

# Implementing and Analyzing Network Commands in Cloud and Edge Computing Environments with Cisco Simulators

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## Abstract

*The present review examines edge and cloud topologies and compares them according to latency. Instead of using distant data centers like cloud computing platforms, edge computing designs process data physically close to the source. Increased demand for Internet of Things (IoT) devices, which are growing more concerned with real-time data processing and analysis, has fueled the expansion of edge computing and cloud computing. In essence, each of these designs offers distinct approaches to data management and job processing, each with its own set of benefits and drawbacks. It has been observed that, in contrast to cloud computing architectures, which provide scalability over the long term, edge computing systems gradually reduce latency. Empirical research and a review of the literature showed that while Edge may be excellent at reducing latency, it has problems with long-term scalability. Cloud computing, on the other hand, is excellent at scaling and cutting costs, but it has issues with latency. In order to build effective systems that will satisfy all of the applications' significant requirements, it is advised to have a thorough understanding of these structural variations.*

**Keywords:** Edge computing, cloud computing, latency reduction, efficiency, scalability, performance, privacy/security, data processing, empirical analysis, system design

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## INTRODUCTION

The growth of edge computing and cloud computing has been driven by increased demand for the Internet of Things (IoT) devices which are becoming increasingly concerned with real time data processing and analysis. Each of these architectures basically provides different ways of managing data and processing tasks, each of which presents unique advantages and disadvantages [1,2].

It is vital to clarify the distinction between edge and cloud computing, as well as potential collaborative activities [3]. This knowledge leads to efficient and flexible systems that are adapted to the needs of today's applications [4]. Edge computing basically is a distributed computing framework that brings computing and storage resources closer to where data is generated, i.e., it refers to the preprocessing of the data [5] in proximity to its origin. This is done to minimize the latency [6], and to reduce the dependence on centralized data centers [7].

The debate on edge versus cloud computing is about finding balance between data sources and centralization of assets. According to some edge computer advocates, reducing the distance of computation from data results in the reduction of latency along with improved response time and the additional protection of privacy and security [8]. The rapid advancement of cloud and edge computing has significantly transformed modern networking, necessitating more advanced approaches for managing distributed systems, enhancing performance, and ensuring security. As businesses transition to these sophisticated infrastructures, managing networks has become increasingly intricate, especially when integrating various computing models. In this scenario, Cisco simulators have become invaluable tools for simulating network environments and testing configurations prior to deployment. These simulators provide an efficient platform for experimenting with network commands and topologies, aiding in the learning process and allowing engineers to troubleshoot and optimize networks within a controlled virtual environment.

This article delves into the application and analysis of network commands within cloud and edge computing settings, with an emphasis on how Cisco simulators can bridge the gap between theoretical network designs and practical implementations. By evaluating the features of these simulators, the article highlights their significance in helping network professionals gain a deeper understanding of the complexities associated with cloud and edge architectures.

This review basically investigates the pros and cons of edge computing with regards to its latency reduction, efficiency, scalability and performance. Tools like Tracer and Ping can be utilized to assess the effects on latency and data transfer efficiency. Furthermore, the review discusses the outline of edge and cloud computing models, latency considerations, detailed experimental methodologies and findings, and its implications. Planning for effective systems that can adjust to modern applications with shifting requirements requires an understanding of the complexity of edge and cloud device designs.

## **LITERATURE REVIEW**

The combination of Edge Computing with Cloud Computing is a rapidly evolving field, as seen by the plethora of research articles on different areas concerning this domain. Simion E's "Towards Seamless Serverless Computing Across an Edge-Cloud Continuum" and "Optimize Cloud Computations using Edge Computing" are published in line with how serverless computing can be made to be integrated seamlessly between Edge and Cloud environments hence addressing the questions that come with these new trends [9, 10]. Likewise, the book titled "Integration of cloud computing with Edge Computing" delves into composite patterns and models for both edge and cloud computing which offer insight on hybrid architectures' design [11].

In the context of Edge Computing designs, for example, research publications such as "Edge-Cloud Computing for Internet of Things Data Analytics: Embedding Intelligence in the Edge with Deep Learning" often describe the function that Deep Learning plays in addition to cloud migration tactics [12,13]. Such studies provide exceptional insights into practical installation of edge resources and cloud technologies [14]. Additionally, "Combining Edge and Cloud Computing for low-power, Cost-effective Metagenomics Analysis" shows that integrating Edge and Cloud resources will result in both cost-effectiveness and metagenomics analysis efficiency.

The existing research papers on this area also go into specific applications and use cases of the integration of Edge Computing with Cloud Computing, as can be seen from "Collaborative Cloud and Edge Computing for Latency Minimization" and "Future Edge Cloud and Edge Computing for Internet of Things Applications" [15]. The studies highlight new patterns, challenges and opportunities in integrating Edge and Cloud resources for different IoT purposes. In general terms, the reviewed literature on merging cloud and edge computing consists of a variety of scientific output; ranging from theories to practical works that are expected to bring forth revolutionary progressions in distributed computing architectures.

Research in Edge and Cloud computing spans big data analytics, cyber security, networks and computer science which necessitates teamwork of computer architecture scholars to address complicated issues. The fusion of different fields equips the market with a complete knowledge base for satisfying the taste buds of diverse types of customers. IoT applications rely heavily on streamlined internet connection speeds to communicate effectively with the cloud network. By increasing such network command instructions, IoT applications can fully function without any disruptions thereby ensuring a convenient user experience. Similarly, these commands are essential for making IoT devices operate normally while providing network health monitoring support as well as edge-to-cloud communications or QoS management

## **EDGE COMPUTING VS CLOUDCOMPUTING**

### **Edge Computing**

The structure of edge computing refers to users' undertaking computation at the end, where it consumes information and therefore enhances responsiveness while preserving bandwidth. Such architecture is suited for applications that need minimal latency such as internet of things (IoT) and augmented reality [16]. There are several levels of this type of architecture including: edge things, edge devices, and edge data centers [17]. Each level in this hierarchy carries out some kind of information processing. All-edge- devices have a built-in database [10].

### **Cloud Computing**

Cloud computing architecture has a more centralized data server approach [18]. The architecture consists of two parts, front end and back end. The front end has cloud infrastructure, that is basically data storage, server, etc. Application, storage, and service make up the backend portion of the architecture [19]. Software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS) are the three main variants of this architecture [20]. It provides scalability, security, fault tolerance and accessibility but lacks in latency since data processing is done at centralized data centers [21, 22].

### **Comparison**

Both Edge and Cloud Computing architectures which aims to keep data privacy and security secure. Edge Computing enhances data privacy by securing all the sensitive information local which helps in reducing the risk of cyber threats. Alternatively, cloud computing needs to assign data to third-party providers which helps in raising concerns about data privacy, security, and compliance with regulations. Cloud service providers provide strong security measures in spite of the measure's organizations must ensure compliance with privacy security and reduce the risks. Also, cost considerations play an important role in adjusting to both architectures. For edge computing, the deployment and management of edge infrastructure can result in higher costs at early levels, But Cloud computing can save costs over time. Organizations which use cloud computing pay only for resources in cloud through a tiered pricing model. Hybrid architectures, which combines the mixture of both edge and cloud computing offers a middle ground which utilizes the strengths of either edge or cloud. By understanding the differences and considerations we can conclude decisions about architectural design and deployment, ensuring optimal performance and scalability.

## **EXPERIMENTAL SETUP AND METHODOLOGY**

We used latency as a test to compare both architectures using "ping" and "tracert" commands. For comparison, we mimicked both architectures and ran simulations on the Cisco Packet Tracer.

### **Environment Simulation**

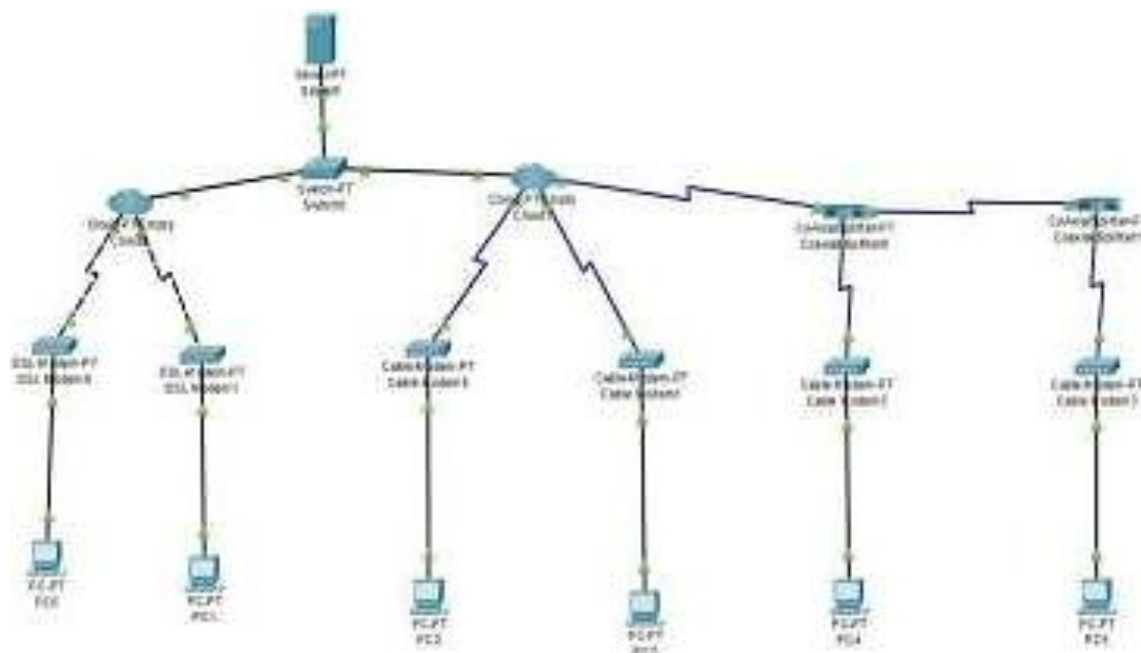
We mimicked both architectures and ran simulations on the Cisco Packet Tracer for Edge computing and Cloud computing. A combination of routers, switches, modems, and end devices were used to simulate real-world scenarios. Summary of Devices Used to show in Table 1.

**Table 1.** Summary of Devices Used.

No.	Name	Uses
1.	Cloud	It is used to connect to local network internet or other remote networks.
2.	Switch	Establish efficient communication between devices on the same network segment
3.	Server	Simulate various networks within network services within the network architecture.
4.	Router	Facilitates the exchange of data between devices in different IP address ranges.
5.	Modem	Simulates the interface between the local network and the internet service provider.
6.	Coaxial Splitter	distributes the signal to various devices.

**Cloud Computing Architecture**

The server is connected to the switch. Two clouds are connected to the switch (Cloud0 and Cloud1). Finally, cloud0 is connected to two modems connected to PC0 and PC1. Cloud1 is connected to two modems connected to two PCs, and CoaxialSplitter0. Cloud Computing Architecture shown in Figure 1. This CoaxialSplitter0 is connected to Modem2 and CoaxialSplitter1. The modem is connected to PC4 and modem CoaxialSplitter1 which connects PC5 again. This strategy will improve the connectivity between the networks and enable data transfer.

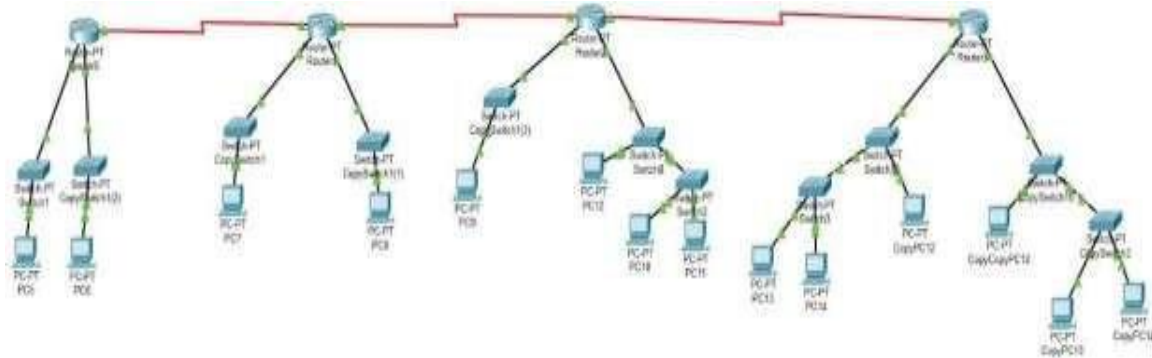


**Figure 1.** Cloud Computing Architecture.

**Edge Computing Architecture**

Edge Computing Architecture, Edge Computing architecture Router 0, Router 1, Router 2, Router 3 use four routers Router 0 is connected to two switches, switch 1 and Switch 2, each of which is a separate set of PCs, PC0 and... PC1. Edge Computing Architecture shown in Figure 2. Ping Reading on Cloud Architecture and Edge Architecture shown in Table 2.

This configuration improves network flexibility and adds redundancy. Similarly, Router 1 has the same architecture as Router 0. For Router 2, 2 Switches are connected, and then one switch is connected to the other, and then to PC10 and PC11. Tracert Evaluation shown in Figure 3. Router 3 has 2 switches, another switch for both, and a PC connected to the network. Tracer Reading on Cloud Architecture and Edge Architecture shown in Table 3. Switch 3 and its copy are then connected to PC 2. Edge computing lowers latency and bandwidth usage by processing data near its source. Ping and Tracert Comparison for Cloud and Edge Architectures shown in Figure 4.



**Figure 2.** Edge Computing Architecture.

### Ping Latency Evaluation

The 'ping' command was used to analyze the latency in the architectures.

**Table 2.** Ping Reading on Cloud Architecture and Edge Architecture.

S/N	Edge	Cloud
1.	39 ms	69 ms
2.	25 ms	68 ms
3.	24 ms	61 ms
4.	13 ms	61 ms
5.	43 ms	74 ms
6.	25 ms	70 ms
7.	5 ms	60 ms
8.	22 ms	71 ms
9.	26 ms	75 ms
10.	15 ms	70 ms
11.	32 ms	67 ms
12.	21 ms	70 ms
13.	45 ms	69 ms
14.	19 ms	60 ms
15.	34 ms	71 ms
16.	32 ms	67 ms
17.	21 ms	69 ms
18.	45 ms	70 ms
19.	19 ms	69 ms
20.	34 ms	64 ms

### Tracer Latency Evaluation

The 'tracert' command was used to analyze the latency in the architecture.

**Table 3.** Tracer Reading on Cloud Architecture and Edge Architecture.

S/N	Edge	Cloud
1.	4 ms	27 ms
2.	4 ms	24 ms
3.	3 ms	21 ms

4.	3 ms	24 ms
5.	3 ms	26 ms
6.	4 ms	25 ms
7.	5 ms	26 ms
8.	5 ms	20 ms
9.	5 ms	25 ms
10.	4 ms	26 ms
11.	7 ms	22 ms
12.	5 ms	25 ms
13.	4 ms	29 ms
14.	4 ms	23 ms
15.	8 ms	23 ms
16.	6 ms	25 ms
17.	7 ms	22 ms
18.	7 ms	22 ms
19.	6 ms	25 ms
20.	6 ms	25 ms

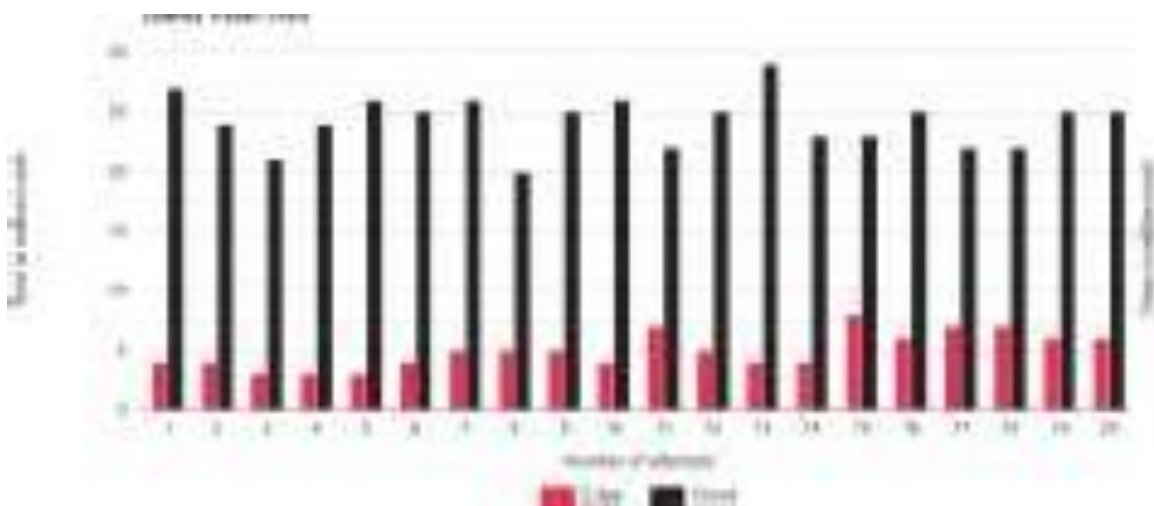


Figure 3. Tracert Evaluation.

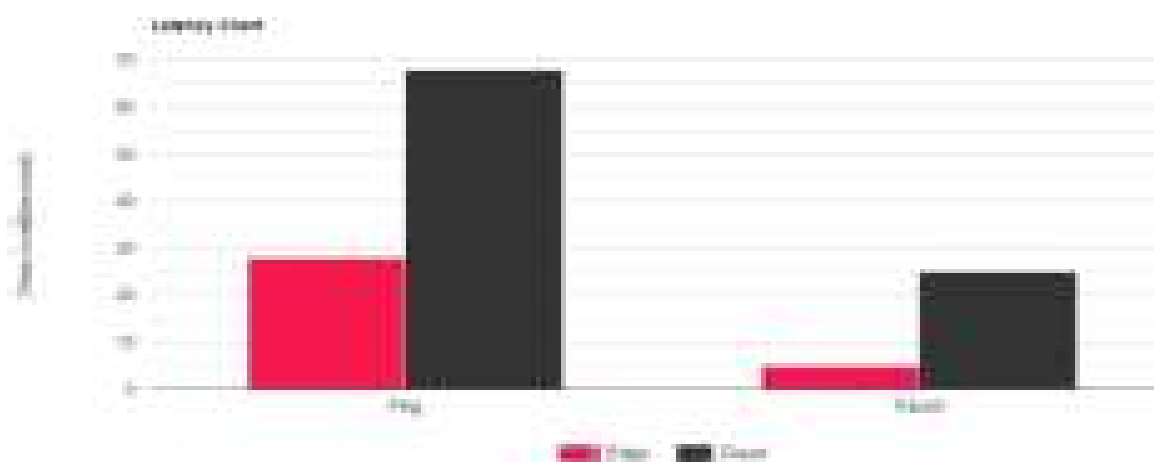


Figure 4. Ping and Tracert Comparison for Cloud and Edge Architectures.

## CONCLUSION

In conclusion, our review illustrates the architectural differences between Edge and Cloud Computing and their latency performance. We found that Edge Computing offers less latency processing data closer to its source of generation compared to cloud computing for ping and tracer commands since cloud computing architecture centralizes data processing to distant centers that can introduce latency. Both these Architectures offer their own set of pros and cons. Data security and privacy are top priorities for both cloud computing and edge computing. Future research could be a comparative study exploring privacy and security in distributed computing settings, these security and hybrid designs maximize speed, scalability, and cost-effectiveness by utilizing the advantages of both cloud computing and edge computing.

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