the outsourcing of data to designated data centers. However, to manage these huge data stores, centralized data centers, such as cloud storage cannot afford auspicious way. There are many challenges that must be addressed in the traditional network architecture due to the rapid growth in the diversity and number of devices connected to the internet, which is not designed to provide high availability, real-time data delivery, scalability, security, resilience, and low latency. In future the implementation of resource allocation problem by taking both load balancing and delay minimizing into account.

REFERENCES

1. D. K. Yadav, P. Mishra, S. Jayanthu and S. K. Das, "Fog-IoT-Based Slope Monitoring (FIoTSM) System With LoRa Communication in Open-Cast Mine," in IEEE Transactions on Instrumentation and Measurement, vol. 70, pp. 1-11, 2021, Art no. 9514611, doi: 10.1109/TIM.2021.3126018.
2. E. Baccarelli, M. Scarpiniti, A. Momenzadeh and S. S. Ahrabi, "Learning-in-the-Fog (LiFo): Deep Learning Meets Fog Computing for the Minimum-Energy Distributed Early-Exit of Inference in Delay-Critical IoT Realms," in IEEE Access, vol. 9, pp. 25716-25757, 2021, doi: 10.1109/ACCESS.2021.3058021.

3. H. Tran-Dang and D. -S. Kim, "FRATO: Fog Resource Based Adaptive Task Offloading for Delay-Minimizing IoT Service Provisioning," in IEEE Transactions on Parallel and Distributed Systems, vol. 32, no. 10, pp. 2491-2508, 1 Oct. 2021, doi: 10.1109/TPDS.2021.3067654.
4. H. Tran-Dang and D. -S. Kim, "A Distributed Resource Allocation Algorithm for Task Offioading in Fog-enabled IoT Systems," 2021 Twelfth International Conference on Ubiquitous and Future Networks (ICUFN), 2021, pp. 455-460, doi: 10.1109/ICUFN49451.2021.9528792.
5. M. Whaiduzzaman, M. J. N. Mahi, A. Barros, M. I. Khalil, C. Fidge and R. Buyya, "BFIM: Performance Measurement of a Blockchain Based Hierarchical Tree Layered Fog-IoT Microservice Architecture," in IEEE Access, vol. 9, pp. 106655-106674, 2021, doi: 10.1109/ACCESS.2021.3100072.
6. R. Marini, W. Cerroni and C. Buratti, "A Novel Collision-Aware Adaptive Data Rate Algorithm for LoRaWAN Networks," in IEEE Internet of Things Journal, vol. 8, no. 4, pp. 2670-2680, 15 Feb.15, 2021, doi: 10.1109/JIOT.2020.3020189.
7. V. -D. Gavra and O. A. Pop, "Usage of ZigBee and LoRa wireless technologies in IoT systems," 2020 IEEE 26th International Symposium for Design and Technology in Electronic Packaging (SIITME), 2020, pp. 221-224, doi: 10.1109/SIITME50350.2020.9292150.
8. S. S. Vedaei et al., "COVID-SAFE: An IoT-Based System for Automated Health Monitoring and Surveillance in Post-Pandemic Life," in IEEE Access, vol. 8, pp. 188538-188551, 2020, doi: 10.1109/ACCESS.2020.3030194.
9. R. Tiwari and K. Mishra, "Performance Analysis of Spectrum Sensing over Cognitive Radio Network with Joint Transmission," 2022 IEEE International Conference on Current Development in Engineering and Technology (CCET), Bhopal, India, 2022, pp. 1-6, doi: 10.1109/CCET56606.2022.10080214.
10. M. Patel and R. Tiwari, "A result analysis of pilot assisted channel estimation in MIMO-STBC systems over time-varying fading channels," 2017 International Conference on Information, Communication, Instrumentation and Control (ICICIC), Indore, India, 2017, pp. 1-4, doi: 10.1109/ICOMICON.2017.8279145.