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Navigating the Edge–Cloud Continuum: A State-of-Practice Survey

Anmol S. Budhewar[1], Tushar Manohar Visave[2], Aditya Sharad Borade[3], Vaibhav Bandu Jondhale[4], Aditya Rahul Narkhede[5]

[1]Assistant Professor, Department of Computer Engineering, Sandip Institute of Technology and Research Centre, Nashik, Maharashtra, India

[2]Department of Computer Engineering, Sandip Institute of Technology and Research Centre, Nashik, Maharashtra, India

[3]Department of Computer Engineering, Sandip Institute of Technology and Research Centre, Nashik, Maharashtra, India

[4]Department of Computer Engineering, Sandip Institute of Technology and Research Centre, Nashik, Maharashtra, India

[5]Department of Computer Engineering, Sandip Institute of Technology and Research Centre, Nashik, Maharashtra, India

E-mail: anmolsbudhewar@gmail.com (ORCID: 0009-0002-9112-107X), tusharvisave2005@gmail.com, adityaborade392@gmail.com, vaibhavjondhale749@gmail.com, narkhedeaditya8@gmail.com

Abstract — Internet of Things applications, artificial intelligence, and latency sensitive services have grown at a fast pace in recent years and this growth has brought out the shortcomings of traditional cloud computing when it comes to meeting real time processing needs. In response, the Edge Cloud Continuum has come up as a distributed computing paradigm that brings together the strengths of edge and cloud infrastructures to provide scalable, low latency, and resource efficient services. This survey offers a wide ranging review of the recent progress made in the Edge Cloud Continuum, covering its architecture, enabling technologies, orchestration strategies, resource management techniques and application areas. It also looks into the major challenges such as interoperability, security, workload distribution and energy efficiency that affect real world deployments. Drawing on an analysis of recent studies, this paper points out the current research trends, brings attention to the gaps that still exist and puts forward a conceptual framework to guide future research and development. Through this work researchers and practitioners are given a clearer picture of where the field currently stands and where the opportunities lie within the evolving Edge Cloud Continuum ecosystem.

Keywords: Edge Cloud Continuum, Edge Computing, Cloud Computing, Internet of Things, Resource Orchestration.

I. INTRODUCTION

A. Background

Digital technologies have advanced quickly over the past years and this has reshaped the modern computing landscape in a significant way [1], [2]. Technologies that are now emerging such as the Internet of Things, Artificial Intelligence, Big Data, fifth and sixth generation communication networks and cyber physical systems have sped up the growth of intelligent applications in many different domains [3], [4]. Domains such as smart cities, autonomous transportation, industrial automation, healthcare monitoring, precision agriculture and immersive technologies keep generating huge amounts of data that need to be processed on time and used for intelligent decision making [5], [6]. Industry trends suggest that billions of connected devices will soon be communicating and exchanging information in real time and this places demands on existing computing infrastructures that have not been seen before [2].

Cloud computing has for a long time acted as the backbone of modern digital services offering scalable computing resources, flexible storage and service provisioning on demand [1], [7]. Many organizations have adopted cloud platforms widely because they are able to process large scale workloads and at the same time cut down infrastructure costs through virtualization and resource sharing [1]. Because of cloud computing there have been remarkable advancements in data analytics, machine learning, and enterprise applications [2]. That said the ongoing rise of latency sensitive and data intensive applications has brought out several limitations of centralized cloud architectures [8], [9]. When data from distributed devices is sent all the way to distant cloud data centers it leads to communication delays uses up a large amount of network bandwidth and raises the chances of network congestion [4], [8]. These shortcomings have pushed researchers to look into distributed computing paradigms that can process data closer to where it is generated [1], [2].

B. Motivation

Edge computing was brought in as an extension of distributed computing to get around the shortcomings of cloud centric computing placing computational resources close to end devices [8], [9]. Rather than sending all the generated data to centralized cloud servers edge computing allows local processing to happen at nearby edge nodes, gateways or Multi access Edge Computing servers [8]. Because of this response time comes down considerably, bandwidth usage is reduced and real time applications that need immediate decisions can be supported [4], [8].

Edge computing does help with many latency related issues but it was never meant to fully replace cloud computing [1]. Compared with centralized cloud infrastructures edge devices generally have limited processing power, storage capacity and energy resources [10]. Tasks such as complex machine learning model training, long term data storage and large scale analytical processing still rely heavily on cloud resources [2].

Because of this depending only on cloud or only on edge computing is not enough to meet the varied requirements of modern distributed applications [1], [7]. This is what has led to the development of the Edge Cloud Continuum a collaborative computing paradigm that brings edge, fog and cloud resources together into one unified computational environment [1], [11]. Instead of treating cloud and edge infrastructures as two separate entities the continuum lets applications distribute their workloads dynamically based on latency requirements, resource availability, network conditions and Quality of Service constraints [3], [10]. This kind of collaboration helps improve resource utilization while still keeping scalability and responsiveness intact [3].

C. Edge Cloud Continuum Overview

The Edge Cloud Continuum can be seen as the next stage in the evolution of distributed computing, where IoT devices, edge nodes, fog servers, regional data centers and centralized cloud platforms work together seamlessly [1], [11], [12]. In such an environment computational tasks get executed at whichever layer suits the application requirements the best [13]. Operations that are sensitive to delay like sensor data processing, object detection or emergency response get handled near the network edge, while tasks that need heavy computation such as deep learning model training and historical data analysis are pushed to cloud data centers [13], [14].

As enabling technologies keep maturing, the adoption of the Edge Cloud Continuum has picked up pace [2]. Containerization platforms like Docker orchestration frameworks such as Kubernetes virtualization technologies Software Defined Networking Network Function Virtualization Artificial Intelligence Digital Twins and Federated Learning all work together to support intelligent workload management across distributed infrastructures [15], [16], [17], [18]. On top of that 5G along with the upcoming 6G communication technologies bring ultra low latency connectivity, which makes communication among different types of computing resources more efficient [18], [19].

Because of all this the Edge Cloud Continuum has turned into an enabling platform for a wide range of application domains covering intelligent transportation, systems smart manufacturing, healthcare, environmental monitoring, industrial automation, autonomous vehicles and smart city services [5], [6].

D. Research Challenges

Even with its considerable advantages putting the Edge Cloud Continuum into practice is still not an easy task [1], [11]. Because distributed computing environments are heterogeneous in nature this brings in complexities around resource management, workload scheduling, service orchestration and infrastructure coordination [3], [20]. Computing resources vary quite a bit in terms of processing capability, storage capacity, communication bandwidth and energy availability which makes efficient workload allocation a tough optimization problem to solve [10].

Keeping interoperability intact among devices, platforms and service providers that are built on different technologies and standards is another big challenge [11]. Because of dynamic user mobility, fluctuating network conditions and application requirements that keep changing adaptive scheduling mechanisms are needed that can relocate services without disrupting application execution [21], [22], [23]. Security and privacy are equally important concerns here since sensitive information moves across multiple distributed nodes that could be operating under different administrative domains [24], [25].

Energy efficiency has also turned into a critical research issue especially for battery powered IoT devices and edge nodes that have limited resources [10]. Researchers keep investigating intelligent scheduling algorithms, AI driven resource management, distributed orchestration, container migration strategies and secure communication protocols in an effort to make continuum based computing environments more efficient and reliable [17], [20].

E. Motivation and Contributions of This Survey

Over the past few years, the Edge Cloud Continuum has drawn a good deal of attention from both academia and industry [1], [2]. A number of studies have looked into specific aspects of this paradigm such as resource management, computation offloading, service orchestration, security, artificial intelligence, containerization and application deployment [3], [13], [20]. That said most of the existing surveys tend to focus on individual research areas instead of giving a full picture of the current state of practice [3], [13]. Also the fast emergence of technologies like Digital Twins Federated Learning. AI driven orchestration, Kubernetes based deployment and 6G networking has expanded the research landscape by a good margin which makes an updated survey both timely and needed [15], [18], [26].

This survey sets out to give a comprehensive overview of the Edge Cloud Continuum looking at recent advancements, architectural developments, enabling technologies, application domains and research challenges. Unlike earlier reviews that stick to isolated topics this paper brings together recent research published between 2020 and 2026 to present a holistic view of the field. The main contributions of this survey can be summed up as follows:

- An overview that traces the evolution from cloud computing to the Edge Cloud Continuum.
- A detailed look at the architectural components and enabling technologies that support the continuum.
- A state of practice analysis covering recent research on resource management, orchestration, computation offloading, security, AI integration, and application deployment.
- A comparative analysis that brings out the strengths and limitations of existing approaches.
- An identification of the key research challenges, open issues, and opportunities for future research.

II. LITERATURE REVIEW

The fast growth in Internet of Things devices, artificial intelligence and latency sensitive applications has sped up how distributed computing paradigms have evolved [1], [2]. Traditional cloud computing does offer almost unlimited computational and storage resources but its centralized architecture often finds it hard to meet the strict latency, bandwidth and privacy requirements that modern applications demand [8], [9]. These shortcomings are what led to the emergence of the Edge Cloud Continuum which brings edge, fog and cloud resources together into a single unified computing environment [1], [11]. Recent studies have looked at various aspects of this paradigm, covering architecture,

resource management, computation offloading, distributed intelligence, service orchestration and emerging technologies [3], [13], [20].

The sections that follow summarize the major contributions made by existing research.

A. Evolution of the Edge Cloud Continuum

In the early days distributed computing solutions relied mostly on centralized cloud infrastructures to process and store large volumes of application data [1]. Cloud computing does provide high computational capability and scalability but the growing number of IoT devices has produced enormous amounts of latency sensitive data that cannot always be processed efficiently in centralized data centers [8], [9]. To deal with these limitations edge computing brought computational resources closer to the data sources while fog computing added an intermediate processing layer between the edge devices and the cloud [4], [8].

Recent research has taken these ideas further into the Edge Cloud Continuum where computing resources get distributed dynamically across several interconnected layers [1], [11]. Moreschini et al. described the Cloud Continuum as an integrated environment that allows cloud, edge and intermediate computing resources to cooperate seamlessly while also supporting workload mobility and flexible resource utilization [1]. The Edge Cloud Continuum as a unified architecture that lets software components and services move dynamically across different computing layers depending on application requirements [11]. Together these studies lay down the conceptual foundation for modern distributed computing environments and point to the need for standardized architectures along with interoperable resource management mechanisms [1], [11].

B. Resource Management and Intelligent Orchestration

Efficient resource management continues to be one of the most critical challenges in Edge Cloud environments mainly because of heterogeneous devices, dynamic workloads and the limited computational resources available at the edge [3], [20]. To deal with this, existing studies have put forward numerous scheduling, orchestration and workload allocation techniques aimed at improving system performance while still meeting Quality of Service requirements [10], [20].

Walia et al. in their comprehensive review, break resource management down into resource provisioning, task offloading, scheduling, service placement and load balancing [20]. Their study also shows how Artificial Intelligence and Machine Learning techniques improve decision making by making adaptive resource allocation and workload prediction possible [20]. In a similar way the survey on integrated computing, caching and communication puts emphasis on collaborative resource management by jointly optimizing communication, computation and caching resources across the cloud to edge continuum [3]. Taken together these studies suggest that intelligent orchestration brings noticeable improvements to scalability, resource utilization and service reliability [3], [20].

C. Computation Offloading and Service Deployment

Computation offloading makes it possible for computationally intensive tasks to run on suitable computing nodes rather than on resource constrained end devices [13]. Using this technique brings down processing latency, saves energy and makes applications more responsive [10], [13].

Several recent studies have looked into different offloading strategies that take application characteristics, resource availability and network conditions into account [13], [27]. The survey on computation offloading in the Edge to Cloud Compute Continuum introduces federated execution models that support distributed processing across heterogeneous infrastructures while also tackling challenges like workload partitioning, execution coordination and decentralized resource management [13]. Alongside this, studies on service provisioning point to the importance of adaptive deployment strategies that can dynamically place services across edge and cloud layers based on application requirements [22], [28], [29], [30]. These approaches help improve computational efficiency while still supporting real time IoT applications [13], [22].

D. Distributed Intelligence and Artificial Intelligence Integration

Artificial Intelligence has turned into a fundamental component of modern Edge Cloud systems making intelligent resource allocation, distributed learning and adaptive decision making possible [2], [20]. Instead of depending only on centralized cloud processing systems today are increasingly spreading machine learning workloads across edge devices and cloud servers [2], [26], [31].

Rosendo et al. carried out a systematic review of distributed intelligence bringing out the role played by machine learning frameworks, experimental platforms and reproducible evaluation methodologies within the Edge to Cloud Continuum [2]. Their work points to major challenges tied to performance optimization, heterogeneous infrastructures, and the scalable deployment of AI workflows [2]. Along the same lines, the survey on Edge Computing for the Internet of Everything talks about integrating AI with blockchain, digital twins and 6G communication networks to improve system intelligence, security and operational efficiency [4]. These studies show that distributed intelligence is set to become a key enabling technology for the next generation of continuum architectures [2], [4], [32], [33].

E. Emerging Applications and Future Challenges

The Edge Cloud Continuum has already found success across many domains, including smart cities, healthcare, Industry 4.0, autonomous transportation and intelligent surveillance [5], [6], [34], [35], [36]. What these applications need is low latency communication, real time analytics, high scalability and reliable service delivery [4], [5].

Even though there has been significant progress a number of challenges are still unresolved. Existing literature keeps pointing to interoperability, standardized architectures, intelligent orchestration, security, privacy preservation, energy efficiency and seamless workload migration as the major research issues [3], [20], [24], [25]. Going forward computing environments are also expected to bring in technologies such as 6G communication, federated learning, digital twins and AI driven automation to enhance what the continuum can do even further [15], [18], [26]. Continued research in these areas will be essential if scalable, secure and intelligent distributed computing ecosystems capable of supporting fast evolving digital applications are to be developed [2], [3].

TABLE I. COMPARATIVE SUMMARY OF THE REVIEWED LITERATURE

Ref.	Paper	Year	Focus Area	Methodology	Key Contribution	Limitation
[1]	Cloud Continuum: The Definition	2022	Cloud Continuum	Systematic Mapping Study	Provides a unified definition and characteristics of the Cloud Continuum.	Does not propose implementation or resource management techniques.
[2]	Distributed Intelligence on the Edge to Cloud Continuum	2024	Distributed AI	Systematic Literature Review	Reviews distributed machine learning frameworks and AI deployment strategies.	Limited real world validation of proposed frameworks.
[3]	Integrated Computing, Caching and Communication in the Cloud to Edge Continuum	2024	3C Resource Management	Survey	Introduces integrated management of computing, caching, and communication resources.	Security and interoperability require further investigation.
[4]	Edge Computing for Internet of Everything: A Survey	2022	Edge Computing	Survey	Reviews AI, blockchain, digital twins, and future technologies supporting edge computing.	Primarily focuses on edge computing rather than the complete continuum.
[11]	Towards Characterization of Edge Cloud Continuum	2023	Architecture	Conceptual Review	Defines architectural characteristics and research challenges of the Edge Cloud Continuum.	Does not include implementation or performance evaluation.
[13]	Computation Offloading in the Edge to Cloud Compute Continuum	2025	Task Offloading	Survey	Presents taxonomy of computation offloading and federated execution models.	Energy aware scheduling remains an open issue.
[18]	IoT Service Orchestration in Edge Cloud Continuum With 6G: A Review	2026	Service Orchestration	Review	Discusses orchestration techniques and future 6G enabled continuum environments.	Practical deployment scenarios are still limited.
[20]	AI Empowered Edge Resource Management for IoT Applications	2024	Resource Management	Comprehensive Review	Classifies AI techniques for scheduling, offloading, and resource allocation.	Practical deployment and implementation remain limited.
[28]	Service Provisioning in Edge Cloud Continuum: Emerging Applications for Mobile Devices	2023	Architecture & Applications	Survey	Reviews architecture, enabling technologies, and mobile applications.	Limited discussion on AI driven orchestration.
[37]	Managing the Cloud Continuum: Lessons Learnt from a Real Fog to Cloud Deployment	2021	Practical Deployment	Experimental Study	Demonstrates real world deployment and operational challenges.	Focuses on a specific deployment environment.

III. PROPOSED METHODOLOGY

The fast evolution of the Edge Cloud Continuum has opened up significant opportunities to improve the performance of distributed computing systems [1], [2]. That said the literature review shows that existing studies mostly focus on individual aspects such as resource management, task offloading, service placement, distributed intelligence or security taken one at a time [3], [13], [20]. Very few approaches bring these functionalities together into a unified framework that can support heterogeneous IoT environments while still maintaining low latency, efficient resource utilization, scalability and secure communication [11], [18]. To address these gaps this survey puts forward a conceptual methodology made up of four interconnected methods. The framework brings together intelligent data acquisition, adaptive resource orchestration AI based task offloading and secure performance monitoring to offer a holistic approach for running the Edge Cloud Continuum efficiently. Fig. 1 shows the overall workflow of the proposed methodology.

The proposed methodology is made up of the following four methods.

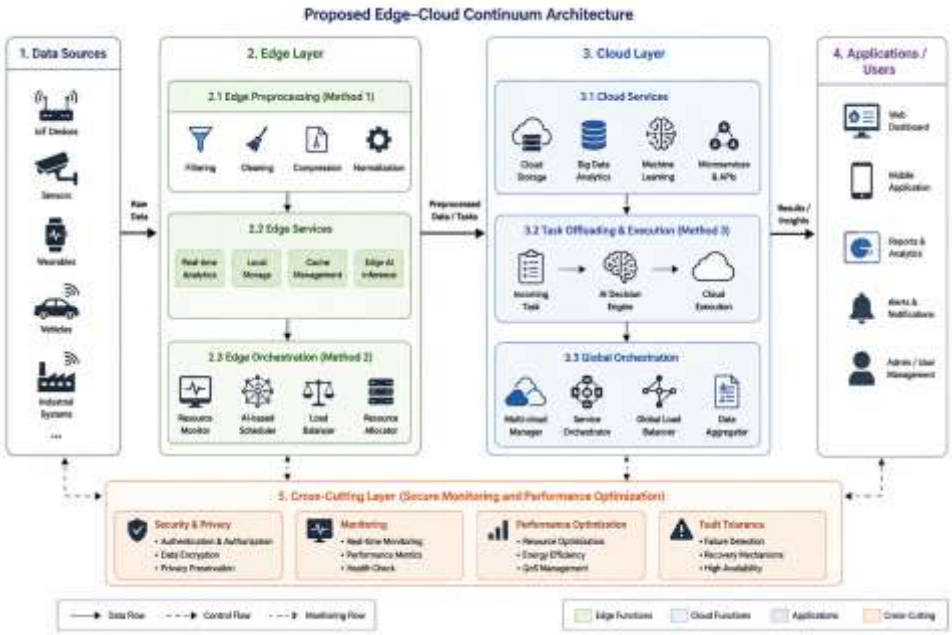


Fig. 1. Proposed Architecture of the Edge Cloud Continuum Framework

A. Intelligent Data Acquisition and Edge Preprocessing

The first method is about collecting data from IoT devices, sensors and smart endpoints, while cutting down unnecessary communication overhead through local preprocessing at the edge [4], [8]. The incoming data goes through filtering, cleaning, validation and compression before it is sent up to the higher computing layers which improves communication efficiency and cuts down redundant data transfer [3], [14]. This keeps bandwidth consumption low, brings down processing latency and improves the quality of data used for the computational tasks that follow [4], [8].

Once processed the data is passed on to the resource orchestration module where computational resources get allocated based on the workload requirements. (see Fig. 2)

The preprocessing operation can be represented as:

$$D_p = f(D_r) \quad (1)$$

where:

Dr = Raw sensor data
Dp = Pre-processed data
f(.) = Filtering and preprocessing function

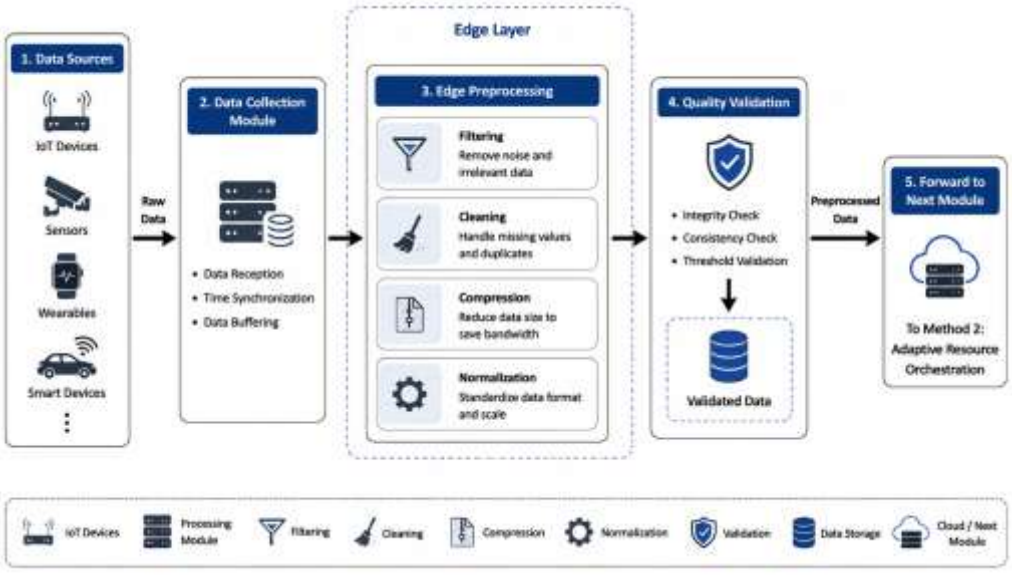


Fig. 2. Workflow of the Proposed Intelligent Data Acquisition and Edge Preprocessing Method

B. Adaptive Resource Orchestration

Once preprocessing is done computational resources are dynamically allocated across edge and cloud nodes [3], [20]. This method keeps a continuous check on CPU utilization, memory availability, bandwidth and network latency in order to decide the most suitable execution environment for the incoming workloads [10], [20]. Adaptive orchestration helps balance load better, keeps resource congestion away and improves Quality of Service by distributing workloads according to how much resource is currently available [3], [17]. (see Fig. 3)

Resource allocation is represented as:

$$R_a = \text{argmax } U(R_i) \quad (2)$$

where:

Ra = Selected computational resource
Ri = Available resource
U(Ri) = Resource utilization function

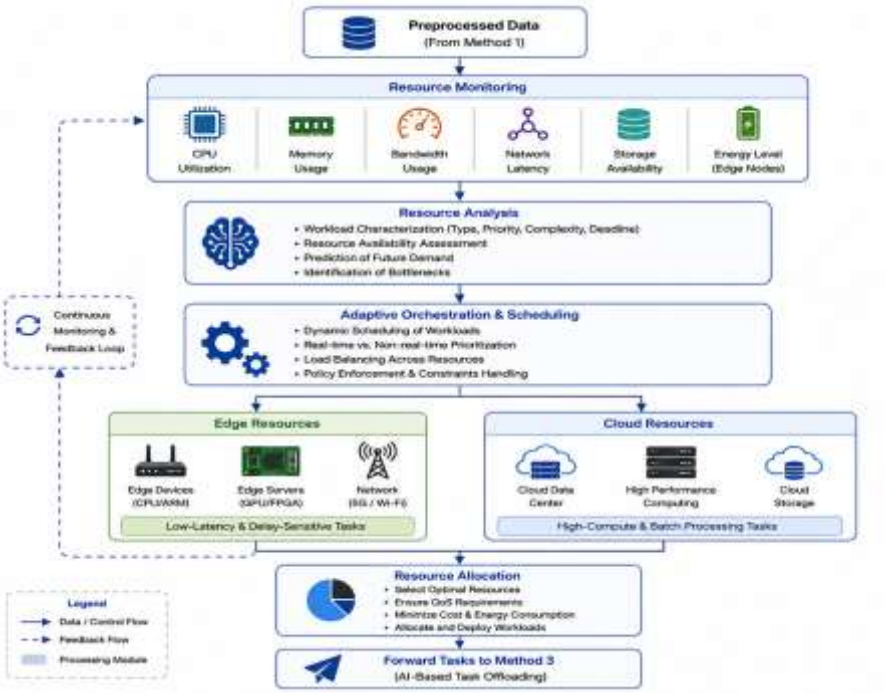


Fig. 3. Proposed Workflow for Adaptive Resource Orchestration

C. AI Based Intelligent Task Offloading

This method decides whether a computational task should run locally at the edge or be moved over to cloud resources [13], [27]. The AI based decision making process looks at latency, workload size, network conditions, computational capacity, and application priority to find the best execution location [13], [20]. Intelligent task offloading keeps response time to a minimum while getting the most out of resource utilization and overall system efficiency [10], [13]. (see Fig. 4)

Task allocation can be expressed as:

$$T_o = \text{argmin}\ (L + E + C) \quad (3)$$

where:
To = Selected execution node
L = Communication latency
E = Energy consumption
C = Computational cost

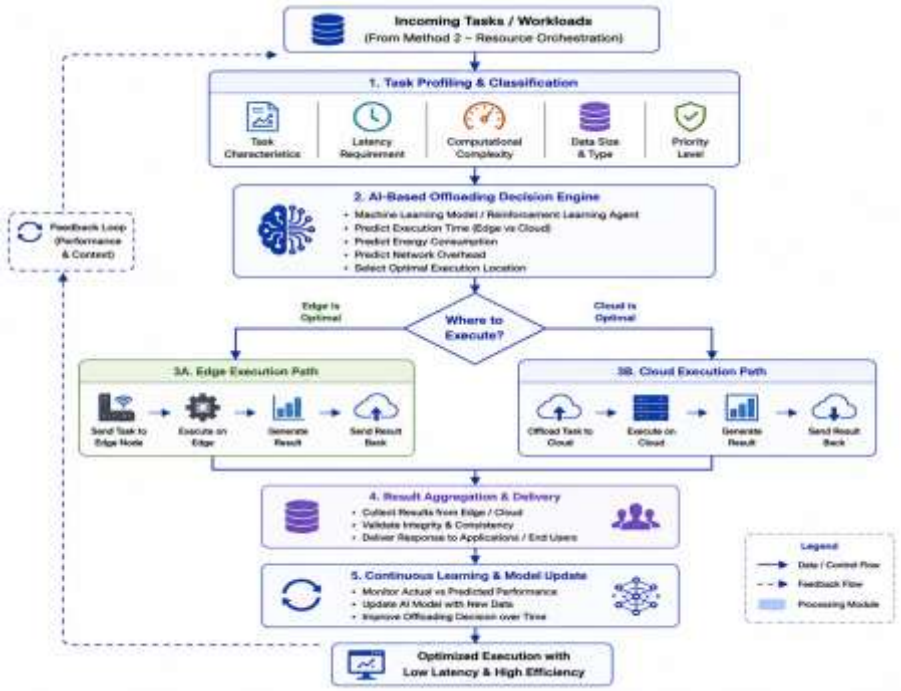


Fig. 4. Proposed Workflow for AI Based Intelligent Task Offloading

D. Secure Monitoring and Performance Optimization

The last method keeps a continuous watch on system performance so that reliable operation is maintained throughout the Edge Cloud Continuum [10], [20]. Performance indicators like latency, throughput, resource utilization and network traffic get analyzed at regular intervals to catch abnormal behavior and fine tune resource allocation [3], [20]. Security mechanisms such as authentication, encrypted communication and anomaly detection go a long

way in protecting distributed services while keeping operations reliable [24], [25], [38], [39].

System performance is evaluated using:

$$P = T / L \quad (4)$$

where:

P = System performance

T = Throughput

L = Average latency

This kind of continuous monitoring makes proactive optimization possible which in turn improves scalability, reliability and Quality of Service. (see Fig. 5)

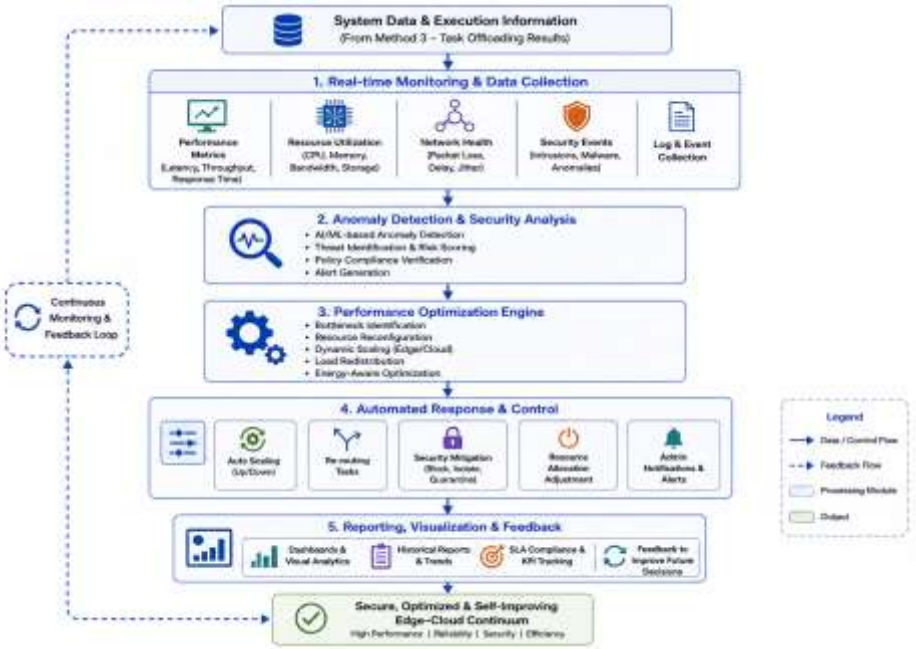


Fig. 5. Proposed Workflow for Secure Monitoring and Performance Optimization

IV. RESULTS

The comparative analysis of the ten representative studies summarized in Table I, drawn from the literature reviewed in Section II, brings out the current state of practice in the Edge Cloud Continuum. First, the foundational studies have consolidated the definition and characteristics of the continuum, establishing it as a unified environment in which cloud, edge and intermediate resources cooperate [1], [11]. Second, resource management and orchestration form the most actively studied theme: AI empowered techniques for provisioning, scheduling, task offloading, service placement and load balancing are consistently reported to improve resource utilization, scalability and Quality of Service in heterogeneous IoT environments [3], [20]. Third, computation offloading strategies, including federated execution models, reduce processing latency and energy consumption by placing tasks on the most suitable nodes across the continuum, although energy aware scheduling is still reported as an open issue [13]. Fourth, service orchestration is moving towards 6G enabled environments, in which orchestration techniques are expected to support the stricter latency and reliability requirements of emerging applications [18]. Finally, the real world fog to cloud deployment study confirms that continuum architectures are practically deployable, while also exposing the operational challenges that arise outside controlled environments [37].

The results of the analysis also show a clear pattern in the limitations of the existing work, as recorded in Table I. Most of the reviewed contributions are surveys, reviews or conceptual studies, and practical deployment and implementation are repeatedly reported as limited [2], [20]. Security and interoperability are identified as requiring further investigation even within integrated resource management frameworks [3], and the orchestration approaches proposed for 6G enabled environments still lack practical deployment scenarios [18]. The proposed methodology of Section III responds to this pattern by combining the four functions that the reviewed literature mostly treats in isolation — intelligent data acquisition and edge preprocessing, adaptive resource orchestration, AI based task offloading, and secure monitoring with performance optimization — into a single conceptual framework for the continuum.

V. DISCUSSION

The findings indicate that the field is shifting from defining the continuum to operating it intelligently. Earlier work concentrated on architecture and definitions [1], [11], whereas recent studies concentrate on AI driven orchestration, distributed intelligence and integrated management of computing, caching and communication resources [2], [3], [20]. This shift makes orchestration the central research problem of the continuum, because computing resources differ widely in processing capability, storage, bandwidth and energy availability, and workloads must be placed dynamically as network conditions and application requirements change [10], [20]. The offloading relation of Section III expresses the resulting trade-off directly: the execution node is selected by jointly minimizing communication latency, energy consumption and computational cost, so no single layer of the continuum is optimal for every task [13], [27].

Three gaps remain decisive for future work. Interoperability between devices, platforms and providers built on different technologies and standards is still unresolved [11], and security and privacy must be preserved as sensitive data moves across nodes administered by different domains [24], [25]. Energy efficiency remains critical for battery powered IoT devices and resource constrained edge nodes [10], and seamless service migration under user mobility requires

further attention [22], [23], [40]. The main limitation of this survey is that it is a narrative review of the selected literature published between 2020 and 2026, and the proposed framework is conceptual: it has not yet been implemented or experimentally evaluated. Implementing the framework and benchmarking it on representative workloads, together with the integration of federated learning, digital twins and 6G networking, is therefore the natural next step [15], [18], [26].

VI. CONCLUSION

The Edge Cloud Continuum has come up as a promising computing paradigm bringing together the strengths of edge and cloud infrastructures to keep up with the growing demands of modern IoT and latency sensitive applications [1], [2]. This survey went through recent advancements in architecture, resource orchestration, task offloading, security and application domains while also bringing out the role played by enabling technologies such as AI, MEC and 5G/6G networks. Through a comparative analysis of existing studies, key research gaps were identified including interoperability, intelligent resource management, security and energy efficiency. To tackle these challenges a conceptual methodology made up of four integrated methods was proposed to support efficient data processing and workload distribution across the continuum. Going ahead, developments in artificial intelligence, federated learning, digital twins and sustainable computing are expected to strengthen this paradigm even more [15], [18]. All in all the Edge Cloud Continuum lays down a strong foundation for building scalable, secure and intelligent distributed computing systems that can meet the evolving requirements of next generation digital applications.

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