Chapter-2
Literature Review

A literature review is a critical and comprehensive summary and analysis of existing scholarly research and publications relevant to a specific topic or research question. Its primary purpose is to provide an overview of the existing knowledge, identify research gaps, and establish the context and significance of the new study within the academic discourse. By identifying relevant studies, analyzing key findings, and synthesizing information from various sources, researchers can develop a well-supported theoretical framework and justify their research objectives. A well-conducted literature review showcases the researcher's ability to critically evaluate and integrate existing knowledge, laying the foundation for a new study and contributing to the advancement of the field. The chapter includes the previous studies related to Fog, IoT[1], Cloud computing, and machine learning algorithms for developing task offloading and resource allocation models.

2.1 IoT Overview

According to IEEE[2] Communication Magazine, the IoT is a framework that gives every object a digital representation and online presence. More precisely, the IoT intends to provide brand-new services and applications that connect the real and virtual worlds. M2M[3] communications serve as the foundational communication for interactions between Things and cloud-based applications. Oxford Dictionaries provides a summary definition that calls the Internet an element of “IoT the interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data”.

Aalsadie (2022) discussed that billions of physical objects have been connected thanks to the development of IoT cloud computing to share and gather data for various uses. Despite significant developments, some latency-specific applications are still impractical in the real world because of the limitations of current IoT devices and the distance between the cloud and IoT devices. Fog computing, which makes use of the availability of computing and storage resources at the edge of the network close to the IoT devices, has been created to address the difficulties of

[1] Internet of Things
[2] Institute of Electrical and Electronics Engineers
[3] Machine-to-Machine

latency-sensitive applications. Fog computing does, however, have several drawbacks, including heterogeneity, storage, processing, and memory constraints. As a result, it necessitates a suitable job scheduling technique for making the most use of computing resources at the Fog layer. This article offers a thorough analysis of several job scheduling techniques used in fog computing. It examines and contrasts several task scheduling techniques created for a Fog computing environment to highlight their benefits and drawbacks.

Abohamama (2022) says that applications for the IoT are now essential for raising living standards. However, the resources of conventional cloud data centers are under strain due to the growing volume of data produced by IoT devices. Because of this, cloud data centers are unable to meet the needs of IoT applications, especially those that demand fast response times. A more contemporary computing model called Fog computing brings cloud resources out to the network's edge. Task scheduling is still difficult under this computer paradigm, though. For bag-of-tasks applications in the cloud-fog environment, a semi-dynamic real-time task scheduling technique is presented in this paper. Task scheduling is formulated as an optimization issue using permutations in the suggested scheduling technique. For each scheduling cycle, a modified version of the genetic algorithm is employed to give several permutations for jobs that have arrived. The jobs are then assigned to a virtual machine with enough resources to meet the lowest expected execution time, in the order determined by the best permutation. According to an optimality analysis that was done, the suggested algorithm performs comparably to the best option. In terms of make pan, total execution time, failure rate, average delay time, and elapsed run time, the suggested method is also contrasted with the first fit, best fit, the genetic algorithm, and the bee's life algorithm.

Atzori, Iera, and Morabito's (2010) comprehensively delve into the intricate landscape of the IoT. The authors meticulously dissect the key components of IoT, spanning architectures, communication protocols, and diverse application domains. Their thorough analysis not only identifies challenges but also sheds light on the myriad opportunities within the IoT realm. This work stands as an invaluable resource, catering to researchers, practitioners, and policymakers alike, providing a holistic understanding of the evolution and impact of IoT.

Bandyopadhyay and Sen (2011) focus on the applications of IoT, accentuating technological challenges and standardization issues. This work is pivotal in bridging the theoretical concepts of IoT with pragmatic considerations, serving as a practical guide for industry professionals navigating the intricate landscape of IoT implementation and standardization.

Berman, Cabrera, Jebari, and Marrakchi's (2022) contribution to Patterns introduces the innovative "impact universe" framework. This framework serves as a compass for assessing and prioritizing public interests in IoT deployments, addressing ethical considerations and societal impacts. The work significantly contributes to the ongoing discourse on responsible IoT development, offering crucial insights for policymakers and industry leaders striving to align IoT innovations with societal needs.

Borodin's (2014) article in Educational Resources and Technologies anticipates the transformative potential of IoT in education. By envisioning the integration of IoT into educational settings, the author foresees a paradigm shift in how information is accessed and disseminated, laying the groundwork for discussions on leveraging IoT for educational advancements.

Bubnova and Kryukova's (2014) work in Economics and Society explores the intersection of IoT and customer-centric strategies in modern business practices. Focusing on social client-oriented technologies, the authors illuminate the evolving dynamics of customer engagement. This article serves as a valuable resource for businesses seeking to leverage IoT to enhance customer experiences and adapt to the dynamic landscape of market trends.

The China Internet Watch Team's report (2023) forecasts China's substantial investment in the IoT, projecting spending to reach an impressive US$298 billion by 2026. The comprehensive analysis highlights key IoT market trends in China, offering valuable insights into the nation's technological landscape and its strategic positioning in the global IoT arena. The report serves as a vital resource for industry stakeholders, businesses, and researchers seeking to understand and navigate China's dynamic IoT market.

Chiang (2016) surveyed various articles on fog and IoT. The authors overviewed the research opportunities of Fog Computing. They provide summarized information about the opportunities and challenges of Fog, over the networking context of IoT. The fundamental challenges discussed are like stringent latency requirements, network bandwidth constraints, resource-constrained devices, cyber-physical systems, uninterrupted services to the cloud, and security threats etc.

DeMedeiros, Hendawi, and Alvarez's (2023) survey, published in Sensors, focuses on AI-based anomaly detection in IoT and sensor networks. This research critically examines the integration of artificial intelligence into anomaly detection systems, providing a thorough understanding of current trends and advancements. The survey is a valuable reference for researchers and practitioners involved in IoT security, offering insights into the evolving landscape of anomaly detection.

Duarte's (2023) exploration of the number of IoT devices becomes particularly relevant in understanding the proliferation of connected devices. As the IoT continues to expand, Duarte's work, available on Exploding Topics, offers valuable data and insights into the sheer scale and growth of IoT devices. This information is crucial for stakeholders, businesses, and policymakers shaping the future trajectory of IoT.

Dubravac and Ratti's (2015) form part of the IoT report series by American International Group. The document critically analyzes the trajectory of IoT, exploring whether its development represents an evolutionary process or a revolutionary shift. This whitepaper is a foundational resource for professionals, policymakers, and academics seeking a nuanced understanding of IoT's historical development and future implications.

Guinard, Trifa, Karnouskos, Spiessand Savio's (2010) delve into interacting with the Service-Oriented Architecture-based IoT. The study emphasizes aspects like discovery, query, selection, and on-demand provisioning of web services in the context of IoT. This work is essential for researchers and practitioners involved in IoT architecture and service provisioning, providing insights into the fundamental principles shaping IoT interactions.

Guzuyeva's (2018) contribution in the proceedings of the IV International Correspondence Scientific and Practical Conference focuses on the application of information technology in large and small businesses. The research explores the role of IT in different business scales, offering practical insights into the varied applications of technology in contemporary business environments. This work serves as a valuable reference for academics, business professionals, and policymakers interested in the intersection of information technology and business operations.

Hakan's (2023) focus on bibliometric analysis and scientific mapping of IoT, featured in the Journal of Computer Information Systems, contributes to the scholarly understanding of IoT research trends. The work employs bibliometric techniques to map the landscape of IoT research, offering valuable insights into the growth, trends, and focal points of the field. This research is particularly relevant for academics, researchers, and institutions seeking to comprehend the current state and future directions of IoT research through a quantitative lens.

Katal (2022) discussed the development of new methods to make cloud operations more accessible has increased with the proliferation of IoT devices. The IoT has grown over the past ten years as a result of ongoing developments in hardware, software, and communication technologies, with a daily increase in the number of linked items. The creation of an adequate system architecture capable of processing and storing all of the data is required due to the enormous volume of data generated by these devices. The separate idea of "Fog computing" and the integrated fog-to-cloud computing paradigm is particularly important in this regard for decentralizing the cloud and bringing services closer to the finished system. Fog computing's main objective is to improve common IoT situations by minimizing delays and saving traffic by bringing awareness to the entrance point. Fog computing applications include real-time requirements, wireless networks, and low-power devices. An appropriate Fog computing protocol should be portable, adaptable, and lightweight in light of these factors.

Tzavaras, Mainas, and Petrakis (2023) presented an innovative OpenAPI framework designed for the Web of Things. Published in the IoT journal, the paper introduces a framework that leverages OpenAPI specifications to enhance the interoperability of

Web of Things applications. The authors provide insights into the development and implementation of this framework, contributing to the ongoing discourse on standardization and interoperability in the IoT domain.

Uckelmann, Harrison, and Michahelles (2011) propose an architectural approach for the future IoT. This seminal work, presented in the book "Architecting the IoT," lays out a comprehensive framework for understanding the architecture of IoT systems. The authors explore crucial aspects such as communication protocols, data models, and system components, providing a foundational resource for researchers, practitioners, and educators involved in IoT architecture.

Van Kranenburg (2014) delivers an open lecture on the IoT, contributing valuable insights to the discourse on IoT concepts and applications. This lecture, conducted at MEPhI, covers fundamental aspects of IoT, fostering a deeper understanding of the technology's implications in various domains.

Wagan (2022) conducted a comprehensive review focusing on the Internet of IoMT[4] and converging technologies with real-time applications. Published in the Journal of King Saud University – Computer and Information Sciences, the paper provides an in-depth exploration of IoMT, offering valuable insights into its applications and the integration of trending technologies in the healthcare domain.

Wang (2013) presented a system framework for security management in enterprise systems. Published in Systems and Behavioral Research Science, the research work addresses critical aspects of security management, offering a systematic approach to enhance the security posture of enterprise systems. The authors contribute valuable knowledge to the field of enterprise security.

Wattics (2011) provides insights into smart metering, emphasizing its role in energy management. As a key player in the energy management sector, Wattis offers information on smart metering solutions, contributing to the broader understanding of technologies aimed at optimizing energy consumption.

[4]Internet of Medical Things

Withers (2023) explores how organizations in the AP[5] region can effectively harness the power of the IoT. The article, featured in Computer Weekly, provides strategic insights and recommendations for APAC businesses aiming to leverage IoT technologies for enhanced operations and growth.

Wu, Sheng, and Zeadally (2013) delve into RFID, examining its opportunities and challenges. Published in the book "Next-generation Wireless Technologies," the chapter provides a comprehensive overview of RFID technology, shedding light on its applications, benefits, and challenges that need to be addressed for widespread adoption.

Xing, Li, Wilamowska-Korsak, and Zhang (2013) presented a comprehensive review of Operations Research in service industries. Published in Systems and Behavioral Research Science, the paper explores the applications of operation research methodologies in optimizing service processes across various industries. The authors contribute valuable insights into the role of operation research in enhancing operational efficiency in service-oriented sectors.

Xu (2011) provides a comprehensive exploration of enterprise systems, examining their state-of-the-art features and future trends. Published in the IEEE Transactions on Industrial Informatics, the paper contributes to the understanding of evolving enterprise technologies, making it a valuable resource for researchers and professionals in the field.

Ystgaard (2023) conducted a comprehensive review focused on the theory, principles, and design requirements of the human-centric IoT. Published in the Journal of Ambient Intelligence and Humanized Computing, the paper emphasizes the importance of user-centric design in IoT systems, contributing to the development of more inclusive and user-friendly IoT technologies.

Yudidharma (2023) conducted a systematic literature review, focusing on messaging protocols and electronic platforms used in the IoT for building smart homes. Published in Procedia Computer Science, the review provides a comprehensive overview of the state-of-the-art IoT protocols and platforms for smart home

[5]Asia-Pacific

applications. The authors contribute valuable insights into the technological landscape shaping smart home development.

This section describes in detail the different communication protocols used in fog computing and makes comparisons between them based on important criteria. The explanation of the research difficulties for the communication protocols of fog computing serves as its conclusion.

2.2 Fog and Edge Computing

Fog and edge computing, helps devices to get faster results by processing the data simultaneously received from the devices. Fog computing helps in filtering important information from the massive amount of data collected from the device and saves it in the cloud by sending the filtered data.

Ahmad (2021) discussed that the number of people utilizing the Internet has increased with the spread of smart gadgets worldwide. The primary goal of the fog computing paradigm is to connect a vast array of intelligent objects billions of objects to create a bright future for smart cities. Due to the widespread use of smart gadgets, it is anticipated that these devices will produce enormous volumes of data and transmit that data through the Internet. Fog Computing also refers to an edge-computing architecture that lessens the problem by implementing knowledge discovery at the edges utilizing a data analysis technique. To create a sustainable infrastructure for smart cities, the IoT and Fog Computing techniques can cooperate. The weighted round-robin scheduling technique is the one the author suggests be used to execute the job from one fog node to another fog node and finally to the cloud. First, IoT infrastructure for smart cities is designed using a Fog simulator and the emergent Fog Computing idea. Then, data gathering and routing are done using the spanning-tree routing protocol. The establishment of quick transmission and user communication via 5th Generation networks is also envisaged. The effectiveness of our suggested method is then assessed in terms of reaction time, latency, and data use.

Bittencourt, Lopes, Petri, and Rana (2015) presented research on P2P, Parallel, Grid, Cloud, and Internet Computing, this work is likely to explore virtual machine migration in Fog computing. The authors may discuss the challenges and potential benefits associated with migrating virtual machines in Fog computing environments, contributing to the understanding of resource management in distributed systems.

Bose, Aujla, Singh, Kumar, and Cao (2019) investigated the application of blockchain as a service for software-defined networks, focusing on potential denial-of-service attacks. The authors may discuss how blockchain technology can be leveraged to enhance the security of software-defined networks and address challenges related to denial-of-service attacks.

Dsouza, Ahn, and Taguinod (2014) introduce a policy-driven security management framework for fog computing in their 2014 paper presented at the IEEE International Conference on Information Reuse and Integration. The work may propose a preliminary framework and provide a case study, contributing valuable insights to the development of security management strategies in fog computing environments.

Huang, Yang, and Wang (2017) work is likely centered around secure data access control in fog computing for the IoT. The authors may discuss innovative techniques such as ciphertext update and computation outsourcing to ensure secure data access, particularly crucial in the context of IoT where data privacy is paramount.

Kumar (2022) says that network's edge, Fog computing provides an integrated key to enable communications, data collection, device management, services capabilities, storage, and analysis. This makes it possible to install infrastructure that is centrally controlled in a highly dispersed setting. The most important uses of Fog computing for smart city infrastructure are covered in the current study. The most crucial issue arises when operating a large number of IoT-based services in a smart city context. To deliver novel services, thousands of smart things, cars, phones, and people connect; in this situation, the fog computing infrastructure may be very helpful from a data and communication standpoint. Three primary topics are the subject of this section

a) The deployment of data and applications in fog nodes
b) 5th Generation connectivity leveraging the fog infrastructure
c) Fog-based data management and analytics

These fog computing applications are illustrated with working models from all angles. The effective integration of smart city infrastructure has new use cases. An increasing interest in smart cities has also been taken into account while presenting the difficulties and prospects.

Martin (2017) discussed the OpenFog security requirements and its approaches. This paper provided a security overview of OpenFog architecture and also provided a survey on the functional requirements and the technical approaches. This paper aims to simulate further dialogue on security in OpenFog and fostering future development of novel technologies and practices.

Mebrek (2017) introduces a solution for the increasing demand for IoT devices through the study of the Fog Computing suitability assessment. The authors focus on energy consumption and the Quality of Service as two important aspects of the performance of Fog computing. Therefore, they present the modeling of these two metrics in the fog. The authors expressed the problem as constrained optimization and solved it efficiently using Evolutionary Algorithms. The authors stated that their approach stands out as an energy-efficient solution.

Mohamed (2017) says that Unmanned Aerial vehicle-based Fog Computing IoT aims to utilize the advantages and features of both technologies to effectively support IoT applications. This proposed Unmanned Aerial Vehicle Fog provided fast deployment of Fog capabilities at remote or challenging locations to effectively support dynamic IoT applications. The authors proposed that Unmanned Aerial vehicles equipped with Fog computing capabilities can be used to travel to a specific location when needed and remain in that location to support their IoT applications. The authors discussed some scenarios for such deployments, their advantages, and the issues involved when using the proposed model.

Naha (2018) surveyed trends, architecture, requirements, and research directions. This survey paper is useful to industries and research communities to synthesize and identify the requirements for Fog Computing. The authors overviewed Fog definition, research trends, and the technical difference between Fog and cloud. The authors investigated numerous proposed Fog architectures and discussed the components of these architectures. The authors discussed the taxonomy of Fog computing by considering the requirements, as well as authors discussed the research gap in resource allocation and scheduling, fault tolerance, simulation tools, and Fog-based microservices. Also addressed the limitations of current research work, and presented open issues and future direction for Fog computing.

Pek, Buttyán, and Bencsáth (2013) survey likely provides an extensive overview of security issues in hardware virtualization. The authors may cover various security challenges associated with hardware virtualization, offering valuable insights into securing virtualized environments.

Pooranian (2017) proposed a distributed Fog-based networked architecture that preserves energy in Fog data centers. The authors present a new Internet of Everything architecture for Fog centers to implement the resulting Fog of Everything technology platform. The authors also present the energy-aware algorithm adopt Fog data centers and obtain numerical performance, for a real-world case study that shows that their approach saved energy consumption in Fog data centers.

Ren, Zhu, Qi, Wang, and Sangaiah, A.K. (2019) explore identity management and access control based on blockchain in edge computing for the industrial IoT. The work may discuss how blockchain technology enhances security measures, ensuring robust identity management and access control in industrial IoT environments.

Tao et al. (2019) published a survey of virtual machine management in edge computing. The authors may provide a comprehensive overview of challenges, techniques, and future directions in the management of virtual machines within the context of edge computing.

Sabireen (2021) discussed that performance, security, latency, and network failure are just a few of the problems that integrated cloud computing must contend with as IoT applications continue to grow. These problems are solved by bringing cloud computing closer to the IoT thanks to the development of fog computing IoT. The main purpose of the fog is to deliver the data produced by the edge IoT devices. Instead of sending the data to a cloud server, local processing, and data storage are carried out at the fog node. When compared to the cloud, fog computing offers high-quality, quick-response services. Fog computing may thus be the best choice for enabling the IoT to provide a reliable and highly secure service to a large number of IoT customers. It enables management of services and resource provisioning outside of central control, closer to devices, at the network edge, or eventually at locations designated by SLAs[6]. Fog computing is a prevalent element, not a substitute for cloud computing While providing the option to connect with the cloud's data center, it permits information processing at the edge. The author presents different computing paradigms, fog computing features, an extensive reference architecture of fog with its various levels, a thorough analysis of fog with IoT, different fog system algorithms, and also systematically examines the challenges in fog computing, which serves as a middle layer between IoT sensors or devices and cloud data centers.

Satyakam (2021) says that Fog Computing is sometimes referred to as edge computing, which broadens the cloud computing concept while increasing productivity and reducing latency. With the help of cloud computing, Fog computing is employed to keep up with the steadily expanding demand for IT[7]-related services. With the rapid advancement of IT, fog computing is emerging as a desirable method for retrieving and transforming data connected to IoT applications. This article examines the idea, the architecture, and the use of Fog computing in both current and future applications. Fog technology is quite sophisticated and diverse. One of the main difficulties in running the research work objective is to review recent research on resource distribution in the fog region. The purpose of this survey is to understand the use of Fog computing and make some changes to current technology.

Savya (2021) says that for smart manufacturing, Fog computing offers processing, storage, and network services. The task requests, terminal equipment, and fog nodes, on the other hand, are very heterogeneous in a smart factory. For example, different task characteristics of terminal equipment include high real-time demands for fault detection tasks, high calculation requirements for production scheduling tasks, high storage requirements for inventory management tasks, and so on. The Fog nodes also include a variety of processing capabilities, making powerful fog nodes with

[6]Service Level Agreements
[7]Information Technology

large computational resources competent to assist terminal equipment in processing difficult tasks like factory inspection, defect detection, status analysis of devices, and so forth. With the dispersed architecture that Fog computing offers at the network's edges, access is low-latency, and application requests are handled more quickly. With this increased computational power, new techniques for managing and allocating resources may be created to benefit the Fog infrastructure.

Sood and Mahajan (2017) presented a Wearable IoT sensor-based healthcare system designed for identifying and controlling the Chikungunya virus. The work likely explores the integration of wearable IoT sensors into healthcare, aiming to enhance real-time monitoring and management of viral outbreaks. The authors may discuss the technical aspects of the system, potential applications, and the impact on public health.

Syed (2016) discussed a fog computing pattern, contributing to the field of pattern languages in programs. Patterns often encapsulate proven solutions to recurring problems, and this work may offer insights into common challenges and effective solutions within the context of fog computing.

Wadhwa and Aron (2018) presented at IEEE International Conference on Parallel & Distributed Processing, likely offer a comprehensive exploration of Fog computing integrated with the IoT. The paper may delve into the architecture, applications, and future directions of this integration, shedding light on the evolving landscape of Fog computing in conjunction with IoT.

Yuan and Li (2018) introduced a reliable and lightweight trust computing mechanism for IoT edge devices. The authors may discuss how multi-source feedback information fusion contributes to enhancing trust in IoT edge devices, addressing reliability and security concerns associated with these devices. The research is likely to be beneficial for understanding and implementing trust mechanisms in IoT edge computing environments.

Both fog and edge computing aim to process data more efficiently, enabling faster response times and reducing the need for long-distance data transmission and storage. These technologies will continue to play a crucial role as we move towards more interconnected and data-intensive systems.

2.3 IoT and Fog Computing Applications

Popular Fog computing applications include smart grids, smart cities, smart buildings, vehicle networks, and software-defined networks. Despite the broad utilization of cloud computing, some applications and services still cannot benefit from this popular computing paradigm due to inherent problems of cloud computing such as unacceptable latency, lack of mobility support, and location awareness.

Aljumah (2018) discussed Fog Computing related security issues. They stated that Fog Computing poses a threat to privacy and security of the data and services. The existing security and privacy mechanisms of cloud computing cannot be applied to Fog computing due to the distributed structure, mobility, and heterogeneous nature. This paper provides an overview of present issues in Fog computing.

Aljumah and Ahanger (2018) conducted a comprehensive examination of Fog computing and its associated security issues, presenting their work at an international conference. Reviews, such as theirs, are essential for synthesizing existing knowledge and providing valuable insights into the security challenges associated with Fog computing. This work is particularly valuable for those seeking a consolidated understanding of these issues.

Alonso (2017) proposed Fog computing using public resource computing and storage. Authors introduced the idea to use public-resource computing and storage techniques to shift the workload of the cloud. In this idea, the devices work as participants, who form a data center between cloud and end devices. The participant can be any type of device, from a traditional personal computer to smartphones or tablets, etc. The authors simulate the use of participating nodes in video transfer applications and their results show that the proposed system can be used to solve the bandwidth and computation issue that affects the cloud storage system the author concluded that their system is a feasible solution for applications that process or store public data.

Alrawais, Alhothaily, Hu, and Cheng (2017) delve into the intersection of Fog computing and the IoT, emphasizing security and privacy issues. Given the proliferation of IoT devices and the crucial role of Fog computing in their ecosystem, this research likely scrutinizes challenges related to data security and user privacy. The findings are likely to be pertinent for professionals engaged in designing and securing IoT systems.

Alwarafy (2020) presents a comprehensive survey addressing security and privacy issues in edge-computing-assisted IoT. Published in the IEEE IoT Journal, their work offers a systematic examination of security and privacy concerns in the context of edge computing and IoT. The authors provide insights into the current state of research and outline potential directions for addressing security challenges in this evolving landscape.

Badidi, and Ragmani (2020) propose an architecture for QoS[8]fog service provisioning, contributing to the optimization of Fog computing resources. Published in Procedia Computer Science, their work focuses on enhancing the provisioning of services in fog environments while considering QoS requirements. The authors offer a detailed architecture and discuss its implications, providing valuable insights for researchers and practitioners aiming to improve service quality in fog computing.

Chiang and Zhang (2016) provide an overview of research opportunities at the intersection of fog computing and the IoT. Published in the IEEE IoT Journal, their work addresses the evolving landscape of research possibilities within the context of fog computing and IoT. The authors discuss key challenges, potential applications, and future directions, offering valuable insights for researchers and practitioners exploring this dynamic field.

Delfin (2019) explores the emergence of Fog computing as a new era in Cloud computing. Presented at the International Conference on Computer, Mathematics, and Control, their work contributes to defining the landscape of Fog computing as a distinct paradigm. The authors discuss the characteristics and potential applications of Fog computing, providing valuable insights for researchers, practitioners, and enthusiasts aiming to understand the evolving dynamics of cloud computing.

Din (2018) Published in IEEE Access in 2018work focuses on trust management techniques for the IoT. The study likely offers a survey of existing trust mechanisms,

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[8]Quality of Service

addressing the unique challenges posed by the IoT environment. Trust is crucial in IoT systems, and this research is likely to provide valuable insights for ensuring secure and reliable IoT deployments.

Ema (2019) assesses the suitability of integrating Fog computing alongside Cloud computing. Contributes to the ongoing discourse on the complementary roles of Fog and Cloud computing. The authors discuss the advantages and challenges of using Fog computing alongside cloud resources, offering valuable insights for researchers and practitioners navigating the integration of these computing paradigms.

Gandotra and Lall (2020) focus on the evolution of air pollution monitoring systems, particularly for green 5thGeneration, transitioning from cloud to edge computing their work contributes to the development of environmentally conscious solutions for air quality monitoring. The authors discuss the shift from traditional cloud-based systems to edge computing, providing valuable insights for researchers and practitioners involved in environmental monitoring and the deployment of green technologies.

González-Martínez (2015) presented a comprehensive survey on the intersection of cloud computing and education, offering a state-of-the-art analysis. Published in Computers & Education, their work is instrumental in understanding the transformative impact of cloud technologies on educational practices. The authors delve into various facets, from infrastructure to pedagogical approaches, contributing a valuable resource for educators, policymakers, and researchers in the field.

Heck (2018) investigates the current status and future trajectories of IoT applications within the realms of fog and edge computing. The research work provides a roadmap for understanding the evolving landscape of IoT deployment. The authors discuss potential applications and challenges, contributing valuable insights for researchers, developers, and industry professionals involved in the convergence of IoT, fog, and edge computing.

Henze (2020) addresses the critical issue of data handling requirements in cloud storage systems, providing insights into compliance measures. Published in the IEEE Transactions on Cloud Computing, their work contributes to the evolving landscape of cloud security. By emphasizing the importance of adhering to data handling standards, the authors offer valuable guidance to practitioners and researchers navigating the complexities of secure cloud storage.

Huttunen (2019) explores the synergy of big data, cloud computing, and data science in the domains of finance and accounting their work sheds light on the transformative impact of cutting-edge technologies in financial practices. The authors provide valuable insights into the applications and implications of big data and cloud computing in the financial sector.

Kaur (2020) conducted a systematic literature review addressing security issues within the Fog computing environment. Published in the International Journal of Wireless Information Networks, their work critically examines the current state of security concerns in Fog computing. The authors provide a comprehensive overview, identifying challenges and proposing potential solutions, making it a valuable resource for researchers and practitioners navigating the security landscape of Fog computing.

Khan (2017) presented a comprehensive review of Fog computing security, focusing on current applications and security solutions. Published in the Journal of Cloud Computing, their work provides a detailed analysis of security challenges in Fog computing environments. The authors explore existing applications and propose security solutions, contributing valuable insights for researchers, practitioners, and policymakers concerned with the secure implementation of Fog computing technologies.

From the view of Lai (2021) discussed that the application of the IoT and Fog computing are essential to the development of smart cities because they allow for the administration and interchange of massive amounts of data. The expansion of transportation, tourism, industries, as well as business, has been made possible in recent years by the two major sectors of Fog computing and the IoT. Therefore, the establishment of a smart city will require careful research as well as approaches to use technology innovation to increase the city's strengths. Increase the city's power on numerous fronts. To address the difficulties of network scalability and large data processing, we have explored the advantages of Fog computing in this study using an IoT architecture that is integrated with Fog computing. As a result, the IoT system's design is created in a way that allows the smart city to operate more effectively through network transmission, information processing, and intelligent perceptions.

Li (2016) provides an overview of the progress and challenges in mobile edge computing. Presented at the IEEE Mobile Cloud, their work addresses the dynamic landscape of mobile edge computing, discussing advancements and potential hurdles. The authors contribute valuable insights into the current state of research and development in mobile edge computing, making it a useful resource for researchers and practitioners exploring the integration of computing resources at the network edge.

Mao (2017) conducted a survey focusing on mobile edge computing from the communication perspective. Published in the IEEE Communications Surveys & Tutorials, their work offers a comprehensive analysis of mobile edge computing, emphasizing communication aspects. The authors delve into key challenges, solutions, and research directions, providing valuable insights for researchers, practitioners, and industry professionals involved in mobile edge computing.

Marbukh (2019) FoNUM[9] for the effective management of Fog computing resources, the research work contributes to the optimization of resource utilization in fog computing environments. The author introduces FoNUM as a framework, discussing its implications and potential applications. This work is valuable for researchers and practitioners seeking to enhance the efficiency and utility of Fog computing resources.

Matrouk (2021) says that applications for the IoT have emerged as the most significant methods in the world for facilitating interactions between people and objects to improve quality of life in recent years. Consequently, as more devices are employed in these applications, massive volumes of data will be generated. In 2012, Cisco put out the concept of Fog computing, which sits in between end users 'IoT devices and cloud computing. While Fog computing does not completely replace Cloud computing, it does lessen its downsides, increase its efficiency, and offer storage and computing capabilities at the edge of the internet. The job is a tiny

[9] Focuses on Fog Network Utility Maximization

portion of work that needs to be finished in a certain amount of time. Task scheduling becomes difficult in Fog computing because of the varied and scattered resources it incorporates. To find the best solution for the NP-hard issue of task scheduling, efficient task scheduling techniques must be used. In the preceding years, several scheduling algorithms were suggested; most of them were used in cloud computing, while a smaller number were used in fog computing. The primary current scheduling methods in fog computing are reviewed and analyzed in-depth in this study.

Mebrek (2017) proposes an efficient green solution addressing energy consumption and delay considerations in the context of IoT-fog-cloud computing. Presented at the IEEE NCA[10], their work contributes to the development of environmentally sustainable solutions for the integration of IoT, fog, and cloud computing. The authors discuss the challenges and benefits of their proposed approach, offering insights for researchers and practitioners aiming to enhance the efficiency of energy usage in such computing environments.

Naha (2018) conducted a comprehensive survey examining trends, architectures, requirements, and research directions in Fog computing. Published in IEEE Access, their work provides an extensive overview of the evolving landscape of Fog computing. The authors delve into key aspects, offering insights into trends, architectural considerations, and future research directions. This survey is a valuable resource for researchers, practitioners, and policymakers interested in the state of Fog computing.

Parikh, Dave, Patel, and Doshi (2019) explore security and privacy issues in cloud, fog, and edge computing. This research likely offers a comparative analysis of security challenges across these computing paradigms, providing insights into the unique considerations for each. As computing architectures continue to evolve, understanding the nuanced security and privacy issues is crucial, making this work relevant for researchers and practitioners alike.

[10] Network Computing and Applications

According to Priyadarshinee (2021) by identifying the crucial success criteria in the Indian context, the paper offers a two-stage SEM-ANN[11] model for the establishment of Smart cities using Fog Computing and the IoT. The study offers a brand-new element, called fog computing. The IoT is further broken down into three independent variables: IoP[12], IoS[13], and IoE[14]. A study of 13 smart cities and 379 respondents was used. ANN[15] and SEM[16], which quantify both linear and non-linear interactions respectively, are used to analyze the data. The results of SEM show that Fog computing has significantly benefited from the IoT, IoP, and IoS. The sole exception in the study for the direction of future research in this field is that IoE hurts Fog computing. IoT was shown to have a significant impact on Fog computing in the subsequent layer of ANN analysis using the Structural Equation Modeling accepted variables as input Fog computing. IoT was shown to have a significant impact on Fog computing in the subsequent layer of ANN analysis using the SEM-accepted variables as input Fog computing. Results from the Structural Equation Modeling and neural network are also compared.

Sha (2020) conducted a survey examining edge computing-based designs specifically addressing security concerns in the IoT. Published in Digital Communication and Networks, their work explores the intersection of edge computing and IoT security. The authors provide an overview of existing designs, shedding light on the current landscape of security solutions for IoT within the context of edge computing.

Stojmenovic and Wen (2014) presented at the Federated Conference on Computer Science and Information Systems, introduced the Fog computing paradigm. This foundational work likely outlines various scenarios where Fog computing can be applied and explores associated security issues. As pioneers in the field, the authors contribute key insights into the potential applications and security considerations of Fog computing.

[11]Structural Equation Modeling-Artificial Neural Network
[12]Internet of People
[13]Internet of Services
[14]Internet of Energy
[15]Artificial Neural Networks
[16] Structural Equation Modelling

Yi (2015) conducted a survey addressing security and privacy issues in Fog computing. Presented at the International Conference on Wireless Algorithms, Systems, and Applications, their work contributes to understanding the multifaceted challenges surrounding security and privacy in Fog computing environments. The authors explore existing issues and propose potential solutions, offering valuable insights for researchers, practitioners, and policymakers concerned with the secure implementation of Fog computing technologies.

Zhang (2018) provide a comprehensive examination of security and trust issues within Fog computing. As Fog computing becomes increasingly integral to network architectures, understanding the associated challenges becomes paramount. The authors likely explore various dimensions of security concerns, ranging from data integrity to trust establishment. The survey format indicates a broad analysis of existing literature, offering valuable insights for researchers, practitioners, and decision-makers navigating the evolving landscape of Fog computing security.

The study's findings support the building of additional Smart Cities and assist India's government reach its goal of creating 100 SC[17] as it moves toward sustainable development IoT and Fog computing are revolutionizing industries by connecting everyday objects to the internet and processing data closer to the source. They find applications in smart cities, healthcare, manufacturing, and agriculture. In smart cities, they monitor traffic and enhance public safety. Healthcare benefits from remote patient monitoring, while manufacturing gains real-time quality control. Agriculture uses IoT for precision farming. These technologies enable real-time data analysis and control, transforming the way we live and work by increasing efficiency and reducing latency in various sectors.

2.4 Fog Computing and Smart Cities

Fog computing is a technology that is rapidly influencing emerging digital technologies and applications. There are many challenges in maintaining the data through Fog computing technologies, these challenges are mentioned along with their security concerns that help for the transition from cloud to Fog

[17]Smart Cities

Abbas, Shaheen, Elhoseny, Singh, and Majid (2018), introduce a novel approach to developing sustainable smart cities using self-regulated agent systems and Fog computing. It employs systems thinking to address the complexities of urban environments, offering valuable insights into creating intelligent and eco-friendly cities. The integration of self-regulated agent systems and Fog computing showcases a forward-looking perspective on urban development.

Ahmed (2019) delivers a thorough examination by presenting a comprehensive taxonomy and a set of requirements tailored for Fog computing applications. It systematically categorizes various applications and delineates crucial criteria that are integral to their successful implementation within Fog computing environments. The work serves as a valuable resource for both researchers and practitioners, offering a structured guide for navigating the intricate landscape of Fog computing applications. With its detailed classification and outlined criteria, the study contributes significantly to enhancing the understanding and practical deployment of Fog computing technologies.

Adel (2020) says that the architecture dispersed throughout a region is referred to as Fog computing architecture. This architectural arrangement primarily focuses on software for the aim of constructing a good network, as well as physical and logical network components. Users may communicate flexibly thanks to Fog computing architecture, which also makes sure that storage services are kept up to speed for handling data. However, it has been noted that the real-time application aspect of Fog computing architecture has greatly increased its relevance in the field of education. The survey's primary goal is to provide a comprehensive literature evaluation of the technology of Fog computing in the IoT system for education. The survey also concentrates on assessing the crucial elements that play a significant role in the fields of education as well as looking into the limitations and results related to the use of Fog computing technologies in educational systems from the perspectives of privacy, security, and agility.

Al-khafajiy, Baker, Asim, Guo, Ranjan, Longo, Puthal, and Taylor (2020) this research introduces COMMITMENT, a fog computing trust management approach, addressing the critical aspect of trust in distributed environments. The proposed model contributes to enhancing trustworthiness in fog computing systems, making it a significant addition to the field of trust management in decentralized computing.

Alavi, Jiao, Buttlar, and Lajnef (2018) focused on the integration of the IoT in smart cities, this paper presents a state-of-the-art review and outlines future trends. It provides an extensive overview of IoT-enabled smart cities, offering valuable insights into current advancements and potential directions for future development.

Arcaini, Riccobene, and Scandurra (2015) research work delves into the modeling and analysis of MAPE-K[18] feedback loops for self-adaptation in software systems. By focusing on the MAPE-K feedback loop, the authors provide insights into the mechanisms of self-adaptation, contributing to the broader field of autonomic computing.

Atlam, Walters, and Wills (2018) according paper comprehensively explores fog computing in conjunction with the IoT. It offers a critical analysis of the role of Fog computing in IoT scenarios, highlighting its potential benefits and challenges. The work serves as a valuable resource for researchers, practitioners, and policymakers interested in the intersection of fog computing and IoT.

Badraddin (2019) explore the effectiveness of service decomposition in Fog computing architecture for the IoT. It investigates how breaking down services in Fog computing environments can enhance the efficiency of IoT applications. The findings contribute to optimizing the design and deployment of services in Fog computing for improved IoT functionality.

Baouya, Chehida, Bensalem, and Bozga (2020) presented at the Mediterranean Conference on Embedded Computing, this paper explores the joint use of Fog computing and blockchain for massive IoT deployment. It investigates the synergies between Fog computing and blockchain technologies, providing insights into potential applications and benefits in large-scale IoT scenarios.

Bellavista, Berrocal, Corradi, Das, Foschini, and Zanni (2019) they surveyed offers an in-depth examination of Fog computing in the context of the IoT. It covers a wide

[18] Monitor, Analyze, Plan, Execute, and Knowledge

range of topics, including architectures, communication protocols, and application domains specific to Fog computing for IoT. The survey is a valuable resource for researchers and practitioners seeking a comprehensive understanding of the intersection of Fog computing and IoT.

According to Bonomi (2012), they surveyed that the characteristics of Fog Computing make it an appropriate platform for critical IoT services and applications like connected cars, smart grids, smart cities, and wireless sensor and actuator networks. The author mentioned three main applications that are suitable for the Fog computing architecture. First, connected vehicles, where cars are connected to other cars and the surrounding environment. Second, smart grid, is an intelligent power supply system for widely distributed suppliers and consumers. Third, wireless sensor networks, are widely geographically distributed sensors for environment monitoring systems.

Bosman, Lukkien, and Verhoeven (2011) work focuses on gateway architectures for service-oriented application-level gateways. It addresses the challenges and considerations in designing gateways that facilitate communication between service-oriented applications. The research is particularly relevant for those involved in the development and optimization of gateway systems.

Bourque and Fairley's (2014) research work outline the knowledge areas essential for software engineering practitioners. As a widely recognized resource, Software Engineering Body of Knowledge serves as a guide for educators, professionals, and organizations in understanding the key concepts and practices in software engineering.

Brogi, Forti, and Ibrahim (2018) researcher investigates the cost aspects associated with deploying fog applications. By addressing the economic considerations of deploying applications in Fog computing environments, the authors contribute to the understanding of the financial implications and challenges in Fog application deployment.

Cheng (2018) proposed easy programming of IoT services, authors stated the issues in current programming models. As per author the most of the existing Fog Computing frameworks either lack services programming models or defined programming models based on their own private data model and interfaces. So, the openness and interoperability of smart cities are quite limited. To tackle this problem authors proposed an approach to design and implement a new Fog Computing framework, named Fog Flow, for IoT smart city platforms. The proposed framework may allow developers to program elastic IoT services easily over the cloud and edges. In this paper to showcase how smart city use cases can be used with Fog Flow authors describe different use cases and implement the application for anomaly detection of energy consumption in smart cities.

Dang (2017) addressed the data security and performance issues. For this, the authors proposed a Region-based Trust-Aware technique for trust-based computation allocation to fog nodes of the region. The authors also proposed privacy-aware role-based access control for fog nodes and also developed a mobility management service that handles the changes in users and fog device's locations.

Ghobaei-Arani (2020) discusses the fundamental difficulty in fog computing is scheduling. Tasks that need computational intensity and tasks that require data intensity are separated into two categories in a Fog environment. The task execution time is shortened because the scheduler migrates the data to the high-productivity resource when scheduling jobs that need intensive computation. On the other hand, it is tried to minimize the amount of data transfer when scheduling the tasks needing data intensity. As a result, data transfer takes less time.

Hamza and Attila (2020) explore approaches to integrating blockchain with Fog computing, addressing the intersection of these two emerging technologies. The work provides insights into the challenges and opportunities associated with combining blockchain and Fog computing, contributing to the ongoing discourse on secure and decentralized systems.

Hutun, Sariand Austerberg (2019) investigated the security implications of Fog computing in the IoT, this paper provides insights into potential security challenges and solutions. It contributes to the growing body of knowledge on securing IoT ecosystems, particularly in the context of Fog computing.

Khakimov (2018) discussed the study of Fog Computing Structure. As the authors discussed, the growth of mobile traffic, the support of mobility, and geometric distribution are no less important. So, the emergence of Cloud computing for centralized storage, retrieval, and management of information, and integration to different mobile applications is an important task, for Fog computing is introduced by Cisco, which is designed for local processing of tasks on Fog devices. In this paper, authors emulated the operations of network nodes under Fog computing conditions.

Kumari (2019) says that current power grid system has to be upgraded since there is a rising daily demand for electricity. The contemporary, ICT-based smart grid has already taken the place of the conventional electricity system. As the volume, velocity, and diversity of the data generated by Singapore's smart meters fluctuate, it is difficult to store, handle, and evaluate. Cloud computing, which offers real-time response for several applications, is used to store and analyze the data. Fog computing is a novel technique that places most of the computer resources near to the end users, and has evolved to address the latency issue during data processing. To bridge the gap between the processing power of remote data centers and SDs[19] in SG[20] systems, it functions as a bridge between SG and Cloud computing. In the forthcoming fifth generation, it is necessary to set up an advanced sensors and measurement system with a communication network backbone to address the difficulties 5th Generation. To determine the amount of energy needed by smart devices at the fog layer, we have addressed the architecture of SG about Fog computing in this work. Additionally, the setting of 5thGeneration network infrastructure is examined about the communication and computing components. The authors investigate the impact of Fog computing on reaction time, transmission delay, and energy management expenses for applications with a high sensitivity to delays.

Luigi (2010) considered a seminal work, this survey by Atzori, Iera, and Morabito provides a comprehensive overview of the IoT. It covers key aspects such as architectures, communication protocols, and application domains, offering a foundational understanding of IoT concepts. The survey has been widely cited and remains a fundamental reference in the IoT literature.

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[19]Smart Devices
[20]Smart Grid

According to Qasem (2020), Fog computing is a novel network architecture and computing paradigm that performs some processing tasks using user or near-user devices (network edge). As a result, it gives cloud computing greater flexibility than that offered by ubiquity networks. In this research, a flexible hierarchical Fog computing-based smart city is suggested. By utilizing several network designs, including Cloud computing, autonomous network architecture, and ubiquitous network architecture, the suggested design seeks to solve the drawbacks of the earlier methods. In light of this, the suggested method reduces the latency of data processing and transmission with allowed real-time applications, distributes the processing jobs among edge devices to lower the cost of data processing, and enables cooperative data interchange among the applications of the smart city.

The architecture consists of five primary layers that may be raised or combined depending on how much data is processed and sent in a given application. Connection layer, real-time processing layer, neighborhood connecting layer, primary processing layer, and data server layer are the related layers. Utilizing simulating fog computing scenarios, a case study of a unique smart public parking, travel, and direction adviser was built, and the findings demonstrated a considerable reduction in real-time application latency, as well as cost and network use as compared to the Cloud computing paradigm. Additionally, compared to a stationary Fog-computing design, the suggested technique does not significantly compromise time, cost, or network consumption while increasing the scalability and dependability of the users' access.

According to Songhorabadi (2020), the development of smart cities today, particularly in location-aware, latency-sensitive, and security-critical applications (like emergency fire events, patient health monitoring, or real-time manufacturing), heavily depends on more sophisticated computing paradigms that can meet these requirements. Because it is situated closer to the end devices, Fog computing, a strong Cloud computing supplement, plays a significant role in this respect. However, the methods used in smart cities are typically cloud-based, which limits the flexibility and dependability as well as the security and time-sensitive services.

This research work suggests a systematic literature review (SLR[21]) for the cutting-edge Fog-based technologies in smart cities to circumvent the limits of the cloud and other associated computing paradigms, such as edge computing. In addition, a proposed taxonomy is divided into three types based on the content of the examined studies: service-based, resource-based, and application-based. Additionally, each class's evaluation criteria, tools, techniques, merits, and demerits are examined in this SLR. Additionally, each class's proposed algorithm types are specified. By categorizing future trends and difficulties into useful sub-classes, it is possible to give complete and distinct open topics and challenges while also taking into consideration different viewpoints.

Velasco (2018) reviewed distributed and ultra-dense Fog Computing infrastructure, which can be allocated at the extreme edge of wired and wireless networks for telecom operators to provide multiple unified, cost-effective, and new 5thGeneration services, such as Network Function Virtualization, Mobile Edge Computing, and services for third parties e.g., smart cities, vertical industries or IoT. The proposed architecture consists of three main building blocks: a scalable node that is seamlessly integrated into the Telecom infrastructure; a controller, focused on service assurance that is integrated into the management and orchestration architecture of the Telecom operator, and services running on top of the Telecom infrastructure.

Zhang (2020) discussed building "smart cities" makes extensive use of Fog computing and IoT technologies, which has the potential to significantly improve the administration and interchange of urban information. Fog computing and the IoT, two emerging network technologies, may be utilized to make it simpler to create smart cities, which are beneficial for the growth of urban business, industry, and other industries as well as tourist and transit management. As a result, the creation of a smart city will significantly strengthen the city's capacity for overall growth.

[21]Systematic Literature Review

We examine the benefits of Fog computing and suggest a Fog computing-based IoT architecture that successfully addresses the issues of huge data processing and network scalability. Based on this, a layered fog computing network architecture is suggested to improve the city's functioning through different intelligent perceptions, information processing, and network transmission techniques.

2.5 Resource Allocation and Task Scheduling Technique

Task scheduling and resource allocation are mandatory parts of cloud computing research. The efficiency of resource uses depends on the scheduling and load-balancing methodologies, rather than the random allocation of resources. Cloud computing is widely used for solving complex tasks

Aazam (2015) discussed a system for supplying resources in a Micro data center using fog. This document unequivocally indicates that resources are calculated and managed based on variable customer service client relinquish likelihood. Based on previously predicted resources from the service provider, this model offers the best service possible to its clients. This mechanism is evaluated using the Cloud Sim toolkit, and a probabilistic model is utilized to estimate the availability of resources. This technique aids in determining the precise number of resources that the client will require. Additionally, it decreases resource waste, boosts revenue, and may be used in a wide range of cloud service provider scenarios.

Aazam (2015) provided a method to estimate resources for a Fog-based mini data center and created a pricing structure for an IoT. Issues including resource estimation, reservations, and pricing strategy for current and potential clients depending on their attributes were all tackled in this research work. Using data from previous resource usage by cloud service users, resources are allotted to existing clients. As a result, resource prediction and pre-allocation are also based on user behavior and the likelihood that resources will be used in the future. This method makes it simpler for all types of cloud service providers to anticipate how their customers will use their resources.

Abdul-Qawy (2015) introduces the power of information and communications technology ICT[22] as it becomes a vital component of our infrastructure that is essential to our way of life by enabling the connecting of heterogeneous devices in various ways. To mention few, examples include personal computing, sensing, surveillance, smart homes, entertainment, transportation, and video streaming. The Internet is a vital living system that is continually changing and growing, giving rise to new technologies, applications, protocols, and algorithms. As wireless communication trends pick up speed, mobile broadband, and Internet access are becoming increasingly innovative. Communication devices that don't require infrastructure are becoming more common, intelligent, powerful, connectable, compact, affordable, and simple to install. This introduces a new direction for ICT civilization in the future the IoT. The IoT, formerly known as Machine-to-Machine communications, has recently gained prominence in the ICT industry and research communities. We present an overview of the IoT paradigm, its concepts, principles, and prospective advantages in this article. We concentrate on the key IoT technologies, developing protocols, and well-known applications. This introduction might be useful for anyone who wants to learn more about the IoT and get involved in its development.

Abomhara (2014) discussed connecting common things, connectivity fosters the growth of the IoT. Because even little interactions between these things might contribute to collective intelligence in an IoT network, the connectivity of these objects is crucial. It makes things compatible with and accessible via networks. By connecting smart items and apps, this connection can open up new commercial prospects for the IoT. The IoT requires connectivity that goes beyond just attaching a Wi-Fi module and calling it a day. Network compatibility and accessibility are made possible via connectivity. Accessibility involves joining a network, whereas compatibility gives everyone the same capacity to use and create data. If this seems familiar, it's probably because Metcalfe's Law applies to the IoT

[22]Information and Communications Technology

Attar and Sutagundar (2018) research work provides a survey on resource management for fog-enhanced services and applications. It comprehensively reviews existing approaches and strategies for managing resources in Fog computing environments. The survey serves as a valuable resource for researchers and practitioners seeking an overview of the state-of-the-art in fog computing resource management.

Bitam (2018) discussed the better distribution of a set of jobs among all the Fog computing nodes and suggested a BLA[23]. When compared to the genetic algorithm and particle swarm optimization algorithms, the suggested approach performs better in terms of execution time and memory allocation. However, the suggested technique has a low degree of scalability. Additionally, it ignores the dynamic work scheduling. Furthermore, the approach has only been evaluated by the BLA, authors on tiny datasets, and task execution reaction time is lengthy.

Chen (2014) discussed the main function of the IoT is data collection from its surroundings, which is made possible by the dynamic changes that occur around the devices. These devices' states fluctuate dynamically, for instance, whether they are sleeping or waking up, connected or not, and in various contexts that include temperature, location, and speed. The quantity of devices fluctuates dynamically with a person, place, and time in addition to the status of each gadget. Device context, such as location and speed, as well as the states of devices, such as sleeping and waking up, connected and/or disconnected, also alter dynamically. Additionally, the quantity of devices may fluctuate.

Confais (2017) proposes a first-class object store service for fog facilities. The proposed system is built with Scale-out Network Attached Storage 2 system and Inter Planetary File System 3, a Bit Torrent-based object store spread throughout the fog infrastructure. Authors used Scale-out Network Attached Storage on each site to reduce inter-site exchanges that are mandatory for metadata management in Inter Planetary File System implementation. This experiment gives direction to improve the performance and fault tolerance of Fog.

[23]Binary Lion Algorithm

Edemacu and Bulega (2014) explore the resource sharing between M2M and H2H[24] traffic under a time-controlled scheduling scheme in Long-Term Evolution networks. The research addresses the challenges of efficiently allocating resources to accommodate both M2M and H2H communications, contributing to enhanced network performance.

As per the research, Giordano (2016) Global Smart City projects are made possible by new IoT applications that make use of ubiquity in connection, big data, and analytics. With the help of these brand-new apps, users will be able to monitor, manage, and control devices remotely as well as extract valuable insights and information from huge streams of real-time data. The adoption of new paradigms is necessary to support this novel approach. To develop control systems based on the decentralization of control functions across distributed autonomous and cooperative entities that are operating at the edge of the network, agent technology is integrated with the emerging notion of Fog computing in this study. The Rainbow platform aims to minimize the computation's distance from the physical component. Using adaptive and decentralized algorithms that take advantage of the concepts of collective intelligence, multi-agent systems running on top of Rainbow develop smart services.

As per Gu (2015) a methodology for heuristic resource management in fog was put forth by the author. For the formulation of this problem, mixed linear programming and mixed nonlinear programming serve as the fundamentals. To cut costs in Medical Cyber-Physical Systems, they proposed a two-step nonlinear heuristic approach. They demonstrated that this method performs better than previous algorithms by comparing it to the existing greedy technique. Due to the high computing complexity of the mixed integer linear programming model, they used a two-phase linear heuristic approach to lower the cost of medical cyber-physical systems.

Hamdoun, Rachedi, and Ghamri-Doudane (2015) the paper introduces an interference-aware bipartite graph approach for radio resource sharing in MTC[25]

[24]Human-to-Human
[25]Machine Type Communication

within Long-Term Evolution Advanced Networks. The work addresses the challenges of efficient radio resource allocation for MTC applications, contributing to improved communication reliability and performance.

Hassan (2015s) authors focus on the most current research directions in this area to highlight the IoT idea in general and discuss the major issues of the IoT ecosystem. IoT a new technology that expresses a contemporary wireless communications network, may be characterized as an intelligent and interoperable node connected to a dynamic global infrastructure network. It also aims to execute the connection notion of everything from anywhere at any time. The IoT environment has a wide range of challenges that have an impact on their performance. These challenges can be categorized into two groups: i) General challenges, like communication, heterogeneity, virtualization, and security; and ii) Unique challenges, like WSN[26], and QoS, which is thought of as a factor that unites both general and special challenges.

As per Heer (2011) is focused on the security problem in IP-based IoT systems. The author claimed that the internet serves as the foundation for all device connectivity in an IoT system. Security concerns in IP[27]-based IoT systems are therefore a major problem. Additionally, the capabilities and life cycle of every IoT system object should be taken into account while designing the security architecture. It also incorporates the use of security standards and a trusted third party. It is also desired to have a security architecture that can grow to accommodate both small- and large-scale IoT objects. The study made the point that because the IoT has spawned a new kind of cross-network communication between various objects, standard end-to-end internet protocols are unable to accommodate this communication. Therefore, to assure end-to-end security, new protocols need to be established taking the translations at the gateways into account. All communication-related levels have their security concerns and needs. As a result, if just one layer's criteria are met, the system will be susceptible, hence security needs to be provided for all layers.

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[26]Wireless Sensor Networks
[27]Internet Protocol

Hoang and Dang (2017) present paper an optimization approach for task scheduling in fog-based regions and the cloud. The work addresses the coordination and scheduling challenges in distributed fog and cloud environments. Optimizing task scheduling enhances resource utilization and performance in fog computing architectures.

Jia, Hu, Zeng, Xu, and Yang (2018) authors present a double-matching resource allocation strategy designed for Fog computing networks with a focus on cost efficiency. This strategy aims to optimize the allocation of resources to tasks in a way that enhances cost-effectiveness. The work contributes to the economic viability of fog computing networks.

Kimovski (2018) introduces an adaptive nature-inspired fog architecture, presenting a novel approach to designing Fog computing systems. The architecture draws inspiration from natural systems to enhance adaptability and efficiency in fog environments. By presenting this innovative perspective, the authors contribute to the development of more resilient and self-adapting Fog computing infrastructures.

Liu (2018) proposed object tracking using fog-based intelligent surveillance in public spaces. In this system, Fog computing platform was deployed to accelerate the proposed tracking approach. The tracker was constructed to take multiple positions' detections. The detection position was then adjusted as per the optical flow of the object and the alternate template was stored with the template update mechanism, and all were computed at the fog layer.

Li, Zhao, Gong, and Zhang (2019) researcher address energy-efficient computation offloading and resource allocation in fog computing environments for the Internet of Everything. The authors propose strategies to optimize the allocation of resources and the offloading of computations, contributing to the energy efficiency of fog-based Internet of Everything systems.

Liu, Qi, Zhou, and Wu (2018) the authors propose a task-scheduling algorithm for fog computing environments based on classification mining. This algorithm leverages data classification techniques to optimize task scheduling in fog computing systems. The work addresses the challenge of efficient resource utilization in dynamic fog environments, contributing to the improvement of task execution in such settings.

Liu, Yang, Wang, and Mao (2018) propose a dispersive stable task scheduling algorithm designed for heterogeneous fog networks. This algorithm aims to optimize task scheduling by considering the diverse characteristics of nodes in heterogeneous fog environments. The work contributes to the efficient utilization of resources in fog networks with varying capabilities.

Mohan and Thangavel (2013) focus on resource selection in grid computing environments, incorporating trust evaluation using feedback and performance metrics. The work addresses the challenges of selecting trustworthy and efficient resources in grid environments, contributing to the overall reliability of grid-based computing systems.

Ni, Zhang, Jiang, Yan, and Yu (2017) research work introduces a resource allocation strategy for Fog computing based on priced timed Petri nets. This modeling approach enables the efficient allocation of resources in fog environments, considering both time and cost factors. The strategy contributes to the effective utilization of resources in Fog computing architectures.

Paharia (2018) says that Fog Computing is a protective mechanism against Distributed Denial of Service attacks. The authors proposed an architecture to block the malicious traffic generated by the Distributed Denial of Service attack from user to cloud. Fog functions as a filtering layer for the traffic generated. This study primarily works to improve the overall performance of the network and enhances the reduction in traffic forwarded to the cloud.

Pham et al. (2017) research work introduces an innovative and cost-effective approach for task scheduling, focusing on collaborative efforts between cloud and fog computing. The primary goal is to dynamically allocate tasks in a manner that optimizes both cost and performance considerations. By adopting a collaborative strategy, the proposed approach enhances resource utilization efficiency and improves the overall execution of tasks. This novel method not only addresses the challenges of task allocation in a dynamic environment but also contributes to achieving a balance between cost-effectiveness and high performance. The integration of cloud and fog computing in task scheduling demonstrates a forward-thinking solution that can potentially bring about significant advancements in optimizing computational resources and task execution efficiency.

Prakash and Ravichandran (2012) research authors propose an efficient resource selection and binding model for job scheduling in grid computing environments. This model aims to optimize the allocation of resources for executing jobs, contributing to improved efficiency and performance in grid computing systems.

Rahmani (2015) says that IoT communication is dominated by wireless nodes. Many wireless protocols are tuned to utilize less power for functioning, limited communication, or increased coverage range due to resource limitations at the perception layer. Currently, the sector offers a wide range of various approaches. To speed communication with the cloud layer and combine these many wireless protocols, the fog layer is in a perfect position. As a result, system reliability is increased, security is provided, communications between devices are routed, and the administration of sensor and actuator subnetworks is aided. Furthermore, this layer enables the compatibility of diverse protocols by detecting and comprehending the representation format. Non-IP-based devices may now be seen and reached over the Internet thanks to the Fog layer.

According to Ravi (2016), Fog's architectural design makes it simple to operate and communicate with the devices on the platform. The physical layer is the foundational component of a Fog computing system. This layer is in charge of connecting many tools or devices to a common platform and facilitating information flow. There are devices, terminals, sensors, and virtual sensors in the physical layer. The nodes of this layer are managed according to their purposes, and sensors in this layer are decentralized to detect data from surrounding places faster and communicate it to a higher layer of the architecture. The monitor layer, which is the second layer in the Fog computing architecture, keeps an eye on resource utilization as well as the performance of nodes and sensors. The preprocessing layer, which is the next layer in the Fog computing architecture, is in charge of maintaining the record data and carrying out information analysis.

Saini (2019) says that a worldwide network made up of people, intelligent things, smart gadgets, information, and data transformed thanks to the IoT. It goes without saying that as more gadgets connect to the internet, the difficulties in protecting the information they broadcast and the communications they start grow. IoT device usage has increased significantly over the years, mostly in the home and in manufacturing. With the former, a whole ecosystem centered on Amazon's Echo devices that make use of the Alexa Voice Service has been created. Apple, Google, and Microsoft have all done the same. The onus of protecting the devices falls to the platform providers because they are separate, closed platforms. We focus on cyber security in manufacturing and associated industries in this study. As more and more equipment and devices are brought online, sectors including manufacturing, oil and gas, refining, pharmaceuticals, food and beverage, water treatment, and many more are continually trying to add the necessary levels of security. Manufacturers of devices and plant operations managers are under continual pressure to safeguard their physical assets from cyber threats. Additionally, there are significant differences between each of these businesses' data types, IoT device topologies, threat management challenges, and compliance requirements.

In the research study done by Shalini (2019), paradigm of Cloud computing has been advanced or extended by Fog computing. It is a sophisticated distributed system that works over the whole network; it keeps data near to the user and speeds up information delivery. In this study, the architecture of Fog computing is discussed. The various levels are used to describe how Fog computing functions. The downsides of Cloud computing and how Fog computing addresses them were explored, along with certain obstacles, unresolved problems, and Fog computing applications in many sectors.

Skarlat (2016) provided a method to estimate resources for a Fog-based mini data center and created a pricing structure for an IoT. Issues including resource estimation, reservations, and pricing strategy for current and potential clients depending on their attributes were all tackled in this research work. Using data from previous resource usage by cloud service users, resources are allotted to existing clients. As a result, resource prediction and pre-allocation are also based on user behavior and the likelihood that resources will be used in the future. This method makes it simpler for all types of cloud service providers to anticipate how their customers will use their resources CSP[28]. Fog colonies are small data centers made up of a lot of Fog cells. The network may switch from centralized to decentralized processing with the help of the Fog colonies, which also facilitate requests from the fog cells for resource provisioning tasks. By managing fog cells, Fog orchestration manages the Fog colony and offers resource provisioning services via the Fog cloud interface.

Sun and Zhang (2017) present a resource-sharing model based on a repeated game in Fog computing environments. The model explores the dynamics of resource sharing over time, considering the repeated interactions between nodes. The proposed approach contributes to a deeper understanding of resource-sharing dynamics in Fog computing systems.

Wang (2019) proposes to address the issue of terminal devices with constrained computational capabilities, excessive energy consumption, and offer a job scheduling HH[29] algorithm for various fog nodes. The IPSO[30] method and the IACO[31] algorithm is combined in the HH algorithm. MATLAB is used by the writers to evaluate their work. Results of the experiment demonstrate that the algorithm outperforms IPSO, IACO, and RR[32]on three performance criteria Make-span, energy consumption, and reliability. After all, the clustering of tasks and fog nodes is not covered by this approach.

The research study was done by Yin (2018), As an extension of cloud computing, Fog computing has been proposed to offer processing, storage, and network service at the network edge. If the intermediary layer between the industrial cloud and terminal device is taken into account, Fog computing can offer a plethora of computational and storage capabilities, such as defect detection and status analysis of devices in assembly lines. However, the deployment of novel virtualization technologies in the job scheduling and resource management of Fog computing is hampered by limited resources and low-latency services. As a result, we create a

[28]Cloud Service Providers
[29] Hybrid Heuristic
[30]Improved Particle Swarm Optimization
[31]Improved Ant Colony Optimization
[32]Round Robin

new work scheduling model by taking containers into account. Then, to guarantee task completion on time and maximize the number of concurrent jobs for the Fog node, a task scheduling algorithm is built. Finally, by the properties of the containers, we suggest a reallocation strategy to decrease task delays. The outcomes show that our suggested task scheduling technique and reallocation strategy may successfully decrease task delays and increase the number of processes running concurrently in Fog nodes. Considers the function of containers in a task scheduling paradigm. To increase the number of concurrent jobs for the Fog node and ensure that tasks are completed on time, they also created a task scheduling algorithm. Additionally, they suggested a reallocation strategy to decrease task latency based on the features of the containers. When a job's request is approved, the task scheduler distributes it. The work is delivered directly if it can only be finished in the cloud or the fog node. The task scheduler will need to choose where to put it as long as the cloud and the fog node both successfully execute the task. Low-computing tasks are carried out at fog nodes, whilst high-computing tasks are sent to the cloud. The suggested algorithm and reallocation method shorten task delays and increase the efficiency with which Fog nodes use their resources. However, the authors overlook the computing time on the cloud, which in a practical scenario should be considered. To shorten task execution time, the picture positioning of containers is also an important issue that has to be resolved.

Yin, Luo, and Luo (2018) address task scheduling and resource allocation in Fog computing with a focus on containers for smart manufacturing. This work explores the use of containerization technology to enhance the efficiency of task scheduling and resource allocation in fog environments, specifically in the context of smart manufacturing.

Yang, Wang, Zhang, Chen, Luo, and Zhou (2018) introduced a maximal energy-efficient task scheduling algorithm tailored for homogeneous fog networks. The focus is on optimizing energy consumption in Fog computing environments with uniform node characteristics. The proposed algorithm aims to achieve efficient task scheduling while minimizing energy usage, contributing to sustainability in Fog computing.

Yang, Zhao, Zhang, Chen, Luo, and Wang (2018) introduced a delay energy-balanced task scheduling algorithm designed for homogeneous fog networks. The algorithm aims to balance both delay and energy considerations in the scheduling of tasks, contributing to improved overall system performance. DEBTS addresses the trade-off between latency and energy consumption in fog computing environments.

Yuan (2017) proposed a fast search and find density peaks-based fog node location technique. The authors used a density peaks-based fog node location strategy to locate the fog nodes and determine their resources. To locate fog node authors treated this problem as a clustering problem with different attributes. To perform this, they proposed an improved Fast Search and Find of Density Peaks-based fog node location algorithm, which uses time-sensitive features of IoT applications and improves the fast search and finds density peaks clustering algorithm to make this clustering algorithm more robust and adaptable.

Zhenqi, Haifeng, Xuefen, and Hongxia (2013) research focus on the uplink scheduling algorithm for massive M2M and H2H services in Long-Term Evolution networks. The study addresses the specific challenges associated with coordinating uplink communications for diverse services, contributing to the optimization of network resources.

The literature review is very promising for future research in Fog Computing and its different applications in Smart Cities. In above literature reviewed different proposed Fog Computing architectures. The literature also identified challenges like security and privacy issues, scheduling, and allocation of resources, etc. These challenges can be achieved using research in fog computing, IoT, and traffic congestion through ML[33] revealing the significant impact of ML techniques in addressing traffic-related challenges in IoT-based fog computing environments. Fog computing is a decentralized architecture that extends Cloud computing capabilities to the edge of the network, enabling real-time data processing and reducing latency for IoT devices. ML algorithms are leveraged to analyze the massive data generated by IoT devices, predict traffic patterns, and optimize traffic flow. The review highlights the use of ML-based traffic prediction models, such as time-series forecasting, neural

[33] Machine Learning

networks, and support vector machines, to accurately predict traffic congestion and provide timely information to drivers and transportation authorities. Moreover, the integration of fog computing and ML facilitates real-time data analytics and decision-making, enabling adaptive traffic management and intelligent resource allocation to alleviate congestion and improve overall traffic efficiency. The literature demonstrates the potential of Fog computing and ML in transforming transportation systems, reducing traffic congestion, and enhancing the overall transportation experience in smart cities and urban environments.