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# Infrastructure as Code Strategies and Benefits in Cloud Computing

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This is to certify that the doctoral study by

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has been found to be complete and satisfactory in all respects,
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Walden University
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Abstract

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by

Jeffrey Chijioke-Uche

MS, Walden University, 2020

MS, Thomas Edison State University, 2020

DS, Harvard University, 2021

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Information Technology

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## Abstract

Hybrid and multicloud infrastructure implementation without automation and versioning strategy can negatively impact organizations' productivity. Organization leaders must ensure that infrastructures are implemented using the infrastructure as code (IaC) strategy because implementation solutions, including automated and DevOps procedures, provide assets for repeatable infrastructure implementation use cases. Grounded in the disruptive innovation theory, the purpose of this qualitative pragmatic inquiry study was to explore strategies solution architects use to implement IaC architecture using repeatable assets with DevOps procedures in cloud computing. The participants were seven solution architects in the information technology (IT) industry within the United States who have successfully implemented IaC in hybrid and multicloud within the past 3 years in cloud computing with DevOps procedures. Data were collected using semi-structured interviews, a focus group, and IT industry documents. The data analysis processes were analyzed using thematic analysis Eight themes emerged: IaC benefits, IaC cloud computing models, IaC cloud service providers, IaC configuration best practices, IaC DevOps practices, IaC implementation tools, IaC Kubernetes platforms, and IT infrastructure design practices. A specific recommendation is for organizational leaders to implement the IaC approach as it offers sustaining and disruptive innovation benefits, in addition, space agencies such as the National Aeronautics and Space Administration (NASA), European Space Agency (ESA), et al., could use this study in their mission infrastructures. The implications for positive social change include the potential to make the user application offerings affordable as it supports IT innovation in hybrid and multicloud globally.

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# Dedication

First, I need to thank God; I would not have made it this far without God's assistance, wisdom, guidance, and strength. Also, this is dedicated to my mother, Mrs. Grace Obinka Uche, who, through her encouragement, gave me the inspiration and support to take off on this journey as a child. Mom, thank you, the memory is permanent, and I appreciate your kind words. I am also grateful to my father, Engr. Tobias Iwejuo Uche, who never accepts anything less than "excellent" in my academic performance. Dad, you set the bar height for me, and I appreciate it; you always let me know that ambition cannot wait and that the "impossible" is nothing; thank you because I saw through the lens of those your words as inspiration for my doctoral journey. I appreciate your support. To my siblings, Helen Uche-Ogbonna, Steven Uche, Christopher Uche, Franklin Uche, Anthonia Uche-Ike, and my Niece Shantel Uche, thank you for supporting me despite my unavailability to attend some of your events because of this doctorate journey. To my good friend, Nkem Mary Onyekwere-Eke, for your supportive and kind words during my doctoral journey; I wish you all the best and thank you.

Furthermore, my entire supportive extended family gave me encouragement and support while I was on the doctoral journey. You periodically reminded me that "nobody said it would be easy." Your collective kind words of reassurance motivated me and helped me move towards this journey's completion. Thank you to all of you; I have an amazing and loving family. Ultimately, I would like to dedicate this study to God; *Lord,* thank you – I am only a drop of ink from a pen in your hands that you used to design this doctoral achievement to your glory; I am humble.

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Section 1: Foundation of the Study

## Background of the Problem

Since the emergence of cloud computing, information technology (IT) practitioners have been searching for “repeatable” and “automated” strategies for cloud-based infrastructure (Masood et al., 2020); thus, infrastructure as code (IaC) is a practice by which IT solution architects create and implement IaC as source codes. IaC is also a technique to manage IT infrastructure reference architectures with versioned source codes using “automated” processes as repeatable infrastructure implementation development and operations (DevOps) procedures (Rahman et al., 2019). IaC emerged from the disruptive innovation theory (Christensen et al., 2018). IaC arose from IT practitioners ’ quests for failed IT infrastructure’s shorter downtime during disaster recovery, automation capabilities, and repeatable release strategies that are part of a code solution. IaC is stored as code logic with version controls. IaC tools provide the strategies used by IT practitioners to create reference architectures (RA) (e.g., virtual network, gateway, subnets, containers). IaC is cloud-agnostic, and with its declarative framework, nature cannot encroach on the users ’application space (Gandhi et al., 2020).

In contrast, the incumbent operating procedure is not a repeatable solution in cloud computing IT infrastructure implementation (Rahman et al., 2019). The manual functional requirement design approach has been around for several decades in the IT industry (Younas et al., 2020). However, it was the only option for creating IT infrastructure architecture before the emergence of IaC as a disruptive innovation (Christensen et al., 2018). It does not support architecture automated deployment through

code, and it takes multiple hours to complete its designs and disaster recovery process because of the manual process involved (Christensen et al., 2018). That is a problem because longer IT disaster recovery time for impacted infrastructure creates a revenue loss for organizations. When an innovation emerges that enhances performance on features that organizations generally appraise but expect improvement (e.g. the recording density of disk drives and capacity), the technology incumbents tend to succeed if the emerged innovation is adopted (Christensen et al., 2018).

## Problem Statement

IaC is a method by which infrastructure can be created and supported with an automation process based on DevOps software development practices because of IaC code-centric repeatable compatibility in automatically managing infrastructure resources in cloud computing platform ecosystems (Sandobalín et al., 2020). The deployment time when using IaC strategies takes an average of 60 seconds with "automation," while incumbent solution (standard) "manual" strategies deployment time takes an average of 600 seconds regardless of the cloud service provider (Sandobalín et al., 2020). The general IT problem is that some IT organizations rely on manual architecture solutions in cloud computing because IaC automated architecture solutions using DevOps procedures are not in place. The specific IT problem is that some IT solution architects lack strategies to implement IaC architecture using DevOps procedures in cloud computing.

## Purpose Statement

This pragmatic qualitative inquiry study aimed to explore strategies used by solution architects to implement IaC architecture solutions using DevOps procedures in

cloud computing. This exploration's targeted population was solution architects in the IT industry within the United States who have successfully implemented IaC within the past 3 years in cloud computing with DevOps procedures. The research's implementation approaches may help reveal the strategies used in implementing IaC in cloud computing. Thus, the implementation strategies may help host and develop social media applications and other public applications cost-effective for application developers and help the National Aeronautics and Space Administration's (NASA's) exploration mission to the international space station. Therefore, it may also contribute to positive social change by making the public offering of social media applications and other public applications (e.g., mobile applications, Web applications) to end-users stay affordable or free to use and support innovation in IT globally.

## Nature of the Study

I used the qualitative method because the research objective was to explore the extensive knowledge of the strategies used by solution architects in implementing IaC architecture solutions using DevOps procedures in cloud computing. I chose the qualitative method because its comparative analysis provides standards of good practice. The qualitative method provides acceptable practice standards to distinguish between positive cases prominent to a given result and negative cases not prominent to a given result (Sietz et al., 2019). I did not select the quantitative method because it requires researchers to use statistics for the data analysis, which was not required in this case study. Quantitative research methods consist of complex statistical and meta-analyses of case studies (Sietz et al., 2019). Mixed methods research incorporates quantitative and

qualitative methods; thus, I did not choose mixed methods. Combining qualitative and quantitative approaches highlights using mixed methods to collect data with complex statistical analysis procedures (Sietz et al., 2019).

I used a pragmatic qualitative inquiry design because it allows researchers to collect comprehensive data as raw textual data from multiple information sources (e.g., interviews and focus groups). There are benefits to using more than one sample in qualitative research (Jabkowski, 2018). Pragmatic inquiry permits the researcher to use a thematic content analysis concept to explore complex real-world problems (Gear et al., 2018). The thematic content analysis approach from pragmatic qualitative inquiry classifies data from individual interviews and focus-group transcripts into patterns to generate rich, thick data in a qualitative research study (Golub et al., 2020). Ethnography design intends to examine human culture in a natural setting unit; therefore, it was not a fit for this study as I did not intend to examine cultural settings. As the depiction of empirical data on humans, ethnography has been used in cultural studies (Henao & Marshall, 2019). A possible alternative is a phenomenological design that helps researchers understand the significance of people's lived experiences; therefore, the phenomenological design was not a good fit for this study. I did not intend to examine people's lived experiences induced by culture. There has been a continuous lamentable disconnect between the use of phenomenological focus on lived experiences induced by culture in experimental research and theoretical research case study (Carney, 2020). I did not choose a qualitative multiple case study design because it requires gatekeepers to give consent, which is time-consuming. Kerins et al. (2019b) concluded that the selected

organizations would be required through gatekeepers to consent before the researcher accesses the participants.

## Research Question

What strategies are used by IT solution architects to implement IaC architecture using DevOps procedures in cloud computing?

## Interview Questions

- Q01: What cloud deployment model did you use to implement IaC with DevOps procedures or principles? Which cloud service provider did you use and why?
- Q02: What configuration management tools have you used to store IaC sensitive variable tokens to avoid data security breaches during IaC implementation? Why did you use these tools?
- Q03: How have you used Terraform, ARM template, Puppet, Ansible, Kubernetes, Docker, and Version Controls technologies to implement IaC? Explain any other similar technologies used in IaC implementation.
- Q04: What tools do you use for the implementation of IaC? Please explain why you use the tools and how you use them, including describing which one is the most efficient recommendation for adopting the IaC strategy by any IT organization that wishes to transition their IT architecture.
- Q05: What IaC approaches do you use for infrastructure implementation? Please explain in both public and private cloud computing platforms, where applicable.
- Q06: How do you use IaC during infrastructure failure disaster recovery? Please explain any significant role played by IaC's automation capability in the recovery of

failed infrastructure architecture. Highlight any other significant IaC benefit you can think of concerning IaC.

- Q07: What are the IaC implementation tools that you use? Please explain the associated cloud computing platform. That is where the tools are used or supported. Highlight IaC architecture component tools, if applicable.
- Q08: What are your IaC implementation strategies? Please explain your IaC lifecycle strategy in the DevOps best practice procedure lifecycle until it gets to production.
- Q09: What drawbacks can you elaborate on in utilizing IaC implementation strategies? You can give a few scenario examples.
- Q10: Why is IaC practice considered predisposition with cloud-agnostic tools used to implement infrastructure architecture in grid and cloud computing?

## Conceptual Framework

Collins and Stockton (2018) concluded that conceptual frameworks are functions of the literature that map out a specific study's directions; thus, the researcher must choose theories that best fit the research study to improve its quality. For this pragmatic qualitative inquiry study, the conceptual framework I used was disruptive innovation theory (DIT), developed by Christensen in 1997. Christensen (1997) postulated that companies could be successful if the organization’s leadership supports new technology innovations instead of refusing to acknowledge the new technology or avoiding new technology innovation implementation. DIT is the foundation of the sequence of mature technology innovation studies available today (Christensen et al., 2018). DIT

concentrates on identifying radical innovation that can change for good the way organizations implement solutions to operate their businesses (Christensen et al., 2018). DIT's radical nature impacts can change the organization's existing core business logic model and create a new business model that could perform better than the existing process with diverse business value activities (Christensen et al., 2018). Valle and Oliver (2020) emphasized that disruptive innovation is a welcome development in the technology industry because it creates opportunities to build new technologies that fill the industry gaps.

In this research study, the focus was to explore the strategies used by IT organizations 'solution architects in implementing IaC architecture using DevOps procedures in cloud computing. IaC evolved from DIT concepts in cloud computing because it has a unique way of implementing infrastructures. IaC, with its automation capabilities, as a DIT concept, disrupts the use of the legacy infrastructure practice, which is the use of the standard manual infrastructure operating practice in cloud computing by IT organizations.

## Definition of Terms

*Amazon Web Services*: Cloud computing services are provided by Amazon (Greenstein, 2020). Its subscription platform supports IaC strategies (e.g., Terraform, Docker, Kubernetes). IaC innovation practices are supported by the Amazon web services platform (Hemon et al., 2020).

*Ansible*: An IaC open-source software used in the implementation process with the control state of the infrastructure for reusability and consistency in some private or public clouds (Rahman et al., 2020).

*Azure resource manager:* Microsoft IaC software is used in the implementation process with the infrastructure's control state for reusability and consistency on the Azure cloud computing platform (Rahman et al., 2020).

*Declarative syntax:* A code programming concept for developing the IaC; it states the logic of computation in the code with no description of control flow statements as seen in native programming languages (Wang, 2018).

*Docker images:* A programming language-agnostic container image (Smet et al., 2018). Docker images are pushed and retrieved from the image cloud server so that the microservices application powered by IaC in cloud computing can be reused recursively. It is a container holding logical algorithms for applications running as microservices in the cloud (Jiang et al., 2021).

*Harness continuous integration and continuous delivery*: Development and operations services for continuous integration, delivery, improvement, and collaboration concerning infrastructure and application systems support and delivery. It is also a procedure used to implement IaC for different resources. The utilization of development and operations in cloud computing, a combination of tools used for continuous integration in application lifecycle management, is key to efficient infrastructure management (Kersten, 2018).

*Idempotence approach:* An IaC update strategy whereby updating can be applied numerous times without changing the result beyond the target infrastructure's initial application; it provides reusability and consistency, focusing on the target environments (Rahman et al., 2019).

*Kubernetes container*: An open-source software container-orchestration strategy, running as clusters for automating computer application deployment in the IaC infrastructure platform (Jin et al., 2020).

*Reusable code*: Alogical set of instructions stored in the version control system in the cloud reused to create, update, and manage infrastructure. It is a valuable strategy for developing codes for infrastructure support models (Cervera, 2019). It is a code development pattern, an integral part of DevOps lifecycles in cloud computing for continuous integration and delivery (Trihinas et al., 2018).

*Terraform:* An IaC open-source cloud-agnostic software is used to implement the Infrastructure's control state for reusability and consistency (Rahman et al., 2020).

## Assumptions, Limitations, and Delimitations

### Assumptions

Assumptions in any study are truthfully making multidimensional premises by effectively reducing the odds that have to be unequivocally determined in the long run (Rademacher & Wagner, 2020). This study's first assumption was that participants would answer questions truthfully. The second assumption was that the sample size would be large enough to achieve data saturation such that if any of the four interview participants revealed information that none others had stated, I kept on with more participant

interviews until no more new data was revealed. The third assumption was that the findings might effectively be transferred for implementation by other solution architects. This research study's final assumption was that the selected participants from the selected population sample size would be well-informed about cloud computing and IaC implementation strategies using DevOps procedures.

**Limitations**

A study's limitations are defined as those visible effects in the research that are contingent on the extent to which the dependencies of a particular category of data at a given sample on the previous samples are limited to a finite state without any opportunity to exceed boundary (Lecocq et al., 2019). One limitation was that this research study's accuracy was contingent on participants' semistructured interview responses' reliability and credibility regardless of participants' sample size in the qualitative research study. A second limitation was that the participants' opinions might not reflect what would have become standard operating procedures due to the topic's relative newness.

**Delimitations**

Delimitations are research study boundaries that inform the perception of controls within the researcher's abilities because the research boundaries inhibit the researcher from creating unforeseen prospects that may not let the study accomplish its goals (De Buitrago, 2019). The first delimitation in this study was my ability to select IT solution architects within the United States in the IT industry who have successfully implemented IaC within the past 3 years in cloud computing using DevOps procedures. A second delimitation was that the study focused only on strategies relevant to the implementation

of IaC in cloud computing using DevOps and did not include other IT or non-IT processes or strategies in the industry not related to IaC.

## Significance of the Study

### Contribution to IT Practice

This study may be valuable to IT organizations and practitioners interested in developing infrastructures with automation capabilities, rapid deployment, support, and management features. Such IT applications infrastructure may host and support mobile applications, organizations ’general applications, and global users ’social media applications in cloud computing platforms with ease and unlike the implementation processes offered by standard-manual Infrastructure. It may also help NASA's exploration mission in the international space station by providing the opportunity to build remotely controllable and deployable infrastructures. The IaC implementation supports a code-centric tools approach that uses automated source codes to create and execute cloud infrastructure resources (Sandobalín et al., 2020). Most IT practitioners follow DevOps procedures in cloud computing infrastructure management, where their objective is to deliver and support web application infrastructures rapidly at high capacity. Each cloud provider (e.g., Azure, Amazon Web Services [AWS], Google Cloud Platform [GCP], Alibaba Cloud, Oracle Cloud, and IBM Cloud) offers different infrastructure resources (e.g., interview protocol [IP], virtual machine, containers, satellite). This study may offer implementation strategies that these IT practitioners could use to deploy these infrastructures quickly to achieve the DevOps objectives.

## Implications for Social Change

This study may contribute to positive social change as IT organizations developing systems such as social media applications for end-users may offer the subscriptions and download access of the social media applications end-product at a lower or free rate because they use IaC implemented strategies in the development of the application. The implementation of IaC in the development of social media applications by IT organizations may also help change the willingness of the potential end-users to use the applications. It may also change some end-users disinclination to have the passion for using these social media applications as subscription fees may be at a lower rate or free to download. The application developers may have flexibility in creating the applications made possible by this study's findings.

## A Review of the Professional and Academic Literature

The literature review presents a variety of relevant literature associated with the strategies used by IT solution architects to implement IaC in cloud computing using DevOps procedures, which was the focus of this pragmatic qualitative inquiry study. The literature review is essential to every research study. Part of its purpose is that it provides a foundation of knowledge on the topic, places the research within the context of existing literature, makes a case for why further study is needed, categorizes areas of prior scholarship to avert duplication, gives credit to previous researchers, recognizes the need for additional research that justifies the current research occurrence, identifies inconstancies such as open questions left from previous or similar research, research gaps, and conflicts in previous studies, and finds the relationship of works in the appraisal

of its contribution to the topic and to other works related to the current research topic to provide validity elements of the current research topic.

This literature review is organized to cover the DIT, the conceptual framework selected for this study as a seminal literature source to the study's foundation. For the literature to enhance the study's quality and validity, the review consists of peer-reviewed works conducted in the past 5 years as qualitative research. Apart from this overview subsection, this literature review consists of IaC, cloud computing, and conceptual framework: DIT and application to specific IT problem subsections.

The databases used while searching for the study's topic-relevant keywords included JSTOR, IEEE Xplore, Semantic Scholar, U.S. Government sources, Journals Online, EBSCOhost, ProQuest, Science Direct, SAGE, Scopus, and Walden Library databases. The study's topic-relevant keywords used while searching the databases included *cloud computing, IaC, infrastructure as code, cloud computing model, DIT, IaC benefits in cloud computing, solution architects cloud computing tools, infrastructure as code strategies, IaC and Kubernetes, infrastructure as code DevOps procedures, DevOps IaC strategies, cloud computing models for IaC, cloud computing models for IaC, coding patterns for IaC scripts, IaC programming language, infrastructure as code programming language, version controls, Git version control, DevOps procedures, cloud computing models for infrastructure as code, gaps in infrastructure as code concept, IT solution architects DevOps expertise, IaC and Docker relationship, version control utilization in IaC, infrastructure as code automation capabilities, cloud deployment models, platform as a service, software as a service, just in time in cloud computing,*

*cloud computing benefits, Kubernetes and infrastructure as code, microservices, Docker and infrastructure as code, ansible and infrastructure as code, Terraform and infrastructure as code, ARM and infrastructure as code,* and *microservices and infrastructure as code*.

A total of 226 article sources, including 10 government-published articles and two seminal article sources, have been integrated into this research, while 213 of these articles are scholarly or refereed, and that is 95.6% scholarly. Of the 226 integrated article sources, 224 were recently published within 5 years of this study's projected completion date. Within these 226 integrated article sources, 120 of these articles are included in the literature review. Of the literature review articles, 118 articles were recently published within 5 years of this research study's projected completion date. Also, of the 120 literature review articles, 112 article sources are scholarly or refereed, 93.3% scholarly.

## Infrastructure as Code and Cloud Computing

### Cloud Computing Fundamentals

Cloud computing is defined as on-demand access, through the internet (Lehr et al., 2019), to computing resources (e.g., applications, virtual servers, physical servers, development tools, data storage, networking capabilities, and others) hosted at an isolated data center managed by cloud services providers (e.g., AWS, Azure, Google Cloud, IBM Cloud, Alibaba Cloud, Salesforce, Oracle Cloud, Tencent Cloud) to run a business or private files and applications (Goode, 2020). Emeras et al. (2019) concluded that AWS dominates cloud computing globally. The National Institute of Standards and Technology

(NIST) confirmed that cloud computing is offered in four different models: private cloud, public cloud, hybrid cloud, and community cloud (NIST, 2018).

There has been a substantial progression of computing concepts within the last 10 years. The most known and established one is cloud computing, a concept born from the need to use computing resources as a utility rather than a stagnant system (De Donno et al., 2019). Cloud computing has permitted the easy development of new technologies. It has been an exceptionally prevalent research topic until an irresistible proliferation of intelligent technologies such as the Internet-of-Things (IoT) revealed all the limitations of the incumbent computing concept (Qi & Tao, 2019).

In common practice within the information system industry, most IT organizations have utilized cloud computing technology because of its benefits in delivering business solutions since it emerged (Alarifi et al., 2020). Cloud computing is an expanding technology, and cloud services providers, such as IBM Cloud, Google Cloud, AWS and Microsoft Azure, Alibaba Cloud, and Salesforce, have uninterruptedly added more cloud service resources for their cloud environments to keep their odds of competition and meet the global customers' increasing needs for disruptive innovation development (Alsenani et al., 2020). Several diverse organizations migrate to cloud-based solutions for their IT-based infrastructure and applications because of innovation opportunities like disruptive vehicular multimedia cloud computing platforms (Siddiqi et al., 2020).

In the information systems industry, virtualization technologies are initial elements for a wide variety of computing developments initially utilized in various roles to improve operating systems for cloud computing (Benkhelifa et al., 2019). However,

virtualization has expanded to fully utilize computing hardware in a remote data center provided by cloud service providers for cloud computing innovations (Siasi et al., 2020). The accumulation of differing virtualization methods has permitted the building of complete information system environments and has supported the concept of cloud computing to offer innovations like IaC, regardless of cloud computing. It provides various benefits over incumbent native hardware computing models (El-Sayed et al., 2018).

Computing needs have been expanded for various fields such as financial, healthcare applications, engineering, geographical science, education, and business (Dubey et al., 2019). Cloud computing has been exceptionally accepted as a capable solution for disruptive innovation and the IT industry problem-solving platform (Sekaran et al., 2019). Cloud computing is a high-performance computing model that provides services through the internet and implements huge scientific applications in the cloud (El-Sayed et al., 2018).

Cloud computing can distribute three main kinds of "models" as "services," namely software as a service (SaaS), infrastructure as a service (IaaS), and platform as a service (PaaS); IaaS cloud provides enormous computing hardware infrastructure platform and software resources in the shape of services (Benkhelifa et al., 2019). PaaS cloud delivers a platform where users can deploy their applications and use the existing platform for building their application, while in the SaaS cloud, users can only run an application on cloud infrastructure (Alsenani et al., 2020). Cloud computing can also deliver two different kinds of cloud "processes" as "code," namely IaC and pipeline as

code (PaC), where both IaC and PaC are disruptive innovations with high interests in the IT industry (Rahman et al., 2019).

## IaC Fundamentals

IaC is defined as an IT architecture feature implementation in cloud computing, which is a procedure to automate the provisioning of IT infrastructure, allowing the organization to build, deploy, and "scale-out scale-in*"* cloud applications automatically, rapidly, at a reduced cost, and less risk during support (Rahman et al., 2019). IaC limitations in cloud computing are tiny, as its performance is not overemphasized (Lecocq et al., 2019).

## IaC Improves DevOps Lifecycle

By simplifying provisioning and ensuring infrastructure consistency, IaC can assertively hasten every phase of the DevOps lifecycle. IT solution architect practitioners can rapidly provision development sandboxes and continuous integration-continuous deployment server environments (Li, Liu, et al., 2018). On the other hand, IT quality assurance practitioners can rapidly provision "full-fidelity" test server environments. IT operations can rapidly provision infrastructure for security and user-acceptance testing. Finally, when the application code passes testing, the application code and the production infrastructure it runs on can be deployed in one step by pushing a button (Rafi et al., 2020a).

## Cloud Services Providers Enabled IaC as Cloud Agnostic

Among the cloud service providers such as AWS, Azure, and GCP, the IaC strategic deployment and management tools unanimously supported by all the cloud

service providers, as compared to Table 1, made IaC cloud-agnostic and disruptive innovation for infrastructure design, deployment, and management in the IT industry (see Emeras et al., 2019). The Domain Name System (DNS) is a cloud infrastructure resource as a set of naming and numbering rules for related top-level domains, which before the emergence of IaC could only be created or designed using the incumbent manual process; today, DNS can be automatically deployed with IaC strategy, and the infrastructure code can be immediately reused (Greenstein, 2020). IaC enhances application cloud deployment because of the "core network" (Gandhi et al., 2020). According to Figure 1, cloud computing, fog computing, and edge computing have latency, power, and bandwidth properties, but cloud computing provides the most potent core network required by any disruptive innovation application to thrive in the cloud (see Ghasemi et al., 2020). Shen et al. (2019) emphasized that cloud computing supports group data sharing among cloud-enabled resources.

The cloud computing platform, in general, is an evolving model for enabling a ubiquitous and on-demand shared pool of configurable computing resources (Dörnenburg, 2018). Users typically provision these resources rapidly in cloud computing using the IaC strategies. Snyder and Curtis (2018) concluded that cloud computing exists as a public and private cloud. They emphasized that cloud computing enables the creation of agile-DevOps for application lifecycle management and plays a massive role in infrastructure implementation. The authors stressed that cloud computing provides opportunities to build new technologies and deliver them faster to customers regardless of geographical location as it has the capabilities to provide clusters in grid interconnected

services. Dörnenburg (2018) elaborated that cloud computing deployment models such as public, private, or hybrid models fit into organizations 'computing demands in all ramifications because it offers various cloud computing services models, which comprise IaaS, SaaS, PaaS, and serverless computing, depending on the cloud service provider. The author suggested that organizations can host their applications with any cloud service provider of their choice and may still have the ability to configure and manage their cloud resources.

**Table 1**

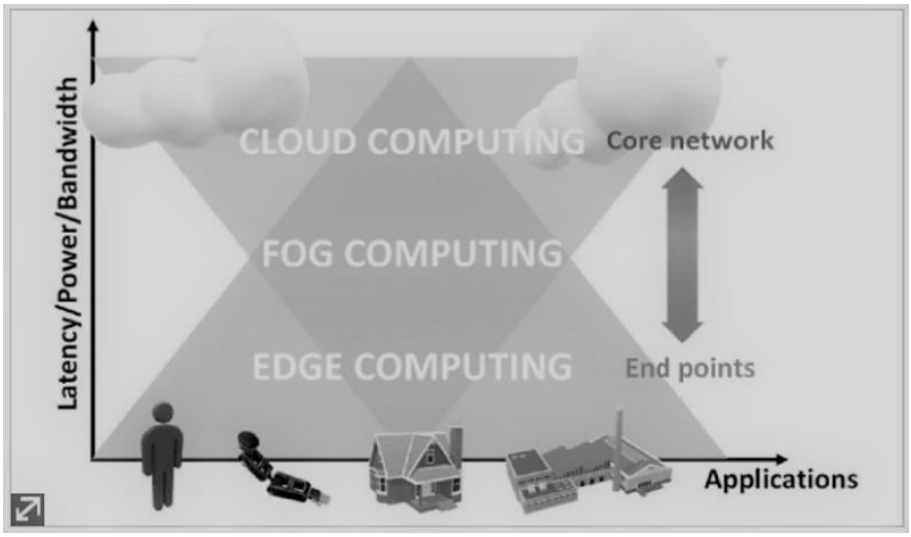
*Disruptive Cloud Service Providers for IaC as Cloud Agnostic*

| Disruptive cloud provider | Resources | Disruptive tool |
|---|---|---|
| Microsoft Azure | A virtual machine, App Gateway, Storage account, Kubernetes(AKS), Container Registry, SQL server, CosmoDB, CDN, OpenShift, Azure DNS | Terraform, ARM, Azure CLI, AzureDevOps |
| Google Cloud Platform | Kubernetes(GKE), Container Registry, Artifact Registry, SQL Server, MySQL, OpenShift | Terraform, GC SDK |
| Amazon Web Services | EC2, Kubernetes(EKS), MySQL server, Elastic Container Registry, S3, DynamoDB, API Gateway, CloudFront, Route53, OpenShift | Terraform, AWS CLI, CodeCommit |
| IBM Cloud | OpenShift, Cloud Pak for Data, Cloud Pak for Security, Cloud Pak for Automation, Kubernetes | Terraform, IBM CLI, Tekton, IBM Cloud Native, Schematics |

*Note.* Adapted from "Disruptive Incumbents: Platform Competition in an Age of Machine Learning," by C. Hemphill, 2019, *Columbia Law Review, 119(7), 1773–1792*. 

**Figure 1**

*Cloud Computing and Edge Computing in Core Network*




*Note.* Adapted from "Computing in the Blink of an Eye: Current Possibilities for Edge Computing and Hardware-Agnostic Programming," by M. Ghasemi et al., 2020, *IEEE Access, 8*, 41626-41636. Copyright 2020 by Creative Commons License and adapted with permission granted by Creative Commons (see Appendix B).

## Evolutionary Studies on Technology Innovation

### IaC Delivers Fast

IaC automation capabilities significantly speed the provisioning of IT infrastructure with the DevOps process for testing, development, and production, scaling-out, scaling-in, or taking down production IT infrastructure for scheduled maintenance (Jeon et al., 2020). The IaC process translates infrastructure into "versioned code" using Terraform, chef, ansible, and Azure resource manager (ARM) tools for reuse. IaC can automate the provisioning of legacy IT infrastructure that "time-consuming" processes might

otherwise dominate, a problem found in the incumbent solution because of zero resource code reuse ability (Xiong et al., 2018). Ren et al. (2019) concluded that the collaborative communication between cloud and edge computing accounts for latency minimization to deliver applications and services as fast as possible.

**IaC Has Improved Consistency**

Configuration waft happens when ad-hoc configuration modifications and revisions result in asymmetric test, development, and deployment environments due to inconsistency in application code (Hou et al., 2019). This problem can result in security vulnerabilities, application deployment, and risks when developing applications and services that meet rigorous compliance standards. IaC avoids waft by providing the exact copy of the environment every time required (Zhu et al., 2019).

Carney (2020) believed that even though embodied, embedded, enactive, and extended (4E) interdisciplinary research technology innovation is very much in trend, its cognition effect has received relatively few critical evaluations as a disruptive innovation; therefore, the qualitative research method is an excellent fit to explore the evolved innovation. To explore 4E cognition, Carney evaluated multiple research methods and selected to use qualitative ethnography design because of its focus on culture. Most innovation research authors do not use the phenomenological approach when working on innovation case studies. They concluded that there had been a continuous lamentable disconnect between using the phenomenological focus of lived experiences in a theoretical research case study (Fernández & Valle, 2018). Those authors' viewpoints are that IaC is an innovation that evolved due to disruptive innovation. Rafi et al. (2020b)

postulated that DevOps challenges are manageable because of cloud computing deployment models' availability.

Critical technology infrastructure solutions provide the essential services that support systems' economic productivity and security because of disruptive innovations (Almoghathawi & Barker, 2020). These critical technologies are possible because of continuous research on innovations that the objective is to develop a better solution of doing things with technology other than ways provided by the incumbent solutions (Almoghathawi & Barker, 2020). As a result, organizations' disruptive innovation concept adoption is rising because of its benefits (Rao et al., 2019). Its impacts shift the paradigm in the IT industry because imagined ideas from research are made possible by disruptive innovation delivered through DevOps, thereby making the IT industry quality-aware (Alnafessah et al., 2021). Similarly, with a focus on wireless technology, innovations such as machine and deep learning techniques are employed practically in every aspect of technology designs today due to their capability to estimate multifaceted non-linear models; making it possible for any associated designed wireless product to have the capability of extenuating the objectionable effects of wireless propagation information in the product (Belmonte-Hernández et al., 2019). Several years ago, this capability was imagination but was made possible by disruptive innovation concepts in technology, which aimed to disrupt the incumbent way of developing wireless products in IT (Belmonte-Hernández et al., 2019).

Experts suggest that market economies are apt to underprovided innovation concepts in economic theory because of the decent public nature of understanding new

products and their benefits (Bloom et al., 2019). Therefore, the empirical indication from the United States and other forward-thinking economies globally supports the disruptive innovation concept for technology and non-technology approaches because disruptive innovation is the only way for the IT industry in the global market to secure long-run productivity for the IT market for sustainability (Bloom et al., 2019). Disruptive innovation changes the market direction economically when new technology developed with DIT concepts enters the market; the disruption is at the market level and shifts the incumbent protocols at the organization level on how IT organizations are doing business with the technology products and services. IaC, as a product of disruptive innovation, entered the technology market to change how organizations are doing business with technical infrastructures; it brought automated machine capabilities to disrupt the incumbent practice (Hemphill, 2019).

While IaC is a disruptive innovation product with a primary focus on the IT industry, the healthcare industry was not left out of the benefits of disruptive innovation because of the use of incumbent way or pattern of providing healthcare services in the United States and around the world helped to increase the cost of healthcare services leaving most people to have the inability of affording healthcare services (Galea, 2018). A couple of years ago, health technology experts asked questions; if the disruptive innovation in health care improves populations' health? Forward-thinking IT researchers and software developers responded and made a strong statement by introducing e-health, electronic health records, and doctor-on-demand solutions using the concept of disruptive innovation (Galea, 2018). These technological solutions to the healthcare industry helped

improve populations' health globally. Manning et al. (2018) added that disruptive innovation in almost all the economic sectors globally is like sweepstakes to win the future in technology, business, and society (Manning et al., 2018). IaC as disruptive innovation is a contributing factor; hence, this research study and other IT studies are alike.

Pyne et al. (2020) emphasized the importance of disruptive innovation by demonstrating small synthetic aperture radar (SAR) satellite development. In their evaluation of the small SAR satellite innovation, the authors concluded that the SAR has numerous benefits for remote sensing applications contrasted to the incumbent optical satellite links like the continuous image possession even at night, including during cloudy weather conditions. They added that the conventional SAR observation innovation requires large or medium-size satellites weighing some hundred kilograms to operate, unlike the incumbent requiring only a large kilogram size for the satellite to operate (Pyne et al., 2020). Pyne et al. attributed the success of the invention and demonstration of disruptive innovation concepts applied to the technology's design and implementation. Raska (2019) elaborated on the importance of disruptive innovation in technology when applied to military technology equipment development. The author emphasized that applying disruptive innovation in military technology equipment development is essential. Raska believed that disruptive innovation had contributed immensely to military equipment development in optical satellite links, cloud computing, big data analytics, artificial intelligence, virtual and augmented reality, robotics, advanced sensors, and the internet of things.

In the perspective of cloud computing digital transformation concerning business operations, companies and businesses need to react flexibly in IT support and management to fast-shifting markets and disruptive technologies (Schön et al., 2020). Customer and user satisfaction are essential to succeed in today's business for companies that rely heavily on IT to operate and offer products and services globally (Schön et al., 2020). IaC provides agile user experience design capabilities for rapid infrastructure setup and implementation to achieve business objectives, enabling organizations to focus on their product users' needs and customer services (Schön et al., 2020). On the other hand, the automotive industry was transformed by applying disruptive innovation to design and develop self-driving cars. Few experts say that we need new rules for self-driving cars because the effects of disruptive innovation in the technology used in self-driving cars created an autonomous status for the designed cars (Stilgoe, 2018). The author emphasized that autonomous cars changed the world in twos – that is, in anticipated and completely unanticipated effects as the author suggested that new rules would be helpful, especially in the issuance of driving licenses. However, the suggestion concluded that the new rules should be flexible in ensuring that self-driving car technology made possible by disruptive innovation in technology is safe to avoid unintentional consequences as customers embrace the disruptive technology benefits (Stilgoe, 2018).

**Performance Guarantees For Cloud-Deployed Applications**

Gandhi et al. (2020) provided performance guarantees for cloud-deployed applications research; they argue that applications with a dynamic workload requirement

need access to a flexible infrastructure to meet implementation assurances and reduce resource expenses. It concluded that cloud computing provides the flexibility to size the Infrastructure on demand. However, cloud service providers (e.g., Microsoft Azure, IBM, Alibaba Cloud, Oracle Cloud, Amazon AWS Cloud, GCP) lack the influence and prominence of user-space applications, making it hard to correctly size the Infrastructure regardless of the organization's deployment model. This literature supports the study concerning IaC implementation in cloud computing platforms because cloud deployment for applications delivers repeatable development and operation processes.

**The Thematic Coding And Analysis**

In qualitative research, Golub et al. (2020) worked on health facility cleaners' extended role in maternity care in Kenya. They used a qualitative research method that in-depth, face-to-face interviews using a semi-structured guide. The authors interviewed fourteen participants working at three public health resources in Nairobi and Kiambu Counties, Kenya. Results were thematically coded and categorized using a thematic content analysis approach, which enhanced the study's reliability and validity. Therefore, this research used a qualitative research method; it followed the same approach that has enhanced study reliability and validity by conducting a semi-structured interview (Whelan et al., 2019).

This study's results had thematic codes and were categorized using thematic content analysis as part of the data analysis. Qualitative data gathering analysis for IT research can be very complicated without a thematic process (Henao & Marshall, 2019). This research is based on a thematic analysis of IT solution architects' responses to open-

ended semi-structured interview questions. As qualitative research becomes progressively more distinguished and valued, it must be handled thoroughly and meticulously to generate significant and valuable outcomes (Golub et al., 2020). For research to be acknowledged as dependable, qualitative investigators must prove that data analysis has been conducted in an exact, reliable, and comprehensive way through systematizing, recording, and revealing the approaches of analysis with sufficient elements or components to allow the reader to determine whether the procedure is credible (Whelan et al., 2019).

**Disruptive Innovation Dilemma On Incumbents**

Christensen (1997) stressed that the tempo of technological advancement exceeds organizations' requests for high-performance technologies (Christensen, 1997). Thus, incumbents can over-operate the market by delivering more feature-rich, advanced products and services that organizations require, thus allowing a gap at the market's base amongst organizations' desires and accomplishments. It provides a gap that opens a new process for an entrant (Muller, 2020), as depicted in Figure 1. In another dilemma, for organizations, there could be a strategically critical difference between different types of IT innovation and the business prototypes operated upon by the organizations—in this context, innovation can emerge in an industry, which could disrupt the way organization do business (Christensen, 1997).

Moreover, most of the innovations support innovations that positively advance services and products and the scopes of performance that mainstream consumers have been looking for and that the markets have historically valued and yearned to have

(Christensen, 1997). Such innovations enable incumbents to operate their IT platforms better and succeed with higher profitability and higher performance margins if they adopt IT innovation (Christensen et al., 2018). NCBI (2021a) emphasized that rejecting IT innovation is more than likely to put the incumbent off the market because sustainable IT innovation is imperative for organizational existence in the unstable IT market environment of the digital age.

**The Mandate To Innovate Devops In Cloud Computing**

Dalla Palma et al. (2020) emphasized that the development and operations (DevOps) procedure is the primary path to introducing technology innovations into organizations 'end-user systems. Dalla Palma et al. (2020) concluded that application managers are adopting modular contracting strategies in DevOps as a way to integrate in-house software development and DevOps efforts and participating in technology and innovation boards that propose the prospect of introducing technologies to satisfy requirements in their backlog or to offer new capabilities of which the customer was unaware potentially. Cloud computing models help development and operations succeed in IT (NIST, 2018).

DevOps is part of the practice in cloud computing that contributes immensely to application lifecycle management. The invention of cloud computing models such as hybrid, community cloud, private cloud, and public Cloud mandated a request to innovate DevOps 'automated practice in cloud computing (NIST, 2018). IT organizations capitalized on cloud computing technology and DevOps to develop multiple new

technologies that forever changed the IT industry's face with cloud computing-internet infrastructure (Greenstein, 2020).

**Infrastructure As Code Mapping Strategy**

Rahman et al. (2019a) worked on a systematic code mapping study of *infrastructure-a-code* research studies. They concluded that IaC is the procedure to automatically configure infrastructure resource dependencies and provides local and remote instances. The authors believed that IT practitioners consider IaC a fundamental pillar to implementing DevOps practices, helping them deliver software and services to end-users rapidly. Aluya (2018a) concluded that IT organizations, such as Netflix, Google, Github, Mozilla, and Facebook, have adopted IaC implementation strategies as disruptive innovations.

Sandobalín et al. (2020) worked on the effectiveness of tools to support Infrastructure as code mapping. Sandobalín et al. (2020) emphasized using infrastructure-as-code (IaC) in cloud computing as new disruptive technology innovation. Experts stressed that disruptive innovation is a methodology in information systems to develop products and services with improved capability contrary to the incumbent capabilities (Aluya, 2018b). Sandobalín et al. (2020) indicated that the IaC methodology supports the strategies of code-centric tools, which allows it to store the Infrastructure as versioned code – proving to be disruptive in contrast to the incumbent solutions.

**IaC Research Interests And Sustainability**

Sietz et al. (2019) worked on archetype analysis in sustainability research, a mixed-method study that evaluated sustainability research using archetype analysis.

Using qualitative and quantitative methods, the authors showed patterns of factors and processes that repetitively structure social-ecological systems patterns. There is no “one-size-fits-all” method to sustain research because it is new in a particular field (Rahman et al., 2019a). Using mixed methods (qualitative and quantitative), the author discussed the advantages and disadvantages of a range of archetype analysis methods in sustainability research along gradients that captured temporally dynamic, spatial variations, causality, and normativity variables, which were evaluated with obtained statistics concerning IaC investigations.

Rahman et al. (2019a) argued why IaC research should be sustained. Rahman et al. stressed that the search for IaC has been in trend for decades, long before Azure was invented. Aluya (2018a) concluded that innovation disrupting incumbent technology practices does not mean there are still no gaps in the IT industry’s research. Therefore this study is contributing to IaC research sustainability in the IT industry. Future research in IaC is likely to thrive in the mixed-method research method. According to Rahman et al. (2019a), mobile phone technology’s emergence ushered in searching for innovations once IT experts unveiled the mobile phone capabilities.

The research trend continued as the study conducted by Rahman and Williams (2019) was on source code properties of malfunctioning infrastructure as code texts. The study emphasized that part of Infrastructure’s significant benefits as code is that software could be deployed with an automated process, but any defect in infrastructure properties as code could hinder the infrastructure software delivery. (Rahman et al., 2019a).

**IaC As A Defense Supporting Instrument In The Cloud**

Cloud can build and implement preventive strategies to deny threats access to a critical system. For example, at a tent in the desert or on a ship at sea, warfighters could operate the local software and hardware using the cloud platform to access applications at the tactical edge, orchestrated with a more substantial cloud ashore (Li et al., 2019). With the integration of IaC as part of the Cloud's defense application, operators can be self-sustaining in the fight against threats (Rahman et al., 2019a). The IaC benefits in cloud computing extend the Navy cloud infrastructure's critical pieces to enable the Navy to employ higher-level artificial intelligence as a defense mechanism(Tu et al., 2018). It also helps the Military develop machine learning to expedite improved decision-making, operations, command, and control, at the tactical edge (Wang et al., 2020b).

It is imperative to emphasize that IaC in cloud computing can host next-generation technical resources such as augmented reality, artificial intelligence, internet-of-things, and human-machine defense teams (Li et al., 2019). By combining IaC and cloud computing with new warfighting defense procedures, operators may have decision advantages and generate operational effects at the tactical edge that are not achievable with incumbent IT infrastructure (Rahman et al., 2019a). IaC in cloud computing contributed to the emergence of artificial intelligence in cybercrime combat because the AI could be released as containers rapidly (Wang et al., 2020b). Liu et al. (2020) concluded that there might be no military cyber defense equipment if IT innovation is not supported by the information systems industry with cloud computing concepts. Torkura

et al. (2020) believed that most data breaches and cyber-attacks in cloud infrastructure are human manual errors that automated Infrastructure can prevent.

## Conceptual Framework: DIT

### Overview Of DIT

DIT was the adopted conceptual model for this research study, and Christensen developed the theory in 1997. Christensen (1997) concluded with the theory that organizations that adopt innovations are more than likely to succeed in meeting customers 'needs than those organizations rejecting new technologies. Disruptive innovation has gained popularity among its proponents in the IT industry, especially in Cloud computing-related innovation in IT infrastructure, software development, artificial intelligence, and medical technology, which showed during the world COVID-19 pandemic lockdown (NCBI, 2021b). Schön et al. (2020) concluded that every organization must be accommodating in today's world, with the rapidly transforming IT markets and disruptive technologies; thus, applying the DIT concept is essential.

Christensen et al. (2018) evaluated DIT as an integral component of intellectual history and directions for future research related to new technology as it traced the theory's evolution. He maintained that the DIT concept had earned considerable popularity among experts in technology innovation within the present century; thus, it needs to be cited frequently as part of the conceptual framework by researchers interested in innovation research. DIT emphasized that incumbents nearly always win, but disruptive innovations have been proven to sustain lead (Christensen, 1997). Wang et al. (2020a) emphasized that cloud computing as a disruptive technology development

platform is fetching more and more popularity for solving problems that need high concurrency and many resources; thus, some organizations are comfortable using cloud computing technologies, while some organizations resist and use incumbent technologies due to lack of strategies.

**DIT Evolution**

Understanding DIT's principles and concepts and disruptive technology based on Christensen's conceptualization can illustrate deliberate curves of technological options implementation and demanded implementation in several global market sectors. Initially, a new product based on disruptive technology underperforms the incumbent products in the mainstream market and is the most wanted by clients 'performance scopes (Li et al., 2019). Over time, the new technology disrupts the incumbent by using the data points where the incumbent solutions cannot satisfy customers 'needs (Christensen, 1997).

IaC emerged from DIT concepts in cloud computing. Disruptive technology innovation creates a shift in the organization's core business logic, and this shift would also present technology change resistance from the organization's business operation stakeholders (Aluya, 2018a). DIT, developed by Christensen in 1997, has achieved tremendous success in start-up organizations as the start-up organization leaders developed new Infrastructure to adjust to disruptive innovation to meet today's dynamic business technological expectations (Muller, 2020).

Unlike the established organizations 'implementation process, DIT has the characteristics to tear down the incumbent core business logic systems and Infrastructure to build a new one (Christensen et al., 2018). Therefore, in general, the start-up

organizations and established organizations that used the DIT concept were more successful than organizations that refused to acknowledge technology innovation as it evolved; subsequently, the evolution of DIT for decades, the trend has proven its benefits in technology innovation (Aluya, 2018a). Disruptive innovation is helpful in both the development of an IT innovation, in the use of the innovation within the organizations for business use cases, and the distribution of the new IT products market because it takes into consideration the data points where the incumbent solutions failed then improved it to create new options (NCBI, 2021b).

**Pros And Cons Of DIT**

Proponents of DIT argue that it helped shape technology's sustenance globally, assisting organizations in discovering a modern way to do business using technological innovations (Castillo-Vergara & García-Pérez-de-Lema, 2020). In the wake of cloud computing breaking into the IT market a few decades ago, DIT proponents applied the theory to benefit cloud computing arrival to develop long-anticipated technology products that can only be sustained with cloud computing models (Cuntz et al., 2020).

DIT proponents emphasized that disruptive technology only provided a slight effect to the low-end of the market; over time, but when its performance enhances to the point where it can meet the mainstream market's needs, disruption occurs in the entire market to the point where the technology innovation takes over the incumbent position (Aluya, 2018a). Proponents argued that this vibrant procedure and trajectory from the low-end market to the mainstream by innovations as market entrants create what is known as the "disruption" according to the original theory of disruptive innovation

(Castillo-Vergara & García-Pérez-de-Lema, 2020). Consequently, disruptive technologies trigger organizations that adopt the innovation to fulfill current customer needs in the competition market, which organizations that rejected the innovation failed to do with the incumbent solutions (Aluya, 2018b).

Schwalbe and Henrique (2018) concluded that DIT detractors argue that incumbent solutions are beneficial to the organizations because the organization's employees are already experts in using the incumbent solution. Nevertheless, incumbent proponents quickly realize that their products and service continue to be valuable for a few customers that rely on the old journey to keep their loyalty amidst the entrance of disruptive innovations into the competitive market. The incumbent critical sustenance in the competitive market is based on their belief in their former experience in producing and handling the products and services in the past; so for the ultimate survival, the incumbents believed that they could withstand the disruptive innovations in the competitive market by applying "economic theory" as an opposition or displacement resistance tool (Martínez-Vergara & Valls-Pasola, 2020).

However, the proponents of DIT disagree with the idea that those incumbent solutions are beneficial to the organizations because the principle could lead to the organization's end 'of existence in the competitive market as customers are constantly yearning to change and new approaches for products and services which drives innovations in the likes of information system industries (Aluya, 2018a). Nokia ceased to compete in the technology market because it refused to embrace DIT concepts in the wake of mobile phone innovation; Kodak lost its place in the camera market because it

failed to embrace its disruptive idea (Aluya, 2018b). Blockbuster lost its place in the market to Netflix because it stayed away from the disruptive innovation of streaming movies online with Cloud computing innovation (Li et al., 2019).

Detractors of DIT made a further argument by emphasizing that the DIT idea is questionable; the theory for disruptive innovation is always severely disapproved by business owners in the IT industry; most of them are proponents of incumbents and economic theory (Si & Hui Chen, 2020). The DIT oppositions often assess Christensen's research approach and hypothesis for DIT, and they always found both pragmatic measurement factors used for the theorem deficient but only from their point of view (Martínez-Vergara & Valls-Pasola, 2020). The critiques identified several symptoms of problems within DIT from their perspectives, citing that the innovation theorem hypothesized that incumbents are failures by default at the sight of innovation, and they stopped short of presenting the root cause of why the DIT hypothesis signified that incumbents are a failure at the sight of an entrant disruptive innovation in the competition. Sabourin (2020) concluded that the detractors often argue against DIT and states that it is not true that incumbents fail because they did not meet the standard delivered by the entrant innovation, and it is not true that some organizations are successful because they chose newer technologies.

Schwalbe and Henrique (2018) indicated that the detractors believed DIT overemphasized its effectiveness with the creative destruction idea's support. Schwalbe and Henrique argued that the incumbent failed because the success of the innovative products and company was possible only because they were not subject to similar

regulations as the incumbent. Thus, disruptive innovation entities, products, and organizations operate at significantly lower costs, attracting more customers and organizations and eliminating the incumbent from the competition. Sabourin (2020) emphasized that disruptive innovation and creative destruction alter the incumbent technology business competition model. So, detractors alleged that regulation of a perfect market or competition for a particular product and controlled competition regulation tends to delay the incumbent efficiency or even bring it to a standstill to make it look like it failed because of the entrance of disruptive innovation into the perfect market (Schwalbe & Henrique, 2018). Martínez-Vergara and Valls-Pasola (2020) concluded that DIT detractors are built on a specific belief inclined to "economic theory." The authors stressed that the theory states in parts that the market has a sequence of procedures that may alter profit; therefore, the detractors explore the implications of competition regulation, creative destruction, and the role of a business's model to justify the failure of the incumbent instead of attributing the failure trigger to disruptive innovation which credits DIT.

DIT has attracted the interest of researchers and practitioners across many areas, which includes detractors. However, innovation theory has developed new business models and strategies for organizations that adopted and applied them in the business process (Martínez-Vergara & Valls-Pasola, 2020). Despite the increasing scholarly attention to DIT in cloud computing studies, its definition has not yet been understood because there is still a severe misinterpretation and misappropriation of the concept and implication of disruptive innovation (Si & Hui Chen, 2020). The knowledge of the phrase

“disruptive” and the “complex nature of this innovation” has prompted some misinterpretations of DIT in the IT industry study, and the meaning remains vague to detractors that embraced “economic theory” instead (Martínez-Vergara & Valls-Pasola, 2020).

Contrary to DIT's hypothesis, Blume et al. (2020) concluded that DIT’s oppositions think incumbents can withstand disruptive innovation threats. Therefore, Blume et al. emphasized that detractors say that the shortening of product life cycles complemented by the swift development of disruptive innovations and disappearing industry boundaries is symptomatic of various possibly disruptive threats brought to the competition by the DIT concept. Muller (2020) argued that DIT needs a revamp because it was overemphasized. Muller stressed that detractors believed that incumbents ’survival depends on their competence to successfully antedate and manage threats presented by the disruptive innovation concept. Thus, the author emphasized that the detractors argue that the incumbents ’early anticipation of the disruptive threats presented by the disruptive innovations allows incumbents to prepare or react to their impacts; hence, the approach is crucial in stopping disruptive innovation threats. Blume et al. (2020) proposed the disruption evolution framework (DEF), which conceptualizes the pattern of disruptive innovation threats on the incumbents along with three phases (i.e., materialized, apparent, and threat possible) as well as differentiates four interconnected types of signals (i.e., company signals, catalyst, context, and capability) and threats (i.e., policy threats, competitor, customer, and product). DEF's objective was to help incumbent technology users oppose DIT concepts.

**Application Of DIT To IaC And Cloud Computing**

The DIT conceptual framework is compatible with all the cloud computing research studies. Because it is a conceptual framework whose objective is to get the business logic model right or to an improved state than the incumbent business logic, it always promotes improvements and enhancements from existing cloud computing conditions (Aluya, 2018a). It explores new ways of implementing a cloud computing solution from the outlying market perspective to the conventional market perspective (Aluya, 2018b). It is imperative to note that DIT concept implementation is a slow process that takes much time to build because it would have to deal with stakeholders ' resistance as part of the development life cycle(Christensen et al., 2018). DIT's main objective is to help organizations maximize business productivity by providing enhanced business logic models, especially cloud computing (Christensen, 1997).

DIT supports spawns and technology innovation development, enhancing business-critical systems performance (Christensen, 1997). Thus, DIT supports a qualitative case study because this research emphasis was to explore the implementation of IaC in Cloud computing within IT organizations (Aluya, 2018a). DIT's application in cloud computing technologies considers the incumbent technologies 'failing points (NCBI, 2021c). The trend of digital transformation has become prevalent in recent years because of the emergence of disruptive technology in the market (NCBI, 2021c). Yeganeh et al. (2019) suggested a cost optimization method for mobile cloud computing by capacity, which can be modified at the infrastructure level made possible by cloud-computing disruptive support nature.

The DIT conceptual framework also supports the development of cloud computing systems and newly evolving technologies. The DIT concept gave birth to cloud computing inventions like AWS, GCP, Microsoft Azure, and Netflix, early adopters of DIT concepts (Christensen et al., 2018). Cloud computing emerged as disruptive innovation; therefore, numerous IT business opportunities emerged from multiple organizations, including start-up organizations that used the DIT principle to disrupt the market (Aluya, 2018b).

Consequently, new cloud computing technologies were also referred to as disruptive innovation concepts because they altered organizations 'incumbent way of doing business, which helped them gain a competitive edge over their competitors (Christensen et al., 2018). IaC is a product of DIT in the IT industry today and is widely used by the tech giants such as FaceBook, Google, Amazon, Microsoft, IBM, et seq. These tech giants adopted IaC because of its cloud-agnostic nature, unlike the incumbent DevOps practice for infrastructure design, support, deployment, and management (Rahman et al., 2019a). IaC, as a core product of DIT, introduced automated deployment of infrastructure and versioning of the infrastructure using the code version control systems to create reusability, which is lacking in the incumbent practice. Organizations that capitalized on IaC added features to edge over their competitors in the market (Rahman & Williams, 2019). Part of the IaC features disrupting the incumbent practice is that after committing IaC code to the repository, like a regular code, the changes made to the code could be automatically checked with DevOps with continuous integration (CI) in line with the continuous delivery (CD) cycle (GSA, 2018).

Implicitly, disruptive innovation changes the way organizations operate a business in the market to stay ahead of their competitors because of its new implementation and use cases it brings with it (Aluya, 2018a). Netflix did not achieve a mainstream presence until after it disrupted its business operation, which was going from DVD mail-in service to online streaming – it was then that they toppled Blockbuster permanently in the market (Aluya, 2018b). However, organizations 'disruptive technologies threaten IT leaders because they find it challenging to incorporate new cloud computing technology as demand increases proportionately (Christensen et al., 2018). Therefore, IT leaders ' implementation of DIT concepts strategically changes the way organizations do business. For organizations to sustain constant technology changes, the technology implementation process requires constant enhancements to fit the organization's products and services in the market (Christensen et al., 2018).

**Supporting Conceptual Model**

The supporting theories in this research study that could have been used as the conceptual framework are decomposed theory of planned behavior (DTPB) developed by Taylor and Todd, the theory of task-technology fit (TTF), developed by Goodhue and Thompson, the technology acceptance model 2 (TAM2) developed by Venkatesh and Davis.

The Decomposed TPB comprises three main factors influencing intention and actual behavior adoption: perceived behavior control, subjective norms, and attitude (Alamri et al., 2020). De Jonge et al. (2020) concluded that Davis and Venkatesh explored the adoption of internet banking innovation utilizing the DTPB to believe that

the theory is mainly used for products and services already in the marketplace because it uses the view of society, which is the subjective norm to make an informed optimal on whether to use the existing or incumbent market product with a high level of comfort. Kwon and Silva (2020) believed that subjective norms could influence an individual's decision to adopt technology innovation because the influential factor is that the society or community must accept the change before adopting it. I did not use the DTPB model because its subjective norm element contradicts the adopted DIT objective.

Alamri et al. (2020) concluded that TTF is all about individual impact in technology adoption decisions with or without subjective norm influence. The individual impact is referred to the improved efficiency, effectiveness, and or higher quality of a decision made by an individual in technology adoption (Alamri et al., 2020). The model believed that the "good fit" between technology and task increases the probability of utilization and improves the performance effect since the technology innovation or technology meets the task needs and wants more directly. It is an appropriate model for investigating the definite convention of technology innovation, mainly testing innovation or new technology products to get customers 'feedback on their quality (Alamri et al., 2020). Provided that technology innovation is accepted as expected by DIT principles, another model can get customers 'feedback on the innovation (Christensen et al., 2018). I did not use TTF because it is meant for measuring the technology applications already released in the marketplace (e.g., Amazon Alexa, Google home) in contrast to DIT, which encourages the user to permanently adopt new technology that just arrived at the

market for the sole purpose of disrupting the incumbent solution that may not meet customers ’need.

De Jonge et al. (2020) emphasized that Davis and Venkatesh developed DTPB by perceiving TAM2 as a typical model for new technology acceptance based on the technology’s frequent utilization for both voluntary and mandatory platforms. Unlike TAM, the predecessor, TAM2 offered more detailed explanations for why users found a given methodology helpful (NCBI, 2018). TAM2 uses a three-point-in-time approach; the theory states that the reasons are: pre-implementation, one-month post-implementation, and three months post-implementation (NCBI, 2018). TAM2 hypothesizes that users ’mental evaluation of the balance between essential objectives at their job and the consequences of performing the job duties using the appropriate technology tool helps as a basis for creating insights regarding the usefulness of the technology they accepted to do the job tasks (De Jonge et al., 2020). While TAM2 performed well in both voluntary and mandatory platforms, I did not use the theory because it requires the users to be in either a voluntary or mandatory environment to make an acceptance decision concerning the technology they intend to use to do their job. It appeared conditional in contrast to DIT, which can be applied without conditions.

Diffusion of Innovation (DOI), developed by Rogers, is a theoretical framework compatible with DIT. U.S. Department of Agriculture first applied and used DOI. Later, it was used in the public health sector; DOI is also one of the original social science theories compatible with DIT, which achieved ground by propagating through a particular social system in business and technology (Rogers, 1962).

**Contrasting Conceptual Models**

In evaluating this study's conceptual framework, contrasting theories were identified. Theories contrasting the study's adopted conceptual framework were the theory of reasonable action (TRA) developed by Fishbein and Ajzen, the technology acceptance model (TAM) developed by Davis, Bogozzi, and Warshaw, and innovation diffusion theory (IDT), which is sometimes referred to as "diffusion of innovation" (DOI) theory developed by Rogers.

The definition of behavioral "intention" in TRA is the same as in TAM; however, TAM's difference contrasted to TRA excludes subjective norms (NCBI, 2018). TAM is an adjustment of TRA explicitly customized for modeling user acceptance of information systems (Jang et al., 2021). On one part of the objective, TAM is looking to clarify specific computing technology acceptance using a theoretical and parsimony justified model (Al-Maatouk et al., 2020); in another part of the theory's objective, it is looking to use the organizations 'behavioral intention to adopt an innovation, which the model believed may predict the actual benefits of the technology innovation in question. TAM is one of the applied theories in the IT-related research literature; it remained the most inexpensive model to apply in real-time use cases and research studies related to IT innovations. I did not use TAM because part of its objective is to use organizations ' behavioral intent to predict if a new technology is beneficial or not at that particular point in time. In contrast, my research study intends to encourage IT organizations to adopt new technologies, a DIT initiative.

DOI theory concentrates on implementing and creating change using new technologies or technology innovation (Al-Rahmi et al., 2019). What is significant is that I did not select DOI because I am not concentrating on IT professionals distributing cloud computing; instead, my focus is to explore the strategies used in implementing IaC as a disrupting technology innovation; therefore, my adoption of using DIT is appropriate for this study.

Meanwhile, the French sociologist Gabriel Tarde did the initial diffusion research over a hundred years ago when he plotted the initial S-shape diffusion curve of innovation. Today, the sociologist's S-shape curve is important because most technology innovations have an S-shape adoption rate from users 'viewpoint. In another view, Rogers 'theory reflects persistent concern in the topic and researchers 'general acceptance of the "S-curve" that illustrates the diffusion of innovations and researchers ' general acceptance of Rogers 'postulation of "adopter categories," for example, "innovators" vs. "slackers." DOI has often been used to explore the diffusion procedure, which comprises four phases: consequences, diffusion through the social system, invention, and time. The information emanates through innovation from technology products and services to agricultural practices (Al-Rahmi et al., 2019). I did not use TAM because part of its objective is to use organizations 'behavioral intent to predict if a new technology is beneficial or not at that particular point in time. In contrast, my research study intends to encourage IT organizations to adopt new technologies, a DIT initiative.

IDT or DOI is a specific interaction procedure where partakers generate and communicate information to achieve a mutual knowledge of using or implementing a process (Rogers, 1962). IDT or DOI is particularly applicable to incumbent principles but not limited to where organizations that rely on incumbent solutions to do business encourage their workforces to share a mutual knowledge of how to use and implement an existing process for a particular solution to not to adopt an innovation but to continue using what is at their disposal (Rogers, 1962). IDT or DOI in technology innovation is conveyed via a specific path over time amongst the supporters of a social system in technology; for this reason, IDT or DOI study has highlighted five(5) characteristics areas; (i) communication path used in the adoption process of innovation, (ii) innovation characteristics which influences the adoption decision, (iii) decision-making process that happens when organizations consider adopting an innovation, (iv) the consequences for organizations and society of adopting innovation, and (iv) organizations individualities that make them likely to adopt an innovation (NCBI, 2018). I did not choose IDT or DOI because it discourages organizations from adopting innovations contrasted to DIT objectives.

TRA is one of the most prevalent theories used in technical literature and is all about identifying one factor that determines the behavioral intention of an individual's approaches toward that behavior (Kwon & Silva, 2020). Compared to TAM's definition of knowledge "attitude," TRA defined knowledge "attitude" as the individual's assessment of an entity, and it defined "belief" as a connection between the entity and some intention, while it defined "behavior" because of intention attributes (Jang et al.,

2021). Opinions are sentimental and based upon a set of philosophies about the idea of behavior for individuals that thinks with specific patterns (e.g., we get the job done here with the manual process, if it is not broken, do not change it); these patterns of thinking influences decision to adopt an innovation (Jang et al., 2021). Another influence is the individual's "subjective norms" of what they observe in their immediate society's attitude. This particular behavior includes but is not limited to examples such as: "everyone owns a car, and it is a status to have one,"; which implies that the individual can only accept an innovation if others are using the same technology instead of the individual explicitly looking at the benefits of the innovation to his or her application in business or personal utilization purposes (Kwon & Silva, 2020). I did not choose to use TRA because of its subjective norm influential factor contrasting DIT, where the DIT supports the innovation's immediate adoption because of its benefits to society.

**DIT Similar Studies**

Several similar studies have been previously conducted in many areas using DIT concepts where the DIT concept was applied in various technological innovations to ascertain the benefits of DIT in technology innovation. This section reviewed similar studies as follows:

Kagumba and Wausi (2018) conducted a research study on organizational culture's influence on adopting information and communication technology (ICT) innovation following technological disruption using the DIT concept. Kagumba and Wausi (2018) emphasized that disruptive ICT technologies such as mobile computing and artificial intelligence alter how small and medium-sized enterprises (SMEs) discover,

connect, and communicate. Implementing such technological innovation rests on the advancement of employee values, expectations, and behavior to use disrupted technology to perform their company duties (Kagumba & Wausi, 2018). The authors concluded that the purpose of the research is to explore and recognize the influence of organizational culture on employee values and behaviors in adopting technologies produced by DIT concepts for ICT technologies. DIT disrupted ICT technologies such that the SMEs have new ways to do business, but the challenges are how to cope with the changes that come with it. In contrast, my research study explores DIT concepts, which are the strategies used by IT solution architects in implementing IaC in cloud computing.

Aluya (2018b), in the case study of Nokia Corporation, leading to Microsoft's acquisition, has a pro view. The study concluded that Nokia failed to use DIT concepts in cloud computing and emerging technology innovation in the IT market. Several companies have the intention to apply DIT concepts to improve and meet the market demand from customers (Rahman & Williams, 2019). Nokia deviated from such aspects, which led to the sustainability problem in the IT market. While the study explored why Nokia failed, which results from rejecting disruptive technology ideas, my case study objective is to explore the strategies used by solution architects to implement IaC in cloud computing and apply DIT principles that encourage users to adopt disruptive innovations.

Aluya (2018a) worked on a case study of Apple Corporation's use of large datasets using DIT to evaluate the study. The research study evaluated the history of dataset storage and emphasized that app corporations have used the DIT concept to develop big data solutions in cloud computing. As part of their strategy to acquire Nokia,

the author emphasized that Microsoft mapped the DIT concept against the mobile phone market's potential and business sectors' information systems. It provided the disruptive result directly proportional to the “technological” sector globally, proving that the disruptive innovation concept has the tiniest failure margin than any other innovation applicable theory. That was a “Go” approval for the merger and acquisition. Aluya (2018a) is inclined toward the DIT concept, as is my research study.

Hannibal and Knight (2018), through their case study of additive manufacturing (AM), concluded that AM is an emergent technology with disruptive innovation effects that is shifting the nature of production, sourcing, and other value-chain activities. The authors stressed that AM could significantly “disrupt” the structure and operations of international business for good because of its inclination to disruptive innovation that performs better than the incumbent solution within the international business sectors, including information systems and the manufacturing economic section. (Aluya, 2018a) stressed that the majority of large IT organizations in recent times had shifted their attention to the adoption of disruptive innovation concepts as Apple Inc. became one of the technology giants globally to embrace the ‘disruptive” technology impact of “big data” and “large datasets” in both the personal computer and smartphone innovations in the IT market. Hannibal and Knight’s (2018) study inclined toward the DIT concept, and my research study also inclines to the same concept.

Rahman et al. (2020b), in their study, emphasized that the “as code” postfix in IaC refers to applying “software engineering events,” such as version control, to maintain IaC scripts, which is one of the features that gave IaC its disruptive nature from DIT

concept as an emergent technology in cloud computing. The authors stressed that without applying these innovative features in IaC, defects that can have severe consequences might be created in IaC scripts, and with that, IaC may not be any different from the incumbent solution in the infrastructure design and implementation. The authors added that a systematic review of anti-patterns 'development for IaC scripts is one of the "disruptive innovation" concept engines which guides practitioners in identifying activities to avoid defects in IaC scripts. Rahman et al. (2020b) indicated that features gave IaC its disruptive nature. My research study explores the solution architects 'IaC implementation strategies as it is a new technology in the IT industry.

Tamburri et al. (2019) worked on IaC implementation strategies in their study. The authors concluded that IaC features extracted from the DIT concept equipped IaC with disruptive DevOps practices. The authors stressed that DevOps involves a set of practices that speed up the time required to roll out software product changes and that this capability possessed by IaC is disruptive in contrast to the incumbent solution that failed to achieve such fit using DevOps procedures. The study emphasized that one such DevOps practice is automating deployment and delivery with infrastructure as code (e.g., automated scripts that ideally carry out 1-click deployment). The incumbent failed in the IT industry, thus IaC's emergence as a disruptive innovation. The study suggested that the disruptive innovation concept is provided an effective solution through infrastructure as code in determining the modeling and information representation paradigm in the design, deployment, and support of infrastructure using DevOps practices. The authors added that the standard scripting language for infrastructure as code is adopted as an innovative

technology principle known as “intent modeling.” Tamburri et al. (2019) highlighted the innovative features DIT embedded in IaC; therefore, my research inclined in the same direction by applying DIT to the research study.

Qumer Gill et al. (2018), in their study, concluded that DevOps is complicated as used in the IT industry. Through the study, the authors indicated that IT organizations are uncertain how to successfully create a DevOps capability for the continuous delivery and continuous delivery of information management systems because of constant disruptive innovations evolving in the industry. The authors ’study compiled and analyzed DevOps by applying well-known innovations with DevOps strategies. Their study provided a knowledge base to support the informed, effective, and less risky adoption of DevOps practices for information management systems in integrating disruptive technologies propelled by DIT concepts, especially IT infrastructure management and support. My research study agreed with Qumer Gill et al. (2018) by applying the disruptive innovation concept and exploring the strategies used by solution architects in IaC implementation with DevOps procedures.

Rahman et al. (2019a) concluded that the adoption of new technologies has increased amongst practitioners, researchers, and organizations because of disruptive innovation, proving useful in several global industries. The authors also stated that part of their objective is to help practitioners and researchers identify research areas related to IaC by conducting a systematic mapping study of IaC-related research. Even though interest in disruptive technologies has been expanding progressively for over a decade in various industries, the current state of IaC research with DIT remains under-explored

with all its benefits in cloud computing and other economic sectors (Rahman & Williams, 2019). A review of existing literature in a specific research domain can help researchers get an overview of the particular domain and discover prospective of the focused technology and DIT research topics that could benefit from a further systematic investigation of the innovation (De Buitrago, 2019). One approach to reviewing existing DIT inclination to any potential innovation for a particular research domain is to perform a methodical mapping study of disruptive innovation directly proportional to its industry or business sector (Aluya, 2018a).

As Rahman et al. (2019a) stressed, interest in adopting new technologies has increased amongst practitioners and researchers. The statement justified my research interest where IaC emerged as new technology and disruptive innovation, commonly applied to cloud computing literature concerning new technologies. Therefore, I used DIT as a conceptual framework because it aligns with Rahman et al.'s (2019a) findings for IaC.

## Application to Specific IT Problem

### IaC Implementation Terraform Strategy

Terraform is an open-source software implementation strategy that gives solution architects and practitioners the ability to define and provision infrastructure using a "declarative" programming language as JavaScript Object Notation (JSON), which is a cloud-agnostic approach (Rahman & Williams, 2019). Converted monolithic applications to microservices are easy to manage and support the integration of IaC in the application structure because Terraform can help convert applications to adapt (Aksakalli et al.,

2021). Without Terraform in IaC as part of the infrastructure implementation, practitioners and organizations find it challenging to design microservices networks; in most parts, even when they manage to design the microservices, the application's network support becomes unsupportable with reduced quality of service, QoS (Ding et al., 2020). In essence, the use of Terraform in IaC implementation has become the engine for building microservices infrastructure in cloud computing. It can design any part of the microservices infrastructure network as a coding algorithm to provide the required optimization opportunity when needed (Gao et al., 2020). In the IT industry, IaC "declarative" coding syntax is used in Terraform strategy when converting monolithic applications to microservices IaC architecture; therefore, IaC declarative scripting strategy is also known as the functional strategy for IaC code architecture (Rahman et al., 2020b). In the "declarative" terraform coding syntax, the solution architects or the practitioners within the code architecture identify the required final state of the infrastructure they want to provision, then terraform handles the rest of the process at runtime of the provisioning (Rahman et al., 2020b).

The use of Terraform technology strategy in IaC architecture orchestration provides the opportunity to use HCL implementation strategy, which helps to reduce extended downtime in the disaster recovery process; that negatively affects organizations 'business productivity maximization when cloud computing infrastructure is in place, but IaC implementation strategies are missing (Rahman & Williams, 2019). Before IaC in the cloud, there was a massive gap in mitigating failed infrastructure in the IT industry; Terraform made it possible for organizations to rapidly mitigate

infrastructure disasters in the cloud (Bao et al., 2019). Monolithic applications pose many risks to organizations; with the emergence of IaC, organizations began to develop microservices in the cloud (Calderón-Gómez et al., 2020). Organizations have faced challenges while implementing microservices in an on-prem platform (Bass, 2018). As part of IaC innovation in the public cloud, the terraform opened the doors of opportunities for organizations to implement microservices with ease and minimal infrastructure code for reusability (Cerny et al., 2020).

**IaC Implementation Automation Strategy**

Kubernetes is one of the inevitable strategies in IaC implementation that can practically build and deploy applications seamlessly with Docker without paying attention to what programming language the IT practitioner used to build the microservices application backend (Han et al., 2020). With Kubernetes running as clusters, the deployment of the microservices Kubernetes could be overwhelming without IaC automation capabilities in the DevOps life-cycle (Jin et al., 2020). On the other hand, Kwon and Lee (2020) emphasized that microservices deployment may be more complex in cloud computing if Docker is not in the picture. Other inventions such as the internet-of-things, augmented virtual reality, and artificial intelligence have a significant dependency on IaC automation capability in cloud computing, and they run as microservices framework managed with DevOps automation procedure (Lin et al., 2019). IaC automation capabilities in cloud computing are not overemphasized or assumed (Rademacher & Wagner, 2020).

A Microservices framework could be defined as a small, individually versioned code delivered via IaC architecture, which is discoverable through service discovery mechanisms and can communicate with other services (Lyu et al., 2020). Since the services are independent, each is self-contained and executes a single business capability because of IaC architecture (Raji et al., 2020). As the technology evolved, the global technology market continued to search for a dependable microservice orchestration framework; IaC was able to deliver that dependable microservices structure the IT industry has been searching for several decades ago when the quest for plug-and-play IT architecture started for edge intelligent computing (Wen et al., 2020). IaC's “imperative” strategy is the opposite of the “declarative” strategy used in the implementation of microservices with IaC architecture (Rahman et al., 2020b). The imperative strategy is also known as the procedural strategy. The imperative strategy helps the practitioners and the solution architects organize automation scripts that provide the resource infrastructure as one step. Lescisin and Mahmoud (2021) emphasized that machine learning-based monitoring application development is manageable and repeatable through DevOps automation.

IaC's ability to provide automation in design, deployment and management created cost-effective edge intelligent computing in the IT industry (Zhao et al., 2020). For sustainability of efficiency, deployment, flexibility, and fast artificial intelligence (AI) services at the network edge as microservice; it is recommended to use IaC container innovation to manage pod resources in the system because of IaC automation capabilities so that the complex network edge applications could be managed effortlessly as the

requests and responses are received automatically (Lin et al., 2019). In China, disruptive technology adoption gave rise to robotics engineering to solve problems bigger than humans (Cheng et al., 2019). IaC is a disruptive technology that has come to stay in the IT industry to solve DevOps and IT architecture problems for IT organizations.

**IaC Implementation Idempotence Strategy**

Idempotence is a strategy in IaC implementation used by most solution architects and practitioners within the IT industry as part of DevOps procedures; therefore, defined as the strategy that a deployment command in the code is always set to the explicit target environment (e.g.,, development, user acceptance test, production) during DevOps release process (Rahman et al., 2019a). Idempotence strategy is also applied to self-service cybersecurity monitoring as an "enabler strategy" to introduce security practices in a DevOps environment; such that it is the same configuration that is versioned as code, regardless of the environment's starting state so that the environment can be replaced in terms of cyber-attack or compromise (López García et al. et al., 2020). IaC practice follows the DevOps code pull request principle in the IT industry for code integration proposals (Ortu et al., 2020). Thus, the idempotency strategy automatically configures an existing target or removes the existing target and reestablishes a new environment with a simple update command in the DevOps release pipeline. Consequently, with IaC, practitioners modify the environment description and version the configuration model as code, usually in well-documented declarative or imperative code formats such as JSON, HCL, or YAML programming language. The DevOps release pipeline executes the model to configure and deploy the target environments such as development, user

acceptance test, and production with the mirrored model. If the practitioner needs to modify any of the environments, they can edit the source code and redeploy the update, not the target environment (Rahman & Williams, 2019). IaC idempotence strategy allows DevOps practitioners to test applications in production environments at the beginning of the development cycle to eliminate drift or inconsistency. These practitioners expect to provision multiple test environments consistently and on-demand. Infrastructure or architecture exemplified as part of the code can also be validated and tested to avoid standard deployment or release issues; at the same time, the cloud computing platforms dynamically provision and tear down environments based on IaC declarative or imperative definitions in the code (Díaz et al., 2019).

**IaC Implementation Codifying Strategy**

Codifying in IaC implementation is how IaC scripts are stored in version control software alongside application products (Wang, 2018). An organization that embraces this strategy has its definite infrastructure files alongside its product application code and can quickly deploy both infrastructure and application in one release run. Going back to an old version for a preferred date and time stamp is no more challenging than finding the appropriate version control commit and rolling up a new deployment using the included configuration (Gil et al., 2020). Practitioners ’are confident that every technology product release works because they have been testing them along the way because of infrastructure codifying principles. The confidence saves practitioners time, which pays the practitioners back with better software delivered more quickly, unlike the incumbent infrastructure practice (Gil et al., 2020).

The critical part of the IaC codifying strategy is that practitioners check in those changes alongside the features they support and not separately (Wang, 2018). Part of codifying strategy in IaC implementation is that a feature's infrastructure requirements should be a part of a feature's merge or branch request. Practitioners often need to deploy code for testing or request business verification, so having infrastructure defined with the support code makes that easy (Rahman et al., 2020b). When practitioners or solution architects split feature code from infrastructure definitions, they are almost back to its incumbent implementation—codifying implementation strategy emphasizes how to implement IaC the right way and ensures that practitioners and solution architects define the infrastructure according to business needs (Rahman & Williams, 2019).

**IaC Implementation ARM Strategy**

Azure Resource Manager (ARM) is an IaC implementation strategy that allows practitioners to design, develop, deploy, and manage infrastructure for the Azure platform with a defined set of code algorithms stored on version control software (Wang, 2018). To implement IaC for Azure resources, practitioners use ARM templates as the scaffolding baseline. An ARM template is a JSON programming "pattern" that describes your project's infrastructure and configuration (Gil et al., 2020). The ARM template uses "declarative syntax," which lets solution architects and practitioners state what they intend to deploy without writing the sequence of programming instructions to create it (Gil et al., 2020). In the ARM template, the solution architects and practitioners specify the resources to deploy and the properties for those resources per target environment (Gil et al., 2020). The ARM template code can be modified; this modification capability

allows the practitioners to support the infrastructure effectively and on-demand (Wang, 2018).

The use of the ARM implementation strategy comes with the following benefits in terms of solving specific IT problems in IaC implementation:

*Orchestration:* Practitioners and solution architects do not have to worry about the complexities of ordering operations. ARM strategy orchestrates the deployment of interdependent cloud infrastructures such that it is created in a series (Wang, 2018). When feasible, ARM can deploy the infrastructures in parallel so that the IaC deployments finish faster than serial deployments. The practitioners deploy the infrastructure template through one declarative command rather than multiple imperative commands (Gil et al., 2020).

*Repeatable results:* ARM repeatedly deploys the infrastructure throughout the development lifecycle and is certain that the organizations 'infrastructures are deployed consistently (Wang, 2018). ARM Templates are "idempotent," which means practitioners can deploy the same infrastructure template numerous times and still get the same infrastructure types in the same state (Gil et al., 2020). Practitioners can develop one infrastructure ARM template representing the organization's business model's desired state rather than developing multiple discrete infrastructure ARM templates to represent the business model (Wang, 2018). It merely means that the solution architects can apply a patch to the ARM template to update existing and running infrastructure (Wang, 2018).

*Declarative syntax:* In the design and development of IaC scripting, the ARM templates allow the practitioners and solution architects to create and deploy an entire

Azure infrastructure in a declarative form within the code design configuration. It means that practitioners can deploy not only a particular resource but also the network infrastructure component of that resource (e.g., a virtual machine with a public IP address, a virtual machine with an application gateway, and a virtual machine with the virtual network) to create portability in supporting the IaC baseline (Wang, 2018).

**IaC Implementation Immutable and Mutable Strategies**

In terms of implementation strategy adoption, for solution architects and IT practitioners, the most critical decision in implementing IaC in cloud computing when "automating" infrastructure with IaC is selecting the strategy for mutable or immutable infrastructure (Wang, 2018). Mutable infrastructure can be amended or restructured after being provisioned initially, while Immutable infrastructure takes IaC to the next logical step, basically hardening infrastructure to ensure further the benefits it offers (Gil et al., 2020).

An immutable IaC implementation benefits because it provides additional consistency and reliability in the organization's infrastructure and additional conventional deployment DevOps procedures (Rahman et al., 2020b). Immutable strategy mitigates and completely avoids problems common in mutable infrastructures, such as "snowflake servers" and "configuration drift." Nonetheless, using an immutable IaC implementation strategy often involves comprehensive solutions for handling ephemeral deployment automation and fast server provisioning in a cloud computing environment (Wang, 2018).

**IaC Implementation TDD Strategy**

Test-driven development (TDD) as an IaC implementation strategy is when the infrastructure test codes are written before the actual infrastructure code. The infrastructure's functional code is written and continuously modified until the tests are passed (Siddiqui & Khan, 2019). It ensures the new infrastructure is relatively stable and encourages solution architects or practitioners to write the code needed; cleaner and test cases can also be automatically generated and used to help write infrastructure documentation (Li et al., 2018b). Practitioners or solution architects can write their testing framework with any programming language in the TDD implementation strategy but focus on testing the state or definition of infrastructure code algorithms (Siddiqui & Khan, 2019). So, in TDD, for unit or state (contract) testing, the tests involve verifying the code used in the design and development; hence in TDD strategy, infrastructure frameworks are required to have acceptance tests to ensure that the infrastructure resources are adequately created as expected by the business model (Yang et al., 2020).

IaC implementation TDD strategy involves using server testing tools (e.g., Goss and Inspec) to access high-level states' relationships and leading actions (Seok et al., 2020). Goss is an infrastructure-server spec option tool for validating a server’s configuration in cloud implementation; it eases writing manual tests by allowing the user to generate tests from the current system (Benkhelifa et al., 2019). Part of the utilization is that once the test collection is written, the tests can be waited-on, served as a health endpoint, o executed. InSpec supports all major operating systems (e.g., Linux and Windows) and is cloud-agnostic. So, it allows practitioners or solution architects the

liberty to run compliance and security tests on any cloud platform (e.g., Azure, AWS, Google Cloud, IBM cloud, or Alibaba cloud) because infrastructure development requires to concentrate on security features in a thorough approach (Siddiqui & Khan, 2019).

**IaC Implementation Cloud Strategy**

IaC implementation cloud strategy is a process by which practitioners deploy IaC using Terraform open-source software(OSS) to "any" cloud service provider platform such as Azure, AWS, Google Cloud, IBM Cloud, Alibaba cloud, and Digital Ocean without any restriction (Rahman et al., 2020b). IaC implementation strategies in cloud computing is a new technology innovation, which is also a new technique to deploy and manage infrastructure reference architectures in cloud computing by using versioned source code stored in the repository in automated processes, rather than using incumbent standard operating procedures and manual processes (Rahman & Williams, 2019). IaC implementation in the cloud evolved from DIT, which has disrupted the incumbent infrastructure implementation in the cloud (Rahman et al., 2019a).

IaC implementation cloud strategies 'objective is to introduce reusability and automation processes in IT infrastructure architecture to help IT organizations handle extended downtime during disaster recovery within any cloud model, including private cloud, public cloud, hybrid cloud, or community cloud (Rahman & Williams, 2019). To manage and have IaC rapid disaster recovery process during IT infrastructure failure, the IaC implementation cloud strategy concerning the versioned script must include innovative IaC programming language strategies. These programming languages enable strategies such as Topology, Orchestration Specification for Cloud Applications

(TOSCA), Hashicorp Language (HCL), and Azure Resource Manager (ARM)), which are the industry's best IaC orchestration strategies (Rahman et al., 2020b).

**IaC Implementation Ansible Strategy**

IaC implementation Ansible strategy is a process by which practitioners or solution architects deploy IaC using Ansible open-source software (OSS) to a "particular" cloud service provider platform that supports it (Sandobalín et al., 2020). Ansible is an OSS that is extensively used by practitioners or solution architects to define, design, modernize and provision the IaC resources in cloud computing platforms such as Azure, AWS, Google Cloud, IBM Cloud, Alibaba cloud, and Digital Ocean. Ansible strategy utilizes the infrastructure programming language, YAML, to define the algorithms needed to indicate infrastructure components in its playbook (Sandobalín et al., 2020). The significant difference between Ansible and other IaC open-source tools is that it strictly uses YAML programming language as its scripting and configuration; however, its adopted scripting pattern makes it a fluid IaC strategy in Amazon Web services (Rahman et al., 2020b); see Figure 2.

Ansible poses roles, which are a sequence of reusable responsibilities (Rahman et al., 2020b). In supplement, it holds a cluster, an online archive comprising upwards of 20000 functions, supported by third-party developers, which users can incorporate into their playbooks (Rahman et al., 2020b). Functions often make widespread use of variables so that their users can create the parameters for their performance. For instance, a task that installs a database driver has variables. Thus, the reusability of the Ansible IaC strategy is parametrized the code structure with the variables in such a way for users to

have the ability to specify particular configuration values for the driver, be able to modify the version of the installed resources (e.g., database software, virtual machine, and app services) alongside other capabilities (Sandobalín et al., 2020).

Rahman et al. (2020b) proposed that Ansible is compatible with Terraform such that both can be combined in one solution to create a strategy that can deploy any infrastructure successfully. The authors added that IT infrastructures in public, private, or hybrid cloud platforms could also be managed and supported by combining Ansible and Terraform, thus, enabling organizations to deploy, scale, and test microservices applications running IaC architecture at ease. The authors stressed that Ansible has an extremely simple setup process with a minimal learning curve, it can be used as a non-root in terms of access control, it helps the users to manage machines quickly and in parallel, can manage new remote machines instantly, without bootstrapping any software, it helps to avoid custom-agents and additional open ports, be agentless by leveraging the existing SSH daemon, described by the authors as the easiest IT infrastructure automation tool to use, its utilization focuses on infrastructure security, review, suitability, review, and rewriting of infrastructure algorithm. Ansible is easy to integrate into any cloud platform but primarily delivered by Redhat/IBM.

**Figure 2**

*Ansible Requirements for IaC in AWS*

| No. | Requirement |
|---|---|
| R1 | The infrastructure should be deployed in a specific region of Amazon Web Services. |
| R2 | A security group should enable TCP incoming connections to virtual machines through three specific ports. Moreover, the security group should enable all outgoing connections from virtual machines. |
| R3 | A security group should enable TCP incoming connections to a load balancer through port 80. Moreover, the security group should enable all outgoing connections from the load balancer. |
| R4 | A set of virtual machines should be launched in a specific availability zone in a selected region of Amazon Web Services. Each virtual machine should have an explicit virtual CPU and RAM. Moreover, each virtual machine should have a specific operating system and web server installed. |
| R5 | A load balancer should distribute the workload among virtual machines. The load balancer should respond to client requests and validate that all virtual machines connected are available. Moreover, the load balancer should work in a specific availability zone in a selected region of Amazon Web Services. |
| R6 | The load balancer uses a health check element to validate the state of virtual machines connected through check intervals using the TCP protocol and a specific port number. It is necessary to wait for a particular time (in seconds) to notify an error check. The load balancer should receive a precise amount of consecutive errors in order to change a virtual machine to an "unhealthy" state, whereas it should receive a specific number of state verification probe successes in order to change a virtual machine to a "healthy" state. |
| R7 | The load balancer uses a listener element to respond to client requests through the use of the TCP protocol and the port 80, in addition to distributing all workloads to virtual machines by means of a specific port. |
| R8 | Virtual machines should be registered to the load balancer, in such a way that the load balancer can distribute the workload among all available virtual machines. |

*Note.* Adapted from "On the Effectiveness of Tools to Support Infrastructure as Code: Model-Driven Versus Code-Centric," by J. Sandobalín et al., 2020, *IEEE Access, 8,* 17734–17761. Copyright by Creative Commons License and adapted with permission granted (see Appendix C).

## Transition and Summary

Section 1 was the foundation of the study, which covered the abstract, the background of the study, problem statement, purpose statement, nature of the study, research question, interview question, conceptual framework, operational definitions, assumptions, limitations, and delimitations, the significance of the study, review of professional and academic literature. Section 1 provided the necessary background of the study using all these subsections listed above. Those subsections provided the research study's objective and focus concerning IaC strategies and benefits in cloud computing.

Section 2 is the project information and procedures of the research study. It covered the restatement of the purpose statement, the role of the researcher, participants, further discussion of research method, further discussion of research design, population and sampling, ethical research, data collection instruments, data collection technique, data organization technique, data analysis, and reliability and validity.

Section 3 is the research study application for professional practice and implications for social change. It also covered the study's purpose, presentation of findings, application to professional practice, implications for social change, recommendations for action, recommendations for further research, reflections, and conclusion.

Section 2: The Project

## Purpose Statement

This pragmatic qualitative inquiry study aimed to explore strategies used by solution architects to implement IaC architecture solutions using DevOps procedures in cloud computing. This exploration's targeted population was solution architects in the IT industry within the United States who have successfully implemented IaC within the past 3 years in cloud computing with DevOps procedures. The research's implementation approaches may help reveal the strategies used in implementing IaC in cloud computing. Thus, the implementation strategies may help host and develop social media applications and other public applications cost-effective for application developers and help NASA's exploration mission to the international space station. Therefore, it may contribute to positive social change by making the public offering of these social media applications and other public applications (e.g., mobile applications, Web applications) to end-users stay affordable or free to use and support innovation in IT.

## Role of the Researcher

I was the primary data collection instrument for this qualitative research study. In qualitative research, the researcher is engaged in all study phases, from characterizing an idea to the configuration, interviewing research participants, interpreting results, confirming findings, and coding concepts and themes. According to the National Center for Biotechnology Information (NCBI), the researcher is central to the instrumentation process used in qualitative research (NCBI, 2019). I created the interview questions and

the IP guide and chose the research participants. As the vital instrument for data collection, I collected data personally from the research participants.

Regarding the researcher's relationship with the research topic, the IaC strategies, and benefits in cloud computing, I have 15+ years of experience working in the IT industry, and I have developed IaC in cloud computing using DevOps procedures within the last 5 years. The participants were solution architects working for IT organizations in the United States, and the criteria for selecting the interview participants was that they must have implemented IaC in cloud computing within the last 3 years using DevOps procedures. Pessoa et al. (2019) concluded that interviews are helpful if a research technique employed in the study design explores how participants understand specific issues according to their ideas and their own words and experiences related directly to the research topic. I did not have a relationship with any of the participants.

In terms of ethics protocols in the research study, as research that involved human subjects, I needed to obtain assent from each participant because it was essential to ensure that each participant was respected and protected from harm resulting from their participation. Wöhrer et al. (2020) emphasized that researchers should follow specific methods when working with participants to obtain assent because assent involves comprehensive information regarding nature, the purpose of the study, and how the information is used and stored to have sufficient information to decide on their participation (Wöhrer et al., 2020).

Because I was working with IT organizations as a case, part of the research's ethics protocol was to ensure voluntary assent throughout the interview process, establish

rapport with interviewees, and provide a comfortable interview environment. Dow and Boylan (2020) concluded that the information presented to participants must be clear and understandable and focused only on the research question and research topic. Wang and Hannes (2020) emphasized that the researcher must ensure the comprehension of this information presented to make an informed choice by the participants, and by following these procedures, researchers can make the participants comfortable while reducing the risk of harm to them in the study.

For the researcher to mitigate personal bias, Burles and Bally (2018) accentuated the importance of research ethics because personal abilities are also likely to be concentrated on issues that individuals believe are important, thereby creating personal bias. I adhered to Walden University's institutional review board (IRB) policies to meet ethical standards. Burles and Bally also elaborated that bias can be reduced to demonstrate the study's reliability through a set and repeatable procedures.

The IP included interview questions and participants 'readiness inspection. I conducted the interviews using predefined open-ended, semistructured questions. This approach allowed me to delve deeper into information as the research participants responded, and I managed the interview guidelines by ensuring that unforeseen issues such as room temperature control, low lighting, and noise distractions did not occur. Mueller (2019) concluded that providing details about organizing and conducting semistructured interviews with open-ended questions as part of the IP is required in any qualitative research study.

I used semistructured interviews, a focus group, and industry document analysis as part of my data collection because of thematic data analysis in my study. However, I did not conduct the focus group until I reached data saturation with at least four interviewees. Semistructured interviews were the primary collection instrument in my study. Semistructured interviews allow the participant(s) to express how they see the situation while allowing a researcher to seek clarification when needed (Jenner, 2018). Kerins et al. (2019a) emphasized that pragmatic qualitative inquiry is more efficient when researchers use semistructured interviews for individual participants and focus group participants in data collection. Bergen (2018) supported using focus groups because it promotes data saturation. Mackieson et al. (2019) emphasized that document analysis is knowledge-based regarding the applied thematic analysis for data extraction. It demonstrates how step-by-step implementation of a purposeful methodology using reliable documentary data can effectively increase rigor and transparency, reducing potential bias in qualitative analysis. Mackieson et al. demonstrated the effectiveness of document analysis in a qualitative study by clarifying key terms that eliminated the challenges of analyzing textual data to consider the value of textual document data as a reliable data source; by applying thematic analysis, they produced reliable value in strengthening qualitative research using document analysis.

## Participants

For this pragmatic qualitative inquiry study, part of the criteria for eligible participants is that an IT industry must have employed them. In this study, each participant was located in the United States. The solution architect had implemented IaC

architecture solutions using DevOps procedures in cloud computing within the last 3 years using the best practices of the IT industry. Also, each participant must have been at least 21 years of age at the interview time. Young et al. (2020) concluded that eligible participants 'criteria for a qualitative study verify that they have direct knowledge of the study topic and objectives, generating rich and reliable data via their respective interview responses. Abbott et al. (2018) concluded that reliable qualitative data could be collected through semistructured interviews with open-ended questions if the researcher selects participants who met the study's eligible criteria.

Because I used a qualitative pragmatic research design, part of the strategy to gain access to the participants was by performing a web search; through the web search results, I identified participants in the IT industry in the United States who used IaC solutions and DevOps standard procedures to deliver IT services. Within this IT industry, by performing a comprehensive web search on the IT industry, I identified solution architects who had experience implementing IaC with DevOps procedures in cloud computing. Once I identified the solution architects who met the study's eligibility criteria within the IT industry, I looked up their email addresses to communicate with them. After I had their names and email addresses, I emailed them a letter of invitation; one letter was for those participants I interviewed individually, and there was a different one for those solution architects who participated in the focus group as there were different time commitments and differing levels of confidentiality for each sample. Therefore, I had two different consent forms because of the two samples (the individuals and focus group). The invitation letter asked the participants to reply, "I consent." After

they consented to participate in the study, I asked them for available times. Kerins et al. (2019a) emphasized that pragmatic qualitative inquiry is more effective when researchers select participants from a particular industry to explore real-world problems and practical solutions. Timonen et al. (2018) concluded that pragmatic qualitative inquiry participants must have expert knowledge of the research topic to offer practical solutions to the industry's problem during a focus group discussion.

After obtaining the participants 'consent to participate in the study, I devoted quality time to building a working relationship with participants and answering any questions before the interview sessions. Visser et al. (2019) concluded that gaining access to participants is one of the first ethical challenges to meet because establishing a relationship based on trust is indispensable. Kaźmierska (2018) suggested that researchers devote quality time to building a working relationship with the selected participants after signing the consent form and providing the availabilities once participants' trust has been gained. Dow and Boylan (2020) emphasized that by default, participants are concerned that the research might harm them or jeopardize their job; therefore, the researcher must provide the participants 'details showing that the study is harmless, including informing the participants that the study has entity approval to be conducted.

Part of the strategies I used to establish a working relationship with participants was by being open and honest with them and appearing as credible and trustworthy as possible. Oscar et al. (2018) emphasized that once the trust of participants has been gained, researchers need to devote quality time to build a rapport with the selected

participants by the researcher being open and honest with participants about the purpose and expectations of their study as well as by choosing the words they use with great care and trying to appear as credible and trustworthy as they can be. Atakav et al. (2020) concluded that establishing working relationships with the participants or population in a qualitative research study or a mixed-method study is very important because it contributes immensely to the production of reliable data freely.

## Research Method and Design

### Research Method

I used the qualitative research method for this research study because of the anticipation of exploration patterns in the research; the qualitative research method allows the researcher to explore strategies and approaches used by experts for a particular phenomenon (Côté-Boileau et al., 2020). Santana-Cordero and Szabó (2019) also emphasized that when working with research that requires investigation of a particular phenomenon, the researcher must incorporate an exploration of document analysis and semistructured interviews to utilize qualitative research exploratory and explanatory opportunities.

I used the qualitative research method because I explored strategies used by solution architects to implement IaC using DevOps procedures in cloud computing. The qualitative research method allowed me to apply document analysis and semi-structured interviews in the exploration to answer the study's research question to improve the research validity and reliability. Rashid et al. (2019) concluded that qualitative research methodology enables researchers to explore sophisticated phenomena in-depth within a

specific framework for more than a single case. Janis et al. (2020) emphasized that the qualitative study is used to enrich the study's competency, validity, and dependability within each condition and across different circumstances and understand the similarities and differences between cases to improve the study's reliability. Kerins et al. (2019a) emphasized that qualitative studies help the researcher draw on multiple viewpoints and sources of evidence, such as observations followed by interviews, focus groups, and document analysis to allow for a comprehensive depth and breadth inquiry.

In contrast, quantitative research was not appropriate for my research study because I did not collect numerical or statistical data. Quantitative research is statistical because it uses numbers to determine a research study (Côté-Boileau et al., 2020). Quantitative research was unsuitable for this study because it deals with figures and is statistical. The National Institutes of Health (NIH) confirmed that quantitative research uses independent and dependent variables to generalize relationships and verify research problem statements and questions (NIH, 2018). This study's data collection was based on the participant's responses to the semistructured interview questions and organizational documents that were not statistical. Qualitative research uses verbal responses transcribed from audio-recorded interviews, written notes by the researcher, and nonverbal cues to explore phenomena during the interview. Therefore, a quantitative research method would not have provided an in-depth description of my problem statement because I did not use a hypothesis in this research study.

In further contrast, a mixed-method for this study was not appropriate either. According to the U.S. NIH Office of Behavioral and Social Sciences (2018), a mixed-

method is a research study consisting of qualitative and quantitative research methods that can be time-consuming. The mixed-method was unsuitable for this study because it combines qualitative and quantitative methods; thus, it would have been time-consuming to use both in my research study. In using mixed-methods comprising qualitative and quantitative methods, the researcher must know multiple methods, including these two, which allows the researcher to use both methods 'strengths and minimize the weaknesses, enabling the researcher to use mixed-method quantitative results to support the qualitative findings in one part and quantitative findings in the other (Champagne-Poirier et al., 2021). Because this study relied on an in-depth exploration of the problem statement, quantitative data were not suitable, and mixed methods did not apply to this study.

**Research Design**

I used a pragmatic qualitative inquiry design to concentrate on eccentric decision-makers in real-world industry situations. The process of using a pragmatic qualitative inquiry design in a qualitative study is to have the ability to identify a problem and view it within its most extensive environment (Kerins et al., 2019a). This pragmatic design approach can lead to individual decision makers 'research inquiry, which pursues answering the research question to solve the identified problem or offer a potential solution. A pragmatic research design was appropriate for this study. Therefore, I sought to identify the strategies most expert solution architects use in implementing IaC using DevOps procedures in cloud computing. This study concentrated on the IT industry, and the solution architects in the industry who met the eligibility criteria were considered

potential participants. This research design approach helped answer the study's research question and improve its validity, dependability, and reliability. Timonen et al. (2018) emphasized that pragmatic research allocates an opportunity for more in-depth knowledge of the explored strategies by viewing it via the colloquial sense of the ecosystem presented through interview responses by expert decision-makers ecosystem where the problem emanated. Kerins et al. (2019a) concluded that the pragmatic approach takes the same direction other designs take in the qualitative method. The authors added that the difference is that pragmatic has the potential to return a real-world situation problem-solving result; because it focuses on a more extensive view of the problem by taking on the entire industry instead of selecting multiple cases, the authors stressed that it is best adapted to based on the objective of the research question and the study in general.

The ethnographic design is based on the researcher's understanding of the social and cultural perspectives of the small scale of people (Ebneyamini & Sadeghi Moghadam, 2018). The ethnographic design is not suitable for my study because it focuses on understanding small-scale people's social and cultural perspectives. The ethnographic design is also time-consuming because the researcher must spend considerable time understanding the small-scale people's language and unfamiliar culture (Ravindran et al., 2020). My study did not require an in-depth understanding of solution architects 'culture or social habits regarding implementing IaC architecture using DevOps procedures in cloud computing. In the ethnography design approach, the researcher lives in the participant's social world. I did not necessarily live in the solution architects '

environments to understand their social and cultural perspectives as ethnography design requires (Ebneyamini & Sadeghi Moghadam, 2018). My study focused on exploring strategies used by solution architects to implement IaC architecture using DevOps procedures in cloud computing. Ethnography includes living in the participant's natural environment and experiencing their daily lives (Côté-Boileau et al., 2020). While living in the participant's environment includes long-term dedication and engagement in their culture, ethnography was not viable for my research study because I explored the strategies used by solution architects to implement IaC architecture using DevOps procedures cloud computing.

The phenomenological design approach focuses on a particular group of people (Mohajan, 2018). The researcher needs to understand the participants 'experiences and perceptions of phenomenological design (Ebneyamini & Sadeghi Moghadam, 2018). My study was not about one or more solution architects 'lived experiences, but it is about the strategies used by solution architects to implement IaC architecture using DevOps procedures in cloud computing. The researcher in phenomenological design attempts to comprehend a specific population's perception of phenomena through their understanding (Frechette et al., 2020). In my research study, I did not attempt to understand solution architects 'behavior when implementing IaC. Instead, my study explored solution architects' strategies to implement IaC architecture using DevOps procedures in cloud computing.

While multiple cases adhere to almost all the protocols the rest of the designs are subjected to, it is considered appropriate in a research study if the researcher intends to

use a gatekeeper to access the participants and the organizations ’documents. It is also appropriate if the researcher intends to recruit several participants from several organizations regardless of industry, such as collecting multiple cases from multiple organizations. This study did not collect data from multiple organizations; instead, it collected data from multiple technology industry-based participants and global IT industry documents. Kerins et al. (2019b) postulated that a multiple case study is appropriate for a research study if the gatekeeper is accessible and there is established access to the participants through an effective gatekeeper. The authors also emphasized that approval must be granted to the researcher before any organizational document accessibility can be utilized in multiple case studies.

To ensure data saturation in the study, I interviewed at least four individual participants and three focus group participants from the IT industry to get data saturation in the semi-structured interviews; thus, data saturation was not attained if any participant revealed new information in that case, I continued with more interviews until no more new information was discovered. Also, I achieved data saturation by conducting semi-structured interviews with solution architects in the IT industry who were participants until no new information was available. The participants met the research’s eligibility criteria to ensure comprehensive, quality data generated from the interview. To pursue data saturation, part of my strategy was to ask the research participants identical semi-structured interview questions in chronological order without skipping questions or going out of order. I reviewed data from my diary and field notes to identify concerns raised during the interview. Data saturation is pivotal in the qualitative research method because

it ensures that no new information is valuable to the study of the generated new themes or codes skipped in the data collection (Eakin & Gladstone, 2020). Data saturation is paramount in qualitative research to ensure that no data critical to the research question answers were left out because data saturation is the point at which no new data is found during the data collection process, and the collection of further data is not necessary at this point (Mavhandu-Mudzusi, 2018).

## Population and Sampling

In this study, the population was IT solution architects in the IT industry who have successfully implemented IaC using DevOps procedures in cloud computing. To identify these strategies in the IT industry, the study's focus for the sample in the population was all the solution architects in the IT industry who have implemented IaC using DevOps procedures in cloud computing within the United States at least 21 years old. Tuthill et al. (2020) emphasized that participants in a selected population of qualitative research studies are selected based on their shared experience and expertise in the phenomenon of interest that answers the research question. In qualitative research, Cook and Bergeron (2019) concluded that strategies are needed to better engage hard-to-reach populations in research for data collection, especially populations with the knowledge of the research topic, which is an attempt to generate rich and thick data for data reliability and dependability in the study.

I used purposive sampling in this qualitative research study. Using purposive sampling provides convenience and focuses on the IT industry's features that had strategies in implementing IaC using DevOps procedures in cloud computing, which

helped answer the study's research question to accomplish its purpose. The study's sample size formula was to individually interview at least four solution architects and interview another three participants who are also solution architects as a focus group in the IT industry to produce a sample size of at least seven. McCrae and Purssell (2018) purported that purposive sampling is a non-random sampling technique used to select a sample of participants from a specified discipline, such that the selected sample has the features that met the research purpose. Purposive sampling is used to select the research participants because it is a popular approach used in qualitative research to select an explicit group of people based on their knowledge or skill regarding a specific research topic capable of delivering the research purpose or objective (Walsh et al., 2020).

In terms of justifying the participant's selection, there were two sample sizes of at least seven total; sample 1 includes four individuals who participated in interviews, and sample 2 includes three focus group participants. It ensured data saturation at the point of data collection elastic scope to guarantee that no new information was available. Therefore, data collected from the individual interviews conducted among the first three participants were compared to the data generated from the other three participants interviewed as a focus group. The participating sample was asked the same semi-structured questions repeatedly because there was a tendency that no new information would be available at some point of the data collection from the sample size, thereby achieving data saturation. Glenton and Carlsen (2019) emphasized that sample size is determined based on the principles of data saturation in research, where the principle suggest that, with as few as four as the sample size, there was a tendency that no

additional information would be found if the same question is repeated among the sample size in search of answers to the research question. Walsh et al. (2020) believe that obtaining a sample size in a qualitative study allows the researcher to use interviews to collect data. Abram et al. (2020) postulated that qualitative research methods generate prospects for qualitative researchers to drive beyond the specific researcher method, where the person recruits, transcribes, interviews, and analyzes a small research sample size to attain data saturation.

The participants were selected through expert sampling via the research eligibility criteria for this study to be part of the sample size, indicating that they know and experienced the strategies used in implementing IaC with DevOps procedures in cloud computing. Etz et al.(2019) concluded that using expert sampling helps the researcher focus on the experts who know the research topic, which improves data triangulation. Beresford et al. (2020) emphasized that expert sampling helps qualitative research data collection generate reliable data because the participants in the interviews are experts in the research topic.

The interview setting was a recorded audio-video conference powered by Microsoft Teams due to social distancing pandemic state laws at the time; so that participants could freely accept or make an alternative suggestions. This interview setting decision is imperative because interviewing the participants in a setting of their choice helped make them comfortable sharing their insights freely, enhancing privacy, and creating a positive relationship between them and me. Islam et al. (2021) supported the notion that an interview setting is potent in a qualitative study using semi-structured

interviews because it provides a comprehensive understanding of the research topics. Mavhandu-Mudzusi (2018) recommended that it is essential to add to the IP a step to ask for consent to audio-record the interview and write field notes to capture remarks that may not be captured in the audio recordings, such as the interview setting and non-verbal gestures.

I ensured data saturation by continuously comparing or contrasting data from the individual interviews, focus group, and document analysis until no new data was available, revealing that further data collection from the population or document was no longer necessary. Also, I used the same IPs for all the individual participants interviewed (see Appendix G for IPs) to ensure that the same pattern for data generation is used, thereby setting up data saturation possibilities. On the other hand, the focus group protocols were slightly different, which was that it would have the same interview questions, but the questions would not be directed to a particular participant in the first half of the session; which means that it would be more of open-floor discussions where group participant with the knowledge would answer the question. In the middle of the focus group session, the protocol pattern was switched to direct questions to each group member. Maher et al. (2018) emphasized that the IP, review of interview questions, and cues address the notion of data saturation in qualitative research data collection to ensure precision in data analysis. The authors stressed that data saturation had achieved pervasive recognition as a practical principle in qualitative research; thus, it is a data collection point where no new data is available after the same IPs have repeatedly been used on the sample size to generate data.  Xu and Zammit(2020) concluded that data

saturation is an elastic concept in a qualitative research study. The authors stressed that the same data would start returning to the collection during data collection because no new data would be available, and further data collection or analysis would be unnecessary. The authors also added that data saturation is generally taken to reveal that, based on the data that have been collected from the sample size or analyzed from any organizational document previously, further data collection and or analysis are unnecessary at the point of saturation provided that the same data collection protocols are used.

## Ethical Research

The participants were given the ability to withdraw from the study by choice, and the researcher gave the participants the guarantee to adhere to the ethical conduct of a research study that involves human subjects. The conduct includes respecting the participants ’decisions at any study stage. So, had the participants choose not to participate in the study after accepting to, and or if they opted out not to participate in the research study while data collection was in progress, the data would have been deleted from records. In addition to that step, the participant would have been informed of the action as part of the ethical provisions of the research study as recommended by Walden University institutional review board's ethics rules (IRB). Careful thoughts of upholding ethical standards must be in place when choosing research participants for a research study, and the ethical consideration must include the researcher respecting the decision of any participant to withdraw from the study (Held, 2020). According to Love et al. (2019), assent must be obtained from all participants who consented to participate in the research

study voluntarily; thus, the assent allows participants the right to retract or stop the audio recording during any session of the interview if they do not feel comfortable, without retaliation.

I let the participants know that I completed a CITI doctoral research course. It built trust and assured them that ethical principles would be followed during the research study (my CITI certificate is in Appendix D). As part of the ethical protection standard in line with the IRB policies, the participants were allowed to opt-out of the study if they desired with no questions asked. Therefore, my contact information, including e-mail and telephone number, was provided to the participants if they chose to withdraw from the research study whenever they wanted to. Dimla et al. (2020) asserted that full disclosure and voluntary participation are pivotal in the ethical protection of participants for any study that involves human subjects. Garcia-Quiroga and Agoglia (2020) concluded that researchers' and participants ’ethical challenges in qualitative research include a lack of research training experiences; thus, researchers involving human subjects should be incredibly attentive to the ethical protection elements. Researchers should be ethically, methodologically, politically sensitive, and coherent regarding the participants. Stahlke (2018) emphasized that although qualitative research ethics have typically focused on participant ethical protection risk, there is an increasing acknowledgment that researchers themselves face ethical protection risks, including the emotional impacts of research on sensitive topics.

I adhered to the IRB research ethics in a research study that involved human subjects. The research ethics requires three basic ethical principles, which are (a)

beneficence, (b) respect for individuals, and (c) justice (NCBI, 2020); thus, I used the semi-structured IPs that followed ethical research standards (IP document is in Appendix G) and assent procedure. McCracken (2020) concluded that researchers must respect people's rights rather than present a show of "good faith" in any research study involving human subjects as participants. Dow and Boylan (2020) emphasized that the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research wrote a report in support of the Belmont report in which the commission enforced specified policies and guidelines to protect vulnerable populations in a research study which includes mandating IRBs to authorize, oversee, and evaluate the research to protect subjects involved in the research process.

To safely maintain the participants 'data, all participants 'information was stored in a USB drive with a safe storage password and placed in a personal library secure box safeguarded with a lock and key code. The information to store includes the interview responses, the participant letter of invitation (see Appendix E), and the business invitation letter (see Appendix F). Therefore, I maintained the data safely for five years to safeguard the participant's confidentiality by leaving it in the personal library secure box. At the expiration of the five-year storage period, the data stored in the USB drive, electronic documents, and any paper document collected without recovery are destroyed. Cantero-Garlito et al. (2020) emphasized that it is essential to safeguard with secure data storage the participants 'confidentiality and protect participants 'responses. Chauvette et al. (2019) assured confidentiality and anonymity while conducting a research study. The

participants ’confidentiality is protected by assigning each organization a unique identification number, and all the data stored has password protection.

There was a $25 VISA gift card incentive for participants in this study; the gift card was mailed to each participant at the end of their interview session. The approach is essential in this study, especially in this COVID-19 pandemic era. There was a scarcity of IT industry participants due to IT practitioners ’potential unavailability because most of them were busy supporting IT systems for work-from-home platforms in their respective organizations. This sudden engagement can cause a scarcity of participants in the IT industry, but with the study offering $25 VISA gift card incentives to participants, some potential participants voluntarily participated. Incentives make participants feel appreciated (Hege et al., 2018). Mahali and Swartz (2018) supported motivational strategies to incentivize research participants to participate in a research study voluntarily. Garcia-Quiroga and Agoglia (2020) concluded that participation incentives could be given as gift cards to appreciate the participants' time and effort volunteered from their respective tight schedules because “people” are enthusiastic about participating in future similar research previous participation effort is recognized. Thus, the authors supported that every volunteer work needs to be appreciated and recognized, even as a community service. The authors believed that respecting and recognizing participants ’ volunteered time and effort is also part of the research ethics when human subjects are involved.

I obtained IRB approval for my doctoral studies as Walden University requires before engaging partner organizations or participants. IRB approval number: 06-03-21-

0653109. Griffin and Leibetseder (2019) stated that the research should get approval from the IRB, which formed the ethics committee to agree if the research study is harmful and justifiable. Islam et al. (2021) emphasized that the ethical committee's main ethical concerns are the participants 'safety, comfort, and consent to remain informed and valid throughout the participants 'recruitment, data collection, data management, and data dissemination. NCBI (2020) emphasized that the Belmont report developed an ethical guide to safeguard and protect research participants 'rights in a research study. The data are coded with alpha-numeric codes regarding the applied ethical principles. It is such that mere looking at the data documents or this final report, the content cannot reveal the individual or organization's real name that participated in the study. The protection approach protects the confidentiality of the individuals and the organizations as agreed during the recruitment to maintain research ethics. However, participants were discouraged from sharing personal information outside the study's research topic or research question. Chakraborty et al. (2020) emphasized the importance of confidentiality in sharing details during the interview, not part of the research questions. They discouraged participants from sharing identifiable details not part of the interview questions. On the other hand, they encouraged researchers to exclude from documenting any indefinable details provided by participants to protect the confidentiality of the participating organizations 'individuals to sustain the research ethics. In a research study that involves human subjects, to overcome some of the ethical challenges linked to participants in the research study, which includes protecting participants 'confidentiality

and or privacy, it is critical to code their information and store data safely as part of ethical compliance (Darnhofer, 2018).

## Data Collection

### Data Collection Instruments

As the researcher, I was the primary data collection instrument as I conducted semi-structured interviews to collect the participants 'data. Gerlach (2018) emphasized that from a particular viewpoint and consistency with framing research as decolonizing, the researchers are not viewed as a neutral or isolated instruments in the study's data collection. The author stressed that the researchers are instead viewed as people who convey their social characteristics, including their social, cultural, historical, theoretical, political, and personal self, into the research data collection process; thus, the researcher is the primary data collection instrument. Eakin and Gladstone (2020) concluded that the researcher is the primary generative and synthesizing instrument for data collection and transformation into qualitative research's critical products, including explanations, concepts, and open-ended response detail analysis.

Therefore, as the primary data collection instrument, during the interview, I asked the participants the same semi-structured questions associated with the research question and the research topic; data was collected from their responses according to the semi-structured open-ended interview questions. Semi-structured interviews consist of open-ended questions to generate comprehensive data from the participants (Danielsson & Berge, 2020). Islam et al. (2021) concluded that combining semi-structured interviews with open-ended questions generates rich data which is reliable; thus, qualitative semi-

structured interviews are a widely used technique when the primary research objective is to explore the thoughts of the participants on a research topic in their own words in an attempt to find answers for the research question.

In a research study, when using pragmatic inquiry as a data collection approach, focus groups as an instrument allow the researcher to have participants as group members with a panel of inquiry setting-like. It is an opportunity to see the real-world technical problem raised by the research question and the problem statement from experts' lenses in the selected inquiry industry. Each focus group member brought their expertise to the table to give the researcher an array of data for a particular interview question that may answer the research question when no new information was available. In the study, it helped in the research study quality improvement. Kerins et al. (2019a) supported having a focus group in a pragmatic inquiry design as a data collection approach because the authors believed it would help extract a real-world solution for real-world problems with experts ’participation in the data collection process.

I used open-ended semi-structured interview questions (see Appendix G). These are the semi-structured open-ended questions and IPs. Etz et al. (2018) emphasized that open-ended questions are commonly used in qualitative research study semi-structured interviews, and a feasible and efficient method is required to analyze responses generated from open-ended questions. Ponizovsky-Bergelson et al. (2019) recommended that as part of the IPs, an open-ended question cannot be created to produce answers that may be “yes” or “no” or “specific information”; instead, it should be created such that the answers produced emerged with details.

I used document analysis to collect data in this study. Therefore, I collected IT industry documents related to IaC, which include documents for technologies such as DevOps, Kubernetes, Docker, cloud computing deployment models, cloud computing service models, cloud service providers, Terraform, Chef, Ansible, Puppet, and continuous integration – continuous delivery (CICD). These IT industry documents were collected from NIST, IEEE, Microsoft Azure, AWS, GCP, Alibaba Cloud, IBM Cloud, Redhat, Oracle cloud, Harness, and Harshicorp. IT industry documents are very reliable because the industry deals with real-world (pragmatic) cloud-computing problems as it believes that cloud computing is a standard for empowering convenient, on-demand network access to a mutual pool of configurable computing resources for organizations around the world in an attempt to achieve business objectives (NIST, 2019).

Regarding how data collection instruments or techniques are used, IPs (see Appendix G) guided the data collection process in this study, and there were two different protocols: one for an individual interview and one for the focus group interview. Also, part of the protocol is that the semi-structured interview questions are all open-ended questions. The participants provided detailed information about the study phenomena; responses are audio-recorded and transcribed. Ritterbusch et al. (2020) recommended that the semi-structured interview duration be between 30 and 60 minutes. Danielsson and Berge (2020) concluded that the semi-structured interview should consist of open-ended preset interview questions that elicit participants' responses. Lee et al. (2018) emphasized that the IPs allow researchers to ask participants the same questions in a similar chronological order. The authors added that it is to let the contrast of answers

with all participants address internal consistency validity and quantify the responses; because research validity is susceptible due to the dependence on the understanding of responses, and the data collection protocols should include document analysis.

I enhanced the data collection's reliability and validity by member checking; I shared a summary of the transcribed data with the participant to verify my understanding of the responses or required additional information. I did this by scheduling follow-up meetings to review the researcher's interpretation of the data. Koelsch (2018) also recommended using a reflective journal communicated, observed behavior, and concerns raised during the interview as part of member checking; thus, member checking is used to assess the validity of the research participants 'responses. Young et al. (2018) concluded that methodically asking interview questions allows easy comparison of participants ' responses, enhancing identifying themes and codes.

**Data Collection Technique**

The techniques I used to collect data in this study are semi-structured interviews with individual participants, focus groups, and data from documents obtained from reputable sources in the IT industry. I did not conduct the focus group until after I had reached data saturation with the at-least-four interviewees. The IT industry document data sources comprised the National Institute of Standards and Technology (NIST), Institute of Electrical and Electronics Engineers (IEEE), and cloud computing service providers (Microsoft Azure, AWS, GCP, IBM, Hashicorp, Harness, and RedHat). The semi-structured interview technique was audio recordings and transcribed for each participant. The data collection process via semi-structured interviews concentrated on

the solution architects in the IT industry with the IaC implementation strategies using DevOps procedures in cloud computing. So, there were individual interviews of solution architects, and data were collected through the interviews, and there were interviews of solution architects in a focus group where data were also collected. The same questions were asked during each interview session to attain data saturation, and no new information was available, signifying data saturation. Appendix G shows the open-ended questions that generated rich and thick data from the participants 'responses and the IPs, illustrating the techniques. IaC is cloud-agnostic and widely implemented by the IT industry for innovations; the document analysis technique was a technique to review IaC related documents from cloud computing service providers (e.g., Microsoft Azure, AWS, GCP, IBM, Hashicorp, Harness, and RedHat"), field notes, and a personal diary or reflective journal to generate rich and thick thematic code data.

Step 1 of the IP ($I_{Pr1}$) was the interview initiation and a participant's procedure review. This step includes; letting the participant know that interview is voluntary, letting the participant know that the interview duration is 30 – 60 minutes, letting the participant know that he or she can stop the interview at any time, and letting the participant know that data is marked anonymous, and getting the participant's verbal consent to set-on the audio recorders. Zhang et al. (2018) emphasized that the data collection method in a qualitative study that ensures data saturation includes data collection techniques such as active recruitment, focus group interviews, and individual interviews. Data through these approaches can be collected via face-to-face or teleconference and audioconference mediums. Lobe et al. (2020) concluded that many researchers currently working on

research projects distinct to the pandemic are being forced to change from face-to-face data collection to some other form of data collection medium. The authors added that such mediums include phone or internet-based; the authors stressed that when an interview participant or focus group participant is socially distanced but keen to participate in the study that the use of video-conferencing is also an excellent alternative to face-to-face, which can generate a rich, thick data for the study.

Step 2 of the IP ($I_{Pr2}$) was to set twin audio recorders for capturing data; it includes: 1st Audio Recorder set as the primary recorder (AR1), 2nd Audio Recorder set as a backup (AR2), setting both audio recorders on, and then start the interview. Step 3 of the IP ($I_{Pr3}$) was to interview for the initial probe questions, including Q01, Q02, and Q03. Step 4 of the IP ($I_{Pr4}$) was to interview for the targeted concept questions, including Q04, Q05, and Q06. Step 5 of the IP ($I_{Pr5}$) was to interview for the targeted follow-up questions, including Q07, Q08, and Q09. Step 6 of the IP ($I_{Pr6}$) was to interview for the targeted wrap-up questions, including Q10. Zhang et al. (2018) concluded that the semi-structured interview is the most common data collection technique for a qualitative study because of its advantages, including generating rich and thick data with reliability. Lobe et al. (2020) emphasized whether data should be collected through face-to-face or video conferences that IPs and ethics must apply to the qualitative research study.

Step 7 of the IP ($I_{Pr7}$) was to set the twin recorder off, including turning off AR1 and AR2. Step 8 of the IP ($I_{Pr8}$) was the interview endpoint, including thanking the participant for voluntarily participating, scheduling of follow-up meeting, and explaining the steps involved in the follow-up meeting. Hou and Feng (2019) postulated that

reflexive document analysis provides the critical reflection of knowledge production synthesis as the critical concept of discovering phenomenon strategies that can be compared with data collected from other sources for data saturation determination and data reliability verification. Mueller (2019) recommended that the structure of typical IPs include coding the IP steps such that the structure would not be challenging to evaluate or reference. The author added that IP for a large population might be too unwieldy to manage effectively and maybe too challenging during member checking as researchers find it difficult to refer to a particular step. Kerins et al. (2019a) believed that the semi-structured ability to support audio recording and transcription perfectly fits into qualitative research study because it helps researchers to be able to collect raw data used for thematic analysis.

Regarding the advantages and disadvantages of data collection techniques such as semi-structured interviews, part of the advantages of semi-structured interviews is determining data saturation which confirms that no new information is available. It also offers the opportunity to capture data via a recording device, allowing the researcher to review the collected data as many times as possible for accuracy. On the other hand, part of the disadvantages of the semi-structured interview is that it is labor-intensive. It also requires inexperienced researchers to quickly keep the regulation rules in all ramifications as anything short of that can violate research ethics with human subjects, so it requires special research training. Document analysis, one of the data collection techniques, provides advantages to the research to achieve data saturation by comparing the data captured through semi-structured interviews and data captured from the

organizational document analysis to ensure that no new information is available; on the other hand, it is a labor-intensive disadvantage. Danielsson and Berge (2020) emphasized that while the lack of interference from external sources on participants during semi-structured interviews is considered a strength because it provides data reliability, it is also labor-intensive to conduct semi-structured interviews, a disadvantage in qualitative research data collection when using the technique. Islam et al. (2021) concluded that one of the main advantages of the semi-structured interview is that it allows the researcher to create open-ended questions that can generate reliable data from the interviewees; and as well as allow the researcher to compare interview collected data and document analysis data to reveal data saturation. Kerins et al. (2019a) emphasized that using multiple data collection techniques such as semi-structured interviews and document analysis in a qualitative study provides in-depth and thick data to understand the phenomena better.

Focus group advantages include allowing participants to view the phenomenon from each others 'viewpoint to affirm that a strategy or process in the industry is a standard procedure or best practice. The purpose of the focus group is to confirm the findings from the interviews; thus, in this study, the focus group was treated just as a group interview. The Focus group also helps the researcher validate data collected from individuals with the focus group panel's views. Focus group data can also verify data collected from the interviews and industry documents to see the practical impacts. Therefore, I did a thematic analysis of the interview data before conducting the focus group to help have findings for the focus group. Part of the focus group's disadvantage was that it was labor-intensive because the researcher would have to work hard to get

different participants to agree to be available simultaneously to collect data. Jenkinson et al. (2019) asserted that some progress in focus group research methodology has resulted in greater alignment between other data collection techniques and focus group moderation. The authors stressed that it has enhanced and rendered increasingly influential when knowledge, insights, and group work skills are employed as part of data collection techniques by bringing eligible participants to become focus group members. Ridgeway et al. (2019) emphasized that the data collection technique with a focus group discusses the research topic, which involves group expert collaborations. It may provide a platform for experts to share information and opinions, especially on topics widely used in the industry as standard procedures. It also privileges participant interactions; while the moderator poses open-ended questions and facilitates the flow of conversation. The authors also stressed that focus group participants could also ask and answer questions during the session as they learn more about it. The focus group protocol is different from the individual IP because the same participant answers all the same questions in the individual IP. The focus group protocol allows the rotation of who answers the question first as it was a panel of inquiry approach.

I conducted a test run of my IPs (see Appendix G) with co-workers. It helped me refine data collection procedures and instruments; to prepare a better and more precise research design if needed. The test run did not influence my bias. Data collected from the pilot study was not used as this test run data were removed from storage and destroyed at the end of the pilot test run sessions. Webb et al. (2020) emphasized that acquiring access to potential participants is challenging for a large-scale and exploratory study but

seemed easy for a small-scale study. Malmqvist et al. (2019) concluded that a considerable study test run needs to be carried out with the IP, and this step should be considered an essential requirement in advance of the main study to ensure trustworthiness and utility adjustment if needed to create an opportunity for enhancing the main study's quality or protocols.

I used member checking to enhance the study quality. Member checking of the data interpretation or transcript review was critical in this research study to enhance quality and explore credibility. I achieved member checking by reviewing my interview summary with the participants to validate my understanding of responses and provide any additional information until no new data is available. Wright et al. (2019) concluded that member checking is also known as participant or respondent validation of findings, a technique for exploring the credibility of results. Bremner (2020) emphasized that, at the very least, qualitative researchers conducting time-limited semi-structured interviews may choose to include member checking, which is when participants are allowed to validate the data and identify any changes they wish to make. Ebersöhn and Malan-Van Rooyen (2018) asserted that, with member checking, the researcher ensures that data collected were represented truthfully. The authors added that an asynchronous approach during the interview might create a space through the open-ended questions, which may not reflect on participants' intended contributions and the theme found in the organizational document; thus, the use of member checking provided the opportunity for participants to make desired corrections to improve the quality of data collected.

**Data Organization Techniques**

I used a systematic data collection pattern to generate individual data: I transcribed audio-record from interviews, created research logs, created reflective journals, and created coded label catalogs. I used NVivo software v.12, a computer-assisted software built with data tracking and analysis capabilities to organize systematically and individually created data. The initial step in simplifying the data organization process was systematically organizing the transcribed audio-record interviews, research logs, reflective journals, and labeling catalogs that undergo the data organization process. I achieved these by importing each data into the NVivo software v.12 using the in-built data tracking feature of the software, which is very intelligent in data organization. This import process helped keep track of the large volume of data generated, especially the raw data, and the software was able to do this in a few seconds. For the transcriptions from the semi-structured interviews, each question Id was grouped into a "node" by the NVivo v.12 software when imported. The node was the question Id of the semi-structured interview, which, in return, created node trees pointing to every answer label, and each label held data about its question Id corresponding to answers (see Appendix G for semi-structured interview question Ids). Since this was a qualitative research study, the research question was labeled RQ in the catalog for good tracking and matching purposes. Starblanket et al. (2019) emphasized that cataloging, reflective journals, research logs, and interview transcriptions of raw data are easily tracked if an intelligent preprogrammed system such as computer-assisted software is used in qualitative research data organization. Maher et al. (2018) concluded that constant

interaction with the data is integral to research design methodology; therefore, cataloging procedures such as sticky notes, paper, and colored pens should generate data tracked with intelligent CAQDAS software appropriate data organizations.

I had research logs that needed evaluation for my data organization. It held all the data for my research search terms, date of search and lookup, and participants' follow-up meeting activities concerning the research study – providing me with an understanding and bigger picture of the study's processes. The research log was tracked using the NVivo v.12 software. Haven et al. (2020) emphasized that it is essential at the start of qualitative research to have some activity data log that can be thought of as a systematic research log the researcher can evaluate or make reference to during data analysis. This approach improved the study's quality because every research data or activity enhances the research quality. Risling et al. (2019) concluded that a research logbook is helpful because some participants taking part in a research study sometimes use electronic devices to capture, record, and log their activities, which may help the research member-check. Thus, some researchers have found their or participants 'research logs helpful during member checking.

I had reflective journals and used NVivo v.12 software to create an audit trail of decisions from the reflective journal to improve the study's quality and validity. It was helpful when analyzing and transcribing the semi-structured interviews with participants. The reflective also served as my journal to track my thoughts, concerns, and questions about each segment of the proposal process and review; the data collected was vital in the research study. Liao (2020) emphasized that the data is audio or video-recorded to help

strengthen reflectivity and reflexivity after inviting all the participants for semi-structured interviews in a study. It is essential to reflect on the researcher's reflective journal using thematic analysis. Adekoya and Guse (2020) concluded that after qualitative research interviews focused on searching for the research question answers through the participants, it is imperative to use reflective journals to augment the interview responses for the study's quality improvement for the researcher's clear understanding of the captured responses.

I created catalogs of labeled codes. It was achieved using a deductive coding catalog approach, a top-down approach where I started by developing a codebook with my initial set of codes based on my research questions, literature reviews, and conceptual framework. I then read through the data and assigned excerpts to codes. My label codes closely resembled the initial stage's codebook at the end of my cataloging process. This cataloging approach was appropriate because after cataloging with the label codes, I had a predetermined structure of how I needed my final research findings to be. The catalog was tracked using the NVivo v.12 software. Xu and Zammit (2020) supported the notion that researchers can use a hybrid coding label cataloging approach, combining inductive and deductive approaches in performing coding label cataloging, which provides them with a predetermined structure of their final findings in the study. Champagne-Poirier et al. (2021) supported the notion that the deductive approach is useful in qualitative research data organization and that it is based on preparatory principles enabling the researcher to objectively decode the mediated description of findings using a consistent

standard of measurement to create coded label catalogs which can be organized with computer-assisted software.

I stored and protected the interview collected data on a USB drive. The participant's information was coded and stored on the USB drive with a lock code. The interview transcript, reflective journal, summaries from my field notes, and organizational documents were also stored in the USB drive. All data collected about this research study are digitally stored in the USB drive emails. The storage USB drive is locked in a secure safety deposit box and maintained as the digital email data for 5 years. After five years, all the collected raw data in the USB drive are destroyed without recovery on purpose, and any digital remains, including email data, will be destroyed to sustain the research data confidential ethical procedure standard. Stored research data reuse is not visible; therefore, all the protected USB data containing the research data are destroyed after five years. Chauvette et al. (2019) concluded that changing technological landscape makes it possible to digitally store data, which creates an opportunity to reuse data anywhere in the world for later use. Thus, this digital storage movement proliferates and becomes widely accepted as publicly funded research agencies are mandating that researchers open their digitally stored research data for sharing and reuse by upcoming researchers. Flynn et al. (2018) emphasized that in any qualitative research context, the researcher–participant relationship, the technical issues, the recruitment of the participants, the participants 'information confidentiality, the acquiescence of the participants, recording and transcribing of captured data all constitute ethical concerns;

thus the manner at which any associated data is stored is principal to compliance of ethical research standards.

## Data Analysis

For the data analysis process in this research, I used the data triangulation process to facilitate data validation through cross-recognition from semi-structured interviews, external documents from reputable sources such as the IEEE, NIST, and the IT industry cloud service providers(e.g., Microsoft Azure, AWS, GCP, IBM, Hashicorp, Harness, RedHat). Wang and Tan (2019) suggested that the co-integration of data from multiple sources for evaluation as an error correction model is designed to solve multiple data sources analysis difficulties. Thus, data triangulation is essential for data validation from more than two sources (individual interviews, focus group interviews, and external documents) to minimize measurement bias during thematic analysis. The interview was recorded and transcribed to create a thematic analysis opportunity. Identifying themes was made by examining interview transcripts or other printed material to identify themes or codes. My data analysis was deductive with careful bias handling because my study was explorative and used an existing conceptual framework. Burles and Bally (2018) emphasized that it is essential to understand one's own bias and ensure it is monitored throughout the study process because poor handling of the researcher's bias during data triangulation could reduce a qualitative research study's quality. Furman et al. (2019) concluded that triangulation is not just about validation but about strengthening and broadening one's understanding of collected data; therefore, it can produce innovative

conceptual framing, leading to multi-perspective meta-interpretations produce innovations.

I used thematic analysis to interpret the collected qualitative data in the research study because thematic analysis supports systematically coding data features across the entire data set and collating data relevant labels to each code. In a qualitative research study, thematic analysis is a strategy used by researchers to interpret qualitative data in a broad and in-depth way by identifying themes and codes to answer the research question (Liebenberg et al., 2020). Qualitative data analysis uses a universal approach to interpret the research participants 'viewpoints and understanding of a specified research topic (Williamson et al., 2020). Brower et al. (2019) emphasized that researchers use several computer-assisted qualitative data analysis software (CAQDAS) to help in the data analysis process. (Brower et al., 2019) concluded that the decision to use the CAQDAS is based on ease of access, recommendations from peers, and the quality it adds to the researcher's data thematic analysis. Computer-assisted software promotes thematic data analysis's reliability, validity, and trustworthiness through triangulation, member checking, and audit trail (Beresford et al., 2020). Thematic analysis capabilities promote the reliability and validity of qualitative research data. Since categorizing the semi-structured interviews 'data content during thematic analysis is time-consuming, computer-assisted software makes the thematic analysis process much more manageable through systematic data management in-built features for coding (Maher et al., 2018).

The logical and sequential process in the data analysis initial step was the analytical steps: data documentation evaluation, an appraisal of data from notes I jotted

down as reflective notes, research logs, document analysis data, and transcribed from the semi-structured audio-recorded interviews. The next logical step was the organization or categorization of the data into concepts identified and refined essential concepts vital to the iterative qualitative research process, contributing to the study's reliability. The subsequent logical step in the data analysis was examining relationships and mapping associated data. Examining relationships is the concentration of the data analytic process because it allows the researcher to move from a simple explanation of the people and sceneries to descriptions of why things occurred the way they did with those people in that setting, which in this study's case I sought to find the strategies used by solution architects in IaC implementation using DevOps procedures in cloud computing. At this point, the answer to the research question (RQ) was visible. The next step of the logic and sequence in the data analysis was reflexivity. It was essential because it was all about confidence in the conclusions from my field research study, and it also was all about an honest and informative account of how I interacted with participants in the field, what problems I encountered, and how these problems were or were not resolved. Also, I employed reflexivity because such a "natural history" of the development of the evidence enabled me to evaluate the findings and reflect the interpretivist philosophy that guides qualitative researchers to improve the study's data quality. Gilmore et al. (2019) concluded that a requirement for that data analysis process takes a retroductive approach that advances common reasoning techniques of induction or deduction that refers to identifying hidden data. Starblanket et al. (2019) emphasized that the data analysis

process often reverts to a raw data viewpoint without adequate engagement, hiding the required data to answer the research question.

The conceptual plan for coding, mind-mapping, and identifying themes was by uploading the entire collected data into the NVivo v.12 software for analysis. This plan was to achieve conceptualization, coding, and categorizing on the fly using the power of the NVivo v.12 software in data analysis. The uploading of the documents to computer-assisted qualitative data software per participant's response enhances data comparison (Wohlfart, 2020). NVivo software v.12 was used for qualitative data analysis, and the associated implications deliver data extraction consistency; it helps researchers ' qualitative research design approach to generate a clear endpoint that was grounded in practice to maximize researcher's data interaction in a variety of learning using in-built analysis process which was rigorous and productive (Maher et al., 2018). Starblanket et al. (2019) concluded that NVivo software v.12 was one of the perfect computer-assisted applications for thematic analysis in qualitative research study data analysis because of its rich built-in features and theme identification.

I selected theme codes and phrases to focus on the critical theme codes and correlate the key theme codes with the literature to help answer the research question (RQ). It was to have the ability to perform an in-depth and comprehensive analysis of the semi-structured audio-recorded interviews, external document data, field notes, and reflective journals. This approach was to identify emerging themes such as common words, descriptions, and experiences related to IaC implementation strategies using DevOps procedures in cloud computing linked to the RQ. The study's conceptual

framework was part of the literature published after the University approved my proposal. These focuses were streamlined by employing a collective consensual data analytic procedure (CCDAP) using the CAQDAS approach, NVivo v.12 software utilization. I used NVivo software v.12 to analyze data by preparing and importing it to familiarize and code data to create data families and relationships between the interviews and IT industry document data. I conducted a final analysis of the coding file using the computer-assisting software. With CAQDAS, researchers apply the codes to sentences and paragraphs (Morgan & Nica, 2020). NVivo software v.12 helps organize theoretical and conceptual relationships in data collected from interviews and external documents (Brower et al., 2019). The NVivo software v.12 features makes it easy to access codes, themes, and relationship maps by intelligently analyzing the data collected from interviews and external documents (Wohlfart, 2020). In qualitative research data analysis, such as case studies and pragmatic research designs, the CCDAP process is streamlined by first doing a thematic analysis of the data using computer-assisted applications like the NVivo software and others (Starblanket et al., 2019).

## Reliability and Validity

### Reliability

In a qualitative research study, the researcher's role in a research study is to ensure that the research findings are reliable and valid; the reliability of a study focuses on consistency and results that can be replicated, and it may vary in the richness of data within comparable measurements to help researchers pilot the valuation of intercoder reliability (O'Connor & Joffe, 2020). I ensured that the semi-structured interviews were

conducted using an interview guide (see Appendix G) in which I asked the participants the same questions in chronological order by following IPs ($I_{Pr}$). Spiers et al. (2018) concluded that in a qualitative research study, reliability also refers to consistency in how the researcher codes data at multiple points and can ask the same research questions to each participant in the study, which addressed the research question with trustworthiness that, on the external, appeared to reflect the values of qualitative inquiry processes in all ramifications.

The research study's reliability depended on how honest the participants' responses were and whether they answered questions thoroughly, producing rich, thick data tailored towards answers to the research question. As part of the ethics, participants are informed that their identities are protected by alphanumerically coding their confidential responses. A reliable study must be valid and depends on the participants ' unbiased honesty and precision to the semi-structured interview questions (Meraz et al., 2019). The four techniques that measure study reliability are dependability, credibility, transferability, and confirmability; because they are the guiding principle for meeting objectivity in a qualitative research study (Eldh et al., 2020).

## Validity

### *Dependability*

I ensured dependability in the study by using the same IP (see Appendix G) to ask the participants the same questions in the same chronological order. Dependability tests the trustworthiness and consistency of a research study; and ensures that other scholars could use the same data to produce similar patterns (Eldh et al., 2020). Dependability

could also be attained when a researcher uses the same data and gets the same outcome (Fitzgerald & Lowe, 2020).

De Kleijn and Van Leeuwen (2018) identified that an audit trail is one of the procedures used to ensure dependability. I used my reflective journal to document any concerns during the research study. The reflective journal's use also helped me identify patterns and themes. Liao (2020) asserted that a study's consistency and trustworthiness are contingent on the researcher keeping a decision trail with a reflective journal. I used my reflective journal to document any issues or decisions that ensure clarity and transparency. Maintaining a decision trail also helps ensure trustworthiness by making the researcher's decision clear and transparent (Pessoa et al., 2019). A study's trustworthiness depends on the participants providing truthful and complete answers to the interview questions (Bischoping, 2018). I asked the same questions to the chronologically ordered participants. The participants were allowed to choose the preferred choice of where the interview was held. I explained why and how the research process would enhance trustworthiness.

Furthermore, I informed the participants that all responses would be confidential and stored within a memory USB drive that has password protected and locked up in a location only accessible by me. The participant's responses 'consistency is sufficient if member checking (Koelsch, 2018). The member checking was done by having participants review my summary of the transcript responses to ensure that my understanding of the interview data was accurate and that no new data was available.

### *Credibility*

I was cognizant of the delicate ways personal bias may influence participants' credibility claims and knowledge assertions; this is imperative when checking the data. Therefore, member checking was achieved by sharing the semi-structured interview data among the participants during a follow-up meeting to understand their provided responses. Getting a clear understanding of their responses through member checking improved the study's credibility. A qualitative research study's credibility relies on the researcher defending the honesty of their work; therefore, I had defended this study's honesty before a panel of academic supervisors, and this committee of academic supervisors approved. Haven et al. (2020) concluded that using data triangulation of multiple sources such as semi-structured interviews and comparing it with organizational documents verified the research findings to improve its credibility. Williams et al. (2021) described data triangulation as a strategy that employed multiple sources to validate data in a research study. The member checking strategy ensures that responses are believable and truthful; member checking and data triangulation work simultaneously to ensure the credibility of research studies (Williams et al., 2021).

### *Transferability*

I accomplished transferability through data collection, in-depth analysis of rich and broad data from participants during interviews, and organizational documents analysis. To get a reasonable sample size, I used two samples of individuals and focus groups of at least 3 IT industry participants. To ensure transferability during the interview, I chronologically used the same interview questions for each research

participant and focus group participant. Member checking was done during a follow-up interview to discuss my summary of the interview transcript with each participant separately to determine if the participant feels the summary represents their views and experiences and that no new data is available. Another way I ensured transferability was to give a thorough description of the context of this research study and my assumptions; thus, I achieved this by providing every detail of the research components to ensure that the knowledge was transferred to the reader to make repeatability possible. Elshaer et al. (2020) supported that similar criteria used to assess a study's thoroughness must apply to practical evidence from the developed assumptions. Goopy and Kassan (2019) concluded that epistemological assumptions regarding valid and transferable research fall into two qualitative inquiries when they detail every research component.

### *Confirmability*

Confirmability enhances the objectivity of the research study by using an audit the trail to maintain the transparency and validity of the study (Eldh et al., 2020). During the research study, I kept track of my observations, concerns, and decisions to establish transparency in my reflective journal. Audit trails serve as a blueprint for the research study, which outlines the researcher's process (Liao, 2020). Therefore, this blueprint makes the study replicable in different settings and populations. This audit trail also represents the participant's responses, not the researcher's biases or perspectives (De Kleijn & Van Leeuwen, 2018). Kerins et al. (2019a) described the audit trail as a vital technique for determining confirmability. The reflective journal notes keep track of the steps conducted during the research study and establish objectivity (Liao, 2020).

Moreover, future researchers can use the notes in my reflective journal to learn how and why determinations are made during this research study.

## Data Saturation

To achieve data saturation, if any of the four interview participants revealed information that none had mentioned, I ensured data saturation by interviewing additional participants and repeatedly comparing the interviewees' themes until no new information was available. I also analyzed the IT industry documents to compare themes. It was the same for my reflective journal's field notes and decision trail. I conducted these contrasts until no new data was available, confirming data saturation. Member checking also enhances data saturation; data saturation can be achieved when no new data, themes, or codes are identified during member checking (Williams et al., 2021). Mavhandu-Mudzusi (2018) concluded that the sample size should be recruited such that it was possible to compare data until data saturation is reached; data saturation is considered the point in a research study at which no new information is found during the interview process. Xu and Zammit (2020) emphasized that data saturation is an elastic concept in qualitative research data collection and comparison; because it is a process of data collection where the same data is returned to the collection, which indicates that no new data was available, and any further data collection was not required.

## Transition and Summary

In Section 2, I reaffirmed the purpose statement. I also described the researcher's role, participants, research method, research design, population and sampling, ethical research, data collection instruments, data collection techniques, data organization

techniques, data analysis, and reliability and validity. The researcher's role in this study was to become the primary data collection instrument for this qualitative research study. Participants 'eligibility criteria in this study were that they must be employed in the IT industry and have effectively implemented IaC in cloud computing using DevOps procedures within the last three years. This study's research method was qualitative research because it was appropriate for its objective; the anticipation was to explore the strategies used by solution architects in IaC implementation using DevOps procedures in cloud computing. This study's research design is a pragmatic qualitative inquiry design because the study concentrated on practical problems in the IT industry. However, the research question explored the strategies used by solution architects in IaC implementation using DevOps procedures in cloud computing. The study's exploration concentrated on the solution architects in the IT industry, where there were contrasts within and between the sample sizes for the validity of responses received via interviews. The population was all the solution architects in the IT industry in the United States with the strategies used in the implementation of IaC using DevOps procedures in cloud computing within the IT industry, the population with the practical problem; thus, the population samples was at least four participants who were individually interviewed and at least three focus group members that were jointly interviewed concerning the strategies used by solution architects in IaC implementation using DevOps procedures in cloud computing.

Ethical research for this study's primary objective was to obtain signed approval to participate in the study from each participant. The data collection instrument

centerpiece was me, who acted as the primary data collection instrument by conducting semi-structured interviews to collect the participants 'data. The data collection technique for this study was semi-structured interviews and data extraction from the IT industry documents. The semi-structured interview technique was audio-recorded and then transcribed in the individual sample category and the focus group for each participant. Appendix G shows the open-ended questions that generated rich and thick data from the participants 'responses and the IPs, illustrating the techniques. The data organization technique in this study for cataloging was NVivo software v.12, a computer-assisted and qualitative research software appropriate for cataloging and data analysis. The initial step in simplifying the data organization process was to have the data undergo the organization process by importing it into the NVivo software v.12 using the in-built software techniques. Data analysis used triangulation to facilitate data validation through cross-recognition from semi-structured interviews, document analysis, and other data sources. This study's reliability and validity were measured with four factors: dependability, credibility, transferability, and confirmability.

Section 3 covered the application for professional practice and implications for social change. In Section 3, I presented the following research components: the introduction, presentation of findings, application to professional practice, implication for social change, recommendations for action, further research, reflections, and conclusion. The introduction includes in part the purpose statement. The presentation of findings includes the research question. Thus, application to professional practice includes a detailed discussion on the findings 'applicability concerning IT's professional practice.

The implication for social change consists of expressed implications in terms of tangible improvements to individuals, communities, organizations, institutions, cultures, or societies. Recommendations for action contain recommendations that flow logically from conclusions, containing steps to the right action. Recommendations for further research listed recommendations for further study related to improved practice in IT. Reflections incorporated a reflection on the researcher's experience within the Doctoral Study process in which the researcher discussed possible personal biases or preconceived ideas and values. The conclusion closed with a solid concluding statement about the study.

Section 3: Application to Professional Practice and Implications for Change

## Introduction

This pragmatic qualitative inquiry study aimed to explore strategies used by solution architects to implement IaC architecture solutions using DevOps procedures in cloud computing. This exploration's targeted population was solution architects in the IT industry within the United States who had successfully implemented IaC within the past 3 years in cloud computing with DevOps procedures. The research's implementation approaches may help reveal the strategies used in implementing IaC in cloud computing.

Eight major themes emerged from this study's findings: (a) IaC benefits, (b) IaC cloud computing models, (c) IaC cloud service providers, (d) IaC configuration best practices, (e) IaC DevOps practices, (f) IaC implementation tools, (g) IaC Kubernetes platforms, and (h) IT infrastructure implementation approaches. These eight major themes are consistent with the trends revealed in the literature of the study. Each theme was supported by all the compared literature and the study's conceptual framework, which proved how important cloud computing features are to businesses and organizations in running a day-to-day enterprise, private solutions, and applications in their respective operating industries. Cloud computing IT infrastructures help organizations deliver business products globally without boundary limitations in the market (Goode, 2020). Using the cloud computing fundamentals that emerged as part of the study findings themes can help corporate entities to attain success in their respective operating industry. It is also consistent with IT architecture feature implementation in

cloud computing, as explained by the literature review; the findings from the eight emerged major themes are described and explored in the next section.

## Presentation of Findings

The study's research question was: *What* strategies are used by IT solution architects to implement IaC architecture using DevOps procedures in cloud computing? The eight major themes illustrate potential strategies IT solution architects used to implement IaC architecture using DevOps procedures in cloud computing. $\Omega_1$ denotes the total participants involved in the study findings, and $\Omega_2$ denotes the total IT industry documents used in the study findings. The source of data collections included four individual participants (solution architects), three focus group participants (solution architects) all from the United States of America, and 58 IT industry documents from NIST, NASA, IEEE, IET, AWS, IBM, Microsoft Azure, Capgemini, JFrog, Fairwinds, HashiCorp, Digital Ocean Cloud, Oracle Cloud, Redhat, Harness, and Google Cloud, where the pivot of IT industry documents number of references was 3621. Tables 2 and 3 present the data collection sources used in the study findings. Notations $\acute{\omega}_1$ and $\acute{\omega}_2$ are the sums of counts in the participants and IT industry data sources per the theme. Human participants are involved in the study that requires IRB approvals; therefore, the Walden University IRB approval number is 06-03-21-0653109. The study data analysis was performed with NVivo v12 plus powered by QSR international. Each participant was assigned a participant ID, and each participant's collected data through the interview were transcribed to produce transcript files that were assigned transcript IDs respectively for identification and data analysis references query. Likewise, each of the collected IT

industry documents was assigned a document ID for data analysis references when queried using NVivo v12 plus. In addition, each participant's transcript and IT industry documents were assigned case classification as interviews and journal articles, respectively.

**Table 2**

*Interview Participant Data Sources*

| Interview session | Participant ID | Transcript ID | Transcriber |
|---|---|---|---|
| Individual (1-on-1) | | | |
| Participant 1 | P1 | Transcript-01 | Researcher |
| Participant 2 | P2 | Transcript-02 | Researcher |
| Participant 3 | P3 | Transcript-03 | Researcher |
| Participant 4 | P4 | Transcript-04 | Researcher |
| Focus group | | | |
| Participant 5 | P5 | Transcript-05 | Researcher |
| Participant 6 | P6 | Transcript-06 | Researcher |
| Participant 7 | P7 | Transcript-07 | Researcher |

*Note.* $\Omega_1=7$, where $\Omega_1$ is the number of human participants in the study; Walden University IRB approval number is 06-03-21-0653109. See Appendix I.

**Table 3**

*IT Industry Document Journal Article Data Sources*

| Document ID | Journal article author | Title |
|---|---|---|
| IT industry doc-01 | AWS | Cloud Computing Deployment and Service Models |
| IT industry doc-02 | AWS | Infrastructure as Code strategies |
| IT industry doc-03 | Capgemini Inc. | DevOps Strategy in IaC |
| IT industry doc-04 | Fairwinds Inc. | Kubernetes Security Tools in IaC |
| IT industry doc-05 | Harness Inc. | Kubernetes Platform with IaC approach |
| IT industry doc-06 | Harness Inc. | DevOps and Infrastructure Automation |
| IT industry doc-07 | Harness Inc. | Deploy to Kubernetes using IaC |
| IT industry doc-08 | IBM | Infrastructure as Code and Disruptive Innovation |
| IT industry doc-09 | IEEE | Characteristics of IaC in Disruptive Innovation |
| IT industry doc-10 | IEEE | Disaster Recovery based Infrastructure as Code |
| IT industry doc-11 | Microsoft Azure | What is Infrastructure as Code? |
| IT industry doc-12 | Microsoft Azure | GDPR Compliance when using IaC and IaaS |
| IT industry doc-13 | Microsoft Azure | What is DevOps in Cloud Computing? |
| IT industry doc-14 | IEEE | Infrastructure as Code (Code Versioning) |
| IT industry doc-15 | IEEE | Infrastructure as Code (Script Security) |
| IT industry doc-16 | IEEE | Infrastructure as Code (Code Versioning) |
| IT industry doc-17 | IEEE | Infrastructure as Code (The Patterns) |
| IT industry doc-18 | IEEE | Infrastructure as Code (Azure RM) |
| IT industry doc-19 | NIST | Cloud Computing, 800-171 and 800-53 |

| | | |
|---|---|---|
| IT industry doc-20 | NASA | Cloud Computing |
| IT industry doc-21 | NASA | IaC application to professional practice |
| IT industry doc-22 | NASA | Infrastructure as Code for Cloud Computing |
| IT industry doc-23 | NASA | Using AWS Cloud Computing in Space mission |
| IT industry doc-24 | IBM/Redhat | Ansible for IaC CICD |
| IT industry doc-25 | IBM/Redhat | Ansible IaC Automation Strategies |
| IT industry doc-26 | JFrog Inc. | Docker Guide For Everyone |
| IT industry doc-27 | HashiCorp | Terraform Kubernetes Multi-Cloud |
| IT industry doc-28 | US Dept. of VA | VA Technical Reference Model v 21.11 |
| IT industry doc-29 | Microsoft Azure | What are Microservices? |
| IT industry doc-30 | Microsoft Azure | What is Continuous Delivery? |
| IT industry doc-31 | Microsoft Azure | What is DevOps? |
| IT industry doc-32 | Microsoft Azure | What is DevOps Culture? |
| IT industry doc-33 | Microsoft Azure | What is Infrastructure as Code? |
| IT industry doc-34 | NASA | In Cloud Computing |
| IT industry doc-35 | NASA | Applying Disruptive Innovation Theory in Emerging Markets for Crew On-Orbit Transportation |
| IT industry doc-36 | NASA | OSS Tools Popularize Infrastructure for Cloud Computing |
| IT industry doc-37 | NASA | How NASA uses AWS Cloud Computing to protect life and infrastructure on earth |
| IT industry doc-38 | AWS | NASA Case Study: Infrastructure as Code |
| IT industry doc-39 | Harness Inc. | Kubernetes Deployments |
| IT industry doc-40 | NIST 500 | NIST Cloud Federation Reference Architecture |
| IT industry doc-41 | NIST | Why Infrastructure as Code? SP 800-171 |

| | | |
|---|---|---|
| IT industry doc-42 | IET | Infrastructure as Code - What Is It, and Why Should My Engineers Care? |
| IT industry doc-43 | IBM | Continuous Delivery |
| IT industry doc-44 | IBM | Reusable Elements for Designing Cloud-Native Applications |
| IT industry doc-45 | IBM/Redhat | Ansible Automation Platform |
| IT industry doc-46 | IBM/Redhat | Automate your network with Redhat |
| IT industry doc-47 | IBM/Redhat | DevOps: Securing the Container Workload |
| IT industry doc-48 | Google Cloud | Kubernetes Versions |
| IT industry doc-49 | NIST | Current laC Practices and Approach |
| IT industry doc-50 | HashiCorp | Terraform Enterprise |
| IT industry doc-51 | HashiCorp | Terraform Language Documentation |
| IT industry doc-52 | HashiCorp | Terraform Modules |
| IT industry doc-53 | Microsoft Azure | Infrastructure as code |
| IT industry doc-54 | IEEE | On the Effectiveness of Tools to Support Infrastructure as Code: Model-Driven Versus Code-Centric |
| IT industry doc-55 | Microsoft Azure | NIST Cybersecurity Framework - CSF |
| IT industry doc-56 | Microsoft Azure | NIST Cybersecurity Framework – Cloud computing |
| IT industry doc-57 | Microsoft Azure | Details of the NIST SP 800-53 |
| IT industry doc-58 | Microsoft Azure | New Azure Blueprint simplifies compliance with NIST SP 800-53 |

*Note*. $\Omega_2$=58, where $\Omega_2$ is the number of IT industry documents used. See Appendix J.

## Theme 1: IaC Benefits

Theme 1 (IaC benefits) emerged following its occurrence on the participants ’data transcripts and IT industry document journals, respectively, as shown in Table 4. The participants ’data sources from the interview sessions and IT industry documents revealed that IaC benefits include rapid infrastructure deployment, preventing snowflakes, preventing environment drift, offering idempotence, NASA remote infrastructure support, disaster recovery, and cost savings and automatic deployment.

### *Findings From Participants*

All participants' data revealed that IaC benefits include infrastructure deployment, snowflake prevention, environmental drift prevention, idempotence, contribution to space research, disaster recovery, cost savings, and automated deployment IaC approach. Participants 1 and 2 indicated that they contributed to the development of the “information system infrastructure” within their organizations, which involved “Kubernetes services implementation in enabling NASA to automate the deployment of multiple Kubernetes powered Daskhub infrastructures used in the ISS;” the participants indicated that the use of “IaC methodology was a critical factor in the development of a space research agency's earth information system infrastructure.”

Participant 1 verified that “IaC as a disruptive innovation is a huge discovery in the IT industry.” Both Participants 1 and 2 further added that IaC implementation in AWS allowed them to provision JupyterHubs, Dasks, HPC clusters, NLP AI, and some other technologies within a few hours as supposed to incumbent technologies that would have taken a couple of weeks and sometimes months to provision; therefore, they

experienced rapid infrastructure deployment benefits because of employed IaC strategies. Participant 2 emphasized that he was “able to build HPC clusters with IaC’s terraform tool, which was very fast.” Participant 1 also stated that deployment automation is why he adopted the IaC approach. Furthermore, Participant 2 stated that the organization he worked for considered cost savings offered by IaC as the foundation of adopting the IaC approach and added that the usefulness of IaC in NASA space research while he was working with the national space agency helped him to be successful in the implementation of IaC in cloud computing.

Participant 3 indicated that “disaster recovery enhancement offered by IaC is why most of his clients implemented the IaC approach” and indicated that “the IaC approach was beneficial to [his organization] in the implementation of defense mechanism solutions.” While Participant 4 agreed with Participant 3, he also added that the “idempotence offered by the IaC solution is of great importance to their company.” Participant 5 affirmed that the IaC approach's ability to prevent environment drift is because of a decision-maker for their organization in adopting IaC strategies. Participant 6 agreed with Participant 5 and added that “prevention of snowflakes by the IaC approach was a key benefit considered by their CTO when they adopted the IaC solution to replace their incumbent strategy.”

While Participant 7 agreed with Participants 5 and 6, he added that “IaC solution rapid infrastructure deployment benefits played a huge role in their IT leaders’ decision to adopt the IaC approach because it helped them manage the infrastructures remotely.” IT organizations could build and manage their remote system infrastructures using the

IaC approach, enhancing their artificial intelligence systems design and automated implementation (Tu et al., 2018). The findings indicated that all the participants' confirmed Theme 1 through 7 transcripts in 183 references in the data sources.

***Findings From IT Industry Documents***

IT industry document-19 verified that IaC "implementation strategies are a vast resource in the agency's space research exploration." It highlighted that NASA space exploration requires remote infrastructure support to design superstorm monitoring systems. The document confirmed that it is because:

> superstorms such as the one that occurred three decades ago, which was estimated to occur only once every 50 years, threaten the earth each time it occurs; thus, the document added that NASA experts who study extreme events, like super-volcanoes or asteroid impact, frequently refer to these occurrences low frequency or high consequence events which threaten the earth.

The document stated a need to create a remote infrastructure mechanism outside the earth to monitor its occurrence exists. IT industry document-38 revealed that "NASA scientists are involved in understanding what turns an average solar storm" into a superstorm, just as meteorologists have understood how a tropical storm over the ocean turns into a hurricane.

To achieve this, NASA adopted the IaC approach, which they implemented on the AWS cloud. The document revealed that this strategy gave space exploration a massive benefit of using the infrastructure innovation and new technologies introduced by the IaC approach to achieve the agency's objective of protecting the earth from the superstorm by

having predictive systems launched remotely and accessed via AWS cloud. “Janet Kozyra,” Heliophysicist at NASA, was quoted by IT industry document-38, where she stated, "With AWS, we can take every particular piece of data that we have on superstorms, and use anomalies to advance the models that forecast and classify superstorms effectively;” she added that “idempotence,” “automated deployment,” “cost savings,” “disaster recovery,” “prevention of snowflakes,” and “rapid infrastructure” deployment were IaC benefits that helped NASA to be successful in the objective of earth’s protection because of the implementation of the new technologies such as the ability to create “AWS Kinesis data stream,” “AWS lambda,” and “AWS S3 infrastructures” using an IaC approach. IT industry document-30 revealed that in cloud computing, one of the benefits of using the public cloud is to have the ability to create a cost-saving model by using infrastructure deployment technologies such as IaC, which is supported by the public cloud.

IT industry document-27 revealed that the “implementation of IaC helps organizations have rapid-deployment” solutions. IT industry document-25 revealed that Redhat OpenShift is an “IaC support platform that provides automated deployment infrastructures.” IT industry document-24 confirmed that Redhat OpenShift supports the “CICD process to enhance disaster recovery” of infrastructures deployed via the IaC solution. IT industry document-35 revealed that NASA could create disruptive innovation in space research by adopting the IaC model for remote infrastructure management. IT industry document-28 revealed that building infrastructure reference architectures can never be easier than using the IaC approach as it provides a security configuration pattern

aligned with the organization's security model. The findings indicated that 37 IT industry documents confirmed Theme 1 in 784 references in the data sources.

### *Connections to the Conceptual Framework*

According to Christensen (1997), in the DIT theorem, organizations may be successful if they adopt new technologies; thus, the application of DIT as the conceptual framework in this study proved true in Theme 1 findings because both the participants and the IT industry documents showed the benefits of adopting new technologies that the IaC benefits presented under Theme 1. The study's findings for Theme 1 are consistent with DIT because organizations anticipate the future for technological advancement, particularly for organizations seeking a reasonable industrial advantage with technology, which is also an essential benefit component delivered by the IaC approach (see Aluya, 2018a). Technology road mapping and forecasting techniques, based on extrapolating past trends, provide some guidance on what happens when organizations and IT leaders reject new technologies (Aluya, 2018b).

DIT verified that the future in technology is often anything but stable and deterministic; thus, adopting new technologies helps the disrupters or the organizations meet the challenges of new technologies in the future (Muller, 2020), which helps such organizations create sustainability models in their operating industry. The IaC approach is a disruptive technology as revealed by Theme 1, and it has all the elements confirmed by the conceptual framework for disruptive technology as found in Theme 1, thus forming the part of the foundation of the success of the conceptual framework confirmed when technology innovation such as IaC approach is adopted.

One of the most reliable models in business operation is the failure of a leading organization to stay at the top of their operating industries when new technologies change, and their failure is always about 80% of their inability to invest in the new technology (Christensen et al., 2018). DIT emphasized that the organizations that failed at the change of new technology in their operating industry are those organizations that rejected the new technologies due to several reasons; that is, most of these failed organizations either failed because they were unable to see the benefits of the new technology or because they are not a proponent of new technology and thus could not accept it. Theme 1 specified the IaC benefits to help organizations see the benefits of adopting IaC innovation, and the conceptual framework supports Theme 1.

***Literature Comparison and Support***

Evolutionary studies on technology innovation emphasized that IaC benefits include delivering fast and improving environment deployment consistency (Jeon et al., 2020). The phenomenon of IaC benefits that it delivers fast is what the findings of IaC benefit from the Participants and IT industry document journals for Theme 1 described as “rapid infrastructure deployment” while the literature’s views that IaC has improved consistency is what the findings of IaC benefit from the Participants and the IT industry documents described as prevention of environment drift as well as prevention of snowflakes. IaC's rapid deployment capabilities are key features for disrupting incumbents. Organizations in their operating models require fail-fast and recover-fast; thus, IaC innovation fits into that strategy, especially in need of disaster recovery of a failed infrastructure. Alarifi et al. (2020) emphasized that in the past, system

administrators had to meticulously provision and set up all the hardware and software needed to run applications, and they did it manually. So, this process is unsustainable in the modern software delivery and development lifecycle where organizations' IT practitioners are expected to deploy hundreds of apps daily. Therefore, IaC innovation allows organizations to automatically and rapidly deploy networks, databases, virtual machines, and other infrastructure modules to build the cloud environment they need to test and run their apps (El-Sayed et al., 2018).

DIT by Christensen (1997), as applicable to this study, emphasized that adopting new technology lies with the organization's readiness to disrupt themselves from the incumbent approach even when they are aware that the disruption may take time to mature for a visible return on investment which delivers the success of their specific organization objective. The conceptual framework theory stated that disruption could take time to mature and clarify why incumbent users normally ignore disruptive opportunities in cloud computing. The theory emphasized that disrupters tend to focus on getting the organization prototype, rather than merely the product, just right, unlike the incumbents. In this case, NASA wanted to get a prototype right for predicting superstorms; then, they adopted the IaC approach in AWS, showing that they are disrupters rather than incumbents. The conceptual framework stated that disruptive technologies typically enable new markets to emerge. There is strong evidence that organizations entering these emerging markets early by adopting the new technologies have significant first-mover benefits over later entrants or those that reject the new technologies provided by any innovation. IaC benefits revealed by the findings from both

the participants and the IT industry showed that the benefits are due to the embedded new technologies in the IaC approach; thus, the literature supports Theme 1.

**Table 4**

*References of Major Theme 1: IaC Benefits*

| Major theme | Participants | | Documents | |
|---|---|---|---|---|
| | Count | References | Count | References |
| IaC benefits | 7 | 183 | 37 | 784 |

*Note.* $\Omega_1$=7, $\acute{\omega}_1$=7, $\Omega_2$=58, $\acute{\omega}_2$=37. See Appendix H.

**Theme 2: IaC Cloud Computing Models**

Theme 2 (IaC cloud computing models) emerged from data sources of participants and IT industry documents. The occurrence summary of the theme is shown in Table 5. The IT industry document journals and participants 'transcripts verified that the deployment models comprise hybrid cloud, multicloud, private cloud, and public cloud, while the service models comprise IaaS, PaaS, and SaaS made up the cloud computing models.

***Findings From Participants***

Participant 1 stated that most of his clients are using IBM cloud, and because of that, he implements IaC with a hybrid cloud deployment model and IaaS service models more than the rest of the deployment and service models. Participant 2 revealed that he implements IaC mostly with the "private cloud deployment model" and the "PaaS service model more than the rest." Participant 3 stated that he implements IaC with the public cloud deployment model and SaaS service model more than the rest of the deployment

and service models. Participant 4 indicated that he implements IaC with the multi-cloud deployment model and IaaS service model more than the rest. Participant 5 agreed with Participant 1 that IaC implementation is a good strategy as both participants adopted the same model combinations. Participant 6 agreed with Participant 2 as both participants adopted the same model combinations. Participant 6 stated that a "hybrid cloud is a special cloud for organizations interested in utilizing its private cloud alongside public clouds in IaC implementation."

Participant 7 agreed with Participant 3 as both participants also adopted the same deployment and service models. Participant 7 further stated that "in an era when it is not unusual for an enterprise to install hundreds of applications into production every day and when infrastructure is continuously being spun up, dither down, and scaled up and down in response to the developer and user demands, an organization needs to automate infrastructure in order to control costs, decrease risks, and respond with speed to new business prospects and competitive threats." Therefore Participant 3 supplemented by saying that "IaC makes this automation possible." Explicitly, Participants 1 to 7 indicated that they use "all the mentioned deployment models (hybrid cloud, multi-cloud, private cloud, and public cloud)" as part of their Infrastructure as Code implementation strategies. The findings indicated that all the participants' confirmed Theme 2 through 7 transcripts in 341 references in the data sources.

***Findings From IT Industry Documents***

IT industry document-41 indicated that "most IT practitioners use more hybrid clouds as part of their Infrastructure as Code implementation strategies." IT industry

document-40 revealed that most organizations use the “hybrid cloud in IaC implementation because they take advantage of their private cloud while using public cloud resources.” IT industry document-27 verified that “terraform is cloud-agnostic and can be used on all the cloud deployment and service models.” IT industry document-06 stated that “DevOps procedures are compatible with deployment and service models in the IaC approach.” IT industry document-07 verified that “deployment models used in the IaC approach include hybrid cloud, multi-cloud, private cloud, and public cloud, whereas service models include IaaS, PaaS, and SaaS.”

IT industry document-29 verified that “terraform technology is used to implement IaC in the Azure platform.” IT industry document-24 verified that “OpenShift offers a hybrid cloud deployment model in IaC implementation, delivered with Terraform or CloudFormation.” IT industry document-42 confirmed that “the hybrid cloud deployment model is important in IaC implementation.” IT industry document-54 verified that “the cloud deployment models enhance automation procedures as part of IT practitioners' core strategies used in implementing IaC.” Industry document-57 stated that “in using new technology concepts such as the IaC approach, IT organizations may handle protracted downtime during disaster recovery regardless of the adopted cloud model combination applied in the solution,” which improves the operational efficiency model (Rahman & Williams, 2019). The findings indicated that 52 IT industry documents confirmed Theme 2 in 2366 references in the data sources.

### *Connections to the Conceptual Framework*

DIT by Christensen (1997) stated that disruptive innovation means reinventing the operational model, a technology, or inventing something new by embracing new strategies delivered by the innovation. According to study findings, IaC incorporates cloud deployment models and service models as part of its implementation strategies, which help organizations reinvent their operational models or invent new ones by effectively handling critical-mission systems. Schön et al. (2020) revealed that adopting new technology takes time to mature and sometimes may be slow in maturity, but it helps the disrupters meet their needs in the operation industry. The importance of using IaC in cloud computing is that it is a new technology with disruptive innovation concepts to bridge the gap created by the incumbent technologies in the operating market (Sandobalín et al., 2020).

In their analysis of DIT, Christensen et al. (2018) elaborated that disruptive technologies are easily identified by companies that are inclined to accept new technologies and have the zeal to go to the market with new ideas and new solutions. NCBI (2021b) added that disruptive Innovations have the potential to be an incredibly positive force in the market, such that when it gets to the operating market, they target the low-end of the market, thereby causing the incumbents to be expensive to support. Cloud computing deployment and service models disrupted the IT industry by offering the opportunity to automate infrastructures, allowing the IaC principle to be innovated by experts. Li et al. (2019) confirmed that the principles of disruptive technology could be beneficial to areas across society, including the healthcare industry, education industry,

and the IT industry, because of cloud computing models. The conceptual framework supports Theme 2.

***Literature Comparison and Support***

Computing need has been developed for various fields such as financial, healthcare applications, engineering, geographical science, education, space research, and business (Dubey et al., 2019). Cloud computing is offered in four different models: private cloud, public cloud, hybrid cloud, and community(multi) cloud (NIST, 2018). Both the participants and the IT industry documents confirmed the cloud computing models highlighted by the literature of the study because cloud computing has been extremely accepted as an efficient solution for disruptive innovation and the IT industry problem-solving mechanism (Sekaran et al., 2019). Adopting new technology from innovations like IaC expects that the organization that adopted the new technology needs technology maturity. The conceptual framework emphasized that technology maturity means developing the lab or the inventor with core technology to a scalable, repeatable solution state. IaC cloud computing models are classified as core technology with new utilization patterns that may involve maturity to succeed.

Christensen (1997) thought his theorem in DIT clarified that the time for new technology maturity could be shorter but certainly evolves through various maturity stages to address: new technology learning curve, new technology value proposition, ease of adoption by practitioners, financial sustainability of the adoption by the company, and pricing model of the new technology. These components of technology innovation maturity propel users' success when the IaC approach is adopted as part of cloud

computing models in the IT industry. As a supporting conceptual model to DIT, DOI theory concentrates on implementing and creating change using new technologies or technology innovation (Al-Rahmi et al., 2019), which edifies DIT's purpose in the technology and the applicability of both DIT and DOI in cloud computing. The applicability of both theorems supports the need for the implementation of IaC.

**Table 5**

*References of Major Theme 2: IaC Cloud Computing Models*

| Major theme | Participants | | Documents | |
|---|---|---|---|---|
| | Count | References | Count | References |
| IaC cloud computing models | 7 | 341 | 52 | 2366 |

*Note.* $\Omega_1$=7, $\acute{\omega}_1$=7, $\Omega_2$=58, $\acute{\omega}_2$=52. See Appendix H.

**Theme 3: IaC Cloud Service Providers**

Theme 3 (IaC cloud service providers) emerged from participants and IT industry documents data sources. The occurrence summary of the theme is shown in Table 6. Participants 'transcript files and the IT industry documents verified that the leading cloud service providers in the IT industry are AWS, Azure, Alibaba Cloud, Google Cloud, IBM Cloud (Redhat), and Oracle Cloud.

***Findings From Participants***

Participant 1 stated that he implements "IaC on AWS and Azure." Participant 2 indicated that their "organization uses Azure Cloud to implement IaC." Participant 3 stated that he uses "Google Cloud to implement IaC." Participant 4 revealed that "IBM Cloud is the cloud platform suitable for implementing IaC because of OpenShift support

it offers." Participant 5 stated that their "organization uses a multi-cloud deployment model including Oracle Cloud and Redhat OpenShift to implement IC." Participant 6 indicated using a "hybrid cloud deployment model that includes Azure Cloud in implementing IaC." Participant 7 confirmed that in implementing IaC, IBM Cloud is the cloud service provider he uses. Participant 7 further stressed that "IaC is also an essential DevOps practice, indispensable to a competitively paced software delivery lifecycle." He added that "It enables DevOps teams to quickly build and version infrastructure in the same approach they version application source-code and track these versions to avoid discrepancy among IT environments that may run into serious issues during deployment."

According to the participants' data source, AWS, Microsoft Azure, Google Cloud, and IBM cloud emerged as the joint pivotal cloud service provider because their cloud platforms support the IaC implementation approach. Participants' data also revealed that Alibaba Cloud and Oracle cloud jointly emerged as runners-up. Participant 7 disclosed that his "CTO decided to use IBM Cloud, based on the service performance and security delivered by the provider's platform and OpenShift integration ease in the platform," which enhances the "implementation of IaC using terraform as-a-service." Participant 1 emphasized that "IBM's IaC capabilities, which include customizable and shareable prototypes, can place the foundation for improving applications, no matter where you are on your journey to cloud." The findings indicated that all the participants' confirmed Theme 3 through seven transcripts in 347 references in the data sources.

***Findings From IT Industry Documents***

IT industry document-38 stated that "AWS Cloud supports a hybrid cloud deployment model for IaC implementation." HashiCorp revealed that "all the cloud services providers use the core IaC tool(terraform)." The IT industry document-24 confirmed, "IBM as the z-series cloud provider dominant with dynamic workload introduced a decade ago in the IT industry, including support for IaC implementation." IT industry document-31 stated that "Azure Cloud supports the Redhat OpenShift platform to implement IaC." IT industry document-42 revealed that "Alibaba Cloud is part of the cloud service providers' dominant market in offering the Kubernetes platform, supporting IaC implementation." IT industry document-54 stated that "IBM Cloud as a service provider has robust security in terms of cloud security, making it a cloud platform for financial institutions to use cases for critical-mission workload transmission, which also supports IaC implementation."

IT industry document-40 stated that the "Kubernetes service offered by various cloud service providers is a new technology that opened the doors for implementing IaC in cloud computing" and "should be adopted by organizations looking to implement containerization to migrate critical-mission workloads from incumbent infrastructures." IT industry document-25 stated that "Terraform is a useful declarative provisioning and infrastructure orchestration tool which is cloud-agnostic that lets IT practitioners automate the provisioning of all aspects of their enterprise cloud-based and on-premises infrastructure in any cloud service providers' platform such as IBM, Azure, AWS,

Alibaba, and or Oracle Cloud." The findings indicated that 55 IT industry documents confirmed Theme 3 in 3621 references in the data sources.

***Connections to the Conceptual Framework.***

DIT theorem supports organizations adopting new technology because it helps them succeed instead of discarding the new technologies to rely on incumbent technologies. According to Christensen (1997) verification of disruptive innovation reason to act, the author concluded that new technologies allow organizations to deliver new concepts through various mediums. Cloud service providers' platforms are the medium leading pack of distributing new technologies incorporated into the IaC approach (Emeras et al., 2019). Disruptive innovation technology theorem position was to prove that the basis of the structure of mature technology improvement available today, which are enjoyed by organizations, appeared to be as a result of these organizations using the new technologies through the cloud service providers as early adopters instead of rejecting them at the time when offered these cloud service providers (Christensen et al., 2018). As revealed by Theme 3, IaC cloud service providers are the hub in the IT industry for delivering new technologies, and disrupters may experience new technology maturity stages if they consume these new technologies delivered through this hub.

Gandhi et al. (2020) asserted that applications with a dynamic workload requirement deployed via any cloud services provider's platform would need access to a flexible infrastructure to meet implementation assurances to reduce resource costs and external threats. The conceptual framework confirmed that the solution maturity stage is one of the phases disrupters experience when new technology is adopted; so, in the

solution maturity stage, disrupters need a systematic way to address priorities, such as release systems and communications methods with all the end-users of the technology, as this forms part of the success in using the new technology (Alnafessah et al., 2021). Public and private cloud joint utilization is made possible by the cloud service providers in the form of a hybrid cloud due to cloud computing innovation the cloud service providers invested in. The hybrid cloud is the IaC implementation strategy used by 7 out of 7 of the participants that took part in this study, and 55 out of 58 of the IT industry documents validated that cloud service providers are IaC implementation strategy; thus, Theme 3 is supported by the conceptual framework as the findings remained consistent with DIT.

***Literature Comparison and Support***

Cloud services providers enabled IaC as cloud-agnostic (Greenstein, 2020). Amongst cloud service providers, the IaC strategic deployment and management tools are unanimously supported by all the cloud service providers, making IaC a cloud-agnostic and disruptive innovation for infrastructure design, deployment, and management in the IT industry (Emeras et al., 2019). And while enterprises are deploying more multi-cloud resources using IaC, it is obvious that their IT budgets are increasingly going to cloud service providers. The majority of the cloud service providers support managed services capable of offering IaC-compatible services such as Redhat OpenShift on AWS, Cloud Pak for Data, et al. (Gandhi et al., 2020).

According to Goode (2020), Microsoft Azure Cloud, AWS Cloud, and GCPs are big data, and analytics workloads cloud service dominants in the IT industry. The author

verified that hybrid cloud and traditional data c cloud service provision are dominated by IBM, Dell Technologies, Hewlett-Packard Enterprise, and VMware. These cloud service providers offer different kinds of cloud deployment models, service models, and tools that support IaC implementation. Terraform is one of the widely used IaC tools in the IT industry. It is software with incredible flexibility, supporting all the major cloud service providers, including; AWS Cloud, Google Cloud, and Azure Cloud. The literature supports the study's findings of Theme 3 with consistency aligned with previous work in cloud computing and cloud service providers.

**Table 6**

*References of Major Theme 3: IaC Cloud Service Providers*

| Major theme | Participants | | Documents | |
|---|---|---|---|---|
| | Count | References | Count | References |
| IaC cloud service providers | 7 | 347 | 55 | 3621 |

*Note.* $\Omega_1$=7, $\acute{\omega}_1$=7, $\Omega_2$=58, $\acute{\omega}_2$=55. See Appendix H.

**Theme 4: IaC Configuration Best Practices**

Theme 4 (IaC configuration best practices) emerged through the participants ' transcripts and IT industry documents in the study findings. The occurrence summary of the theme is shown in Table 7. The participants 'transcript files and IT industry document verified that IaC configuration best practices include: break-fast, low-nesting, config management, reusability of abstraction, secret injection, and use of vaults for secrets.

***Findings From Participants***

Participant 1 revealed that “in the IaC configuration, he applies reusability of abstraction and cost-saving to improve configuration security”; the participant added that in their “hybrid cloud environment where IaC is implemented,” so emphasized that “they use multiple clouds (private from IBM and public cloud from AWS) for efficient application delivery.” The participant also confirmed that this strategy gives their organization “a cost-efficient platform to deliver cloud resources using the IaC approach because it delivers the ability and liberty to move between various cloud platforms as per the needs and convenience.” Participant 2 confirmed that “using a low-nesting approach is part of their IaC implementation strategy.” Participant 3 verified that “secret injections are best practices in IaC implementation regarding security.” Participant 4 confirmed that he uses “default config management built into DevOps tools” to implement IaC. Participant 5 indicated that he uses “third-party secret vault software for secret management in their organization.” Participant 6 agreed with participant 2 that “low-nesting is a good strategy because of the enhanced security it enforces.”

Participant 7 agree with Participant 1 that the reusability of abstraction is an effective strategy in IaC implementation; and that vaults usage in IaC implementation is also one of their organization’s implementation strategies when handling sensitive configuration objects. Participant 7 also added that “Ansible is a configuration as code tool that provides roles that are a set of tasks that work together to solve a problem.” The participant added that “these roles can be imported on Playbooks in Ansible, which tune the needed variables or configuration and just run.” Participant 2 revealed that

"Terraform is a tool to create and maintain infrastructure and resources, commonly from cloud providers such as IBM, Azure, AWS, GCP, and Azure." The participant stressed that "in terraform configurations, you can import Modules which is great about Terraform configuration because you can find community-supported modules in Terraform. The modules are officially supported by cloud service providers, which users can find tons of it at Terraform Registry." The findings indicated that all the participants' confirmed Theme 4 through 7 transcripts in 230 references in the data sources.

***Findings From IT Industry Documents***

The IT industry document-49 revealed secret injection "as an alternative to vault usage in secret configuration management in the IaC approach." IT industry document-20 verified that "applying IaC configuration strategies such as secret injection and vaults usage allows IT, practitioners, to handle the security components of IaC implementation for sensitive data in terms of security." IT industry document-58 verified that "using vault for secrets in the IaC approach and reusability of abstraction is a good security strategy." IT industry document-15 verified that "the reusability of abstraction under IaC configuration is part of IT industry security best practices." IT industry document-12 stated that "IaC configuration and its version control capabilities give IT practitioners the flexibility of managing secrets and sensitive data in the implementation procedure."

IT industry document-10 verified that "IaC allows the deployment of infrastructures with security configuration that reads from a third-party vault." IT industry document-18 revealed that "low-nesting is one of the features IaC introduced as configuration best practices to enhance infrastructure management." IT industry

document-44 verified that “reusability of abstraction is an important feature IBM offers through its IaC schematics.” It added that “the possibility of version control committing and rolling up a new deployment using the included IaC configuration management contributes to the security feature utilization in IaC IT infrastructure design and implementation as part of the new technology stack principle incorporated into IaC innovation.” The findings indicated that 51 IT industry documents confirmed Theme 4 in the data sources.

### *Connections to the Conceptual Framework*

According to Hou et al. (2019), new technology adoption in organizations’ technology modernization is the core part of the DIT theorem. The disruptive innovation technology concept assumes a critical role in any organization’s innovation structure strategies to align with the organization’s operating model. Christensen(1997), in the DIT model applied to this study, stated that disruptive innovation generates new products and values for organizations to disrupt existing ones, such as existing technology concepts. Zhu et al. (2019) emphasized that in the stance of the DIT, IaC's inclusion of configuration best practices as part of its implementation strategies disrupted the incumbent approach in implementing IT Infrastructure in cloud computing. Carney (2020) verified that new technologies might help organizations adapt them to create a sustainable strategy in their various business models, which can offer an opportunity to inherit the positive impacts of the new technologies embedded in several approaches. The author stressed that organizations could unlock innovation through flexible configuration and implementation approaches such as reusability of abstraction, low-nesting, break-

fast, configuration management, and consumption of secret vaults as part of configuration best practices. The conceptual framework supported Theme 4 findings.

Gil et al. (2020) emphasized that a technology stack is a set of tools for implementing intended IT innovation. Therefore, as a rule, a tech stack consists of programming approaches, libraries, programming languages, various development tools, and frameworks (Fernández & Valle, 2018). The combination of all of the above defines the viability and effectiveness of the product, scalability, functionality, and further support. IaC possesses all these properties; in terms of programming languages, IaC tools such as Terraform have their programming language known as HashiCorp Configuration Language (HCL) and other IaC tools where others use JSON compatible language to adapt to the innovation delivery purposes in cloud computing. The incumbent approach in developing IT infrastructure lacks the possession of programming languages. It thus is disrupted by IaC strategies that operate with various programming languages as a code-centric solution for IT infrastructure design, development, and deployment (Rafi et al., 2020b). This, in return, offers rapid deployment concerning disaster recovery. Organizations that are proponents of automated and rapid infrastructure deployment would adopt IaC strategies rather than reject them.

***Literature Comparison and Support***

IaC approach has the automation capabilities to configure infrastructure resource dependency mapping such as secret and defensive data in the provision of instances in the cloud using any of the cloud computing deployment models (Sandobalín et al., 2020). The speed of infrastructure provisioning, while users automate any IT resources on any

cloud service provider's platform using the IaC configuration of the organization's choice, is why IaC disrupts the incumbent approach in the market (Rao et al., 2019). Another is that it improves consistency, such that it helps to eliminate the risk of mismatched environments for development, test, and production; and IaC provides more efficient development such that it helps to accelerate every phase of the IT infrastructure delivery lifecycle, including development provisioning, sandbox provisioning, User Acceptance Test (UAT) provisioning and any environmental set up as a new technology concept in IT infrastructure design and deployments (Almoghathawi & Barker, 2020)

Christensen et al. (2018) emphasized that new technologies provide new strategies and patterns for technology implementation using new best practices, including security configuration improvement patterns and strategies that prevent technology security loopholes and vulnerabilities faced by the incumbent technologies. It added that incumbent technologies are more vulnerable to security threats because they use older technology security configurations already explored by cyber attackers. The authors stressed that new technologies often help improve Return on Investments (ROI) in cloud computing because they help the implementing team to have the ability to benefit from cloud computing's consumption-based cost structure fully and models which are offered by all the cloud service providers in the IT industry (Alnafessah et al., 2021).

**Table 7**

*References of Major Theme 4: IaC Configuration Best Practices*

| Major theme | Participants | | Documents | |
|---|---|---|---|---|
| | Count | References | Count | References |

| | | | | |
|---|---|---|---|---|
| IaC configuration best practices | 7 | 230 | 51 | 1762 |

*Note.* $\Omega_1$=7, $\acute{\omega}_1$=7, $\Omega_2$=58, $\acute{\omega}_2$=51. See Appendix H.

**Theme 5: IaC DevOps Practices**

Theme 5 (IaC DevOps practices) emerged from data sources from participants and IT industry documents. The frequency occurrence summary of the theme is shown in Table 8 below. Both the participants and the IT industry documents verified that core IaC DevOps practices include: ArgoCD, Automated Deployment, Artifactory, AzureDevOps, CICD, Continuous Delivery (CI), Continuous Integration(CD), Git(Github), GitOps, Octopus Deploy, Pipelines, Tekton, and Version Control.

***Findings From Participants***

Participant 1 revealed that he uses the "CICD pipeline in all his IaC implementation of IT infrastructures." Participant 2 indicated that he uses "Terraform as his core IaC tool there; part of the strategies in DevOps is to use the AzureDevops pipeline for automation of the deployment." Participant 3 indicated that the company he works for, "a financial institution, uses IBM Cloud and Redhat OpenShift; thus, they are using Tekton and ArgoCD as part of their DevOps practices IaC implementation, which they deliver with terraform."

Participant 4 revealed that he uses "automated deployment as part of IaC delivery in the DevOps procedure because it helps rapid disaster recovery for IT infrastructures." Participant 5 verified that "continuous integration(CI) is of great importance in his IaC DevOps strategy because it incorporates infrastructure" and "application as one solution."

Participant 6 agrees with Participant 1 but added that he also “considers CICD in the DevOps procedure when implementing the IaC solution.” Participant 7 verified that he agrees with Participants 5 and 6 but added that “using Git, Github, and AzureDevOps are his DevOps repeatability strategies in IaC implementation.” The findings indicated that all the participants ’confirmed Theme 5 through 7 transcripts in 231 references in the data sources.

***Findings From IT Industry Documents***

IT industry document-38 verified that “continuous integration is an integral part of IaC implementation in cloud computing.” IT industry document-24 validated that “continuous integration and continuous delivery offered by Tekton and ArgoCD supports the implementation of IaC schematics using terraform to present enhanced infrastructure design” and “implementation in hybrid.” IT industry document-33 confirmed that “Microsoft offers AzureDevOps, which supports IaC implementation using Git and the pipeline mechanisms.” IT industry document-31 verified that the IaC approach is “compatible with a wide range of DevOps practices which primarily utilizes Git as version control to promote reusability in the IT infrastructure deployment techniques.” IT industry document-26 revealed that “DevOps practices are important in the IaC implementation, so they offer antifactory to support IaC delivery using packages and containers.”

IT industry document-49 verified that “CICD pipelines as part of the DevOps procedure help deliver Kubernetes services compatible with IaC implementation.” IT industry document-27 revealed that “terraform, a major tool in implementing IaC in

cloud computing, is supported by all DevOps CICD methodologies to offer rapid deployment of IaC within any cloud service provider's platform." IT industry document-48 revealed that "automated deployment as part of DevOps practices is the foundation of the procedures that offered IaC implementation its repeatability capabilities." IT industry document-42 supported the views of "AWS and Azure" and added that "IaC implementation would not have achieved its repeatability capabilities without DevOps practices such as Git." IT industry document-07 indicated that the "IaC approach is better than the standard(incumbent) approach because it supports DevOps procedures such as CICD to provide repeatability, rapid deployment of IT infrastructures," and "immutable state infrastructure delivery." It added that "IaC provides an immutable state of implemented IT infrastructure," which is "beneficial because it offers additional reliability and dependability in the provisioned Infrastructure and supplementary regular implementation DevOps practices for repeatability in disaster recovery." The findings indicated that 44 IT industry documents confirmed Theme 5 in 1209 references in the data sources.

***Connections to the Conceptual Framework***

Dalla Palma et al. (2020) emphasized that repeatability is essential in DevOps practices as part of the new technologies introduced by innovations such as IaC used in IT infrastructure deployment. It is because if the user needs to adjust any IT infrastructure to repeat the installation or update it, the IaC source code can be edited and reprovisioned, which is the new technology method introduced by the IaC approach not obtainable in the incumbent IT infrastructure implementation approach (Rahman &

Williams, 2019). Part of the benefits emphasized by DIT in this study is that to interest and retain new and more customers in a technology operating market; all organizations must continuously think of new competencies, products, strategies, services, and creative ways to package these attributes for effective technology sales (Christensen et al., 2018). Cloud computing in business takes all of these to the low-end and high-end markets for disruption.

The conceptual framework (DIT) promotes the use of new technologies in the implementation of resources in cloud computing in; which the framework suggests that companies can have an effective business operation in the utilization of cloud computing resources when running businesses if they apply new technology methods in their implementation instead of continuous use of incumbent technologies; thus, the conceptual framework supported Theme 5 because repeatability is a new technology concept embedded into IaC solution which if any organization adopts IaC it may help such organization in a disaster discovery situation (Rahman et al., 2020b). DIT is also defined as a process by which a product or service operates primarily with minimal functions at the low-end of a market, then persistently moves up to the market's high-end, and eventually displaces any competing incumbent product or service in the same operating market (NIST, 2018).

***Literature Comparison and Support***

Greenstein (2020) emphasized that DevOps practices improve application deployment and management life cycle using the IaC approach. IT solution architects and practitioners could rapidly provision development sandboxes and continuous integration-

continuous deployment server environments using the IaC approach (Li et al., 2018a). DevOps lifecycles procedures integrated as new technology techniques in the IaC approach are extremely useful and innovative because, through the IaC approach, configuration libraries that contain the IT infrastructure specifications are easier to manage, distribute, and reuse the algorithm (Aluya, 2018a). It also ensures that users provide the same environment without discrepancy but with utmost consistency (Rahman et al., 2019a).

DIT emphasized that even when new technologies are tremendously useful and innovative, they cannot work in isolation. They need a platform to run alongside other technologies for integration to allow implementers to install and configure to get them working in terms of developments and operations, known as DevOps in cloud computing (Cervera, 2019). Solution architects and cloud service providers may be enticed to a particular technology if it fills a gap in their offerings or recognizes a meaningful cost-saving gain from incorporating this new technology into their services (Sandobalín et al., 2020). IaC DevOps best practices revealed by the participants and IT industry findings in the study confirmed that the DevOps practices confirmed by the findings are filling the gaps left by the incumbent IT infrastructure design and implementation approach (Aluya, 2018b). The literature supported Theme 5.

**Table 8**

*References of Major Theme 5: IaC DevOps Best Practices*

| Major theme | Participants | | Documents | |
|---|---|---|---|---|
| | Count | References | Count | References |

| | | | | |
|---|---|---|---|---|
| IaC DevOps best practices | 7 | 231 | 44 | 1209 |

*Note.* $\Omega_1$=7, $\acute{\omega}_1$=7, $\Omega_2$=58, $\acute{\omega}_2$=44. See Appendix H.

**Theme 6: IaC Implementation Tools**

Theme 6 (IaC implementation tools) emerged through the participants, and the IT industry documents data sources in the study's findings. The counts and references of the theme occurrence summary are shown in Table 9 below. Both participants and the IT industry documents verify that the core IaC implementation tools are: Ansible, ARM, Chef, Cloudformation, Cloudify, Docker, Dockerfile, Git, Kubernetes, OpenShift, Packer, Puppet, SaltStack, Terraform, TOSCA, and Vagrant. These tools are the core delivery focal point of IaC solutions as they operate as agnostic tools in implementing IaC.

***Findings From Participants***

Participant 1 indicated that the "IaC tools are cloud-agnostic in most parts" and "Terraform's efficiency indicates it in IaC implementation and strategies." Participant 2 revealed that one of their organization's major tools for IaC implementation is "Ansible, which is also cloud-agnostic and compatible with IaC." Participant 3 indicated that "their company's major IaC approach tools are ARM, Chef, Terraform, Docker, and Dockerfile to form a core part of their IaC implementation strategies." Participant 3 indicated that their company uses "Cloudify, Git, OpenShift, and Packer." Similarly, Participant 4 revealed that their company uses "Puppet, SaltStack, TOSCA, and Vagrant." Participant

5 verified that their company's core IaC tools are "Git, Terraform, Dockerfile, Kubernetes, and OpenShift."

Participant 6 verified that their company's IaC implementation tools are "Terraform, Docker, ARM, Git, Kubernetes, and Chef." Participant 7 indicated that their company uses "Ansible, Docker, Dockerfile, and SaltStack as IaC implementation tools." The participant added that "Terraform is IaC's most used cloud-agnostic tool because it is supported by third-party providers and multiple cloud service providers, thereby allowing the users to incorporate any cloud provider of their choice into their Infrastructure as a code design when implemented." The findings indicated that all the participants ' confirmed Theme 6 through 7 participants' transcripts in 345 references in the data sources.

***Findings From IT Industry Documents***

The IT industry document-24 verified "OpenShift and Terraform as core IaC tools." IT industry document-49 verified that "Terraform, Git, Kubernetes, and Docker are all core IaC tools." IT industry document-18 verified that its major IaC tools are "Git, Terraform, and Kubernetes." IT industry document-30 verified that most cloud service providers support a wide range of IaC tools: "Ansible, ARM, Chef, Cloudformation, Cloudify, Docker, Dockerfile, Git, Kubernetes, OpenShift, Packer, Puppet, SaltStack, Terraform, TOSCA, and Vagrant."

IT industry document-03 verified that they implement the IaC approach using "Ansible, ARM, Chef, Cloudformation, Cloudify, Docker, Dockerfile, Git, Kubernetes, OpenShift, Packer, Puppet, SaltStack, Terraform as core IaC tools." IT industry

document-04 verified that IaC tools are primarily “Terraform and Git.” IT industry document-48 and IT industry document-08 verified that “Kubernetes, Terraform, and Git are fundamental IaC tools.” IT industry document-38 verified that the IaC approach in the “deployment of resources in AWS Cloud could be achieved using Terraform and Cloudformation.”

IT industry document-27 verified that “Terraform as IaC basic tools are supported by all the cloud service providers.” IT industry document-57 indicated that “its cloud platform supports Terraform and ARM as IaC tools.” IT industry document-42 revealed that “Git is the central IaC implementation tool because it delivers the versioning and reusability of IaC to deliver the new technology’s expectations.” IT industry document-19 also agrees with the participants ’views on “Git,” and the journal added that “new technologies help organizations to achieve business objectives as well as have the ability to patch or replace incumbent designed infrastructures as version control software such as Git enhances IaC implementation reusability and code management to offer repeatability.” The findings indicated that 42 IT industry documents confirmed Theme 6 in 1222 references in the data sources.

***Connections to the Conceptual Framework***

DIT theorem by Christensen (1997) advised that organizations can achieve their business objectives if they are ready to embrace new technologies and go through new technology maturity stages to achieve business success instead of rejecting the new technologies. Li et al. (2019) confirmed that IaC as new technology as validated in this study's findings through the participants and the IT industry documents that most of the

IaC tools used as part of IaC implementation strategies help organizations succeed. DIT indicated that disruptive innovation identifies technology areas that the incumbent solution has not been fully explored previously, such as repeatability approaches when implementing IT infrastructure (Muller, 2020).

The area IaC explored in this study is to help organizations consider new approaches to running their business applications with the incumbent approach, which has limitations. Christensen et al. (2018) verified that disruptive innovation is based on disruptive technology, making products break away from the original technical track, enter new markets, and gradually occupy the dominant market. NCBI (2021c) emphasized that disruptive technology takes advantage of where the incumbent failed and then used it to thrive in the market. Theme 6 revealed many IaC implementation tools that are not applicable and available to the incumbent implementation approach; this confirmed that the IaC implementation approach capitalized on the gaps of the original technical track of infrastructure implementation(incumbent) to introduce a set of new implementation tools. The conceptual framework supported Theme 6.

***Literature Comparison and Support***

Yeganeh et al. (2019) emphasized through an analysis of Cloud computing fundamentals that computing resources such as applications, virtual servers, physical servers, development tools, and data storage are hosted at an isolated data center managed by cloud services providers to support various infrastructure implementation tools. Cloud service providers such as AWS, Azure, Google Cloud, IBM Cloud, Alibaba Cloud, Salesforce, Oracle Cloud, and Tencent Cloud provide their end-users with inbuilt

infrastructure implementation tools that can be used to run a business or applications at the production level (Goode, 2020). DIT clarified that in the new technology maturity first stage, technologies might be acquired or developed from scratch by large IT organizations who are enthusiastic about experimenting and investing in the new technology tools for long-term purposes because of the recognized benefits of the new technology that aligned with the organization's technology goals (Christensen et al., 2018).

Rahman et al. (2019a) emphasized that such organizations may see a long-term promise and the opportunity to realize a substantial competitive advantage by being the first with new capabilities in their operating industry, or they may recognize the value of the new technology and knowledge they need to dig in for the long term to realize the value of the new technology. Rahman & Williams (2019) clarified that these are advantages of implementing new technologies by early adopters who often engage directly with inventors to solve technical challenges locally. IaC implementation tools, as Theme 6 revealed by the findings, are recognized by the conceptual framework as new tools worth investing in by early adopters of the IaC approach. Rahman et al. (2020b) expounded that version control is an essential part of IaC implementation tools; they revealed that users 'IaC configuration files are kept under source control just like any other software source code file. Aluya (2018a) stressed that deploying IaC also means that users can divide their infrastructure into modular components that can be shared in different ways through automation in the development lifecycle.

**Table 9**

*References of Major Theme 6: IaC Implementation Tools*

| Major theme | Participants | | Documents | |
|---|---|---|---|---|
| | Count | References | Count | References |
| IaC implementation tools | 7 | 345 | 42 | 1222 |

*Note.* $\Omega_1$=7, $\acute{\omega}_1$=7, $\Omega_2$=58, $\acute{\omega}_2$=42. See Appendix H.

**Theme 7: IaC Kubernetes Platforms**

Theme 7 (IaC Kubernetes platforms) emerged from participants' transcript files and IT industry document journal articles. The occurrence summary of the theme is shown in Table 10. Both the participants ’data sources and IT industry documents verified that IaC Kubernetes platforms comprise: ACK (Alibaba Cloud Kubernetes), DOK (DigitalOcean Kubernetes), AKS (Azure Kubernetes Services), EKS (Elastic Kubernetes Services), GKE (Google Kubernetes Services), OpenShift (IBM/Redhat OpenShift Container Platform), and OKE (Oracle Cloud Kubernetes).

***Findings From Participants***

Participant 1 revealed that their company uses “OpenShift in a hybrid cloud deployment model for IaC implementation.” Participant 2 indicated that their company uses “AKS in a hybrid cloud deployment model for IaC implementation.” Participant 3 stated that their company uses “EKS in private cloud deployment models for IaC implementation.” Participant 4 revealed that their company uses “ACK in multi-cloud deployment model for IaC implementation.” Participant 5 indicated that their company

uses “AKS and OpenShift in a hybrid cloud deployment model for IaC implementation.” Participant 6 stated that their company uses “GKE and DOK to deliver IaC implementation for clients.” Participant 7 revealed that their company uses “OKE in IaC implementation on hybrid cloud deployment model.”

Participants 1 and 4 stated that “there is a time factor in disruptive innovation application.” As a result, “organizations are expected to be given time to mature when new technology is adopted,” which is the same as the incorporated Kubernetes platforms in the IaC approach. Participants 6 and 7 added that “this is to say that the principle of continuous learning Kubernetes platforms exists when organizations adopt the IaC approach.” Participant 6 emphasized that “Kubernetes is a cloud resource that can be deployed using the IaC approach and all its networking topology deployed simultaneously.”

Participant 1 added that the “DevOps procedure help in knowledge transfer of the new technologies inherited in the IaC approach as the organizations that adopted IaC mature gradually with the help of DevOps procedures that supports Kubernetes platforms.” Participant 4 stated that “Kubernetes is also known as K8s, and it is also known as a system for automating infrastructure deployments, scaling, and managing containerized applications builts using the IaC approach.” According to Participant 2, “K8s groups containers that make up applications and infrastructures into coherent units for easy administration and discovery.” The findings indicated that all the participants’ confirmed Theme 7 through 7 participants' transcripts in 231 references in the data sources.

***Findings From IT Industry Documents***

The IT industry document-54 verified that "OpenShift, EKS, and AKS dominate the IT industry as major IaC implementation tools that deliver Kubernetes for containerization to hybrid cloud." IT industry document-26 revealed that "OpenShift delivered by IBM/Redhat is a major IaC implementation tool concerning Kubernetes application delivery." IT industry document-38 verified that "EKS is a dominant Kubernetes platform compatible with the hybrid cloud solution for the IaC approach." IT industry document-56 revealed that "AKS is part of its major Kubernetes platforms used in IaC implementation." IT industry document-40 indicated that "Openshift, AKS, and EKS are the IT industry's leading Kubernetes platforms used for IaC implementation"; the journal added that the "financial market highly prefers IBM/Redhat's OpenShift because of its ability to deliver Kubernetes and Cloud Pak for Data(CP4D) required by these companies in delivering critical-mission applications by using IaC approach."

IT industry document-48 revealed that "as the inventor of Kubernetes, what triggered the innovation was that at the launch of their IaaS platform Google Compute Engine, they noticed an interesting delinquent: customers were remunerative for a lot of CPUs, but their consumption rates were tremendously low because they were running VMs which was incumbent at the time"; thus, to solve the problem they invented "Kubernetes platform which is an innovated not used by all the cloud service providers globally to implement IaC solution." IT industry document-14 in the study findings revealed that "because of the high demand for IaC implementation platforms," "IBM acquired Redhat to boost their digital reinventions to meet the IaC market demand,

especially for organizations looking for continuous delivery mission-critical applications or software." IT industry document-48 also verified that "K8s builds upon a concept of running production-level workloads at Google and combined with the best ideas from IaC innovation to deliver IaC best experience using Kubernetes services." IT industry document-20 verified that "Google invented Kubernetes as cloud-native innovation to enhance infrastructure and containerization design and implementation." The findings indicated that 41 IT industry documents confirmed Theme 7 in 2121 references in the data sources.

### *Connections to the Conceptual Framework*

According to Christensen (1997) in DIT theory, organizations could be successful if they adopt new technologies; therefore, some organizations are keen to adopt new technologies such as the Kubernetes platform as a new technology in an attempt to move mission-critical workloads across the clouds are advised by DIT to allow maturity time once it adopted any new technology. It is because the success of the adoption is revealed by the maturity time of the technology within the organization (Han et al., 2020). IaC helps modernize applications in the cloud; thus, organizations are taking advantage of this new technology brought by IaC in modernizing Infrastructure and moving mission-critical workloads across hybrid and private clouds (Rahman et al., 2020b).

While the IaC approach offers new technologies opportunities that may create a learning curve for disrupters, DevOps practices support incremental processes in implementing Kubernetes services compatible with the IaC approach in cloud computing (Hemphill, 2019). Regarding IaC incremental strategy, when deploying IaC resources in

the cloud, the user would specify that the deployment is either an incremental update or a complete update (Jin et al., 2020). The difference between these two deployment modes is how the DevOps pipelines handle resources in the template configuration (Kwon and Lee, 2020). The study findings showed that their Ids could consume existing IaC resources for an update, a technology feature the incumbent approach cannot provide in IT infrastructure design and implementation.

***Literature Comparison and Support***

Rademacher and Wagner (2020) confirmed Kubernetes' effectiveness in IaC implementation. Hemphill (2019) emphasized in the study of "Cloud Services Providers Enabled IaC as Cloud Agnostic" that Kubernetes is a fundamental resource in implementing IaC. Lin et al. (2019) added that the leading cloud service providers such as AWS, Azure, and Google offer Kubernetes platforms such as EKS, AKS, and GKE, respectively, to enable IaC implementation of a cloud-agnostic innovation in the IT industry. The authors verified that to handle the dynamic change of application load in infrastructure architecture, elastic scaling of the resource is an important characteristic of the Kubernetes container cloud platform, making it a viable candidate in the IaC implementation strategy.

Under the study's literature review on IaC Implementation Automation Strategy, Han et al. (2020) emphasized that Kubernetes is one of the inevitable strategies in IaC implementation that can practically build and deploy applications seamlessly with Docker without paying attention to what programming language the IT practitioner used to build the microservices application backend. Raji et al. (2020) clarified that when the load of

the application running on the infrastructure is too high, Kubernetes increases the supply of resources on-demand; on the other hand, when the load of the application decreases in the infrastructure, the idle resources are recycled, thereby reducing costs and increasing resource utilization in the system which is typical IaC objective. Lescisin and Mahmoud (2021) verified that part of the Kubernetes innovation objective is to run its cluster as Docker containers to make it cloud agnostic in the IaC implementation strategy that the literature supported Theme 7.

**Table 10**

*References of Major Theme 7: IaC Kubernetes Platforms*

| Major theme | Participants | | Documents | |
|---|---|---|---|---|
| | Count | References | Count | References |
| IaC Kubernetes platforms | 7 | 231 | 41 | 2121 |

*Note.* $\Omega_1$=7, $\acute{\omega}_1$=7, $\Omega_2$=58, $\acute{\omega}_2$=41. See Appendix H.

### Theme 8: IT Infrastructure Implementation Approaches

Theme 8 (IT infrastructure implementation approaches) emerged through participants' transcript files and the IT industry document journals. The occurrence summary of the theme is shown in Table 12 below. The participants' transcripts and IT industry documents verified that IT infrastructure implementation approaches comprise the IaC and Standard (incumbent) approaches. Both findings verified that organizations' IT practitioners prefer the IaC approach more than the Standard approach because of its automation capabilities, IT infrastructure disaster recovery enhancements, and cost

savings in implementation due to reusability effects and rapid deployment. Theme 8 supported Theme 1.

***Findings From Participants***

Participant 1 revealed that the "IaC approach implements new technologies to improve rapid infrastructure deployment and reduce prolonged disaster recovery while the standard(incumbent) lacks this ability." Participant 2 stated that their "company's CTO approved adopting the IaC approach because of its ability to prevent environment drift that their company has experienced using the Standard approach for nearly 10 years." Participant 3 indicated that their "Chief Technology Officer(CTO) and the Chief Financial Officer(CFO) approved the adoption of the IaC approach because of its cost-savings benefits." Participant 4 stated that the "IaC approach is 60 times faster to implement than the standard (incumbent) approach as part of the IT infrastructure's desired design practices." Participant 5 revealed that their "organization for 8 years had a series of problems with the Standard approach, after which their Vice president of Technology approved adopting the IaC approach."

Participant 6 confirmed that their "organization adopted the IaC approach because of its idempotence capability." Participant 7 indicated that the "standard(incumbent) approach caused their organization to lose $10.4 million four years earlier because of more extended downtime during their infrastructure failure disaster recovery", which took "3 weeks to reinstate completely"; the participant highlighted that "it was because standard(incumbent) approach which their organization used to build the Infrastructure does not support reusability or automated re-deployment" during "failure," therefore after

the “technical incident of four years ago, their organization’s IT leadership tasked them to adopt IaC approach in the implementation of the organization’s Infrastructure which they embraced with its new technology concept.” All the participants agree that the IaC approach in implementing IT infrastructure comprises new technologies and may require a learning curve for solution architects or IT practitioners. . The findings indicated that all the participants’ confirmed Theme 8 through 7 participants transcripts in 309 references in the data sources.

***Findings From IT Industry Documents***

The IT industry document-57 and industry document-40 revealed that “IaC implementation strategies manage and provision an organization’s IT infrastructure using machine-readable configuration files,” rather than employing physical hardware configuration or “manual interactive configuration tools as offered by the Standard approach in IT infrastructure implementation.” IT industry document-54 revealed that “organizations are at an advantage when using the IaC approach because it supports machine-readable automated re-deployment in infrastructure failure disaster recovery.”

IT industry document-42 indicated that “they recommend that organizations embrace the new technology and its learning curve offered by the IaC approach because of its enhancement in disaster recovery.” It added that “most cloud computing infrastructure is being hosted in data centers owned by various cloud service providers,” supporting the IT industry's " IaC approach.” IT industry document-38 indicated that the “IaC approach provides automation and reusability.” Contrarily, the standard approach is incumbent in the industry and does not provide automation and reusability; thus, it lacks

newer technologies in deploying IT infrastructure resources like the EC2. IT industry document-58 stated that the IaC approach offers automation benefits in implementing infrastructure resources in cloud computing.

IT industry document-24 stated that the "OpenShift container platform (OCP) offers the ability to deploy Cloud pak for data services" using the "IaC approach in the hybrid cloud, which is a huge benefit for their global customers seen in their data a year earlier for the go-to-market(GTM) report." IT industry document-30 added that "part of the IaC approach's benefits is the automation and reusability capabilities not offered by the Standard (incumbent) approach." IT industry document-48 stated that in "the present-day IT industry, where the internet of things and artificial intelligence" applications are in "higher demand," thus, the "IaC approach is the preferred strategy in implementing IT infrastructure resources because of its rapid deployment capabilities."

IT industry document-50 revealed that the "IaC approach was their vision in developing Terraform," which is "currently the most used IaC implementation tool in the IT industry" because all the cloud service providers now support the use "of Terraform in the implementation of IaC in the cloud." IT industry document-50 added that "within the last four years, they had recorded over 70% of their new customers from different cloud service providers that converted their organization's Standard (incumbent) built IT infrastructures to IaC built IT infrastructures"; and that they all employed "Terraform as their basic IaC tool in the process as IaC approach is agnostic which Terraform supports." IT industry document-51 predicted that "the future of IT infrastructure design and

implementation in the IT industry leaned more toward the IaC approach" than the "Standard approach." The findings confirmed Theme 8 in the data sources.

***Connections to the Conceptual Framework***

Christensen (1997), in the DIT theorem, proposed that companies could develop a successful operational model with IT infrastructure if their IT leadership supports new technology innovation adoption instead of refusing to acknowledge the new technology or avoid new technology innovation implementation. Strategies to create new market products using IT align with adopting the right IT infrastructure that supports automation and reusability (Christensen et al., 2018). The strategies used in IaC implementation by solution architects from the findings in both participants and IT industry data sources showed that the IaC approach accepts new technologies by organizations or disrupters. The findings in Theme 8 aligned with the conceptual framework (DIT) because all the participants stated that their managers or IT leadership supported the idea of using new technologies introduced by the IaC approach because of its benefits over the Standard(incumbent) approach.

All the participants unanimously confirmed that adopting the IaC approach helped their respective companies achieve their business objectives and be successful in their operations. The findings data from the participants and the IT industry documents for infrastructure implementation approaches proved the conceptual framework using knowledge representation in Theme 8. According to Rahman et al. (2019a), part of the importance of the IaC approach is that it helps organizations configure infrastructure resource dependencies automatically. It also helps organizations to have the ability to

provide local and remote instances automatically with ease (Qi & Tao, 2019). It was justified by the participants ’responses when asked which IT infrastructure design practice provides automation and ease in provisioning instances.

***Literature Comparison and Support***

The literature of this study discussed IT infrastructure approaches, supported the IaC approach under Evolutionary Studies on Technology Innovation, and verified that IaC's rapid delivery capabilities result from incorporated technology innovation in the approach (Jeon et al., 2020). According to Gandhi et al. (2020), they emphasized that IaC delivers faster with automation capabilities that provide important velocity in the provisioning of infrastructures architecture when used with the development and operation procedures for various purposes by the organization, and this is not limited to testing, development, and production, or scaling-out and scale-in use cases. Since IaC is classified as disruptive innovation by the findings, the positive impacts of disruptive technologies in the low-end and high-end market are characterized by its low-end disruptive innovation and high-end disruptive innovation fingerprints in three tiers: Performance measures, Existing customers, Incumbent reaction, and Value network (Siddiqi et al., 2020). See Table 11.

According to Christensen et al. (2018), disruptive technologies have important impacts on the market under three distinctive criteria: Performance measures that impact the low-end market concerns standard products and on the new market vary from the typical product; Existing customers whose impacts on the low-end market work for entrants and the new market vary from the typical product; Incumbent reaction which on

the low-end market desert the low-edge market advertisement and the new market entrants barely use the product (El-Sayed et al., 2018), and Value network which it impacts on the low-end market starts the same as the existing products, and on the new market customer adopt it over time with the help of its maturity influence (Sekaran et al., 2019). Maturity time for disruptive innovation products is the foundation of its success because organizations need to undergo a learning path if the new technology's elements require human training and knowledge transfer (Rahman et al., 2019a). NIST (2018) verified that part of IT infrastructure implementation options and its fundamentals, major cloud service providers' support in the IT market supports IaC implementation approach because of its reusability and automation benefits that the incumbent lacks. The literature supported Theme 8 findings.

**Table 11**

*Model of Disruptive Innovation*

| Disruptive innovation criteria | Low-end market disruptive innovation | New-market disruptive innovation |
|---|---|---|
| Performance measures | Concerning standard product or service | Varies from the typical product or service |
| Existing customers | Works better for newentrants because the existing products or services were high-priced | Varies from the typical product or service |

| | | |
|---|---|---|
| Incumbents' reaction with upward trajectory | Desert the low-edge advertise market section and extend the high-edge market section | New entrants have not used or purchased these products |
| Value of maturity time | Starts the same as theexisting organizations | Disregard and overtime, it adopts the customers that cannot afford the high-end technology |

*Note.* Adapted from "Disruptive Innovation: An Intellectual History and Directions for Future Research," by C. Christensen et al. (2018), *Journal of Management Studies, 55(7) 1043-1078*. Copyright 2018 by Christensen et al., an attribution to NonCommercial-NoDerivatives 4.0 International permission (see Appendix K).

**Table 12**

*References of Major Theme 8: IT Infrastructure Implementation Approaches*

| Major theme | Participants | | Documents | |
|---|---|---|---|---|
| | Count | References | Count | References |
| IT infrastructure implementation approaches | 7 | 309 | 51 | 1252 |

*Note.* $\Omega_1$=7, $\acute{\omega}_1$=7, $\Omega_2$=58, $\acute{\omega}_2$=51. See Appendix H.

## Application to Professional Practice

This study explored the strategies used by IT solution architects to implement IaC architecture using DevOps procedures in cloud computing. The findings of this study, in

conjunction with an analysis of its conceptual framework and a review of academic literature, added to the existing body of knowledge of IaC implementation strategies in cloud computing using DevOps practices to increase infrastructure design and management posture in general within IT industry and, more specifically, in the area of cloud computing (Sandobalín et al., 2020). The findings are pertinent to solution architects, DevOps engineers, cloud engineers, application developers, chief technology officers (CTOs), chief financial officers (CFOs), VP Technology, space research agencies, IT training professionals, and the IT industry, in general, to enhance and strengthen the IT infrastructure design implementation and promote its security, operational, and technical management using versioning, reusability, secret vault, and automation procedures. This study indicated that their participation would enhance the limitations offered by the incumbent(standard) infrastructure design approach in cloud computing.

In conjunction with the increasing demands of infrastructure versioning, reusability, secret management, and automation procedures in cloud computing, training and education are required to enhance IaC implementation strategies to minimize the use of standard(manual) infrastructure design implementation approach, which delivers limitations that impact organizations ’business objectives actualization. By providing IaC implementation strategies with new technologies as supported by the conceptual framework in this study which postulated that organizations could be successful if they adopt new technologies (Christensen, 1997), other organizations may adopt these successful IaC implementation strategies to enhance customers ’trust in consuming

infrastructures located in cloud deployment models such as private cloud, multi-cloud, or hybrid cloud with different cloud service models such as IaaS, PaaS, or SaaS. It is because IaC emerged from the DIT, which is also known as DIT (Christensen et al., 2018); thus, IaC is cloud-agnostic, and with its declarative framework nature (Gandhi et al., 2020), it can be used within any cloud service provider's platform, and the strategy may not have any customer locked-in within any cloud service provider's subscription. It gives organizations the flexibility to migrate to another cloud service provider's platform without reinventing the wheels of their already written infrastructure code in terms of IT practice.

The strategies illustrated by the findings from this study may help organizations seeking to increase their pace of innovation to stay competitive, especially if they are looking to operate a distributed cloud infrastructure to enable a new wave of digital innovation with infrastructure automation (Li et al., 2018a). That was impossible before using the standard(incumbent) infrastructure design approach. Therefore, the findings in this study may help organizations move apps, data, and workloads across different environments without redesigning the app's infrastructure because both the apps and infrastructure are versioned code; both can be managed with version control, thereby giving the organizations 'migration flexibility. The findings showed the possibility of scaling and accelerating cloud platforms for organizations across industries regardless of the cloud service provider utilized (Gandhi et al., 2020) and preserving the independence and neutrality of the organizations 'IT operational model concerning adopted cloud service models. This includes its encouragement to IT leadership to adopt new

technology, as pointed out by the study's conceptual framework, cloud deployment model, and support of the IT industry ecosystems for cloud computing relating to infrastructure design and management.

Notably, investment by IT leadership and organization authorities in IT strategies implementation on an advancing basis might make the IT infrastructure robust and improve the infrastructure design approach that is flexible in management (Xiong et al., 2018), especially in disaster recovery, to avert financial damages and loss. More extended downtime in disaster recovery could lead to substantial financial loss for companies; therefore, organizations need infrastructure that can be reinstated rapidly during disaster recovery. The ability is what the study's findings have revealed with IaC implementing strategies in cloud computing. The IT leadership and authorities' support may enhance the efficiency and effectiveness of the solution architects' strategies in implementing IaC in cloud computing using various DevOps practices to gain the IaC benefits with improved consistency (Zhu et al., 2019).

## Implications for Social Change

This study explored the strategies used by IT solution architects to implement IaC in cloud computing using DevOps practices. Therefore, the findings of the study may contribute to positive social change as IT organizations developing systems such as social media applications for individual or end-users may offer subscriptions and download access to any developed social media apps at a lower or free rate because they used IaC implementation strategies in the development of such applications which offers low capital expenses development. Exploring well-defined IaC implementation strategies

used by solution architects in cloud computing with DevOps practices may be a significant step to ensure that building application product with cost savings as part of IaC benefits delivered by this study's findings. From a social change perspective, the findings of this study may be useful to IT development organizations which may, in return, allow affordability at the low-cost offering of the developed application products for end-user consumption.

Affordability of social media application products developed with IaC strategies by IT organizations may result in free downloads of such application products by end-users and increased usage of such social media apps in communication within the community for safety in natural disasters. These study findings added to the existing knowledge of literature by providing information and knowledge on well-defined IaC implementation strategies by solution architects in IT organizations; thus, the findings can be used to enhance IT infrastructure implementation by using new technologies amongst IT practitioners in cloud computing globally. The study findings may result in positive social change as more strategies are available and affordable to develop cybercrime applications at a lower cost in cloud computing.

The findings also explained that when solution architects implement well-defined IaC implementation strategies, which offer cost savings, IT organizations can offer free downloads or lower-cost apps subscription. Individual or end-users may have the ability to afford the developed apps in the app stores. The study findings identified key factors necessary for implementing IaC in cloud computing using DevOps practices which are beneficial to the end-users in the community. The free app downloads can help the

community find, review and adopt a child or animal without an extra cost attached to their app subscription.

According to Gandhi et al. (2020), before inventing the IaC approach in infrastructure implementation, people have to be hired to perform the monotonous setup work to set up infrastructure. It is such that organizations need network engineers to set up the physical network infrastructure, storage engineers to maintain physical drives, and maintain all of this hardware. Thus, this incumbent approach leads to more overhead, management, and costs for the organization, leading organizations to downsize human capital to afford the costly infrastructure implementation. This proportionally affects the employees of such organizations that are laid off. With the arrival of the IaC approach and when adopted by organizations; they do not have to downsize human capital to afford expensive infrastructure implementation, it is because the IaC approach can handle the networking components of the infrastructure automatically to the extent that the human running IaC script does not have to know how to configure the networking components. In other words, IaC helps organizations to sustain and maintain high human capital retention in their business operation. IaC also offers an automated way of implementing networking component configuration in reference architecture design.

Successful IaC approach strategies, when implemented, may enhance the organizations ’ability the development of mission-critical applications, especially those used in the development of disease control monitoring apps in healthcare, which may benefit society and communities by allowing development organizations to make such apps affordable or free to download by the community because of IaC innovative

technology and cost savings. In extremely regulated verticals such as healthcare and life science environment, adopting the IaC approach in the development of healthcare apps can have substantial benefits for separation of duties, workload drift detection, and change control; it is because it allows the development team to make a rapid change request which includes an appropriate IaC template that can be reviewed, administered and implemented by a detached operational team with minimal risk of a directive being lost or misunderstood at a critical time such as during pandemic when it is little or no time to run full-cycle app development for disease spread and vaccination monitoring.

## Recommendations for Action

I recommend that Solution architects, Cloud engineers, Software developers, Networking engineers, and DevOps engineers as IT practitioners adopt and implement the IaC approach because it benefits organizations. IaC benefits are automated deployment, cost savings, disaster recovery, NASA space research support, idempotence, environment drift, prevention of snowflakes, and rapid infrastructure deployment. IaC provides rapid, fine-grained control of resources to spin up and down IT infrastructure to help support demand and capacity management. Another reason is that the requirements of the resources are already codified in the algorithm, and IaC can play a key role in incident rejoinder and disaster recovery. IaC is cloud-agnostic and supports different cloud computing models, including deployment models (e.g., hybrid cloud, multi-cloud, private cloud, public cloud) and service models(e.g., IaaS, PaaS, SaaS). Because of the IaC strategy, its agnostic nature supports multiple cloud service providers ’platforms (e.g., AWS, Azure, Google Cloud, IBM Cloud, Alibaba Cloud, Oracle Cloud).

I recommend that CTOs, CIOs, and IT organization executives support and budget for implementing IaC. The study findings revealed configuration best practices such as break-fast option, low-nesting, abstraction reusability, secret injection in the configuration, and third-party vaults for secret management. In terms of DevOps, IaC support multiple development and operation practices in cloud computing such as ArgoCD, continuous delivery, continuous integration, Git repository, GitOps, pipelines use cases and Tekton. IaC has multiple implementation tools supported by all the cloud service providers one way or the other. According to the study findings, the recommended IaC implementation tools include Terraform, the most common IaC tool, ansible, ARM(Azure Resource Manager), chef, OpenShift, Cloudformation Dockerfile, puppet, Cloudify, Kubernetes, Packer, Vagrant, and SaltStack. Multiple Kubernetes platforms support these IaC tools (e.g., ACK, AKS, DOK, EKS, GKE, OCP, OKE), and I recommend using the Kubernetes platforms.

I recommend that IT organizations, solution architects, practitioners, and leaders pay attention to the IaC approach and adapt its strategies in implementing IT infrastructures, which is important to its automation and codifying prowess. It is because, unlike the standard approach, which lacks codifying and automation and can feature stale data sets and configurations that do not match the organization's production, the IaC approach allows IT organizations to develop software and code more securely and operate more consistently across different environments, saving time and reducing risk. By codifying and automating the management of infrastructure using the IaC approach, IT organizations and practitioners can produce audit trails of version control to inspect

the underlying code, which is critical to organization security. IaC has a set of reusability features that can accelerate disaster recovery rapidly of infrastructure should the worst happen to any deployed organization's infrastructure, such that the deployed infrastructure is compromised due to a cyberattack. It is a security enhancement delivered by the IaC approach.

Disseminating the findings of this study includes preparing a two-page summary of the findings. The two-page summary of the research findings will be sent to all seven research participants. The study results were also shared globally in academic communities through the ProQuest database to students and scholars. I plan to present the study findings at IEEE conferences and publicize my study in peer-reviewed journals. I also plan on presenting the study findings to IT industry leaders in IEEE, IBM, AWS, Microsoft, NASA, and Redhat, who are key players in the IT industry concerning IaC technology

## Reflections

My knowledge of doctoral-level research developed considerably throughout the research process as I moved from qualitative case study to qualitative pragmatic inquiry research design because of the necessities of the latter in the study. I was confronted and amazed by the level of aspects and alignment that this research study necessitated. During the data collection and analysis segments, I felt overwhelmed because I had to recruit and host multiple participants and extract multiple IT industry documents. Working on this study in the middle of COVID-19 pandemic post impacts, I sometimes felt like quitting because I had schedule blockers and constraints due to the pandemic post effects in the IT

industry mode of operation globally and the U.S in particular, where my sample size is located.

My interest in research on the IaC topic came alive seven years ago; at the time, I was working for an IT company, and part of my tasks was to implement IT infrastructures which included VNets, VPCs, subnets, application gateway, subnets, public IPs, and Security Groups; this implementation was to be completed using the standard approach which can only be accomplished through manual procedure. At that point, I asked myself the first overarching question: Why can't we codify this Infrastructure implementation and automate its deployment? The answer to my question was hidden in the IaC approach, a code-centric procedure with repeatable and automatic abilities to implement and manage infrastructure resources in cloud computing across multiple cloud service providers 'platform ecosystems (Sandobalín et al., 2020).

As a senior solution architect, I am tasked periodically to design and implement IT infrastructures on multiple cloud service providers 'platforms; and I am to implement it manually by using the standard approach, which is not the best solution because of its inability to support the rapid deployment and disaster recovery. This situation formed a specific IT problem for me before I even commenced this doctoral research study, and it stupendously motivated me with the passion for undertaking this study. As an IT professional with over 15+ years of experience, I had some bias before conducting this study about IaC implementation strategies because of my huge experience in IT. However, I minimized my bias by allowing the participants to express themselves without offering opinions.

My knowledge of the topic did not apply any bias to the study because I used open-ended questions throughout the semistructured interview process, resulting in rich, comprehensive data based on the participants 'experiences. I was unaware of how in-depth and time-consuming qualitative pragmatic research study was until I delved into the data collection with four individual participants, three focus group participants, and the data analysis process with NVivo v12 software. Recruiting participants for my study was challenging, and three out of the ten participants I invited to participate in my study were unavailable and did not participate in the study data collection due to COVID-19 post impacts. Member checking was difficult at first to schedule but based on my customer support experience in IT in the last 16 years, I learned that having a quick phone call to the participant proved beneficial instead of another interview for 5-10 minutes. Transcribing the audio-recorded interviews took over three hours for each 30-60 minutes interview due to the low voice level of the participants that I do not have control over.

Analyzing the transcript was also a laborious process because I had to learn how to use qualitative data software – NVivo v12. Overall, I was humbled by the interview process and how willing most participants were to share their experiences with me. The findings from this study identified the IaC implementation strategies used by solution architects with DevOps practices in cloud computing. With this study, I have gained enough knowledge to conduct a qualitative research study that may be used in my next future career. My graduate-level academic writing skills have also improved since I enrolled at Walden University for doctoral study, and I intend to continue building on it

with post-doctoral study, in my view, next. I am now equipped with the doctoral academic skillset in IT to endeavor to develop IaC implementation strategy solutions and write IaC use case whitepapers in cloud computing for the IT industry organizations such as IBM/Redhat NASA, and AWS, IEEE, Microsoft Azure, et al. (See Appendix I).

## Conclusions

From the study findings, the IaC approach provides rapid, well-grained control of IT infrastructure resources in cloud computing to auto-scale up and down IT infrastructures. As part of its benefits, it can support on-demand capability management and cost savings for IT organizations globally. The study affirmed that requirements of IT infrastructure resources in cloud computing are already codified when using the IaC strategy in the implementation infrastructures as the IaC approach can play a crucial role in IT organizations 'incident response and disaster recovery with its rapid infrastructure re-deployment, automation, code reusability, and DevOps practices capabilities. The study explored strategies used by solution architects to implement IaC architecture solutions using DevOps procedures in cloud computing using the specific IT problem to evaluate the lack of IaC implementation strategies amongst IT practitioners in cloud computing. Notably, the study found that organizations tend to reject new technologies because they lack the expertise in implementing them.

In contrast, those that adopt the new technology operate better in their go-to-market strategies as they disrupt the incumbent technologies to operate better in the high-end market. The study also found out that the IaC approach is a disruptive innovation that enabled the cloud revolution where the standard (incumbent) approach has limitations or

fails because, with the IaC approach, a single ops person in an IT organization can start several machine infrastructures at the push of a button or command, and also have them properly configured. Therefore, the findings of this study should have greater applicability to general IT practitioners and the organizations seeking to adopt the IaC approach to benefit from the approach's new technology features in terms of rapid infrastructure automated deployment and support in multi-cloud computing strategies.

# References

Abbott, P., DiGiacomo, M., Magin, P., & Hu, W. (2018). A scoping review of qualitative research methods used with people in prison. *International Journal of Qualitative Methods,17*(1),1-15. https://doi.org/10.1177/1609406918803824

Abram, M. D., Mancini, K. T., & Parker, R. D. (2020). Methods to integrate natural language processing into qualitative research. *International Journal of Qualitative Methods,19,*1-6. https://doi.org/10.1177/1609406920984608

Adekoya, A. A., & Guse, L. (2020). Walking interviews and wandering behavior: Ethical insights and methodological outcomes while exploring the perspectives of older adults living with dementia. *International Journal of Qualitative Methods,19,*1-6. https://doi.org/10.1177/1609406920920135

Aksakalli, I. K., Celik, T., Can, A. B., & Tekinerdogan, B. (2021). Systematic approach for generation of feasible deployment alternatives for microservices. *IEEE Access, 9*, 29505-29529. https://doi.org/10.1109/ACCESS.2021.3057582

Alamri, M. M., Almaiah, M. A., & Al-Rahmi, W. M. (2020). The role of compatibility and task-technology fit (TTF): On social networking applications (SNAs) usage as sustainability in higher education. *IEEE Access,8,* 161668-161681. https://doi.org/10.1109/ACCESS.2020.3021944

Alarifi, A., Dubey, K., Amoon, M., Altameem, T., El-Samie, F. E. A., Altameem, A., Sharma, S. C., & Nasr, A. A. (2020). An energy-efficient hybrid framework for green cloud computing. *IEEE Access, 8*, 115356-115369. https://doi.org/10.1109/ACCESS.2020.3002184

Al-Maatouk, Q., Othman, M. S., Aldraiweesh, A., Alturki, U., Al-Rahmi, W. M., & Aljeraiwi, A. A. (2020). Task-technology fit and technology acceptance model application to structure and evaluate the adoption of social media in academia. *IEEE Access,8,*78427-78440. https://doi.org/10.1109/ACCESS.2020.2990420

Almoghathawi, Y., & Barker, K. (2020). Restoring community structures in interdependent infrastructure networks. *IEEE Transactions on Network Science and Engineering, 7*(3), 1355-1367. https://doi.org/10.1109/TNSE.2019.2927883

Alnafessah, A., Gias, A. U., Wang, R., Zhu, L., Casale, G., & Filieri, A. (2021). Quality-aware DevOps research: Where do we stand. *IEEE Access, 9,* 44476-44489. https://doi.org/10.1109/ACCESS.2021.3064867

Al-Rahmi, W. M., Yahaya, N., Aldraiweesh, A. A., Alamri, M. M., Aljarboa, N. A., Alturki, U., & Aljeraiwi, A. A. (2019). Integrating technology acceptance model with innovation diffusion theory: An empirical investigation on students' intention to use e-learning systems. *IEEE Access,7,*26797-26809. https://doi.org/10.1109/ACCESS.2019.2899368

Alsenani, Y. S., Crosby, G. V., Ahmed, K. R., & Velasco, T. (2020). ProTrust: A probabilistic trust framework for volunteer cloud computing. *IEEE Access, 8,* 135059-135074. https://doi.org/10.1109/ACCESS.2020.3009051

Aluya, J. (2018a). A case study of apple corporation use of large datasets. *Journal of Disruptive Technology, 6*(2). http://www.jofdt.com/product/a-case-study-of-apple-corporation-use-of-large-datasets/

Aluya, J. (2018b). A case study of Nokia Corporation leading to the acquisition by

Microsoft. *Journal of Disruptive Technology, 3*(8). http://www.jofdt.com/product/a-case-study-of-nokia-corporation-leading-to-the-acquisition-by-microsoft/

Atakav, E., Jarvis, L., & Marsden, L. (2020). Researching British [Muslim] values: Vernacular politics, digital storytelling, and participant researchers. *International Journal of Qualitative Methods,19,* 1-11. https://doi.org/10.1177/1609406920938281

Bao, L., Wu, C., Bu, X., Ren, N., & Shen, M. (2019). Performance modeling and workflow scheduling of microservice-based applications in clouds. *IEEE Transactions on Parallel and Distributed Systems, 30*(9), 2114-2129. https://doi.org/10.1109/TPDS.2019.2901467

Bass, L. (2018). The software architect and DevOps. *IEEE Software*, *35*(1), 8-10, https://doi.org/10.1109/MS.2017.4541051

Belmonte-Hernández, A., Hernández-Peñaloza, G., Martín Gutiérrez, D., & Álvarez, F. (2019). SWiBluX: Multi-sensor deep learning fingerprint for precise real-time indoor tracking. *IEEE Sensors Journal*, *19*(9), 3473-3486. https://doi.org/10.1109/JSEN.2019.2892590

Benkhelifa, E., Bani Hani, A., Welsh, T., Mthunzi, S., & Ghedira Guegan, C. (2019). Virtual environments testing as a cloud service: A methodology for protecting and securing virtual infrastructures. *IEEE access, 7,* 108660-108676. https://doi.org/10.1109/ACCESS.2019.2912957

Beresford, M., Jones, J. L., Bausch, J. C., Williams, C. F., Wutich, A., Porter, S.,

Quimby, B., Eaton, W. M., & Brasier, K. J. (2020). Third-party effects in stakeholder interviews. *International journal of qualitative methods,19*-1-9. https://doi.org/10.1177/1609406920966482

Bergen, N. (2018). Narrative depictions of working with language interpreters in cross-language qualitative research. *International journal of qualitative methods, 17,* 1-17. https://doi.org/10.1177/1609406918812301

Bischoping, K. (2018). Revisiting a boy named Jim: using narrative analysis to prompt reflexivity. *International journal of qualitative methods, 17,*1-12. https://doi.org/10.1177/1609406918809167

Bloom, N., Van Reenen, J., & Williams, H. (2019). A toolkit of policies to promote innovation. *The journal of economic perspectives, 33*(3), 163-184

Blume, M., Oberländer, A. M., Röglinger, M., Rosemann, M., & Wyrtki, K. (2020). Ex ante assessment of disruptive threats: Identifying relevant threats before one is disrupted. *Technological Forecasting and Social Change* 158, pages 120103.

Bremner, N. (2020). Time for timelines: The take-home timeline as a tool for exploring complex life histories. *International journal of qualitative methods,19,* 1-13. https://doi.org/10.1177/1609406920948978

Brower, R. L., Jones, T. B., Osborne-Lampkin, L., Hu, S., & Park-Gaghan, T. J. (2019). Big qual: Defining and debating qualitative inquiry for large data sets. *International Journal of Qualitative Methods, 18,* 1-10. https://doi.org/10.1177/1609406919880692

Burles, M. C., & Bally, J. M. G. (2018). Ethical, practical, and methodological

considerations for unobtrusive qualitative research about personal narratives shared on the internet. *International journal of qualitative methods*. https://doi.org/10.1177/1609406918788203

Calderón-Gómez, H., Mendoza-Pittí, L., Vargas-Lombardo, M., Gómez-Pulido, J. M., Castillo-Sequera, J. L., José Sanz-Moreno, J., & Sención, G. (2020). Telemonitoring system for infectious disease prediction in elderly people based on a novel microservice architecture. *IEEE access*, *8*, 118340-118354. https://doi.org/10.1109/ACCESS.2020.3005638

Cantero-Garlito, P. A., Flores-Martos, J. A., & Moruno-Miralles, P. (2020). Care of children with disabilities in rural areas: Meanings and impact on everyday life and health. Study protocol. *International journal of qualitative methods, 19*, 1-7. https://doi.org/10.1177/1609406920947602

Carney, J. (2020). Thinking avant la lettre: A review of 4E cognition. *Evolutionary Studies in Imaginative Culture*, *4*(1), 77. http://doi.org/10.26613/esic.4.1.172

Castillo-Vergara, M., & García-Pérez-de-Lema, D. (2020). Product innovation and performance in SME's: the role of the creative process and risk taking. *Innovation* (0)0, 1-19.

Cerny, T., Jan Svacina, J., Das, D., Bushong, V., Bures, M., Tisnovsky, P., Karel Frajtak, K., Shin, D., & Huang, J. (2020). On code analysis opportunities and challenges for enterprise systems and microservices. IEEE access, 8, 159449-159470. https://doi.org/10.1109/ACCESS.2020.3019985

Cervera, E. (2019). Try to start it! The challenge of reusing code in robotics research.

*IEEE robotics and automation letters*, *4*(1), 49-56, https://doi.org/10.1109/LRA.2018.2878604

Chakraborty, P., Daruwalla, N., Gupta, A. D., Machchhar, U., Kakad, B., Adelkar, S., & Osrin, D. (2020). Using participatory learning and action in a community-based intervention to prevent violence against women and girls in Mumbai's informal settlements. *International journal of qualitative methods, 19*,1-14. https://doi.org/10.1177/1609406920972234

Champagne-Poirier, O., Carignan, M.-È., David, M. D., & O'Sullivan, T. (2021). Understanding and quantifying: A mixed-method study on the journalistic coverage of canadian disasters. *International journal of qualitative methods,20*,1-13. https://doi.org/10.1177/1609406921990492

Chauvette, A., Schick-Makaroff, K., & Molzahn, A. E. (2019). Open data in qualitative research. *International journal of qualitative methods, 18,* 1-6. https://doi.org/10.1177/1609406918823863

Cheng, H., Jia, R., Li, D., & Li, H. (2019). The rise of robots in China. *The journal of economic perspectives*, *33*(2), 71-88. https://www.jstor.org/stable/26621240

Christensen, C. M. (1997). *The innovators dilemma: When new technologies cause great firms to fail. Boston, MA: Harvard Business School Press.*

Christensen, C. M., Mcdonald, R., Altman, E. J., & Palmer, J. E. (2018). Disruptive innovation: An intellectual history and directions for future research. *Journal of Management Studies*, *55*, 1043 - 1078. https://doi.org/10.1111/joms.12349

Collins, C. S., & Stockton, C. M. (2018). The central role of theory in qualitative

research. *International journal of qualitative methods,17,*1-10. https://doi.org/10.1177/1609406918797475

Cook, K., & Bergeron, K. (2019). Using group concept mapping to engage a hard-to-reach population in research: young adults with life-limiting conditions. *International journal of qualitative methods,18,1-8.* https://doi.org/10.1177/1609406919891315

Côté-Boileau, É., Gaboury, I., Breton, M., & Denis, J.-L. (2020). Organizational ethnographic case studies: Toward a new generative in-depth qualitative methodology for health care research? *International journal of qualitative methods, 19,* 1-17. https://doi.org/10.1177/1609406920926904

Cuntz, A., Foray, D., & Mostovova, E. (2020). On the economics of social innovation – a conceptual framework and its policy implications. *Innovation, (22)*4, 469-487. https://doi.org/10.1080/14479338.2020.1735394

Dalla Palma, S., Di Nucci, D., Palomba, F., & Tamburri, D. A. (2020). Within-project defect prediction of Infrastructure-as-Code using product and process metrics. *IEEE Transactions on Software Engineering,14*(8),1-8. https://ieeexplore-ieee-org.ezp.waldenulibrary.org/stamp/stamp.jsp?tp=&arnumber=9321740

Danielsson, A. T., & Berge, M. (2020). Using video-diaries in educational research exploring identity: affordances and constraints. *International journal of qualitative methods,19,*1-9. https://doi.org/10.1177/1609406920973541

Darnhofer, I. (2018). Using comic-style posters for engaging participants and for promoting researcher reflexivity. *International journal of qualitative methods,17,*

1-12. https://doi.org/10.1177/1609406918804716

De Buitrago, S. (2019). Risk representations and confrontational actions in the arctic. *Journal of strategic security*, *12*(3), 13-36. https://www.jstor.org/stable/26775813

De Donno, M., Tange, K., & Dragoni, N. (2019). Foundations and evolution of modern computing paradigms: Cloud, IoT, Edge, and Fog. *IEEE access*, *7*, 150936-150948, https://doi.org/10.1109/ACCESS.2019.2947652

De Jonge, L., Mesters, I., Govaerts, M., Timmerman, A. A., Muris, J., Kramer, A., & van der Vleuten, C. (2020). Supervisors' intention to observe clinical task performance: an exploratory study using the theory of planned behaviour during postgraduate medical training. *BMC medical education*, *20*(1), 134. https://doi.org/10.1186/s12909-020-02047-y

De Kleijn, R., & Van Leeuwen, A. (2018). Reflections and review on the audit procedure: guidelines for more transparency. *International journal of qualitative methods*,*17*,1-8. https://doi.org/10.1177/1609406918763214

Díaz, J., Pérez, J. E., Lopez-Peña, M. A., Mena, G. A., & Yagüe, A. (2019). Self-service cybersecurity monitoring as enabler for DevSecOps. *IEEE Access*, *7*, 100283-100295. https://doi.org/10.1109/ACCESS.2019.2930000

Dimla, B., Wood, D., & Parkinson, L. (2020). A qualitative study on how social workers from regional and metropolitan Queensland, Australia perceive the impact of the national prioritization system on hospital discharge planning: A Study Protocol. *International journal of qualitative methods, 19,* 1-8. https://doi.org/10.1177/1609406920973543

Ding, Z., Wang, S., & Pan, M. (2020). Qos-constrained service selection for networked microservices. *IEEE access*, *8*, 39285-39299. https://doi.org/10.1109/ACCESS.2020.2974188

Dörnenburg, E. (2018). The path to DevOps. *IEEE Software*, 35(5), 71-75, https://doi.org/10.1109/MS.2018.290110337

Dow, B. S., & Boylan, B. M. (2020). Learning from vulnerable populations: methodological implications of interviewing individuals with fetal alcohol spectrum disorder. *International journal of qualitative methods*, *19*, 1-10. https://doi.org/10.1177/1609406920931254

Dubey, K., Shams, M. Y., Sharma, S. C., Alarifi, A., Amoon, M., & Nasr, A. A. (2019). A management system for servicing multi-organizations on community cloud model in secure cloud environment. *IEEE access*, *7*, 159535-159546. https://doi.org/10.1109/ACCESS.2019.2950110

Eakin, J. M., & Gladstone, B. (2020). Value-adding analysis: Doing more with qualitative data. *International journal of qualitative methods*, *19*, 1-13. https://doi.org/10.1177/1609406920949333

Ebersöhn, L., & Malan-Van Rooyen, M. (2018). Making the most of culture and context: Sociocultural strengths and contextual vulnerability when eliciting indigenous resilience insights with remote South African elders and young people. *International journal of qualitative methods*. https://doi.org/10.1177/1609406918798434

Ebneyamini, S., & Sadeghi Moghadam, M. R. (2018). Toward developing a framework

for conducting case study research. *International journal of qualitative methods, 17*, 1-11. https://doi.org/10.1177/1609406918817954

Eldh, A. C., Årestedt, L., & Berterö, C. (2020). Quotations in qualitative studies: reflections on constituents, custom, and purpose. *International journal of qualitative methods, 19*,1-6. https://doi.org/10.1177/1609406920969268

El-Sayed, H., Sankar, S., Prasad, M., Puthal, D., Gupta, A., Mohanty, M., & Lin, C. (2018). Edge of things: The big picture on the integration of edge, IoT and the cloud in a distributed computing environment. *IEEE access*, *6*, 1706-1717. https://doi.org/10.1109/ACCESS.2017.2780087

Elshaer, M., DeCarlo, C., Lein, W., Pandya, H., Ali, A., & Mehta, Y. (2020). Use of long-term pavement performance-seasonal monitoring program data to develop and validate a generalized regression model to predict the in-situ resilient modulus of subgrade soils for pavement design and evaluation. *Transportation research record*, *2674*(5), 673–684. https://doi.org/10.1177/0361198120917383

Emeras, J., Varrette, S., Plugaru, V., & Bouvry, P. (2019). Amazon elastic compute cloud (EC2) versus in-house HPC platform: A cost analysis. *IEEE transactions on cloud computing*, *7*(2), 456-468, https://doi.org/10.1109/TCC.2016.2628371

Etz, R. S., Gonzalez, M. M., Crabtree, B. F., Reves, S. R., & Stange, K. C. (2019). An innovative three-step method for identifying exemplars. *International journal of qualitative methods, 18*, 1-7. https://doi.org/10.1177/1609406919867794

Etz, R. S., Gonzalez, M. M., Eden, A. R., & Winship, J. (2018). Rapid sense making: A feasible, efficient approach for analyzing large data sets of open-ended comments.

*International journal of qualitative methods,17,*1-10. https://doi.org/10.1177/1609406918765509

Fernández, E., & Valle, S. (2018). Tecnología disruptiva: La derrota de las empresas establecidas. *Innovar: Revista de ciencias administrativas Y sociales, 28*(70), 9-22. https://www.jstor.org/stable/26500750

Fitzgerald, A., & Lowe, M. (2020). Acknowledging documentary filmmaking as not only an output but a research process: A case for quality research practice. *International journal of qualitative methods,19,*1-7. https://doi.org/10.1177/1609406920957462

Flynn, R., Albrecht, L., & Scott, S. D. (2018). Two approaches to focus group data collection for qualitative health research: maximizing resources and data quality. *International journal of qualitative methods,17,*1-9. https://doi.org/10.1177/1609406917750781

Frechette, J., Bitzas, V., Aubry, M., Kilpatrick, K., & Lavoie-Tremblay, M. (2020). Capturing Lived Experience: Methodological Considerations for Interpretive Phenomenological Inquiry. *International journal of qualitative methods, 19*, 1-12. https://doi.org/10.1177/1609406920907254

Furman, E., Singh, A. K., Wilson, C., D'Alessandro, F., & Miller, Z. (2019). A space where people get it: A methodological reflection of arts-informed community-based participatory research with nonbinary youth. *International journal of qualitative methods,18,*1-12. https://doi.org/10.1177/1609406919858530

Galea, S. (2018). Will disruptive innovation in health care improve the health of

populations? *The milbank quarterly*, *96*(4), 619-622. http://www.jstor.org/stable/26567725

Gandhi, A., Dube, P., Karve, A., Kochut, A., & Zhang, L. (2020). Providing performance guarantees for cloud-deployed applications. *IEEE transactions on cloud computing*, *8*(1), 269–281. https://doi.org/10.1109/tcc.2017.2771402

Gao, M., Chen, M., Liu, A., Ip, W. H., & Yung, K. L. (2020). Optimization of microservice composition based on artificial immune algorithm considering fuzziness and user preference. *IEEE access*, *8*, 26385-26404. https://doi.org/10.1109/ACCESS.2020.2971379

García, A. J., De Lucas, J. M., Marica Antonacci, M., Castell, W. Z., David, M., Hardt, M., Moltó, G., Plociennik, M., Tran, V., Alic, A. S., Caballer, M., Plasencia, I. C., Costantini, A., Dlugolinsky, S., Duma, D. C., Donvito, G., Gomes, J., & Cacha, I. H. (2020). A cloud-based framework for machine learning workloads and applications. *IEEE access*, *8*, 18681-18692. https://doi.org/10.1109/ACCESS.2020.2964386

Garcia-Quiroga, M., & Agoglia, I. S. (2020). Too vulnerable to participate? Challenges for meaningful participation in research with children in alternative care and adoption. *International journal of qualitative methods,19,*1-11. https://doi.org/10.1177/1609406920958965

Gear, C., Eppel, E., & Koziol-Mclain, J. (2018). Advancing complexity theory as a qualitative research methodology. *International journal of qualitative methods,17,1-10*. https://doi.org/10.1177/1609406918782557

Gerlach, A. (2018). Thinking and researching relationally: enacting decolonizing methodologies with an indigenous early childhood program in Canada. *International journal of qualitative methods,17, 1-8.* https://doi.org/10.1177/1609406918776075

Ghasemi, M. H., Lucía, O., & Lucia, S. (2020). Computing in the Blink of an Eye: Current Possibilities for Edge Computing and Hardware-Agnostic Programming. *IEEE access, 8,* 41626-41636, 2020. https://doi.org/10.1109/ACCESS.2020.2977087

Gil, D., Esteban-Lansaque, A., Borràs, A., Ramírez, E., & Ramos, C. S. (2020). Intraoperative Extraction of Airways Anatomy in VideoBronchoscopy. *IEEE access,8,*159696-159704, 2020, https://doi.org/10.1109/ACCESS.2020.3018590

Gilmore, B., McAuliffe, E., Power, J., & Vallières, F. (2019). Data analysis and synthesis within a realist evaluation: toward more transparent methodological approaches. *International journal of qualitative methods,18,*1-11. https://doi.org/10.1177/1609406919859754

Glenton, C., & Carlsen, B. (2019). When normal becomes normative: A case study of researchers' quotation errors when referring to a focus group sample size study. *International journal of qualitative methods, 18,* 1-6. https://doi.org/10.1177/1609406919841251

Golub, G., Sudhinaraset, M., Giessler, K., Dunlop-Korsness, K., & Stone, A. (2020). The extended role of health facility cleaners in maternity care in Kenya. *International Perspectives on Sexual and Reproductive Health, 46,* 1-7.

https://doi.org/10.1363/46e8320

Goode, S. (2020). Understanding Single Homing and Multihoming User Switching Propensity in Cloud File Hosting Service Relationships. E-Service Journal, 11(2), 34-73. https://doi.org/10.2979/eservicej.11.2.02

Goopy, S., & Kassan, A. (2019). Arts-based engagement ethnography: An approach for making research engaging and knowledge transferable when working with harder-to-reach communities. *International journal of qualitative methods,18,*1-10. https://doi.org/10.1177/1609406918820424

Greenstein, S. (2020). The basic economics of internet infrastructure. *The journal of economic perspectives*, 34(2), 192-214. https://doi.org/10.2307/26913190

Griffin, G., & Leibetseder, D. (2019). Only applies to research conducted in Sweden…: dilemmas in gaining ethics approval in transnational qualitative research. *International journal of qualitative methods, 18,* 1-10. https://doi.org/10.1177/1609406919869444

Han, J., Hong, Y., & Kim, J. (2020). Refining microservices placement employing workload profiling over multiple Kubernetes clusters. *IEEE access, 8,* 192543-192556. https://doi.org/10.1109/ACCESS.2020.3033019

Hannibal, M., & Knight, G. (2018). Additive manufacturing and the global factory: Disruptive technologies and the location of international business. Elsevier Ltd. *International business review*. https://doi.org/10.1016/j.ibusrev.2018.04.00

Haven, T. L., Errington, T. M., Gleditsch, K. S., van Grootel, L., Jacobs, A. M., Kern, F. G., Piñeiro, R., Rosenblatt, F., & Mokkink, L. B. (2020). Preregistering

qualitative research: A Delphi study. *International journal of qualitative methods*, *19*,1-13. https://doi.org/10.1177/1609406920976417

Hege, I., Dietl, A., Kiesewetter, J., Schelling, J., & Kiesewetter, I. (2018). How to tell a patient's story? Influence of the case narrative design on the clinical reasoning process in virtual patients. *Medical teacher*, *40*(7), 736-742. https://doi.org/10.1080/0142159x.2018.1441985

Held, M. B. E. (2020). Research ethics in decolonizing research with Inuit communities in Nunavut: The challenge of translating knowledge into action. *International journal of qualitative methods*, *9*, 1-7. https://doi.org/10.1177/1609406920949803

Hemon, A., Fitzgerald, B., Lyonnet, B., & Rowe, F. (2020). Innovative practices for knowledge sharing in large-scale DevOps. *IEEE Software*, *37*(3), 30-37, https://doi.org/10.1109/MS.2019.2958900

Hemphill, C. (2019). Disruptive incumbents: platform competition in an age of machine learning. *Columbia Law Review*, *119*(7),1973-2000. https://doi.org/10.2307/26810856

Henao, A., & Marshall, W. (2019). The impact of ride hailing on parking (and vice versa). *Journal of Transport and Land Use*, *12*(1), 127-147. https://doi.org/10.2307/26911261

Hou, H., Han, Y. S., Lee, P. P. C., Hu, Y., & H. Li, H. (2019). A new design of binary MDS array codes with asymptotically weak-optimal repair. *IEEE transactions on information theory*, 65(11), 7095-7113, https://doi.org/10.1109/TIT.2019.2923992

Hou, J., & Feng, A. (2019). Juggling multiple identities: the untold stories behind a PhD ethnographic study. *International journal of qualitative methods,18,1-12*. https://doi.org/10.1177/1609406919884147

Islam, I., Goss, S., Nelson, A., & Byrne, A. (2021). Involving high-grade glioma patients and their cares in qualitative research to promote structured physical activity: A mixed-methods study protocol. *International journal of qualitative methods,20,*1-12. https://doi.org/10.1177/1609406920982133

Jabkowski, P. (2018). The effect of using different types of survey sample on sample execution in the European social survey. *Polish sociological review, (202),* 265-278. https://doi.org/10.2307/26531095

Jang, J., Ko, Y., Shin, W. S., & Han, I. (2021). Augmented reality and virtual reality for learning: An examination using an extended technology acceptance model. *IEEE access,9,*6798-6809. https://doi.org/10.1109/ACCESS.2020.3048708

Janis, I., Alias, M., Zulkipli, M., & Muhammad-Sukki, F. (2020). Using illustrations to make decisions on the most appropriate qualitative research methodology: The industry 4.0 scenario. *International journal of qualitative methods, 19,* 1-16. https://doi.org/10.1177/1609406920907247

Jenkinson, H., Leahy, P., Scanlon, M., Powell, F., & Byrne, O. (2019). The value of groupwork knowledge and skills in focus group research: A focus group approach with marginalized teens regarding access to third-level education. *International journal of qualitative methods,18,*1-11. https://doi.org/10.1177/1609406919881853

Jenner, P. (2018). Work-integrated-learning in international business: Exploring stakeholder value for regional export companies. E-Journal of Business Education and Scholarship of Teaching, 12(1), 20-31. https://eric.ed.gov/?id=EJl 183295

Jeon, J., Park, J. H., & Jeong, Y. (2020). Dynamic analysis for IoT malware detection with convolution neural network model. *IEEE Access*,*8*,96899-96911. https://doi.org/10.1109/ACCESS.2020.2995887

Jiang, Y., Liu, W., Shi, X., & Qiang, W. (2021). Optimizing the copy-on-write mechanism of docker by dynamic prefetching. *Tsinghua science and technology*,*26*(3),266-274. https://doi.org/10.26599/TST.2019.9010034

Jin, W., Xu, R., You, T., Hong, Y. G., & Kim, D. (2020). Secure edge computing management based on independent microservices providers for gateway-centric IoT networks. *IEEE access*, *8*, 187975-187990.

Kagumba, F. G., & Wausi, A. N. (2018). The influence of organizational culture on the adoption of ICT innovation following technological disruption: Evidence from Kenyan ICT SMEs. *Journal of disruptive technology*, *7*(2). http://www.jofdt.com/wp-content/uploads/2018/05/Adoption-of-ICT-Innovation-following-Technological-Kenya.pdf

Kaźmierska, K. (2018). Doing biographical research—ethical concerns in changing social contexts. *Polish sociological review*, *203*, 393-411. https://doi.org/10.2307/26531105

Kerins, C., Houghton, C., McHugh, S., Geaney, F., Toomey, E., Hayes, C., Perry, I. J., & Kelly, C. (2019a). Implementation of a calorie menu labeling policy in public

hospitals: Study protocol for a pragmatic research. *International journal of qualitative methods, 18,* 1-10. https://doi.org/10.1177/1609406919878339

Kerins, C., Houghton, C., McHugh, S., Geaney, F., Toomey, E., Hayes, C., Perry, I. J., & Kelly, C. (2019b). Implementation of a calorie menu labeling policy in public hospitals: Study protocol for a multiple case study. *International journal of qualitative methods, 18,* 1-10. https://doi.org/10.1177/1609406919878339

Kersten, M. (2018). A Cambrian explosion of DevOps tools. *IEEE Software*, *35*(2), 14-17, https://doi.org/10.1109/MS.2018.1661330

Koelsch, L. E. (2018). Reflection/commentary on a past article: reconceptualizing the member check interview: http://journals.sagepub.com/doi/full/10.1177/160940691301200105. *International journal of qualitative methods,17,* 1-2. https://doi.org/10.1177/1609406918788196

Kwon, H. R., & Silva, E. A. (2020). Mapping the landscape of behavioral theories: systematic literature review. *Journal of planning literature*, *35*(2), 161–179. https://doi.org/10.1177/0885412219881135

Kwon, S., & Lee, J. (2020). DIVDS: Docker image vulnerability diagnostic system. *IEEE access, 8*, 42666-42673, https://doi.org/10.1109/ACCESS.2020.2976874

Lecocq, T., Harpke, A., Rasmont, P., & Schweiger, O. (2019). Integrating intraspecific differentiation in species distribution models: Consequences on projections of current and future climatically suitable areas of species. *Diversity and Distributions, 25*(7), 1088-1100. https://www.jstor.org/stable/26662607

Lee, V., Coombe, L., Mahoney, R., Allen, C., & Robinson, P. (2018). Incorporating indigenous and non-indigenous worldviews through innovative text analysis: An evaluation of indigenous public health curricula. *International journal of qualitative methods,17*,1-11. https://doi.org/10.1177/1609406918819377

Lehr, W., Clark, D., Bauer, S., Berger, A., & Richter, P. (2019). Whither the public internet? *Journal of Information Policy, 9*, 1-42. https://doi.org/10.5325/jinfopoli.9.2019.0001

Lescisin, M., & Mahmoud, Q. H. (2021). A machine learning based monitoring framework for side-channel information leaks. *IEEE Open Journal of the Computer Society, 2*,139-151, 2021, https://doi.org/10.1109/OJCS.2021.3061445

Li, G., Liu, H., Jiang, Y., & Jin, J. (2018a). Test-based clone detection: an initial try on semantically equivalent methods. *IEEE access*, *6*, 77643-77655, https://doi.org/10.1109/ACCESS.2018.2883699

Li, T., Xiong, N. N., Gao, J., Song, H., Liu, A., & Zhiping, C. (2018b). Reliable code disseminations through opportunistic communication in vehicular wireless networks. *IEEE access*, 6, 55509-55527, https://doi.org/10.1109/ACCESS.2018.2870928

Li, X., Wang, Q., Lan, X., Chen, X., Zhang, N., & Chen, D. (2019). Enhancing cloud-based IoT security through trustworthy cloud service: An integration of security and reputation approach. *IEEE Access,7*,9368-9383. https://doi.org/10.1109/ACCESS.2018.2890432

Liao, W. (2020). Using collaborative video-cued narratives to study professional

learning: A reflective analysis. *International journal of qualitative methods,19,*1-13. https://doi.org/10.1177/1609406920949335

Liebenberg, L., Jamal, A., & Ikeda, J. (2020). Extending youth voices in a participatory thematic analysis approach. *International journal of qualitative methods,19,*1-13. https://doi.org/10.1177/1609406920934614

Lin, M., Xi, J., Bai, W., & Wu, J. (2019). Ant colony algorithm for multi-objective optimization of container-based microservice scheduling in cloud. *IEEE access, 7,* 83088-83100. https://doi.org/10.1109/ACCESS.2019.2924414

Liu, C., Yu, Y., Li, X., & Wang, P. (2020). Application of entity relation extraction method under CRF and syntax analysis tree in the construction of military equipment knowledge graph. *IEEE Access, 8,* 200581-200588. https://doi.org/10.1109/ACCESS.2020.3034894

Lobe, B., Morgan, D., & Hoffman, K. A. (2020). Qualitative data collection in an era of social distancing. *International journal of qualitative methods,19,*1-8. https://doi.org/10.1177/1609406920937875

Love, B., Vetere, A., & Davis, P. (2019). Handling hot potatoes: Ethical, legal, safeguarding, and political quandaries of researching drug-using offenders. *International journal of qualitative methods, 18,* 1-9. https://doi.org/10.1177/1609406919859713

Lyu, Z., Wei, H., Bai, X., & C. Lian, C. (2020). Microservice-based architecture for an energy management system. *IEEE systems journal*, 14(4), 5061-5072. https://doi.org/10.1109/JSYST.2020.2981095

Mackieson, P., Shlonsky, A., & Connolly, M. (2019). Increasing rigor and reducing bias in qualitative research: A document analysis of parliamentary debates using applied thematic analysis. *Qualitative Social Work*, 18(6), 965–980. https://doi.org/10.1177/1473325018786996

Mahali, A., & Swartz, S. (2018). Using qualitative tools as interventionist research strategies for emancipation. *International journal of qualitative methods, 17*, 1-10. https://doi.org/10.1177/1609406918799573

Maher, C., Hadfield, M., Hutchings, M., & de Eyto, A. (2018). Ensuring rigor in qualitative data analysis: A design research approach to coding combining NVivo with traditional material methods. *International journal of qualitative methods,17,*1-13. https://doi.org/10.1177/1609406918786362

Malmqvist, J., Hellberg, K., Möllås, G., Rose, R., & Shevlin, M. (2019). Conducting the pilot study: A neglected part of the research process? Methodological findings supporting the importance of piloting in qualitative research studies. *International journal of qualitative methods,18,*1-11. https://doi.org/10.1177/1609406919878341

Manning, R., Engelke, P., & Klein, S. (2018). The global innovation sweepstakes: A quest to win the future (9-14, Rep.). *Atlantic Studies*. https://doi.org/10.2307/resrep20939.5

Martínez-Vergara, S. J., & Valls-Pasola, J. (2020). Clarifying the disruptive innovation puzzle: a critical review. *European Journal of Innovation Management*, 1-5. https://www.emerald.com/insight/content/doi/10.1108/EJIM-07-2019-

0198/full/html

Masood, A., Yang, P., Sheng, B., Li, H., Li, P., Qin, J., Lanfranchi, V., Kim, J., & Feng, A. D. (2020). Cloud-based automated clinical decision support system for detection and diagnosis of lung cancer in chest CT. *IEEE journal of translational engineering in health and medicine, 8,* 1-13, 2020. https://doi.org/10.1109/JTEHM.2019.2955458

Mavhandu-Mudzusi, A. H. (2018). The couple interview as a method of collecting data in interpretative phenomenological analysis studies. *International journal of qualitative methods,17,* 1-9. https://doi.org/10.1177/1609406917750994

McCracken, J. (2020). Ethics as Obligation: reconciling diverging research practices with marginalized communities. *International journal of qualitative methods, 19,* 1-11. https://doi.org/10.1177/1609406920964336

McCrae, N., & Purssell, E. (2018). Response to calling for a shared understanding of sampling terminology in qualitative research: Proposed clarifications derived from critical analysis of a methods overview by McCrae and Purssell by Stephen Gentles and Silvia Vilches (International Journal of Qualitative Research, 2017). *International journal of qualitative methods, 17,* 1-2. https://doi.org/10.1177/1609406918804684

Meraz, R. L., Osteen, K., & McGee, J. (2019). Applying multiple methods of systematic evaluation in narrative analysis for greater validity and deeper meaning. *International journal of qualitative methods, 18,* 1-6. https://doi.org/10.1177/1609406919892472

Mohajan, H. K. (2018). Qualitative research methodology in social sciences and related subjects. *Journal of economic development, environment and people, 7*(1), 23 48. https://doi.org/10.26458/jedep.v7i1.571

Morgan, D. L., & Nica, A. (2020). Iterative thematic inquiry: A new method for analyzing qualitative data. *International journal of qualitative methods,19,*1-11. https://doi.org/10.1177/1609406920955118

Mueller, R. A. (2019). Episodic narrative interview: capturing stories of experience with a methods fusion. *International journal of qualitative methods,18,*1-11. https://doi.org/10.1177/1609406919866044

Muller, E. (2020). Delimiting disruption: Why Uber is disruptive, but Airbnb is not. *International Journal of Research in Marketing*, 37(1), 43-55. https://doi.org/10.1016/j.ijresmar.2019.10.004

National Center for Biotechnology Information, NCBI. (2018). The use of information and communication technologies by arthritis health professionals to disseminate a self-management program to patients: a pilot randomized controlled trial protocol. *US National Library of Medicine National Institutes of Health*,4, 2055207618819571. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6299300/

National Center for Biotechnology Information, NCBI. (2019). Beyond interviews and focus groups: A framework for integrating innovative qualitative methods into randomized controlled trials of complex public health interventions. *US National Library of Medicine National Institutes*,20,1-329. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6555705

National Center for Biotechnology Information, NCBI. (2020). Why Human Subjects Research Protection Is Important. *US National Library of Medicine National Institutes*, 20(1),16–33. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7122250

National Center for Biotechnology Information, NCBI. (2021a). Convergence innovation in the digital age and in the COVID-19 pandemic crisis. *US National Library of Medicine National Institutes of Health*, *123*,14–22. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7518178

National Center for Biotechnology Information, NCBI. (2021b). Orde ab chao method for disruptive innovations creation (With COVID-19 pandemic case application). *US National Library of Medicine National Institutes of Health*, *11*, 581968. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7904675

National Center for Biotechnology Information, NCBI. (2021c). The Digital Transformation of Business Model Innovation: A Structured Literature Review. *US National Library of Medicine National Institutes of Health*, *11*, 539363. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7874088

National Government of the United States General Services Administration, *GSA.* (2018). Shared infrastructure as code. 18F: Technology Transformation Services. *U.S. General Services Administration*. https://18f.gsa.gov/2018/08/15/shared-infrastructure-as-code

National Institute of Health, NIH. (2018). Best practices for mixed methods research in the health sciences. Office of Behavioral and Social Sciences. *U.S. National Institutes of Health: Department of Health & Human Services*.

https://www.obssr.od.nih.gov/wp-content/uploads/2018/01/Best-Practices-for-Mixed-Methods-Research-in-the-Health-Sciences-2018-01-25.pdf

National Institute of Standards and Technology, NIST. (2018). Evaluation of cloud computing services based on NIST SP 800-145: NIST cloud computing cloud services working group NIST cloud computing program information technology laboratory. *U.S. National Institute of Standard and Technology*, 500(322),1-27. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.500-322.pdf

National Institute of Standards and Technology, NIST. (2019). NIST Cloud Computing Program - NCCP. *U.S. National Institute of Standard and Technology*. https://www.nist.gov/programs-projects/nist-cloud-computing-program-nccp

O'Connor, C., & Joffe, H. (2020). Intercoder reliability in qualitative research: debates and practical guidelines. *International journal of qualitative methods,19*,1-13. https://doi.org/10.1177/1609406919899220

Ortu, M., Destefanis, G., Graziotin, D., Marchesi, M., & Tonelli, R. (2020). How do you propose your code changes? Empirical analysis of affect metrics of pull requests on Github. *IEEE access*, *8*, 110897-110907, https://doi.org/10.1109/ACCESS.2020.3002663

Oscar, R., Ola, L., Robert, K., & Markus, H. (2018). Negotiations and research bargains: Bending professional norms in the effort to gain field access. *International journal of qualitative methods,17*,1-11. https://doi.org/10.1177/1609406918770033

Pessoa, A. S. G., Harper, E., Santos, I. S., & Gracino, M. C. D. S. (2019). Using reflexive

interviewing to foster deep understanding of research participants' perspectives. *International journal of qualitative methods, 18,1-9*. https://doi.org/10.1177/1609406918825026

Ponizovsky-Bergelson, Y., Dayan, Y., Wahle, N., & Roer-Strier, D. (2019). A qualitative interview with young children: What encourages or inhibits young children's participation? *International journal of qualitative methods,18,*1-9. https://doi.org/10.1177/1609406919840516

Pyne, B., Saito, H., Akbar, P. R., Hirokawa, J., Tomura, T., & Tanaka, K. (2020). Development and performance evaluation of small SAR system for 100-kg class satellite. *IEEE journal of selected topics in applied earth observations and remote sensing*, *13*, 3879-3891. https://doi.org/10.1109/JSTARS.2020.3006396

Qi, Q., & Tao, F. (2019). A smart manufacturing service system based on edge computing, fog computing, and Cloud Computing. *IEEE access*, *7*, 86769-86777. https://doi.org/10.1109/ACCESS.2019.2923610

Qumer Gill, A., Loumish, A., Riyat, I., & Han, S. (2018). DevOps for information management systems. *VINE Journal of Information and Knowledge Management Systems*, 48(1), 122-139. https://doi.org/10.1108/VJIKMS-02-2017-0007.

Rademacher, P., & Wagner, K. (2020). Efficient Bayesian sequential classification under the Markov assumption for various loss functions. *IEEE signal processing letters*, *27*, 401-405, https://doi.org/10.1109/LSP.2020.2973854

Rafi, S., Yu, W., Akbar, M. A., Alsanad, A., & A. Gumaei, A. (2020a). Multicriteria based decision making of DevOps data quality assessment challenges using fuzzy

TOPSIS. *IEEE Access*, 8, 46958-46980, https://doi.org/10.1109/ACCESS.2020.2976803

Rafi, S., Yu, W., Akbar, M. A., Alsanad, A., & Gumaei, A. (2020b). Prioritization based taxonomy of DevOps security challenges using PROMETHEE. *IEEE Access*,*8*,105426-105446. https://doi.org/10.1109/ACCESS.2020.2998819

Rahman, A., Farhana, E., & Williams, L. (2020b). *The 'as code' activities*: development anti-patterns for infrastructure as code. *Empirical Software Engineering, 25***,** 3430–3467. https://doi.org/10.1007/s10664-020-09841-8

Rahman, A., Mahdavi-Hezaveh, R., & Williams, L. (2019a). A systematic mapping study of infrastructure as code research. *Information and Software Technology*, *108*, 65–77. http://doi.org/10.1016/j.infsof.2018.12.004

Rahman, A., & Williams, L. (2019). Source code properties of defective infrastructure as code scripts. *Information and Software Technology, 112*, 148–163. https://doi-org.ezp.waldenulibrary.org/10.1016/j.infsof.2019.04.013

Raji, M., Hota, A., Hobson, T., & Huang, J. (2020). Scientific visualization as a microservice. *IEEE transactions on visualization and computer graphics*, *26*(4), 1760-1774. https://doi.org/10.1109/TVCG.2018.2879672

Rao, S. S., Banik, A., Khanna, A., & Philip, D. (2019). Disruptive innovation in aerospace and defense in Indian MSME. *Journal of operations and strategic planning*, *2*(2), 118–131. https://doi.org/10.1177/2516600X19868333

Rashid, Y., Rashid, A., Warraich, M. A., Sabir, S. S., & Waseem, A. (2019). Case study method: A step-by-step guide for business researchers. *International journal of*

*qualitative methods, 18*, 1-13. https://doi.org/10.1177/1609406919862424

Raska, M. (2019). Strategic competition for emerging military technologies: Comparative paths and patterns. *Prism, 8*(3), 64-81. https://doi.org/10.2307/26864277

Ravindran, A., Li, J., & Marshall, S. (2020). Learning ethnography through doing ethnography: Two student—researchers' insights. *International journal of qualitative methods, 19*, 1-11. https://doi.org/10.1177/1609406920951295

Ren, J., Yu, G., He, Y., & Li, G. Y. (2019). Collaborative Cloud and edge computing for latency minimization. *IEEE transactions on vehicular technology*, *68*(5), 5031-5044, https://doi.org/10.1109/TVT.2019.2904244

Ridgeway, J. L., Albertie, M., Pantoja, E., Prescott, D., Zhu, X., & Breitkopf, C. R. (2019). Understanding diverse perspectives on genetic research through focus group talk. *International Journal of Qualitative Methods,18*,1-14. https://doi.org/10.1177/1609406919892476

Risling, T. L., Nussbaum, K., Martinez, J., & Risling, D. (2019). Connecting with clinicians: developing the 5-min digital download to advance interpretive description in health-care research. *International journal of qualitative methods,18*,1-8. https://doi.org/10.1177/1609406919833482

Ritterbusch, A. E., Boothby, N., Mugumya, F., Wanican, J., Bangirana, C., Nyende, N., Ampumuza, D., Apota, J., Mbabazi, C., Nabukenya, C., Kayongo, A., Ssembatya, F., & Meyer, S. R. (2020). Pushing the limits of child participation in research: reflections from a youth-driven participatory action research (YPAR) initiative in Uganda. *International journal of qualitative methods,19*,1-12.

https://doi.org/10.1177/1609406920958962

Rogers, E. M. (1962). *Diffusion of innovations*. New York, NY: Free Press.

Sabourin, V. (2020). Identification and categorization of disruptive innovations according to the strategic scope of the firm. *Disruptive technology*, 1840-1859. http://doi:10.4018/978-1-5225-9273-0.ch086

Sandobalín, J., Insfran, E., & Abrahao, S. (2020). On the effectiveness of tools to support infrastructure as code: Model-driven versus code-centric. *IEEE Access*, *8*, 17734–17761. https://doi.org/10.1109/access.2020.2966597

Santana-Cordero, A. M., & Szabó, P. (2019). Exploring qualitative methods of historical ecology and their links with qualitative research. *International journal of qualitative methods, 18*,1-11. https://doi.org/10.1177/1609406919872112

Schön, E., Thomaschewski, J., & Escalona, M. J. (2020). Lean user research for agile organizations. *IEEE access, 8*, 129763-129773.

Schwalbe, U., & Henrique, S. (2018). Creative destruction and the sharing economy: Uber as disruptive innovation. *Journal of Economics*, *124*, 93–96. https://doi.org/10.1007/s00712-017-0589-6

Sekaran, K., Khan, M. S., Patan, R., Gandomi, A. H., Krishna, P. V., & Kallam, S. (2019). Improving the response time of M-learning and cloud computing environments using a dominant firefly approach. *IEEE access*, *7*, 30203-30212. https://doi.org/10.1109/ACCESS.2019.2896253

Seok, M. G., Sarjoughian, H. S., Choi, C., & Park, D. (2020). Fast and cycle-accurate simulation of RTL NoC designs using test-driven cellular automata. *IEEE access*,

*8*, 2670-2686. https://doi.org/10.1109/ACCESS.2019.2962253

Shen, J., Zhou, T., He, D., Zhang, Y., Sun, Y., & Xiang, Y. (2019). Block design-based key agreement for group data sharing in cloud computing. *IEEE transactions on dependable and secure computing*, *16*(6), 996-1010, https://doi.org/10.1109/TDSC.2017.2725953

Si, S., & Hui Chen, H. (2020). A literature review of disruptive innovation: What it is, how it works, and where it goes. *Journal of Engineering and Technology Management*, 56, 101568. https://doi.org/10.1016/j.jengtecman.2020.101568

Siasi, N., Jasim, M., Aldalbahi, A., & Ghani, N. (2020). Delay-aware SFC provisioning in hybrid fog-cloud computing architectures. *IEEE access*, *8*, 167383-167396. https://doi.org/10.1109/ACCESS.2020.3021354

Siddiqi, M. H., Alruwaili, M., Ali, A., Haider, S. F., Ali, F., & Iqbal, M. (2020). Dynamic priority-based efficient resource allocation and computing framework for vehicular multimedia cloud computing. *IEEE access*, *8*, 81080-81089. https://doi.org/10.1109/ACCESS.2020.2990915

Siddiqui, S., & Khan, T. A. (2019). Test patterns for cloud applications. *IEEE access*, *7*, 147060-147080. https://doi.org/10.1109/ACCESS.2019.2946315

Sietz, D., Frey, U., Roggero, M., Gong, Y., Magliocca, N., Tan, R., & Václavík, T. (2019). Archetype analysis in sustainability research: *Methodological portfolio and analytical frontiers. Ecology and Society*, *24(3).* *https*://doi.org/10.2307/26796999

Smet, P., Dhoedt, B., & Simoens, P. (2018). Docker layer placement for on-demand

provisioning of services on edge clouds. IEEE *transactions on network and service management*, *15*(3), 1161-1174, https://doi.org/10.1109/TNSM.2018.2844187

Snyder, B., & Curtis, B. (2018). Using analytics to guide improvement during an agile–DevOps transformation. *IEEE Software*, *35*(1), 78-83, https://doi.org/10.1109/MS.2017.4541032

Spiers, J., Morse, J. M., Olson, K., Mayan, M., & Barrett, M. (2018). Reflection/commentary on a past article: Verification strategies for establishing reliability and validity in qualitative research: http://journals.sagepub.com/doi/full/10.1177/160940690200100202. *International journal of qualitative methods*, *17*, 1-2. https://doi.org/10.1177/1609406918788237

Stahlke, S. (2018). Expanding on notions of ethical risks to qualitative researchers. *International journal of qualitative methods*,*17*,1-9. https://doi.org/10.1177/1609406918787309

Starblanket, D., Lefebvre, S., Legare, M., Billan, J., Akan, N., Goodpipe, E., & Bourassa, C. (2019). Nanâtawihowin Âcimowina Kika-Môsahkinikêhk Papiskîci-Itascikêwin Astâcikowina [Medicine/healing stories picked, sorted, stored]: adapting the collective consensual data analytic procedure (CCDAP) as an indigenous research method. *International journal of qualitative methods*,*18*,1-10. https://doi.org/10.1177/1609406919896140

Stilgoe, J. (2018). We need new rules for seif-driving cars. *Issues in science and*

*technology, 3*4(3), 52-57. https://doi.org/10.2307/26594264

Tamburri, D. A., Van den Heuvel, W., Lauwers, C., Lipton, P., Palma, D., & Rutkowski, M. (2019). TOSCA-based intent modeling: goal-modelling for infrastructure-as-code. *SICS software-intensive cyber-physical systems*, 34,163–172. https://link.springer.com/article/10.1007/s00450-019-00404-x

Timonen, V., Foley, G., & Conlon, C. (2018). challenges when using grounded theory: A pragmatic introduction to doing GT research. *International journal of qualitative methods,17,* 1-10. https://doi.org/10.1177/1609406918758086

Torkura, K. A., Sukmana, M. I. H., Cheng, F., & Meinel, C. (2020). CloudStrike: Chaos engineering for security and resiliency in cloud infrastructure. *IEEE Access,8,*123044-123060. https://doi.org/10.1109/ACCESS.2020.3007338

Trihinas, D., Tryfonos, A., Dikaiakos, D. M., & Pallis, G. (2018). DevOps as a service: Pushing the boundaries of microservice adoption. *IEEE internet computing, 22*(3), 65-71, https://doi.org/10.1109/MIC.2018.032501519

Tu, S., Waqas, M., Rehman, S. U., Aamir, M., Rehman, O. U., Jianbiao, Z., & Chang, C. (2018). Security in fog computing: A novel technique to tackle an impersonation attack. IEEE Access,6,74993-75001. https://doi.org/10.1109/ACCESS.2018.2884672

Tuthill, E. L., Maltby, A. E., DiClemente, K., & Pellowski, J. A. (2020). Longitudinal qualitative methods in health behavior and nursing research: assumptions, design, analysis and lessons learned. *International journal of qualitative methods,19,*1-21. https://doi.org/10.1177/1609406920965799

Valle, F. D., & Oliver, M. (2020). Blockchain enablers for supply chains: How to boost implementation in industry. *IEEE access, 8,* 209699-209716. https://doi.org/10.1109/ACCESS.2020.3038463

Visser, A., du Preez, P., & Simmonds, S. (2019). Reflections on life design narrative inquiry as a methodology for research with child sex trafficking survivors. *International journal of qualitative methods, 18,* 1-12. https://doi.org/10.1177/1609406919857553

Walsh, S., Jones, M., Bressington, D., McKenna, L., Brown, E., Terhaag, S., Shrestha, M., Al-Ghareeb, A., & Gray, R. (2020). Adherence to COREQ reporting guidelines for qualitative research: A Scientometric study in nursing social science. *International journal of qualitative methods, 19,* 1-19. https://doi.org/10.1177/1609406920982145

Wang, P., Lei, Y., Agbedanu, P. R., & Zhang, Z. (2020a). Makespan-driven workflow scheduling in clouds using immune-based PSO algorithm. *IEEE access,8,*29281-29290. https://doi.org/10.1109/ACCESS.2020.2972963

Wang, Q., & Hannes, K. (2020). Toward a more comprehensive type of analysis in photovoice research: The development and illustration of supportive question matrices for research teams. *International journal of qualitative methods,19,*1-15. https://doi.org/10.1177/1609406920914712

Wang, R., & Tan, Q. (2019). Dynamic model of port throughput's influence on regional economy. *Journal of coastal research, 93(1)* 811-816. https://doi.org/10.2307/26853358

Wang, W., Liu, H., Lin, W., Chen, Y., & Yang, J. (2020b). Investigation on works and military applications of artificial intelligence. *IEEE Access, 8,*131614-131625. https://doi.org/10.1109/ACCESS.2020.3009840

Wang, X. (2018). Secure connectivity in infrastructure-based one-dimensional networks with the presence of random eavesdroppers. *IEEE Access,6,*27558-27568. https://doi.org/10.1109/ACCESS.2018.2836357

Webb, J., Williams, V., Gall, M., & Dowling, S. (2020). Misfitting the research process: shaping qualitative research in the field to fit people living with dementia. *International journal of qualitative methods,19,*1-11. https://doi.org/10.1177/1609406919895926

Wen, Z., Lin, T., Yang, R., Ji, S., Ranjan, R., Romanovsky, A., Lin, C., & Xu, J. (2020). GA-par: Dependable microservice orchestration framework for geo-distributed clouds. *IEEE transactions on parallel and distributed systems, 31*(1), 129-143. https://doi.org/10.1109/TPDS.2019.2929389

Whelan, M., HubkaRao, T., Stang, A., Freedman, S., Macpherson, A., Howard, A., & Hagel, B. (2019). Child bicyclist perspectives on danger and injury circumstances in the built environment. *Children, youth and environments, 29*(2), 77-91. https://doi.org/10.7721/chilyoutenvi.29.2.0077

Williams, H. M., Hunter, K., Griffin, B., Kimble, R., & Clapham, K. (2021). Fire and smoke: Using indigenous research methodologies to explore the psychosocial impact of pediatric burns on aboriginal and Torres strait islander families. *International journal of qualitative methods,20,*1-14.

https://doi.org/10.1177/1609406921990486

Williamson, C., Van Rooyen, A., Shuttleworth, C., Binnekade, C., & Scott, D. (2020). Wuity as a philosophical lens for qualitative data analysis. *International journal of qualitative methods,19*,1-11. https://doi.org/10.1177/1609406920926885

Wohlfart, O. (2020). Digging deeper?: Insights from a novice researcher. *International journal of qualitative methods,19*,1-5. https://doi.org/10.1177/1609406920963778

Wöhrer, M. D. V., Jesser, M. D. A., Mataloni, B., & Schmidt, A. (2020). Insights from setting up the first wave of a qualitative longitudinal study. *International journal of qualitative methods,19*,1-12. https://doi.org/10.1177/1609406920954057

Wright, A. L., Gabel, C., Ballantyne, M., Jack, S. M., & Wahoush, O. (2019). Using two-eyed seeing in research with indigenous people: An integrative review. *International journal of qualitative methods, 18*,1-19. https://doi.org/10.1177/1609406919869695

Xiong, R., Li, Z., Shi, J., Wu, Z., & Jin, J. (2018). HirePool: optimizing resource reuse based on a hybrid resource pool in the cloud. *IEEE Access,6*,74376-74388. https://doi.org/10.1109/ACCESS.2018.2884028

Xu, W., & Zammit, K. (2020). Applying thematic analysis to education: A hybrid approach to interpreting data in practitioner research. *International journal of qualitative methods,19*,1-9. https://doi.org/10.1177/1609406920918810

Yang, P., Liu, Z., Xu, J., Huang, Y., & Pan, Y. (2020). An empirical study on the ability relationships between programming and testing. *IEEE access, 8*, 161438-161448. https://doi.org/10.1109/ACCESS.2020.3018718

Yeganeh, H., Salahi, A., & Pourmina, A. M. (2019). A novel cost optimization method for mobile cloud computing by capacity planning of green data center with dynamic pricing. *Canadian Journal of electrical and computer engineering*, *42*(1), 41-51, https://doi.org/10.1109/CJECE.2019.2890833

Younas, M., Jawawi, D. N. A., Shah, M. A., Mustafa, A., Awais, M., Ishfaq, M. K., & Wakil, K. (2020). Elicitation of nonfunctional requirements in agile development using cloud computing environment. *IEEE access, 8*, 209153-209162. https://doi.org/10.1109/ACCESS.2020.3014381

Young, J. C., Rose, D. C., Mumby, H. S., Benitez-Capistros, F., Derrick, C. J., Finch, T., & Mukherjee, N. (2018). A methodological guide to using and reporting on interviews in conservation science research. *Methods in Ecology and Evolution*, *9*(1), 10-19. https://doi.org/10.1111/2041-210x.12828

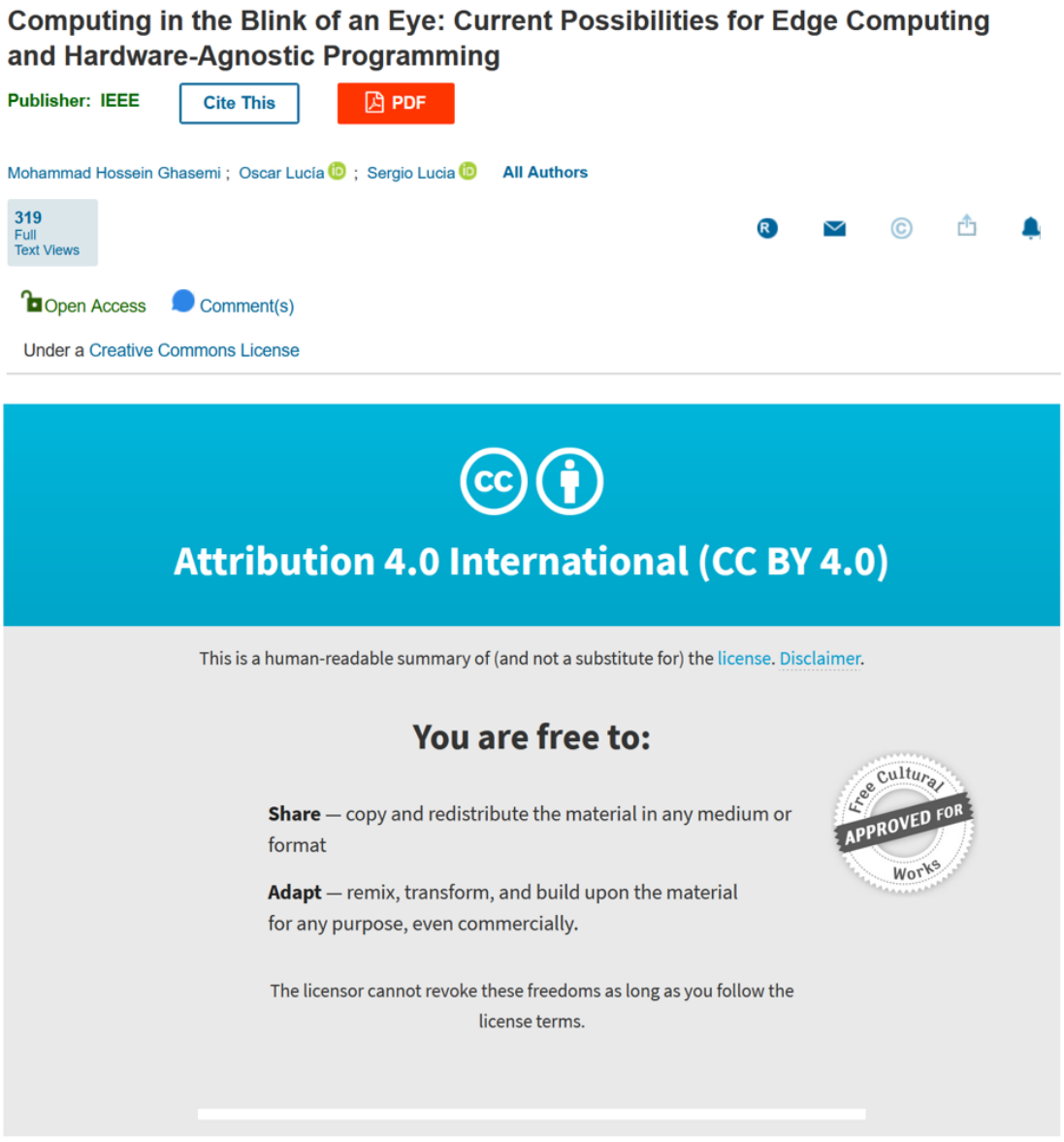
Young, K., Miller, E., Ekberg, S., & Bradford, N. (2020). The experiences and healthcare needs of families living with pediatric brain tumor: A longitudinal qualitative study protocol. *International journal of qualitative methods*, *19*, 1 – 8. https://doi.org/10.1177/1609406920981324

Zhang, A. J., Albrecht, L., & Scott, S. D. (2018). Using twitter for data collection with health-care consumers: A scoping review. *International journal of qualitative methods*,*17*,1-13. https://doi.org/10.1177/1609406917750782

Zhao, P., Wang, P., Yang, X., & Lin, J. (2020). Towards cost-efficient edge intelligent computing with elastic deployment of container-based microservices. *IEEE access*, 8, 102947-102957. https://doi.org/10.1109/ACCESS.2020.2998767

Zhu, B., Shum, K. W., Li, H., & Anta, A. F. (2019). On the duality and file size hierarchy of fractional repetition codes. *The Computer journal*, 62(1), 150-160, https://doi.org/10.1093/comjnl/bxy094

Appendix A: Granting Permission to Use Figure 1



# Appendix B: Granting Permission to Use Table 1

**Course: DOCTORAL STUDY MENTORING**

**University/Institution:** WALDEN UNIVERSITY
**Start of term:** 12/18/2020
**Course number:** ITEC-8100
**Number of students:** 1

**Instructor:**
**Your reference:** JEFFREY S. CHIJIOKE-UCHE
**Accounting reference:** DOCTOR OF INFORMATION TECHNOLOGY
**Order entered by:** JEFFREY S. CHIJIOKE-UCHE

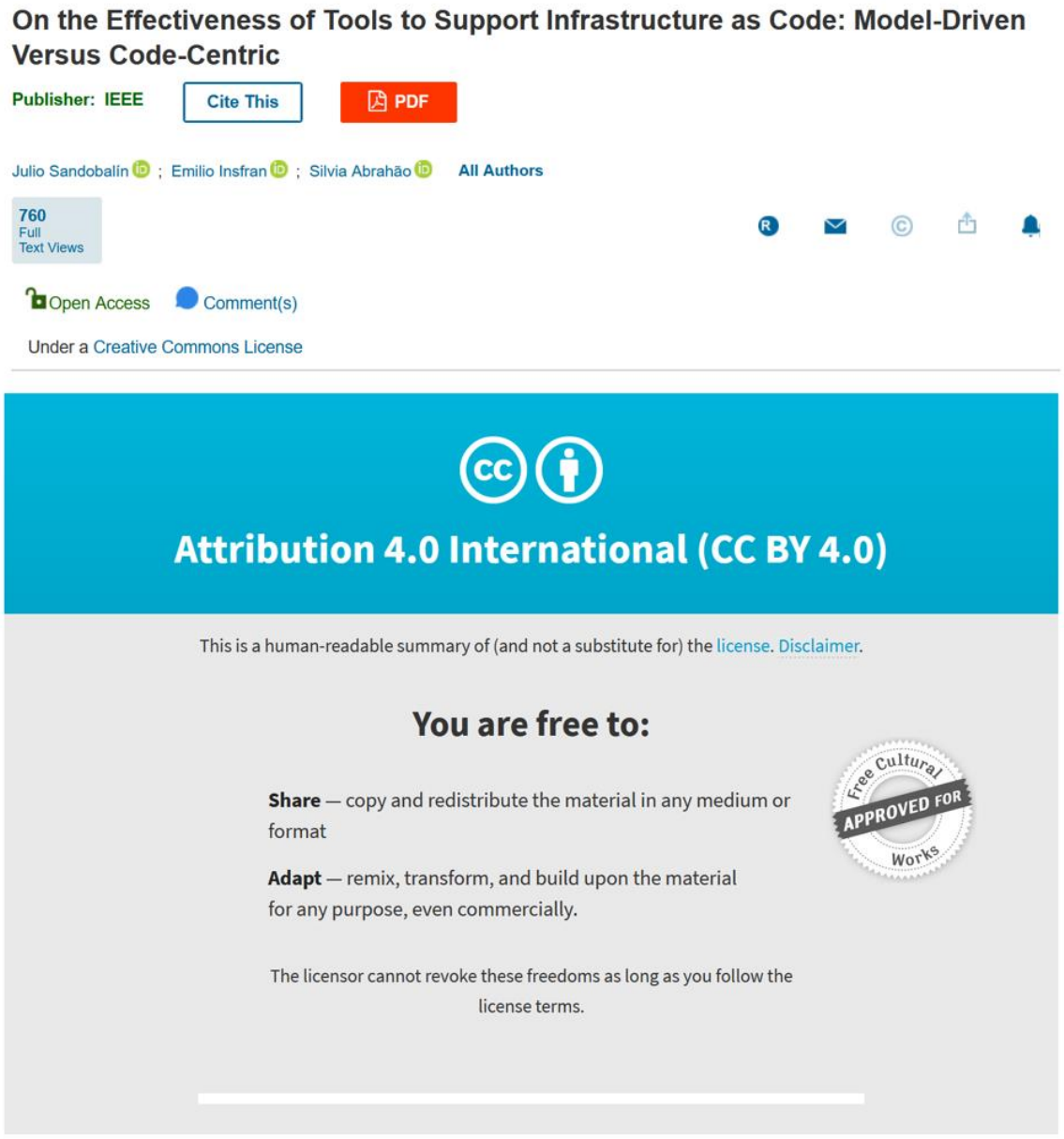
**Columbia law review**

| | |
|---|---|
| **Order detail ID:** | 72384354 |
| **ISSN:** | 0010-1958 |
| **Publication Type:** | Journal |
| **Publisher:** | COLUMBIA LAW REVIEW ASSOCIATION |
| **Rightsholder:** | COLUMBIA LAW REVIEW ASSOCIATION, INC. |
| **Author/Editor:** | COLUMBIA UNIVERSITY ; ESTREICHER, SAMUEL |

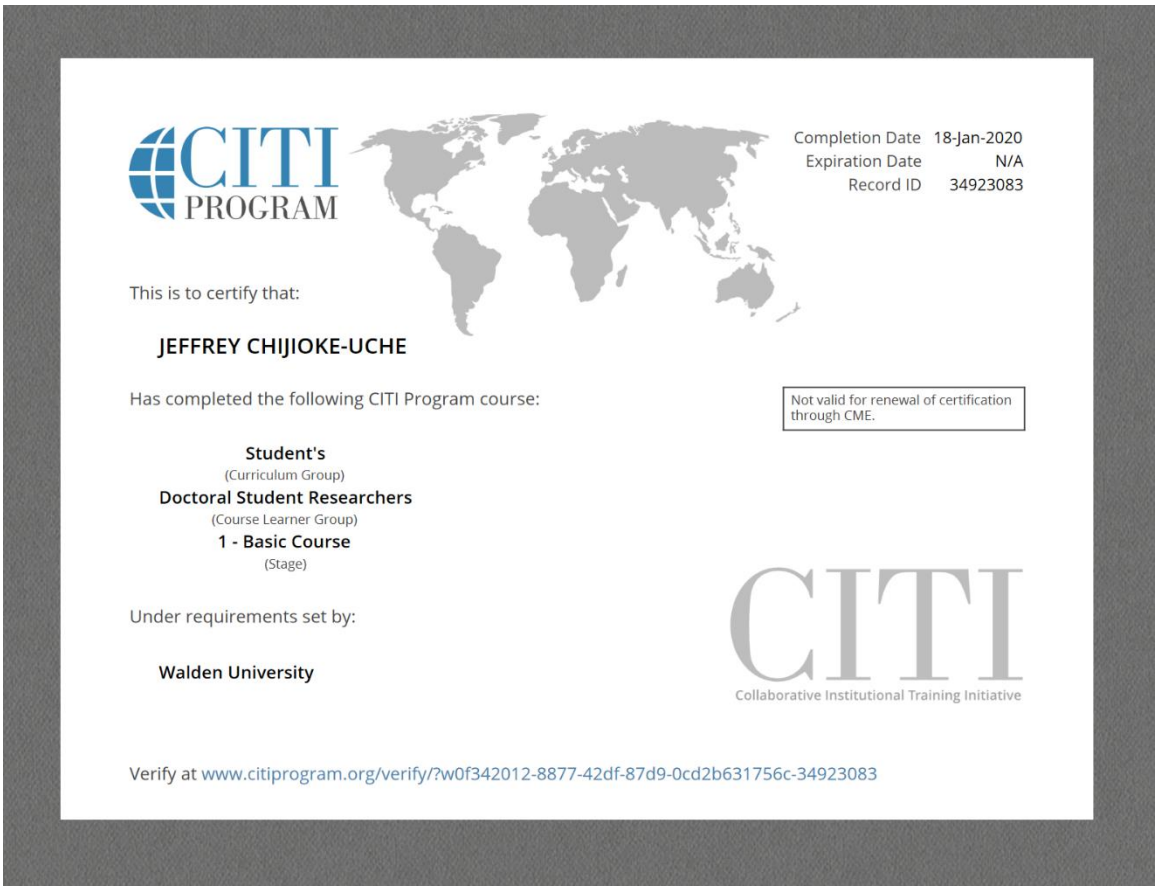
**Permission Status:** **Granted**

| | | |
|---|---|---|
| **Permission type:** | Use in electronic course materials | |
| **Type of use:** | Use in an e-coursepack | |
| **Per Page Fee:** | $ 0.10 | |
| **Page range(s):** | 1973-2000 | |
| **Total number of pages:** | 28 | |
| **Number of students:** | 1 | **$ 6.30 ($6.30 per student)** |

Appendix C: Granting Permission to Use Figure 2



# Appendix D: CITI Doctoral Student Researchers Certification



CITI PROGRAM

Completion Date 18-Jan-2020
Expiration Date N/A
Record ID 34923083

This is to certify that:

**JEFFREY CHIJIOKE-UCHE**

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

**Student's**
(Curriculum Group)
**Doctoral Student Researchers**
(Course Learner Group)
**1 - Basic Course**
(Stage)

Under requirements set by:

**Walden University**

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?w0f342012-8877-42df-87d9-0cd2b631756c-34923083

# Appendix E: Individual Participant's Letter of Invitation

{{TODAY's DATE}}

Dear {{Name of Potential Research Participant}},

**Participant Letter of Invitation for Doctoral Study in Infrastructure as Code(IaC)**

Your infrastructure-as-code expertise in implementing cloud computing makes you an ideal candidate to participate in my doctoral research study. I hope you will accept my invitation.

My name is Jeffrey Chijioke-Uche, and I am currently a doctoral student in Walden University's Information Technology program. My study is titled *Infrastructure as Code(IaC) Strategies and Benefits in Cloud Computing*.

As the sole researcher for this study, I will be conducting interviews with experts like yourself who have knowledge and experience on solution architects' strategies to implement IaC solutions in cloud computing using DevOps procedures. The topics include Kubernetes, Terraform, ARM template, Ansible, Docker, Puppet, Cloud service providers (AWS, Azure, GCP, IBM Cloud, Oracle Cloud, Alibaba cloud), Automation with CI/CD, DevOps, Version controls, secure Configuration management (KeyVault, Vaults, Library), and Cloud computing deployment models(Public, Private, Hybrid), and Cloud computing service models(PaaS, IaaS, SaaS) strategies.

The interview will last for 60 minutes for ten questions which will cover part of the topics above, depending on which you prefer to talk about during the session. You are free to stop at any time during the interview session.

Participation in this study is entirely voluntary. If you agree to participate, you have the right to refuse to answer any questions that make you feel uncomfortable or completely withdraw all or part of the information already provided even after completing data collection without any prejudice or consequence. The interview will be a semi-structured interview via Microsoft Teams or Zoom. There will also be a brief follow-up after the interview to confirm my understanding of your comments.

After completing the process, I will send you a $25 VISA gift card as a token of appreciation for your time and expertise.

I truly appreciate your time and effort in willingly participating in this study. Please read the attached Informed Consent Form. If you agree to the terms of that form, please reply to this email with the words: "*I consent*." Please, when you reply, kindly indicate *dates/times* you will be available for the interview. When I get your reply, I will respond with *Teams* or *Zoom* meeting schedule invite.

Thank you.

## Appendix F: Focus Group Participant's Letter of Invitation

{{TODAY's DATE}}

Dear {{Name of Potential Research Participant}},

**Participant Letter of Invitation for Doctoral Study in Infrastructure as Code(IaC)**

Your infrastructure-as-code expertise in implementing cloud computing makes you an ideal candidate to participate in my doctoral research study. I hope you will accept my invitation.

My name is Jeffrey Chijioke-Uche, and I am currently a doctoral student in Walden University's Information Technology program. My study is titled *Infrastructure as Code(IaC) Strategies and Benefits in Cloud Computing*.

As the sole researcher for this study, I will be conducting interviews with experts like yourself who have knowledge and experience on solution architects' strategies to implement IaC solutions in cloud computing using DevOps procedures. The topics include Kubernetes, Terraform, ARM template, Ansible, Docker, Puppet, Cloud service providers (AWS, Azure, GCP, IBM Cloud, Oracle Cloud, Alibaba cloud), Automation with CI/CD, DevOps, Version controls, secure Configuration management (KeyVault, Vaults, Library), and Cloud computing deployment models(Public, Private, Hybrid), and Cloud computing service models(PaaS, IaaS, SaaS) strategies.

The interview will last for 60 minutes for ten questions as a focus group interview which will cover part of the topics above, depending on which you prefer to talk about. The session will have two other participants as focus group members like yourself who will help answer the questions in whichever area they feel. You are free to stop at any time during the interview session.

Participation in this study is entirely voluntary. If you agree to participate, you have the right to refuse to answer any questions that make you feel uncomfortable or completely withdraw all or part of the information already provided even after completing data collection without any prejudice or consequence. The interview will be a semi-structured interview via Microsoft Teams or Zoom.

After completing the process, I will send you a $25 VISA gift card as a token of appreciation for your time and expertise.

I truly appreciate your time and effort in willingly participating in this study. Please read the attached Informed Consent Form. If you agree to the terms of that form, please reply to this email with the words: "*I consent*." Please, when you reply, kindly indicate *dates/times* you will be available for the interview. When I get your reply, I will respond with *Teams* or *Zoom* meeting schedule invite.

Thank you.

## Appendix G: Interview Questions and IPs

### Interview Questions

- **Q01:** What cloud deployment model did you use to implement IaC with DevOps procedures or principles? Which cloud service provider did you use and why?
- **Q02:** What Configuration management tools have you used to store IaC sensitive variable tokens to avoid data security breach during IaC implementation? Why did you use these tools?
- **Q03:** How have you used Terraform, ARM template, Puppet, Ansible, Kubernetes, Docker, and or Version Controls technologies in the implementation of IaC? Explain any other similar technologies used in IaC implementation.
- **Q04:** What tools do you use for the implementation of IaC? Please explain why you use the tools and how you use them, including describing which one is the most efficient recommendation for adopting the IaC strategy by any IT organization that wishes to transition their IT architecture.
- **Q05:** What IaC approaches do you use for infrastructure implementation? Please explain in both public and private cloud computing platforms, where applicable.
- **Q06:** How do you use IaC during infrastructure failure disaster recovery? Please explain any significant role played by IaC's automation capability in the recovery of failed infrastructure architecture. Highlight any other significant IaC benefit you can think of concerning IaC.
- **Q07:** What are the IaC implementation tools that you use? Please explain the associated cloud computing platform. That is where the tools are used or supported. Highlight IaC architecture component tools, if applicable.
- **Q08:** What are your IaC implementation strategies? Please explain your IaC lifecycle strategy in DevOps best practice procedure lifecycle until it gets to production.
- **Q09:** What drawbacks can you elaborate on, which exist in your utilization of IaC implementation strategies? You can give a few scenario examples.
- **Q10:** Why is IaC practice considered predisposition with cloud-agnostic tools used to implement infrastructure architecture in grid and cloud computing?

**Individual Interview Protocol**

[$I_{Pr1}$:] Initiation: Interview procedure review with participant

- Let the participant know that interview is voluntary.
- Let the participant know that the interview duration is 30 – 60 minutes.
- Let the participant know that he/she can stop the interview at any time.
- Let the participant know that data is kept confidential.
- Get participant's verbal consent to set-on the audio recorders.

[$I_{Pr2}$:] Data Recorder: Set twin audio recorder on

- $1^{ST}$ Audio Recorder set as the primary recorder: AR1
- $2^{ND}$ Audio Recorder set as a backup: AR2
- Set-on audio recorders.
- Start Interview.

[$I_{Pr3}$:] Interview: Initial probe questions

- Q01, Q02, Q03

[$I_{Pr4}$:] Interview: Targeted concept questions

- Q04, Q05, Q06

[$I_{Pr5}$:] Interview: Targeted follow-up questions

- Q07, Q08, Q09

[$I_{Pr6}$:] Interview: Targeted wrap-up question

- Q10

[$I_{Pr7}$:] Interview: Set twin recorder off

- Turn off AR1
- Turn off AR2

[$I_{Pr8}$:] Interview: Endpoint

- Thank the participant for voluntarily participating.
- Schedule follow-up meeting.
- Explain to the participant the steps involved in the follow-up meeting.

**Focus Group Interview Protocol**

[$I_{Pr9}$:] Initiation: Meeting procedure review with participant

- Let the participants know that the meeting is voluntary.
- Let the participants know that the meeting duration is 30 – 60 minutes.
- Let the participants know that anyone can opt-out at any time.
- Let the participants know that data is kept confidential.
- Get participants' verbal consent to set-on the audio recorders.

[$I_{Pr10}$:] Data Recorder: Set twin audio recorder on

- 1ST Audio Recorder set as the primary recorder: AR1
- 2ND Audio Recorder set as a backup: AR2
- Set-on audio recorders.
- Start Interview.

[$I_{Pr11}$:] Interview: Initial probe questions:

- **Q01** [*directed to P1*], **Q02** [*directed to P2*], **Q03** [*directed to P3*]

[$I_{Pr12}$:] Interview: Targeted concept questions:

- **Q04** [*directed to P2*], **Q05** [*directed to P3*] **Q06** [*directed to P1*]

[$I_{Pr13}$:] Interview: Targeted follow-up questions:

- **Q07** [*directed to P3*], **Q08**[*directed to P1*], **Q09**[*directed to P2*]

[$I_{Pr14}$:] Interview: Targeted wrap-up question: *Directed to a particular participant*

- **Q10** [directed to P1]

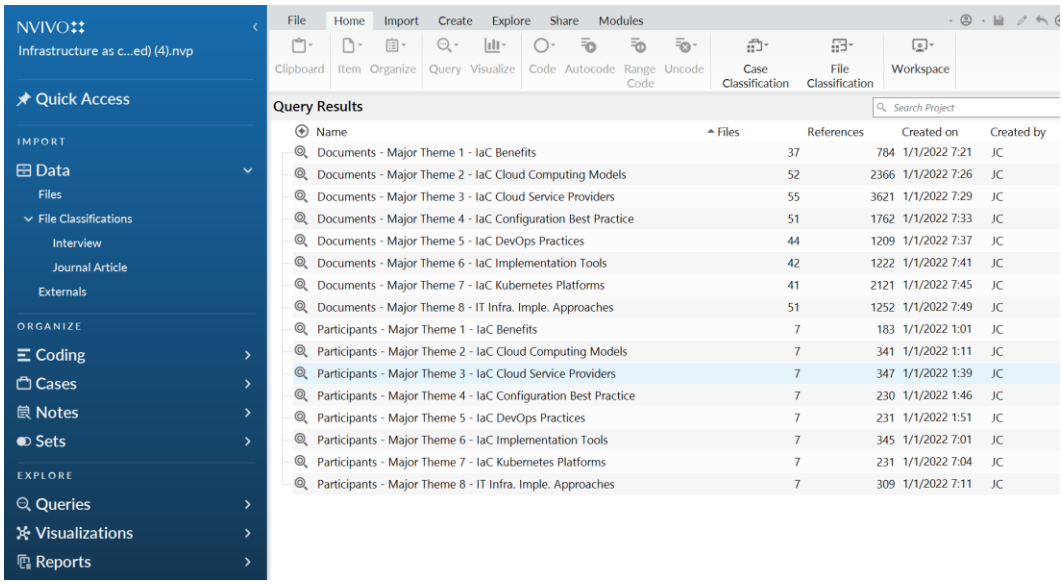
[$I_{Pr15}$:] Interview: Set twin recorder off

- Turn off AR1
- Turn off AR2

[$I_{Pr16}$:] Interview: Endpoint

- Thank the participants for voluntarily participating.
- Explain to participants the steps involved in the follow-up meeting.

# Appendix H: Major Themes References Query Results Evidence




| Name | Files | References | Created on | Created by |
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| Documents - Major Theme 2 - IaC Cloud Computing Models | 52 | 2366 | 1/1/2022 7:26 | JC |
| Documents - Major Theme 3 - IaC Cloud Service Providers | 55 | 3621 | 1/1/2022 7:29 | JC |
| Documents - Major Theme 4 - IaC Configuration Best Practice | 51 | 1762 | 1/1/2022 7:33 | JC |
| Documents - Major Theme 5 - IaC DevOps Practices | 44 | 1209 | 1/1/2022 7:37 | JC |
| Documents - Major Theme 6 - IaC Implementation Tools | 42 | 1222 | 1/1/2022 7:41 | JC |
| Documents - Major Theme 7 - IaC Kubernetes Platforms | 41 | 2121 | 1/1/2022 7:45 | JC |
| Documents - Major Theme 8 - IT Infra. Imple. Approaches | 51 | 1252 | 1/1/2022 7:49 | JC |
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| Participants - Major Theme 4 - IaC Configuration Best Practice | 7 | 230 | 1/1/2022 1:46 | JC |
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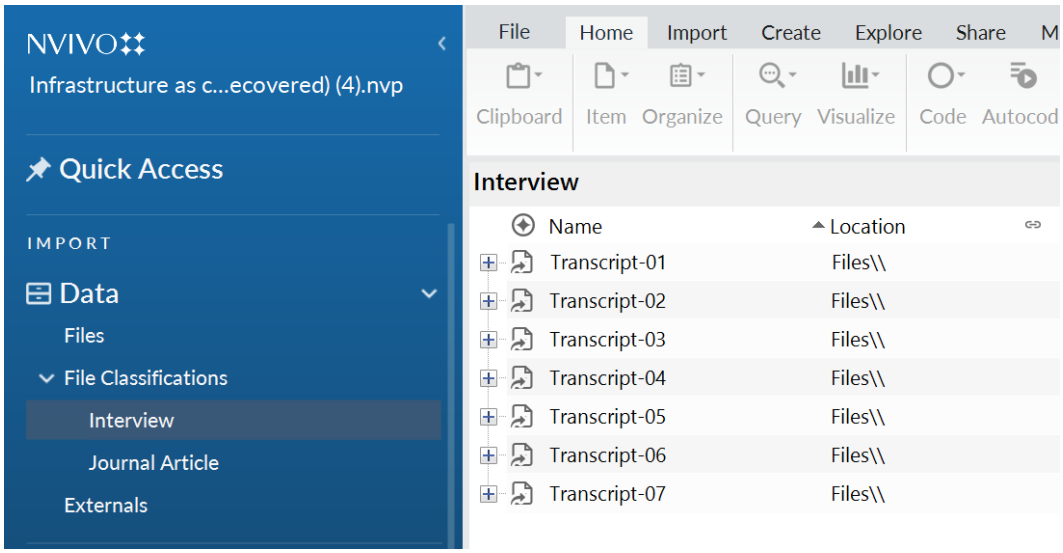
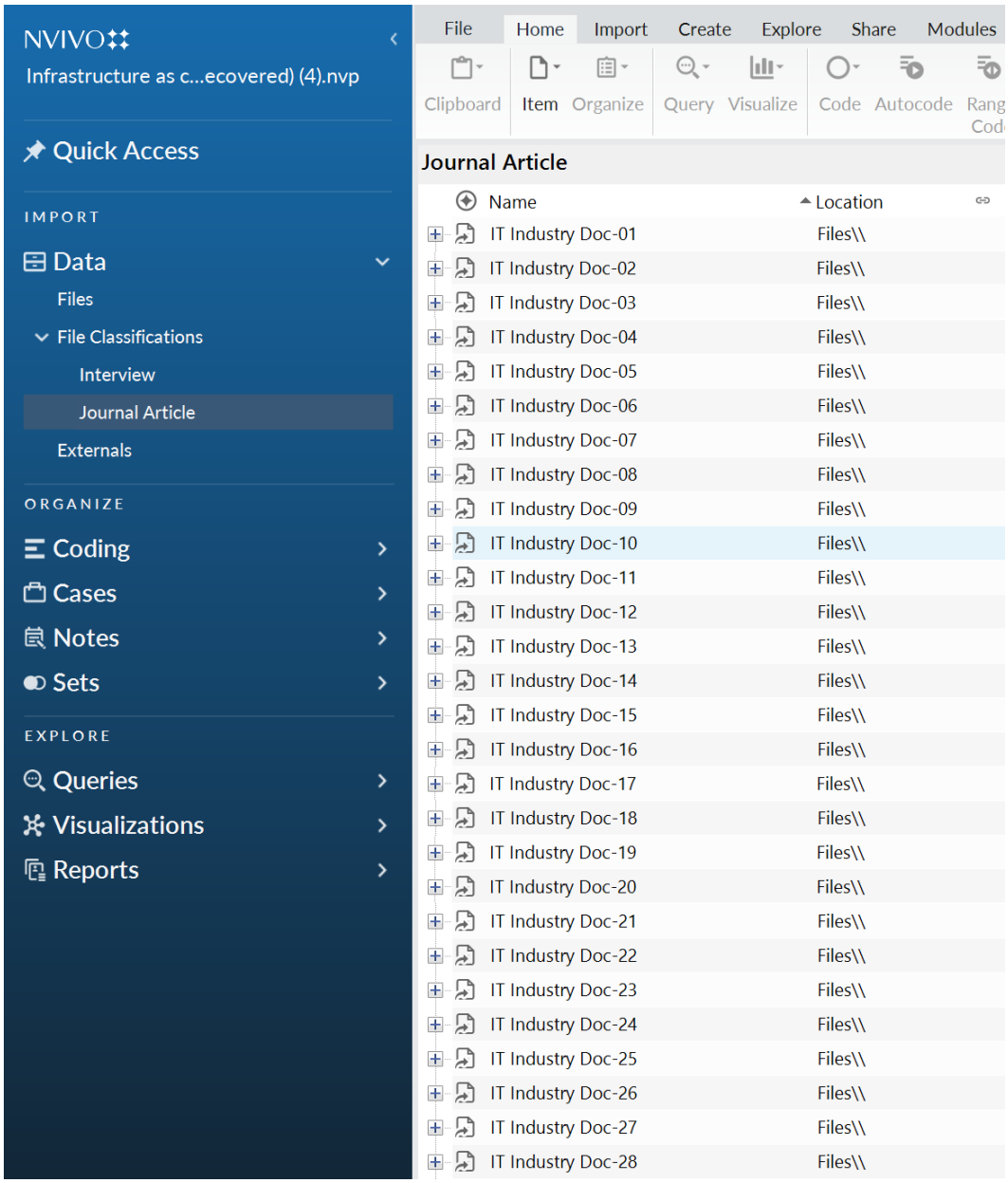
| Participants - Major Theme 8 - IT Infra. Imple. Approaches | 7 | 309 | 1/1/2022 7:11 | JC |

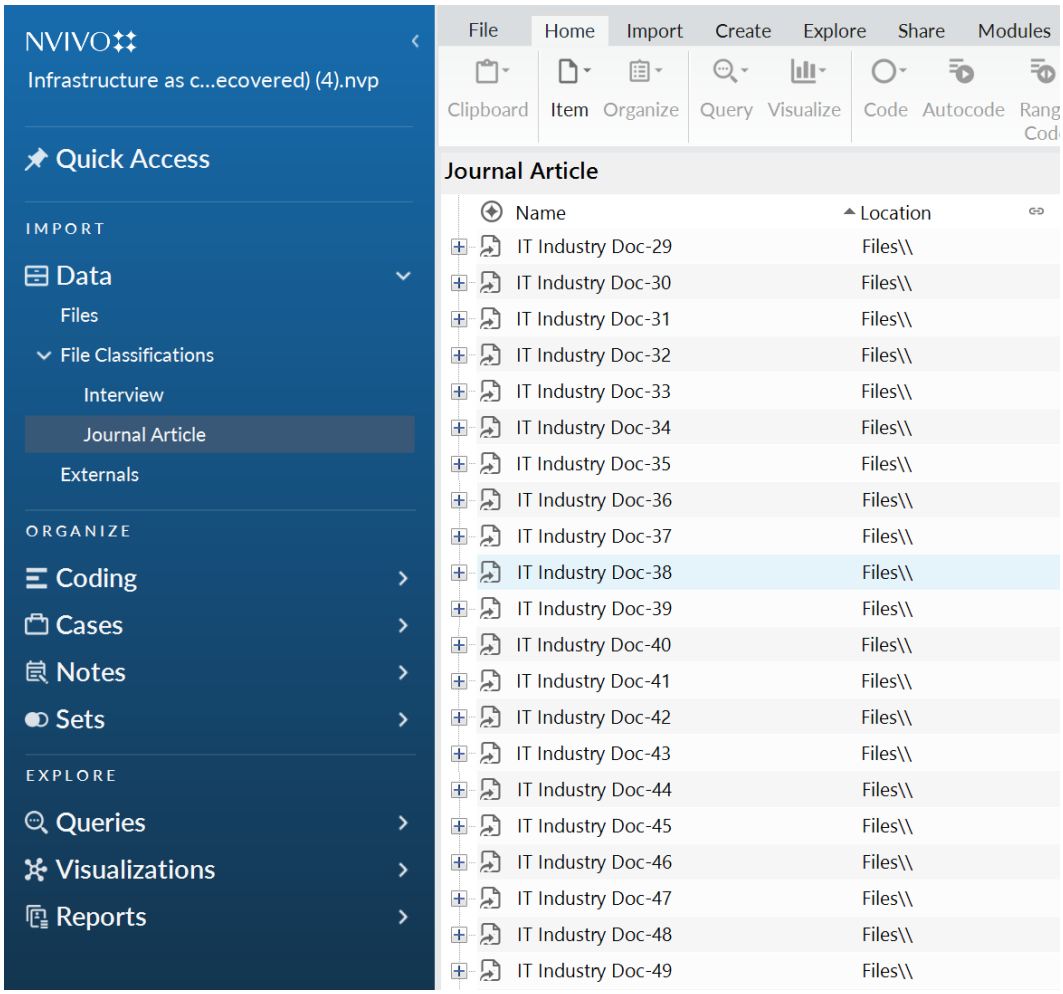
# Appendix I: Participants' Transcripts Evidence



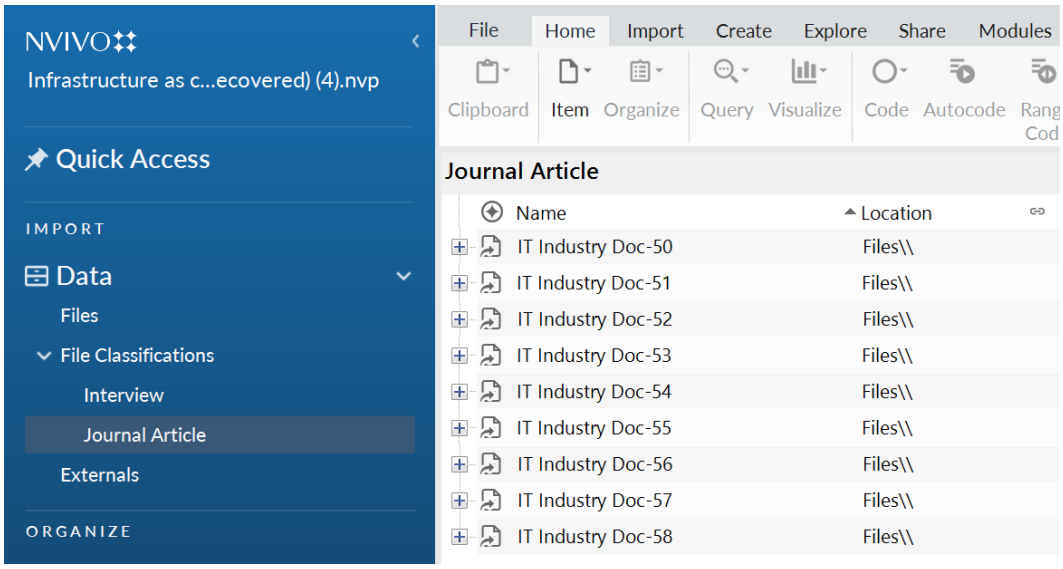
Appendix J: IT Industry Document Journal Articles Evidence



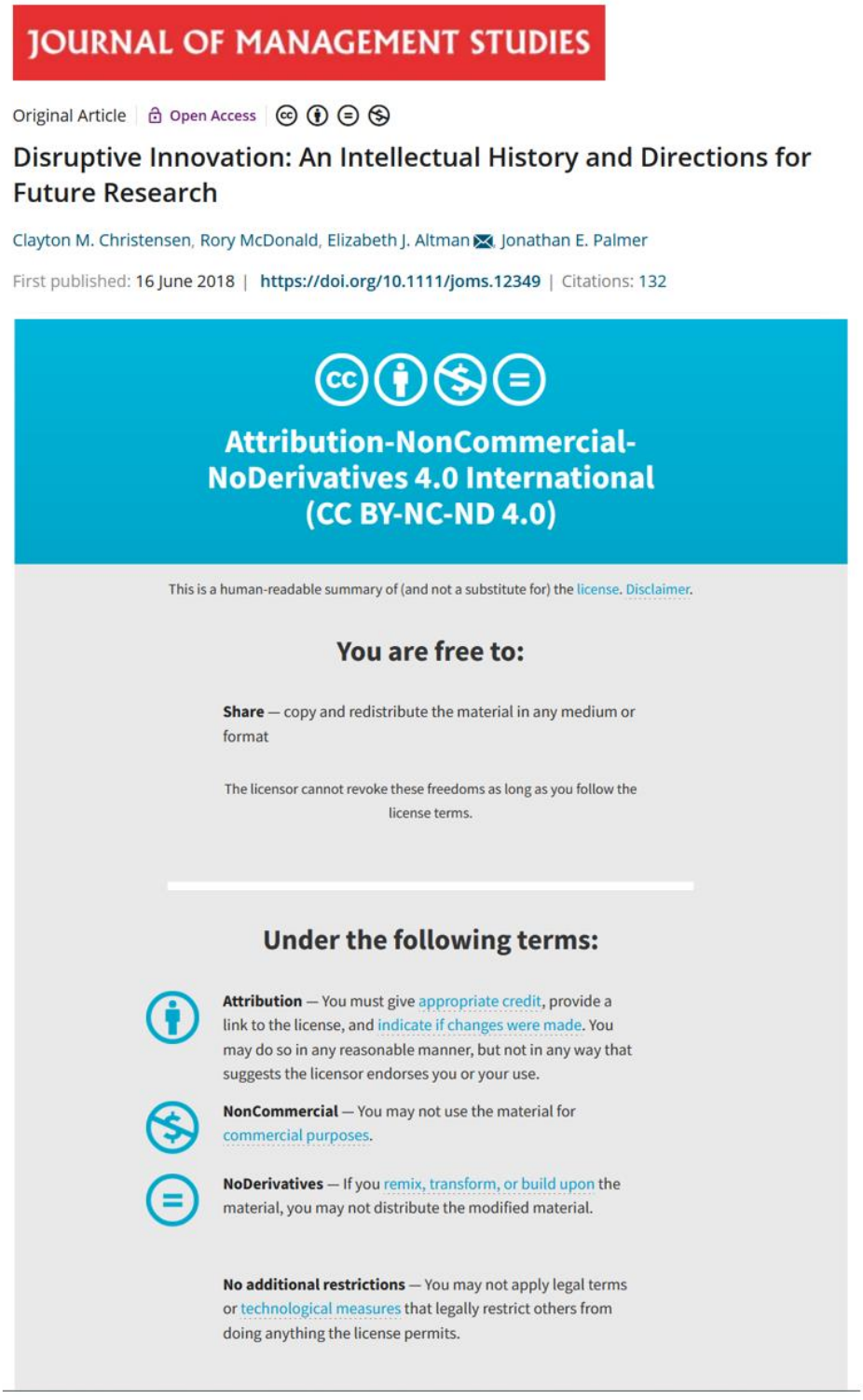
**Continued: IT Industry Document Journal Articles Evidence**



**Continued: IT Industry Document Journal Articles Evidence**



Appendix K: CC Granted Permission to Use Table 11



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Clayton M. Christensen, Rory McDonald, Elizabeth J. Altman, Jonathan E. Palmer

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