Managing IoT and Mass Communication in 6G: Strategies for Low Latency Real-Time Applications through Proximity-Based Request Handling

Fariborz Rasoulie
Faculty of Electricity, Computer and Advanced Technologies, Urmia University, Iran; st_f.rasouli@urmia.ac.ir

ABSTRACT

The anticipated integration of 6G technology within the telecommunications sector is poised to significantly enhance communication capabilities in the forthcoming years. The proliferation of 6G within Etisalat's infrastructure is expected to concurrently drive the expansion of the Internet of Things (IoT), facilitating its operation across a diverse array of mobile and stationary devices. Within the IoT domain, particularly under the 6G framework, certain applications necessitate real-time operation and thus warrant prioritization over others in terms of communication and data transmission. The strategic clustering of users, based on assigned weight factors, can bolster the prioritization process, thereby optimizing the efficiency of real-time applications. This paper delineates methodologies for expediting user connectivity—termed 'real-time'—and delineates them from non-time-critical applications. The implementation of Density-Based Spatial Clustering of Applications with Noise (DBSCAN) is proposed as a viable strategy for clustering IoT devices, thereby managing the increased volume of smaller, more granular data packets characteristic of 6G networks. Utilizing DBSCAN clustering facilitates the preemptive identification of potential user congestion and traffic, enabling the deployment of the outlined strategies to mitigate service degradation and maintain data transfer rates. This research explores the formulation of a prioritized scheduling system for requests, wherein, as per the DBSCAN algorithm, real-time applications are accorded elevated execution precedence.

***Keywords*— IoT in 6G, Real-time applications Clustering IoT, Priority in real time apps, Algorithm DBSCAN**

1. Introduction

The emergence of 6G technology marks the beginning of a revolutionary era in communication, promising an unprecedented increase in capability. This new communication paradigm is expected to provide pervasive and highly reliable connectivity with minimal latency for all users. A significant portion of this volume of users' communication traffic, particularly in urban areas, will heavily rely on wireless communication. The introduction of 6G is likely to lead to a significant increase in communication activities, with the Internet of Things (IoT) becoming an essential part of everyday life. Therefore, it is crucial to develop protocols that enhance usage and efficiency, ensuring compatibility with a wide range of devices, both moving and fixed, across various scales [1]. Effective management of device communication traffic is vital to prevent data congestion and user overload, thereby maintaining the integrity of communication networks. Projections suggest a significant rise in the number of IoT devices, from 30 billion between 2020 and 2025 [2].

In communications discussions, it makes sense that all users of any application should enjoy low latency and high reliability. However, there are situations where base stations or any other service provider can have problems with many requests from different users. With many requests, each serving station can act as a bottleneck for a part of the network. On the other hand, consider a situation where in an area with users and a large number of

---

http://dx.doi.org/10.22133/ijwr.2024.427353.1196

Citation. F. Rasoulie, "Managing IoT and Mass Communication in 6G: Strategies for Low Latency Real-Time Applications through Proximity-Based Request Handling", *International Journal of Web Research*, vol.6, no.2,pp.89-96, 2023, doi: http://dx.doi.org/10.22133/ijwr.2024.427353.1196.

**Coressponding Author*
Article History: Received: 27 September 2023 ; Revised: 4 December 2023; Accepted: 27 December 2023.

connections and data exchange, everyone wants a low delay in service, so this issue and the management of mass requests can be a major problem in 6G [3]. Consider, for example, a telesurgery scenario loop where communication is required to have very low delays for the physician and nano sensors and operating robots. In the meantime, the service network should be able to distinguish between requests that should have very little delay compared to other requests and normal applications. For this purpose, we provide a solution under the title of having a higher priority in communication for real-time users using the Density-Based Spatial Clustering of Applications with Noise (DBSCAN) method to establish a connection. DBSCAN clustering algorithm has the ability to create clusters with different volume sizes and different densities. Also, the ability to adjust the operating range considering efficiency and reliability is one of the important and obvious features of this method. In this article, we use the DBSCAN method to assign specific priorities to users, and according to their usage, we cluster users' requests in order to have the least delay in connections. Also, we put hard real-time requests that can't tolerate delays on a higher executive priority. In this study, we employed the Sklearn dataset within the Python environment, utilizing the Pandas library for testing and evaluation of the model.

2. Background 5G & 6G

The use of the fifth-generation communication protocol is currently being used all over the world. Also, the sixth generation (6G) of communication takes on different dimensions due to different applications from its previous generation (5G). 6G will increase global traffic in the future and we will see an explosive growth in the number of users [4]. The sixth generation of communication should be in such a way that it can perform tasks in different types of different and heterogeneous devices [5]. The 6th generation brings with it emerging technology and technologies that were not in the previous generations and only in 6G [6]. This generation of communication will provide users with high reliability along with very low delays and stable connections. Therefore, the latest generation of communication protocol is in the initial and research stages that should be addressed.

Naturally, along with the advantages of this generation, it has challenges such as the volume and number of data packets in it, which should be designed to design a new protocol based on the ability to manage and control data packets in different types of devices (small and large, mobile and non-mobile) [7]. to be 6G must have the ability to perform tasks and establish communication in various types of large and small devices anytime and anywhere. Hence it is referred to as having everything connections in a variety of applications [8]. In 6G, we will see the technology of communication through large smart surfaces, and this means the ability to simultaneously support more users than 5G. In this section, we will discuss various aspects of 5G and 6G communications. The expansive connectivity potential of 6G highlights its foundational role in the development and proliferation of novel technologies, which will operate within a three-dimensional [9] and global framework. 6G is expected to utilize Low Earth Orbit (LEO) satellites to establish robust connections and facilitate data rates on the order of terabits per second [10, 12]. Some of the technologies that are expected to advance with 6G include holographic and tactile internet. This period will also see ongoing improvements in wearable and implantable devices, brain-computer interfaces (BCI), unmanned aerial vehicles (UAVs), autonomous systems, and augmented, virtual, and mixed realities, solidifying their importance in the realm of rapid communication systems [11]. Table 1 and Figure 1 presents a comparison of the features between the fifth and sixth generations of communication technologies. These characteristics express the power of 6G in the future and its bold role. With a specialized view of the above table, it can be found that the next generation communications with new parameters and features provide communications with very high capability, much less delays and at the same time more scalability for the future [13, 14]. 6G has increased end-to-end latency requirements from five milliseconds to less than one millisecond. In 6G, the processing delay is 10 nanoseconds, which shows a significant improvement compared to the previous generation [15]. It has also increased the traffic capacity in an area to one gigabit per second per square meter. Reliability has also reached the optimal value of 99.99999, which expresses an important role in applications.

2.1. Real-time applications

As shown in Figure 2, real-time applications include human intra-body chips for monitoring vital signs, doctor robots, hospitals, assistive drones, search and rescue robots and drones, and the like. Also, most of these applications have a deadline time and must complete their tasks in a short period of time. Therefore, these applications require acceptable quality of service and high data rates in communications and connections [16, 17]. In fact, there are time-sensitive applications where time plays a critical role, including time-sensitive machines or sensitive networks [18]. For example, consider the remote surgery scenario. performing surgery on the patient's body remotely requires nano

Table 1. 6G VS 5G.

Parameters	***5G***	***6G***
Peak data rate	20Gbps	**1Tbps**
Data rate that the user experiences	100Mbps	**<1Gbps**
Delay end-to-end	1ms	**>1ms**
Mobility	500km/h	**1000km/h**
Reliability	99.999%	**99.99999%**
Signal bandwidth	100MHz	**1GHz or more**
Location accuracy	about 10m	**in centimeter**
Covering	Normal	**3D**
Delay in processing	100 ns	**10 ns**
Type of support devices	➢ Smartphones ➢ Sensors ➢ Drones	➢ Sensors & DLT devices ➢ XR & BCI equipment ➢ Smart implants chip & CRAS

sensors so that it can work easily and without error inside the body and perform its task. From this point of view, having the stable and at the same time, fast communication with high reliability is one of the goals and responsibilities of 6G [19, 20]. So obviously user clustering can be useful. Making a distinction to give priority to applications and real-time programs with higher priority and lower priority is one of the important requirements in creating stable and fast communication.

3. Related work

The challenge of managing mass requests and users traffic requires a big data model. As classified in [21], the traffic (in 6G) flow forecasting approaches can be divided into three categories: 1) Optimistically; 2) parametric; and 3) nonparametric methods. Given the wide range of conditions for short-term traffic flow prediction, we will delve into these three categories in detail, taking into account various traffic scenarios. Optimistic methods refer to traffic forecasting models that rely on mathematical statistics, such as historical averages and clustering approaches. Despite their simplicity and efficiency, these methods fall short in capturing the uncertainty and nonlinearity inherent in traffic dynamics.

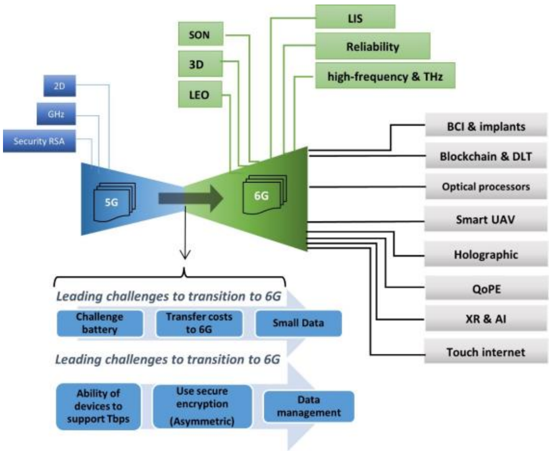


Figure. 1. Features, applications and challenges in the transition process from the fifth generation to the sixth generation.

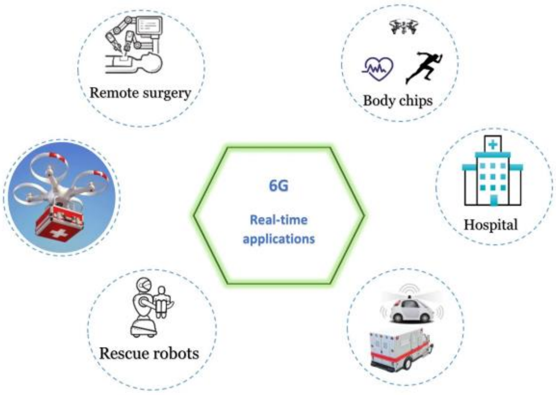


Figure. 2. Real-time applications that 6G should support and IoT activity expands in them.

Parametric methods employ the overall data distribution to derive a set of parameters and predict future traffic trends. Some common methods include ARIMA and its variant SARIMA, which are based on time series analysis [23, 25], as well as the macroscopic traffic flow analysis model for improved accuracy [22, 26], among others. Despite their high predictive accuracy, these methods involve a complex parameter estimation process and have been found to be ill-suited for unstable traffic conditions. Also, the majority of nonparametric methods are driven by data and do not impose any restrictions on data distribution. These include techniques such as neural networks and pattern recognition methods, among others. Locality-sensitive hashing (LSH) is one of the methods introduced to extract traffic patterns over time. But this method is non-parametric and highly sensitive to time. Locality-sensitive hashing (LSH) is one of the methods introduced to extract traffic patterns over time. But this method is non-parametric and highly sensitive to time. Also, Li et al. [27] applied Bayesian networks to execute a multi-measure chaotic time-series prediction method. Dai et al. [24, 25] formulated a GRUs model, which uses traffic data to forecast short-term traffic flow. However, these studies primarily focus on time series, neglecting broader contexts. To address these limitations, Zhang et al. [26] used convolutional neural networks (CNNs) to integrate time and spatial data for traffic flow analysis. Despite these advancements, all the aforementioned neural network methods share common drawbacks: they lack high interpretability and heavily rely on the scale of the data [28].

Generally, given the diverse contexts in which existing research is conducted, it's challenging to determine the superiority of a method. However, when compared to non-parametric methods, many researchers have found parametric methods to be superior due to their robust self-learning and adaptive capabilities. Consequently, we propose a data-driven parametric method that can yield more precise training outcomes in a relatively short response time. Our theoretical and research findings indicate that our approach can be seamlessly integrated into an online traffic control system, resulting in improved performance. In this paper, we will use the Poisson approach to solve the traffic problem.

4. Purpose method

In this section, we consider a scenario where we cluster users using the geographic location and power of IoT devices. We assume that most devices can communicate with each other through the D2D method. It performs clustering based on the information and data that the user requesting the high-priority service receives from nearby devices. Also, we consider it as core. In this study, we used the Sklearn dataset in the Python environment and used the Pandas library to test and evaluate the model. Also, we used the Twitter Sentiment Analysis Dataset with 2401 tweets and user IDs and assigned different priorities to them. In total, we divided the data set into three parts: train, validation and test. The ratio of division is 70%, 15% and 15%, where 70% is related to train.

***Algorithm*:** DBSCAN clustering algorithm is a method in which data in a certain range can form a cluster together. In such a way, there is a factor named Min-point that specifies the number of users that must exist in the desired radius from the core, and we must have the same number of users in a desired area to form the cluster. Also, the radius of the desired area of the core to form the cluster is represented by (ε) Epsilon. Therefore, we assume the core as a device that itself requires a low delay in information transmission and on the other hand, it initiates clustering to determine priority. Also, the data that is not included in the clustering are considered as noise data. It can be seen in Figure 3.

***Scenario*:** In this scenario, each device has its own sending and receiving capacity and range. Also, we assumed that the devices can communicate with each other using the Ad-hoc method. In this way, users who are close to each other form a cluster. When the desired clusters are completed in our problem, it can be clearly seen that when the number of clusters in a part of the desired target community becomes more and bolder, we should expect more congestion of users and traffic in that area. Now this is crowding can be caused by gatherings, festivals and even unforeseen crises or any other reason.

Clustering is done on the kernel side based on signals received from nearby users. Based on the strength of signals received from others, the core obtains information about their location and their uses. On the other hand, we assume that every service request has a priority, and we categorize them according to Table 2, and for each type of them, we consider a weight factor for prioritization according to the applications. According to Table 2, we consider specific parameters for each application, which are used to determine and assign each user's priority according to the table. In the table, the types of applications are categorized, and a different label is assigned to each type. The first row of the table shows real-time applications that do not tolerate errors and do not waste time. Which we consider under the heading of high Priority. Because these applications do not have the ability and tolerance of time delay and require ultra-fast connections. These types of applications could include remote surgery using nano-sensors to move and work inside the patient's body and vital signs

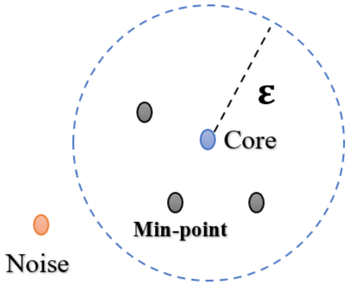


Figure. 3. Structure of Algorithm DBSCAN for clustering.

Table 2. Prioritize applications

Priority	***Applications***
High	Real time
Medium	Normal
Low	No priority

monitoring chips in the human body and such things. In addition, it can include chips that are placed in human bodies and are mobile. This category of applications has a deadline and their connections and data transfer should be done with high priority. Otherwise, and the impossibility of providing an acceptable data rate in the desired time period means that the connections will not be made and the information packets will be sent unsuccessfully.

In the second row, there are normal uses that can include watching movies, sending text, and things like that. This type of applications has a shorter time limit than real-time applications, and if necessary, they can be delayed in cases that are seen with a medium priority label. In the last row, there are applications whose conditions do not have a time limit and bear more time costs and are known as low priority. And they can establish their communication and transfer data at another time.

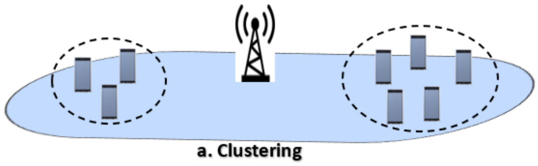
Therefore, after the applications are categorized according to specific parameters and a time tag is assigned to each of them, a weight coefficient is assigned to each tag to determine the position of each user in the clustering. For this purpose, real-time applications are assigned a higher weight factor, which means that they have a deadline and should have a higher priority. And their connections and communications cannot be delayed.

5. Mechanism & Result and discussion

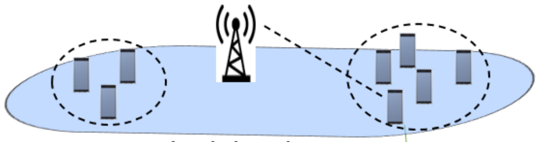
As shown in Figure 4, it is clearly seen that after user A decides that he needs a fast and real-time connection, he can consider himself as the core and use the data. And it starts clustering with signals received from nearby users. Finally, after clustering, when user A knows the number of users and devices in his cluster and what their requests and programs are, he can set the priorities according to Table 2 and send his request to the closest Send workstation. To receive service from the base station in the shortest time. Even if that station is busy and working at its maximum capacity. Meanwhile, it is important to mention that when the clustering radius is small, more and smaller clusters are formed. Also, when we consider the number of users that must be in a cluster to form a cluster, the probability of creating clusters decreases because the algorithm needs to find more examples in a certain radius to form a cluster. For this purpose, we must consider both parameters as suitable and practical.

Clustering process for assigning priority to users:

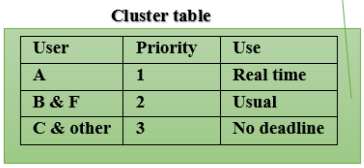
1) Collect data from nearby devices. (Devices are connected via D2D method).



a. Clustering



b. Priority assignment



Cluster table

User	Priority	Use
A	1	Real time
B & F	2	Usual
C & other	3	No deadline

Figure. 4. The process of clustering and assigning priority to user A due to having real-time application and fast connection to the workstation.

2) Whenever the core feels that it needs the data of the surrounding devices, it can collect them in various ways.

3) Clustering based on the data collected by the kernel according to the algorithm DBSCAN. So that clustering can be done according to the power of the core to send and receive data signals, and this power can be different in each core and depending on whether it is mobile or non-mobile. Also, clustering in mobile nuclei can be done continuously depending on their mobility. But it is much less possible to do this in non-mobile cores.

4) Notifying the priorities to the devices in the cluster and informing the workstation of the priorities and receiving service from it.

In total, solutions to determine priority:

- Each device uses communication methods to send signals to nearby devices that include their applications, positions and power. This data can also be collected through MDT. (MDT is a method that enables operators to collect data from users' devices in a network to improve service quality and reduce costs).
- Clustering is initiated by a user who prioritizes real time and does not tolerate time delay. Therefore, it considers itself the core. And depending on different parameters, it places its nearby devices in its cluster.

- When the kernel clustering is finished, priority tables are created based on that, and the kernel gets to know which user and application have the priority to receive service from the workstation. When it comes to the conclusion that it has a higher priority, it tries to receive service from the nearby workstation by sending signals under the title that it has a higher priority. (of course, in the meantime, the device can inform other devices in the cluster about its priority).

5.1. Poisson function

Also, we calculate the Poisson random variable and the probability distribution for the clusters that are formed. In this case, using Equ(1), we calculate the outage probability and service quality drop for the clusters. And we get the number of lost connections using Poisson probability. Therefore, suppose that the random variable X is the number of successes in a Poisson experiment, then its probability function will be as follows:

$$P(X = x) = e^{-\lambda}\frac{\lambda^{x}}{x!}; \quad \lambda > 0, \quad x = 0, 1, 2, \dots \tag{1}$$

If I consider the average number of events in a unit of time equal to λ, it is wise to calculate the average number of events in t equal to the time unit t λ.

For example:

Let's assume that in a cluster, the probability that connections will be returned with a lower priority due to the presence of users and real-time applications is equal to 1%. The probability that five connections will be rejected and returned among 300 clusters formed in an area can be seen in Table 3 In the first row. As can be seen in Table 3, we calculated the probability of missing connections for different clusters. Therefore, considering 300 clusters and with a probability of 1% returning and rejecting connections with lower priority, we calculated the probability of not connecting for 5 and 10 devices. We also calculated for the clusters with the number of 500 and 700 as a result of these calculations which can be seen in Table 3. Therefore, it can be concluded that as much as the number of devices with the same 1% equal to probability increases in a cluster, the probability of connection failure decreases significantly.

Table 3. Calculation of Poisson probabilities for clusters with different parameters.

	Clusters	*Returning connection*	*Probability of rejection (%)*	*Possible answer*
1	300	5	1%	**0.1008**
2	300	10	1%	**0.0008**
3	500	5	1%	**0.1754**
4	500	10	1%	**0.0181**
5	700	5	1%	**0.1277**
6	700	10	1%	**0.0709**

5.2. Assessing Proposed Method: Innovation VS Merits

The innovation that the Density-Based Spatial Clustering of Applications with Noise (DBSCAN) method brings is not using computing servers. Obviously, due to the communication and group management of user requests with each other, we do not need any active and concurrent servers. Due to assigning a higher priority to each of the real-time requests, these requests can proceed without delay and spending more time than establishing connections. In this way, real-time requests will experience higher reliability and less uncertainty in communication. In addition, the emergence of clusters with different traffic volume and density is one of the advantages of using the DBSCAN clustering algorithm. In this method, real-time requests such as remote surgery have higher priority than other users' normal requests (such as video or music). On the other hand, the existence of a larger volume of communication traffic (round trip) to detect the priority of users can be one of the weak points of the proposed method.

6. Conclusions

This research examines the deployment of 6G technologies, with a focus on real-time applications, to achieve satisfactory Quality of Service (QoS) and data rates within a specified timeframe. The study proposes a prioritization scheme where non-critical applications in high-traffic areas are assigned lower priority to expedite the implementation of real-time applications within the Internet of Things (IoT). This ensures stable and reliable connections for time-sensitive applications. In scenarios where congestion is prevalent, such as file sharing, streaming, and social networking, effective management of network resources is essential. The proposed model prioritizes applications requiring swift operation, such as telesurgery enabled by nano sensors, vital sign monitoring via intra-body chips, and emergency rescue robots. The objective is to minimize communication delays, thereby providing the anticipated data speeds through optimal resource allocation within the IoT. Users' requests are directed to the nearest service station to minimize service latency. The methodology delineated in this paper distinguishes real-time applications, ensuring they maintain high service quality without disruptions. For model testing and evaluation, the Sklearn dataset was utilized on the Python platform, specifically leveraging the Pandas library. The study highlights the advantage of employing a density-based clustering method, which facilitates the formation of user groups with disparate traffic volumes and densities. However, it also acknowledges the method's limitations in scenarios with minimal communication load. Also, the best performance of the proposed method is in clusters with a batch size of 300, which is less likely to reject users' requests. It is obvious that by adjusting the parameter ε, the size of the clusters can be adjusted according to the criterion of reliability and uncertainty in communication.

Declarations

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

No funding was received for conducting this study.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors declare that they have no conflicts of interest.

Acknowledgements (optional)

The authors of the paper warmly thank the editor and editorial office of International Journal of Web Research, who provided great assistance to the entire process, as well as all the referees who provided valuable assistance in evaluating the submissions.

Appendix

Acronym	Definition
6G	6 Generation.
5G	5 Generation
AI	Artificial intelligence.
AR	Augmented reality
BCI	Brain computer interface.
CRAS	Connected robotics and autonomous system.
CNN	convolutional neural Network.
D2D	Device to device
DQL	Deep Q-learning
DBSCAN	Density based spatial clustering of applications with noise
IoT	Internet of things
LEO	Low Earth orbit
ILP	Integer linear programming
MEC	Mobile edge compute
MDT	Minimization of drive test
MR	Mixed reality
PSO	Particle swarm optimization
QoS	Quality of service
UAV	Unmanned aerial vehicle
VR	Virtual reality

References

[1] I. F. Akyildiz, A. Kak, and S. Nie, “6G and Beyond: The Future of Wireless Communications Systems,” in IEEE Access, vol. 8, pp. 133995-134030, 2020, https://doi.org/10.1109/ACCESS.2020.3010896.

[2] A. Montazerolghaem, “Efficient Resource Allocation for Multimedia Streaming in Software-Defined Internet of Vehicles,” in IEEE Transactions on Intelligent Transportation, vol. 24, no. 12, Dec. 2023, https://doi.org/10.1109/TITS.2023.3303404.

[3] A. Mondal and S. Misra, “FlowMan: QoS-Aware Dynamic Data Flow Management in Software-Defined Networks,” in IEEE J. Sel. Areas Commun., vol. 38, no. 7, pp. 1366-1373, 2020, https://doi.org/10.1109/JSAC.2020.2999682.

[4] N. Chen and M. Okada, “Toward 6G Internet of Things and the Convergence with RoF System,” in IEEE Internet of Things Journal, vol. 8, no. 11, pp. 8719-8733, 2021, https://doi.org/10.1109/JIOT.2020.3047613.

[5] F. Guo, F. R. Yu, H. Zhang, X. Li, H. Ji and V. C. M. Leung, “Enabling Massive IoT Toward 6G: A Comprehensive Survey,” in IEEE Internet of Things Journal, vol. 8, no. 15, pp. 11891-11915, 2021, https://doi.org/10.1109/JIOT.2021.3063686.

[6] O. L. A. Lopez, H. Alves, R. D. Souza, S. Montejo-Sánchez, E. M. G. Fernández and M. Latva-Aho, “Massive Wireless Energy Transfer: Enabling Sustainable IoT Toward 6G Era,” in IEEE Internet of Things Journal, vol. 8, no. 11, pp. 8816-8835, 2021, https://doi.org/10.1109/JIOT.2021.3050612.

[7] N. Parvaresh, M. Kulhandjian, H. Kulhandjian, C. D'Amours and B. Kantarci, “A tutorial on AI-powered 3D deployment of drone base stations: State of the art, applications and challenges,” in Vehicular Communications, vol. 36, p. 100474, 2022, https://doi.org/10.1016/j.vehcom.2022.100474.

[8] W. Saad, M. Bennis, and M. Chen, “A Vision of 6G Wireless Systems: Applications, Trends, Technologies, and Open Research Problems,” in IEEE Network, vol. 34, no. 3, pp. 134-142, 2020, https://doi.org/10.1109/MNET.001.1900287.

[9] C. L. Stergiou, K. E. Psannis, and B. B. Gupta, “IoT-based big data secure management in the fog over a 6G wireless network,” in IEEE Internet of Things Journal, vol. 8, no. 7, pp. 5164-5171, 2021, https://doi.org/10.1109/JIOT.2020.3033131.

[10] H. Viswanathan and P. E. Mogensen, “Communications in the 6G Era,” in IEEE Access, vol. 8, pp. 57063-57074, 2020, https://doi.org/10.1109/ACCESS.2020.2981745.

[11] Y. L. Lee, D. Qin, L. C. Wang, and G. H. Sim, “6G Massive Radio Access Networks: Key Applications, Requirements and Challenges,” IEEE Open J. Veh. Technol., vol. 2, no. December 2020, pp. 54–66, 2021, https://doi.org/10.1109/OJVT.2020.3044569.

[12] Y. L. Lee, D. Qin, L. C. Wang, and G. H. Sim, “6G Massive Radio Access Networks: Key Applications, Requirements and Challenges,” in IEEE Open J. Veh. Technol., vol. 2, pp. 54-66, Dec. 2020, https://doi.org/10.1109/OJVT.2020.3044569.

[13] H. Tataria, M. Shafi, A. F. Molisch, M. Dohler, H. Sjöland and F. Tufvesson, “6G Wireless Systems: Vision, Requirements, Challenges, Insights, and Opportunities,” in Proc. IEEE, vol. 109, no. 7, pp. 1166-1199, 2021, https://doi.org/10.1109/JPROC.2021.3061701.

[14] R. Arshad, H. Elsawy, L. Lampe and M. J. Hossain, “Handover Rate Characterization in 3D Ultra-Dense Heterogeneous Networks,” in IEEE Trans. Veh. Technol., vol. 68, no. 10, pp. 10340-10345, 2019, https://doi.org/10.1109/TVT.2019.2932401.

[15] S. A. Al-Ahmed, M. Z. Shakir, and S. A. R. Zaidi, “Optimal 3D UAV base station placement by considering autonomous coverage hole detection, wireless backhaul and user demand,” in J. Commun. Networks, vol. 22, no. 6, pp. 467-475, 2020, https://doi.org/10.23919/JCN.2020.000034.

[16] P. Yang, Y. Xiao, M. Xiao and S. Li, “6G Wireless Communications: Vision and Potential Techniques,” in IEEE Netw., vol. 33, no. 4, pp. 70-75, 2019, https://doi.org/10.1109/MNET.2019.1800418.

[17] K. Dedecius and R. Zemlicka, “Sequential Poisson Regression in Diffusion Networks,” in IEEE Signal Process. Lett., vol. 27, no. 5, pp. 625-629, 2020, https://doi.org/10.1109/LSP.2020.2987723.

[18] M. Cheraghchi, “Expressions for the entropy of basic discrete distributions,” in IEEE Trans. Inf. Theory, vol. 65, no. 7, pp. 3999-4009, 2019, https://doi.org/10.1109/TIT.2019.2900716.

[19] W. U. Mondal and G. Das, “On Exact Distribution of Poisson-Voronoi Area in K-Tier HetNets with Generalized Association Rule,” in IEEE Commun. Lett., vol. 24, no. 10, pp. 2142-2146, 2020, https://doi.org/10.1109/LCOMM.2020.3002532.

[20] S. Manzoor, Z. Chen, Y. Gao, X. Hei, and W. Cheng, “Towards QoS-Aware Load Balancing for High Density Software Defined Wi-Fi Networks,” in IEEE Access, vol. 8, pp. 117623-117638, 2020, https://doi.org/10.1109/ACCESS.2020.3004772.

[21] M. Adhikari and A. Hazra, “6G-Enabled Ultra-Reliable Low-Latency Communication in Edge Networks,” in IEEE Communications Standards Magazine, vol. 6, no. 1, pp. 67-74, Mar. 2022, https://doi.org/10.1109/MCOMSTD.0001.2100098.

[22] B. M. Williams and L. A. Hoel, “Modeling and forecasting vehicular traffic flow as a seasonal arima process: Theoretical basis and empirical results,” J. Transp. Eng., vol. 129, no. 6, pp. 664-672, 2003, https://doi.org/10.1061/(ASCE)0733-947X(2003)129:6(664).

[23] J. Xiao and Z. Wang, “Traffic speed cloud maps: A new method for analyzing macroscopic traffic flow,” Physica A, Stat. Mech. Appl., vol. 508, pp. 367-375, Oct. 2018, https://doi.org/10.1016/j.physa.2018.05.122.

[24] Y. Li et al., “Multiple measures-based chaotic time series for traffic flow prediction based on Bayesian theory,” Nonlinear Dyn., vol. 85, pp. 179-194, Feb. 2016, https://doi.org/10.1007/s11071-016-2677-5.

[25] G. Dai, C. Ma, and X. Xu, “Short-term traffic flow prediction method for urban road sections based on space–time analysis and GRU,” IEEE Access, vol. 7, pp. 143025-143035, 2019, https://doi.org/10.1109/ACCESS.2019.2941280.

[26] W. Zhang, Y. Yu, Y. Qi, F. Shu, and Y. Wang, “Short-term traffic flow prediction based on spatio-temporal analysis and CNN deep learning,” Transportmetrica A, Transp. Sci., vol. 15, no. 2, pp. 1688-1711, 2019, https://doi.org/10.1080/23249935.2019.1637966.

[27] L. Qi et al., “Privacy-aware data fusion and prediction with spatialtemporal context for smart city industrial environment,” IEEE Trans. Ind. Informat., vol. 17, no. 6, pp. 4159-4167, June 2021, https://doi.org/10.1109/TII.2020.3012157.

[28] W. Zhong et al., “Multi-dimensional quality-driven service recommendation with privacy-preservation in mobile edge environment,” Comput. Commun., vol. 157, pp. 116-123, May 2020, https://doi.org/10.1016/j.comcom.2020.04.018.

Fariborz Rasoulie is interested in computer engineering and computer science and data processing. He received his bachelor's degree in computer engineering in 2019. Also, in 2023, he successfully obtained his master's degree in the field of computer engineering and computer networks from Urmia National University. He is currently a doctoral candidate in the field of computer engineering. Also, some of his favorite topics are data mining, artificial intelligence, software design, deep learning, and current topics related to computer science. Also, the field of AI and sixth generation (6G) communication is also his research area.