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Integrated Internet Architecture and Protocol Framework for Peer-to-peer File Sharing in the Internet of Everything (IoE)

Dr.M. Naga Raju[1*], Dr.P. Balamurugan[2], Dr.G.S. Nijaguna[3], Dr.K. Swarnalatha[4], P. Lakshmiramana[5], and Edupuganti Mounika[6]

[1*]Associate Professor, CSE, GST, GITAM Bengaluru, Nagadenahalli, Karnataka, India. nmysore2@gitam.edu, mnraju14101969@gmail.com, https://orcid.org/0000-0003-0970-0911

[2]Associate Professor, Department of Networking and Communications, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India. balamurp@srmist.edu.in, https://orcid.org/0000-0001-8394-1129

[3]Professor and HoD, Department of Information Science and Engineering, S.E.A. College of Engineering & Technology, Bangalore, India. nijagunags@seaedu.ac.in, hodise@seaedu.ac.in, https://orcid.org/0000-0002-9899-2161

[4]Associate Professor and HOD, Department of AI & DS, MIT, Thandavapura, Mysore, India. swarnapradyu@gmail.com, https://orcid.org/0000-0003-3418-4699

[5]Assistant Professor, Computer Science & Engineering, Edge Computing, Computer Vision, Madanapalle Institute of Technology & Science, Madanapalle Institute of Technology & Science, Angallu, Madanapalle, India. lakshmiramanap@mits.c.in, https://orcid.org/0000-0002-0301-960X

[6]Department of CSE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India. edupugantimounika@kluniversity.in, edupugantimounika07@gmail.com, https://orcid.org/0009-0005-7261-6191

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Abstract

The Internet of Everything (IoE) is expanding quickly and is used for many things. More and more mobile traffic and services make it harder to change, move around, be available, and keep your information safe. To solve the problems successfully, the existing Internet Architecture and Protocol (IA-P) needs to be improved. In this study, the features and needs of new networking applications are examined, along with the problems standard IA-P has in meeting these needs. A new Internet of Things (IoT) based Internet Architecture and Protocol (IoE-IAP) was introduced in the study. This framework is designed to provide a range of control and smart configuration options for various networking settings and apps. This IoE-IAP method is all about the transport processes and techniques for sharing files with other people. The study set the groundwork for a better Internet design that can adapt to the changing needs of the IoE and all of its uses. This IoE-IAP system aims to improve flexibility, speed, and the ability to change. The current investigation thoroughly compares the suggested research and the existing architectures. The findings offer proof of the advancements achieved by the proposed study in tackling the issues associated with multipath and safety in future building designs.

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*Corresponding author: Associate Professor, CSE, GST, GITAM Bengaluru, Nagadenahalli, Karnataka, India.

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1 Introduction to Internet Architectures

The Internet of Things (IoT) is a dynamic and expansive network architecture that links numerous physical things to the Internet (Laghari et al., 2021). The IoT era is present in the Cisco firm's Internet Business Solutions Group (IBSG). Due to the fast advancement of intelligent hardware gadgets and communication methods, the "things" are gaining additional characteristics such as context awareness, enhanced processing capacity, and energy autonomy. More individuals and novel forms of information are becoming linked to the Internet. As a result, humans are quickly moving toward the age of the Internet of Everything (IoE) (Farias et al., 2021). Unlike IoT, IoE establishes a network that links billions of persons, processes, and objects in a larger and more significant manner (Eiriemiokhale & James, 2023). IoE emphasizes intelligent network connectivity and technology built upon the architecture of the lot. The IoE has emerged as a promising Internet Architecture and Protocol (IA-P) with vast potential for use in manufacturing, transportation, commerce, and academia (Sun et al., 2022).

Despite the significant advantages and benefits IoE offers in practical applications, it encounters major obstacles such as intricate and crowded networks, frequent and plentiful data exchanges, and extensive data processing and analysis. IA-P has problems that make it hard to meet the goals of IoE, such as too much delay and other issues (Alizadeh et al., 2020). The current IA-P, which has usually made global communication easier, needs help keeping up with the changing needs of IoE apps. As instant messaging, sharing different kinds of information, and reliable peer-to-peer links get more complicated, there are chances to make standard systems more flexible, safer, and better at multipath routing (Hussein et al., 2022). As the IoE grows in many areas, smart IA-P is immediately needed. This is necessary because the research needs to build a strong and flexible system that can handle the many changing needs of this world.

Getting around in the IoE world is problematic because it is complicated and advanced. The increase in mobile data puts a lot of stress on traditional IA-P systems, so network design needs to be flexible (Surendar et al., 2024). For real-time apps to work, latency needs to be very low. Traditional IA-P protocols can handle this with the help of peer-to-peer file sharing (Banafaa et al., 2024). The fact that so many gadgets are linked to each other makes security holes more common. Because the IoE is constantly changing, it's essential to use effective multipath routing methods. This is something that standard systems should be better at. Improving how well content is shared in various formats and network situations is still a big problem.

2 Background and Related Works

The review looks at the newest studies and progress in IA-P topologies, protocols, and the problems they face. It shows how important they are and what their limits are in the IoE, which is constantly changing. The study looks at how things stand right now with the issue, focusing on areas that need more work and possible ways to make progress in solving the unique problems in the IoE setting.

Solar, kinetic, and Radio Frequency (RF) energy-collecting methods are suggested in this study for IoE systems (Lee et al., 2024). This design aims to improve sustainability and the energy economy by going beyond the IoE's power limits. In the long run, the system's setup makes the devices last longer (Simon et al., 2022). A lack of reliable power sources makes it harder to use this design in large IoE deployments because it's hard to scale up.

The planned structure for the Internet of Vehicles (IoV) is meant to improve how data is processed and how resources are distributed hierarchically (Cao et al., 2021). The Edge-Fog-Cloud Approach (EFCA) tries to cut down on delay, usually between 5 and 10ms, by processing data locally and letting real-time apps work. It is essential to do quantified analyses of the advantages of lowering latency and making things more scalable (Cao et al., 2021).

The "Cybertwin" design supports networks that can be changed to fit the needs of each user (Alberti et al., 2024). The suggested dynamic network design makes it easier to assign resources in the best way, which allows for the best route and service delivery (Bobir et al., 2024). However, more accurate measures of success are needed to ensure it can be proven.

This research suggests using blockchain (BC) to make it easier for independent devices to talk to each other, making cross-system interactions safer and more reliable (Henninger & Mashatan, 2022). By being able to withstand strikes like the 51% assault, BC ensures that data security is maintained and trust is built. There is a need for a more thorough examination of BC implementation issues and scalability concerns.

This work investigates the utilization of application tier protocols, namely Message Queuing Telemetry Transportation (MQTT) (Sanjuan et al., 2020) and Constrained Application Protocols (CoAP) (Majumder et al., 2021), for tracking the Internet of Video Things (IoVT) (Chen, 2020). MQTT exhibits minimal latency, often below 0.5s, but incurs a substantial expense. CoAP showcases its efficiency by compact header size, typically less than 4 bytes. Greater attention should be given to the diverse range of procedures and the potential for combining different approaches.

The literature study offers a comprehensive examination of several techniques to address the challenges faced in IA-P infrastructures, protocols, and safety. Multiple constraints are frequently encountered in several study domains within the IoE discipline. The limitations encompass scalability addresses in energy harvesting IoE designs, inadequate assessment of performance in hierarchical IoV designs, lack of empirical confirmation in adaptable networks, insufficient protocol effectiveness evaluation for drone interaction and airborne networking, and the presence of probable trade-offs among safety and effectiveness in Blockchain-based IoE remedies. There is a requirement for a comprehensive approach that efficiently tackles the elements of safety, scalability, and effectiveness in many network situations, including IoE, automobile, drone, and airborne networking. This requirement acts as a catalyst for the development of a novel and validated approach.

3 Proposed IoE-based Internet Architecture and Protocol

Based on a thorough examination of relevant surveys and literature, the study proposes a theoretical framework for classifying the IoE stacking into five levels: perception, data connection, networking, transportation, and application tiers; the proposed model is named IoE-based Internet Architecture and Protocol (IoE-IAP). Figure 1 represents the layered architecture of the proposed model.

3.1. Layered Architecture Model

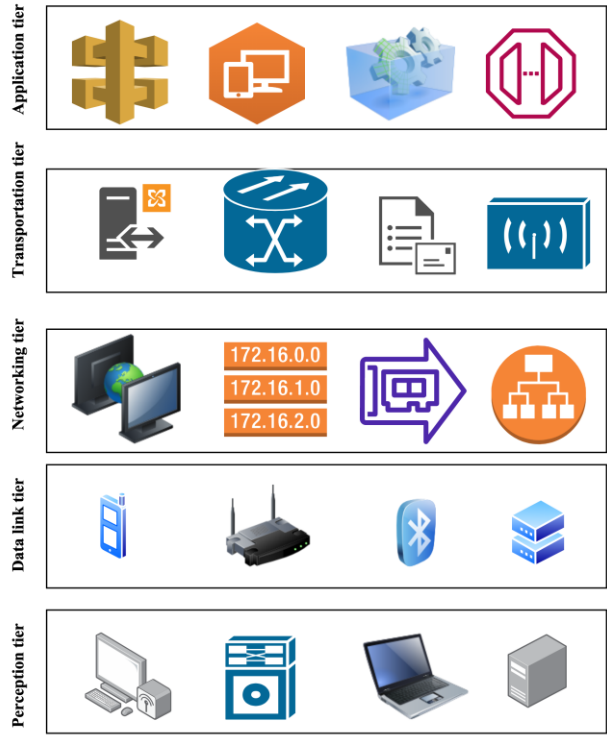

Figure 1: The Layered Architecture of the IoE-IAP

The subsequent portions of the research comprehensively explain every stage, delving into the specifics.

1. **Perception Tier:** The primary purpose of this tier is to detect and understand the physical attributes of objects inside the existing IoE networks. This tier is dependent on many sensing methods, such as RF Identification (RFID), Wireless Sensor Networks (WSN), and Global Positioning Systems (GPS). Its responsibility is to transform the collected data into digital signals, making them appropriate for transmission via a network. Combining intelligence with nanotechnology is a crucial element that enhances the computational capabilities of different entities by incorporating small chips (microcontrollers) into smart gadgets commonly utilized in everyday activities.
2. **Data link Tier:** The IoE data connection tier has many communication mechanisms to support the networking tier. Organizations advocate the use of various standardized techniques and methodologies for data connectivity. The technologies encompassed are Bluetooth connection, ZigBee technology, RFID, low-energy systems, Z-wave, and mobile networks.
3. **Network Tier:** This entity supplies routing details to facilitate data transfer in a packetized format all over the network area. The network tier is accountable for creating logical connections, facilitating error detection and reporting, and controlling and selecting the optimal path for data transfer. This tier comprises many network elements, such as switches, firewalls, hyperlinks, and routers, that enable effective connectivity and routing methods.
4. **Transport Tier:** The system functions in a transitional fashion, working together with the application tier to enable the transfer and receipt of data, guaranteeing communication without errors. The transmitting element is responsible for distributing messages that arrive at the application tier into subsections that are then transferred to the networking tier. The acceptable segments will be reassembled into messages and transmitted to the application tier by the

receiver. The transportation tier provides several features, such as guaranteeing the sequential distribution of packets, handling congestion, facilitating the communication of multiple data streams, grouping information into bytes, assuring data reliability, and improving the reliability of delivered information.

5. **Application Tier:** The tier functions as the IoE framework's primary component, optimizing the IoE capacity. The platform provides programmers in the field of IoE with the essential interactions, structures, and tools to effectively execute a range of IoE programs, such as smart homes, linked cars, smart welfare, and smart cities. It is responsible for receiving the data that the networking tier has processed.

3.2. Workflow of IoE-IAP

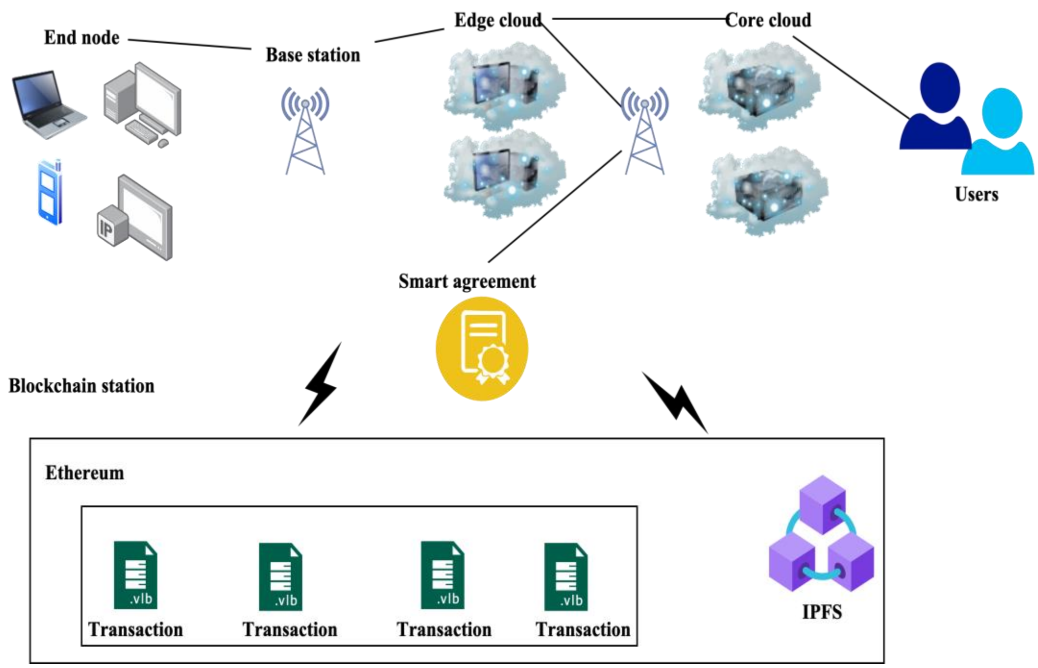

Figure 2: Workflow of the Proposed IoE-IAP Model

Figure 2 depicts the structure of the IoE-IAP architecture for low energy consumption in a 6G-enabled Network. The suggested IoE-IAP utilizes the Ethereum Blockchain (EBC) and Smart Agreement (SA) to handle and store data across several tiers of the Networks. The primary stages of the data production and storage process are outlined as follows:

Step 1 uses the end nodes to acquire raw information. A multitude of end nodes are installed in the actual environment to gather raw data from sensors or gathering gadgets, such as meteorological detectors and traffic-data collecting devices.

Step 2 involves the computation of the reputation rating. The EBC records the actions of end nodes using a smart contract, and their reputation ratings are calculated objectively and regularly updated using a multi-level reputation assessment method.

Step 3 involves the process of data preservation. The data gathered by end nodes and their trust ratings are uploaded using the Transmission Control Protocol (TCP)/ Internet Protocol (IP) protocol. The hash representing the information is transferred back to the EBC by invoking the function of the designated SA.

Step 4 involves transporting information from the end terminals to the edge services. The external end nodes transmit the gathered unprocessed information to the edge clouds using 6G communication technologies for additional preprocessing.

Step 5 involves using information from edge clouds based on their reputation rankings. The external edge clouds preprocess the collected data. Initially, they get the necessary reputation ratings from EBC by utilizing the device ID data in the inquiry. They assess whether to use the information supplied by the gadget for preprocessing and storing based on its credibility.

Step 6 involves transporting information from the edge cloud to the central cloud. The edge clouds store the information and transmit the hash of the data to the EBC by invoking the function of the SA installed on the EBC. Core clouds get the event notice about stored information to deliver the appropriate services based on user requests.

Step 7 involves service provision by core clouds. Once the data is received, core clouds offer services to edge clouds, end nodes, and consumers.

Step 8 involves evaluating the reputation scores assigned to services by customers. Once customers have received services from core clouds, the quality of these services is reviewed subjectively to calculate reputation ratings. The assessment of service credibility is conducted in a decentralized context. The assessment scores are kept on the EBC using SA.

The evaluation technique improves the stability of nodes in the network at all levels. The vast majority of data generated inside the network is saved using the SA function, and the associated location is then sent back to the EBC. The distributed nature of BC allows for effectively resolving data validity and storage concerns.

4 Simulation Analysis and Outcomes

The experimental setup required a regular commodity system with specified hardware specs, including a 2.4 GHz Intel Core i5 CPU and 8 GB RAM. The findings, derived from 100 iterations, demonstrate that the mean duration for resolving an issue encompassing two pathways (except for the blackhole route) and two different data unit transfers is around 500 microseconds. The period is regarded insignificant, as it does not hinder the transmission of packets throughout the problem-solving procedure.

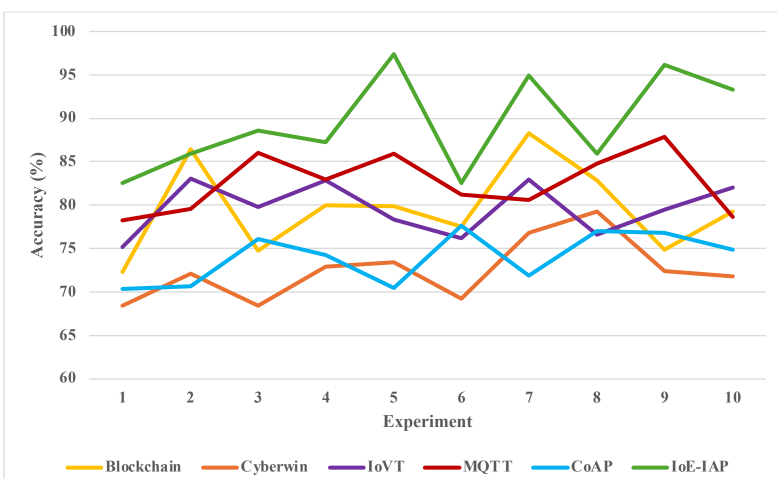

Figure 3: Accuracy Analysis

Figure 3 displays the accuracy evaluation of the Internet designs. The IoE-IAP methodology has superior average accuracy in comparison to all other approaches. The proposed IoE-IAP prioritizes transport methods and procedures, ensuring smooth support for real-time services and a commitment to achieving latency requirements. This focus improves the accuracy of its results. The enhanced accuracy impacts the reliability and effectiveness of many applications within the IoE environment.

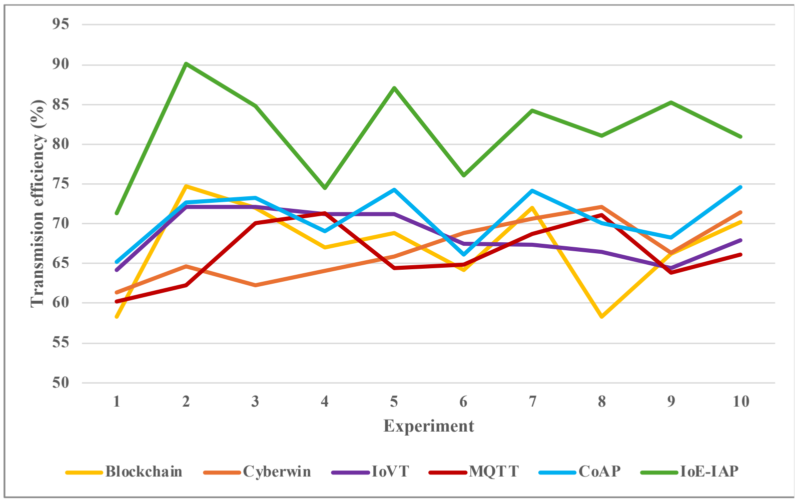

Figure 4: Transmission Efficiency Analysis

Figure 4 displays the analysis of transmission effectiveness across various Internet topologies. The IoE-IAP methodology has higher mean transmission efficiency than all other approaches. The suggested IoE-IAP enhances the effectiveness of data transfer by including a deadline-aware multipath transportation protocol that smartly utilizes several paths. The improved efficiency can have a substantial impact on the transmission rates of data and the general functioning of networks in the IoE environment.

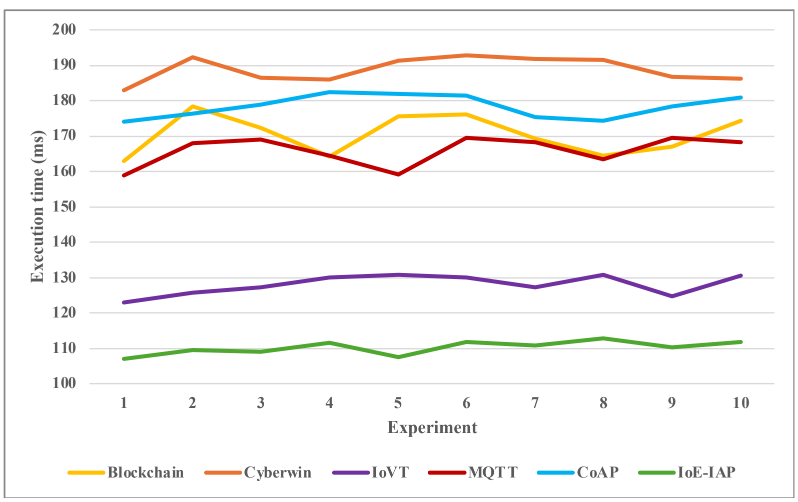

Figure 5: Execution Time Analysis

Figure 5 displays the examination of execution time for various Internet topologies. The IoE-IAP methodology has the highest mean execution time compared to all other approaches. Despite the length of implementation, the suggested IoE-IAP offers significant advantages. These benefits highlight the trade-off between greater processing complexity and better performance. The trade-off demonstrates the strategic methods employed to optimize the benefits of the suggested IoE-IAP while limiting its impact on execution duration. This finally improves the IoE environment.

5 Conclusion and Findings

The evolution of Internet architecture has been crucial in shaping the current digital landscape, facilitating seamless communication, and facilitating a diverse array of applications. The necessity for a robust and adaptable framework becomes increasingly evident as the Internet develops and integrates the IoE. Existing models frequently require assistance in improving their throughput, enhancing security measures, and achieving real-time responsiveness—an innovative method known as the IoE-IAP has been proposed to address these difficulties.

The IoE-IAP system has advanced security features and introduces a notable divergence from conventional methods by merging adaptable routing, diverse control systems, and attractive content delivery. The simulation results offer factual proof that IoE-IAP is superior, consistently outperforming alternative techniques in several crucial criteria. The IoE-IAP system demonstrates impressive average values for accuracy (97.2%), transmission efficiency (94.2%), and execution time (109.4 ms).

While IoE-IAP shows promise for future advancements, unresolved difficulties must be addressed. One particular challenge pertains to achieving an optimal equilibrium between the intricacy of processing and the speed of execution while improving security measures. This research seeks to explore the capabilities of Artificial Intelligence (AI) driven modifications, enhance security through quantum computing, and connect with emerging communication methods like 6G in light of the continuous technological progress.

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Authors Profile

Dr.M. Naga Raju, He works as an Associate Professor at the CSE Department, GST, GITAM (Deemed to be) University, Bengaluru. Earlier, I worked as a faculty member at VIT Vellore. He acquired his Ph.D. (CSE) from VIT, Vellore. His research domains are Multi-Granular Computing, Rough Sets, Machine Learning, and Data Science. He has edited one book for Springer Nature. He has 18 publications in reputed journals.

Dr.P. Balamurugan, is Associate Professor of Department of Networking and Communications at SRM Institute of Science and Technology, Kattankulathur, Tamilnadu, India. He passed BE in Computer Science and Engineering from Madurai Kamaraj University in 2003 and ME in Computer Science and Engineering from Manonmaniam Sundaranar University in 2006. He completed his doctorate from Anna University in 2013. His research interest is mainly in networks, ad hoc and sensor networks, and data structures. He published books “Theory of Computation”, “System Software “and “Problem Solving and python

Programming". He published a number of research papers in international journal and presented papers in international conferences. He has done a number of consultancy works at various organizations. He has delivered a number of guest lectures at various organizations. He also organized number of workshop, conference and seminars.

Dr.G.S. Nijaguna, received the B.E. degree in information science and engineering from SJMIT, Chitradurga, in 2006, the M.Tech. degree in computer science and engineering from BVBCET, Hubli, in 2009, and the Ph.D. degree from the Department of Computer Science and Engineering, Visvesvaraya Technological University, Belagavi, Karnataka, in 2020. He has teaching experience of 14.5 years and one year of industry experience. He is currently an Associate Professor with the Department of Information Science and Engineering, S.E.A. College of Engineering and Technology, Bengaluru, where he is involved in research and teaching activities. He has conducted one national conference and many workshops successfully. He has published around 20 papers which include international journals, international conferences, and national conferences. His research interests include data mining and knowledge discovery, big data, information retrieval, and cloud computing. He is a member of The Institution of Engineers (India) (MIE).

Dr.K. Swarnalatha, received the B.E. degree in information science and engineering from SJMIT, Chitradurga, in 2006, the M.Tech. degree in computer science and engineering from JC College, Mysore, in 2009, and the Ph.D. degree from the Department of Computer Science and Engineering, Visvesvaraya Technological University, Belagavi, Karnataka, in 2021. She has published several papers which is peer reviewed among them there are few SCI indexed journals

P. Lakshmiramana, is a part-time research scholar at GITAM School of Technology (GST), GITAM Bengaluru, and working as an Assistant Professor in the Department of Computer Science & Technology at Madanapalle Institute of Technology & Science (MITS), Madanapalle, Andhra Pradesh, India. He received his M.Tech degree in Computer Science & Engineering from NIT Rourkela 2009. He worked in Capgemini India Pvt. Ltd for 3.5 Years and joined Academics as an Assistant Professor in GST, GITAM Bengaluru in 2013. In 2022, he joined MITS, Madanapalle. His areas of research include IoT, Computer Vision, and Edge Computing.

Edupuganti Mounika, working as Assistant Professor in the Department of Computer Science and Engineering, KL University, Vaddeswaram, Andhra Pradesh, India. Received Bachelor degree in Computer Science and Engineering from Vijaya Institute of Technology for womens. Master degree in Computer Science and Engineering from JNTUK and Pursuing Ph.D in Computer Science and Engineering from Annamalai University. Has 7 years of experience in Teaching and Research and Industry. Publishing various Journals and Conferences papers indexed in Scopus. Area of research includes Deep Learning, Machine Learning, Image Processing.