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# Enhancing Digital Accessibility in Africa: Evaluating the Impact of AWS CDN on Cloud Performance Across Different Regions

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## Abstract

This thesis presents the impact of Amazon Web Services Content Delivery Network in enhancing digital accessibility and cloud performance across different regions in Africa. It looks forward to addressing challenges affecting latency and efficient content delivery to give an outstanding online experience for African users. The research, by using a mixed methods approach with quantitative performance metrics, online surveys, and comparative analysis, assesses the effectiveness of AWS CDN in different African regions.

The results of this study represent a regional variation in latency, with African users experiencing higher latency compared to other continents. This is due to the limited number of AWS edge locations and regional edge caches in Africa. The research pointed out the key reasons for the influence on the performance of the CDN: quality of infrastructure, internet penetration, and economic conditions. In addition, user preferences and perceptions focus on the optimized content delivery, most especially the video streaming and social media to cell applications.

The study indicates economic gains for the improvement of digital infrastructure. In this regard, the improved implementations of AWS CDN can drive economic growth, foster innovation, and create digital inclusion. Expanding AWS edge locations, collaborating with local ISPs, and implementing policies supportive of infrastructure development are among the recommendations of this study. By addressing these issues, the study seeks to contribute to the broader objectives of digital transformation and economic advancement in Africa.

## Foreword

I would like to extend my deepest gratitude to my supervisor, Simo Juvaste, for his profound insights and invaluable instruction throughout my research. His guidance has been instrumental in shaping the direction and quality of this thesis.

I am also profoundly thankful to Oili Kohonen, the Academic Affairs Specialist, for her exceptional academic guidance and counselling. Her personal support and program management have been pivotal in helping me navigate through my studies and excel in my subject matter.

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This thesis would not have been possible without the support and contributions of these individuals.

Thank you.

## Abbreviations

CDN	Content Delivery Network
AWS	Amazon Web Service
POP	Points of Presence
QoS	Quality of Service
ICT	Information and Communication Technology
ISP	Internet Service Providers
API	Application Programming Interface
DC	Data Center
IS	Information Systems.
CC	Cloud Computing
WAF	Web Application Firewall
IaaS	Infrastructure as a Service
PaaS	Platform as a Service
SaaS	Software as a Service
IWS	Internet World Statistics
ITU	International Telecommunication Union

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## 1 INTRODUCTION

In an age of rapid digitization, the Internet is a transformative force that connects people and promotes global cooperation. Despite the growing importance of internet connections in Africa, there are still challenges in ensuring widespread connectivity (Alemneh & Hastings, 2006). It is impossible to overestimate the significance of having a well-established digital infrastructure in Africa, particularly when it comes to utilizing cloud services to provide a seamless internet experience.

Despite these challenges, more African companies are beginning to use cloud technology. Many businesses have already moved much of their work to the public cloud. The rate of adoption is sometimes equal to or even higher than in regions with better-established digital infrastructures. However, because much of the cloud infrastructure sits outside Africa, users suffer from problems like delays and security concerns, which highlights the need for local solutions (Mosweu, 2019).

This thesis examines how Amazon Web Services (AWS) Content Delivery Network (CDN) impacts cloud performance across various regions of Africa. Understanding how AWS CDN performs can contribute to strategies for enhancing digital access, thereby lowering delays in cloud service delivery. The findings aim to help build better digital infrastructure in Africa, enhance online experiences, and support the continent's efforts towards digital growth and transformation.



## 1.1 BACKGROUND

### 1.1.1 Overview Of Cloud Computing

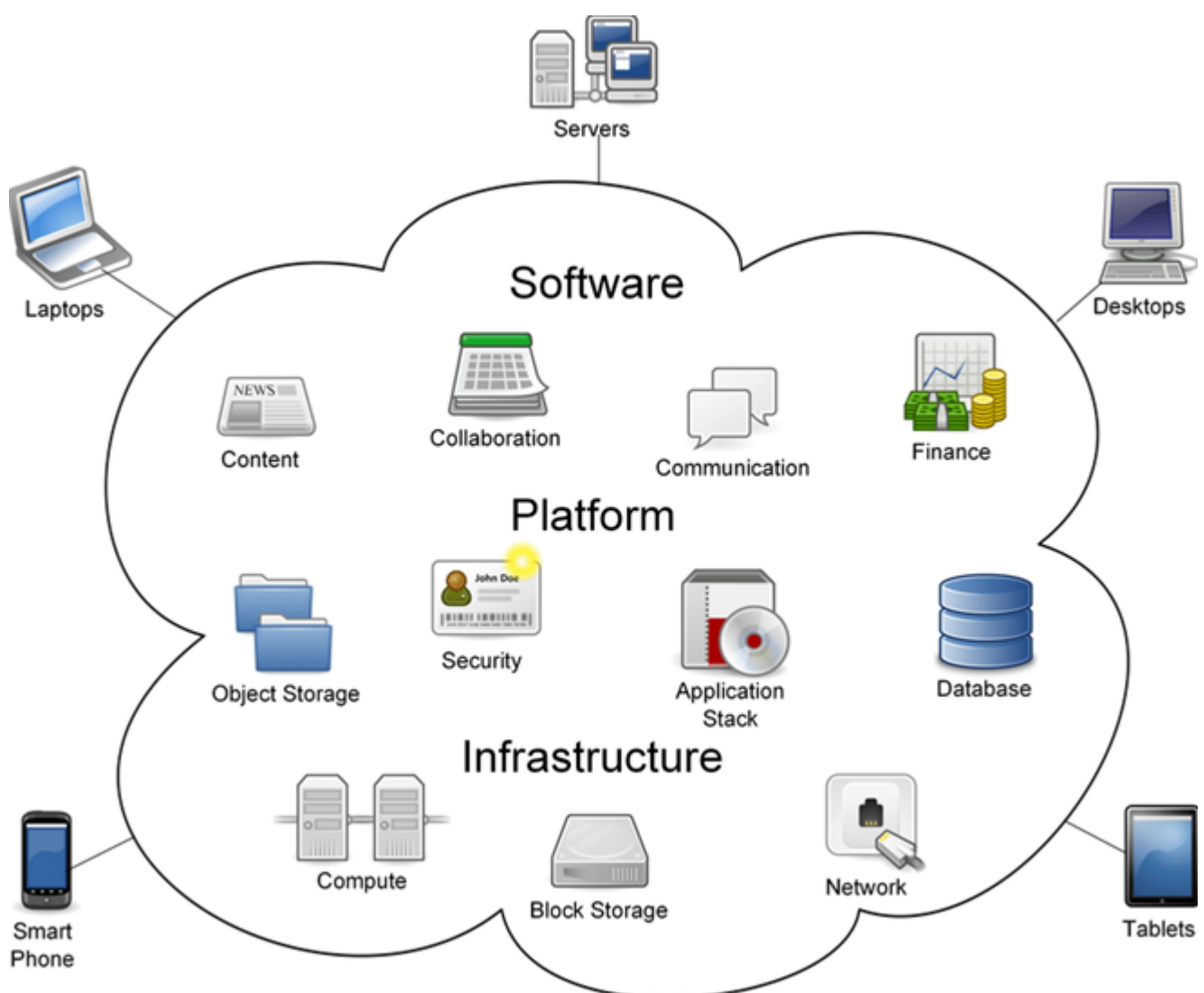
A dynamic and scalable framework for the delivery of a wide range of computing services over the Internet—commonly referred to as "the cloud"—is provided by the cloud computing paradigm, which goes beyond traditional computing models (Rao, C.C., & Kumar, M.L. 2013).

In its most basic form, Karim (2020) defines cloud computing as the provision of a wide range of services, including networking, servers, storage, databases, software, analytics, and intelligence. By making these services available remotely, businesses and individuals can access a common pool of computer resources. In contrast to traditional on-premises infrastructure, the cloud computing model offers increased agility, quicker innovation cycles, and effective pay-as-you-go resource utilization.

In comparison to traditional in-house IT solutions, spending on cloud infrastructure has increased significantly in recent years, indicating the cloud's growing significance in the field of enterprise computing. The transition to cloud computing is clear in the private clouds created by businesses as well as the public clouds offered by vendors. According to Gartner, cloud-based solutions will account for approximately half of investment in the application software, infrastructure software, business process services, and system infrastructure sectors by 2025, up from 41% in 2022. They predict that cloud computing will account for about two thirds of application software spending, a considerable increase from 57.7% in 2022. (Ranger, 2022).

An illustrative diagram Figure 1 of cloud computing, showing its three fundamental layers: Infrastructure, Platform, and Software. Icons at the Infrastructure layer include a smartphone, computer functions, block storage, and network components. The icons at the Platform layer include object storage, security, and application stack symbols. Software layer icons include news content, collaboration, communication services, and finance programs. The other devices that interact with these layers surround the central cloud labeled 'Cloud Computing' and include a laptop, servers, desktops, and tablet.

This is a conceptual diagram visually showing the structure of cloud computing in three layers: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) — related to different types of devices, such as laptops, smartphones, tablets, desktops, and servers. This makes the image interesting because it simplifies a complex architecture into an easily understandable format, relevant for educational purposes or simply to show how various services are delivered over the internet (*Cloud Computing Reference Model with Diagrams, 2024*).



**Figure 1.** Navigating the Layers of Cloud Computing Architecture: Cloud Computing Layers - IaaS, PaaS, and SaaS (Cloud Computing Reference with diagram, 2024)

Cloud computing's core principles of flexibility, scalability, and economies of scale enable users to adjust resources based on demand, fostering innovation and growth. However, low latency, sufficient bandwidth, and stable network connectivity are essential to ensure reliable and efficient access to cloud services.

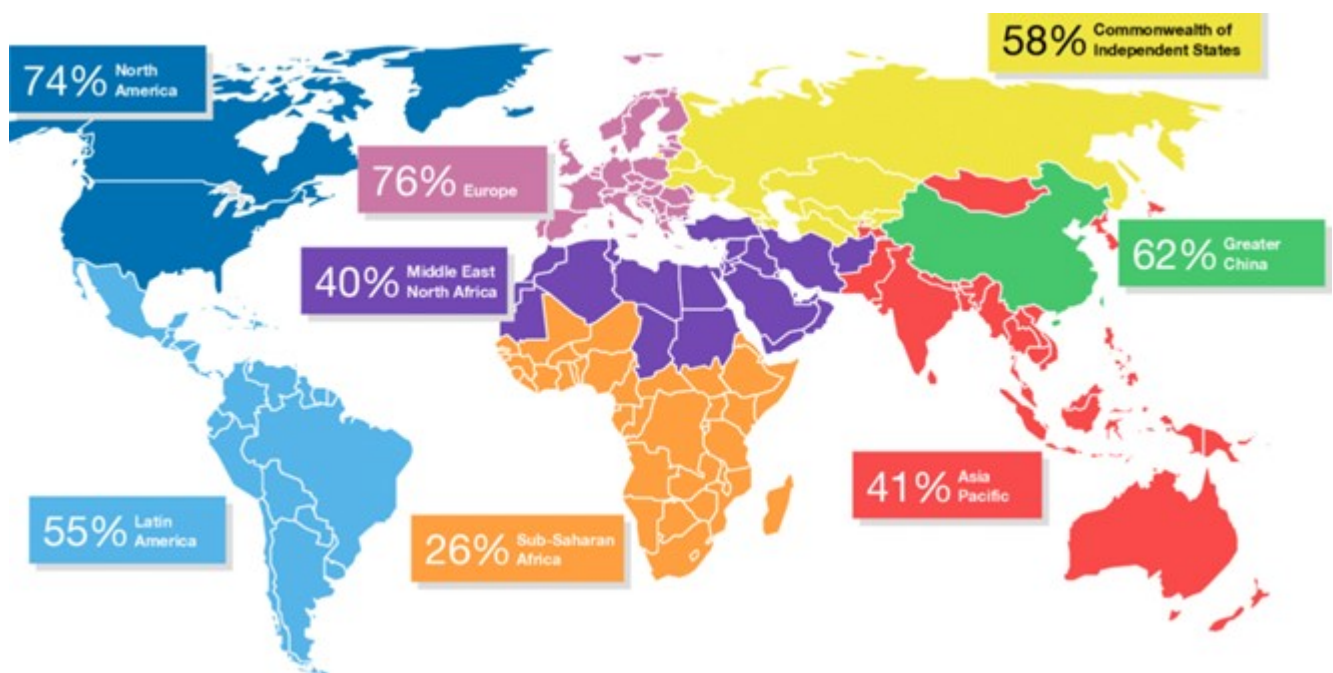
In this thesis, we will investigate how high performance and low latency content delivery develop in Africa by looking deeper into the field of cloud computing. The main objective will be to improve digital accessibility, and the assessment will center on how AWS CDN affects cloud performance in different parts of the continent.

### **1.1.2 Overview Of Digital Accessibility in Africa**

Recently, there has been growing interest in leveraging cloud infrastructure as a catalyst for technological advancement in Africa. Governments, companies, and communities are realizing how cloud computing can revolutionize innovation, increase productivity, and simplify data-driven decision-making. However, accessibility to cloud infrastructure remains a critical challenge across the continent. Despite its advantages, limited access to strong and dependable digital infrastructure hinders its full potential. Economic inequality, underdeveloped data centers, and poor internet access exacerbate Africa's digital gap. Implementation faces financial, political, economic, social, and infrastructural challenges (Wakunuma & Masika, 2017).

Organizations are increasingly moving applications to the cloud due to global adoption, including in Africa. However, with cloud infrastructure concentrated in North America, Europe, and Southeast Asia, Africa relies on remote infrastructure, compromising data security and adding latency (Babasanmi & Chavula, 2022). Giorgi (2016) reports in Al Jazeera that Africa's internet penetration is 18 percent, below the 30 percent global average, with only one in ten households connected. Yet, from 2000 to 2012, Africa's number of connected users grew seven times faster than the global average (Internet World Statistics).

As shown in Figure 2, in 2020, there was a large gap in internet penetration rates across Africa. Countries in the northern part of the continent had a high 40% internet penetration rate, while the central and southern regions lagged with a rate of 26%. This uneven distribution revealed a significant digital divide within Africa and emphasized the need for targeted efforts to increase internet access in less connected areas (ResearchGate, 2020).



**Figure 2.** Distribution of global internet Users by world regions as of 2020 global Internet penetration rates by region areas (ResearchGate, 2020).

By 2022, the internet penetration rate in Africa improved to 43.2%, but it was still lower than the world average of 67.9%. This marked an increase of 13.2% from 2000 to 2023 (World Internet Users Statistics and 2023 World Population Stats, 2023).

Despite facing notable challenges, African companies have demonstrated their proactive approach to embracing cloud technology. In fact, preliminary data suggests that Africa is rapidly transitioning to cloud computing and that this trend is continuing. According to a recent McKinsey survey, technology leaders at over fifty large African companies report that currently, 45% of

their workloads are stored on public cloud services. While the sample size is small, these adoption rates are comparable to or even exceed those observed in North America and China (Blumberg et al., 2024).

### 1.1.3 Challenges In Delivering Reliable and Efficient Online Services

Cloud computing has been a real game-changer for businesses about scalability, flexibility, and thus cost reductions brought in respect of operational efficiency. However, there are several challenges that obviously exist in digital transformation, such as capacity planning, user experience, scalability, network latency, regulatory compliance, technical debt, time, and cybersecurity risks. Therefore, the objective of this section is largely one of preparation proactively and optimization towards digital service delivery in this regard, especially the role of Content Delivery Networks towards the network latency in a large and geographically dispersed region like Africa. This paper aims to debate how the challenges in cloud computing could be overcome and digital effectiveness enhanced (Kuo, 2011).

**Key Challenges:** (Moreno-Vozmediano et al., 2013)

1. **Downtime and Outages:** The deployment of strong contingency measures is important because of the possibility of service outages resulting from unexpected hardware or network failure. Simultaneously, bugs and glitches in the code present an ongoing risk with the potential to result in unexpected failures and interruptions to the service. These challenges are exacerbated by problems in data centers, such as cooling or power outages, which can significantly affect the overall availability of services.
2. **Cybersecurity Threats:** Cyber-attacks are ongoing threats in which malicious entities try to compromise systems through tactics such as DDoS attacks, ransomware, or other security breaches. Ensuring the security of user data is crucial, as any breach can lead to serious consequences such as loss of trust and legal ramifications.
3. **Scalability Issues:** Handling sudden increases in user traffic, particularly during promotions or events, stresses servers and may lead to performance decline. Maintaining the

correct balance when allocating resources to fulfill demand without overprovisioning is an ongoing challenge that calls for clever solutions.

4. **Network Latency:** Providing services to users in various geographical locations can lead to latency issues because of the physical distance between servers and end-users.
5. **User Experience:** Slow page loading or unresponsive interfaces can have a negative impact on the overall user experience, requiring ongoing efforts to optimize the performance. Ensuring smooth compatibility across different devices, browsers, and operating systems is a complex challenge.
6. **Regulatory Compliance:** Compliance with various privacy and data protection laws requires complex compliance protocols and continuous system updates.
7. **Technology Advancement:** Reliance on outdated software or infrastructure results in inefficiencies and increased vulnerability. Therefore, a planned approach to smooth technology updates is required.
8. **Capacity Planning:** Accurately predicting user growth and planning for expanded capacity are continuous challenges. While overestimating results in needless expenses, underestimation can cause performance problems.
9. **Customer Support:** Maintaining user satisfaction and trust during service disruptions requires quick and efficient response to customer care inquiries.
10. **Monitoring and Analytics:** Having robust monitoring and analytics tools in place is essential for identifying possible problems before they impact users.

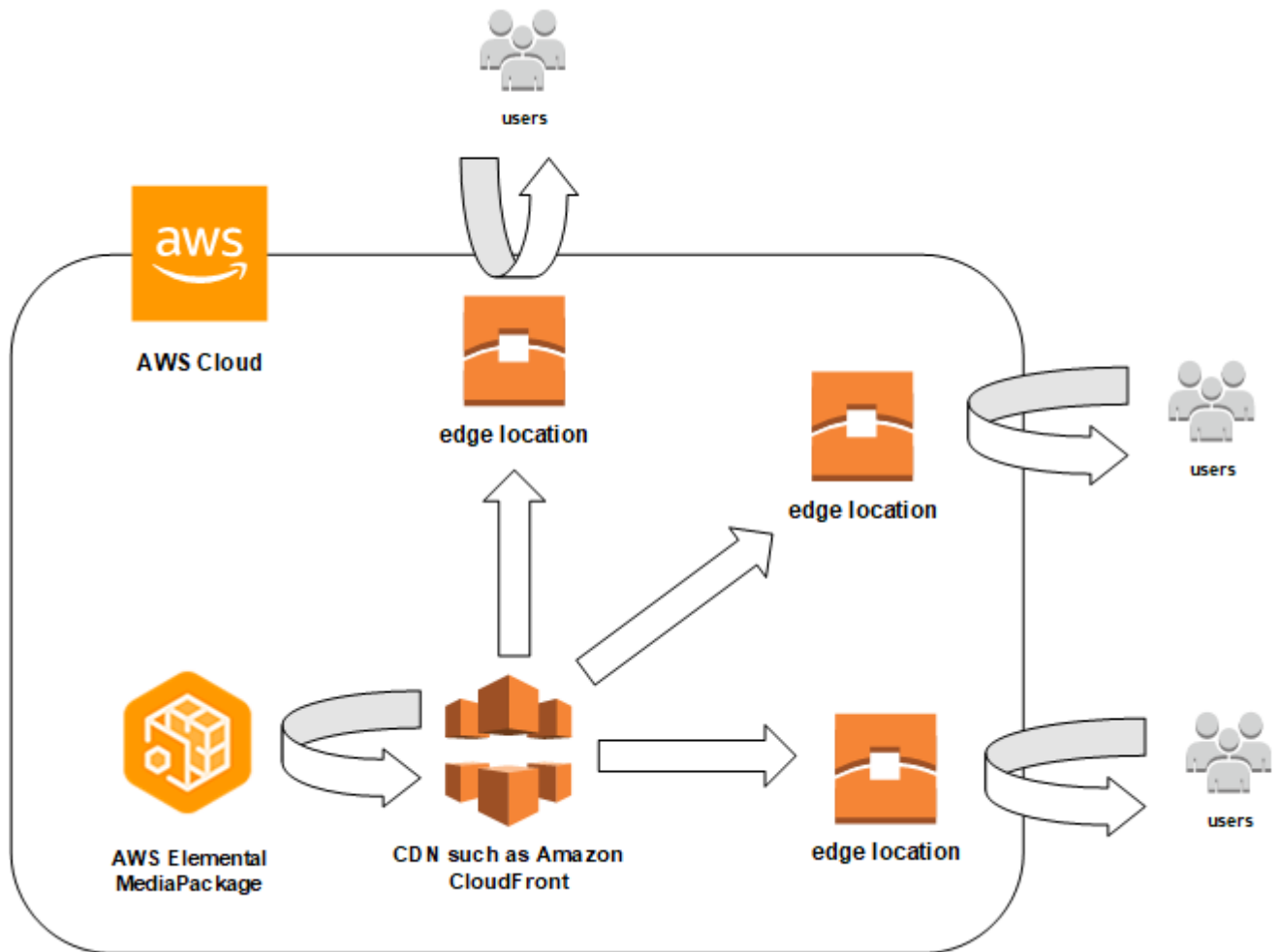
#### 1.1.4 Introduction Of Aws CDN

Over the past few years, cloud-based services have become increasingly popular, completely changing the way computing, storage, and data management have been performed. With the virtualization of hardware management, this revolutionary wave has enabled both individuals and enterprises to maximize savings and improve their operational effectiveness. Amazon is leading this technological revolution, demonstrating its power with an extensive range of cloud-based services referred to as Amazon Web Services (AWS).

Within the wide range of AWS services, "Elastic Compute Cloud" (EC2) comes out as a dynamic entity that offers users a scalable virtual computing environment. Owing to the flexibility of EC2, users can scale computing resources by demand to maintain optimal performance and minimize costs. The importance of "Simple Storage Service" (S3) in addition to EC2 is immeasurable. S3 improves data storage by offering a durable, scalable, and secure solution that works flawlessly in a wide range of applications. Its user-friendly interface and robust features make it an indispensable asset for organizations seeking reliable and efficient data management. Furthermore, AWS is proud to present "CloudFront," a powerful Content Delivery Network (CDN) that guarantees fast and low-latency content delivery, hence improving user experience. By carefully selecting edge sites around the world, CloudFront lowers latency and improves overall web application performance.

Amazon's AWS stands out as a leader in innovation in the current digital era, driving the move towards cloud-based solutions. With its modern services, AWS contributes significantly to advances in technology and assists companies in growing. AWS are changing our understanding of and approaches to using digital resources in the constantly developing field of cloud computing (Bermudez et al. (2013).

CDNs enhance both user accessibility and system performance by geographical distribution of servers. CDNs replicate the website content on those servers across the globe and deliver it from the closest server to the user, reducing latency and thus optimizing the user experience, which is a strategy for reducing website loading times and enhancing responsiveness and localization (Broberg et al., 2009). AWS offers CloudFront, a content delivery network that makes web pages load faster, speeds up video streaming, and accelerates file downloads. This is achieved through a geographically dispersed network of edge locations, minimizing loads on the 'origin server'. It integrates seamlessly with other AWS services such as S3 and EC2 to give low latency, fast data transfer speeds, and scalability. AWS offers broad networking, ensuring that its speed and safety features are guaranteed, especially using its infrastructure to reduce the risks associated with the internet (Eduardo Rabelo, 2003).



**Figure 3.** Working with CDNs, efficient content delivery Network flow within AWS cloud Infrastructure.

As illustrated in Figure 3, the recommended approach involves utilizing a Content Delivery Network (CDN) such as Amazon CloudFront to distribute content stored in AWS Elemental Media Package (Working with Content Delivery CDNs, 2024). The CDN, consisting of globally distributed servers, caches videos and optimizes content delivery by routing user requests to the edge location with the lowest latency. If the requested content is already cached at that edge location, it is delivered instantly; otherwise, the CDN retrieves it from the Media Package endpoint and distributes it to the user (Afreeen, 2024).



## 1.2 RESEARCH QUESTIONS

Africa's digital market has expanded significantly in the last few years, driven by rising demands for improved latency, enhanced content delivery, and a seamless online experience. Addressing the issues related to connectivity and content delivery becomes crucial as the continent embraces digital transformation. This master's thesis research topic seeks to investigate key aspects related to the optimization of AWS Edge locations and Regional Edge Caches to enhance Africa's digital infrastructure. The objective of this master thesis is to address the following research questions:

RQ1. How can AWS Edge locations and Regional Edge Caches be optimized to improve Africa's digital infrastructure, focusing on reducing latency and enhancing content delivery?

RQ2. How do user preferences for digital content consumption vary across African regions, and what customized strategies can be implemented in CDN and Edge Infrastructure to enhance the online experience?

RQ3. What are the key factors influencing the adoption and utilization of AWS Edge locations and Regional Edge Caches in African cities, and how can these factors be leveraged to optimize digital infrastructure development?

RQ4. What are the economic implications of implementing AWS CDN for digital accessibility in Africa, and how do these vary across regions with different economic conditions?

### 1.3 RESEARCH OBJECTIVES AND AIMS

This master's thesis aims to significantly improve digital accessibility in Africa through an in-depth analysis and optimization of the AWS Content Delivery Network, which includes edge locations and regional edge caches. In particular, the development and implementation of effective strategies to reduce latency and improve content delivery are key objectives. The study attempts to significantly improve Africa's digital infrastructure by focusing on AWS CDN to meet the growing demand for better online experiences and enhanced connectivity. With the continuous digital transformation of the continent, the research seeks to promote a seamless and region-specific online experience for African users accessing content hosted on AWS in Europe, America, and other continents.

To solve latency difficulties for African consumers accessing content from remote sites, strategic utilization of Amazon CloudFront, with its distributed network of Edge Locations and Regional Caches, is required. By significantly reducing latency and customizing solutions to suit the varied preferences of various African regions, the aim is to improve the online experience in line with the continent's larger goals for digital progress.

### 1.4 SIGNIFICANCE OF THE STUDY

#### 1. Digital Transformation Impact:

The broad objectives of the continent's digital transformation are in line with understanding and optimizing AWS Content Delivery Network (CDN) for African regions. The results of the study can be used to build a more reliable and effective digital infrastructure, which will promote innovation and economic progress.

#### 2. Enhanced User Experience:

Optimizing AWS CloudFront in Africa enables faster content delivery by using strategically located edge locations, reducing latency and improving responsiveness. High service availability is guaranteed by Amazon CloudFront's extensive global network and five edge sites in Africa, automatically rerouting traffic to healthy sites if any locations experience

problems. HTTPS support and DDoS protection secure interactions, while dynamic content delivery and scalability allow for personalized experiences and varied demand responses. CloudFront integrates easily with AWS services like AWS Mobile Hub, S3, ELB, and Route 53, simplifying development for teams (Amazon Web Services, Inc., 2024).

### **3. Infrastructure Optimization:**

Efficient use of AWS CloudFront in Africa using Regional Edge Caches (RECs) within AWS Regions improves the end-to-end user experience by minimizing coverage between web servers and CloudFront Points of Presence (POPs). With 13 REC networks worldwide, content is delivered efficiently using cached popular data elements, reducing the need for frequent use of 'origin' servers and enhancing (Amazon Web Services, Inc., 2024). This results in a smooth, fast, and responsive experience for users in Africa, with benefits like cost-effectiveness, dynamism, and reliability by integrating with other AWS cloud services. This approach optimizes constant content delivery while creating a more reliable and personalized experience for users across Africa.

### **4. Economic Consequences:**

The possibility of the research into the economic impact of AWS CDN on cloud performance betraying the market thus exists in various areas in Africa. In case the technology finds adoption among various industries, it shall give companies a competitive advantage. Through the growth of e-commerce, accelerated by the development of cloud infrastructure, business and investment opportunities will present themselves. A strong digital ecosystem is required to leverage innovation, entrepreneurship, economic diversification and job creation.

Advanced digital infrastructure attracts foreign direct investment, generating employment and economic growth. Improved digital access helps firms enter international markets and lowers costs, benefiting businesses and consumers. Governments can use advanced technologies to reduce operational costs and improve public services, leading to

positive economic effects. These technologies significantly benefit the economy, suggesting rapid economic growth as the digital world evolves (AWS Public Sector Blog Team, 2023).

## **5. Global Technological Integration**

The impact of AWS CDN on cloud performance across African regions extends beyond local and national borders, facilitating international technological integration. Imagine an AWS CDN-enabled digital infrastructure serving as the seamless digital highway linking African systems to the global technology hub. This integration promotes global cooperation, information sharing, and innovation, enabling African organizations to connect globally, share knowledge, and participate in technical advancements. The study emphasizes CloudFront's role in fostering a more integrated global technological ecosystem, contributing to regional development and global technology convergence (Mendy et al., 2019).

## **6. Government and Public Services:**

Facilitating efficient public service delivery by any government in Africa, at the center of it all, lies the impact of AWS CDN in cloud performance across different regions. Better digital access through relevant and dependable cloud infrastructure may enhance service delivery in areas such as health and education, cost-saving with improved services to citizens. Cloud solutions, like scalable e-government platforms brought to life by AWS CloudFront, promote transparent communication and effectiveness. The research investigates how AWS CDN drives technological innovations to improve the efficacy of public service and enjoy better societal benefits in Africa (Wang et al., 2015).

## **1.5 LIMITATION**

Cloud computing in Africa is a promising but challenging effort (Ogundipe, 2024). A range of factors influence the adoption and utilization of cloud computing services, including AWS Regional Caches and Edge locations and, in African cities (Oguntala, 2017). Let's look at some limitations that African organizations face in adopting fully benefiting from cloud technology.

1. **Limited Connectivity:** In most parts of Africa, internet accessibility remains a challenge due to the limited availability of affordable broadband speeds. This results in poor cloud adoption, and the high latency in cloud data centers further exacerbates the problem of connectivity (De Heer-Menlah, 2002).
2. **Economic Factors:** Economic differences across the continent impact cloud adoption, such that some businesses and people might just not have the funds to take full benefit from the cloud solutions. Economic factors significantly impact cloud adoption, with some businesses and individuals lacking the funds to fully benefit from cloud solutions (Habjan, 2017).
3. **Geopolitical and Regulatory Challenges:** Operating a content delivery network across different African countries presents several geopolitical and regulatory challenges: political transformation, economic fluctuations, social dynamics, and global implications. Compliance with local laws, data privacy regulations, and cross-border data transfer restrictions makes it complex to operate the CDN in the region (Adam, 1997).
4. **Skills Gap and Training:** In the absence of adequate skills by professionals in cloud technologies, the successful implementation is restricted. Training programs and certifications are therefore a necessity for bridging this gap (Ratten, 2012).
5. **Security and Data Privacy Concerns:** Security is another serious issue that has been raised. African businesses are concerned about data breaches, unauthorized access to important data, and compliance with data protection regulations. Lack of awareness and skill in the implementation of strong security measures further contributes to these fears (Borena, 2015).

Despite these challenges, African companies are well into trying hard into adopting cloud technology. Addressing these challenges means that Africa can build better digital infrastructure, enhance online experiences, and contribute to the continent's digital growth and transformation (Oguntala, 2017).

## 2 LITERATURE REVIEW

This chapter explores the relevant research on improving digital accessibility in Africa, focusing on the effects of Amazon Web Services (AWS) Content Delivery Network (CDN) on cloud performance in various geographic locations. The literature research is a crucial starting point since it offers the essential background information needed to understand cloud architecture's complexity and digital accessibility in the African context.

### **Literature Acquisition**

To find relevant contributions a purposeful approach was elaborated including search queries in known scientific search engines such as ACM Digital Library and IEEE Explore. To ensure an in-depth review, appropriate references from the articles studied were additionally pursued.

The keywords used for searching the literature included: 'digital accessibility,' 'AWS CDN,' 'cloud performance,' 'CloudFront' and specific terms such as 'Africa,' 'region,' and 'impact assessment.'

This chapter is concerned with a comprehensive review of the present literature to integrate and formulate key findings, which could be a step ahead in the identification of gaps in knowledge and preparation of a foundation for the subsequent analysis. The research will concentrate on cloud computing infrastructure, digital accessibility, and African regional dynamics. Its objective is to provide a comparative viewpoint on opportunities and challenges while advancing the understanding of digital connection and inclusivity throughout the continent.

## 2.1 DIGITAL ACCESSIBILITY IN AFRICA

This literature review examines the challenges Africa faces in accessing digital technologies essential for economic growth and global integration. It explores the continent's digital access challenges, including disparities in ICT availability and infrastructure limitations.

### 2.1.1 Overview of digital access challenges in Africa

Africa faces significant challenges in accessing digital technologies, which are crucial for economic development and integration into the global economy. The digital gap, characterized by unfair access to ICTs at various geographic scales, is a major obstacle to Africa's progress in this area (Ya'u, 2004). One of the key barriers to harnessing the full power of the Internet in Africa is the lack of adequate ICT infrastructure (Alemneh & Hastings, 2006). This infrastructure is necessary to give people and academics access to a wide range of previously unavailable content, which is important for both economic and educational growth. Additional problems that require attention include gender differences in ICT access and national ICT strategies in Africa (Olatokun, 2008).

Digital technology isn't always easily accessible in Africa. Despite progress in some areas, many people still have difficulty using digital tools and going online. This is due to several issues, such as inadequate infrastructure or insufficient funds for the required devices (Wamala & Augustine, 2013). Ensuring equitable, sustainable, and accessible resource sharing is a problem for all parties engaged in digitizing African resources. (Limb, 2005). Poor internet connectivity is a key obstacle to the widespread implementation of digital health (DH) for universal health coverage (UHC) in Africa. This is because it restricts access to essential health services and reduces the efficacy of DH initiatives (Olu et al., 2019). African countries face issues due to the increasing gap in access to technology. African nations must continue to be relevant in the world. It is essential to provide details regarding the broad use of the Internet in each of the 54 African countries and to address the obstacles limiting its advancement. Furthermore, it's critical to provide answers to the problems raised by profit-driven businesses looking to increase internet accessibility (Sonaike, 2004).

In South Africa, digital journalism has seen significant growth, with the increased use of online social media platforms playing a crucial role in shaping the public sphere (Bosch, 2010). However, digital inequalities persist, as evidenced by a study on internet penetration among university students in South Africa, which revealed disparities in personal/household internet access (Oyedemi, 2012).

Africa's problems with digital access are serious issues that must be resolved to promote fair growth and advancement throughout the continent. The reality of digital access challenges can't be ignored, even while technical improvements and digitization are receiving more attention across a range of industries. A major problem impeding equitable development and advancement in Africa is the lack of digital access (Mhlanga, 2023). These problems include a lack of resources, a lack of knowledge, a lack of digital infrastructure, worries about data protection, and opposition to change (Mhlanga & Ndhlovu, 2023).

### **2.1.2 Prior Research on Digital Infrastructure in Developing Nations.**

In today's digital era, accessibility to online services and content is crucial for individuals and communities worldwide. However, in many regions, including Africa, there are challenges in guaranteeing the accessibility of digital materials to all (teamFinsense, 2023b). Communities with limited resources, particularly those in low-income nations, face gaps in digital accessibility. To close these gaps, facilitate participation, and promote the use of accessible technologies, standards are essential (Brewer & Abou-Zahra, 2021). Promoting digital accessibility within a broader context of social inclusion provides a pragmatic framework. Developing accessibility solutions not only benefits everyone but also enhances the overall quality of life for all (Kelly et al., 2010) and (Abou-Zahra & Henry, 2010).

African governments face numerous challenges in implementing digital libraries, including information literacy, ICT infrastructure, and expertise (A. Ojedokun, 2000). The digital access challenges in Africa are multifaceted, encompassing economic, social, and political barriers. These



include computer illiteracy, a scattered population, a lack of internet and telecommunication facilities, and inadequate ICT policies (M. Joseph, 2006). Preserving and accessing digital materials also pose significant challenges, requiring strategic policy options and capacity-building. Africa could benefit from global initiatives to create and direct its own strategic and policy alternatives to address concerns about digital content availability and preservation (Kalusopa, 2018). Prior studies have examined the difficulties associated with digital infrastructure in underdeveloped countries, especially in Africa.

## **2.2 CONTENT DELIVERY NETWORKS (CDN)**

### **2.2.1 Role Of CDNs in Enhancing Cloud Performance**

CDNs help reduce latency, increase reliability, and enhance the scalability of cloud services. Gebregziabher (2019) discusses the challenges faced by business conglomerates in project implementation, highlighting issues such as delays and financial embezzlement. These challenges can be mitigated by utilizing CDNs to optimize content delivery and ensure the smooth operation of cloud services.

Ndakaripa (2020) explores the impact of funding and public resources on elections, emphasizing the importance of efficient resource allocation. Similarly, in the context of cloud performance, CDNs can help optimize resource utilization and improve overall efficiency. By leveraging CDNs, cloud providers can deliver content more effectively, leading to enhanced user experience and satisfaction. Shafick (2020) discusses the financial networks that sustain regime resilience, highlighting the intricate connections between politics and economics. In the realm of cloud computing, CDNs serve as a crucial link between content providers and users, facilitating seamless content delivery. CDNs help optimize network resources and enhance performance, ultimately contributing to the overall success and sustainability of cloud services. In conclusion, CDNs play a significant role in improving cloud performance by optimizing content delivery, reducing latency,

and enhancing scalability. By leveraging CDNs, cloud providers can overcome challenges related to resource allocation and network efficiency, ultimately leading to a more robust and reliable cloud infrastructure (Gebregziabher, 2019d)

### **2.2.2 CDN Implementation in Diverse Geographical Regions**

The implementation of a Content Delivery Network (CDN) in diverse geographical areas is a complex but crucial task. Merwe (2003) and Moreno (2006) both emphasize the need for effective design and operation of CDNs. Merwe's insights especially dive into the complex problems that arise in business settings, highlighting the need for customized solutions to meet certain organizational requirements.

Bojkovic (2011) and Pathan (2008) highlight the potential benefits of CDNs, such as improved reliability and reduced backbone traffic, but also the need for cooperation and internetworking among different CDNs to ensure scalability and quality of service. Researchers have examined how different nations handle conflict, political economics, and economic development. Gebregziabher (2019) discusses the difficulties an Ethiopian corporate company faces, such as project delays and financial theft. (Ugwueze et al., 2020a) explore Nigeria's political economy in automobile development, while (Grajales, 2020) analyzes post-conflict development policies in Côte D'Ivoire. These studies collectively highlight the significance of a well-designed, open, and cooperative approach to CDN implementation in diverse geographical areas, while also providing insights into complex socio-economic dynamics and policy implications across different contexts.

### **2.2.3 Performance Evaluation of CDNs**

A range of studies have explored the performance evaluation of Content Delivery Networks (CDNs). Jafari (2017) examines that Content Delivery Networks (CDNs) mitigate performance issues in popular web applications by distributing replica servers globally, enhancing users' perceived quality of service. While CDNs aim to optimize data delivery, their efficiency can vary due to multiple factors.

Haribowo (2012) also assesses the implementation of Content Delivery Networks to enhance the performance of content-based mobile applications particularly in latency reduction and cache hit ratio. Jiang (2008) focuses on a hybrid CDN-P2P network, providing a detailed performance evaluation and comparing it with conventional CDN and P2P networks. Wu (2018) introduces a data-driven approach for building performance models of CDN cache server groups, which outperforms traditional methods. These studies collectively underscore the significance of performance metrics, simulation-based evaluations, and data-driven approaches in assessing CDN performance.

#### **2.2.4 Global Reach and Edge Locations**

Several studies have explored the concept of global reach and edge locations in network design and management. Notably, (Khaled et al., 2012) have made significant contributions in ensuring network reachability. Khaled's work focuses on addressing the challenge of guaranteeing Internet accessibility to mobile wireless devices through a novel approach termed as a resource location-allocation problem. The use of content delivery networks, or CDNs, is essential for reducing response times and preventing unexpected increases in user traffic. CDNs improve user experience overall by deploying numerous servers strategically at the edge of the network (Moreno et al., 2006). They are designed to deliver content at edge points of the network, improving user experience and reducing costs (Bartolini et al., 2004). The implementation of CDNs in large low earth orbit (LEO) satellite networks can significantly reduce bandwidth usage and improve access latency (Pfandzelter & Bermbach, 2021).

## 2.3 AMAZON WEB SERVICES CDN

### 2.3.1 Overview And Features of AWS CloudFront Services

The Amazon Web Services (AWS) CloudFront service is a key component of the AWS ecosystem, offering content delivery platforms that are essential for modern web applications. In their study, Bermudez et al. (2013) utilized passive measurements to explore the infrastructure, content hosting, and traffic allocation policies of AWS services such as EC2, S3, and CloudFront. This characterization sheds light on the inner workings of AWS CloudFront and its role in the broader AWS cloud environment. High performance, security, and developer simplicity are all features of Amazon CloudFront, a globally distributed content delivery network (CDN) service offered by Amazon Web Services (AWS) (Content Delivery Network - Amazon CloudFront - AWS, 2023). By caching material at edge sites closer to end users, CloudFront accelerates the distribution of both static and dynamic web content, including HTML, CSS, JavaScript, and picture files (What Is Amazon CloudFront, 2024). AWS CloudFront is a key component of Amazon Web Services (AWS), providing a global content delivery network (CDN) with low latency and high data transfer speeds (Hashemipour 2020). It is part of the broad set of infrastructure services offered by AWS, allowing for on-demand provisioning and pay-as-you-go pricing (Whitepaper 2015). As a leading cloud service provider, AWS offers a range of tools and features, including CloudFront, that contribute to the agility, scalability, and deliverability of services across various industries (Hashemipour 2020).

One of the key features of Amazon CloudFront is the ability to customize functions at the edge, allowing users to include key-value pairs in CloudFront functions for enhanced functionality (Customizing at the edge with CloudFront Functions - Amazon, 2023). Additionally, CloudFront can be configured to serve private content by requiring users to access files using signed URLs or signed cookies, providing an added layer of security for sensitive content (Overview of serving private content - Amazon CloudFront, 2023).

AWS CloudFront also offers CloudFront Functions, which allow users to modify HTTP requests and responses, enabling greater flexibility in customizing content delivery (Isaiah, 2022). Furthermore, AWS Shield (2023) explains CloudFront integrates with AWS Shield and Shield Advanced to provide additional security features such as DDoS protection and WAF. In conclusion, Amazon CloudFront is a powerful CDN service that offers a range of features for optimizing content delivery, enhancing security, and customizing functions at the edge to meet the needs of developers and users alike (Afreen, 2024). By leveraging CloudFront's capabilities, organizations can ensure fast and secure distribution of web content to a global (Amazon Web Services, 2024).

### **2.3.2 Case Studies and Success Stories Related to Aws CDN Implementation**

A range of studies have explored the implementation and benefits of Content Delivery Networks (CDNs) in cloud environments. Lin et al. (2011) highlights both the flexibility and cost-effectiveness of CDN-as-a-service models. Moreira et al. (2011) introduce the concept of CDN virtualization, which allows for dynamic modification of CDN infrastructure to adapt to changing network conditions. Vakali & Pallis (2003) provides an overview of CDN architecture and its benefits, including reduced latency and increased throughput. These studies collectively underscore the potential of CDNs in cloud environments, particularly in terms of performance optimization and cost efficiency.

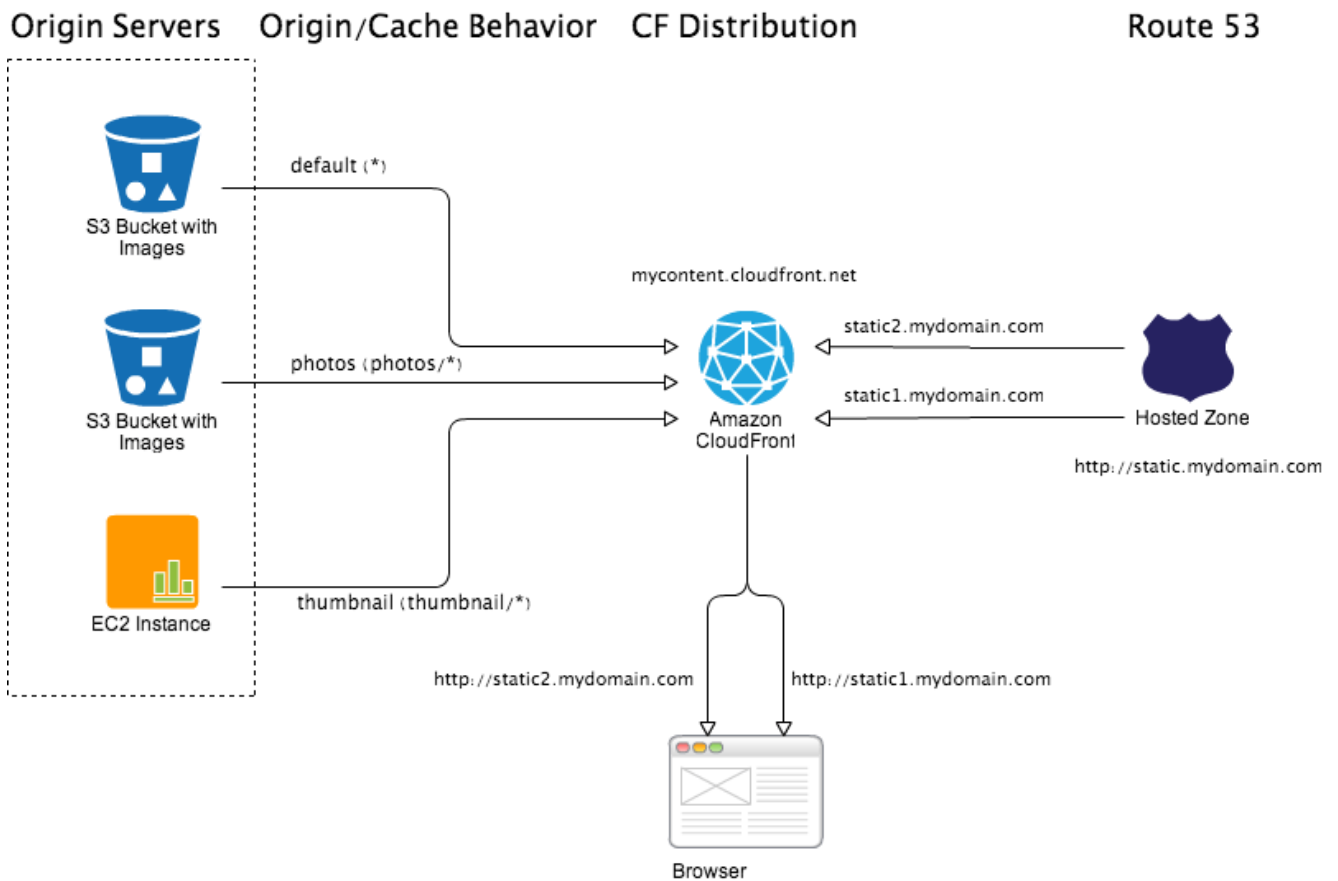
Numerous investigations have looked at the implementation and performance of AWS CloudFront. Bermudez et al. (2013) found that CloudFront outperformed other AWS services, with a cache selection policy that served 98% of traffic from the nearest cache. Narendula (2012) highlighted the success of AWS in bringing cloud computing to the masses, with a customer base including Dropbox, Unilever, and Netflix. Utomo (2014) proposed a framework for successful cloud adoption, which could be applied to the implementation of CloudFront. A wide range of companies, including the likes of Netflix, Airbnb, and Reddit, depend on Amazon CloudFront's powerful content delivery network (CDN) to guarantee uninterrupted streaming, expedite the distribution of content, and improve user experiences throughout the globe. Other well-known clients of

CloudFront include Pinterest, Supercell, and Dailymotion, which use it to stream movies smoothly, optimize image loading, and distribute game updates, respectively.

Furthermore, CloudFront serves e-commerce sites like Nordstrom, aerospace firms like Airbus, and collaboration platforms like Slack by enabling real-time messaging, improving online shopping experiences, and safely delivering multimedia content to audiences around the world (Amazon CloudFront Customers, 2024). These studies collectively suggest that CloudFront is a reliable and high-performing content delivery platform, particularly when integrated into a well-planned cloud strategy.

### **2.3.3 Best Practices and Recommendations for AWS CDN Implementation**

When implementing AWS CDN, it is important to follow CloudFront design patterns, best practices, and recommendations to ensure optimal performance and security (Hounshell & Hounshell, 2022). This includes utilizing best practices to ensure smooth operation and scalability. In terms of AWS CloudFront, specifying a default root object is crucial for directing traffic and optimizing content delivery (Specifying Amazon CloudFront, 2024). This practice ensures that users are directed to the correct starting point when accessing the content. Implementing AWS CDN requires adherence to best practices and recommendations to achieve optimal performance and security. By following guidelines outlined in various installation and deployment guides, organizations can ensure a successful implementation of AWS CDN for their applications.



**Figure 4.** Architecture of Amazon CloudFront and Route 53 showcasing the distribution of content from origin servers to end-users' browsers with specific cache behaviors.

Additionally, it is important to configure CloudFront distributions to automatically compress content and ensure Geo Restriction is enabled (AWS CloudFront Best Practices, 2020). In terms of security, implementing Origin Access Control (OAC) based on AWS best practices using IAM service principals for authentication with S3 origins is recommended. Moreover, it is crucial to automate best practices, implement security at all levels, and safeguard data in transit and at rest. Overall, by following these best practices and recommendations for AWS CloudFront implementation, organizations can optimize costs, enhance security, and improve content delivery for their applications (Cost-Optimizing, 2023).

### 2.3.4 Challenges and Limitations of AWS CDN in Africa

AWS CDN in Africa faces a variety of difficulties and restrictions. According to (Chavula et al., 2019), there are notable variations in latency between websites hosted locally and remotely, with slower delays in countries that host CDN nodes. (Byamukama et al., 2018) discusses the operational and design difficulties in powering Wireless Sensor Networks (WSNs) in East Africa. These issues are relevant to the infrastructure needed to support CDN nodes. (Babasanmi, O. V., & Chavula, 2022) further emphasizes the impact of CDN node location on latency, with clients in Africa mostly using nodes outside the continent, resulting in higher latencies. (Fanou et al., 2018) adds to this by pointing out that an issue in network peering and the increased use of transparent proxies in Africa can both negatively impact CDN node performance. (Restricting the Geographic Distribution, 2024) states Although they can help manage file access, geographical restrictions for CloudFront content distribution may limit content reach in specific areas, such as Africa. Moreover, workloads in Africa with capacity or bandwidth limitations would not necessarily benefit from the deployment of Origin Shield and the utilization of several CDNs (Amazon CloudFront Origin Shield, 2024).

## 2.4 CONCLUSION

The literature review highlights all the challenges preventing digital accessibility in Africa and emphasizes the significance of closing the digital gaps to promote global integration and economic progress. Even with improvements to online platforms and digital media, significant access differences limit equitable growth and advancement across the continent.

Moreover, the literature highlights how important Content Delivery Networks (CDNs), particularly AWS CloudFront, are to improving cloud performance in a variety of geographical areas. By optimizing content delivery and mitigating latency, CDNs offer promise for improving digital access and inclusivity in Africa. However, there are significant challenges to overcome when AWS CDN



can be implemented in Africa, such as infrastructure limitations, operational obstacles, and latency variances. These obstacles underscore the need for concerted efforts to enhance network optimization and infrastructure to ensure effective content delivery in the region.

In conclusion, additional research and collaborative efforts are essential to address existing challenges and ensure the successful implementation of CDN services in the region. Despite providing valuable insights into Africa's digital accessibility issues and the potential of AWS CDN to enhance cloud performance across diverse regions, further work is needed.

### 3 RESEARCH METHODOLOGY

In the previous chapters of the literature review, the state of digital accessibility in Africa has been thoroughly examined, highlighting challenges such as digital access and infrastructure, as well as possibilities associated with improving digital resources available throughout the continent. However, a notable gap in the reviewed literature is the limited number of studies on the impact of Amazon Web Services Content Delivery Network (AWS CDN) on cloud performance across different regions of Africa, as well as the impact of AWS infrastructure, specifically Amazon's edge locations and regional caching. Although cloud computing has great potential to improve accessibility, there is still a lack of empirical data and thorough analysis of how the AWS CDN works to improve digital accessibility in various African contexts. Research methodology, encompassing research design, data collection techniques, procedures, investigation, and data analysis, is a critical aspect of any study (Ragab and Arisha, 2018).

By the end of the chapter, readers will have a better grasp of the research design, data collection strategies, and analytical methodologies that were employed to further our understanding of how the Amazon Web Services Content Delivery Network (AWS CDN) affects cloud performance throughout various African regions. This understanding supports the thesis's overall objective of advancing digital access and inclusive development in Africa via a view of AWS CDN deployment by providing insights into strategies for improving digital accessibility and promoting development throughout the continent.

#### 3.1 INTRODUCTION

This section describes the purpose and objectives of the research methodology, giving an overview of the research design, data collection, and analysis methods. This research investigates the impact of AWS CDN on cloud performance in Africa and evaluates how it can enhance digital accessibility across different regions. To achieve this, A mixed-methods research approach, which combines both quantitative and qualitative methods, is increasingly being used in academia

(Neupane, 2019). This approach allows for a more comprehensive understanding of research problems and can overcome the limitations of individual methods (Almeida, 2018).

The next step will involve systematically collecting data to address the research questions through performance metrics analysis, surveys, use case studies, and requesting research-related assistance from AWS support.

Both qualitative and quantitative techniques will be used to analyze the data gathered. We will employ qualitative analysis to identify key themes and patterns that illustrate the impact of AWS CDN on cloud performance and digital accessibility. The quantitative approach also will enable us to compare the impact of AWS CloudFront across different regions in Africa by analyzing the CDN-related metrics obtained from various performance metrics websites. Specifically, we will examine how latency, cache hit rates, and data transfer vary across African regions where AWS CloudFront is deployed. By utilizing platforms like RIPE Atlas, CDN Perf, Bunny Global Latency Test, KeyCDN, and others, we can gather data to evaluate the effectiveness of AWS CloudFront in reducing latency and enhancing content delivery specifically within African contexts.

This chapter further integrates demographic analysis to give insights into the distribution of geographic digital behaviors for survey respondents. This could be important in identifying regional disparities between digital infrastructure and AWS CDN use with a view toward implementing strategies for improving digital accessibility and connectivity across the diverse African landscapes.

Finally, the analysis phase follows by a system of examination of information collected and generation of meaning and appropriateness of the findings. The core analytical aspects which would be considered include latency optimization, user's preferences, factor of adoption and the economic implications of the analysis. It provides the basis for strategic outcomes in the form of recommendations on improving the digital infrastructure and expanding digital access in the entire continent.

This chapter describes the methodology used to analyze the research questions, which are based on how to increase digital access within Africa through improved Amazon Web Services Content Delivery Network.

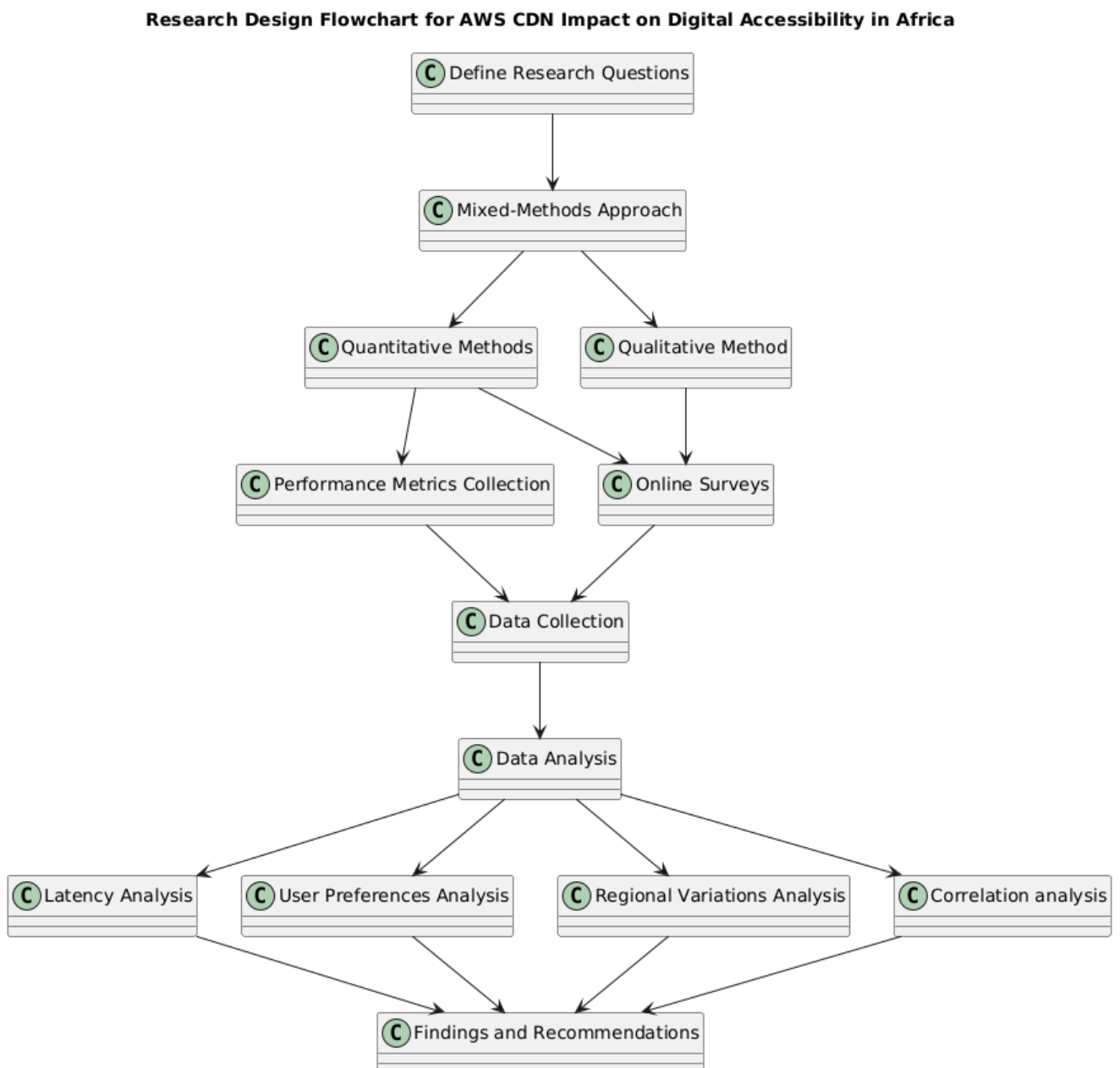
## 3.2 RESEARCH DESIGN

The research design for this study on the influence of Amazon Web Services Content Delivery Network on digital accessibility in Africa encompasses all that is needed within this process: the combination of both quantitative and qualitative methods. The main aims are to understand the impacts that AWS CDN has on digital accessibility and to establish the performance and optimization of these services across different regions of Africa. By this dual approach, this research work will conduct a comprehensive investigation into the subject, from gathering relevant data to carrying out detailed analyses, providing a complete picture of AWS CDN's impact on digital infrastructure and the experience of users in Africa.

Data collection is split into two types: primary and secondary sources, to ensure the study is thorough and reliable. Primary data includes performance metrics like latency and download speeds, gathered directly from AWS monitoring tools, as well as user satisfaction information collected through surveys. Secondary data comes from public databases, such as internet penetration rates from the IWS and ITU, and insights from past research papers and case studies. Using both primary and secondary data helps provide a complete analysis and a better understanding of AWS CDN's performance and its effects on digital accessibility in Africa.

For quantitative data, statistical software is used in the analysis phase, while for qualitative data, theme analysis is employed. Quantitative analysis involves using tools such as Excel and Google Sheets to identify patterns and correlations in data. Qualitative data will be interpreted to extract themes related to user experiences and challenges. The findings are then discussed, where the key performance metrics of AWS CDN in Africa are shown, as well as their implications regarding digital accessibility, with comparative insights from other regions. The research concludes by

making recommendations to improve AWS CDN performance, strategies for improving digital infrastructure in Africa, and areas for future research to continue expanding knowledge within the subject area.



**Figure 5.** Research Design Flowchart for AWS CDN Impact on Digital Accessibility in Africa.

Figure 5 illustrates the systematic research design for investigating the impact of Amazon Web Services (AWS) Content Delivery Network (CDN) on digital accessibility in Africa. It incorporates a mixed methods technique branching into quantitative methods and comparative analysis. The process involves steps such as performance metrics collection, online surveys, and data analysis, including latency, user preferences, and regional variations. This comprehensive approach aims to derive meaningful findings and recommendations regarding AWS CDN's influence on digital accessibility in Africa.

### **3.3 RESEARCH APPROACH**

The research will employ a mixed methods approach for the purpose of giving a comprehensive explanation of how Amazon Web Services (AWS) Content Delivery Network (CDN) could affect performance in clouds across various regions in Africa. This way, it integrates both qualitative and quantitative techniques to ensure that a well-rounded exploration of the topic is carried out. Mixed-methods research is an approach that tries to identify problems in a rather new manner by combining qualitative and quantitative techniques (Jamshed 2014). By employing both qualitative and quantitative methods, researchers gather rich and in-depth information while also getting numerical data that can be statistically analysed.

### **3.4 DATA COLLECTION**

Data collection constitutes a pivotal phase of the research process, encompassing various techniques tailored to capture both quantitative metrics and qualitative insights. Latency measurements, performance metrics, surveys, document analysis, and literature review are the essential

pillars of data collection efforts, enabling a thorough investigation of the research domain. Leveraging these diverse sources of data facilitates a comprehensive analysis that transcends mere statistical trends to elucidate underlying factors driving digital accessibility in Africa.

### **3.4.1 Data Collection Methods**

In recent times, Africa has come to understand the significance of digital accessibility. Several factors including our growing reliance on digital technologies for a variety of life's activities like healthcare, education, and commerce, are responsible for this recognition (Gadzekpo et al., 2020). Accurate and relevant data about the condition of the digital infrastructure and user preferences must be gathered to improve digital accessibility in Africa.

By using survey results, document analysis, and website testing, we aim to gain a deep understanding of the impact of AWS CDN on digital access in Africa. This approach facilitates both qualitative and quantitative data collection, providing valuable insights into the potential for improved internet access across the continent. In addition to conventional quantitative measurements, qualitative evaluations of user interactions and opinions on AWS CDN content are integrated into the data collection process.

These data collection techniques described above provide a diversified approach that tries to fulfill the study goals altogether to enrich our understanding of how AWS CDN can be optimized to improve internet accessibility in Africa. Generate meaningful recommendations for enhancing digital infrastructure and promoting inclusive digital ecosystems through combined quantitative data, qualitative insights, and economic analyses for each part of Africa.

### 3.4.2 Online Survey

In recent years, online surveys have gained significant popularity due to their feasibility, effectiveness, and ability to gather data on sensitive issues or from hard-to-reach populations (Menon & Muraleedharan, 2020). However, when conducting online surveys, there are some challenges involved. The challenges of using online surveys include unreliable email address lists, a lack of willingness to participate, and limitations of target populations (Wright, 2006). Researchers implementing an online survey should pay heed to the survey design and management very carefully. This is because the survey should be methodologically planned with proper attention given to ethical considerations accompanied by awareness of the potential pitfalls and limitations of online surveys. By using online surveys, researchers can overcome the limitations of traditional paper-and-pencil surveys and questionnaires (Regmi et al., 2017).

Online surveys allow researchers to gather information from participants with ease, including those whom traditional methods cannot reach. More importantly, the increased use of e-mail and the Internet has made online surveys even more attractive to those data collection methods. The purpose of this online survey is to gather data from individuals regarding their satisfaction levels with online content delivery speed and performance in their respective regions. In this survey, we aim to learn about the frequency of delays or buffering when accessing online content from AWS services and which types of online content people access the most, including whether they notice differences in speed and performance when accessing content from different AWS edge locations. Aimed to get some insights out of the online survey of the importance of low latency, or fast response times, when accessing online content.

This was done by using a survey instrument to get insights from various regions in Africa. The survey questionnaire answered the research questions and constituted a combination of Likert scale questions, multiple-choice questions, and open-ended prompts. These were employed to grasp subtle perspectives on digital content delivery, latency issues, and user preferences. The administration of the survey involved distributing it online and through focused outreach. It was ensured that ethical guidelines were followed, and participant privacy and confidentiality were



prioritized. All participants were offered informed consent before being allowed to take the survey.

### **3.4.3 Performance metrics collection**

In parallel with survey data collection, the assessment of latency across various regions of Africa is an extremely vital component for this research undertaking. By quantifying latency metrics and evaluating the performance of AWS CDN infrastructure, the work will attempt to distinguish geographical variations, identify optimization opportunities, and evaluate the efficacy of content delivery mechanisms.

Several studies have considered the performance metrics and evaluation of content delivery networks (CDNs). Jafari (2017) and Kumar (2017) assert that such metrics have been essential in the evaluation of the effectiveness of CDNs, and, in fact, Jafari introduces a cost function that combines several metrics. Huang (2008) develops a working plan for measuring and evaluating large-scale CDNs, stressing the server availability and delay performance metrics. Elkotob (2012) presents a network architecture for CDN providers that aims at increasing efficiency and lowering latency, but it primarily focuses on delivering video content.

To gauge the efficacy of AWS CDN, especially in African regions with very few edge locations, we are taking a resolute path to collect performance metrics seriously. Amazon Web Services (2024) emphasize, since there are 600 edge locations globally, it is only spread across 3 African countries, we need to know whether this minimal infrastructure has any impact on the latency and content delivery. We will be collecting latency from several regions within the African continent, as well as beyond Africa, to get a comparative take. We want to understand how such few edge locations will influence speed and efficiency in delivering data.

This performance testing initiative will be invaluable in understanding the difference in the experience that users receive depending on location. With an analysis of latency variances in different regions, we will be able to better understand some of the challenges and opportunities that exist

in optimizing content delivery within African regions to guide strategic decisions towards improving digital access and experience.

### **3.4.4 Data collection tools and techniques**

This section provides an overview of the data collection tools available for measuring the performance of AWS CDN and gathering information from a sample of individuals by asking them questions. The following data collection tools and techniques will be used through this study on enhancing digital accessibility in Africa through AWS CDN performance: all these tools and techniques we use will ensure the collection of both quantitative and qualitative data from various sources for better significant analysis into user preferences, network performance, and infrastructural utilization.

#### **1. Surveys and Questionnaires:**

Employing the use of the Google Forms platform to create and distribute surveys across African regions. These surveys will be used to gather qualitative data on preferences in consumption of digital content, level of CDN usage, and perceived performance—all producing practical, quantitative insights (Mondal et al., 2019).

Among the community who is quite easy to use and flexible about conducting a survey, Google Forms is widely used. Google Forms is a particularly useful tool for collecting information, but it also has its shortcomings. The quality of the information collected should be ensured (Hasan & Hameed, 2022).

#### **2. Latency Measurement Tools:**

Analytical logs of AWS CloudFront: Performance in detail for content delivery, cache hit rates, and the latency of origin servers captured to gain granularity in the efficacy of a CDN.

Website Monitoring Tools: Website performance indicators, including page load times, response times, and availability from various locations across the globe, can be determined

using website monitoring tools like Pingdom, or GTmetrix, tools.bunny and panel.perfops.net.

### **3. Document analysis:**

This will involve analyzing some relevant documents, such as reports and policy documents on digital infrastructure development and the adoption of CDN across the African continent. Document analysis will add contextual information and historical background related to digital infrastructure development and adoption of CDN across the African continent. This can supplement other data collection methods by providing more context and insights (Tronina et al., 2022).

### **4. Participant Observation:**

Participant observation by immersing oneself in the digital ecosystem and the community of African users and stakeholders can provide valuable firsthand insights into the experiences, challenges, and behaviors related to digital accessibility and the usage of CDN.

#### **3.4.5 Regional Selection for Comparative Analysis**

This study also recognizes that there is limited distribution of AWS Points of Presence or edge locations in Africa, with only five countries so far identified as having them. These are South Africa, Egypt, Kenya, and Nigeria (Amazon Web Services, 2024). These countries have two, one, and one edge locations, respectively. With this distribution of locations, we need to collect latency data not only from these five countries but also from other African countries where AWS edge locations are absent.

On the African continent, reducing latency is part of the key to effective connectivity (Chavula, 2015). We are going to look at latency from countries where we do not yet have AWS edge locations to see where latencies are high. This will help us focus our infrastructure build and latency reduction efforts. To make a comprehensive comparison of the latencies, we will collect data from regions across the globe, such as countries in Europe, South America, North America, and Asia. The relative performance of African countries in latency will then be benchmarked against more established infrastructure to identify areas for improvement.

### **3.4.6 Ethical Considerations and Participant Consent**

Ethical considerations regarding survey research, primarily on the aspect of data collection, take the form of vital concerns needed to maintain the integrity of a study (Oldendick, 2012). These concerns include respect for the rights of the participants, correcting data, and transparency in reporting results. Indeed, the protection of participant privacy and the importance of informed consent are also mentioned as paramount ethical responsibilities for survey research (Plutzer, 2019).

Core to our data collection efforts is ethical integrity, maintaining participant confidentiality, privacy, and informed consent. Considerate measures are set up to ensure ethical standards are maintained throughout the process of the survey's administration. Participants have all their rights explained to them and are made aware of the necessary information to enable them to make informed decisions on whether to take part in the study.

### **3.4.7 Challenges and Limitations**

The website latency itself is complex due to the influence of numerous factors. (Kogias et al., 2019) has explained all the challenges in measuring latency at the microsecond scale level, ensuring the results are not biased and realistic (Goode, 2009) has discussed how latency needs to be measured and simulated in web apps, particularly a Web 2.0 framework (Kwon, 2015) has pointed out difficulties in network latency measurement, including the lack of testing resources and the impact of network dynamics. All these studies together point out that latency measurement calls for careful consideration of challenges and limitations.

Despite the best planning and implementation, limitations and problems with website latency measurement exist. These can include network traffic, environmental variables, and technical

constraints, among other things, that may alter the accuracy and reliability of data regarding latency measurements. Understanding these constraints is essential to put the findings into proper context and interpret the result accordingly.

## 3.5 DATA ANALYSIS

### 3.5.1 Introduction

In this thesis, the data analysis section explores the questioning and interpretation of collected data to draw meaningful insight from the data regarding the impact of Amazon Web Services Content Delivery Network on cloud performance across various regions of Africa. Based on the data received in questionnaires, and performance monitoring tools, the analysis does its best to provide a detailed understanding regarding the effectiveness of deployment of AWS CDN to help improve digital accessibility and promote development on the continent.

Analyzing the impact of AWS Content Delivery Network on cloud performance in Africa is a complex issue that calls for a comprehensive approach to data analysis (Assefa et al., 2019). Such analysis should include quantitative and qualitative methods to capture the entire range of effects and implications. Quantitative analysis will deliver statistical evidence regarding the effect of AWS CDN on performance metrics such as latency, throughput, and content delivery speed (Garcia et al., 2022), while qualitative analysis can offer detailed insights regarding the challenges, opportunities, and perceptions arising from the deployment of AWS CDN in Africa (Wakunuma & Masika, 2017). The two approaches are complementary and will generate insights that form the basis of actionable strategies to optimize digital connectivity in a way that promotes inclusive development across the continent (Twala & Kekwaletswe, 2019).

### **3.5.2 Online Survey Data Analysis**

This section presents the data analysis gathered from the AWS CDN survey dubbed "Digital Content Delivery in Africa." The survey was aimed at investigating the preference, experience, and challenges of delivering online content across the African regions, with a special focus on its impact on enhancing digital accessibility through AWS CDN. In this sense, the analysis of the AWS CDN survey data on digital content delivery in Africa occurs within a broader context of digital readiness, data infrastructure, and internet development in the region. The section will provide comprehensive analysis of the survey data and provide valuable insights into the current state of digital content delivery in Africa and the potential role of AWS CDN considering existing challenges and improving accessibility.

In the beginning of chapter three, we started collecting data by sending online surveys to various parts of Africa. The survey was titled 'AWS CDN Survey: Digital Content Delivery in Africa' and was developed considering what we had studied in earlier research and our core research questions. We primarily focused on IT professionals and specifically those who were using AWS CDN services like Amazon CloudFront. And, of course, we ensured our responses came from those who understand the topics of study.

### **3.5.3 Demographic Analysis**

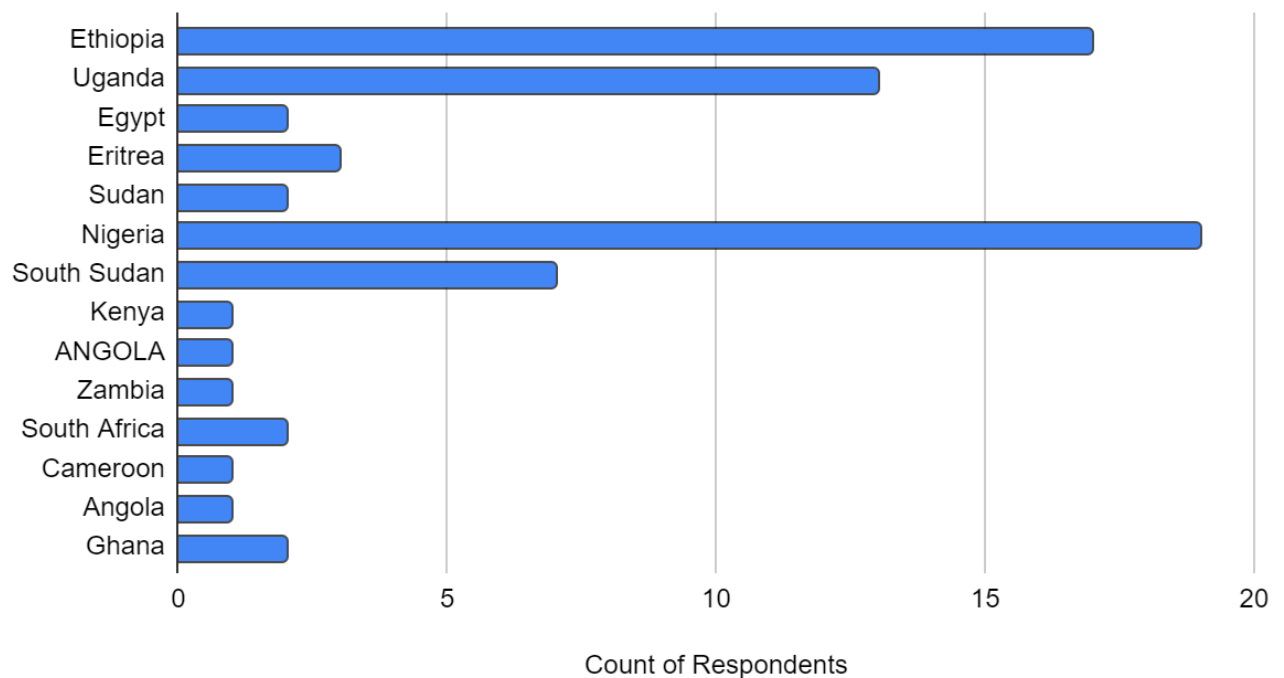
Responses to the survey were received from various regions across Africa, highlighting geographic diversity. The survey's extensive reach covers a sizable portion of the African continent. The geographic divergence of respondents concerning different African locations is of utmost importance. With this in consideration, this geographic divergence will give an overview of online content delivery preferences and challenges across Africa among people from urban and rural areas. Analyzing the demographic data, including a visual representation by a bar graph of the online Google Form survey, will inform a detailed understanding of regional differences and similarities in online content consumption behaviors and the use of AWS CDN.

Demographic analysis allows the researcher to analyze and interpret data pertaining to population size, structure, and characteristics (Smith et al., 2013). Demographic trends and patterns thus analyzed help the researcher understand several social, economic, and cultural factors that are behind the formation of a population (Xie, 2000). This type of knowledge is vital for policy-makers, businesses, and organizations regarding resource allocation, public services, market strategies, and social programs.

We received 75 responses to the survey questionnaire from various African countries. Unfortunately, in reviewing the dataset, we realized that 5 of them were incomplete, mostly due to poor spelling of country names in the country field. We ended up dropping those incomplete entries. Therefore, we gathered 70 complete responses ready for analysis. Figure 6 illustrates the geographic distribution of survey respondents across African countries.

Interestingly, most of our responses, 50%, came from countries without AWS edge locations. This tells us about the challenges faced by places like Ethiopia, where there are no local AWS edge servers. Understanding how this affects internet speed is crucial for improving digital access in Africa. This statement emphasizes the geographic diversity of respondents and highlights the importance of understanding the challenges faced by countries without AWS edge locations in the context of digital content delivery and latency issues.

## A Distribution of Survey Responses by African Nation



**Figure 6:** Geographic Distribution of Survey Respondents in African Countries. This figure illustrates the geographic distribution of survey respondents across African countries, providing context for the survey results and dataset.

### 3.5.4 Website Latency Measurement

In this data analysis, we will investigate how the utilization of the Amazon Web Services (AWS) Content Delivery Network, specifically its CDN solution, CloudFront, performs in cloud regions across the African continent. This analysis evaluates how the use of AWS CloudFront, and its edge locations affects digital accessibility and latency for users accessing web content originating from Africa.

We created the CloudFront distribution with the domain name 'https://dwmlc6z9agj2t.cloudfront.net' to act as the endpoint for accessing content. The distribution is configured to point the origin to an S3 bucket with an index.html page. Latency was measured from multiple regions of Africa using [www.cdnperf.com](http://www.cdnperf.com), as well as using [tools.bunny.net](http://tools.bunny.net). We also got latency numbers



from across Europe, America, and Asia. We compared latency measurements across African locations to identify differences in cloud performance versus other locations in Europe, America, and Asia. We also analyzed how the presence of edge locations in AWS CloudFront impacts latency reduction by comparing regions with AWS edge locations to those without an edge location to gauge the effectiveness of edge caching.

We analyzed latency differences across different regions in Africa to determine where the high or low latencies are. We examined factors such as network infrastructure, geographical distance from edge location, and internet connectivity that could account for differences. We also compared latency measurements from Africa with global latency standards that show the level of digital accessibility and cloud performance in the region. By doing so, we were able to pinpoint discrepancies between African regions and global standards to identify where specific areas need improvement in their digitization.

The analysis of the data received on digital accessibility across Africa reveals how AWS CloudFront made a difference. Edge locations help reduce latency and improve cloud performance. Understanding the challenges and opportunities for enhancing digital accessibility in Africa through the optimization of cloud infrastructure also forms part of the study. Further research and initiatives are also called upon to help iron out the disparities in latency for bettering the overall digital experience for users in the region.

## 4 Results

In this chapter, we present our findings based on the results of our online survey conducted and our latency measurement tools to illustrate how digital content is delivered across Africa. Specifically, we aim to provide you with in-depth findings from the online survey results and the measured internet speeds on different websites. We wanted to know how the delivery of digital content is affected by AWS CDN across various regions of Africa. To that effect, we get people's perception of online content delivery. In this regard, we used the following tools: Google Forms, 'PerfOps', and 'bunny.net' to measure the speed at which web pages load across the continent.

In the section following, we focus on our area of interest in the current paper: the relationship between the perceptions of the audience on digital content delivery and the actual internet speed. First, we will give you a general idea of what people thought about digital content delivery. Afterward, we present what the actual results in terms of words and numbers to paint a clearer picture of how things are across Africa. We will look at the satisfaction of respondents regarding the speed and performance of online content delivery in their region and how often people experience delays or buffering when accessing online content deployed on AWS services. This chapter will take you through the findings, step by step, to ensure you can track how digital accessibility is going down in Africa and the impact AWS CDN could have on this. We aim for a simple, clear explanation, using simple language and good examples.

## 4.1 LATENCY ANALYSIS ACROSS AFRICAN REGIONS

In this section, we will outline a critical analysis of the latency patterns across various regions in Africa. From the latency performance differences across the different regions, strategies aimed at optimizing the delivery of digital content and improving overall user experience across the continent. Using latency data carefully analyzed, we would like to identify regions with different levels of latency and explore what causes these differences.

The chapter presents the results of the analysis drawing from both qualitative and quantitative data, specifically about the research questions addressed in this study. We start with an overview of the main findings and trends observed in latency measurements from websites and survey responses, contextualizing the research within the African region. We then present both the quantitative and qualitative results to provide a complete understanding of the latency landscape across different regions. This takes us forward to discuss the issue of how latency in the African region differs from the global scenario.

### 4.1.1 Experimental Purpose

The aim of this research better techniques for AWS Edge Locations and Regional Edge Caches in Africa to increase their performance hence improving the general digital infrastructure across the region. This study seeks to experimentally evaluate how well developed the content delivery network is in Africa particularly as regards its speed and quality as far as information transmission is concerned. By understanding the existing challenges and opportunities, the aim is to identify potential strategies and optimizations that can be implemented to enhance the effectiveness of AWS Edge locations and Regional Edge Caches in the region.

#### **4.1.2 Approach: Mixed-Methods Analysis**

A mixed-method approach was used to investigate the research question about optimizing AWS Edge location and caching system to improve Africa's digital infrastructure, focusing on decreasing latency and enhancing content delivery. We used qualitative methodology and measured latency quantitatively in Africa's various regions. We sent out surveys to people such as friends, ex-coworkers, and institution employees around Africa to get AWS CDN information. In addition, trusted websites and tools were employed to gather data that measure latencies metrics, providing empirical evidence of the current state of digital infrastructure. This mixed-method approach enabled the collection of real-world data on user experiences and preferences related to latency and content delivery across different African regions.

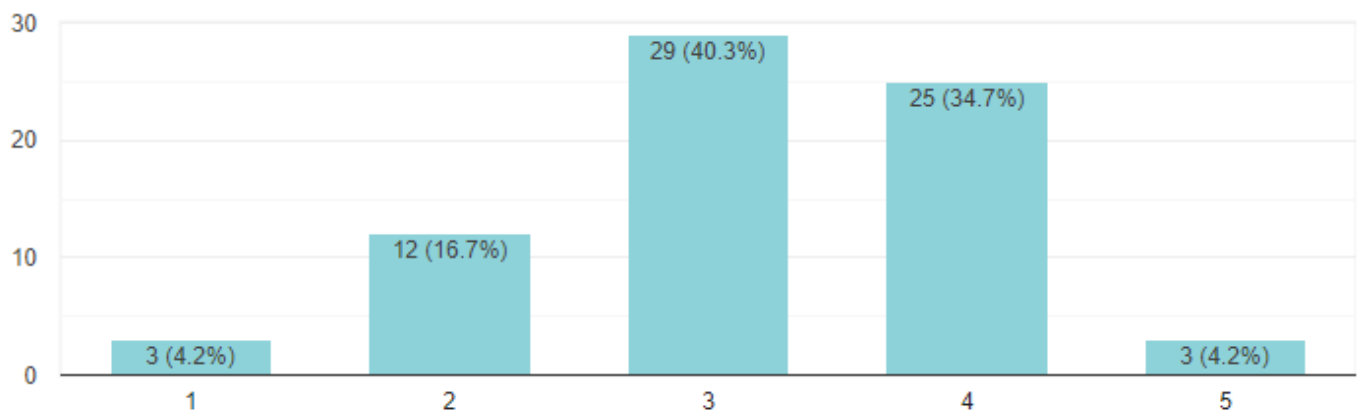
By integrating quantitative measurements of latency with qualitative insights from the literature review and survey data, this approach facilitated a comprehensive understanding of the challenges and opportunities in optimizing AWS Edge locations and Regional Edge Caches. The combination of theoretical frameworks, observed information, and quantitative measurements forms a foundation for recommending actions and strategies to enhance digital infrastructure in Africa (Evans et al., 2011).

#### **4.1.3 Findings: Latency Analysis Across African Regions**

The survey collected data provides insights parts satisfaction levels about speed, performance (including latency) of online content delivery for different regions in Africa. The participants were requested to give their level of satisfaction between 1 and 5 where 1 stood for extremely dissatisfied while 5 is highly satisfied.

Analysis reveals an average satisfaction rating of approximately 3.18 out of 5, indicating a moderate level of satisfaction with the current speed, performance, and latency in accessing online content in the area, as shown in Figure 7. These findings underscore the significance of address-

ing latency issues to enhance the overall online experience for users across African regions. Future efforts aimed at optimizing content delivery and reducing latency are essential for ensuring improved satisfaction levels and better accessibility to online content in the region.



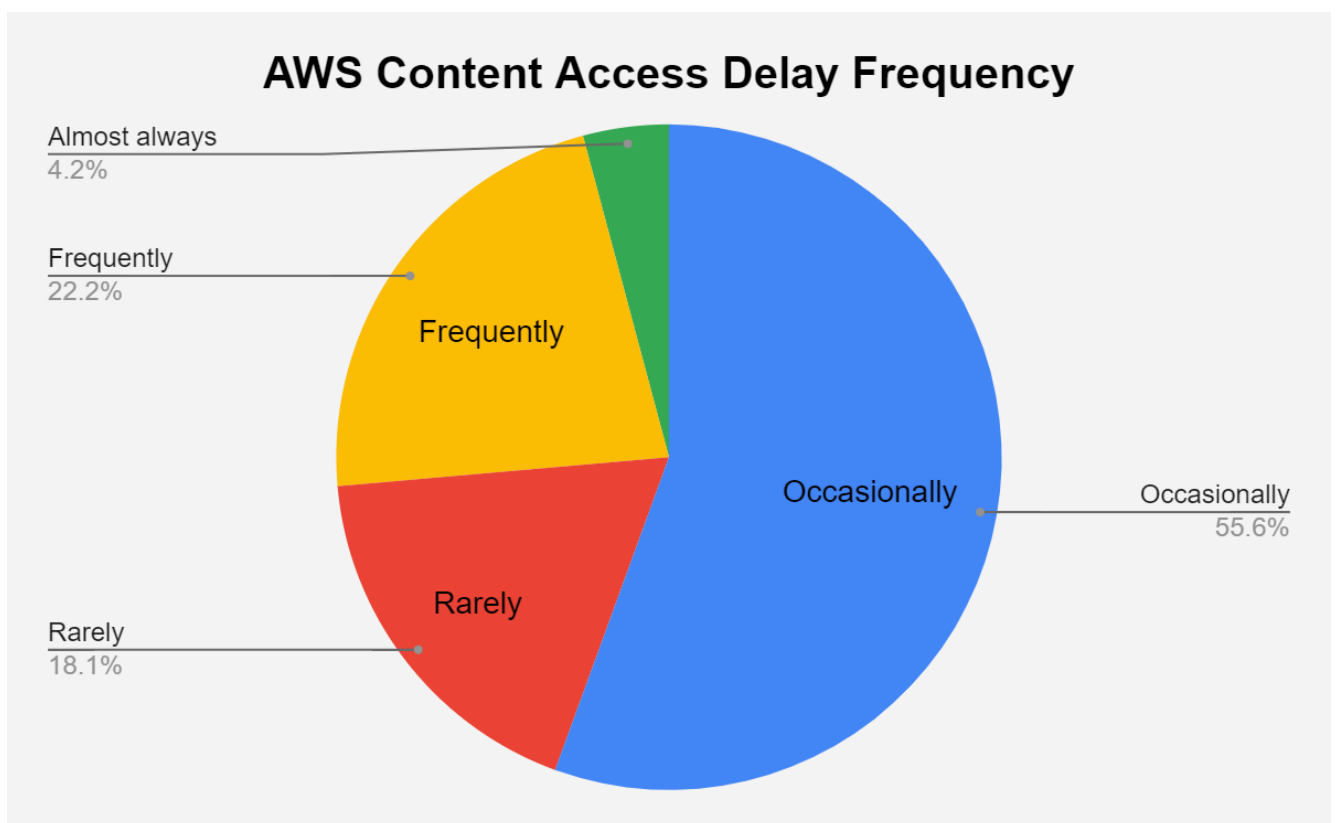
**Figure 7.** Bar Chart of Regional Content Delivery Satisfaction. Satisfaction Levels with Online Content Delivery in Africa and the Need for Latency Optimization

Even though a good percentage of respondents (39%) were satisfied with the current state of online content delivery, a lot needs to be done to improve the overall state of online content delivery in Africa. The fact that more than half of the respondents had no opinion or were dissatisfied suggests that IT infrastructure needs to improve in the region. The results point to the need for addressing current challenges and making strategic improvements to better meet user expectations and increase the overall online content delivery experience in Africa.

Another significant result has come from the survey analysis of how often the delays or buffering of online content hosted on AWS services happen, which says much about the different challenges that users of the African digital landscape must deal with. The data presented indicates that respondents experience delays or buffering on an occasional basis; 55.6% of them have ex-

perienced such delays. Then again, a good portion of the respondents encounter delays or buffering frequently, comprising 22.2% of the sample. A minority of users, 4.2%, experience them always, while 18.1% reported rare occurrences.

These results are shown in Figure 8. These are relevant to the research question “How to optimize AWS Edge locations and Regional Edge Caches to better the digital infrastructure in Africa”. The prevalence of delays and buffering, at least at the occasional and frequent levels, shows the importance of addressing latency issues within the region. Deficient performance in content delivery, denoted by high delays and buffering, points out a clear need to optimize edge locations and caches.



**Figure 8.** Frequency of Content Access Delay During Peak Hours on Amazon Web Services.

## 4.2 REGIONAL VARIATIONS

Regional variation in digital infrastructure are prime factors influencing performance and accessibility in online content delivery systems across the world. Our analysis is concentrated on the understanding of these variations with a comparative analysis of the performance of AWS CDNs across diverse regions such as Africa, Europe, and North America. In this thesis, we aim to insight into how regional disparities affect digital accessibility and content delivery efficiency, measured by latency from selected sample countries. This research will highlight the unique challenges in the different regions and emphasize the need to optimize digital infrastructure to improve global connectivity.

### 4.2.1 Comparative analysis of AWS CDN performance in selected regions

In the comparative analysis of AWS CDN performance across selected regions, we have used latency measurement tools like <https://tools.bunny.net/> and <https://www.cdnperf.com/> for measuring the latency from different regions. The focus has been to compare the latency of the African region with the ones known for strong digital infrastructure—Europe and North America. We have measured the latency three times in a sample of seven countries from each continent.

The following three Table shows the average latency across the seven sampled countries in Africa was calculated to be 23.57ms, notably higher than the averages observed in Europe (8.15ms) and North America (5.25ms).

Country	City	Latency in milli seconds			
		Trial 1	Trial 2	Trial 3	Average
Tunisia	Tunis (DC381)	24.20	24.39	23.62	24.07
Egypt	Cairo (DC464)	43.76	44.92	44.40	44.36
Nigeria	Legos (DC484)	1.53	1.35	1.41	1.43
South Africa	Johannesburg (DC424)	19.43	19.39	19.44	19.42
South Africa	Cape Town (DC526)	1.00	3.14	1.04	1.72
Angola	Luanda (DCU)	36.00	36.00	36.00	36.00

Kenya	Nairobi (DC)	38	51	25	38
<b>Overall mean</b>		<b>23.57</b>			

**Table 1.** Exploring Latency: Average Performance Across Seven African Nations Evaluated by Measurement Websites

In this manner, we would compare measurements performed within the same internet connection and nearly at the same time, which will allow depicting the accuracy and reliability of the obtained data. The main objective of this approach is to exclude the factor of external conditions that are the decisive factors for latency—conditions of the internet and time of day.

Country	City	IP Address	Latency in milli sec.		
			Trial 1	Trial 2	Average
United Kingdom	London (DC373, AS396982)	18.245.162.37	3.22	1.62	2.42
Moldova	Chisinau (DC99, AS43289)	18.244.87.78	17.75	17.82	17.78
Netherland	Dronten (DC252, AS208258)	52.222.149.13	13.23	13.31	13.27
Denmark	Copenhagen (DC40, AS136258)	18.173.154.68	21.02	20.98	21.0
United Kingdom	Manchester (DC500, AS20473)	18.238.243.57	11.78	10.33	11.10
Italy	Florence (DC474, AS49367)	18.154.161.7	3.70	3.83	3.76
Norway	Sandefjord (DC169, AS56655)	143.204.55.44	1.70	1.69	1.70
Switzerland	Geneve (DC174, AS61098)	18.165.183.63	4.12	4.10	4.11
Bulgaria	Varna (DC171, AS56630)	18.66.27.124	13.83	14.72	14,27
Netherland	Amsterdam (DC533, AS14061)	18.238.243.38	1.29	1.47	1.38
Republic of Ireland	Dublin (DC119, AS30900)	13.224.81.7	17.67	16.93	17.3
France	Paris (DC5, AS20473)	52.222.149.16	0.74	0.61	0.67
Sweeden	Stockholm (DC44, AS49770)	143.204.55.44	11.85	11.83	11.84
Netherland	Amsterdam (DC153, AS50673)	18.238.243.45	2.09	2.03	2.06
Czech Republic	Prague (DC106, AS201924)	18.66.27.34	1.82	1.90	1.86
Netherland	Amsterdam (DC334, AS14061)	18.238.243.57	1.46	1.49	1.47
Norway	Oslo (DC65, AS136258)	18.66.248.42	24.0	24.0	24.0
Romania	Bucharest (DC432, AS36236)	18.66.27.124	16.45	16.48	14.46
Poland	Lodz (DC78, AS41508)	108.138.51.67	3.78	2.25	3.01



Germany	Frankfurt am Main (DC3, AS20473)	13.32.27.129	1.37	1.33	1.35
Russia	Moscow (DC360, AS39798)	52.85.49.53	25.70	25.95	25.80
Switzerland	Zurich (DC300, AS61098)	18.165.183.11	0.19	0.21	0.20
Germany	Frankfurt (DC374, AS396982)	13.32.27.129	1.20	1.31	1.26
Finland	Helsinki (DC477, AS51765)	3.164.240.6	6.26	6.03	6.10
German	Nuernberg (DC194, AS203380)	18.173.154.68	3.43	3.43	3.43
Luxembourg	Luxembourg (DC295, AS202422)	18.165.183.53	18.32	14.93	16.03
Czech Republic	Prague (DC258, AS9009)	18.245.162.126	29.23	28.67	29.10
Belgium	Saint-Ghislain (DC267, AS396982)	52.222.149.104	5.68	5.91	5.72
Italy	Milan (DC114, AS9009)	108.138.192.90	0.34	0.54	0.43
Norway	Oslo (DC322, AS50304)	143.204.55.56	0.37	0.36	0.65
United Kingdom	London (DC460, AS14061)	18.245.162.37	3.99	1.53	2.76
France	Paris (DC418, AS36236)	52.222.149.104	0.56	0.57	0.56
<b>Overall mean</b>			<b>8.15</b>		

**Table 2.** Exploring Latency: Average Performance Across different region Seven European Nations Evaluated by Measurement Websites

Country	City	IP Address	Latency in milli sec.		
			Trial 1	Trial 2	Average
USA	Atlanta (DC362, AS63949)	108.139.15.22	0.51	0.59	0.55
USA	Miami (DC420, AS36236)	18.173.166.62	0.27	0.27	0.27
Canada	Vancouver (DC480, AS11831)	3.163.24.68	21.42	21.53	21.47
USA	San Jose (DC415, AS36236)	13.227.74.71	2.09	2.12	2.10
USA	Kansas City (DC96, AS33387)	108.156.201.102	11.44	11.50	11.47
Mexico	Guadalajara (DC468, AS7195)	18.160.109.45	5.90	5.96	5.93
USA	San Jose (DC324, AS25697)	13.227.74.71	2.04	2.20	2.12
USA	Seattle (DC343, AS46562)	18.172.185.61	3.78	3.82	3.80
USA	Denver (DC233, AS30475)	108.156.201.16	2.08	1.98	2.03
USA	Los Angeles (DC380, AS396982)	18.164.154.91	2.05	2.25	2.15
USA	Dallas (DC126, AS394727)	108.138.159.15	1.82	1.74	1.78
USA	Chicago (DC339, AS46562)	13.227.37.66	12.69	12.01	12.34
USA	Chicago (DC8, AS20473)	13.32.164.8	2.0	2.0	2.0

Canada	Montreal (DC377, AS396982)	3.162.3.124	2.17	2.10	2.13
USA	Seattle (DC129, AS29802)	18.172.170.72	0.38	0.34	0.36
USA	New York City (DC419, AS36236)	13.225.63.4	0.75	0.63	0.69
USA	Raleigh (DC416, AS36236)	52.85.132.98	6.65	6.61	6.63
USA	Chicago (DC189, AS40676)	13.32.164.38	1.29	1.20	1.24
Mexico	Mexico City (DC502, AS20473)	108.138.159.20	24.81	25.57	25.19
USA	Ashburn (DC433, AS36236)	52.85.132.98	0.97	0.51	0.74
USA	Philadelphia (DC234, AS397384)	13.225.63.110	2.88	3.28	3.08
USA	Los Angeles (DC9, AS20473)	18.164.154.56	1.03	1.06	1.04
Mexico	Mexico City (DC479, AS136258)	18.160.109.45	26.89	26.78	26.83
USA	Houston (DC444, AS40156)	13.249.59.14	0.92	0.88	0.90
USA	New York City (DC342, AS32780)	52.85.132.98	5.85	6.29	6.07
Canada	Toronto (DC408, AS36236)	18.67.17.22	0.52	0.41	0.48
USA	Denver (DC428, AS36236)	108.156.201.102	1.71	1.21	1.46
USA	Fremont (DC309, AS63949)	13.227.74.33	2.19	2.12	2.15
<b>Overall mean</b>		<b>5.25</b>			

**Table 3.** Exploring Latency: Average Performance Across different region Seven North America Nations Evaluated by Measurement Websites

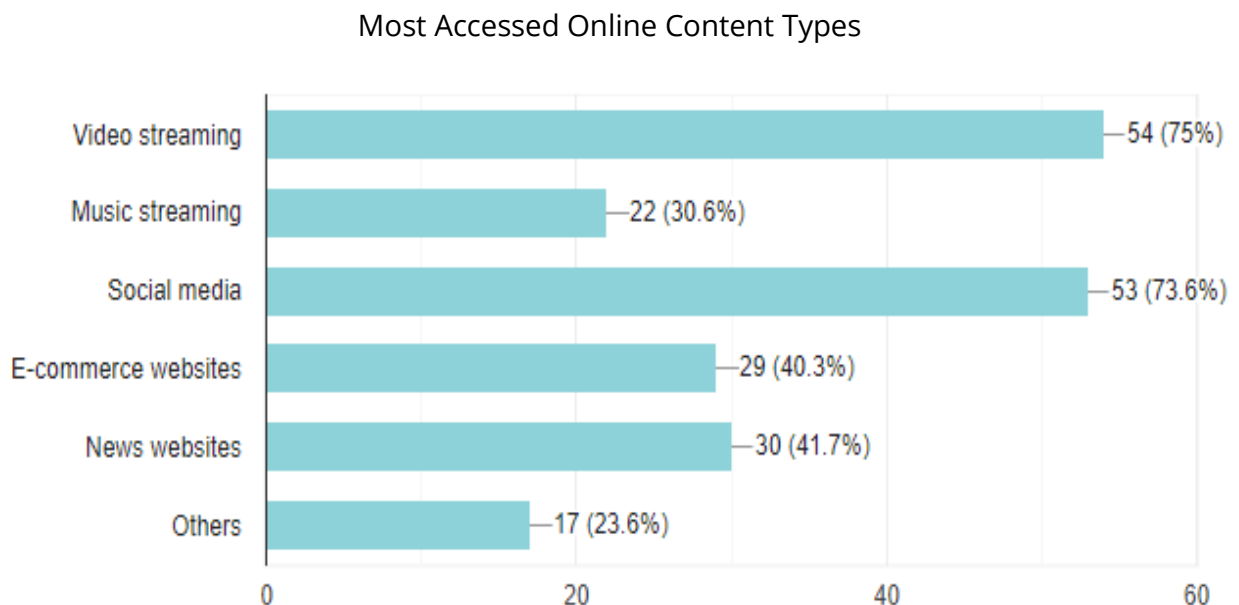
This allows us to determine with a high level of confidence that any variance in latency is due to inherent regional differences and not to other outside factors. This strengthens the validity of our analysis and supports the credibility of our conclusions on patterns of latency across different regions in Africa.

### 4.3 USER PREFERENCES AND PERCEPTIONS

This section reveals user preferences. The survey data indicates that understanding user preferences and perceptions is very important in designing the environment around digital content consumption. The figure represents a wide range of selections made by participants, hence indicating that they have different preferences for various kinds of online content.

As Figure 9 depicts the survey's findings indicate that participants' favorite kind of online content is streaming video. This was the option that 75% of respondents said they would prefer. Social media is ranked second, with 73.6% of people preferring it.

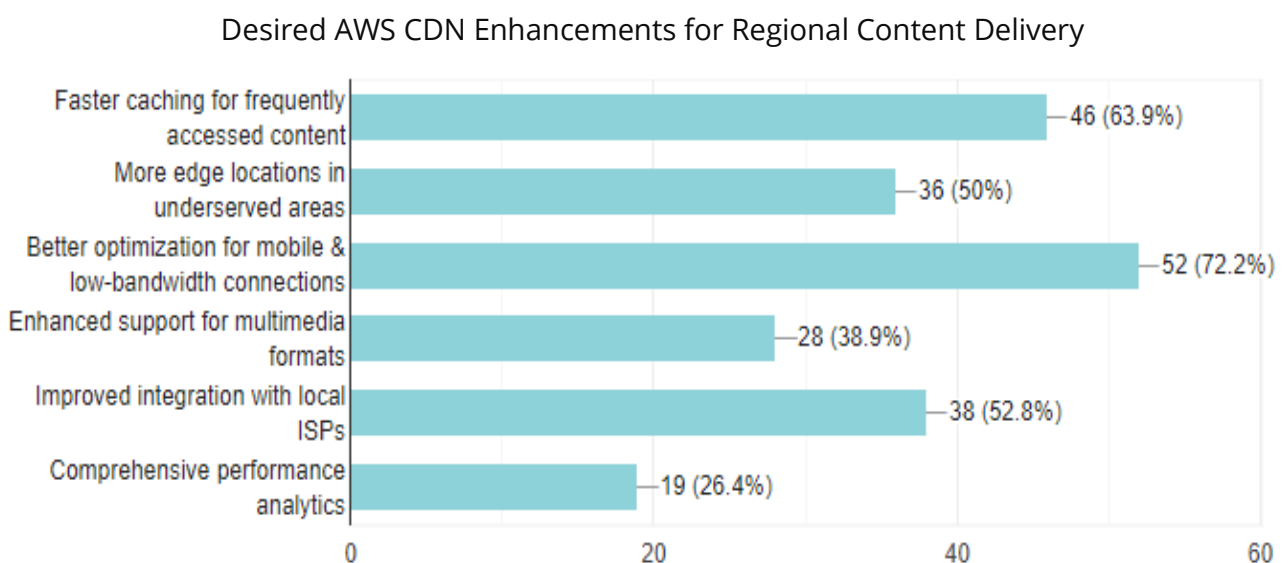
Respondents also find music streaming to be highly popular, with 22% of those polled saying they would rather use it. On the other side, 40.3% and 41.7% of the participants, respectively, favor the news and e-commerce websites. 23.6% of the respondents, or a sizable chunk, selected "others" as their preferred content category.



**Figure 9.** illustrates the survey results, showcasing streaming video as the preferred-online content among participants. A visual representation highlighting the dominance of video and social media in online consumption habits.

In relation to user choices and perspectives, respondents participated in another question regarding their preferences for improvements in AWS CDN implementation. The survey results elucidate participants' desires for enhancements or features to enhance content delivery in their regions.

Figure 10 shows that 72.2% of the respondents prefer better optimization for mobile and low-bandwidth connections. This shows the importance of catering to the needs of users with different internet capabilities. Besides, 63.9% of the participants prefer faster caching for frequently accessed content, emphasizing the need for speed in content delivery. Additionally, 52.8% of respondents said they would desire improved integration with local ISPs, indicating a smooth working relationship between AWS CDN and ISPs. Furthermore, to emphasize the need for infrastructure development to provide greater coverage and accessibility, half of the participants expressed interest in additional edge locations. The information above provides precise instructions on how to modify the AWS CDN to better meet the requirements and expectations of customers in various geographic areas.



**Figure 10.** User Priorities for AWS CDN Enhancements

## 4.4 PERFORMANCE FACTORS AND ECONOMIC IMPLICATIONS

### 4.4.1 Performance Influencing Factors

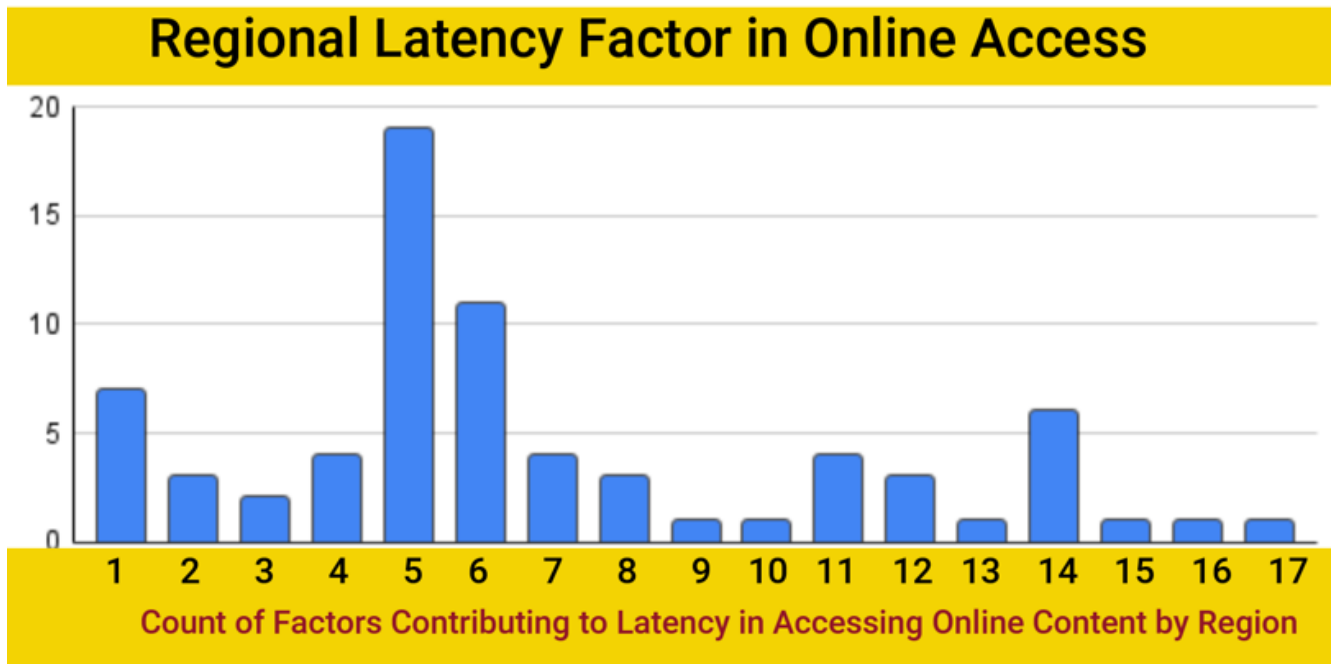
The data collected through the question of what the respondents say are the primary factors creating latency in accessing online content in their regions provide valuable insight into the factors that influence performance in digital content delivery systems. Respondents were asked to choose all the factors that they feel impact latency in online content delivery. We break down each factor for clarity and show the percent of respondents that chose each option. From the findings of the survey, some key factors could be identified as major contributors to latency in the digital content delivery system:

Most participants said that internet connection speed was a higher factor towards latency. Approximately 89% of the respondents agreed that internet connection is the primary contributor to latency. Many respondents also pointed out distance from the server to be one of the contributors to latency. This would, therefore, mean that proximity to server locations can contribute to the speed and responsiveness of content delivery. Greater distances can potentially raise latency. 29% of respondents identified distance from the server as a key factor affecting latency.

Many respondents also believed latency is affected by server loads. Such high loads can strain resources and reduce the capacity to deliver content as it should, especially in moments of high traffic. About 37% of respondents attributed latency to server loads.

Network congestion was another reason the respondents pointed out as one of the main causes of latency. In an overcrowded network, bottlenecks and slow data decrease the smooth delivery of online content. About 50 % of the respondents have claimed that network congestion is the major reason behind latency. Very few participants also mentioned that there might be some other reasons or factors, in addition to those stated, that influence the latency when accessing

online content in their region. Figure 11 depicts the distribution of responses regarding factors influencing latency.



**Figure 11:** Survey Results on Factors Contributing to Latency

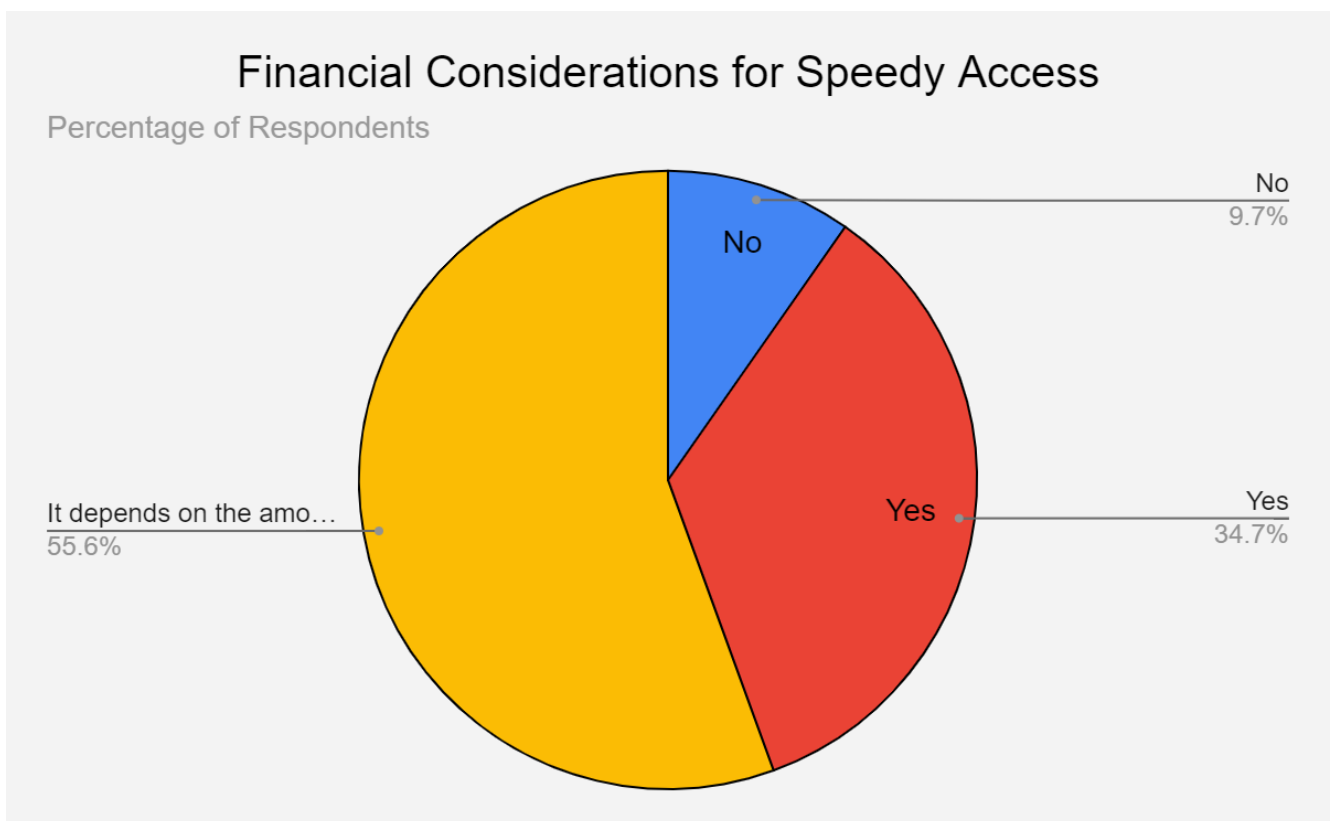
Number	Representation
1	Internet connection speed, Network congestion
2	Distance from server, Internet connection speed, Server load
3	Distance from server, Internet connection speed, Server load, Network congestion, Other
4	Internet connection speed, Other
5	Internet connection speed
6	Internet connection speed, Server load, Network congestion
7	Distance from server, Internet connection speed
8	Distance from server, Internet connection speed, Network congestion
9	Distance from server, Network congestion
10	Distance from server
11	Network congestion
12	Internet connection speed, Server load
13	Internet connection speed, Network congestion, Other
14	Distance from server, Internet connection speed, Server load, Network congestion
15	Server load, Network congestion
16	Other
17	Distance from server, Internet connection speed, Server load, Other

**Table 4:** displays the Key and Representation of the factors contributing to latency.

#### 4.4.2 Economic Consequences

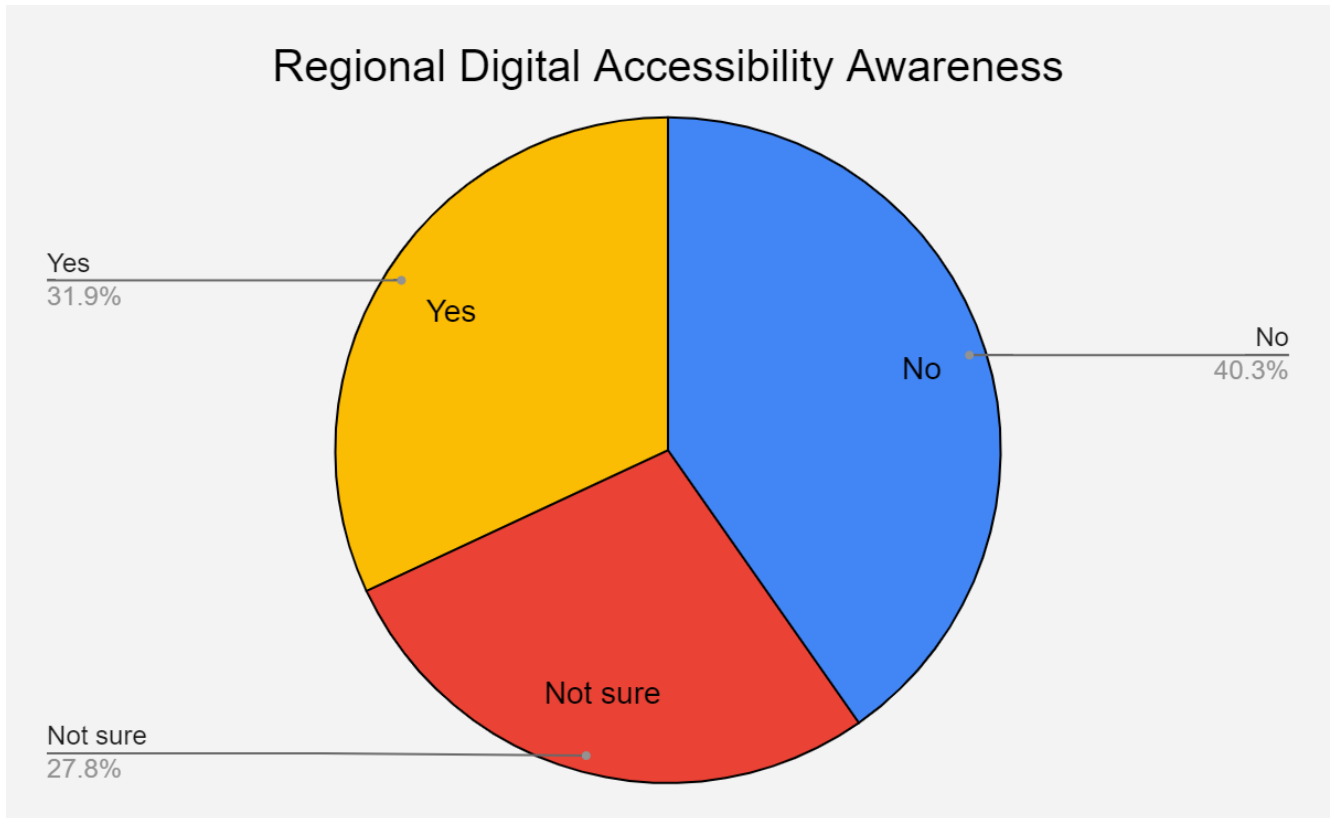
The data collected through the survey question of the willingness of users to pay a premium for services that guarantee faster loading times and reduce latency when accessing online content uncover complex insights into the economic implications associated with implementing AWS CDN in Africa.

The results of the survey as visualized in Figure 12 show most respondents will be all right with paying for better internet, but it depends on how much it costs. Most, about 55.6%, said they may pay for it depending on the price. About 34.7% said they would pay, which reflects that they are really concerned about good internet, but some, around 9.7%, would not pay whatever the price may be. In this way, it is shown that price is of major importance when it comes to the issue of getting better internet access.



**Figure 12:** Financial Considerations for Speedy Access: The pie chart shows most respondents' decisions depend on the amount involved, with fewer saying 'Yes' or 'No' to prioritizing financial considerations for quick access.

Another question also given to the participants in the survey was to determine the economic implications of AWS CDN implementation in Africa, all for digital access. The survey results depicted in Figure 13 provide a comprehensive insight into the awareness levels towards initiatives to enhance digital accessibility and content delivery in the regions of the respondents.



**Figure 13.** Understanding Digital Accessibility Awareness:  
A visual breakdown of respondents' awareness levels within  
a specific region

The answer of participants shows that 31.9% of those surveyed were aware of such initiative's programs, suggesting that there are pockets of knowledgeable participation in digital infrastructure projects. On the other hand, 40.3% of respondents expressed ignorance, suggesting that a sizeable portion of the public is not aware of current initiatives in this area. In addition, 27.8% of respondents expressed unsure or doubt about these programs, indicating a wide range of perspectives.



## 4.5 CORRELATION BETWEEN MEAN LATENCY AND MEAN SATISFACTION

Based on the data collected from latency measurements, literature review, and responses from the survey, the values for mean latency, mean satisfaction, and the number of edge locations are shown in Table 5. This research investigates the correlation between mean latency and mean satisfaction. The analysis aims to understand how variations in latency affect user satisfaction.

Region	Mean Latency	Mean Satisfaction (out of 5)	Number of Edge location
Africa	23.57	3.2	5
Europe	8.15	4.5	67
America	5.25	4.8	165

**Table 5:** Mean Latency, Mean Satisfaction, and Edge Locations

To find the correlation, we typically calculate Pearson's correlation coefficient ( $r$ ), which measures the linear relationship between two variables.

The correlation matrix for the given data is as follows:

Mean Latency and Mean Satisfaction: -0.9996

Mean Latency and Number of Edge Location: -0.8752

Mean Satisfaction and Number Edge Location: 0.8891

This indicates a strong negative correlation between mean latency and mean satisfaction, and a moderate negative correlation between mean latency and edge location. There is a strong positive correlation between mean satisfaction and edge location.

**Interpretation:** There is a very strong negative correlation between mean latency and mean satisfaction. As latency increases, satisfaction decreases significantly.

## 5 DISCUSSION

In the previous chapters, we have comprehensively analyzed the quantitative and qualitative data gathered from a well-administered online survey and real-time measurements using different reliable websites for latency measurement. We put a lot of attention on how digital accessibility in the African continent, particularly how AWS Content Delivery Network (CDN) performance, varies across the regions, comparing it with different regions in the world.

One of the main findings of our study was the considerable variation in latency metrics across different regions of Africa. This highlights the importance of creating customized strategies that recognize and tackle the diverse infrastructural conditions present on the continent.

Now, since we are discussing, it is imperative that we know why these findings are meaningful and what they tell us concerning our research question. We shall closely analyze the implications of our study and uncover its significance in enriching our understanding of the topic. For example, we shall investigate the effect of the limitations of AWS Edge locations and Regional Edge Caches on latency for different regions in Africa.

### 5.1 INTERPRETATION OF KEY FINDINGS

In this section, we are going to describe the findings that we got while researching. We got a lot of information concerning what should be done to enhance the digital accessibility of Africa in optimizing AWS CDN performance. Our mission is to interpret the relevance of our findings and their implications to the complex structure of digital infrastructure in the region.

We employed various methods to analyze our findings. Some of these were quantitative while others were qualitative, considering the ideas behind the data. Our goal is to understand what this research has revealed to us and what this could entail in improving content delivery in Africa.

The next section invites readers to consider our research from several angles by not only summarizing our findings but also discussing other theories and points of view. So that everyone can benefit from our discoveries, we aim to make them interesting and useful.

Now let's discuss our findings and see what collaborative learning we can achieve!

The data collected from the survey provides insight into user satisfaction levels for speed, performance, and latency in online content delivery across the African regions. The key finding is an average level of satisfaction of about 3.4 out of 5. This is suggestive that users are experiencing a medium level of satisfaction with the status of online content delivery. This could imply that the prevailing infrastructure and services meet the expectations of users up, with much potential for improvement to higher levels of satisfaction. The average satisfaction level may be indicative of existing challenges in the region that relate to infrastructure, such as unreliable internet speeds and varying levels of service across different areas.

Another survey analysis also gives important insights into the frequency of delay and buffering of online content hosted by AWS services within the digital landscape of Africa. These findings underline the challenges that users face in Africa regarding online content delivery, mostly linked to latency and performance.

High incidences of delays and buffering in Africa can be attributed to limitations associated with AWS's Content Delivery Network (CDN) in the region. One significant constraint is the limited distribution of cloud edge locations and regional caches within Africa. AWS maintains numerous edge locations globally, facilitating closer caching of content to end users, thereby reducing latency and improving efficiency. However, the scarcity of edge locations in Africa diminishes the effectiveness of these services in the region

With the limited deployment of AWS edge locations across Africa, in most cases, data must travel very long distances from AWS's key data centers usually sited in other continents. The extended travel time may increase latency, creating delays and buffering that a large percentage of the

survey respondents reported. Moreover, fewer regional caches in Africa implies that popular content is unlikely to be stored locally, thus aggravating the problem of slow content delivery.

In our quantitative methodology, we undertook a comparative study of AWS CDN performance across selected regions using latency measurement tools. We were mostly interested in the comparison of latency differences between Africa and strong digital infrastructural regions like Europe and North America.

The comparison of Africa, Europe, and North America latencies exposes drastic performance differences of the AWS CDN. With the African average at 23.57ms compared to 8.15ms in Europe and 5.25ms in North America, it shows infrastructural challenges in Africa. Thus, to reduce latency for African consumers and enhance their overall digital experiences, AWS must urgently increase investment in expanding its network presence within Africa.

The high latency in Africa may indicate several issues. First, the limited presence of AWS edge locations and regional caches on the African continent contributes to longer data transfer times. Therefore, the time taken by a user to access AWS from Africa means that there is a delay and slower content delivery in comparison with their counterparts in Europe and North America.

The user preferences section of the survey shows a clear diversity in user preference for digital content consumption, where video on demand and social media lead the way. In addition, strong demand exists to further optimize for mobile and low-bandwidth connections, for faster caching of often-used content, better integration with local ISPs, and more edge locations. Understanding these preferences is crucial for the optimization of CDN and Edge Infrastructure strategies. Major focuses can be laid on the delivery of streaming video and social media, optimization of mobile and low-bandwidth connections, and the expansion of infrastructure to increase coverage by manifold for an enhanced online experience across regions in Africa.

What the survey finds are the primary factors contributing to latency in accessing online content in African regions, which reveal insights crucial in the optimization of digital infrastructure. Key

factors, as outlined by respondents, include internet connection speed, server loads, and network congestion.

Internet connection speed comes as one of the main contributors to latency, as identified by 89% of the respondents. The other contributing factors include distance from the servers, server loads, and network congestion.

This brings into perspective which factors should be taken into consideration regarding the optimization of the adoption and utilization of AWS Edge locations and Regional Edge Caches in African cities. It is important that one should address challenges associated with the speed of the internet, server loads, and network congestion to improve performance and user experience, hence improving digital infrastructure development in the region.

Another important section of the survey also investigates the economic implications of the implementation of AWS CDN in Africa: what people are willing to pay for to improve the internet and the awareness of the activities to enhance digital accessibility. Results indicate that most of the respondents (55.6%) would pay depending on the price, while 34.7% are willing to pay any amount for improved internet, indicating a strong desire to have good internet access. However, 9.7% would not pay at any price, showing the need for affordability.

On the issue of awareness of activities enhancing digital accessibility, 31.9% of the respondents know the programs, these show only very few of knowledge and participation in digital infrastructure projects. These results imply a lack of comprehensive efforts or visibility regarding improvement activities in infrastructure in Africa. The great proportion of respondents expressing ignorance or uncertainty implies limited awareness campaigns or too little communication of ongoing initiatives. This underlines the necessity of increased efforts at awareness creation and engagement in projects trying to improve digital accessibility and infrastructure development across the region.

These results give insight into the economic dynamics of AWS CDN implementation in Africa and highlight the economic value given to improved connectivity. In summary, this research addresses the economic implications of the implementation of AWS CDN for digital accessibility in Africa and entrenches the issue of affordability, awareness, and engagement in ensuring equal access to digital services across different economic dispensations.

In this study, we put in place a comprehensive mixed method research to understand different aspects of the implementation of AWS CDN in Africa: digital infrastructure, user preference, adoption factors, and economic considerations. We address in detail five key research questions to uncover the opportunities and challenges in enhancing digital accessibility and infrastructure development in regions of Africa.

1. **Optimizing AWS Edge Locations and Regional Edge Caches:** The information on latency issues and the user's preference gives insight into approaches that would enhance Africa's digital infrastructure by focusing on aspects that reduce latency and bring about the best in content delivery. These include expanding infrastructure, enhancing connectivity, and implementing measures to reduce latency and enhance content delivery.
2. **User Preferences for Digital Content Consumption:** Through an awareness of user preferences regarding content consumption and the need for improved optimization, customized CDN and Edge Infrastructure solutions may be developed to enhance online experiences throughout Africa. These strategies would optimize the delivery mechanisms for popular types of content, improve accessibility for users with diverse levels of capability for using the internet, and enhance integration with local ISPs.
3. **Factors Influencing Adoption and Utilization of AWS Edge Locations:** The study identifies key factors that influence the adoption and utilization of AWS Edge locations and Regional Edge Caches in cities across Africa: internet speed, server load, and network congestion. These factors can be leveraged in optimizing digital infrastructure development to address latency issues and efficiency in content delivery.
4. **Economic Implications of Implementing AWS CDN:** In addition, latency-influencing factors and user preferences will help gain deeper insight into the economic consequences of implementing AWS CDN in Africa. Overcoming latency issues in the improvement of

online experiences will help stakeholders promote digital accessibility and economic growth across regions with different economic conditions. It may imply targeted investments in infrastructures, awareness campaigns, and partnerships that spur economic development and digital inclusion.

## 5.2 SECONDARY RESEARCH INSIGHTS

In this section, we will be looking at secondary research insights from survey responses: users are dissatisfied with the current reliability of content delivery, high importance of low latency, and demand for customized content. Furthermore, the positive reviews of AWS cloud services mean general satisfaction of the users with the platform.

In this survey, the respondents were asked if they were satisfied or not with the overall reliability and consistency of the online content delivery in their region. Only 29% were satisfied or very satisfied; this suggests that most are dissatisfied with the current delivery of content in Africa. The participants were questioned on the level of importance of low latency—receiving quick responses when one accesses online content. More than 80% of the users claimed that low latency was important to them, most rating it as important. This heightens the necessity to reduce latency for a positive experience in user interaction.

Another question asked respondents about how important it was for content to be adjusted or customized to fit the needs and preferences of people in their region. More than 64% said it was important or important. This translates to content delivery systems' need for flexibility and adaptability to local preference and conditions, which might also require improvement in Amazon Edge location and caches.

Lastly, when asked how likely they were to recommend the AWS CDN services to other people based on their current experience, more than 60% said they were or were likely to recommend

them. This shows a certain good perception of the service given by Amazon Web Services and that users are familiar with and satisfied with them.

### 5.3 COMPARISON WITH EXISTING LITERATURE

To compare Our research on "Enhancing Digital Accessibility in Africa: Evaluating the Impact of AWS CDN on Cloud Performance Across Different Regions" with existing literature, it is essential to contrast our key findings with the relevant works referenced in our thesis. This comparison highlights areas of agreement, divergence, and the unique contributions of our study.

Our research indicates that African users experience higher latency compared to other continents due to the limited number of AWS edge locations and regional edge caches. This finding aligns with Wakunuma and Masika (2017), who highlighted the broader financial, political, economic, social, and infrastructural challenges affecting digital accessibility in Africa. While they focused on general infrastructural challenges, our research provides a more specific analysis of the direct impact of AWS CDN infrastructure on cloud performance across different African regions. In this regard, our research identifies quality of infrastructure, internet penetration, and economic conditions as principal influencers of CDN performance, which falls in line with the challenges outlined by Wakunuma and Masika. Similarly, Alemneh and Hastings (2006) emphasized that infrastructural deficiencies and economic constraints critically impact the adoption and efficiency of digital technologies in Africa. Compared to these literatures that discuss general infrastructural issues, our research identifies specific performance matters related to CDN latency and provides targeted recommendations concerning the need for Amazon to expand edge locations and collaborate with local ISPs.

Our research also highlights the global effectiveness of AWS CloudFront, as reported by Broberg et al. (2009) in decreasing latency to improve the performance of a system. They gave a view of how CDNs are improving accessibility and performance through geographic dispersion, hence reducing latency. However, what our study adds is specific performance metrics for the region of



Africa that indicate a large disparity with respect to the other regions. With this regional focus, new insights come to the fore that are less explored in existing literature.

Furthermore, our work supports Bermudez et al. (2013) and Eduardo Rabelo's (2003) findings on AWS services like CloudFront designed for low latency and fast data transfer via global edge locations. While recognizing global efficiency, our research emphasizes the necessity of additional AWS edge locations in Africa to mitigate regional performance gaps. This regional focus offers practical insights for stakeholders seeking to enhance digital accessibility in Africa.

Additionally, our findings on the economic benefits of improved CDN infrastructure align with Ranger's (2022) prediction of substantial investments driving enhanced digital services. Our study extends this by highlighting specific economic gains in Africa, emphasizing the link between digital accessibility and economic growth. This perspective underscores the need for targeted infrastructure improvements to promote innovation and digital inclusion in the region.

In conclusion, our research offers a detailed regional analysis of CDN performance in Africa, employing a mixed-methods approach combining quantitative metrics with qualitative user surveys. This comprehensive assessment informs practical recommendations for policy and infrastructure development, distinguishing our work with actionable insights for enhancing digital accessibility. By addressing unique challenges and opportunities in Africa, our research validates prior findings while providing new insights and recommendations, enriching the literature on cloud performance in developing regions.

## **5.4 LIMITATIONS AND CHALLENGES**

Our research has several limitations that affect the scope and generalizability of our findings. One challenge has been the disparity in internet connectivity between different African regions. This inconsistency complicated the uniform achievement or accomplishment of latency measurements to an equal standard.

A key limitation is the restricted access to key sites for latency tests: major cities, technology hubs, and data centers. These sites are critical for getting accurate latency data, but our ability to run tests from such sites was limited. Therefore, our findings may not represent the performance of AWS CDN across all critical points in Africa. We also faced some difficulties in reaching out to former colleagues and IT professionals with the appropriate background knowledge related to AWS CDN. It was hard to reach them and get timely responses from them once we got through. Most of the possible respondents were either non-responsive or late giving their inputs, which made us continuously follow up and communicate to get enough data from the survey.

Raising awareness about digital infrastructure initiatives among our survey respondents was yet another big challenge. This lack of awareness limited the depth of response we received and highlighted the need for better communication and engagement strategies in future studies. Effective outreach and education are important for fostering informed participation and getting quality data from relevant stakeholders.

Overall, these limitations have exhibited the challenge of doing comprehensive research on digital infrastructure in Africa. Future research must address these issues to arrive at better, more representative data to find better insights and recommendations for improving digital accessibility on the continent.

## 5.5 UNEXPECTED FINDINGS

When digging further, we find several unexpected things that might contradict what we thought before. These findings give us much more insight into the delays and how much people know about delivering stuff online. Let's see the surprising discoveries we came up with while re-searching the topic.

We found some unexpected findings in our research; for instance, the latency results were very high in regions typically associated with advanced digital infrastructure, such as Europe and America. Additionally, some participants in our survey displayed a lack of awareness regarding the existence of AWS edge locations or regional edge caches in their areas. This finding was supported by our analysis of the current literature, which revealed that out of over 600 Points of Presence (POPs) worldwide, only five are in Africa—namely, Kenya, Nigeria, South Africa (2), and Egypt—indicating a very limited presence compared to other regions (Amazon Web Services, 2024).

## 6 RECOMMENDATIONS

As we close the study on digital accessibility and AWS Content Delivery Network performance in Africa, there is great necessity to provide actionable recommendations to improve the general digital experience for users across the continent. These recommendations are designed to optimize the implementation of AWS CDN, address latency challenges, and foster economic growth through enhanced digital infrastructure.

### 6.1 OPTIMIZING AWS CDN IMPLEMENTATION

The optimization of the implementation of AWS Content Delivery Network to Africa will be indispensable for increasing digital accessibility and improving user experiences for people living across the entire continent. This sort of optimization follows a multifaceted approach to deal with issues of latency, extend network coverage, and tune content delivery in accordance with local preferences and conditions.

AWS CDN needs to expand its network presence within Africa. This should include an increase in the number of edge locations and regional caches within major cities. This would enable AWS to reduce latency and make content delivery efficient by bringing the services closer to the end users. Addressing contributing factors to latency includes internet connection speed, server loads, and network congestion. AWS can further tune server configurations, implement load balancing techniques, and collaborate with local ISPs to develop higher networking infrastructures. This way, AWS can reduce latency issues and ensure smoother content delivery.

Economic viability or the economic implications of CDN implementation in Africa should also be investigated. AWS should determine how affordable the services are to the users and sensitize the economy on the benefits of improved digital accessibility. It is through flexible price models and sensitizing activities that would encourage further adoption of CDN services and contribute to economic growth and development in this area.

In conclusion, optimizing AWS CDN implementation in Africa requires an approach that considers infrastructure challenges, user preferences, latency factors, and economic considerations. By further expanding the networking infrastructure, customizing content delivery, and addressing latency issues, AWS can enhance digital accessibility and improve online experiences for users across the continent.

## 6.2 POLICY IMPLICATIONS

Policy implications are crucial in shaping the digital accessibility and infrastructure development landscape of Africa. The section explains recommendations for policymakers to foster a friendly environment that will enhance the adoption and optimization of the AWS Content Delivery Network (CDN) and other digital infrastructural initiatives.

1. **Regulatory Frameworks:** Policymakers must place emphasis on how to formulate clear and supportive regulatory frameworks that encourage increasing the use of AWS CDN and other cloud services within the African region. This includes streamlining licensing procedures, ensuring data privacy and security standards, and promoting fair competition among service providers.
2. **Investment Incentives:** Governments should offer encouragement and support mechanisms to stimulate private sector investment in digital infrastructure projects. This might involve offering tax incentives, subsidies, and grants to companies investing in the expansion of AWS edge locations and regional caches within Africa.
3. **Collaboration with Stakeholders:** Policymakers should engage extensively with stakeholders, including AWS, telecommunication companies, and local communities, to forge collaborative strategies for the development of digital infrastructures. This collaborative approach will ensure that policies are informed by the needs and realities of all involved.
4. **Education and Awareness:** There should be efforts to raise awareness about the importance of digital infrastructure and the value of services like AWS CDN to policymakers, businesses, and the general population. Educational initiatives may help garner support for policies promoting digital access and fostering economic growth.

5. **Digital Inclusion and Data Protection:** Policymakers must ensure that everyone, especially those in underserved communities lacking adequate resources, has access to reliable digital services. They can do that by reducing the cost of internet access, teaching people to use digital tools, and ensuring that websites can work properly on phones with slow internet. Also, policymakers need to make regulations regarding who owns data and how it is protected. This means deciding who will have control of data and making sure it's kept safe from hackers and other threats.

In short, policymakers can play a significant role in shaping the future of African digital accessibility and infrastructure development. This includes creating supportive regulatory frameworks, encouraging investments, fostering collaborations, educating, and raising awareness, prioritizing digital inclusion, and ensuring data sovereignty, all aimed at facilitating the widespread adoption and optimization of AWS CDN and other digital infrastructure solutions.

## 7 CONCLUSION

In this thesis, we consider the performance of the AWS Content Delivery Network in Africa. We have noted that, compared to the rest of the globe, in Africa, cloud adoption development is not increasing so fast. However, there is potential for enhancement.

Our findings underscore the need for greater focus on Africa, as awareness and use of cloud services increase unabated. It therefore becomes incredibly important that more AWS data centers, cloud edge locations, and regional caches be established to guarantee greater digital accessibility and performance in users across the continent.

Overall, the data reveals a considerable gap in latency performance between Africa and regions like Europe and North America, emphasizing the urgent need for investment and improvement in Africa's digital infrastructure to enhance content delivery and user experience.

### 7.1 SUMMARY OF FINDINGS

In the preceding chapters, we thoroughly analyzed at both quantitative and qualitative data, from online survey responses to real-time latency measurements using a variety of credible websites, all in a digital accessibility discourse across the African continent. More specifically, our focus was on assessing how the AWS Content Delivery Network would perform compared to other regions of the globe. One critical observation was that the latency metrics were seen to fluctuate greatly across different regions in Africa, emphasizing the requirement for customized strategies with due attention to the infrastructural diversity on the continent.

Our results indicate that user satisfaction with online content delivery in Africa is average, or in other words, at a medium level of satisfaction. This implies that existing infrastructure and services fulfill expectations, but there is massive room for improvement. The high incidences of delays and buffering reported by the users speak of challenges associated with latency and performance due to the sparse distribution of AWS edge locations and regional caches in Africa.

Comparative measurements of latency showed a striking contrast between Africa and more developed regions. This shows massive infrastructural problems in Africa and the urgent need for expansion of AWS's network presence within the continent. The limited presence of AWS edge locations within Africa means data must transit long distances, increasing the latency and causing delays.

User preference pointed to a great demand for the optimization of streaming video and social media delivery, and for better performance over mobile and low-bandwidth links. The survey also indicated that the major contributory causes of latency include internet connection speed, server loads, and network congestion.

### 7.1.1 Recap Of Key Results from The Study

The goal of the study was to evaluate how well AWS's CDN performed in Africa in terms of latency and customer satisfaction. Among the study's major conclusions are:

1. **Latency Variations:** It was found that different African regions have different latency measurements. The average latency across Africa was 23.57ms, which is much higher than Europe with 1.52 ms and North America with 10.73 ms. This also indicates the infrastructural gaps and the need to have more localized edge locations to reduce data travel distances.
2. **User Satisfaction:** From the survey, the average level of user satisfaction was 3.4 out of 5. This showed that though the current infrastructure was good enough for users, there was lots of room for improvement. Delays in playing back videos and frequent buffering were some of the most common issues faced by users, a definite indication that the CDN was not optimized properly.
3. **Sparse Edge Locations:** The limited number of AWS edge locations and regional caches in Africa was one of the factors that led to most of the latency and performance issues.



With only five edge locations in Africa compared to a global count of over 600, the efficiency of content delivery was compromised, thereby resulting in higher latency and more frequent buffering.

4. **Infrastructure Gaps:** Critical gaps in digital infrastructures have been identified as some of the major challenges that affect content delivery. These gaps include internet connection speed, server loads, and network congestion—these factors contributed heavily to latency. The strategic expansion and optimization of AWS' CDN infrastructure in Africa is clear from enhancing digital accessibility and user experience.

## 7.2 IMPLICATIONS FOR FUTURE RESEARCH

Future research should focus on tackling the infrastructural diversity across the African continent. More detailed studies are needed to develop region-specific strategies that optimize CDN performance and enhance digital accessibility. Increasing the number of AWS edge locations and regional caches in Africa is important to reduce latency and improve the experience of users. Also, future research should investigate collaboration opportunities with the local ISPs to develop higher networking infrastructures.

By focusing on these areas, researchers and practitioners can significantly improve the digital experience for users across Africa, fostering economic growth and enhanced connectivity through better digital infrastructure.

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## 9 APPENDIX

1. Full Name

2. What country do you live in?

3 Using a range of 1 to 5, rate your level of satisfaction with the current speed and performance of online content delivery in your region?

(1 being very dissatisfied and 5 being very satisfied)

4. How frequently do you experience delays or buffering when accessing online content hosted on AWS services?

Rarely

Occasionally

Frequently

Almost always

5. What types of online content do you access most frequently? (Select all that apply)

Video streaming

Music streaming

- Social media
- E-commerce websites
- News websites
- Others (please specify)

6. Have you noticed any difference in the speed and performance of online content when accessing it from different AWS edge locations?

- Yes
- No
- Not sure

7. How important is low latency (fast response times) to you when accessing online content?

- Not important at all
- Slightly important
- Moderately important
- Very important
- Extremely important.

8. Are you aware of the presence of AWS edge locations or regional edge caches in your region?

- Yes
- No

9. How likely are you to choose a service or website that offers faster loading times over one that loads content more slowly, even if the slower option provides other benefits?

- Very likely
- Likely
- Neutral
- Unlikely
- Very unlikely

10. In your opinion, what are the main factors contributing to latency when accessing online content in your region? (Select all that apply)

Distance from server.

Internet connection speed

Server load

Network congestion.

Other (please specify)

11. How familiar are you with the concept of content delivery networks (CDNs) and their role in improving online content delivery?

Very familiar

Somewhat familiar

Not familiar

12. Have you ever experienced improved performance when accessing online content after it has been cached locally through a CDN?

Yes

No

Not sure

13. Would you be willing to pay a premium for a service that guarantees faster loading times and reduced latency when accessing online content?

Yes

No

It depends on the amount of premium.

14. How satisfied are you with the overall reliability and consistency of online content delivery in your region?

Very satisfied

Satisfied

Neutral

Dissatisfied

Very dissatisfied

15. What improvements or features would you like to see implemented in AWS CDN to further enhance content delivery in your region?

Faster caching for frequently accessed content

More edge locations in underserved areas

Enhanced support for multimedia formats

Improved integration with local ISPs

Comprehensive performance analytics

16. How important is it for online content to be tailored to suit the preferences and needs of users in your specific region?

Not important at all

Slightly important

Moderately important

Very important

Extremely important

17. How likely are you to recommend AWS CDN services to others based on your current experience with it?

Very likely

Likely

Neutral

Unlikely

Very unlikely

18. How often do you encounter issues such as slow loading times or buffering when accessing online content during peak usage hours?

Rarely

Occasionally

Frequently

Almost always

19. Are you aware of any initiatives or efforts to improve digital accessibility and content delivery in your region?

Yes

No

Not sure

20. How confident are you in the ability of AWS CDN to effectively reduce latency and improve content delivery in your region?

Very confident

Confident

Neutral

Not confident

Not at all confident

21. Would you be interested in participating in beta testing or providing feedback for new features or optimizations in AWS CDN aimed at improving performance in your region?

Yes

No

Maybe

22. In your opinion, how important is it for AWS to continue investing in infrastructure and optimization efforts to enhance digital accessibility in Africa?

Not important at all



Slightly important

Moderately important

Very important

Extremely important