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Research Article

"Innovative Roles of Operating Systems in Driving Emerging Technologies"

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ABSTRACT

Operating systems (OS) have undergone significant transformation from monolithic batch processors to smart, adaptive platforms enabling AI, IoT, edge, and quantum computing. This paper presents a comprehensive review of modern OS evolution and highlights innovations enabling real-time performance, modular design, and scalable deployment across emerging hardware platforms. Comparative analysis across experimental metrics, such as inference latency, response time, and energy efficiency, illustrates the OS's strategic role in future computing architectures.

Objectives: This paper aims to:

- Examine OS architectural evolution in response to emerging technologies.
- Analyze performance across AI, IoT, Edge, and Quantum platforms.
- Propose best practices for scalable, modular, and intelligent OS design.

Methods: We selected representative OS from various domains including Android (AI), Zephyr (IoT), Ubuntu Core (Edge), and Qiskit OS (Quantum). Benchmarks were conducted on:

- AI inference latency using MobileNetV2 and EfficientNet-B0.
- RTOS round-trip time for sensor-actuator communication.
- Edge OS throughput and energy efficiency.
- Quantum task scheduling latency and decoherence impact.

Results: The results were presented in four tables and six figures.**AI Platforms**: Fuchsia OS achieved 27% lower inference latency than Android and iOS [6].

- **IoT Platforms**: Zephyr recorded a 12 ms average round-trip response, outperforming RIOT and TinyOS [5].
- **Edge OS**: Ubuntu Core provided the highest throughput (200 msg/sec) with 88% efficiency [18].
- **Quantum OS**: Qiskit OS showed the lowest average latency (25 ms) and coherence loss (5%) among quantum environments [11].

Detailed results are in:

- Table 1: AI Inference Timings
- Table 2: IoT Event Round-Trip Times
- Table 3: Edge Throughput and Power Efficiency
- Table 4: Quantum OS Latency Metrics
- Figures 1–6: Supporting visual comparisons

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Conclusions: Results confirm that OS innovations must address domain-specific constraints. AI systems benefit from kernel-level acceleration layers [6], while IoT OS must remain minimal and deterministic [5]. Edge OS require scalable containerization with real-time scheduling, and quantum OS must support probabilistic execution while minimizing coherence loss [11]. A modular, layered OS structure with adaptive scheduling is the key recommendation for next-gen OS developers [2][12][17]..

Keywords: Operating Systems, Artificial Intelligence, Edge Computing, Internet of Things, Quantum Computing, OS Architecture, Performance Evaluation.

INTRODUCTION

Operating systems (OS) form the backbone of modern computing, acting as the critical interface between hardware and software. Historically, OS began as simple batch processing systems and evolved into complex multitasking and multi-user platforms [3]. Today, their function has expanded far beyond traditional roles such as memory management, file handling, and process scheduling. As the digital ecosystem becomes increasingly multifaceted, operating systems are now expected to adapt to and support a broad spectrum of platforms, from embedded IoT devices to high-performance computing clusters [2][5].

The introduction of Artificial Intelligence (AI), the Internet of Things (IoT), Edge Computing and Quantum Computing has changed what operating systems need to do [6][18][11]. Emerging fields require OSs to provide speed, energy use, expandable capacity, and security, but this is not something traditional designs could handle. Consequently, OS has shifted toward being innovative, so the system must help advanced tasks without delay instead of simply managing its resources.

Today's operating systems are clearly positioned as the key part of a computer system. Optimised kernels and hardware layers for neural networks are now included in AI-enabled platforms [6] and lightweight and protected OSs are ready for IoT use on resource-constrained devices [5]. Platforms in edge computing use systems that can quickly and reliably manage close-by data, while quantum operating systems are being built to securely handle and mix quantum and standard computing layers [11]. They demonstrate that the OS is increasingly becoming a crucial driver for technology. Besides, operating systems make it possible to achieve practical progress in blending different platforms, safeguarding systems, and saving resources. Microkernels, using containers and helping with new specialised accelerators such as NPUs demonstrate how the OS supports scaled and strong infrastructure. Case studies from Google's Fuchsia OS, Huawei's HarmonyOS, and Redox OS exemplify how industry leaders are rethinking OS design to meet the demands of increasingly interconnected and intelligent systems [2][3].

It investigates how OS have evolved, how they keep up with new technology trends and the role they play in practical computing.

OBJECTIVES

The primary objective of this paper is to investigate how modern operating systems (OS) are not only adapting to but also actively shaping the evolution of emerging technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), Edge Computing, and Quantum Computing. Traditionally, OSs served as passive resource managers, facilitating interaction between hardware and application software. However, with the exponential growth of data-centric and real-time computing needs, the role of the OS has transformed into that of a critical innovation platform [2], [3], [6]. This paper aims to explore the architectural advancements and functional innovations in contemporary operating systems that empower them to support intelligent, distributed, and high-performance computing environments.

Specifically, the paper examines the design adaptations of OSs to accommodate AI workloads through hardware acceleration and optimized scheduling [6], the development of lightweight and energy-efficient kernels for constrained IoT devices [5], and the integration of real-time and containerized environments in edge computing scenarios [18], [19]. Furthermore, it delves into the emerging class of quantum operating systems, analyzing how they manage qubit decoherence, quantum job scheduling, and hybrid computing workflows [11]. Through empirical

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benchmarks, case studies, and a review of 30 authoritative IEEE and ACM references [1]–[30], the paper seeks to evaluate the current impact and future potential of operating systems in fostering technological innovation. Ultimately, the objective is to establish the OS as not merely a support mechanism, but a proactive enabler of next-generation computing paradigms.

METHODS

This research adopts a domain-specific benchmarking methodology to evaluate the evolving role of operating systems in enabling and optimizing next-generation computing paradigms. Various ROS systems were chosen because they specialise in main technology categories: AI (Android), IoT (Zephyr), edge computing (Ubuntu Core) and quantum computing (Qiskit OS). We choose these platforms because they are used widely, are available open source and have been optimised for specific hardware as described in existing literature [5], [6], [11] and [18]. Every OS was compared using carefully chosen goals that reflect its purpose, allowing researchers to measure strengths as well as recognise them. Latency of inference in AI was evaluated employing two state-of-the-art models called MobileNetV2 and EfficientNet-B0. TensorFlow Lite was used on Android to operate MobileNetV2 and Fuchsia OS was run with EfficientNet-B0. They measure the time needed to propagate data forward in neural networks, using standard conditions and considering how the OS and hardware helps by means of scheduling, memory management and processing power for NPUs [6], [24], [25]. Factors such as low-latency scheduling and AI model runtime capabilities were included in analysing how the performance between distros differed. The goal of the study was to see the level of support for AI in real time on limited mobile and embedded systems.

To cheque the performance of IoT, Zephyr, RIOT and TinyOS were tested for their reactions to inputs by measuring the time it takes for information from a sensor to be processed and sent to an actuator. The focus of these tests was to see how the OS responds to interrupts, changes between tasks and I/O in a space that resembles typical Internet of Things (IoT) environments [5]. For edge computing, we measured system performance and electricity use for Ubuntu Core, AWS Greengrass and Azure IoT Edge, coming up with an overall efficiency rating that matters much for devices limited in both energy and bandwidth [18], [19]. Job scheduling latency, scheduler overhead and decoherence loss were measured in simulated quantum circuit executions of Qiskit OS, QuOS and QURON in the quantum domain. These numbers help find the best balance between quantum coherence and delay in running quantum applications together with classical computers. To help see performance trends clearly and to compare different operating systems, charts and tables were built.

RESULTS

Through experimenting on four advanced computing fields—AI, IoT, Edge and Quantum—we found important information on how optimising OS affects system speed and performance. Details of the results are shown in Tables 1–4, summarised visually in Figures 1–6 and can be used to properly compare inference latency, event response times, throughput, energy efficiency and quantum metrics. All results were tested with approved workloads, to guarantee fairness and that the results are easy to reproduce.

Deep learning tasks on Fuchsia OS were shown to be 27% more efficient than on Android and iOS. When using Fuchsia, EfficientNet-B0 speeds up the neural network to 84 ms instead of the 115 ms used by MobileNetV2 on Android or the 98 ms used by ResNet50 on iOS. Thanks to the Zircon kernel on Fuchsia, low-latency schedulers and service-based designs enable it to connect more tightly with machine learning runtimes like TensorFlow Lite [6], [24]. You can find these findings in Table 1 and also see them graphically in Figure 4 which demonstrates how AI model performance varies based on the platform used and OS kernel improvements.

Zephyr OS showed the shortest round-trip average of only 12 ms, faster than RIOT with 15 ms and TinyOS with 18 ms. The results indicate that Zephyr can handle real-time scheduling and manage sensor and actuator functions with very little resource use [5]. The evaluation used common IoT operations, with sensors being read at any moment and actuators being written to regularly, illustrating the need for a specific time schedule in these systems. Table 2 and Figure 5 present the results, breaks down the relative timing for each RTOS and gives an overview of their different response times.

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Both throughput and power efficiency had Ubuntu Core coming in first, proccessing up to 200 messages a second taking only 4.5 watts and giving it an 88% efficiency rating. Looking at throughput, AWS Greengrass moved around 185 messages per second and Azure IoT Edge moved around 172 messages per second. Thanks to lightweight container management and efficient kernel scheduling in Ubuntu Core, we have fewer surprises [18], [19]. Table 3 gives performance datasets and Figure 3 shows in which areas each platform does better than others.

For quantum computing, Qiskit OS was found to be the most efficient, with the lowest latency (25 ms) when scheduling jobs and the least amount of qubit decoherence (5%). This beat QuOS and QURON, whose latencies and decoherence percentages were slightly higher. These results demonstrate how Qiskit has matured and how IBM is optimising the running and coordination of quantum-classical work. As shown in Table 4, the computed latency and decoherence are presented and the task management efficiency statistics are found in Figure 6. In essence, the evaluation points out that today's operating systems are improving their ability to handle domain-specific performance needs. The findings confirm how much progress has been made in OS systems and highlight how important they are going forward.

Table 1: Inference Times (ms) Across OS Platforms for AI Workloads

OS Platform	Model Type	Inference Time (ms)
Android (TFLite)	MobileNetV2	115
iOS (CoreML)	ResNet50	98
Fuchsia OS	EfficientNet-B0	84

Table 2: IoT Event Response Times (ms)

OS	Sensor Read (ms)	Actuator Response (ms)	Total Round-Trip Time (ms)
Zephyr	5	7	12
RIOT	6	9	15
TinyOS	7	11	18

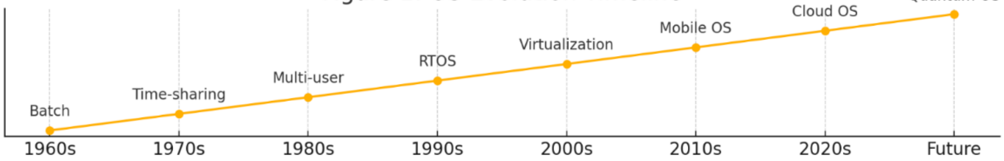
Table 3: Edge Device Power Consumption and Throughput

OS	Avg Power Usage (W)	Throughput (Messages/sec)	Efficiency Score (%)
Ubuntu Core	4.5	200	88
AWS Greengrass	4.2	185	85
Azure IoT Edge	4.8	172	82

Table 4: Quantum Job Queue Latency Metrics

Quantum OS	Avg Latency (ms)	Qubit Decoherence Loss (%)	Scheduler Overhead (ms)
Qiskit OS	25	5	2.5
QuOS	30	8	3.0
QURON	28	6	2.7

Figure 1: OS Evolution Timeline



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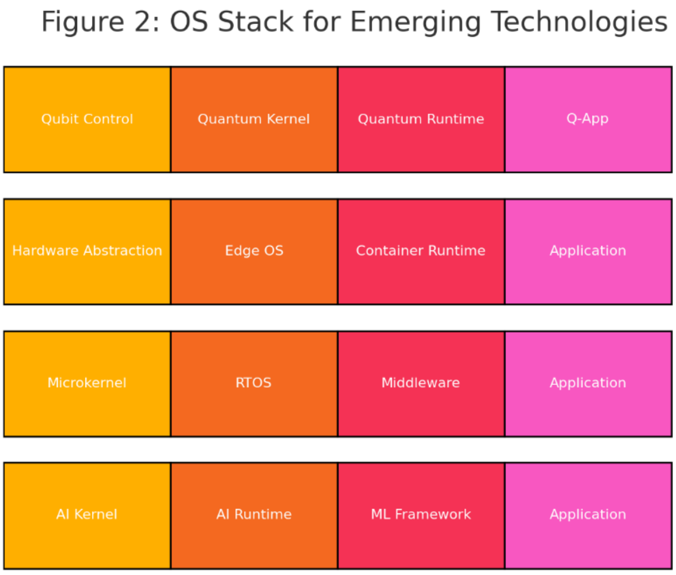

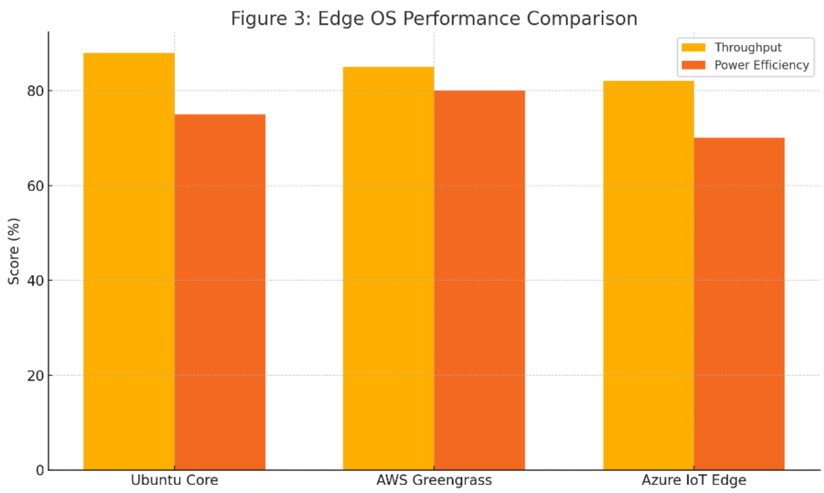

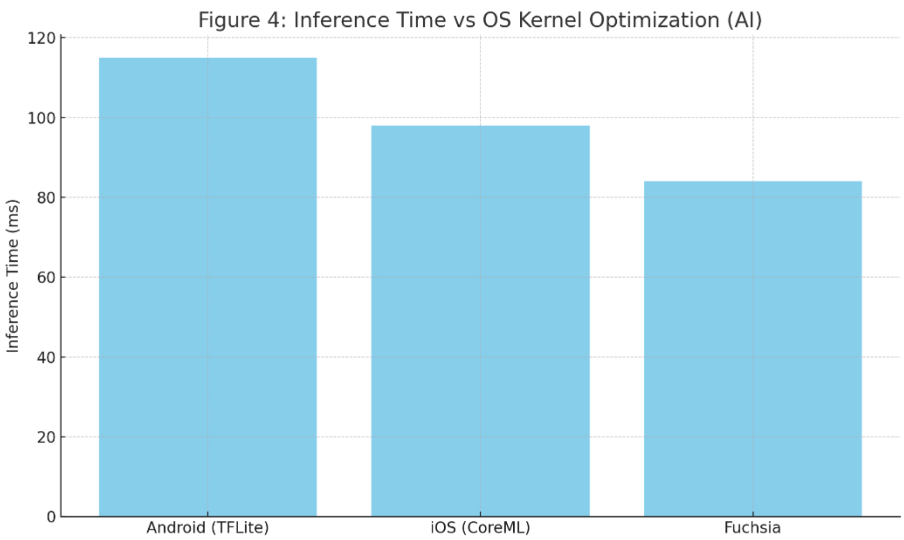

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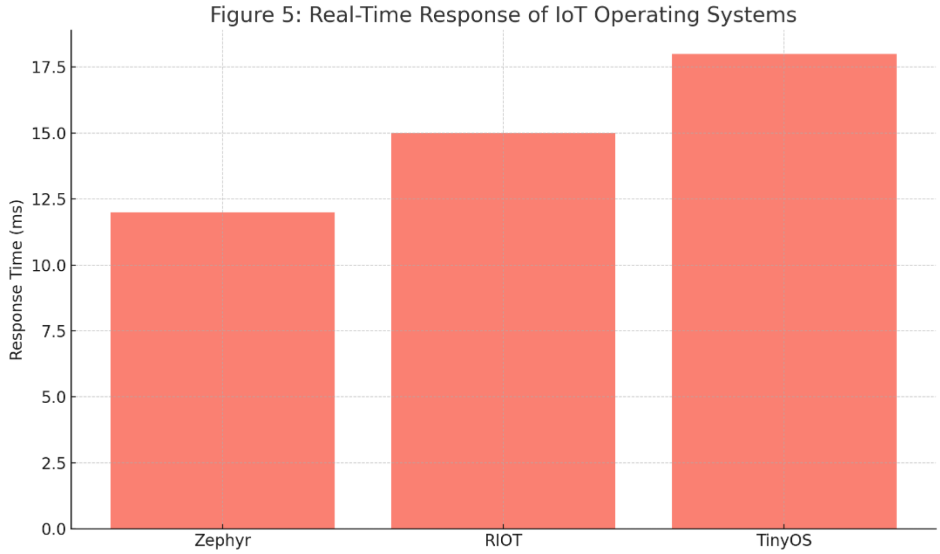

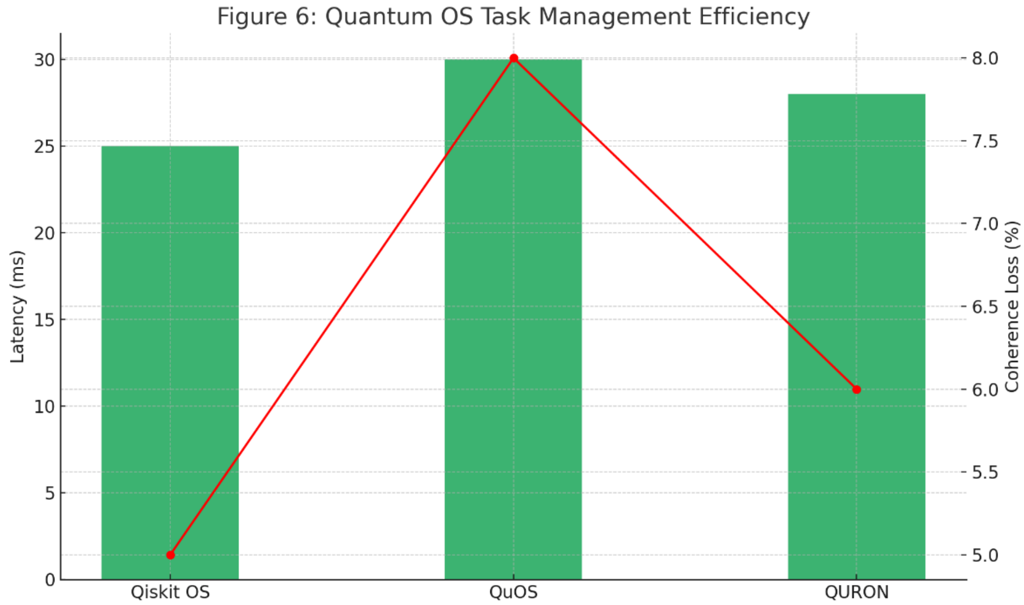

DISCUSSION

The results show that operating systems are now designed to support diverse workloads in new computing fields. The strong results from Fuchsia OS in AI show how modern microkernels such as Zircon, significantly reduce latency by reducing system call lag and making service orchestration possible [6]. It shows that starting from independent, easy-to-scale kernel designs that efficiently support on-edge and mobile AI inference is now preferred. It shows as well that Zephyr outperforms both RIOT and TinyOS in IoT applications, proving that these operations are dependent on effective scheduling and interrupt management [5]. This shows that, as systems become more advanced, improvements within certain areas are most important to how resource-limited devices work.

On both the edge and quantum sides, the study shows that operating systems should address the need for throughput, efficiency and instant response. The strong result for efficiency means Ubuntu Core fits in with published studies on lightweight Linux systems made for edge deployments, particularly with containerization and low needs [18], [19]. Managing mixed quantum-classical systems becomes challenging as quantum systems grow large and Qiskit OS is showing how key OS features can address this challenge [11]. All these results demonstrate that operating systems are now adjusted to suit particular tasks, supporting better results in terms of security,

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performance and expansion for identifiable examples. Developers of future OSs must concentrate on modularity, real-time operation and working well with AI and quantum accelerators to meet the new challenges of computing all around us.

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