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# SOFTWARE LIFECYCLE MANAGEMENT PROCESS FRAMEWORKS AND CLOUD COMPUTING IN SMEs

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## ABSTRACT

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The aim of the study was to examine the relationship between the software development life cycle and cloud computing and analyze their potential compatibilities with the necessary process. In addition, the research integrated both components for enhancing the software development processes in SMEs that ensure the high quality of the software through a cloud-centric approach. Simultaneously, an e-commerce web application was developed using cloud services and angular framework to practically experience and comprehend the prevailing aspects of incorporating Cloud solutions with SME software development life cycle.

Therefore, a mixed-method approach was used to evaluate the research objectives while addressing the research questions holistically. In this regard, qualitative and quantitative data were collected from specialists, professionals, and representatives of SMEs. In this regard, the study found that system monitoring, code repositories and deployment pipelines are the fundamental component of software development management that requires rigorous compatibility evaluation prior to the transition towards Cloud.

Thus, the study concludes that computability evaluation is significantly comprehensive; however, adequate assessment of Cloud compatibility is crucial to ensure a smooth transition.

**KEYWORDS**
Cloud Computing, Cloud Services, Management, Process, Software.

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**ABSTRACT**

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## INTRODUCTION

This introductory phase of the thesis covers the in-detailed background of the chosen research along with the problem statement for which this research has been conducted. Furthermore, this chapter clearly mentions the aim and objectives of the research, which have provided a clear direction to the minds of the readers regarding the relationship between cloud computing and the software life cycle management process and its incorporation into the organisations for the betterment of the development processes and their quality assessment.

According to the research done by Liu et al., (2020), cloud computing has transformed the way of business operations, especially for the SMEs. Akgun, Yilmaz and Clarke (2020) stated that the integral scalability, affordability and flexibility of cloud computing make it an optimal choice for enterprises to evaluate infrastructure and resources that have not been previously accessible.

However, the effective influence of cloud computing needs to adapt existing frameworks of software lifecycle management process to accommodate the features of the cloud environment (Al-Saqqa, Sawalha and AbdelNabi, 2020). Lim, Zheng and Chen (2020) pinpoint that traditional frameworks of software life cycle management process are often rigid and strive to adapt to the distributed and dynamic cloud environment nature. It could result in challenges, such as security vulnerabilities, high costs, and lack of control. To cover the gaps in the existing research Sadeeq et al. (2021) in their research highlight that the SaaS, FaaS, and DaaS should be implemented for the better handling of products and database handling.

Furthermore, according to Khayer et al. (2021), the implementation of cloud computing involves three main service frameworks, including SaaS, PaaS (Platform

as a Service), and IaaS (Infrastructure as a Service). SaaS offers an availability of applications by the service providers through the internet.

However, in IaaS, resources are accessible on the basis of the ability of consumers for allowing them to execute and deploy applications more effectively (Al-Saqqa, Sawalha and AbdelNabi, 2020). Tüzün et al. (2019) further stated that PaaS provides applications that are the same as the settings of traditional desktops to the developers.

### 1.1 Problem Statement and Research Aim

This research has been conducted to address the issues that have arisen in organisations that are related to the inadequacy of the outdated Software Life Cycle Process (SLP) model. Organisations encounter huge obstacles in terms of building and deploying software with high security and quality (Reddy, Thamognudu and Sreeram, 2019). This research proposes a novel approach based on the cloud to be implemented in SMEs to cover the research gap and help improve the process of developing, managing, and quality-assuring software.

This research aims to analyse the relationship between the Software Life Cycle Management Process and Cloud Computing and analyse if they are compatible while integrating together. Moreover, this research integrates both components together in order to enhance software development processes in SMEs that ensure the high quality of the software through a cloud-centric approach. Additionally, the deployment of this cloud-based software on the AWS platform is also briefly discussed in this research.

### 1.2 Research Objectives

**RO1: Comprehensive Understanding:** To determine whether current Software Development Life Cycle processes are compatible with cloud settings and fully

understand the consequences of computing in the cloud for small and medium-sized businesses.

**RO2: Identify Limitations and Challenges:** The first step in incorporating Cloud Computing into software development processes for SMEs is to identify these companies' limitations and obstacles. To find out how well the present models of the software life cycle procedure operate in cloud environments.

**RO3: Propose a Cloud-Centric Software Process Model:** To create a new model for the software life cycle that is tailored to cloud apps and suggest it. To ensure the model can handle the unique characteristics, difficulties, and needs of cloud computing settings.

**RO4: Evaluate and Validate:** To use qualitative research and case studies to assess the suggested model thoroughly. To prove that it improves software quality, cuts development costs, and speeds up delivery dates.

### 1.3 Research Questions

**RQ1:** If Small and Medium-Sized Enterprises (SMEs) want to use cloud computing, how can current SLCP models not meet the demands of these settings?

**RQ2:** Why do SMEs need a specific SLCP Model for Cloud Computing, and what are the unique aspects and difficulties of this technology?

**RQ3:** For Small and Medium-Sized Enterprises (SMEs) working in Cloud Computing (CC) settings, how might a cloud-centric SLCP model improve software development processes while keeping costs down and allowing for more flexibility?

**RQ4:** Based on the suggested SLCP Model, what are the most important factors for SMEs to consider when choosing cloud service providers?

### 1.4 Practical Implementation and Development

A cloud-based e-commerce web application is developed and deployed to overcome the challenges and obstacles of SMEs related to the quality, security and performance of online shopping applications. This web application is based on a multipurpose online store, providing categories of products, including health and beauty, electronics, pharmacy, beverages, and dairy products. Multiple users can sign up and log into this application to add their desired products to the cart and checkout. In addition, users are able to edit the cart by adding and removing the product quantity. Once they add the product to the cart, the total amount is shown at the checkout page to which a user can proceed with the order. This application has been built by implementing the CSLCP model and is deployed on Amazon Web Services. For the development of this web application, Software as a Service (SaaS) has been utilised for the product images and static content, while the order and payment processing are managed by Function as a Service (FaaS). Additionally, for managing a database, this research has utilised Database as Software (DaaS). This application has sped up the delivery process for users while maintaining a secure payment method and experiencing hassle-free online shopping due to the cloud-centric approach.

**Phase 1:** This section is the entire base of the thesis that covers the detailed background of the topic and discusses the research problem along with the aims and objectives of conducting this research.

**Phase 2:** This phase compares and contrasts the previous literature based on the relationship between cloud computing and the software lifecycle management process to analyse the valuable insights of the research.

**Phase 3:** Phase 3 has discusses the methods, tools and technologies that have been utilised to conduct this research and develop cloud-based e-commerce web applications for the improvement of business operations.

**Phase 4:** This is the most important section of the thesis that presents the research outcomes that have come from the survey questionnaire and the cloud software along with their interpretation.

**Phase 5:** Lastly, the key findings and major insights have been summarised in this last section of the thesis.

## 1.5 Research Structure


**Figure 1.** Structure of the Dissertation.

# 2 RESEARCH LITERATURE

This chapter presents a review of the relevant literature concerning the Software Development Life Cycle (SDLC) and cloud computing. In addition, the potential benefits of integrating SDLC and CC for Small and Medium-sized Enterprises (SMEs) are extensively analysed. In this regard, various essential aspects of SDLC, cloud computing and the use of technology in SMEs are discussed to develop a comprehensive theoretical framework.

## 2.1 Significance of Software Development Life Cycle

Sholeh, Fauziyah and Khasani (2020, 2012) emphasise that time efficiency and cost-effectiveness are integral aspects of software development. Additionally, Lee (2020, 111-126) highlights the challenges accompanying the development of software due to cross-functional collaboration, technology upgrades and changing requirements. On this subject, Pargaonkar (2023, 8) accentuates that SDLC is an efficient process that is incorporated by development teams for the designing and constructing of high-quality software applications. Another imperative concern of any software development process is overall security. However, unlike conventional software development that addresses security as a separate stage, SDLC addresses security every step of the way through Development, Security, and Operations (DevSecOps) practices.

In addition, risk mitigation is a critical aspect that determines the direction of development. SDLC is also well-equipped to address such challenges since its adequate implementation can reduce the risks associated with the respective projects. As a result, SDLC empowers analysts and decision-makers to plan accordingly to ensure that the software meets customer expectations during production and beyond.

Moreover, SDLC primarily involves the creation of a detailed plan for guiding the developers through different stages. It also breaks down the software development into smaller modules that can be assigned, concluded, and assessed. Rindell, Bernsmed and Jaatun (2019, 1-8) identify improved visibility, better cost estimations and risk management as the major benefits of using an adequate SDLC model. Similarly, Vennaro (2023, 363-407) signifies SDLC's capability of increasing the visibility throughout the development process further facilitating efficient scheduling, planning and estimation. However, Nguyen and Dupuis (2019, 93-98) assert that such a process can slow down the process of project development. Additionally, Gurung, Shah and Jaiswal (2020, 30-37) describe the various drawbacks of respective SDLC models in terms of flexibility and collaboration. However, it can be observed that the benefits outweigh the consequences, which can also be addressed with certain modifications. The SDLC models such as Waterfall, Agile, V-shaped, Prototyping, and Spiral can ensure utmost consistency. This consistency is instrumental in enhancing the software quality, ensuring that the final product aligns seamlessly with client expectations.

Furthermore, while the SDLC process varies for different projects and teams, the fundamental phases remain the same. According to Pargaonkar (2023, 8), such stages encompass planning, designing, implementation, testing, deployment and maintenance. The initial stage of planning includes activities such as resource estimation, scheduling, cost-benefit analysis, and allocation. Additionally, in this phase, the concerned team accumulates requirements from multiple stakeholders encompassing managers, internal and external experts and customers to create a software requirement specification document.

Proceeding to design, the collected requirements are exhaustively analysed and concerned individuals identify the potential solutions for building the desired software application. The next stage is implementation where the development team

codes the product. The following segment of testing is highly critical since its comprehensiveness determines the product quality. The finalised software is deployed on either the local servers or the cloud involving essential tasks of packaging, environment configuration, and installation. The process is concluded with maintenance with the fixing of potential bugs, resolving customer issues along the monitoring of system's user experience, security and overall performance (Gurung, Shah & Jaiswal 2020, 30-37). Concludingly, despite the different attributes of respective SDLC models, the adequate identification and implementation of the aforementioned crucial software development stages can ensure the maximum quality of the product.

### 2.2 Cloud Computing and its Applications for Software Development

The term cloud computing refers to data and applications being stored and run on the cloud rather than being stored and run on the local computer or on any other equipment (Surbiryala & Rong 2019, 1-7). Afterwards, this data and the applications which are on the cloud are accessed through the internet. As a result, the workload can be shifted from the local computer to the cloud. Lele and Lele (2019, 167-185) describe that the cloud comprises numerous servers which are essentially the computers providing services on behalf of clients also known as data centres. Such servers perform several tasks, including running applications, storing data, data processing, web hosting, and many others.

These servers are all networked together, and they can be accessed on the Internet. As a result, the cloud is a powerful tool that is designed to accommodate the requirements of any scope. However, according to Monserrate (2022), the cloud industry has a bigger carbon footprint than the airline industry since a single data centre devours the equivalent power consumption of 50,000 houses. Data centres consume more energy annually than some nation-states at 200 Terawatt hours (TWh). As a result, the data centres and the network devices that utilise the data

from such sources account for 2% of global carbon emissions (Zhu et al., 2023, 104322).

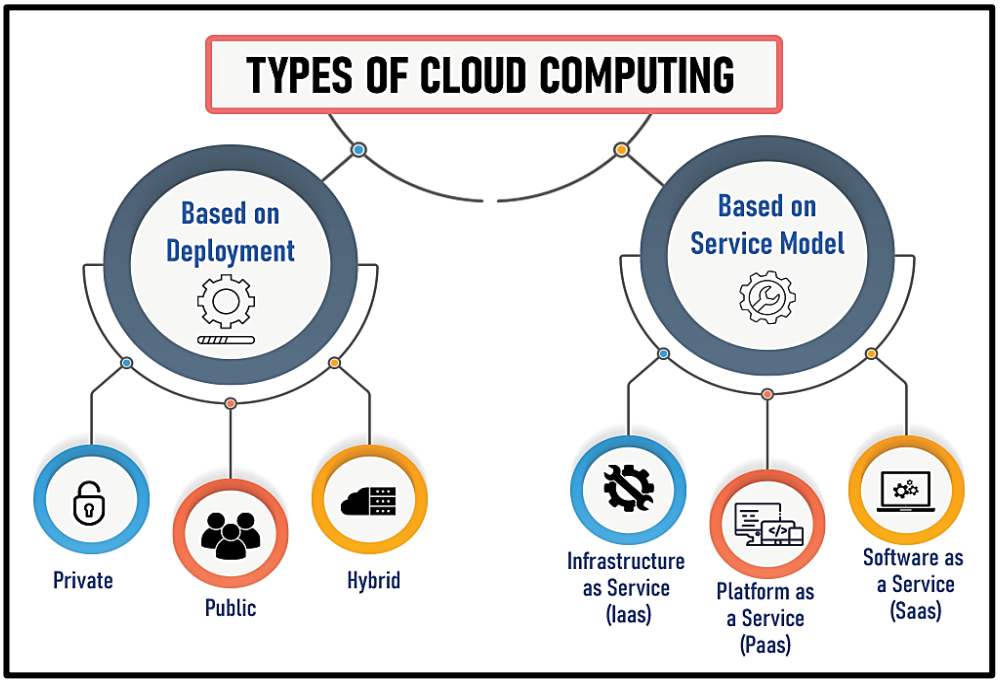


**Figure 2.** Types of Cloud Computing. (Patil and BasuMallick 2022)

Furthermore, on the basis of deployment, cloud computing is further categorised into private, public and hybrid. The computing services in a private cloud are provided through a private Information Technology (IT) network for a specific organisation's dedicated use. Such clouds are monitored by internal resources, and their accessibility is limited for internal usage in an organisation. In this regard, Surianarayanan and Chelliah (2019) identify that multiple benefits including customisation, security, and elasticity, along with additional control, scalability, and self-service are associated with a private cloud. However, Kavis (2023) argues that private clouds are the most expensive option, which requires significant resources in terms of computer components and employees. On the contrary, public clouds are

relatively cheaper since they are offered by third-party providers. Nonetheless, public cloud services are less secure and thus, the control over data is substantially limited. The respective problems of public and private clouds can be addressed through the hybrid cloud, as signified by Dittakavi (2022, 29-45).

### 2.3 Cloud Providers and the Importance of Cyber-Security

On the other hand, the companies owning the cloud are called cloud providers, and their primary purpose is to sell their computers as a service. In 2021, annual revenue of almost £140 billion was generated by cloud computing services (Miller, 2022). According to Borge and Poonia (2020, 53), in the cloud computing industry, the major cloud providers are Amazon Web Services (AWS), Microsoft Azure and Google Cloud Platform. However, cost, security and service quality are the prime factors that determine the selection of these platforms.

Therefore, data security and expenses are the major aspects on which the cloud service is determined. In this regard, Mishra et al. (2022, 614-617) signify that AWS incorporates various efficient and secure methods and tools, as illustrated in Figure 2, for different security measures such as authentication and authorisation, data encryption, firewall, identity management and additional security for cloud services to enhance security.

These modules analyse and secure the network ports, evaluate the privileges escalations and monitor access management.

| SECURITY SERVICES | AWS | AZURE | GOOGLE |
|---|---|---|---|
| **Authentication and authorization** | identity and Access Management(IAM) | Active Directory<br>Active Directory Premium | Cloud IAM<br>Cloud Identity-Aware Proxy |
| **Protection with Data Encryption** | Key Management Service | Storage Service Encryption | – |
| **Firewall** | Web Application Firewall | Application Gateway | – |
| **Identity Management** | Cognito | Active Directory B2C | – |
| **Cloud Services With Protection** | Shield | DDos Protection Service | – |

**Figure 2.** Security Services Comparison of Leading Cloud Service Providers. (Rami 2021)

## 2.4 Implications of Software as a Service, Function as a Service and Database as a Service

Software as a Service (SaaS) is primarily a software licensing model which uses external servers to allow the user to access the software based on subscription terms. Tabrizchi and Kuchaki (2020, 9493-9532) found that using cloud services tends to be a complex procedure. However, SaaS is the simplest cloud model that can efficiently resolve the complications of adopting cloud services. In addition, SaaS usage does not demand high experience or familiarity with managing and using cloud services. At the same time, the SaaS subscription model provides significant benefits, allowing users to buy the services monthly, quarterly or yearly. Such a feature enables novice users to determine and use the most appropriate cloud services. However, data security is highlighted by Díaz, Morales and Fernández (2020, 635-653) as a crucial concern of facilitating from SaaS.

On the other hand, serverless computing has gained significant traction in the market of software development. Such a feature empowers them to build and execute computer programs without having to manage cloud infrastructure. At the same

time, Function-as-a-Service (FaaS) allows computer programmers to "build, compute, run, and manage" application packages as functions without having to maintain their own infrastructure. Therefore, Grogan et al. (2020, 58-75) refer to serverless computing and Function as a Service (FaaS) synonymously. However, Eismann et al. (2021, 4152-4166) argue that event-driven triggers where code runs in response to events or requests are the main focus of FaaS, whereas serverless refers to any category where the server is fully abstracted from the end-user.

Moreover, Database as a Service (DaaS) provides access to a database without the need to establish physical hardware, install software or configure the database. Instead, the server's provider handles most database Administration and maintenance tasks. Chan (2020, 16) asserts that DaaS is usually integrated by corporations initiating digital transformation. Therefore, organisations striving for greater data democratisation prefer DaaS to enable real-time analysis.

### 2.5 Interoperability, Portability and Compatibility

In 2022, the accumulated worth of the global cloud computing industry was £429.7 billion (International Data Corporation 2023). As businesses around the globe are starting to actively consider the adoption of cloud-based solutions for their digital transformation, Ünver (2019, 154-170) believes that adequate evaluation of cloud interoperability, portability and compatibility is crucial to ensure a smooth transition. As a result, in the existing age, the top priorities of businesses worldwide are multi-cloud portability and interoperability. In this regard, Bouzerzour, Ghazouani and Slimani (2020, 1025-1060) specify interoperability as the ability of two cloud computing service providers to interact with each other to streamline the exchange of messages and information. In contrast, portability implies the ability to move data and applications. While the abilities of these two factors are potentially similar, their operation in cloud computing is different. Interoperability represents the respective use of public cloud, private clouds and

customer system Application Programming Interface (APIs). On the other hand, portability concerns APIs to retrieve and import data. On this matter, Ziani and Alfaadhel (2020, 25-41) accentuate that clarification of specific portability and interoperability concerns is critical to accelerate the classification of the “best fit” options and potential development of solutions. Therefore, an explicit comprehension of portability and interoperability is an integral aspect of the ideal planning and design process of new cloud applications and services.

While considering the use of cloud computing to address a business problem, Khayer, Bao and Nguyen (2020, 963-985) assert that compatibility is an essential factor that should be comprehensively examined. Compatibility determines the integration and interoperability of cloud applications and services with other platforms or services. Therefore, the cloud attributes of portability and interoperability have been the centre of major discussions concerning businesses' digital transformation.

### 2.6 Small and Medium-Sized Businesses in the Digital Age

SMEs are considered by Chien et al. (2021, 60495-60510) as the backbone of a nation since the majority of UK private sector businesses are SMEs, subsequently responsible for a major share of employment in the country. In this regard, the UK government often provide incentives, including supportive tax treatment, to help keep SMEs in business. Rajala and Hautala-Kankaanpää (2023, 15-30) believe that the operations of SMEs can be significantly enhanced by digitalisation since it nurtures better productivity. However, the incorporation of advanced technology in SMEs presents multiple challenges. Particular factors encompassing competitive pressure, facilitating conditions, perceived effort, and performance expectancy substantially impact the transitions towards powerful technology. Such aspects along with the limited resources of SMEs constrict them to propose digital transformation.

Often, suppliers are the role of SMEs in a business relationship, and Jones, Hutcheson and Camba (2021, 936-948) observe that manufacturing has undergone significant change in the digital age. However, due to the inherent lack of resources, the adoption and integration of advanced technology remain a pivotal concern for SMEs. At the same time, it is imperative to highlight that the same technology can elevate the efficiency and quality of the SME's overall production. While integrating powerful technology can be a highly expensive procedure, investment in technology determines the success of a business in the existing era.

### 2.7 Integration of Technology in SMEs and Potential Barriers

SMEs must choose an integration model that suits their business needs with limited costs to record success in the integration of enterprise systems and e-commerce applications. During the last couple of decades, the emergence of cloud computing has empowered organisations to transform their information systems. Guo (2021) determined that few SMEs have adopted a pay-per-use model, which has allowed them to reduce their costs by eradicating the expenses affiliated with on-premises systems. Kolb (2019) accentuate that outsourcing internal applications to an "Application Service Provider" (ASP) can provide a centralised service linking the software applications through only a single access point. Therefore, cloud technology can be leveraged with limited risks and fewer resources, also referred to as SaaS. However, barriers relating to technology, organisation and environment restrict the efficient integration of newly developed technologies in SMEs.

Furthermore, Integration Platform as a Service (PaaS) is an emerging category of integration platform for incorporating enterprise applications in a cloud-based environment. Nielsen (2019) determine that such integration can address the challenges instigated by the inability of enterprise applications to elevate beyond organisational boundaries. IPaaS can be applied on-premises to on-premises, cloud

to on-premises and cloud-to-cloud integration scenarios. In this regard, Neifer et al. (2021, 47-55) compare conventional enterprise application integration with IPaaS and found that IPaaS offers reduced complexity, decreased maintenance costs and efficient initial integration of new applications. These benefits of IPaaS are primarily due to the lack of requirement to install or manage any additional hardware or middleware.

### 2.8 Potential Benefits of Cloud Computing for SMEs

Shetty and Panda (2021, 175-188) analyse the potential benefits of adopting cloud services in SMEs, and the following features are generalised from the discussion. The most prominent was the elevation in efficiency, as businesses can use the cloud to acquire information without geographical constraints. As a result, businesses can easily support remote work policies, improving collaboration while saving on-premises resources. Additionally, scalability offered by cloud computing can enable organisations to promptly scale their computational resources as required. Thereby supporting SMEs to save their essential resources and utilise the ones when required. The advent of cloud computing can empower SMEs to automate their menial activities and efficiently allocate resources accordingly.

Moreover, cloud-based solutions can provide SMEs with scalable and cost-effective infrastructure for storing data and accessing software applications. Such measures do not require significant investment upfront in software and hardware, allowing SMEs to integrate cloud services effectively. This aspect can reduce IT infrastructure costs and enhance operational efficiency, particularly for SMEs with inadequate resources.

## 2.9 Theoretical Framework

Theories for cloud computation are identified by Pargaonkar (2023, 8), Vennaro (2023, 363-407), Kavis (2023) and Surbiryala and Rong (2019, 1-7) to develop a cloud-centric framework. In addition, multiple shortcomings of existing SDLC models in terms of essential cloud computing operations are analysed. To overcome such limitations, the framework adopts the parameter-ranking priority levels weightage. Such a strategy is facilitated by the algorithms and functionalities presented by a viable cloud service provider. Additionally, the proposed model for private cloud-based e-commerce applications comprising SaaS, FaaS, and DaaS is constructed and extensively evaluated in accordance with this theoretical framework.

# 3 RESEARCH PLANNING

This chapter determines the complete step-by-step procedure to collect data and analyse it. The reasons for the selection of methodology explained in detail.

## 3.1 Research Methodology and Strategy

Research methods are the strategies and techniques to collect the data for analysis to uncover the findings and develop a better understanding of research (Hays and McKibben, 2021). “Qualitative and Quantitative” forms the sub-types of research methods. The ***mixed method*** has been chosen in the current study because it comprises qualitative and quantitative methods.

According to Khoa, Hung and Hejsalem-Brahmi (2023), the qualitative method gathers data about the experiences and perceptions of individuals regarding a phenomenon. Busetto, Wick and Gumbinger (2020) evaluate that the qualitative research methods allow the identification of the problems from the perspective of the participants of the study. According to Hays and McKibben (2021), qualitative research provides detailed information and thick descriptions related to the problem under research. Moreover, Tracy (2019) finds that qualitative research methods provide statements and expressions of participants, and the conclusion can lead to the development of a new theory.

However, Chen, Li and Talluri (2021) assess that in qualitative research, self-selection bias can occur while selecting the participants of the study. On the other hand, the quantitative research method has also been adopted because it provides the opportunity to gather numerical data and helps in the generalisation of the results. Stockemer, Stockemer and Glaeser (2019) identify that the quantitative methods make the researcher able to collect a larger amount of data. On the other hand, the bias in the qualitative method can be reduced by the quantitative method

(Mackieson, Shlonsky and Connolly, 2019). Therefore, the results of the qualitative study can be cross-checked by quantitative methods to draw relevant conclusions.

Research strategy determines the systematic and step-by-step plan to gather information related to the objectives of the research. Different research strategies are used, such as surveys, case studies, experiments and action research. To gather the data about the research problem, two research strategies have been utilised which are the ***survey and case study strategy.*** The case study has been employed in the current study to obtain insights related to the adoption of software development in the cloud from chosen SMEs.

Welch et al. (2022) find that the case study can help in analysing the real-world experiences of the chosen problem. However, the survey strategy comprises interviews and questionnaires to collect the data. The survey strategy provides flexibility and timely response during the gathering of data, as stated by Carrera-Rivera et al. (2022). The convenience of collecting data through a survey strategy is that the information can be collected through online platforms.

### 3.2 Data Collection Method and Tool

The evaluation of multiple sources to collect the data for conducting the research is the most crucial phase of the methodology. Data can be collected by employing two methods, namely “Primary and Secondary methods. The current study has adopted both methods to gather the data and information from different perspectives. According to Arndt et al. (2022), the primary data collection method allows the researcher to collect data from direct sources which provide quality data. Moreover, the primary data is reliable and unbiased as it comes directly from the participants of the study (Nii Laryeafio and Ogbewe, 2023). On the other hand, secondary data can help in gathering the information in a short time as stated by Dina Diatta and Berchtold (2022). The secondary data provides the opportunity to

access data easily and free of cost. It has been identified that the secondary sources give the opinions and perspectives of the experts in the field, which help in drawing the interpretations of the study (Khoa, Hung and Hejsalem-Brahmi, 2023). The current study has collected qualitative data from secondary and primary sources and quantitative data from primary sources.

The selection of tools to gather the data for the research is very critical and based on the nature of the study. The researcher has selected the interviews and questionnaires to collect primary data and case studies to gather secondary data. The questionnaire provides the flexibility to gather precise and concise numeric data (Mohajan, 2020). Moreover, the semi-structured interviews provided the ability to gather detailed information related to the research phenomenon (Bearman, 2019). Thus, the researcher has adopted both tools to collect data for analysing the compatibility between SLCP and CC in the SMEs.

### 3.3 Sampling Technique , Sample Size and Time Horizon

The sampling technique determines the selection of participants from the whole population. The sampling can be done through probability and non-probability sampling. The current study has employed purposive non-probability sampling to recruit the participants of the study. According to Campbell et al. (2020), purposive sampling selects the participants on the basis of characteristics set by the criteria of the researcher. The participants of the current study were the specialists, professionals and representatives of SMEs. Six participants were recruited from LinkedIn to conduct semi-structured interviews, and 125 participants took part in filling out the online questionnaire. The case study was selected from the SMEs who have adopted software development in the cloud. The consent of the participants was taken before gathering the data and the information. The interviews last 10-15 minutes with each participant through online platforms.

The time horizon to collect the data is very important in research. “Longitudinal and Cross-sectional” are the time horizons used in research. The current study collected data by adopting a cross-sectional horizon. Spector (2019) highlights that the cross-sectional time horizon helps in gathering data at a single point and in a short time.

### 3.4 Data Analysis

One of the critical stages in the research is the analysis of the collected data which provides the interpretations of the findings of the study. The current study selected a narrative method to analyse the data gathered from semi-structured interviews. A narrative analysis can be used to analyse the experiences of the people related to the research problem, as stated by Nasheeda et al. (2019). The secondary data collected from the case studies was analysed using content analysis. Cassell and Bishop (2019) have observed that content analysis analyses data by determining the themes and concepts present in the data. Lastly, the quantitative data has been analysed through the statistical software SPSS. Flatt and Jacobs (2019) evaluate that statistical software helps in analysing quantifiable data and producing concise results.

### 3.5 Software Implementation

This research has included the implementation of cloud-based software, which is an E-commerce application for users to experience secure online shopping. This implementation of a cloud-centric approach ensures the betterment of the software development processes in small and medium-sized SMEs. According to Abbasi et al. (2019), it is challenging to implement cloud-based software in organisations and businesses that are struggling to improve their software development life cycle. However, SMEs experience speed optimisation, increased cost, and security issues if an optimal approach is not implemented. For this

purpose, this research utilised cloud services to build a web application that has been deployed on Amazon Web Services (AWS).

### 3.6 Angular Web Application Development

According to Xing, Huang and Lai. (2019), Angular is often used to build web and mobile applications. This research has adopted Angular for developing an e-commerce website based on online product delivery because the Angular platform offers development from small to enterprise-level projects. The Angular CLI is the most rapid, simplest and suggested way to build an application for even large enterprises with security measures (Callaghan, 2023).

For the purpose of installing Angular on the system, there are a few of the requirements that need to be installed. Firstly, there is a requirement for active and current LTS for Angular. So, the latest version of Node.js was installed on the local system to proceed with the installation. Additionally, node-v could be run on the terminal to ensure version compatibility for the installation of Node.js. Additionally, another requirement includes an NPM package Manager. The Angular applications and CLI are based on npm packages for several functions and features. Pereira (2021) pinpoints that the npm package could be installed using the npm package manager through the command line interface that automatically installs with the installation of Node.js.

Once the prerequisites were followed, the application was set up by running the commands into the terminal.

- **Hardware Requirements and Specifications**

**Table 1.** Hardware Requirements and Specifications.

| Hardware | | Software | |
|---|---|---|---|
| **Requirements** | **Used** | **Requirements** | **Used** |
| CPU | DELL | Browser | Chrome |
| RAM | 6GB | Programming Languages | Angular and JavaScript |
| SSD | 250GB | Cloud Platform | AWS |
| Operating System | Windows 10 | AWS Amplify Libraries | • Amazon Cognito<br>• Amazon S3<br>• AWS AppSync |

## 3.7 Programming Language and Framework

This subsection introduces the programming language and framework utilised in the research to write a script for the Angular web application, including Angular and JavaScript.

Ghelani, Hua and Koduru (2022) highlighted that Angular is a framework of JavaScript mainly used for the development of the front end. This research has also adopted Angular for the development of web applications because it has transformed front-end development rapidly. The research done by Kankaala (2019) pinpoints that JQuery was being used as a library of JavaScript before Angular was introduced, but it was quite an effort and time-consuming to execute an unstructured and complex code in bulk. So, Angular has been introduced, as highlighted by Nguyen (2022), which is easier and simpler to use. Considering Angular for this project has helped save the budget, provided outstanding compatibility on cross platforms, offered numerous built-in materials, and no requirement for code execution.

In the opinion of Athreya et al. (2022), JavaScript is used to build an application entirely. However, it was initially able to run on a browser but as its popularity increased, it is now run on local servers as well. This project adopted JavaScript for the backend development due to its speed, as it runs quickly on the client's browser.

### 3.8 Cloud Services

Cloud computing includes multiple services, including Software as a Service (SaaS) Infrastructure as a Service (IaaS), Function as a Service (FaaS), and Platform as a Service (PaaS) (Mohammed and Zeebaree, 2021). For this project, SaaS, FaaS, and DaaS was adopted.

Software as Services is a software model based on the cloud that is used to deliver web applications for users via the Internet (Surya, 2019). In this project, Amazon S3 was used to display the images of the products on the e-commerce website and their title, category, and description.

According to Rajan (2020), Function as a service enables developing, executing, running, and managing the packages of applications as functions without keeping its infrastructure maintained. For this project, AWS Lambda was utilised for serverless functions, such as the processing of orders and the handling of payment methods and integrations.

DaaS was adopted to manage the Database for this cloud-based web application. The user account handling, including signup and login, product catalogue, and order management, has been handled using Amazon DynamoDB within this project.

After the software development, it is then deployed on a private platform of the cloud, which is Amazon Web Series (AWS). For this purpose, the account was created, and the private cloud was configured properly on it. Once the account had been created, AWS Amplify CLI was installed on it to get connected with the angular framework.

At the time of deployment, the PRPLW-based algorithm was adopted, which is better as compared to the traditional SLP model in order to address issues and challenges related to the cloud. It was chosen for this project because PRPLW enables small and medium-sized enterprises to make better decisions on the basis of workload, security, and performance.

### 3.9 Limitations and Ethical Considerations

The study has a few limitations. The study gathered data from a single point in time due to the budget and time constraints of the academic research. The researcher conducted the research on SMEs only but not on multinational companies. The data was collected from fewer participants, and the sample size can be increased.

The integrity of the research is the major element of the research. The researcher obtained the consent of the participants and followed the ethical protocols to conduct the research. Anonymity and confidentiality were ensured to keep the personal details safe. The case studies selected for the study were selected to enhance the value of the research. The findings of the data have not harmed any person or authority in society.

# 4 IMPLEMENTATION AND INTERPRETATION PHASE OF RESEARCH

This chapter presents the interpretation of participants' responses to develop a comprehensive understanding of SDLC in terms of Cloud computing and services. The author analyses the transcripts of interviews with the research participants by performing a narrative analysis. In addition, the quantitative data is statistically analysed, identifying the impact of cloud integration with SDLC. Lastly, the chapter entails a discussion of findings in contrast with the literature in Chapter 2.

## 4.1 Analysis

Compatibility is established by Ünver (2019, 154-170) as an integral aspect of the evaluation of the Cloud environment, particularly to ensure smooth integration with the current SDLC of an enterprise. However, various inherent components of SDLC can be validated in terms of their compatibility with the cloud environment. In this regard, Participant 1 stated that.

Participant 1 *"We start by analysing the components of our SDLC that can be efficiently shifted to the Cloud. The main components include deployment pipelines and monitoring systems. We simultaneously consult a Cloud expert for the holistic evaluation of compatibility requirements. Another significant aspect of compatibility aligns with the selection of the respective Cloud platform that satisfies the SDLC's needs and goals."*

Such a response highlights that SDLC's components of deployment pipelines and monitoring systems are a priority of IT teams while evaluating the compatibility of their SDLC with the Cloud. System monitoring is responsible for continuously analysing a respective IT system's performance, health, and security. On the other hand, the deployment pipeline is primarily a system of automated processes con-

structed for efficient transportation of new code additions and updates from version control to production. The significance of deployment pipelines is further elaborated by Participant 5, stating as below.

Participant 5 *"The compatibility evaluation is a critical factor for streamlining the transition of SDLC procedures to the Cloud. Thus, we specifically examine such a factor by considering code repositories and deployment pipelines. We also compare and contrast the compatibility in terms of functionalities necessary for the SLDC process. Additionally, we use the AWS Cloud Adoption Readiness tool to support further and satisfy compatibility requirements."*

However, Participant 5 also emphasised the consideration of code repositories for compatibility evaluation. The storage of code and other software development assets, including scripts, tests, and documentation, is critical for a productive SDLC, and thus, the code repository facilitates the aforementioned requirements effectively. At the same time, another prevailing aspect can be observed from both the above responses. Such an aspect primarily involves the use of third-party individuals or software to support the compatibility analysis and subsequent cloud migration. Therefore, it can be confidently asserted that a holistic investigation of fundamental SDLC components is critical to achieving maximum compatibility. Compatibility evaluation is the initial process in adopting the Cloud that further facilitates Cloud migration strategies; thus, considering necessary SDLC attributes is substantially essential.

Additionally, identifying the major attributes of the Cloud environment, particularly to address the requirement of SDLC, is instrumental for the smooth transition. However, the preference of such attributes can vary concerning the organisation,

their respective SDLC model, and the associated practices. On this subject, Participant 4 response entailed as below.

Participant 4 *"In my opinion, the significant feature of a Cloud environment is its resilience and constant availability. The inherent methods used by Cloud providers ensure protection against downtime by eliminating regional dependencies and avoiding single points of failure. Such resilience of the Cloud allows the developers to focus on the development while not worrying about potential outages of resources".*

Software programming and development require significant resources and their availability among IT management. Such is a reason for the high regard for cloud services' resilience and constant availability features. In some cases, even a minor downtime can cause significant disruptions in the process of SDLC. Therefore, several professionals accentuate cloud-based software development, supporting their developers to meet deadlines and accomplish the defined objectives in due time. On the other hand, however, Participant 2 enlisted other attributes of the cloud environment that have been significant for addressing the needs of their SDLC model in the following response.

Participant 2 *"The main attributes in regard to the Cloud environment and SDLC are rapid elasticity and scalability. In this regard, the diverse pool of resources enables scalability for users, allowing the addition or removal of assets concerning networking, storage, and computation. Such an aspect has allowed our enterprise IT teams to avoid end-user bottlenecks and optimise cloud-hosted workloads. At the same time, the characteristic of rapid elasticity is significant as properly configured Cloud applications and*

*services automatically and instantly increase resources to manage the load during an expected surge of resource demands."*

Such a response illustrates the significance of elasticity and scalability in a SDLC which are also attributed as the primary characteristics of a cloud environment. In addition, it can be observed that Cloud services support the smooth modification of resources as per the demand of users. However, the importance of the availability of resources is also exemplified in this response, as elasticity ensures that employees and clients have access to the desired resources as required. At the same time, the respective respondents also emphasise the scalable aspect of cloud computing as it empowers the system to react and adapt to changing demands accordingly. These features of the Cloud are instrumental in a streamlined software development process.

However, multiple factors can potentially hinder the incorporation of Cloud services into software development processes. Therefore, understanding such challenges is critical for supporting the smooth adoption of Cloud-based software development. On this issue, Participant 3 highlighted that.

Participant 3 *"The major hindrance we faced was a decrease in network performance due to relatively higher latency, impacting our cross-team collaboration and production. We identified that the distance between the developer and the Cloud servers is one of the leading causes of challenges in our network. Additionally, the relocation of data to the Cloud was resource-intensive and subject to bandwidth limitations".*

The above statement signifies the complications imposed on the network system during the integration of Cloud services into software development processes. In

particular, the higher latency was asserted as a problem, and similarly, Participant 1 explains that.

Participant 1 *"We observed a decline in the network performance due to the fluctuations in latency affecting Cloud-based software development. On top of this, the distance between the Cloud servers and the developer was forcing delays in the accessing of resources and deployment of applications."*

Therefore, the significant variation in latency can be identified as a recurring hindrance, adversely impacting the transition of enterprises to the Cloud. Such complications can be detrimental to software development as Cloud applications often rely on real-time data processing, also observed in the preference of monitoring systems, and increased latency can introduce bottlenecks that hinder the ability of the system to address vast volumes of data in a timely manner. Therefore, while cloud services can cater to SDLC's various fundamental aspects, achieving such a stage is convoluted with different hindrances, primarily concerning the overall network performance. Consequently, the participants were asked about their respective practices for mitigating the challenges that emerged during the inclusion of Cloud services. In this regard, it is vital to analyse the responses of individual participants who voiced their concerns regarding the hindrances. Thus, Participant 3 replied that.

Participant 3 *"We managed to better address the challenges around network performance through the changes in our data locality and network architecture. The teams concurrently focused on optimising the bandwidth available in the network to mitigate latency-related problems further. We also employed a strategy*

*of data compression and incremental data transfers to facilitate better transfer of data with optimum data bandwidth and throughput."*

Whereas Participant 1 answered;

Participant 1 *"The challenge of the decline in network performance can be controlled by optimising performance. At the same time, complications related to latency were mitigated through a minor revision of network architecture. In addition, we leveraged edge computing to help process data closer to the source, further reducing latency."*

In both cases, one of the solutions was the changes in network architecture. Therefore, it can be believed that firms which did not consider the necessary improvements in their network architecture dealt with the problem of high or unstable latency. Nonetheless, network architecture is the foundation of software applications and development. Thus, revising the architecture in accordance with the adopted cloud provider or service is crucial for avoiding unforeseen challenges. However, to further ensure protection against such complications, the respondents also emphasise strategies such as data compression, incremental data transfers and edge computing.

Due to the weight of such challenges and the extent of relevant mitigation strategies, the worth of adopting cloud computing presents a concern for SMEs, mainly since they operate under a considerably limited budget and resources. Therefore, to propose a cloud-centric software process model, comprehending and analysing the beneficial aspects of integrating cloud services with SDLC is substantial. As a result, the responses included a diverse set of advantages as Participant 4 shared the experience in the following words.

Participant 4 *"I have experienced that cloud-based software development is faster and, thereby, can efficiently adapt to the set of enterprise*

*requirements. The ability to scale across an organisation effectively improved our internal collaboration, facilitating a more cost-effective development process. At the same time, the Cloud infrastructure has enhanced our in-house infrastructure operations, especially reducing the lead times".*

The software development industry is progressing at a very high rate. Thus, the speed of development is critical in accomplishing a competitive edge in a domain that is becoming increasingly saturated. The response also demonstrates the significance of fast development facilitated by the Cloud, signifying this technology as highly beneficial for SMEs. At the same time, from the above response, it can be understood that the Cloud can provide services of any scale as required. In particular, the factor of cost-effective development further strengthens the argument for incorporating the Cloud for the overall benefit of enterprises. However, the relevant answers of Participant 3 and Participant 6 both signify the benefits of Cloud by individually stating that.

Participant 3 *"Due to the integration of Cloud services, we have successfully managed to reduce the development costs. The pay-per-price model has provided the facility to only pay for the resources utilised by the developers. Overall, the ease of accessing necessary resources has empowered our development teams to collaborate seamlessly and deploy software faster."*

Participant 6 *"Integration of the Cloud has allowed us to save resources in infrastructure management and maintenance since the Cloud supplier takes care of such aspects for us. As a result, we can conveniently devote resources to our security teams, developers and network architects, enabling constant improvements and innovation. Also, the pay-per-price model is considerably beneficial*

*since the payment is required for only the resources utilised during the SDLC process".*

The common emphasis observed in both statements is on the pay-per-price model cloud service providers offer. The importance of such a model, especially in terms of cost reduction, is also elucidated by Guo (2021). Such a model only demands the fees of resources utilised by the IT teams, and according to Participant 3 and Participant 6, it significantly benefits the developers, SDLC and subsequently the organisation. The pay-per-price model involves no long-term commitment, provides flexibility and is relatively simple to manage. However, such an option can be costly, depending upon the use of extensive resources. On the other hand, the factor of supporting IT teams and developers with necessary resources is also illuminated in these responses, further emphasising the magnitude of empowering the employees, especially in SMEs, as they generally struggle in terms of funds and assets.

However, based on the specific factors, the appropriate evaluation of the resulting impact of Cloud integration with the respective SDLC is critical to ensure a smooth transformation further. In this regard, Participant 1 replies that.

Participant 1 *"As our main aim is to enhance the overall performance of our software applications, we use a bunch of different software performance metrics. Such metrics include reliability, availability, serviceability, response time and throughput. The use of these metrics promotes an environment where individuals, operations and development teams can collaborate better and continually improve."*

The response elucidates on the consideration of factors entailing reliability, availability, serviceability, response time and throughput. Such features are fundamental for the evaluation of software's quality, signifying the ability to perform in terms of satisfying the specified specifications, along with their efficient maintenance. However, the importance of estimating data throughput is also observed in the answer of Participant 3.

Participant 3 *"Augmenting the network access was our primary objective for adopting the Cloud while improving our SDLC. Therefore, we generally use metrics for evaluating the critical factors of latency, access time, and data throughput. Such attributes further factor into service-level agreements and quality-of-service requirements. We also use specific defect and security metrics, including defect density and code coverage".*

However, the latency and access time measurements are also demonstrated in the above response, along with the data throughput. Stable and low latency is critical for cloud-based software development, as well as the access time, which refers to the time taken to retrieve specific data. These variables correspond to service-level agreements, establishing user expectations regarding the performance and quality of service providers. Therefore, such agreements are substantial for SMEs as they understand the quality of service prior to their final decision.

### 4.2 Statistical Results and Analysis

This study primarily focuses on collecting the primary data from the participants, who are the specialists, professionals, and representatives of the SMEs; The total number of participants from whom the data was collected was 125, and they filled out the survey questionnaire. The main focus of this study was to select the SMEs

that have adopted software development in the Cloud. The participants were recruited through LinkedIn, and the data was analysed using SPSS (Statistical Packages for Social Sciences) software.

### 4.3 Findings from Survey Questionnaire

**Table 1:** Participant's Age.

**Age**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 20-25 years | 10 | 8.1 | 8.1 | 8.1 |
| | 26-35 years | 56 | 45.2 | 45.2 | 53.2 |
| | 36-45 years | 53 | 42.7 | 42.7 | 96.0 |
| | 46-50 years | 5 | 4.0 | 4.0 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

As seen in **Table 2**, 10 participants were aged between 20-25 years (8.1%), whereas 56 participants were aged between 26-35 years (45.2%). A total of 53 participants belonged to the 36-45 age group (42.7%), and 5 participants belonged to the 46-50 age group (4%).

**Table 2:** Participant's Gender.

**Gender**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Male | 84 | 67.7 | 67.7 | 67.7 |
| | Female | 40 | 32.3 | 32.3 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

Shown in **Table 3** , 84 participants (67.7%) were male, while 40 participants (32.3%) were female.

**Table 3:** Participant's Working Experience.

**Working Experience**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Less than 1 year | 3 | 2.4 | 2.4 | 2.4 |
| | 1-5 years | 11 | 8.9 | 8.9 | 11.3 |
| | 6-10 years | 33 | 26.6 | 26.6 | 37.9 |
| | 11- 15 years | 49 | 39.5 | 39.5 | 77.4 |
| | 16-20 years | 28 | 22.6 | 22.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 4** shows the work experience of the participants, only 3 participants (2.4%) had less than one year of work experience , whereas 11 participants (8.9%) had a total work experience of 1-5 years. 33 participants (26.6%) had a total work experience of 6-10 years. 49 participants in number (39.5%) had a total work experience of 11-15 years, and 28 participants (22.6%) had a total work experience of 16-20 years.

**Table 4:** SDLC model and Cloud Environment.

**1. The SDLC model of our firm aligns with the overall requirements of the cloud environment.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 44 | 35.5 | 35.5 | 35.5 |
| | Agree | 79 | 63.7 | 63.7 | 99.2 |
| | Disagree | 1 | .8 | .8 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 5** shows, the respondents' views were regarding the concept of the SDLC model and its implementation in their firms with the overall requirements regarding the cloud environment;79 participants (63.7%) agreed and 44 participants (35.5%) strongly agreed with the concept while only 1 participant (0.8%) disagreed thus showing that SDLC model was considered to be a time-efficient and cost-effective process in terms of developing the designs for cloud environment.

**Table 5:** Attributes of Cloud.

**2. Some of the attributes of the cloud, which include scalability, flexibility or security, are considered to be important for the SDLC.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 48 | 38.7 | 38.7 | 38.7 |
| | Agree | 75 | 60.5 | 60.5 | 99.2 |
| | Disagree | 1 | .8 | .8 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

When the participants were questioned regarding the attributes of the Cloud, which includes scalability, flexibility or security that are considered important for the SDLC, around 48 participants (38.7%) strongly agreed with the statement ( see

**Table 6** ). Only 1 participant disagreed with the above statement. Thus, the results show that scalability and flexibility in cloud computing are important as they refer to the ability to increase or decrease the IT resources that thus help meet the demands.

**Table 6:** Improving SDLC.

**3. In my SME, we have significantly improved the SDLC by incorporating cloud services into software development.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 52 | 41.9 | 41.9 | 41.9 |
| | Agree | 70 | 56.5 | 56.5 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 7,** show respondents' views when asked if the ADLC improved through the implementation of the cloud services into software development, 70 participants (56.5%) agreed and 52 participants (41.9%) strongly agreed that SDLC had been improved through the incorporation of cloud services into software development whereas 2 participants (1.6%) strongly disagreed with the scenario thus signifying that the cloud computing creates a virtual environment and software building which thus complete and automates the testing.

**Table 7:** Challenges During the Adoption of Cloud Computing.

**4. We have faced frequent challenges that arise during the adoption or integration of cloud computing in our SMEs.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 40 | 32.3 | 32.3 | 32.3 |
| | Agree | 79 | 63.7 | 63.7 | 96.0 |
| | Disagree | 5 | 4.0 | 4.0 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 8** shows respondents' view as to whether the SMEs face challenges when adopting or integrating cloud computing, 40 participants (32.3%) strongly agreed whereas 5 participants disagreed , thus signifying that the financial costs included performance issues such as downtime, integration with non-cloud apps, latency problems and bandwidth costs. The leveraging of the infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) hence optimises the resource utilisation. Moreover, the incorporation of DevOps practices hence improves the collaboration and ensures a continuous integration of the delivery within the cloud environment.

**Table 8:** Integration of SDLC for Achieving Tangible Benefits.

**5. With the integration of cloud services in the SDLC, we have achieved tangible benefits.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 45 | 36.3 | 36.3 | 36.3 |
| | Agree | 77 | 62.1 | 62.1 | 98.4 |
| | Neutral | 1 | .8 | .8 | 99.2 |
| | Disagree | 1 | .8 | .8 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 9** shows respondents' view when asked if the integration of the cloud services in the SDLC has resulted in improving the tangible benefits, 43 participants (36.3%) strongly agreed while 1 participant (0.8%) was found to have a neutral opinion. 1 participant (0.8%) disagreed , signifying that cloud computing helps deliver more flexibility and reliability that also helps increase performance and efficiency, thus lowering IT costs. It has also been observed that it helps in improving innovation, which thus allows the SME to achieve faster time to capture the market share.

**Table 9:** Positive Image of Cloud Service on the Development Process of SMEs.

**6. The adoption of cloud services has positively created an impact on the overall software development processes in my SME.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 43 | 34.7 | 34.7 | 34.7 |
| | Agree | 79 | 63.7 | 63.7 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 10** shows the respondents' view when asked if the adoption of cloud services has positively impacted the software development in our SME, 43 participants (34.7%) strongly agreed whereas 2 participants disagreed, thus signifying that the adoption of cloud services has resulted in cost savings. Cloud computing has reduced the cost of hardware, software, and maintenance, which also helps free up funds. Cloud services have also helped lower energy costs since the cloud servers do not need much electricity.

**Table 10:** Performance Evaluation Metrics Impact on SDLC.

**7. The use of performance evaluation metrics has created a positive impact on the SDLC model with the cloud on delivery timelines.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 39 | 31.5 | 31.5 | 31.5 |
| | Agree | 81 | 65.3 | 65.3 | 96.8 |
| | Neutral | 2 | 1.6 | 1.6 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 11** shows the division of participants' opinions regarding the use of the performance evaluation metrics that aim at creating a positive impact on the SDLC model with the Cloud on delivery timelines. 39 participants (31.5%) strongly

agreed, while 2 participants (1.8%) were having neutral opinion and 2 participants (1.6%) disagreed with the above statement signifying that the performance evaluation metrics consists of process metrics, product metrics and resource metrics that ease the working capabilities with the Cloud and also creating a more diverse delivery timelines.

**Table 11:** Integration of Cloud Services on Cost-effectiveness of SDLC Model.

**8. I am very much satisfied with the overall cost-effectiveness of the new SDLC model that fully integrates with the cloud services.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 38 | 30.6 | 30.6 | 30.6 |
| | Agree | 80 | 64.5 | 64.5 | 95.2 |
| | Disagree | 6 | 4.8 | 4.8 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 12** illustrates that, the cost-effectiveness of the new SDLC model has resulted in fully integrating the cloud services; the result shows that around 38 participants (30.6%) strongly agreed with the above scenarios, while 6 participants (4.8%) disagreed, with the above scenario thus signifying that since cloud computing is a cost-saving process, it helps in the full integration of the cloud services for the SMEs.

**Table 12:** Security Implications of Cloud-based SDLC.

**9. We have been monitoring the different security implications that are associated with cloud-based SDLC.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 43 | 34.7 | 34.7 | 34.7 |
| | Agree | 77 | 62.1 | 62.1 | 96.8 |
| | Disagree | 4 | 3.2 | 3.2 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

When the participants were questioned if they have been monitoring different security implications that are linked with the cloud based SDLC, 43 participants (34.7%) strongly agreed, while 4 participants (3.2%) disagreed with the above statement (**see Table 13**). This signifies that integration of the security into the processes resulted in security requirements that are gathered through the functional requirements, since the risk analysis is being taken in the design phase while the security testing took to ensure the cloud based SDLC safety.

**Table 13:** Access to Performance and Efficiency

**10. We have gained access to performance and efficiency through the incorporation of cloud services into our SDLC.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 37 | 29.8 | 29.8 | 29.8 |
| | Agree | 85 | 68.5 | 68.5 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Table 14** shows respondents' view when asked if they have gained access to the performance and efficiency through the incorporation of the cloud services into

the SDLC, 37 participants (29.8%) strongly agreed , while 2 participants (1.6%) disagreed. This signifies that by working with experts, help in becoming proficient at analysing the processes, documentation, tools and different skillsets that helps in the team implementation for the mutually agreed corrective actions in terms of meeting the SDLC process improvement goals.

**Table 14:** Integration of Cloud for Collaboration.

**11. I believe that the integration of the cloud has streamlined the collaboration among my development team.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 47 | 37.9 | 37.9 | 37.9 |
| | Agree | 75 | 60.5 | 60.5 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

When the participants were questioned if they believed that the integration of the Cloud streamlined the collaboration among the development team (**see table 15**), 47 participants (37.9%) strongly agreed whilst 2 participants (1.6%) disagreed. This signifies that cloud computing thus improves collaboration and asynchronous communication and editing. It also helps develop the team's confidence and build collaboration among the team members.

**Table 15:** Success of SDLC model in Cloud Environment.

**12. I am very much confident in the overall success of the SDLC model in the cloud environment.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 43 | 34.7 | 34.7 | 34.7 |
| | Agree | 79 | 63.7 | 63.7 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

When the participants were questioned if they were confident in the success of the SDLC model in the cloud environment (**see Table 16**), around 43 participants (34.7%) strongly agreed. In comparison, 2 participants (1.6%) disagreed, thus signifying that the SDLC helps break down the long and tedious life cycle of software development and makes the SDLC process easy and faster.

**Table 16:** ANOVA Analysis.

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 6.249 | 12 | .521 | 1.068 | .394[b] |
| | Residual | 54.098 | 111 | .487 | | |
| | Total | 60.347 | 123 | | | |

**Table 17** shows the results of the ANOVA analysis. The F-value should be greater than 1.96 and the Sig. value should be less than 0.05%, but the model shows that the F-value is 1.068 ($F < 1.96$) while the Sig. The value is 0.394 ($P > 0.05$), thus rejecting the model.

**Table 17:** Reliability Analysis.

**Case Processing Summary**

| | | N | % |
|---|---|---|---|
| Cases | Valid | 124 | 100.0 |
| | Excluded[a] | 0 | .0 |
| | Total | 124 | 100.0 |

a. Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .763 | 12 |

**Table 18** shows the reliability analysis of the questionnaire. It was observed that for reliability analysis, the value of Cronbach's Alpha should be greater than 0.7 in order to make the questionnaire reliable. In the above table, the value of Cronbach's Alpha is 0.763 (CA > 0.7), thus signifying that the questionnaire is valid and acceptable.

### 4.4 Discussion

The significance and role of multiple factors are identified during the interpretation of participants' responses in regard to software lifecycle management and cloud computing. However, it is important to further discuss the analysis with the information presented within the Literature Review. In this regard, Ünver (2019, 154-170) highlights that adequate assessment of Cloud compatibility is crucial to ensure a smooth transition. Similarly, the responses further contributed to such a factor by specifying certain SDLC aspects integral to the Cloud compatibility evaluation. On the other hand, Gurung, Shah and Jaiswal (2020, 30-37) and Khayer, Bao and Nguyen (2020, 963-985) accentuate various attributes of Cloud compu-

ting and signify that despite the different characteristics of respective SDLC models, the adequate identification and implementation of Cloud services can ensure the maximum quality of the product. On this particular matter, the representatives of SMEs demonstrated the significance of the Cloud attribute of constant availability and resilience, allowing IT teams to streamline the process of software development.

Moreover, Nielsen (2019) determines that the integration of SDLC and the Cloud presents a certain set of challenges due to the inability of enterprise applications to elevate beyond organisational boundaries. However, participant responses indicate otherwise, as they are more focused on the initial challenges, such as the outdated network architecture and the consequent limitations. Nonetheless, SMEs are starting to improve their network architecture are address the concerning complications. In this regard, Neifer et al. (2021, 47-55) also emphasise the limitations of conventional enterprise systems and applications. In contrast, regarding the cloud-centric software process model, Shetty and Panda (2021, 175-188) identify elevation in efficiency, scalability and cost-effectiveness as the primary benefits of adopting cloud services in SMEs. Resultingly, a similar set of themes is observed within the responses as SMEs are facilitating from the aforementioned benefits that have significantly enhanced their enterprises. However, estimating the impact of such factors is necessary for devising further plans and improvements in software lifecycle management and cloud computing, as suggested by Pargaonkar (2023, 8). Therefore, the SMEs consider the factors for evaluation as data throughput, latency, access time and lead time.

According to Sholeh, Fauziyah and Khasani (2020, 2012), the SDLC in SMEs with the integration of cloud computing has been introduced to the different SMEs that have brought a transformative change, as the main objective was the overall integration of cloud computing in terms of having a necessitating profound compre-

hensive SDLC within the cloud setting for the SMEs. The overall software development journey from conception to deployment has undergone different paradigm shifts as cloud technology has complicatedly intertwined into different phases (Vennaro, 2023, p.363-407). The implementation of the cloud resource resulted in facilitating the scalability, collaboration, and agility that help SMEs streamline their development processes. Along with this, the transitioning of the cloud centric SDLC in the SMEs has also set different hurdles, which include planning timeframes, prototyping, neglecting to engage the stakeholders while aligning with the other challenges thus surface in the form of security concerns, data privacy issues and the rise of bottlenecks in the network connectivity (Gurung, Shah & Jaiswal 2020, 30-37).

There are also limited financial resources present in SMEs that have thus posed different restrictions while investing in the robust cloud infrastructure; this thus aims at identifying and understanding the different limitations that are considered to be important for the crafting of the effective strategies needed to mitigate the risks while also ensuring the smooth integration of cloud computing into the SDLC of SMEs (Surbiryala & Rong 2019, 1-7). Along with this, the SDLC model is considered important for cost-effectiveness and time-efficiency in order to develop the different designs that are considered important for the cloud environment. The study also shows that the scalability and flexibility in cloud computing are important as they help increase or decrease the different IT resources that help meet the changes demanded (Zhu et al., 2023, 104322). The use of cloud computing also includes the proposal of cloud-centric software processes that help tailor the different needs of SMEs. Cloud computing thus provides a virtual environment and software building that completes the automation of cloud computing testing (Dittakavi, 2022, 29-45).

### 4.5 Software Application

A cloud-based software application was developed using AWS, Angular web application development, and PRPLW-based CSP algorithm. The developed E-commerce application allows users to shop online. The implementation of a cloud-centric approach comprising SaaS, FaaS, and DaaS ensures that the developed application satisfies the necessary requirements. SaaS was used for delivering web applications to users via the Internet. Additionally, Amazon S3 has been used to display the images of the products on the e-commerce website and their title, category, and description. FaaS allows for the development, execution, functioning and management of applications as functions. In addition, AWS Lambda was utilised for serverless functions, such as processing orders and handling payment methods and integrations. At the same time, DaaS was used as the Database for this cloud-based web application. In this regard, Amazon DynamoDB was utilised for user account handling, including signup and login, product catalogue, and order management. Overall, the use of AWS was significant since it ensured optimisation with only the cost of resources utilised.

Furthermore, Angular was used as a framework to build the proposed application. The use of this framework was substantial since it facilitated the smooth development of e-commerce applications based on online product delivery. In this regard, the role of Angular CLI was fundamental, allowing rapid and straightforward development of the application while considering the necessary security measures. Therefore, considering the project and Angular requirements, JavaScript was used as a programming language, providing real-time testing and prompt prototyping of the e-commerce application.

# 5 FINAL PHASE OF RESEARCH

This chapter concludes the results and analysis in terms of the research objectives. In addition, recommendations are enlisted, along with the potential implications. The author describes the areas of future work to ensure the long-term validity of the study.

## 5.1 Research Summary

On the basis of results and analysis, it can be concluded that SMEs are actively considering incorporating cloud-based solutions to facilitate digital transformation and consequently improve their management practices. However, compatibility evaluation remains critical in ensuring a smooth transition of software management processes to a respective Cloud. In this regard, various factors were identified to address different business problems. Such aspects primarily involve the adequate consideration of fundamental SDLC components. A holistic analysis of compatibility requirements is also significant since it further determines the integration and interoperability of cloud applications and services with the developed e-commerce application. Therefore, such a procedure is substantial to fully cater for the needs of SMEs in terms of their SDLC and their relocation to the Cloud.

Moreover, the Cloud comprises various imperative attributes and offers diverse services to its users. Similarly, AWS was chosen as the cloud service provider for the development of applications due to its comprehensive offerings, which can support digitisation of operations for SMEs at a scale that supports companies of their size. In this regard, on the basis of the qualitative analysis, it can be determined that SMEs prefer the use of Cloud-based software development primarily due to the constant availability the resilience of cloud services. As both in the experience of the author during the development of cloud-based e-commerce applications and the analysis of participant responses, the significance of over-the-clock

availability and resilience of the Cloud is particularly elucidated. While operating under the constraints of funds and resources, SMEs cannot afford any disruptions in the software applications and their development. Therefore, numerous professionals assert incorporating cloud-based software development to support their developers in meeting deadlines and accomplishing the company objectives efficiently.

Furthermore, the Cloud offers numerous benefits to its users; however, scalability can be observed as the primary advantage factor for SMEs. The results emphasise smooth modification of resources per users' demand as the fundamental feature of the Cloud, appreciated by the relevant professionals in the SMEs. At the same time, rapid elasticity is also beneficial since it ensures that developers in the SMEs and their respective clients can access the desired resources on runtime as required. Overall, scalability is crucial because it provides the ability to react and adapt to changes in demands accordingly and efficiently. As a result, scalability is the optimal choice for enterprises to gain access to resources that have not been previously accessible. Consequently, SMEs can promptly scale their computational resources while saving essential resources.

Nevertheless, it can be concluded that multiple factors can potentially hinder the integration of Cloud computing with software development processes. In this regard, the author experienced various challenges during the development and deployment of the cloud-based e-commerce web application, particularly concerning its overall performance and security. However, the results indicated a problem within the network architecture of different SMEs, further impacting the quality of cloud-based software development and applications. Thus, addressing such challenges is integral to effectively the SDLC's different fundamental aspects. At the same time, it can be observed that SMEs have successfully identified the deficiencies in their conventional system, particularly during the integration of the Cloud. Therefore, while the complications hindered SMEs' progress towards Cloud

integration, the companies could identify and address the individual hindrances accordingly.

There are multiple challenges that can occur during the digital transformation, primarily involving Cloud computing. However, the benefits of the Cloud outweigh the difficulties, as observed in the results and analysis of relevant benefits. On this subject, the advantage of fast development has gained significant traction among professionals in SMEs. This attribute is crucial for software development firms to produce high-quality products in a limited time, especially to maintain a competitive edge in the industry. In addition, the factor of cost-effective development further strengthens the argument for incorporating the Cloud for the overall benefit of enterprises. In addition, from the results, it can be identified that SMEs are opting for the Pay-per-use model. Cloud service providers extensively use such a model to charge only for the services provided to the respective user. Therefore, transparency and flexibility of the Pay-per-use model are the fundamental causes for their relatively higher preference among SMEs. The author also experiences the significance of this model as SaaS substantially contributed towards the development of the proposed e-commerce application.

Additionally, during the development of the e-commerce application, the use of Cloud services significantly elevated the efficiency of the overall process. The Cloud empowered the author to acquire resources as required without any major constraints. Despite the minor variations in the project specifications, the author was able to react and adapt as necessary, primarily due to the convenient scalability of cloud-based software applications. Therefore, such a feature can empower SMEs to scale their computational resources on runtime effectively. At the same time, the author observed that the Cloud ensures appropriate infrastructure for storing data and managing software applications. Such measures do not require significant investment upfront in software and hardware, allowing SMEs to integrate cloud services effectively. This aspect can reduce IT infrastructure costs

and enhance operational efficiency, particularly for SMEs with inadequate resources.

### 5.4 Recommendations and Implications

Transitioning to the Cloud is a major shift of technology for any organisation, especially SMEs since they typically function under limited financial resources. Therefore, for SMEs to adopt cloud solutions requires the initial acquisition of relevant knowledge and skills for the robust development of processes for ongoing operations. On the basis of the comprehensive analysis of both qualitative and quantitative data, the basic practice of understanding the specific business in terms of compatibility is identified. Thus, gaining clarity on the main attributes of the Cloud is significant to plan the transition accordingly. Another aspect of inappropriate IT infrastructure and cloud adoption strategy was identified during the analysis. Therefore, SMEs must devise a cloud migration strategy and revise their existing IT infrastructure to gain the maximum advantage of the Cloud services, as also emphasised by Balobaid and Debnath (2020, 7-12). At the same time, such a practice is highly integral for SMEs to avoid potential unforeseen challenges that can hinder the overall process. However, SMEs can effectively fulfil their plan to facilitate the Cloud and enhance their software development management by doing so.

Moreover, establishing a powerful data governance policy is instrumental to SMEs for the safeguarding of their assets. Additionally, the implementation of strict data governance laws has become vital for businesses planning to integrate Cloud computing, particularly in the existing digital age. In this regard, it was observed that SMEs are outsourcing their process of cloud integration to expert cloud consultants and also benefiting from different cloud readiness assessment tools. Therefore, by collaborating with cloud security experts and leveraging services, including the use of encryption of databases, virtual private networks, access control,

and more, SMEs can ensure a smooth transition with the necessary data governance policy in position, as also suggested by Repetto, Carrega and Rapuzzi (2021, 251-266).

### 5.3 Research Limitations and Future Work

The study has a few limitations, primarily in regard to the "mixed-method research" used for highlighting the relationship between software development management and the inclusion of Cloud computing. Therefore, the data collection and subsequent analysis were highly complex and required supplementary resources. In addition, the research was limited to SMEs and did not consider multinational companies with extensive resources. On the other hand, the data was collected from fewer participants, and the sample size can be increased in future work. However, the study entails a comprehensive analysis of the defined objectives and identified specific areas of importance. As a result, future researchers can further build on this study and explore such factors in-depth individually. At the same time, the inclusion of a conceptual framework and resulting hypotheses can provide a better foundation for the statistical analysis of the quantitative data.

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# APPENDICES

## **APPENDIX A.** Interview Questions

1. How do you evaluate the compatibility of your SDLC procedures with the cloud environment?
2. In your informed opinion, what are the main attributes of the cloud environment to cater for the requirements of the adopted SDLC model?
3. What hindrances have you faced during the incorporation of cloud services into software development processes?
4. How did you handle the challenges that arise while adopting or integrating cloud computing for your enterprises?
5. In your experience, what have been the beneficial aspects of integrating cloud services with SDLC?
6. On what factors do you measure the impact of the new SDLC model with the cloud on delivery timelines and development costs?

**APPENDIX B.** Interview Transcript

**Participant # 1**

**How do you evaluate the compatibility of your SDLC procedures with the Cloud environment?**

I emphasise the identification of current SDLC areas that can significantly improve through Cloud adoption. For instance, we evaluate the potential relocation and compatibility requirements of monitoring systems, deployment pipelines, testing environments and code repositories with the Cloud. We also use a Cloud readiness assessment tool to streamline the process of transitioning.

**In your informed opinion, what are the main attributes of the Cloud environment you consider in terms of the SDLC model?**

A while ago, we wanted to increase the network access to improve the overall process of SDLC. Therefore, upon comprehensive analysis, we decided to switch some of our data and applications to the Cloud. Therefore, such an attribute of the Cloud is significant for our SDLC as we plan to shift our data and applications to the Cloud entirely.

**What hindrances have you faced during the incorporation of Cloud services into software development processes?**

We observed a decline in the network performance due to the fluctuations in latency affecting Cloud-based software development. On top of this, the distance between the Cloud servers and the developer was forcing delays in the accessing of resources and deployment of applications. In addition, during the transition to the Cloud, dependency on the internet was a critical factor that, at times, also hindered the smooth integration of the Cloud.

**How did you handle the challenges that arise while adopting or integrating Cloud computing for your enterprises?**

The challenge of the decline in network performance can be controlled by optimising performance. At the same time, complications related to latency were mitigated through a minor revision of network architecture. In addition, we leveraged edge computing to help process data closer to the source, further reducing latency.

**In your experience, what have been the beneficial aspects of integrating Cloud services with SDLC?**

In my experience, the most substantial aspect of integrating Cloud services with SDLC is the reduction in development costs. Through Cloud computing, we authorised the access of all the necessary resources to the developers, eliminating the need for a significant initial investment in software and hardware. We have also subscribed to a pay-per-use model, and as a result, we only have to pay for the resources used by the developers, reducing operational costs.

**On what factors do you measure the impact of the new SDLC model with the integration of the Cloud?**

As our main aim is to enhance the overall performance of our software applications, we use a bunch of different software performance metrics. Such metrics include reliability, availability, serviceability, response time and throughput. The use of these metrics promotes an environment where individuals, operations and development teams can collaborate better and continually improve.

**Participant # 2**

**How do you evaluate the compatibility of your SDLC procedures with the Cloud environment?**

We start by analysing the components of our SDLC that can be efficiently shifted to the Cloud. The main components include deployment pipelines and monitoring systems. We simultaneously consult a Cloud expert for the holistic evaluation of compatibility requirements. Another significant aspect of compatibility aligns with the selection of the respective Cloud platform that satisfies the SDLC's needs and goals.

**In your informed opinion, what are the main attributes of the Cloud environment you consider in terms of the SDLC model?**

The main attributes in regard to the Cloud environment and SDLC are rapid elasticity and scalability. In this regard, the diverse pool of resources enables scalability for users, allowing the addition or removal of assets concerning networking, storage, and computation. Such an aspect has allowed our enterprise IT teams to avoid end-user bottlenecks and optimise cloud-hosted workloads. At the same time, the characteristic of rapid elasticity is significant as properly configured Cloud applications and services automatically and instantly increase resources to manage the load during an expected surge of resource demands.

**What hindrances have you faced during the adoption or incorporation of Cloud services into software development processes?**

The primary hindrance was during the identification of suitable architecture that can facilitate our enterprises. The limitation of necessary resources, including the lack of monetary funding and the non-availability of cloud-proficient staff, further

complicated the incorporation of Cloud services. In addition, data governance was another obstacle, as we did not have adequate experience in managing the Cloud.

**How did you handle the challenges that arise while adopting or integrating Cloud computing for your enterprises?**

We understand that our company does not have of necessary resources. However, since the transition to the Cloud was integral for the growth of the firm, we decided to hire a team of Cloud experts to help support our plans and ensure smooth integration of Cloud computing with our enterprises.

**In your experience, what have been the beneficial aspects of integrating Cloud services with SDLC?**

The most beneficial aspect of integrating Cloud services has undoubtedly been the improved security of our data and applications. The security and reliability factor of the Cloud has allowed our teams to store and access data without stressing over data breaches or other security issues. Additionally, tools such as data encryption and access control have significantly enhanced the overall security of our applications developed within the SDLC.

**On what factors do you measure the impact of the new SDLC model with the integration of the Cloud?**

We employ various necessary metrics to evaluate the software performance on the Cloud. The metrics for performance testing primarily involve stability, speed and scalability. On the other hand, in regard to the evaluation of network performance, we measure the throughput of data and response time of services to provide the highest quality to our consumers continuously.

**Participant # 3**

**How do you evaluate the compatibility of your SDLC procedures with the Cloud environment?**

To ensure the compatibility of our SDLC procedures with the Cloud environment, we initiate the comprehensive evaluation of Cloud service providers. In this regard, we compare the needs of our enterprises with the reliability, functionality, and costs of the respective Cloud service providers. Afterwards, the planning and execution of an adequate Cloud migration strategy is instrumental for minimising the impact and downtime of SDLC.

**In your informed opinion, what are the main attributes of the Cloud environment to cater for the requirements of the adopted SDLC model?**

I have come to understand that ubiquity is a major part of the Cloud's utility. Such a feature has allowed our authorised personnel to upload and access the data from anywhere with an internet connection. As a result, it has facilitated our hybrid work model, as our employees can log on and work from any location.

**What hindrances have you faced during the incorporation of Cloud services into software development processes?**

The major hindrance we faced was a decrease in network performance due to relatively higher latency, impacting our cross-team collaboration and production. We identified that the distance between the developer and the Cloud servers is one of the leading causes of challenges in our network. Additionally, the relocation of data to the Cloud was resource-intensive and subject to bandwidth limitations.

**How did you handle the challenges that arise while adopting or integrating Cloud computing for your enterprises?**

We managed to better address the challenges around network performance through the changes in our data locality and network architecture. The teams concurrently focused on optimising the bandwidth available in the network to mitigate latency-related problems further. We also employed a strategy of data compression and incremental data transfers to facilitate better transfer of data with optimum data bandwidth and throughput.

**In your experience, what have been the beneficial aspects of integrating Cloud services with SDLC?**

Due to the integration of Cloud services, we have successfully managed to reduce the development costs. The pay-per-price model has provided the facility to only pay for the resources utilised by the developers. Overall, the ease of accessing necessary resources has empowered our development teams to collaborate seamlessly and deploy software faster.

**On what factors do you measure the impact of the new SDLC model with the integration of the Cloud?**

Augmenting the network access was our primary objective for adopting the Cloud while improving our SDLC. Therefore, we generally use metrics for evaluating the critical factors of latency, access time, and data throughput. Such attributes further factor into service-level agreements and quality-of-service requirements. We also use specific defect and security metrics, including defect density and code coverage.

**Participant # 4**

**How do you evaluate the compatibility of your SDLC procedures with the Cloud environment?**

The evaluation of current SDLC features with respect to Cloud services is fundamental. Therefore, we mainly analyse the compatibility in terms of code repositories and testing environments. To further ensure and satisfy compatibility requirements, we also use a tool called CAST Highlight. In addition, our teams focus on documenting the essential factors concerning the compatibility of our system with the respective Cloud environment. We further employ a culture of feedback and transparency to ensure continuous adherence to the compatibility requirements.

**In your informed opinion, what are the main attributes of the Cloud environment to cater for the requirements of the adopted SDLC model?**

In my opinion, the significant feature of a Cloud environment is its resilience and constant availability. The inherent methods used by Cloud providers ensure protection against downtime by eliminating regional dependencies and avoiding single points of failure. Such resilience of the Cloud allows the developers to focus on the development while not worrying about potential outages of resources.

**What hindrances have you faced during the incorporation of Cloud services into software development processes?**

Running applications and storing confidential data in the Cloud have increased our concerns regarding data privacy and security. Thus, ensuring the safety of the data and application relocation to the Cloud was a major hindrance that required comprehensive analysis. On the other hand, the limitations of bandwidth caused problems for data transfer.

**How did you handle the challenges that arise while adopting or integrating Cloud computing for your enterprises?**

We mitigate the challenges I just discussed by ensuring data encryption, proper access controls and total compliance with relevant regulations to safeguard information from data breaches or unauthorised access. Whereas in regards to addressing the data transfer and bandwidth complications, we implement necessary practices encompassing incremental data transfers after the compression of data.

**In your experience, what have been the beneficial aspects of integrating Cloud services with SDLC?**

I have experienced that cloud-based software development is faster and, thereby, can efficiently adapt to the set of enterprise requirements. The ability to scale across an organisation effectively improved our internal collaboration, facilitating a more cost-effective development process. At the same time, the Cloud infrastructure has enhanced our in-house infrastructure operations, especially reducing the lead times.

**On what factors do you measure the impact of the new SDLC model with the integration of the Cloud?**

We intend to develop highly usable software applications for our clients, and thus, we use multiple usability metrics to evaluate digital accessibility, learnability, memorability, and efficiency. However, Lead time is our most important metric that signifies the duration of a particular task. In addition, our teams measure the availability, reliability, and serviceability to examine the respective SDLC model with the Cloud holistically.

**Participant # 5**

**How do you evaluate the compatibility of your SDLC procedures with the Cloud environment?**

The compatibility evaluation is a critical factor for streamlining the transition of SDLC procedures to the Cloud. Thus, we specifically examine such a factor by considering code repositories and deployment pipelines. We also compare and contrast the compatibility in terms of functionalities necessary for the SLDC process. Additionally, we use the AWS Cloud Adoption Readiness Tool to support further and satisfy compatibility requirements.

**In your informed opinion, what are the main attributes of the Cloud environment to cater for the requirements of the adopted SDLC model?**

I regard the constant availability of a Cloud environment as a substantial characteristic of the Cloud. Cloud service providers integrate various techniques to ensure that users have access to the necessary resources whenever required. As a result, we support our teams to maintain their primary focus on the development of top software products.

**What hindrances have you faced during the incorporation of Cloud services into software development processes?**

The initial step of identifying the appropriate Cloud service provider resulted in a hindrance as we did not have Cloud experts available within the organisation. Therefore, ensuring data safety and privacy significantly hindered the transition to the Cloud. However, once we got a hold of these issues, we were faced with a number of other complications such as low speed of data transfer and the necessity of constant internet connection.

**How did you handle the challenges that arise while adopting or integrating Cloud computing for your enterprises?**

We crafted and initiated a programme for the training of our existing IT team while employing new workers. This programme was conducted under the supervision of an expert Cloud consultant recommended by a fellow of mine. The emphasis of the programme was to train employees with new Cloud tools and skills to adapt to the new processes and workflows effectively.

**In your experience, what have been the beneficial aspects of integrating Cloud services with SDLC?**

Better data security has certainly been the advantageous factor of incorporating Cloud services with SDLC. Such a feature has empowered our IT team to store the data securely on the Cloud. At the same time, the inherent security attributes of the Cloud have substantially improved the overall security of data primarily used in the SDLC.

**On what factors do you measure the impact of the new SDLC model with the integration of the Cloud?**

The critical factors of data throughput and access time are the prime variables we use to measure the impact of the new SDLC model with the integration of the Cloud. Such evaluation further supports the analysis of the consequential effects of quality-of-service requirements and service-level agreements. Also, the metrics of code coverage, defect density, along defect detection percentage significantly support the assessment of security and defects.

**Participant # 6**

**How do you evaluate the compatibility of your SDLC procedures with the Cloud environment?**

We evaluate the compatibility of our SDLC procedures with the Cloud environment by using the Cloud readiness assessment tool. Through this tool, we examine the compatibility of Cloud services with necessary functions associated with the SDLC. More importantly, we identify the applications that are not only compatible but can integrate with the Cloud at minimal cost and resources.

**In your informed opinion, what are the main attributes of the Cloud environment to cater for the requirements of the adopted SDLC model?**

The expansion of network access due to the Cloud has been a transformational factor as we build our hybrid model of work. Hybrid work is a vital part of our SDLC, and thus, integrating with Cloud services has been effective so far. As a result, we can control authentication and enable our employees to share and access data from the comfort of either their homes or workplaces.

**What hindrances have you faced during the incorporation of Cloud services into software development processes?**

During the incorporation of Cloud services into software development processes, we identified that our network latency has become unstable. Prior to the transition, we were aware that delays could occur due to distances between the Cloud servers and the developer. However, initially, we could not have estimated the extent of it. At the same time, governance of data was highly challenging as we wanted to ensure the use of relevant policies.

**How did you handle the challenges that arise while adopting or integrating Cloud computing for your enterprises?**

We adopted Content Delivery Networks "(CDNs)" to mitigate network latency. CDNs can cache and distribute data from physically distributed points of presence, reducing data transfer time. We also made use of edge computing for better data processing and subsequently decreasing latency. Simultaneously, we conducted regular data quality checks at various stages of the Cloud integration process to address data governance challenges.

**In your experience, what have been the beneficial aspects of integrating Cloud services with SDLC?**

Integration of the Cloud has allowed us to save resources in infrastructure management and maintenance since the Cloud supplier takes care of such aspects for us. As a result, we can conveniently devote resources to our security teams, developers and network architects, enabling constant improvements and innovation. Also, the pay-per-price model is considerably beneficial since the payment is required for only the resources utilised during the SDLC process.

**On what factors do you measure the impact of the new SDLC model with the Cloud on delivery timelines and development costs?**

Improving network speed and efficiency were the basic reasons for performing Cloud-based software development. These factors are also imperative for reducing lead time, subsequently meeting delivery timelines and lowering development costs. Therefore, the measurement of access time, latency and data throughput are the most concerning factors of evaluation.

**APPENDIX C.** Survey Questionnaires

1. **What is your age?**

- ☐ 20 – 25 years
- ☐ 26 – 35 years
- ☐ 36 – 45 years
- ☐ 46 – 50 years
- ☐ More than 50 years

2. **What is your gender?**

- ☐ Male
- ☐ Female
- ☐ Prefer not to say

3. **Working Experience**

- ☐ Less than 1 year
- ☐ 1-5 years
- ☐ 6-10 years
- ☐ 11-15 years
- ☐ 16-20 years

You are requested to fill in the following questionnaire using the scale below.

| Strongly Agree (1) | Agree (2) | Neutral (3) | Disagree (4) | Strongly Disagree (5) |
|---|---|---|---|---|

| Survey Questions | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. The SDLC model of our firm aligns with the overall requirements of the cloud environment. | | | | | |
| 2. Some of the attributes of the cloud, which include scalability, flexibility or security, are considered to be important for the SDLC. | | | | | |
| 3. In my SME, we have significantly improved the SDLC by incorporating cloud services into software development. | | | | | |
| 4. We have faced frequent challenges that arise during the adoption or integration of cloud computing in our SMEs. | | | | | |
| 5. With the integration of cloud services in the SDLC, we have achieved tangible benefits. | | | | | |
| 6. The adoption of cloud services has positively created an impact on the overall software development processes in my SME. | | | | | |
| 7. The use of performance evaluation metrics has created a positive impact on the SDLC model with the cloud on delivery timelines. | | | | | |
| 8. I am very much satisfied with the overall cost-effectiveness of the new SDLC model that fully integrates with the cloud services. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 9. We have been monitoring the different security implications that are associated with cloud-based SDLC. | | | | | |
| 10. We have gained access to performance and efficiency through the incorporation of cloud services into our SDLC. | | | | | |
| 11. I believe that the integration of the cloud has streamlined the collaboration among my development team. | | | | | |
| 12. I am very much confident in the overall success of the SDLC model in the cloud environment. | | | | | |

**APPENDIX D.** SPSS Results

**Age**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 20-25 years | 10 | 8.1 | 8.1 | 8.1 |
| | 26-35 years | 56 | 45.2 | 45.2 | 53.2 |
| | 36-45 years | 53 | 42.7 | 42.7 | 96.0 |
| | 46-50 years | 5 | 4.0 | 4.0 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Gender**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Male | 84 | 67.7 | 67.7 | 67.7 |

| | | | | | |
|---|---|---|---|---|---|
| | Female | 40 | 32.3 | 32.3 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Working Experience**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Less than 1 year | 3 | 2.4 | 2.4 | 2.4 |
| | 1-5 years | 11 | 8.9 | 8.9 | 11.3 |
| | 6-10 years | 33 | 26.6 | 26.6 | 37.9 |
| | 11- 15 years | 49 | 39.5 | 39.5 | 77.4 |
| | 16-20 years | 28 | 22.6 | 22.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**1. The SDLC model of our firm aligns with the overall requirements of the cloud environment.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 44 | 35.5 | 35.5 | 35.5 |
| | Agree | 79 | 63.7 | 63.7 | 99.2 |
| | Disagree | 1 | .8 | .8 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**2. Some of the attributes of the cloud, which include scalability, flexibility or security, are considered to be important for the SDLC.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 48 | 38.7 | 38.7 | 38.7 |
| | Agree | 75 | 60.5 | 60.5 | 99.2 |
| | Disagree | 1 | .8 | .8 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**3. In my SME, we have significantly improved the SDLC by incorporating cloud services into software development.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 52 | 41.9 | 41.9 | 41.9 |
| | Agree | 70 | 56.5 | 56.5 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**4. We have faced frequent challenges that arise during the adoption or integration of cloud computing in our SMEs.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 40 | 32.3 | 32.3 | 32.3 |
| | Agree | 79 | 63.7 | 63.7 | 96.0 |
| | Disagree | 5 | 4.0 | 4.0 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**5. With the integration of cloud services in the SDLC, we have achieved tangible benefits.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 45 | 36.3 | 36.3 | 36.3 |
| | Agree | 77 | 62.1 | 62.1 | 98.4 |
| | Neutral | 1 | .8 | .8 | 99.2 |
| | Disagree | 1 | .8 | .8 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**6. The adoption of cloud services has positively created an impact on the overall software development processes in my SME.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 43 | 34.7 | 34.7 | 34.7 |
| | Agree | 79 | 63.7 | 63.7 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**7. The use of performance evaluation metrics has created a positive impact on the SDLC model with the cloud on delivery timelines.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 39 | 31.5 | 31.5 | 31.5 |
| | Agree | 81 | 65.3 | 65.3 | 96.8 |
| | Neutral | 2 | 1.6 | 1.6 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**8. I am very much satisfied with the overall cost-effectiveness of the new SDLC model that fully integrates with the cloud services.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 38 | 30.6 | 30.6 | 30.6 |
| | Agree | 80 | 64.5 | 64.5 | 95.2 |
| | Disagree | 6 | 4.8 | 4.8 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**9. We have been monitoring the different security implications that are associated with cloud-based SDLC.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 43 | 34.7 | 34.7 | 34.7 |
| | Agree | 77 | 62.1 | 62.1 | 96.8 |
| | Disagree | 4 | 3.2 | 3.2 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**10. We have gained access to performance and efficiency through the incorporation of cloud services into our SDLC.**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 37 | 29.8 | 29.8 | 29.8 |
| | Agree | 85 | 68.5 | 68.5 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**11. I believe that the integration of the cloud has streamlined the collaboration among my development team.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 47 | 37.9 | 37.9 | 37.9 |
| | Agree | 75 | 60.5 | 60.5 | 98.4 |
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**12. I am very much confident in the overall success of the SDLC model in the cloud environment.**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Strongly Agree | 43 | 34.7 | 34.7 | 34.7 |
| | Agree | 79 | 63.7 | 63.7 | 98.4 |

| | | | | | |
|---|---|---|---|---|---|
| | Disagree | 2 | 1.6 | 1.6 | 100.0 |
| | Total | 124 | 100.0 | 100.0 | |

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Esti-mate |
|---|---|---|---|---|
| 1 | .322[a] | .104 | .007 | .698 |

.

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 6.249 | 12 | .521 | 1.068 | .394[b] |
| | Residual | 54.098 | 111 | .487 | | |
| | Total | 60.347 | 123 | | | |

**Reliability**

**Scale: ALL VARIABLES**

**Case Processing Summary**

| | | N | % |
|---|---|---|---|
| Cases | Valid | 124 | 100.0 |

| | | | |
|---|---|---|---|
| | Excluded[a] | 0 | .0 |
| | Total | 124 | 100.0 |

a. Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .763 | 12 |