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The Strategic Case for Cloud-Native

Developing a business perspective of cloud-native applications

Master's Thesis

Business Administration and E-business

by

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Abstract

By providing cost-effective and on-demand IT infrastructure, cloud computing has evolved to become an integral part of organizations' business operations. On cloud-based infrastructure, organizations run applications to perform business-critical processes, e.g. communication services or resource planning systems. However, the cloud-maturity level of the applications within an organization influences the degree to which the benefits of cloud-based infrastructure can be leveraged. The term cloud-native describes applications that are designed with the intention to fully leverage the benefits of cloud-based infrastructure and has received increasing attention in both practical and academic contexts in recent years. Although a noticeable amount of research has been conducted on how to transform existing legacy applications to cloud-native from a technological perspective, little is known about the business value of cloud-native. Consequently, the research aims to fill the gap in academic research around the strategic implications of implementing cloud-native applications (CNAs). To operationalize an investigation of the strategic implications of CNAs, an initial conceptual model is crafted based on the academic literature on CNAs and the Digital Business Strategy framework developed by Bharadwaj et al. (2013). The conceptual model is examined with semi-structured interviews in the context of two companies employing CNAs. Overall, the multi-case study finds that the characteristics of CNAs enable the realization of the four themes of Digital Business Strategy, namely, scope, scale, speed, and sources of value creation and capture. Moreover, twelve distinct strategic implications from CNAs are presented in the revised conceptual model coined the "The Cloud-Native Strategy Model". The Cloud-Native Strategy Model predominantly reflects beneficial strategic implications arising from CNAs. Yet, the model also incorporates drawbacks from implementing CNAs. Subsequently, these strategic implications are found to impact overall business performance. Hence, business and IT managers need to carefully consider the implementation of CNAs based on the organization's individual cost-benefit-ratio. The Cloud-Native Strategy Model presented in this research can provide a comprehensive decision-making aid for this managerial assessment.

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List of Abbreviations

Abbreviation	Definition
API	Application Programming Interface
AWS	Amazon Web Services
CEO	Chief Executive Officer
CI/CD	Continuous Integration and Deployment
CIO	Chief Information Officer
CNA	Cloud-Native Application
CNCF	Cloud Native Computing Foundation
CoE	Center of Excellence
CPU	Central Processing Unit
DevOps	Development and Operations
ERP	Enterprise Resource Planning
FaaS	Function as a Service
FinTech	Financial Technology
GDPR	General Data Protection Regulation
IaaS	Infrastructure as a Service
IaC	Infrastructure as Code
IPO	Initial Public Offering
IS	Information System
IT	Information Technology
OS	Operating System
PaaS	Platform as a Service
RAM	Random Access Memory
SaaS	Software as a Service
SDN	Software Defined Networking
SOA	Service Oriented Architecture
SQL	Structured Query Language
VM	Virtual Machine

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1. Introduction

1.1. Background

The ubiquitous digitalization of the economy forces organizations from all industries to evaluate digital business opportunities and adapt to rising customer expectations emerging from new technologies (Weinman, 2015). Companies failing to adequately respond to recent technology trends put their overall competitiveness at risk, thereby ultimately endangering the survival of the organization (Fitzgerald et al., 2014; Sebastian et al., 2017).

One technology that has gained significant momentum in the business world over the last decade is cloud computing (Gill et al., 2019). Cloud computing has become integral to business operations for a broad range of organizations (Marston et al., 2011). Its significance is illustrated by its extensive utilization in enterprises. According to Nash (2019), the global rate of enterprise adoption of cloud computing has surpassed the adoption rate of every other major technology trend. Thus, cloud computing is no longer only applied by technological forerunners such as software start-ups, but also established organizations undergoing digital transformations. Cloud computing has radically changed the delivery and consumption of IT services for businesses (Gangwar et al., 2015). A central appeal to cloud computing, regardless of industry or size, is the on-demand access to IT infrastructure via internet connection. By making physical servers in data centers at the organization's premises redundant, cloud infrastructure removes the complexity and inflexibility of running IT infrastructure locally. Consequently, organizations benefit from an increasing focus on achieving business goals while reducing IT infrastructure costs at the same time (Venters & Whitley, 2012; Kratzke, 2018). Accordingly, cloud computing has become a core competence with executive awareness beyond the IT department or CIO (Weinman, 2015). From a managerial perspective, the growing adoption of cloud computing has brought a new strategic layer of organizations' IT strategy (Low et al., 2011; Weinman, 2015). Central determinants of implementing cloud computing include both technological and organizational factors, such as the existing application landscape, the preferred cloud service model, and the employees' current cloud competencies. Ultimately, the perceived competitive advantage of utilizing cloud computing presents a decisive factor for its adoption (Gangwar et al., 2015).

Cloud computing is often investigated from one of two perspectives - a service delivery model perspective or a deployment model perspective (Kratzke, 2018). From the service delivery model perspective, organizations generally have three cloud service models to choose from, i.e. Software- (SaaS), Platform- (PaaS) or Infrastructure-as-a-Service (IaaS) (Kratzke & Quint, 2017). Fundamentally, the service models differentiate to the degree they allow the user control and involvement over the cloud service. Specifically, in a SaaS model, users merely use applications on cloud infrastructure. The interface of applications are web browsers, and thus does not require installation, e.g. a webmail application. In a PaaS model, operating systems and tools are provided to the users, who then develop the applications themselves on the provided platform. Finally, with an IaaS model, users are only provided with cloud-based infrastructure. Therefore, the users develop and manage the tools for application development, and the applications themselves (Kratzke, 2018; Mell & Grance, 2011). From a deployment perspective, three different cloud deployment models are available, i.e. public, private, or hybrid cloud, which each offers different levels of management, flexibility, and security. In a public cloud, infrastructure is hosted from third-party servers, and it is thus the vendor who makes the shared infrastructure available to the user. On a private cloud, infrastructure is hosted by the individual organization, which accordingly directly manage and control the company's data. Finally, a hybrid cloud model combines the private and public cloud, with the central benefit being that the organization can pose stricter control over some data in the private cloud while leveraging the advantages of public cloud in other parts of the organization (Marston et al., 2011). The different service delivery and deployment models are central elements of cloud computing and increase the complexity and comprehensiveness of an IT strategy (Weinman, 2015). Hence, different aims and levels of ambition around the adoption of cloud computing bring individual implications to organizations' IT strategy.

In recent years, the term cloud-native has gained momentum within the fields of IT infrastructure and software development (Greverie, 2017). On a high level, cloud-native describes the practice of building and running applications designed specifically for cloud infrastructure (Foster & Gannon, 2017; Spillner et al., 2018). Although the particular approach may vary between individual organizations, applications developed and deployed cloud-natively share some central organizational and technological characteristics. Foster & Gannon (2017) describe cloud-native applications broadly as *"[...] applications [deployed] as microservices, packaging each part into its own container, and dynamically orchestrating those containers to optimize resource utilization"*

(p. 335). A comprehensive review of the characteristics of cloud-native applications is provided in chapter 2 of the thesis.

As indicated, the adoption of cloud-native is on the rise. In 2017, 15 percent of new applications developed within companies across industries were considered to be cloud-native. By 2020, this number is expected to grow to 32 percent (Greverie, 2017). The rising significance of cloud-native is further illustrated by the growing adoption of individual elements of cloud-native applications (CNAs hereafter). Microservices, which present a core technology of CNAs, are projected to be utilized in 80 percent of application development in 2021 (IDC, 2017). Further, the utilization of application containers, another key cloud-native technology, is expected to more than triple from 2019 to 2023 according to Gartner (as cited by Christiansen, 2020). Yet, the implementation of cloud-native requires a fundamental transformation of software development practices that encompasses both technical and organizational elements. A shift to CNAs thus brings new demands for the development and operation of software applications (Gannon, 2017).

1.2. Research Motivation

As mentioned, cloud computing implies manifold strategic or business value to organizations. These strategic implications are well researched and documented by the literature within this field (e.g. Aljabre, 2012; Iyer & Henderson, 2012; Weinman, 2015). Yet, even though CNAs present a concept directly adjacent to cloud computing, a research gap exists regarding the strategic implications of them. While considerable research has been conducted around the implementation of individual elements of cloud-native architectures and the technological requirements hereof (e.g. Shen et al., 2019; Toffetti et al., 2017; Gannon et al., 2017), limited research has been investigating the strategic implications for businesses. Within this paradox, the research at hand aims to fill this gap by fundamentally examine the business case for cloud-native. Despite the contribution to the literature, the thorough investigation of the topic shall yield to practical implications for business and IT stakeholders. This motivation leads to the following research question of the thesis:

What are the strategic implications of implementing cloud-native applications?

To provide guidance throughout the research process and answer the overall research question of the thesis, the following sub-questions have been formulated:

1. *How is cloud-native defined in the academic literature, and what elements does it include?*
2. *How can the characteristics of cloud-native applications be conceptually linked to business strategy?*
3. *What are the practical experiences of different companies implementing cloud-native applications from a strategic perspective?*
4. *What can be synthesized about the business value of cloud-native applications?*

Guided by the above sub-questions, the main objective of the research is thus the documentation of the strategic implications from the implementation of CNAs from real-world sources. Therein, the key strategic awareness points for organizations interested in adopting CNAs in the future shall be derived.

1.3. Research Structure

Overall, this thesis can be divided into six chapters shown in Figure 1.

- **Chapter 1** accounts for the background, motivation, and research question underlying this thesis.
- **Chapter 2** provides the theoretical background regarding cloud-native applications and presents a reference framework for the understanding of strategic implications within an IT context. Further, the conceptual link between cloud-native applications and business strategy is elaborated based on existing literature. The resulting conceptual model serves as the theoretical foundation for the thesis' analysis.
- **Chapter 3** outlines the thesis' applied research methodology, including the choice of research philosophy, strategy, design, and approaches to data collection and analysis.
- **Chapter 4** provides the empirical findings of the two case studies from Zalando and Adidas.
- **Chapter 5** discusses the results of the case analyses in the light of academic literature, ultimately leading to a revised conceptual model on the strategic implications of CNA implementation.
- **Chapter 6** finally presents the thesis' conclusions and reflects its research quality, potential limitations, and suggestions for future research.

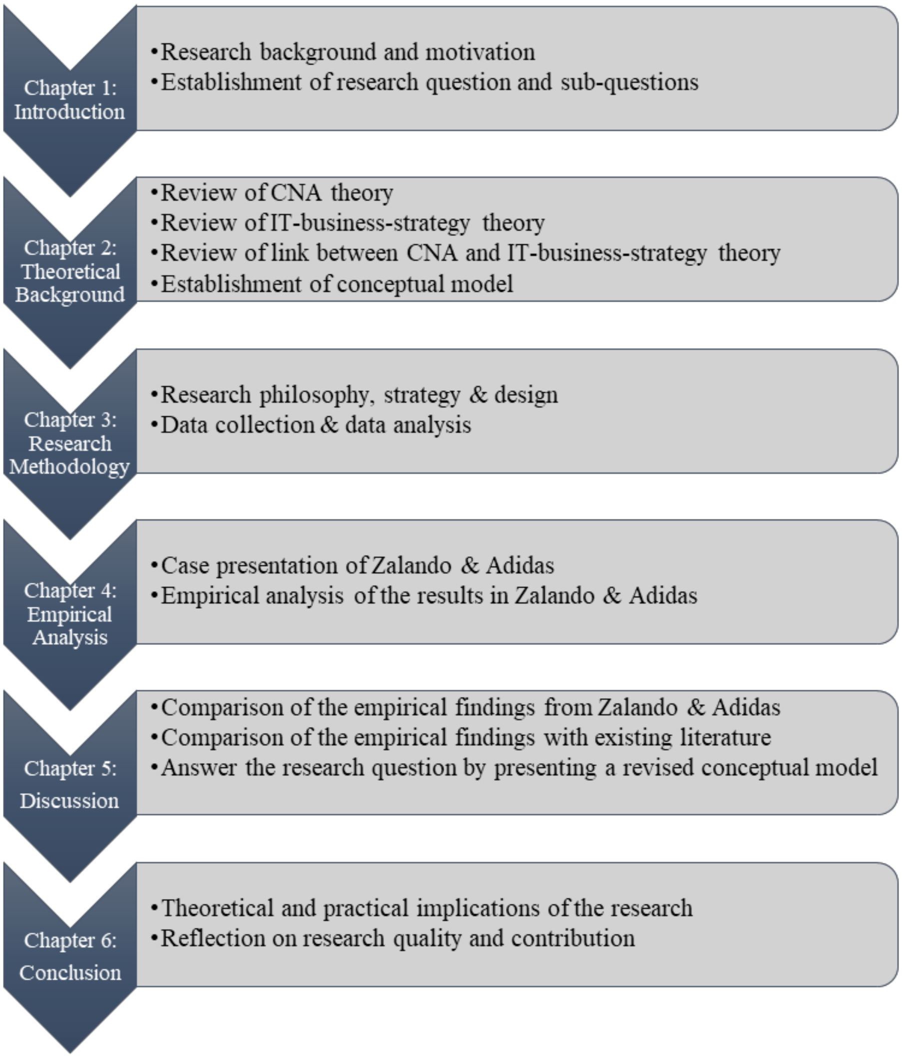

Figure 1: Structure of the thesis at hand (Own representation).

2. Theoretical Background

2.1. Cloud-Native and CNAs

As stated above, the following section seeks to establish the conceptual understanding of cloud-native applications as a basis for the subsequent research of its strategic implications. The term cloud-native roots within academic research. Its emergence can be traced back to a study around pattern-based cloud architectures by Andrikopolous et al. (2012). It was not until 2015 the term began to gain wider popularity in the industrial context (Kratzke & Quint, 2017). It is important to note that cloud computing and cloud-native do not present opposites, but compliments. Whereas cloud computing disrupted the provision of IT infrastructure for businesses, cloud-native disrupts the development and operations of applications running on that infrastructure (Nova & Garrison, 2018). It is *"[...] designed to fully exploit the potential of cloud infrastructures."* (Shen et al., 2019). In this sense, Spillner et al. (2018) propose a four-stage model categorizing the cloud maturity of software applications:

1. **Legacy** applications are not designed to run in cloud environments, requiring manual installation and resource provisioning.
2. **Cloud-enabled** applications technologically fit cloud hosting due to virtualized deployment but are isolated from external cloud platform services, i.e. databases.
3. **Cloud-aware** applications seamlessly integrate external cloud platform services.
4. **Cloud-native** applications take full advantage of cloud platforms by maximizing availability, elasticity, and resiliency automatically.

A constantly developing definition of cloud-native stems from the industry association cloud-native computing foundation:

> *"Cloud-native technologies empower organizations to build and run scalable applications in modern, dynamic environments such as public, private, and hybrid clouds. Containers, service meshes, microservices, immutable infrastructure, and declarative APIs exemplify this approach. These techniques enable loosely coupled systems that are resilient, manageable, and observable. Combined with robust automation, they allow engineers to make high-impact changes frequently and predictably with minimal toil"* (CNCF, 2020)

In their meta-level review around the constituents of CNAs, Kratzke & Quint (2017) incorporate their findings to synthesize a definition of CNAs, which remains singular within the academic literature, and serves as the definition used in this research:

> *"A cloud-native application (CNA) is a distributed, elastic and horizontal scalable system composed of (micro)services which isolates state in a minimum of stateful components. The application and each self-contained deployment unit of that application is designed according to cloud-focused design patterns and operated on a self-service elastic platform"* (Kratzke & Quint, 2017, p.13).

Kratzke & Quint's (2017) definition incorporates manifold aspects of CNAs, which are discussed in the following.

2.1.1. Properties of CNAs

Firstly, Kratzke & Quint (2017) depict the properties of CNAs, which include elasticity and scalability. **Elasticity** refers to the adaptation of IT resources to changes in system workload. High elasticity means to rapidly and continuously match the provisioning of IT resources as close as possible to demand (Herbst et al., 2013).

Similar, yet to be differentiated, is **scalability**, which *"[...] is the ability of the system to sustain increasing workloads by making use of additional resources [...]"* (Herbst et al., 2013, p. 25). Opposite to elasticity, scalability does not concern how close demand and resources are matched, but how frictionless further resources can be added or removed from the system. CNAs are designed to scale with *"[...] thousands of concurrent users"*. (Gannon et al., 2017, p. 17). Horizontal scaling, as specified in the CNA definition by Kratzke & Quint (2017), means the addition of individual resource instances to the overall cluster of resources. Vertical scaling describes the expansion of the existing resource instances by adding further capacity (i.e. CPU, RAM) (García et al., 2008).

2.1.2. Architecture of CNAs

The properties of CNAs are realized through its architecture. The core of the CNA architecture is represented by **microservices**. Microservices root in the paradigm of Service-Oriented-Architecture (SOA) and were pioneered by Netflix and Amazon after their first appearance in 2011 (Dragoni et al., 2017; Fowler & Lewis, 2014).

From a historical angle, microservices emerged as a solution for the drawbacks presented by monolithic applications. Monolithic applications describe *"[...] software application[s] whose modules cannot be executed independently."* (Dragoni et al., 2017, p. 1). As a result of various hard- and software dependencies, monolithic applications are complex to maintain and limit scalability. When updating only minor application parts, the whole system needs to be rebooted, causing lengthy downtimes and development interruptions for applications.

In contrast, microservices modularize large monolithic applications into small, independently updatable and scalable units. According to Fowler & Lewis (2014), microservice architectures present

> *"[…] an approach to developing a single application as a suite of small services, each running in its own process and communicating with lightweight mechanisms […]. These services are built around business capabilities and independently deployable by fully automated deployment machinery […]"* (para. 2).

To achieve this level of independence, the single microservices also have clear technical limits and limited responsibility (Gannon et al., 2017). Each microservices represents a business functionality that is *"[…] doing one thing well"* (Kratzke & Quint, 2017, p.12), such as authentication or the shopping cart within e-commerce (Hasselbring & Steinacker, 2017). This modularity, which results in a high degree of autonomy in the development and operations of microservices, is also referred to as "loose coupling" (Fehling et al., 2015; Dragoni et al., 2017).

Further, this entails that microservices manage their individual database. This is opposite to monolithic applications that utilize one large database which comes with drawbacks. Different data conceptualizations in different services may lead to representation and access issues, e.g. when one large database is used for both sales managers and marketing managers with different data representation requirements (Fowler & Lewis, 2014). Moreover, the higher the volume of the database, the longer a single data request will take (Behara, 2018). On the contrary, microservices with "exclusive" databases allow for a close correlation between business functionality and the database conception. The "bounded context" creates further service modularity and ensures the use of the data model fitting the particular service (Kratzke, 2018).

To sustain consistency between different database instances, e.g. shopping cart and checkout in a webshop, the service databases communicate data via standardized APIs. Thereby, the required data, e.g. billing information, can be read without directly accessing or changing another database instance (Fowler & Lewis, 2014)

Figure 2 compares a monolithic with a microservices application architecture. The monolithic architecture comprises a single module including all application services, such as user interface, business logic, and data interface, that access a shared database. In contrast, the microservices architecture consists of several fine-grained microservices that access individual databases, each representing different business functionalities that are ultimately united in the end-user interface.

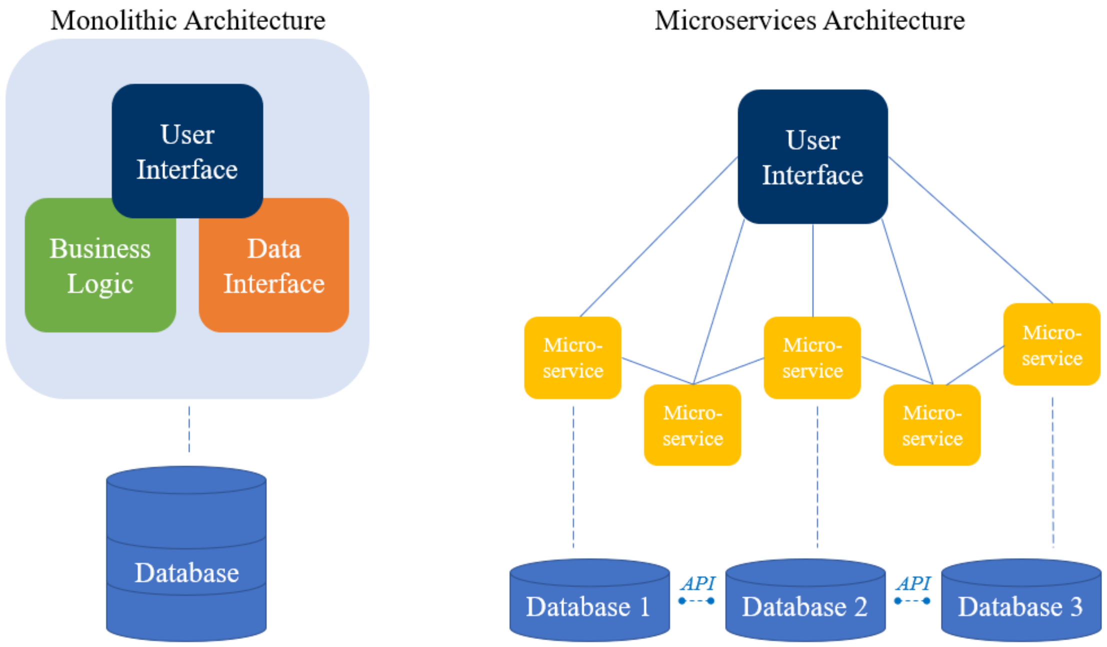

Figure 2: Monolithic vs. microservices architecture (Own representation).

With their distributed character, microservices enable elasticity and horizontal scalability. This means that they can be rapidly executed and terminated across many resource instances (Kratzke, 2018). Therefore, they must be deployed within environments that allow for the quick deployment, termination, and migration of microservices (Gannon et al., 2017; Spillner et al., 2018).

Thus, **application containers** (containers hereafter) emerged as "packaging" for microservices. They represent another crucial architectural element of CNAs. Containers present an advancement of virtual machines (VMs). VMs encapsulate applications and isolate them from the underlying IT resource, such as physical server hardware. Yet, VMs perform as if they were running directly on physical servers. This enables remote access to applications independent from the location of the underlying IT infrastructure. Thus, VMs constitute the technological backbone of cloud computing (Kratzke, 2018).

Technically, a VM "virtualizes" a physical server with an abstraction layer, the so-called hypervisor. This enables the packaging of an operating system (OS), e.g. Windows or Linux, within the VM. With this "guest OS", multiple applications with a different OS can be operated on the same underlying IT infrastructure (Kratzke, 2018). Consequently, the resource utilization of the underlying IT resources is increased compared to running single applications on dedicated servers. Yet, a VM contains further application dependencies besides the guest OS. These include binary files, libraries, and lastly the hosted application itself. Therefore, VMs have a large overhead of multiple gigabytes and takes several minutes to initialize.

In contrast, containers refrain from packaging a guest OS. Instead, the OS on the underlying infrastructure is shared across multiple container instances (s. Fig. 3). This reduces the overhead from 40 percent as in VMs to only 10 percent (Casalicchio, 2017).

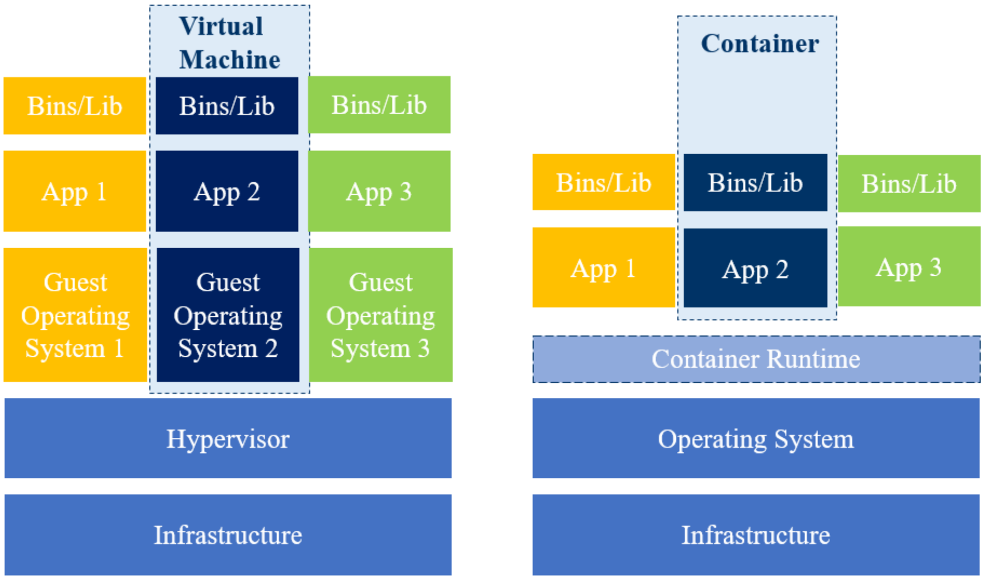

Figure 3: Virtual Machines versus containers (Own representation based on Kratzke, 2018).

This lightweight operating system virtualization (as opposed to machine virtualization in VMs) allows a container unit to be initialized within milliseconds, whereas the initialization of a VM can take several minutes (Kratzke, 2018).

By only encapsulating the application modules with their binary files and libraries, containers further offer a high degree of standardization. This allows containers to be portable across different infrastructure environments, such as physical servers, or VMs in private or public clouds[1] (Kratzke, 2018; Gannon et al., 2017).

Containers are also more resource-efficient than VMs (Kratzke, 2018). This is because of their resource-sharing on operating system level instead of the hardware level (Kratzke, 2018). Fig. 4

[1] Containers can be operated on both physical servers and VMs. In practice, containers and VMs are often implemented complementary, meaning that containers are deployed within a VM, as also shown in Fig. 4 (Rubens, 2017).

shows the advancement of application deployment from the perspective of resource efficiency. The deployment of single applications on dedicated servers with fixed capacity leads to inefficient resource utilization, since applications may not utilize the full server capacity. By employing VMs, multiple applications can be isolated from each other and deployed on a separate abstraction layer on top of these servers. While this increases the server density, the large size of VMs still creates resource inefficiencies. With the abstraction of the OS, containers can further increase the resource density by deploying several fine-grained applications or microservices within a VM or server (ibid.).

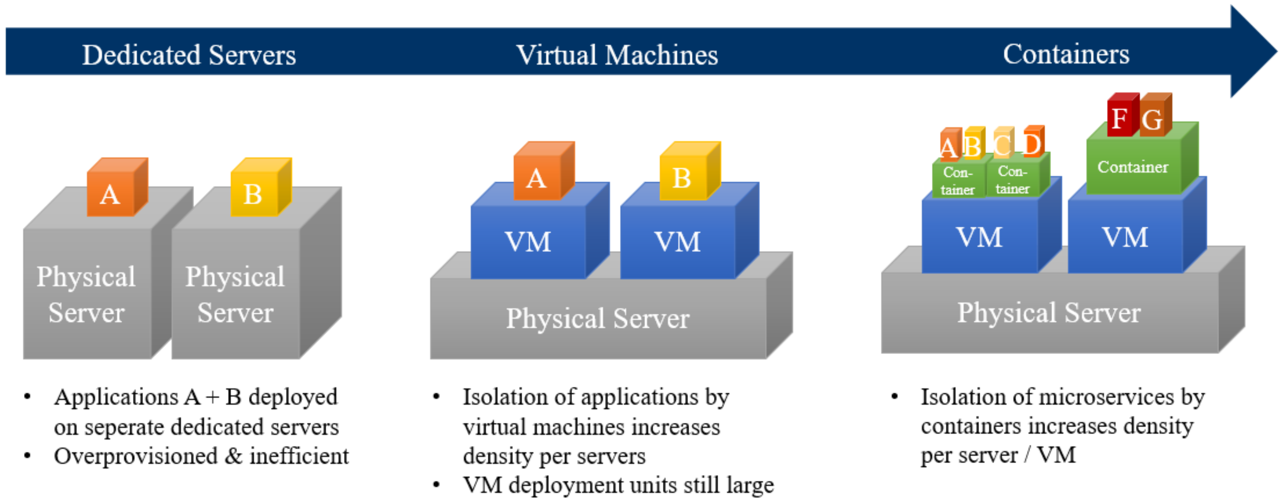

Figure 4: Evolution of resource efficiency in application deployment (Own representation modified from Kratzke, 2018)[2].

Altogether, these characteristics make containers the optimal deployment unit of microservices. Yet, a myriad of microservices packaged into an equally large number of containers comes with challenges in managing such a distributed application at scale. These include e.g. the balancing of web-traffic load between container instances or the monitoring of the application for failed components (Gannon et al., 2017).

Consequently, **container orchestration** or self-service elastic platforms emerged as another architectural layer of CNAs (Kratzke, 2018). Container orchestration represents the 'fabric' that interweaves containerized microservices (Gannon et al., 2017). Platforms such as Kubernetes, Mesos, or Docker Swarm *"[…] allow cloud and application providers to define how to select, to deploy, to monitor, and to dynamically control the configuration of multi-container packaged applications in the cloud."* (Casalicchio, 2017, p.2). Further, container orchestration platforms

[2] In contrast to Kratzke (2018), Fig. 4 does not incl. functions-as-a-service deployment to limit the technical scope of the research at hand.

enable the security and governance of containerized environments (Khan, 2017). By employing automated scaling, container orchestration platforms further increase the resource density. (Kratzke, 2018).

Summarizing, below Figure 5 presents a simplified overview of the typical architectural constituents of CNAs. The infrastructure layer is either composed of the public cloud infrastructure of IaaS providers, the companies own IT resources via a private cloud infrastructure or hybrid cloud infrastructure as a combination of both. At the elastic platform layer, the container orchestration platform governs the configuration and scaling of the service composing layer, which constitutes of containers running on this platform. Within these containers, microservices create the application layer (Kratzke, 2018).

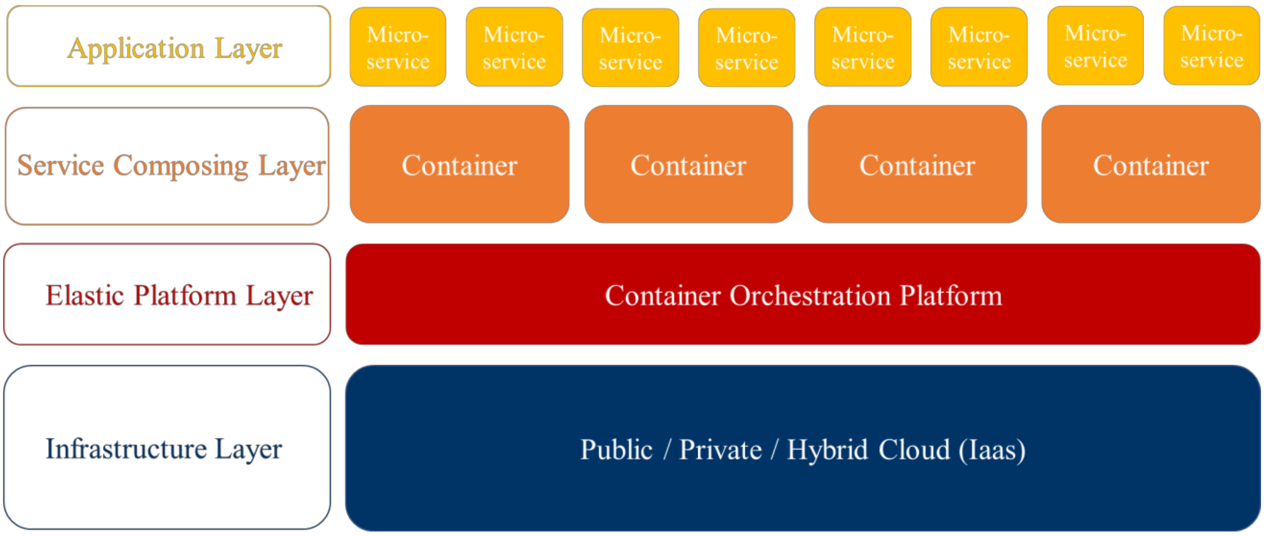

Figure 5: Simplified architectural overview of a typical cloud-native application (Own representation based on Kratzke, 2018).

2.1.3. Cloud-Native Methods

To create and maintain the architecture for CNAs, Kratzke & Quint (2017) further mention that cloud-native methods need to be employed. Cloud-native methods include the **DevOps methodology** as well as **software design patterns**[3].

In particular, the DevOps methodology presents a crucial cornerstone of CNAs. Rooting in agile software development, DevOps unites development *(Dev)* and operations *(Ops)* teams (Jabbari et

[3]A discussion of software design patterns lies outside the scope of this research, since they concern specific (technical) processes within software design. It can be referred to Kratzke & Quint (2017) for an overview over the most important cloud-native software design patterns.

al., 2016). DevOps constitutes the opposite of the traditional waterfall methodology in software development. Processes designed with the waterfall methodology foresee the subsequent execution of process milestones within specialized teams (s. Fig. 6). On the contrary, DevOps presents a continuous process of developing, testing, and deploying applications. IT teams of previously separated units are unified within product-centric, rather than project-centric teams (Fowler & Lewis, 2014).

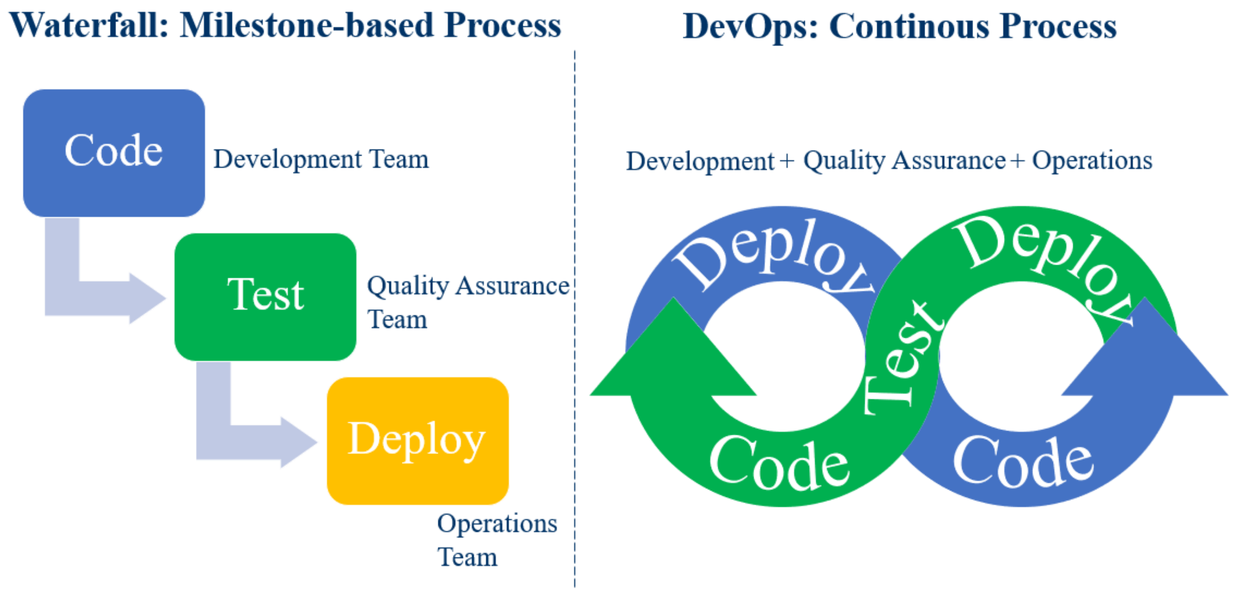

Figure 6: Waterfall versus DevOps methodology (Own representation).

DevOps aims to accelerate software delivery, enhance software stability, and align business and IT goals more closely (Perera et al., 2017). As suggested by Lwaktare et al. (2015), DevOps can be categorized into four dimensions, each addressing a drawback arising from the waterfall methodology:

- **Collaboration:** Improving cross-functional communication by shared product responsibility in small product teams
- **Automation:** Decreasing manual operations and human error by introducing continuous deployment of application modules (i.e. microservices) and resources (i.e. containers)
- **Measurement:** Enabling application performance measurements and quality assurance by tracking application data in real-time (i.e. container orchestration)
- **Monitoring:** Improving the detection of problems by consolidating monitoring data and systems used by development and operations teams

To accelerate the software delivery cycle, DevOps works to minimize the time between an application change and its transfer to a production environment. This velocity is reached through automation techniques such as continuous integration and deployment (CI/CD) (Balalaile et al., 2015). Simultaneously, a high level of software quality is embraced by measurement and monitoring, which is facilitated by continuous application monitoring and quality testing through shared tools (Perera et al., 2017; Forsgren et al., 2019).

Alongside the practices directly related to the software delivery lifecycle, DevOps represents a company culture. The implementation of DevOps emphasizes shared responsibilities for end-user applications by both operations and development teams. In addition, the mutual process transfer from software development to IT operations and vice versa breaks up cross-functional silos. Apart from the implementation of monitoring and automation via shared tools, a collaborative, feedback-driven environment is the cornerstone for DevOps (Perera et al., 2017). Although DevOps practices can be used to develop and operate monolithic applications, the distributed nature of microservice architecture, breaking functionalities down in 'bite-sized' pieces, fully aligns with the DevOps aims and paradigms (Fowler & Lewis, 2014). Thus, the DevOps methodology relates to the idea of designing organizational structures according to their underlying systems, also coined as Conway's Law (Conway, 1968; Kratzke & Quint, 2017).

2.1.4. Cloud-Native Principles

Kratzke & Quint (2017) finally suggest cloud-native principles as a meta-level constituent of CNAs. Firstly, **softwareization** shifts the operation of functionalities from hard- to the software. It concerns networking, i.e. by software-defined networking (SDN) as well as infrastructure, such as infrastructure-as-code (IaC). Instead of replacing hardware elements, functionalities can be introduced or enhanced by solely updating the software, allowing flexible configurations and fast deployment times (Condoluci & Mahmoodi, 2018).

Secondly, Kratzke & Quint (2017) mention the utilization of **automation platforms** as a further cloud-native principle, which is exemplified through container orchestration platforms (2.1.2.) or DevOps tools such as CI/CD pipelines (2.1.3.).
Lastly, **migration and interoperability** present key principles for CNAs according to Kratzke & Quint (2017). In contrast to monolithic applications, which are constrained by their underlying

infrastructure, CNAs and especially containers offer the portability of applications across different types of IT resources by employing containers (Gannon et al., 2017). Therefore, CNAs are well suited to support hybrid- and multi-cloud environments (Kratzke & Quint, 2017).

2.1.5. Overview of CNAs

All In all, cloud-native applications include multi-faceted dimensions which are interlinked with each other, as Figure 8 below illustrates. At a high level, the common principles of CNAs (softwareization, automation platforms, migration, and interoperability) set the direction for its architectural elements (microservices, containers, container orchestration), whose concrete composition and development are enabled by cloud-native methods (DevOps, software design patterns). Finally, CNA properties (elasticity, scalability) are inherent to applications following a cloud-native architecture (ibid.).

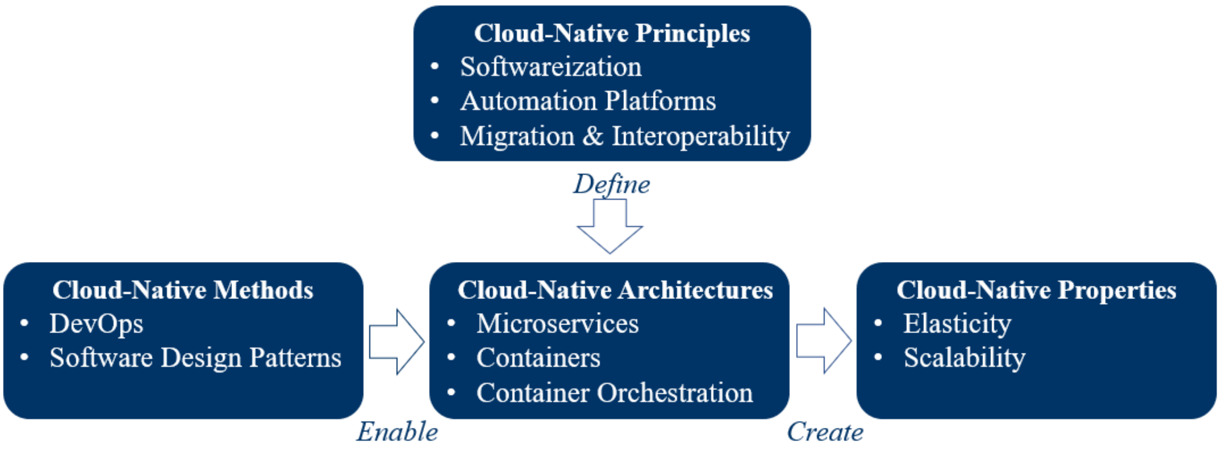

Figure 7: Overview of CNA dimensions (Own representation based on Kratzke & Quint, 2017).

For a more detailed comparison, Appendix 1 provides a multi-dimensional overview of the key differentiators between CNAs and traditional applications, which are herein understood as monolithic or legacy/cloud-enabled applications. By having taken multiple perspectives of CNAs and its demarcation to traditional applications into account, the following section continues with the elaboration of the general interrelation between business and IT strategy to provide a framework for the further investigation of the strategic implications arising from CNAs.

2.2. IT-Business Strategy

This section serves the purpose to determine a business strategy framework to concretize the term "strategic implications" as per the research question of the thesis. In this relation, existing academic business strategy frameworks are reviewed to subsequently provide the basis for analyzing the strategic implications of CNAs.

As the number of academic business strategy frameworks based on a company's' circumstances such as industry, history, etc. is plentiful, two predefined selection criteria are put forth to narrow the review:

- **Criterion 1:** The framework should consider IT. This is due to the nature of the thesis' interest in the interrelation between business and IT
- **Criterion 2:** The framework should be generic/non-industry specific. These criteria are selected to support the generalizability of the thesis' research concepts.

Based on the predefined criteria, four strategy frameworks were found suitable to delineate strategic implications concerning CNAs. The strategy frameworks are shown below in Table 1, listed by published year in ascending order.

Author(s) (year)	Strategy Title	Proposed Concepts
Chen et al. (2010)	Information Systems Strategy	• IS Innovator • IS Conservative
Bharadwaj et al. (2013)	Digital Business Strategy	• Scope • Scale • Speed • Sources of Value Creation and Capture
Weinman (2015)	Digital Disciplines	• Information Excellence • Solution Leadership • Collective Intimacy • Accelerated Innovation
Ross et al. (2017)	A Great Digital Strategy	• Customer Engagement Strategy • Digitized Solution Strategy

Table 1: Overview of reviewed IT business strategy frameworks (Own representation).

Where the frameworks of Chen et al. (2010), Weinman (2015), and Ross et al. (2017) perceive the role of IT as a support function guided by business goals, Bharadwaj et al. (2013) differs with a fusion perspective to IT strategy and business strategy. By discarding the premise that IT strategy should be subordinary to business strategy, Bharadwaj et al. (2013) further reject that there is a desired end-state of IT competence for organizations. Moreover, Bharadwaj et al. (2013) argue that the need for a fusion of IT and business strategy grounds in the importance of responding to new technology developments to remain competitive. Therefore, Bharadwaj et al. (2013) incorporate specific IT concepts into the framework, e.g. cloud computing. For these reasons, the Digital Business Strategy by Bharadwaj et al. (2013) is selected as the framework to operationalize an understanding of "strategic implications" of utilizing CNAs.

The underlying basis for Bharadwaj et al.'s (2013) strategy formation is that external digital trends in parallel with organizational shifts around IT *"are fundamentally reshaping the traditional business strategy"* (Bharadwaj et al., 2013, p. 472). Examples of external digital trends are the growth of cloud computing, and examples of organizational shifts are an increased mandate for the CIO in business decisions and a generally increased attention to IT across the organization (Bharadwaj et al., 2013). Combined, external digital trends and organizational shifts have led to a digitalization of *business processes, firm capabilities, products and services, and key interfirm relationships in extended business networks* (Bharadwaj et al., 2013, p. 471). As argued by Bharadwaj et al. (2013), this digitalization trend ought to be reflected in the overall business strategy.

Consequently, it is no longer adequate to perceive the IT strategy as decoupled from the business' overall strategy or as a subordinate driver as in IT alignment theory (Bharadwaj et al., 2013). Instead, Bharadwaj et al. (2013) propose a framework to fuse IT and business. The fusion of business and IT is understood as the necessary response to take the phenomenon of IT strategy *"[...] beyond efficiency and productivity metrics"* (Bharadwaj et al., 2013, p. 472) and drive competitive advantage from IT resources. Accordingly, Bharadwaj et al. (2013) urge business leaders to *"[...] shift the thinking around IT, not as a functional-level response, but as the fundamental driver of business value creation and capture"* (Bharadwaj et al., 2013, p. 480).

Bharadwaj et al. (2013) define four themes under the Digital Business Strategy: scope of Digital Business Strategy, the scale of Digital Business Strategy, speed of Digital Business Strategy, and sources of value creation and capture.

The following subsections will outline the central concepts of the Digital Business Strategy framework (Bharadwaj et al., 2013), exemplified in *italics*. Subsequently, a conceptual model integrating the concepts of the Digital Business Strategy framework (Bharadwaj et al., 2013) to CNAs will be presented in section 2.3.

2.2.1. Scope of Digital Business Strategy

The first theme of Bharadwaj et al.'s (2013) Digital Business Strategy is scope. Within this theme, the strategic management must define the portfolio of products and services under its direct control and ownership (Bharadwaj et al., 2013). Drawing the boundaries of the Digital Business Strategy is important, as it unveils how the Digital Business Strategy can work to make the organization more effective in relation to its external environment, including competitors. The need for an extension of the organization's scope derives from the fact that *IT transcends traditional functional areas* in the organization, for example marketing, operations, customer service, etc. (ibid).

Moreover, a fundamental question that should be addressed under the scope of the Digital Business Strategy is how the exploitation of *digitalization of products and services* should be pursued (Bharadwaj et al., 2013). More precisely, the organization needs to define its target interoperability to other platforms and products, and adjust its scope accordingly. An exemplary reason to extend scope is to leverage new developments in technology to increase the scope of Digital Business Strategy, such as with the implementation of cloud computing (ibid.).

Further, organizations may aim to adjust their position in their business ecosystem with the Digital Business Strategy. Again, this results from the transcending character of IT, which has intertwined the organization's digital activities to its alliances, partnerships, and competitors, i.e. broadened the ecosystem. IT has thus *extended the scope beyond firm boundaries* (Bharadwaj et al., 2013). A Digital Business Strategy that increases the scope of its ecosystem is exemplified by a standardized IT infrastructure within the supply chain network, as this facilitates collaboration between stakeholders.

2.2.2. Scale of Digital Business Strategy

The second theme addressed by Bharadwaj et al. (2013) is the scale of Digital Business Strategy. Bharadwaj et al. (2013) note that economies of scale have been a fundamental driver for profitability since the industrial age. However, in a Digital Business Strategy, scale is not limited to physical production but extends to the organization's digital activities.

An example of digital scalability is the utilization of cloud computing infrastructure to *rapidly scale up or down* the organization's digital capabilities. By enabling on-demand network access to a shared pool of customizable computing resources, cloud computing infrastructure brings the possibility for increased availability (Bharadwaj et al., 2013). While cloud computing requires technical expertise, the organization attains the capability to dynamically respond to shifting business requirements, such as demands from the marketplace (ibid.).

To further enhance scalability, it may be advantageous to leverage *network effects within multisided platforms* to differentiate products and services. Network effects occur when the value of a product or service increases as more users adopt it (Shapiro & Varian, 1999). Network effects can be achieved from digitally interconnected partnerships, where a product or service from one company is consumed on another company's platform. With this approach, both companies can increase the number of users while at the same time differentiating themselves from competitors. Accordingly, *scaling based on alliances and partnerships* is becoming increasingly relevant to share digital assets that can benefit the profitability of participating organizations in the collaboration. A collaborative scaling strategy can be illustrated from loyalty programs and mutual online cross-selling to other companies (Bharadwaj et al., 2013).

Related to scale, Bharadwaj et al. (2013) additionally discuss the *scaling under conditions of information abundance*. The increased ubiquity of heterogeneous information, i.e. data from IoT devices or social networks, requires organizations to establish competences in the collection and analysis of big data to scale their digital strategies.

2.2.3. Speed of Digital Business Strategy

The third theme of the Digital Business Strategy relates to speed. According to Bharadwaj et al. (2013), the speed of critical business functions is expected to increase when introducing new digital capabilities to the organization. Thus, speed is examined in the Digital Business Strategy framework from multiple dimensions.

Digital investments can accelerate the *speed of product launches*. An added digital dimension to increase speed can be placed in both the development and production phase of the product. With the accelerated rate of product launches, organizations may systematically link their inventory system to the suppliers' inventory system to enhance efficiency in the supply chain. This exemplifies how IT can be leveraged to increase the *speed in supply chain orchestration* (Bharadwaj et al., 2013). This is yet another example of how IT extends the business ecosystem, as organizations may need to extend the coordination with stakeholders outside the organization boundary.

Moreover, a Digital Business Strategy can work to increase the *speed of decision-making*. The capability to quickly make decisions and respond to real-time customer requests has become increasingly important in the context of social media, as Bharadwaj et al. (2013) notes. One approach to accelerate the speed of decision-making digitally is the introduction of platforms that allow decision-makers to retrieve information directly at its source. Thereby, the passing of information through multiple and perhaps irrelevant layers of management is avoided. In this relation, digital means can also increase the speed of *network formation and adaptation* within the organizational hierarchy. Digital applications and platforms can work to design, manage, or change existing organizational networks, which can enable organizations to respond more quickly to customer demands or market changes.

2.2.4. Sources of Value Creation and Capture

The last theme of Digital Business Strategy by Bharadwaj et al. (2013) is sources of value creation and capture. Here, the starting point is that IT has brought new ways to differentiate products or service offering to its customers.

IT brings new opportunities to *increase the value from information* as digital platforms allow for continuous, real-time updates of the information. Further, the gathering of user data can personalize the service offerings for the individual customer (Bharadwaj et al. 2013). Information on digital platforms thus brings the possibility to improve the quality of the information by democratizing content, i.e. allowing end-users to create, edit, and distribute the information themselves (ibid.).

Moreover, an IT strategy may also generate value from a *multi-sided business model*. A multi-sided business model is applied when a service provided in one layer works to capture value at a different layer. An example is the provisioning of a travel service to end-users at one layer while also selling personalized travel advertisements to third parties based on the end-user's data on another layer. As multi-sided business models often involve coordination and collaboration between multiple organizations, a logical extension is the establishment of *coordinated business models in network* (Bharadwaj et al., 2013). Here, organizations can coordinate the timing of respective offerings and receive feedback to co-create value from their multi-sided business models.

Lastly, Bharadwaj et al. (2013) note the *value appropriation through control of digital industry architecture*. With the introduction of digital points of control that may be decoupled from the main product, companies can reinvent the value appropriation and market share mechanisms of entire industries. This can be illustrated by the licensing revenue captured by Apple's iOS software within the telco industry.

2.3. Strategic Implications of Implementing CNAs

To bridge the theoretical gap between the description of CNAs and the Digital Business strategy, the following section relates CNAs with the four themes of Digital Business Strategy introduced by Bharadwaj et al. (2013).

2.3.1. Enablement of Scope through CNAs

Scope is the first theme of the Digital Business Strategy, and it refers to the level of embedment of IT with business functions (Bharadwaj et al., 2013). The deep integration of IT with the business functions is one of the fundamental organizational settings enabled by CNAs.

According to Fowler & Lewis (2014), the break-up of monolithic applications in microservices comes with a profound organizational shift (Kratzke & Quint, 2017). Following Conway's Law, companies employing monolithic applications operate a centralized IT unit that is detached from the organization's business units (Conway, 1968; Fowler & Lewis, 2014). In this type of organization, the IT department is constituted of specialists, e.g. software engineers, IT infrastructure operators, or database administrators, who gradually implement IT initiatives of the business lines from top-down. The utilization of the waterfall methodology creates further sequential dependencies between the isolated IT teams (Fowler & Lewis, 2014; Gienow et al., 2019).

In contrast, the microservices approach promotes the **fusion of IT and business capabilities** (Fowler & Lewis, 2014; Kratzke & Quint, 2017). By isolating specific product problems, the most suitable software design, e.g. a specific coding language or database technology, can be applied without compromising other business services. Since microservices encapsulate a service's entire business logic, a broad set of software functionality, e.g. user interface or storage, needs to be covered holistically. These multifaceted capabilities are further reflected by cross-functional teams (Fowler & Lewis, 2014). Cross-functional teams consist of IT as well as business stakeholders, e.g. software engineers, user experience designers, project managers, or DevOps managers.

Working collaboratively, the teams are responsible for the development and operations of their respective product or service, e.g. the search function of a webshop. The paradigm of *"You build it, you run it"*, illustrates the shift of responsibility from a centralized IT team to decentralized product teams (ibid.). Where monolithic applications were managed top-down in central IT units, distributed CNAs are managed "bottom-up" in small DevOps teams. This shift leads to **shared product ownership** (Fowler & Lewis, 2014; Kratzke & Quint, 2017). As a result of this ownership, the product teams need to be in continuous exchange with its users, collect customer feedback and respond to their needs (Fowler & Lewis, 2014; Hasselbring & Steinacker, 2017). Thereby, business and IT are directly interwoven, as Fowler & Lewis (2014) state: *"Rather than looking at the software as a set of functionality to be completed, there is an on-going relationship where the question is how can software assist its users to enhance the business capability."* (para. 22). The convergence of business and IT units through product-centric, cross-functional teams directly relates to Bharadwaj et al.'s (2013) conception of digital business strategies as transfunctional. Through the microservice approach, the lines between business and Digital Business Strategy dissolve and IT becomes the main driver of business capabilities (Bharadwaj et al., 2013; Fowler & Lewis, 2014).

With modular CNAs, companies can moreover develop, test, and integrate new products and services (Fowler & Lewis, 2014). This flexibility also concerns the handling of data from different sources. Bharadwaj et al. (2013), as well as Weinman (2015), state the data aggregation and analytics capabilities of cloud infrastructure. Customer data from a multitude of endpoints, such as mobile and IoT appliances, can be collectively analyzed in a central cloud infrastructure. With an application design that fully exploits cloud resources, companies can thus extend their traditional scope with new product and service offerings for **heterogeneous customer touchpoints** (Weinman, 2015; Bharadwaj et al., 2013). Unlike monolithic applications, which depend on the device and its specific OS they are deployed on, CNAs are architected for application portability, i.e. through the principles of migration and interoperability realized through containers (Stine 2017; Kratzke & Quint, 2017). Accordingly, Stine (2017) mentions the high degree of (mobile) device diversity as one of the main motivations to adopt CNAs. This diversity ultimately enables companies to extend their scope by offering products and services through novel touchpoints. An example can be seen in banks, which need to offer their financial services not only in the branch or ATM but also mobile devices order to remain competitive with fully digital FinTech companies (Ericsson et al., 2012).

Bharadwaj et al. (2013) further discuss the **integration of an organization into business ecosystems** as a measure to extend the scope of Digital Business Strategy. In this context, the implementation of CNAs is advantageous compared to monolithic applications. Monoliths entail the business logic of an entire application, thus restricting the sharing of single services with external ecosystem firms. With the principles of migration and interoperability, CNAs enable the sharing of application modules with external ecosystem participants (Stine, 2017). The application portability of standardized containers facilitates the integration of services that are using different system configurations, e.g. the transfer of external services to another end-device (ibid.). This portability is further emphasized by the loose coupling of modularized microservices. Loose coupling allows for the re-usability of microservices modules across heterogeneous IT environments (Dragoni et al., 2017; Kratzke & Quint, 2017). For partners offering joint digital services, this allows for the use of the IT infrastructure that best suits their individual needs. For example, a bank can employ a private cloud to analyze and store sensible credit data within its proprietary infrastructure, whereas a cooperating FinTech company could utilize a public cloud to offer the bank's services more cost-efficient on mobile devices. Even though different IT resources are employed, CNAs enable both the bank and the FinTech company to rely on the same set of containerized microservices. This illustrates how the modular sharing and the integration of CNAs into various contexts allow firms to tap into new market niches.

Table 2 condenses how CNAs enable the scope of Bharadwaj et al.'s (2013) Digital Business Strategy:

Scope of Digital Business Strategy	
Dimensions of Business Strategy (Bharadwaj et al, 2013)	Transcending of traditional functional and process silos
	Digitization of products and services and the information around them
	Extension of scope beyond firm boundaries and supply chains to dynamic ecosystems
CNA Enablement of Business Strategy Implementation	Microservice architecture enables fusion of IT and business capabilities
	DevOps & microservices enforce shared product ownership
	Application portability enables heteroegenous customer touchpoints
	Application portability & modularity enable ecosystem sharing & integration

Table 2: Enablement of the Scope of Digital Business Strategy through CNAs (Own representation based on Bharadwaj et al, 2013).

2.3.2. Enablement of Scale through CNAs

Scale is the second theme discussed by Bharadwaj et al. (2013). The scale of Digital Business Strategy can be achieved through the scalability of the CNAs technical infrastructure of cloud computing (Bharadwaj et al., 2013). It is well established that the shared access to pooled cloud resources via a pay-as-you-go model ultimately leads to cost savings while increasing the service availability (Gajbhiye & Shrivastva, 2014; Iyer & Henderson, 2012; Kratzke, 2018; Weinman, 2014). Yet, the sole migration of monolithic applications from physical servers to cloud infrastructure comes still with inefficient utilization of IT resources. From a cost perspective, it is estimated that 35 percent of companies' total cloud budget worldwide is wasted on idle or overprovisioned cloud resources (Juneja, 2019).

CNAs, by contrast, fully exploit the cloud's scaling potential with the properties of elasticity and scalability. Thereby, **IT cost efficiencies** are realized. By the automated scaling of IT resources with container orchestration platforms, workloads can be more tightly matched with the actual demand of the service (Kratzke, 2018). Since services are only requested according to business needs, there is a minimal number of idle resources. Moreover, containers use the underlying resources more efficiently (ibid.). Additionally, Stine (2017) mentions the possibility of horizontal scaling as one of the main motivations for CNA adoption. The horizontal scaling of microservices allows distributing workloads to more cost-efficient instances. Rather than scaling to few large, yet expensive units, horizontal scaling allows the extension across a high number of inexpensive resources. Thereby, lower unit economics and higher economies of scale can be realized (Stine, 2017). In their comparative study of costs of monolithic and microservice architectures, Villamizar et al. (2017) find that a microservice architecture enables infrastructure cost savings of up to 13,4 percent.

Also, service availability impacts overall business scalability (Bharadwaj et al., 2013). CNA's horizontal scalability, short deployment times of microservices, and the use of automation with container orchestration allow for the rapid adaptation of service infrastructure to real-time business needs (Stine, 2017, Gienow et al., 2019; Kratzke, 2018). Consequently, CNAs enable **high service availability**, enabling parallel requests from *"thousands of [globally distributed] concurrent users"* (Gannon et al., 2017, p. 17). Online video streaming services serve as an example of how increased system availability with CNAs impacts the scalability of digital business models. Netflix's former vice president of cloud architecture, stated 2016: *"[Netflix] ha[s] eight times as many streaming members than [it] did in 2008, and they are much more engaged, with overall viewing growing by three orders of magnitude in eight years"* (Izrailevsky et al., para. 2) This exponential growth would have not been possible with the regular outages that were experienced while operating a monolithic application in an on-premises data center. The CNA architecture based on microservices limited the "blast radius" of service failures. Additionally, service monitoring and recovery were automated with container orchestration platforms, enabling Netflix to guarantee 99,99 percent of service availability (Netflix, 2020; Izrailevsky et al., 2016).

Further, since the elasticity of CNAs matches the IT resource provisioning with customer demand, a minimum application latency time is enabled. In Weinman's (2015) work on the of the strategic value of cloud infrastructure, this is referred to as *"[...] dynamic optimization [...]"* (p. 67), allowing *"[...] maximum throughput [and] minimum delay [...]"* (p. 67). Thereby, CNAs ensure a **high service quality** at any scale. Consequently, end-users develop trust in the stability of the application, which results in a higher customer loyalty (Gannon et al., 2017; Power & Weinman, 2018).

CNAs also **facilitate scalability through business ecosystems**. Business value from strategic partnerships can be harnessed via APIs, which enable the creation of open platforms and are characteristic for CNAs (Kratzke & Quint, 2017; Bharadwaj et al. 2013). The portability and modularity of containerized microservices additionally allow for the facilitated exchange of business capabilities in a broader ecosystem, since the same services can be reused in different system environments (Dragoni et al., 2017). An example of the scalability via business ecosystems integration is the emerging technology of Edge Computing, which delivers and analyses data at the point of its creation, i.e. in IoT devices or autonomous vehicles. Because of their flexibility, containers emerged as the standard to deploy applications at this "network edge". This allows e.g. city governments to integrate data from private mobility providers and scale the mobility options with citizen growth (Cisco, 2018; Hsieh et al., 2018).

Table 3 summarizes how the scale of digital business strategies is extended by the use of CNAs:

Scale of Digital Business Strategy	
Dimensions of Business Strategy (Bharadwaj et al, 2013)	Rapid digital up/down-scaling
	Rapid scaling potential through network effects within multisided platforms
	Scaling under conditions of information abundance
	Scale through alliances and partnerships
CNA Enablement of Business Strategy Implementation	Automated scaling through container orchestration enables IT cost savings
	Scalability & automation of container orchestration and microservices increase service availability
	Dynamic optimization of cloud infrastructures allow for high service quality
	Application portability & modularity enable ecosystem sharing & integration

Table 3: Scale of Digital Business Strategy realized by CNAs (Own representation based on Bharadwaj et al, 2013)

2.3.3. Enablement of Speed through CNAs

Speed, which is Bharadwaj et al.'s (2013) third theme driving digital business strategies, is also an important motivation for the adoption of CNAs (Stine, 2017). At its core, CNA architectures and methods aim to accelerate the software release time (Jamshidi et al., 2018). Thus, they are representing the technical as well as the organizational implementation of the speed of product launches mentioned by Bharadwaj et al. (2013).

Continuous delivery of features and updates in DevOps teams and the update of microservices with only minor application downtime allows the constant iteration of products and services (Gannon et al., 2017; Kratzke, 2018). Further, the direct cross-collaboration in DevOps teams shortens the lines of communication. This results in an **acceleration of decision-making** in the software release process (Gienow et al., 2019; Shen et al., 2019; Toffetti et al., 2017). Consequently, dedicated product teams can focus on encapsulated business capabilities.

Moreover, by automating software testing and production processes with DevOps tools, companies can manage a high frequency of deployments while maintaining the stability of overall systems (Vogels, 2014). The time of deploying finished code into production, i.e. lead time, can be less than one day for firms that incorporate DevOps methodologies, compared to up to six months for companies that neglect the use of DevOps (Forsgren et al., 2019). Further, by employing microservices, organizations are *"[...] turning an idea on some product manager's or other project member's whiteboard into a feature running in production, as quickly as possible."* (Jamshidi et al., 2018, p. 25). Ultimately, microservices thus enable a **fast release of software features** (Jamshidi et al., 2018; Forsgren et al., 2019).

With the portability and modularity of containers, microservices, and APIs, CNAs also accelerate the dynamic adaptation of business ecosystems (Gienow et al., 2019; Kratze et al., 2018). Thereby, CNAs enable **fast network formation and adoption** in the sense of Bharadwaj et al. (2013).

The relations between the speed of digital business strategies and CNAs are presented in Table 4:

Speed of Digital Business Strategy	
Dimensions of Business Strategy (Bharadwaj et al, 2013)	Speed of Product Launches
	Speed of Supply Chain Orchestration
	Speed of Decision Making
	Speed of Network Formation and Adaptation
CNA Enablement of Business Strategy Implementation	Continous Delivery & cross-functional teams accelerate decision-making
	DevOps & Microservices enable fast release of software features
	Application portability & modularity enable fast network formation and adoption

Table 4: Speed of Digital Business Strategy realized by CNAs (Own representation based on Bharadwaj et al, 2013).

2.3.4. Enablement of Value Creation and Capture Sources through CNAs

Lastly, Bharadwaj et al. (2013) define sources of value creation and capture as key themes for digital business strategies.

Presenting a result from the implementation of microservices, cross-functional teams with product ownership are in close exchange with end-users. Thus, they can iterate services based on customer feedback (Fowler & Lewis, 2014). Consequently, CNAs **increase the value from customer information** in the sense of Bharadwaj et al. (2013), which is amplified by the previously discussed ability to deliver products and services across heterogeneous customer touchpoints. Further, by leveraging loosely coupled microservices that *"do one thing well"* (Kratzke, 2018, p.7), best-of-breed technologies can be attached to specific business capabilities. This can be seen to enable companies to *"[...] fine tune their actions and personalize their offerings based on customer preferences [...]"* (Bharadwaj et al., 2013, p. 477) based on end-user' information.

At the same time, the **value creation from multi-sided business models** mentioned by Bharadwaj et al. (2013) is enabled with CNAs, as the facilitation of ecosystem sharing and integration discussed in section 2.3.1. suggests.

In close relation to this, cloud infrastructure facilitates **value capture through coordinated networks** (Bharadwaj et al., 2013). The provisioning of cloud infrastructure for a broader audience allows the coordination and integration of external value sources. According to Weinman (2015), cloud infrastructure plays an important role in open innovation. Since centralized cloud infrastructure, allows the sharing of data with globally distributed stakeholders, companies can connect internal and external expert knowledge to solve specific business problems and therewith capture new value (Weinman, 2015).

Table 5 summarizes the driving implications of CNAs for the source of value creation and capture in digital business strategies:

Sources of Value Creation and Capture in Digital Business Strategy	
Dimensions of Business Strategy (Bharadwaj et al, 2013)	Increased Value from Information
	Value Creation from Multisided Business Models
	Value Capture through Coordinated Business Models in Networks
	Value Appropriation through Control Digital Industry Architecture
CNA Enablement of Business Strategy Implementation	Cross-functional teams & shared product ownership increase value from customer information
	Application portability & modularity enable value creation from multi-sided business models
	Open innovation with cloud infrastructures enables value capture through coordinated networks

Table 5:Sources of Value Creation and Capture in Digital Business Strategy realized by CNAs (Own representation based on Bharadwaj et al, 2013).

2.3.5. Conceptual Model for Strategic Implications of CNAs

As the review of the existing literature around CNAs in the light of the reference theory by Bharadwaj et al. (2013) suggests, the CNAs enable the implementation of Digital Business Strategies. More specifically, the characteristics of CNAs, which consist of principles, methods, architecture, and properties, are found to enable the four themes of Digital Business Strategy. Thus, the research at hand assumes the scope of Digital Business Strategy, scale of Digital Business Strategy, speed of Digital Business Strategy, and sources of value creation and capture as the strategic implications arising from the implementation of CNAs. As argued by Bharadwaj et al. (2013), the implementation of the four themes of Digital Business Strategy ultimately leads to increased business performance. These causal relationships are reflected in the conceptual model presented in Figure 8, which serves as the basis for the analysis of the empirical data collected.

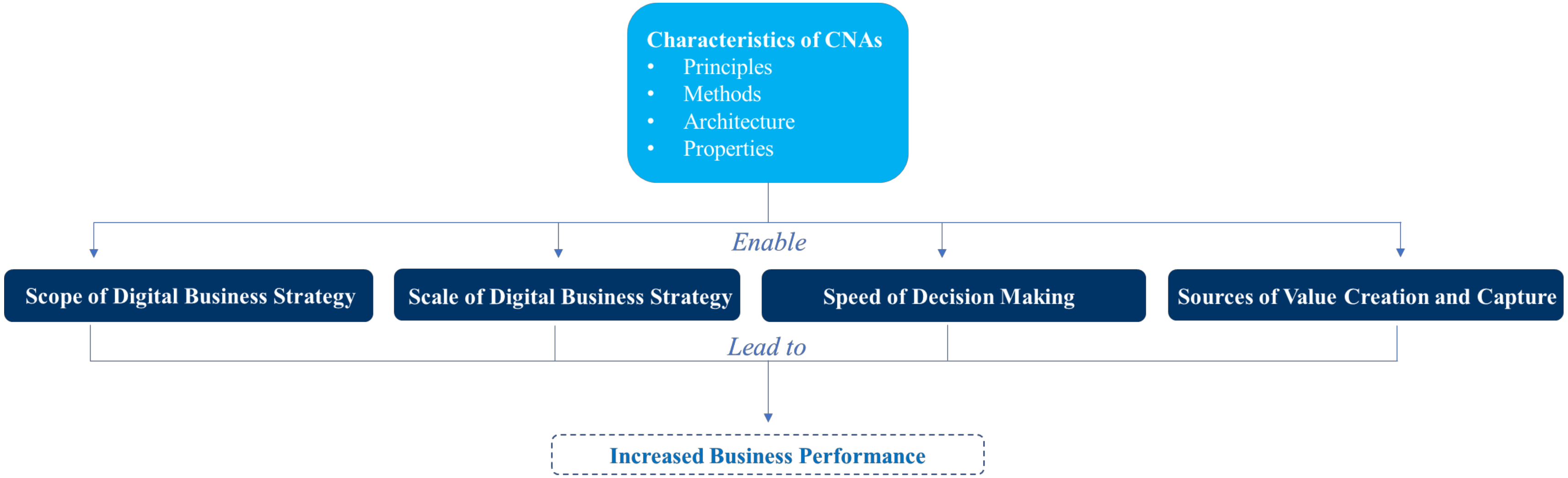

Figure 8: Conceptual model for strategic implications of CNAs (Own representation).

3. Research Methodology

This chapter presents the methodological framework applied in the thesis. By outlining the thought-processes behind the selection of research philosophy and design, the research transparency is increased. This is intended to strengthen the overall quality of the research's findings (Saunders et al., 2016).

3.1. Research Philosophy

The following section reflects the philosophical assumptions under which premises the research has generated new knowledge. As explained in the presentation of the research question, the research aims to uncover the strategic implications of adopting CNAs. This complex problem was tackled with a critical realist worldview. Critical Realism provides a solid foundation to develop causal explanations that take technological and organizational factors into account when investigating a specific technical phenomenon (Wynn & Williams, 2012). Thus, Critical Realism is well suited in the research context of CNAs.

The central premise of Critical Realism is that reality exists independently from human perception, and this reality has its inherent order (Tsang, 2014; Egholm, 2014). However, as the reality in its entirety is not directly observable to the human senses, Critical Realism divides the world, i.e. reality, into three levels (Fleetwood, 2014). This stratification of reality constitutes the ontology of Critical Realism (Egholm, 2014).

Beginning from the outermost level, the *real level* includes the structures and causal mechanisms that create the basis for events and actions to occur. The real level is thus not directly observable, yet it represents the enduring entities that influence reality, e.g. the market (Mingers et al., 2013; Egholm, 2014). Consequently, the *actual level* represents the events that have been created or activated based on the structures and mechanisms stemming from the real level. The events at the actual level occur regardless of a witness' experience or interpretation of it. Important to note is that the relationship between the mechanisms in the real level and the events of the actual level are contextual. Therefore, the actual level is used to describe and explain, but not to predict future events (Egholm, 2014). Finally, the *empirical level* is the level of reality where experiences and events can be observed (Tsang, 2014). Accordingly, it is at the empirical level where the development of new theories and the testing of existing ones occurs. The empirical level thus becomes evident when the research collects and processes data. However,the observations made in the empirical level are influenced by the observer's previous experiences (Fletcher, 2017). Appropriately, transparency in the methodological decision-making process is important in critical realist research philosophy (Saunders et al., 2016).

All in all, by conducting observations in the empirical level, which combined constitute events in the actual level, which accordingly are outcomes based on the activated mechanism in the real level, it is under critical realist ontology possible to conceptualize and subsequently analyze a phenomenon (Mingers et al., 2013; Tsang, 2014). A graphical illustration of critical realist stratified ontology constituted from the real, actual, and empirical level, is shown below in Figure 9.

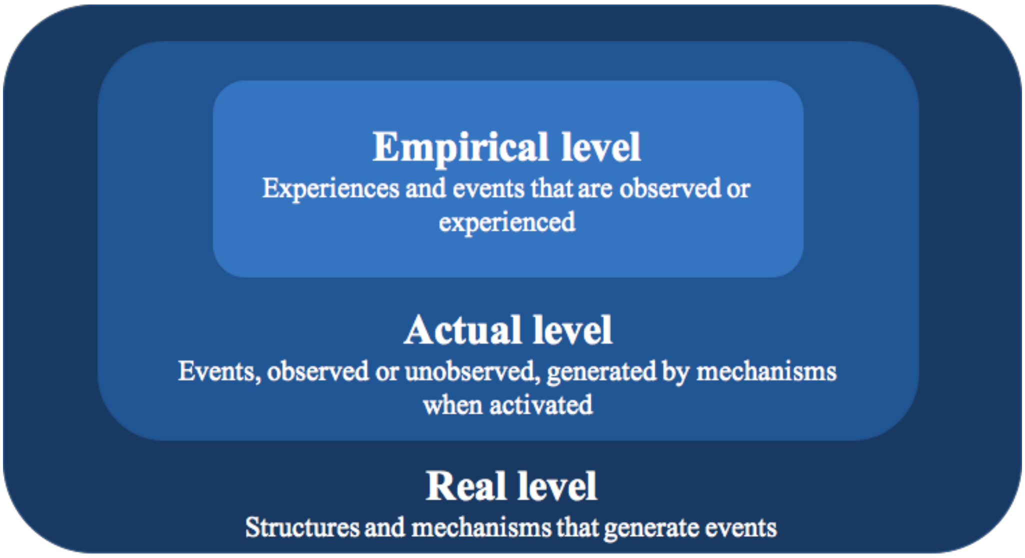

Figure 9: Stratified ontology in Critical Realism (Own representation based on Egholm (2014).

Elaborating on the inevitability of the researcher's influence at the empirical level, Critical Realism understands all knowledge as created in a social context based on existing knowledge (Egholm, 2014). Knowledge is therefore influenced, even dependent on the people who create it (Fleetwood, 2014). Value-laden inquiries are thus an inevitable fact of critical realist research. Yet, this bias must be minimized through awareness of the context and objective data processing. The notations above are reflected in the practical approach to data collection, which are outlined in the sections on research strategy (3.2.) and research design (3.3.).

Yet, the central implication arising from the outlined stratified ontology, is that the establishment of causality between the levels of reality is fundamental for the research (Fletcher, 2014). To unveil the strategic implications of adapting CNAs, the research must therefore first understand and thoroughly characterize the object of study, which is provided from individual case presentations. Then the research can continue with synthesizing the abstract (theory) with the concrete (data collected) whilst being aware of the context in which the interviewees present themselves in (Danermark et al., 2002; Saunders et al., 2016).

3.2. Research Strategy

The research philosophy provides the guiding principles throughout the research. Therefore, the methods applied, and the subsequent analysis of data must be compliant with the assumptions of Critical Realism (Saunders et al. 2016). In other words, to ensure reliable research there is a commitment to Critical Realism that must be upheld both during the phases of data collection and data analysis (Fletcher, 2017).

With the critical realist philosophy in mind, it is crucial to achieve an adequate interplay between theory and data during analysis. Therefore, the applied research strategy alternates between theory and data to isolate the contextual condition necessary for a particular causal mechanism to take place. Also understood as theoretical redescription, abduction is the process of re-describing and re-contextualizing the empirical data to the theoretical concepts (Fletcher, 2017). The processual logic behind abduction is thus to begin with an observation before turning to a theory that can account for the initial observation (Danermark et al., 2002). In effect, the research takes a frame and applies it to a new, different context. Abductive reasoning can be defined as a "*thought operation, implying that a particular phenomenon or event is interpreted from a set of general ideas or concepts"* (Danermark et al. 2002, p. 205). Thus, it presents a mode of interference that is focussed on reaching well-founded conclusions from the given premises. With its iterative characteristic, the central benefit of abduction is that it allows for the formation of novel theory in unexplored contexts (Egholm, 2014; Danermark et al., 2002).

As data at first glance can be insignificant observations, applying abductive reasoning brings specific requirements to the research. A so-called "detective's flair" is necessary to link relevant data to the context of the particular situation (Egholm, 2014). In this relation, Eisenhardt (1989) describe the benefits of utilizing multiple investigators to enhance the richness of the data, as "*(...) different perspectives increase the likelihood of capitalizing on any novel insights there may be in* *the data*" (Eisenhardt, 1989, p. 538). The benefits of abduction are thus enhanced by systematic data analysis by all members of the research.

Following the abductive reasoning in analysis, Critical Realism urges us to apply retroduction to take a step back to unveil "*(...) the necessary contextual conditions for a particular causal mechanism to take effect and to result in the empirical trends observed*" (Fletcher 2017, p. 189). Thus, the retroductive activity constitutes a transcendental argumentation, as we move from the empirical level to the real level (Danermark et al., 2002). Retroduction as a strategy of inference is an essential part of Critical Realism, as it takes the manifested phenomena observed into consideration. Further, it links them to the structures and mechanisms that cause them. As retroduction is concerned with establishing causality, it constitutes the epistemology of Critical Realism (Tsang, 2014).

3.3. Research Design

The research applies a multiple case-study design, wherein the unit of analysis are organizations applying CNAs. A case-study approach was selected due to its potential to generate in-depth insights into a phenomenon in its real-life context (Saunders et al., 2016). The two present cases were selected based on their relevance to the research topic and their expected potential to provide rich descriptions and understandings of cloud-native implications. Keeping the critical realistic worldview in mind, the case organizations analyzed in the thesis cannot be investigated in a vacuum. Accounting for the case organizations' context is crucial, both due to the critical realist research philosophy and the case study approach (Fletcher, 2017; Yin, 2014). As a result, a detailed account of the case organizations' context related to cloud-native is provided before the analysis of the respective case organizations.

As the case organizations were selected with the premise that they are applying CNAs, they are selected from theoretical sampling (Eisenhardt, 1989). Further, the benefit of relying on more than one case is a strengthened measurement validity, i.e. measuring what is claimed to be measured (Eisenhardt, 1989; Saunders et al., 2016). In this perspective, the research is conducted by two pieces of research under the same prerequisites, which returns to the importance of accounting for the context of each case.

3.4. Data Collection

This research applies a qualitative research design with data collection via semi-structured interviews. In combination with a case study, the flexibility of semi-structured interviews is desired, since it allows the researchers to gain an in-depth and contextual understanding of the investigated phenomenon (Eisenhardt, 1989).

The interviewees were selected based on their expected insights related to CNAs from a technological or organizational perspective. Further, some interviewees suggested colleagues who they thought would be of relevance to the research. Thus, the research also applied a "snowball" sampling strategy (Saunders et al., 2016). The interviews were based on the themes derived from the theory discussed in Chapter 2. The interview guide is available in Appendix 2. With semi-structured interviews, the strategy of each interview varied, as the organizational (case) and individual context, e.g. interviewees level of seniority and business function, differed from each other (Kvale & Brinkmann, 2015). This led to some questions being omitted in some interviews, whereas additional questions were asked in other interviews to fully understand the informants' reality in the context of their organization.

Interviewees were informed that the interview would be recorded, and they were sent the interview guide approximately a week before the interview. All interviews were conducted in English, despite this not being the native tongue of the interviewees. This is however not perceived to influence the data quality negatively as all interviewees work in an English-speaking environment and are thus used to articulate their work in English. Further, all interviews had both researchers present in order to achieve the benefits of multiple investigators as argued by Eisenhardt (1989). The complete list of interviewees is shown below in Table 6.

Company	Alias	Position	Date	Length
zalando	Z1	Senior Software Engineer, Cloud Infrastructure	17/02-20	52:08
	Z2	Engineering Lead, Cloud Infrastructure	24/02-20	50:17
	Z3	Senior Project Manager, Zalando IT	26/02-20	43:47
	Z4	Lead Software Engineer, B2C Platform	06/03-20	49:10
adidas	A1	Director, Software Engineering	19/02-20	49:12
	A2	SVP, Technology Enablement 1	02/03-20	53:20
	A3	SVP, Technology Enablement 2	03/04-20	52:52

Table 6: List of interviewees

3.5. Data Analysis

To comply with the Critical Realism ontology, a guideline for qualitative data analysis is outlined by Fletcher (2017). Critical realism urges us to look for tendencies, as opposed to laws, in the data. This is because Critical Realism is interested in causality and prediction for the individual case(s), not a universal truth (Fletcher, 2017). The approach applied to the data coding in the thesis was thus to find tendencies through the critical realist concept of "demi-regularities", and from there try to find an explanation to the demi-regularity based on theory, assuming it did not occur at random (Danermark et al., 2005). Practically, this meant using a directed coding approach, in which a list of codes is derived from background literature to hold against tendencies in the data (Hsieh & Shannon, 2005). A coding table summarizing the derived themes from the background literature with examples of the collected data is shown in Table 7.

Theme	Concept	Description	Empirical Example
Scope	Fusion of Business & IT	The breaking up of functional silos, integrating IT capabilities into business functions	*"[...] in the reorganization of 2017, [...] all the tech teams integrated with the commercial department"*
	Product Ownership	Product development teams' responsibility exceeds development work, e.g. to include operations	*"As soon as you deliver an application within the company, it's all done by the 'you own it, you run it' model"*
	Standardization	Defining central standards throughout in the organization	*"So that's why we created a central team on the most common use components to steer and control"*
	Cultural Adaptation	Change in organizational culture required to leverage new technology	*"The transformation is affecting the teams a lot. Because we had a different structure, things are changing"*
Scale	System Availability	The probability that a system is working, i.e. available	*"The customers do not experience downtime and we react much better to peaks of usage"*
	IT Cost Efficiency	The degree to which existing IT resources are utilized	*"[usage of] Kubernetes results in less operational overhead"*
	Compliance	Achieving compliance with legislation	*"GDPR compliance is now easier [because] all data within a cluster is going through the same Ingress"*
Speed	Agility	Ability to respond quickly to changes in business demands	*"[...] a microservice based architecture will allow us to react to changes much faster"*
	Productivity	Ability to make new employees reach full productivity quickly	*"Our aim is to make a new developer fully productive in within the first month"*
Source	Technology Openness	Increase the range of compatible technology to leverage new sources of value	*"This is definitely one of the bigger advantages of microservices, that you are able to use new technologies more simply"*
	Ecosystem Sharing	Sharing of software to externals to increase collaboration	*"The benefit from cloud-native is you can share smaller components and put them on a different license"*
	IT Complexity	Increase in complexity resulting from technology openness and external collaboration	*"But it has a downside: it's significantly more complex. You have much more moving systems"*

Table 7: Concept-based coding summary.

All data was audio-recorded, anonymized, and transcribed, which is provided in Appendix 3. This approach is understood to decrease the researcher bias of the research, as it provides an accurate record of the interviewees' experiences (Saunders et al., 2016). Moreover, the quotations used in the analysis were 'cleaned' for incorrect language to generally increase the readability of quotations (Kvale & Brinkmann, 2015). When a concept described between the interviewee and the researchers was implicit, additional words have been added to the quotations in brackets to clarify the meaning. This is to ensure the same understandability for the reader as the researchers.

4. Empirical Analysis

4.1. Case Presentation: Zalando

4.1.1. Company Background on Zalando

Founded in 2008, Zalando is a German e-commerce company selling own and other brands' fashion items on its online platform. In the fiscal year of 2019, Zalando reached a total revenue of 6,4 billion EUR from its presence in 17 European countries. The company employs roughly 14,000 people (Zalando, 2020), of which approximately 1.200 are software engineers (Z1, 01:46).

The initial business idea of Zalando was to set a new standard for online retailing from offering free delivery and return. This model became a success and has continued to be the foundation of Zalando's customer offerings, although with a significantly broader selection of brands and items. The early success in Germany gave Zalando's leadership an ambition to increase its outreach. Thus, Zalando started its European expansion from 2009 to 2012, which included investments in new warehouses and fulfillment centers, as well as differentiated marketing strategies across countries (Zalando, 2020). The company went public on the Frankfurt Stock Exchange in 2014. Today, Zalando positions itself as *"Europe's leading online fashion and lifestyle platform"* (Zalando, 2020, p. 6).

Zalando applies a customer-centric business strategy, meaning that it is ideally the customers' needs that are guiding the company's focus (Wagner & Majchrzak, 2016). In the corporate strategy, Zalando's customer-centric approach becomes tangible from the company's efforts to *"(...) address emerging and foreseeable customer needs and pain points by offering a unique fashion experience through websites and mobile applications"* (Zalando, 2020, p. 122). From Zalando's corporate strategy, the company's customer-centric efforts have threefold focus: 1) "Offering a comprehensive assortment", i.e. to offer what is currently in fashion, 2) "personalized discovery and inspiration", i.e. to provide individual recommendations on items based on previous purchases, and 3) "attractive convenience proposition", i.e. easy purchasing process followed with fast delivery (Zalando, 2020, p. 93).

Given the volume of parcels Zalando ships on a daily basis, the efficiency of the company's logistical operations is fundamental for its success. Zalando currently holds 11 fulfillments centers across central Europe, and with four more under construction. It is Zalando's strategy to continue investing in localized fulfillment centers as this *"integration of fashion, operations and online technology provides the capability to deliver a compelling value proposition to both customers and fashion brand partners"* (Zalando, 2020, p. 93). In the fulfillment centers, inbound goods from suppliers are stored and sorted, so that they are ready to be sent to the customer as soon as the order is placed. The fulfillment centers operate on a mix of manual labor and automated processes when picking the ordered items into the parcels sent to the customers.

Apart from a handful brick-and-mortar outlets located in Germany, Zalando's revenue exclusively comes from purchases made on Zalando's online retailing platform Zalando.com. The platform is a fully integrated link between Zalando's fulfillment centers and distribution partners, allowing Zalando for having adequate stock and provide speedy delivery to customers. In 2018, the platform handled 3.1 billion visits and 116 million orders.

4.1.2. From Monolith to Cloud-Native at Zalando

From its founding in 2008 until 2010, Zalando's e-commerce-system was based on the open-source online-shop-framework Magento. The solution provided by Magento relied exclusively on the programming language PHP and database technology MySQL, leaving little leeway for adapting to Zalando's growth (Jacobs, 2020; CNCF, 2020). In order to operate an e-commerce-system suitable to Zalando's scaling needs, the Magento-based online-shop was completely re-designed in 2010 (Jacobs, 2020). Yet, the re-design transformed the open-source framework provided by Magento into a large monolithic application developed by Zalando (Jacobs, 2020).

With further business growth accompanied by its IPO in 2014, Zalando investigated further ways to transform their applications to support its accelerating scaling needs (Z2, 05:07). Moreover, new features such as same-day-delivery or an online-shopping assistant were planned to be rolled out. Consequently, Zalando shifted its e-commerce-shop into a cloud-based platform (CNCF, 2020b). In the course of this migration, Zalando's monolithic applications were moved to cloud infrastructure provided by Amazon Web Services (AWS). Along with its cloud migration, Zalando introduced the organizational concept of "Radical Agility" in 2015 (Jacobs, 2020). This organizational change shifted the access to technology, e.g. cloud resources and responsibility, e.g. for IT operations, away from centralized IT teams towards more than 200 independent engineering teams. During the AWS migration, every team re-architected their monolithic applications into containerized microservices, deployed on their individual cloud accounts (CNCF, 2020b). The internally developed cloud platform STUPS was introduced as a company-wide "access pool" for the available technology. Zalando's developers would refer to STUPS for tools and components available for the development and operations of applications, such as container instances. Yet, since STUPS provided engineering teams with full autonomy about their technology choice, the large diversity of the IT portfolio created compliance as well as operational and IT cost issues (Z3, 02:21).

Because of the problems arising from STUPS, several measures were taken to centralize operations management. In 2017, a central "developer productivity" department was introduced, while the organizational separation between business and technology was resolved and replaced by the concept of product-focused teams (Jacobs, 2020). Further, the container orchestration platform Kubernetes was rolled-out. The Kubernetes platform was managed by the "developer productivity" team and now provided a centralized management layer for the decentralized cloud infrastructure (Z3, 04:19-04:36). Additionally, a "Developer Journey" model was implemented, which aimed to provide a framework for the technologies used as opposed to the very open STUPS model.

In 2018, Kubernetes was developed an internal Continuous Integration & Deployment process (CI/CD pipeline), thus adding further automation of features to the container orchestration platform. The interplay of both technologies represents Zalando's "Cloud Native Application Runtime". In 2019, the STUPS platform officially depreciated, while the company-wide migration of more than 4.000 applications into the Kubernetes platform was initialized (Jacobs, 2020).

The CNA transformation of Zalando is shown in Fig. 10. In summary, Zalando's shift from monoliths to CNAs started with the transformation of the externally developed online-shop system Magento into a self-developed e-commerce-application. Yet, same as Magento, Zalando's new system represented a large monolith operated directly on physical servers. This monolith was decomposed into microservices while the transition towards a cloud-based infrastructure was executed in 2015. The custom system STUPS presented the platform for IT employees' access to software development and operations resources. STUPS was then replaced by the implementation of Kubernetes as a central cloud-native management layer for Zalando's distributed microservice application.

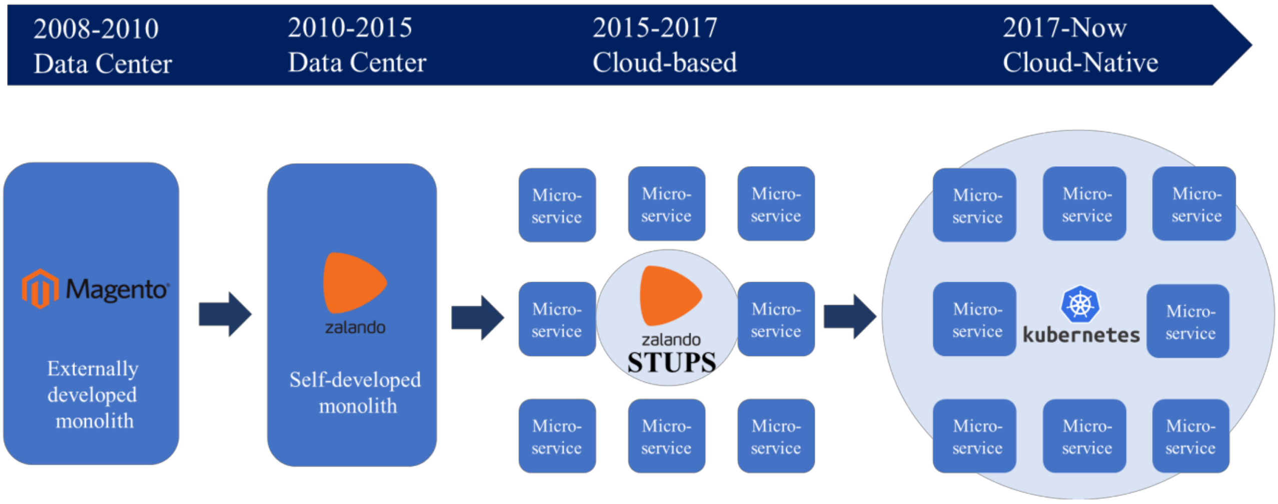

Figure 10: CNA transformation at Zalando (Own representation).

At the time of interviewing, 70 percent of Zalando's applications were running on the Kubernetes platform (Z1, 01:53). The analysis will examine the degree the migration to CNA has enabled various themes of Digital Business Strategy, as illustrated by the thesis' conceptual model outlined in section 2.3.5.

4.2. Scope of Digital Business Strategy at Zalando

4.2.1. Fusion of Business & IT

Zalando's internal scope was extended in the course of an organizational redesign following the migration to a cloud-native platform. The rollout of a company-wide container orchestration platform caused a shift from siloed business and IT to a fusion of the functions:

> *"There was a split between the commercial department that needed the tech department to deliver something. They were two different teams. Then, in the reorganization of 2017, […] all the tech teams dealt with the commercial departments" (Z1, 13:15-13:33).*

The convergence of business and IT stakeholders resulted in a substantial change regarding the overall self-understanding of Zalando as a company. While Zalando was mainly perceived as a technology company developing solutions within e-commerce, the cloud-platform-based approach enabled the company to broaden its scope:

“They were just merged together to a more holistic team with parts of tech and parts of non-tech people, which means that Zalando is not so clearly a tech company anymore” (Z1, 13:34-13:46).

The interdependencies between the roles are evident from both the business and IT perspective. For Zalando’s engineering teams, the tight linkage with business roles now appears to be self-evident. When asked for the frequency of collaboration with business units, Z4 states:

“All the time. I have a project managers and product owners as part of my team” (Z4, 11:40-11:43).

At the same time, technology functions became indispensable for business operations such as pricing or logistics. The transformation towards a cloud-native orchestration platform enabled Zalando to integrate separate business units and enhance their capabilities with the use of cross-functional IT solutions, e.g. data analytics. Z2 exemplifies the fluid transition between these capabilities with the process of pricing forecasts, which not only involves internal stakeholders from different business units but also external buyers:

“Both the buyers as well as the people who plan the capacity for the warehouses [are involved]. If you want to optimize for a certain target, you would need to work with both the buyers as well as the people from logistics to get data on what you want to buy when, what you want to sell and how“ (Z2, 06:51-07:19).

The interconnection between the internal pricing and logistics departments with external buyers requires the exchange of cross-functional data, which is facilitated by Zalando’s centrally managed container orchestration platform. The container orchestration platform and its subsequent fusion of business and IT functions enabled Zalando not only to improve the information flow concerning specific business processes but also to collect company-wide data for continuous efficiency improvement:

“[…] it gives us better visibility, so that we can say: ‘Hey, look we have all this inefficiency. Every month [of this inefficiency] amounts to this much in euros […]. What are some creative ways that we might be able to reduce that?” (Z3, 34:27-34:41).

More specific technology decisions can be also supported by the increased transparency through company-wide data visibility:

“Now that everyone is on this infrastructure, we notice that inter-service communication latency is too high. What can we do to reduce [latency]? And what's the impact?’ So, it gives us a lot more visibility and a lot more options to have a greater impact within Zalando” (Z3, 34:41-34:59).

Accordingly, the fusion of business and IT leads to higher operational transparency, allowing e.g. for the tracing of inefficiencies. At the same time, the "crowdsourcing" of possible mitigations or optimizations is enabled. Conclusively, CNA enables an extended internal scope, which impacts the fusion of the two functions. This fusion of business and IT leads to increased cross-functional collaboration and transparency.

4.2.2. Product Ownership

In parallel with the fusion of business and IT departments through cross-functional teams, Zalando's microservice-based application architecture led to a highly modularized organization. Within Zalando, 1,200 software engineers are distributed into a high number of small teams:

> *"[There are] between 200 and 300 teams and these of course also vary in size. [...] That is really a lot people and we have more than 2,000 applications that are registered as live applications […]" (Z1, 46:42-47:08).*

Comparable to the technical characteristics of loosely coupled, independent microservices, teams are designed around isolated business applications. While the application's sizes relatively to Zalando's for platform decreased, the product teams' responsibility regarding their applications increased:

> *"As soon as you deliver an application within the company, it's all done by the 'you own it, you run it' model. It doesn't matter if it's externally facing or not, you are basically responsible for it" (Z2, 20:55-21:24).*

In contrast to the bundling of system responsibility through a centralized IT team department, the responsibility for Zalando's CNAs is distributed across a high number of teams. While the "blast radius" of the applications itself is narrowed down, the range of functional responsibilities broadens to

> *"[…] not only developing it, but actually being uncalled for it, debugging it, fixing it, aligning with a business partner on the functionality and then also offering their services inside of Zalando to be consumed" (Z2, 05:48-06:08).*

Compared to rather delineated areas of team responsibility in large monolithic applications, i.e. software development or testing, the scope of CNAs teams' responsibility for their application covers the full application lifecycle. Subsequently, this shift in the scope of responsibility

“[…] creates a stronger sense of ownership. Actually, you value the availability of all the features, because you will get called in the night if something goes wrong” (Z2, 22:21-22:38).

According to Z2, this high degree of ownership within product teams ultimately leads to increased business value. Compared to large teams working on monoliths, teams responsible for CNAs are more diligent in the development and operations of existing as well as new applications:

“What definitely helps in our case is that teams think of their services as they own it. That is only possible if […] you have smaller teams delivering value, because the larger a team is, the less responsibility you feel. [In small teams], you will definitely think twice if you want to introduce your service and if you can actually provide a good service level for that service” (Z2, 39:25-40:02).

Overall, the characteristics of cloud-native microservices widen the scope of the responsibility of product teams at Zalando, since they shift from single process areas to the end-to-end development and operations process. At the same time, the scope of the services’ functionality is narrowed down, thus more manageable by small teams. Consequently, the ownership for the respective service increases. Eventually, the quality level of single services is improved.

4.2.3. Standardization

Furthermore, the use of the container orchestration platform Kubernetes as an element of CNAs allows a high degree of standardization regarding IT operations or IT security at Zalando:

“We have centralized teams that provide security functionality. We also have centralized infrastructure teams that provide resources to all the business teams. Basically, there's a plan for which infrastructure to use. We have standardized Kubernetes clusters that we can use for deployment” (Z4, 12:04-12:30).

The standardization through CNAs allows for the re-usability of technologies and applications since they are already proven in other contexts:

“Cloud-native infrastructure with things like Kubernetes and the ecosystem around it, you can definitely say it allows us to standardize to a certain way of handling deployments and operations, and this also […] allows a lot of re-usability of existing applications” (Z2, 35:44-36:26).

As existing applications can be integrated into other business contexts, the re-usability relates to a broader internal scope for Zalando. The standardization of certain technology pieces alongside the centralized orchestration platform ultimately allow Zalando's product teams to focus on the business functionality of their applications:

> *"[By operating CNAs] any business that has a lot of internal development can hopefully focus more on their delivery of business functionality rather than taking care of things like infrastructure management" (Z2, 35:01-35:19).*

This business focus is amplified by the smaller size of services. With CNAs, Zalando's product teams have a higher business focus compared to monolithic application design (Z1, 07:48, 2020). On a strategic level, the standardization via a CNA-based platform shall not only sharpen the focus of product teams but translate directly into end-customer benefits:

> *"[…] if we take the operational burden off teams, they will be able to focus on delivering more value to our customers" (Z3, 10:27-10:37).*

Not only existing but also new IT employees benefit from the technology standardization with Zalando's CNA platform. According to Z2, a high standardization allows for a broader company scope related to human resources, since external software engineers are already familiar with the used tool sets (Z2, 36:40-37:15).

Moreover, the standardized CNAs allow for the extension of scope to not only to Zalando's engineering teams but also external capabilities, e.g. from suppliers. The re-usability gained from the modularity of Zalando's microservices and allows for the integration of external applications into Zalando's platform and vice versa, as Z2 states:

> *"We have third party integrations. I have been part of a team that had been on something like that before. We had an integration of a database with a modular approach, basically a shared database" (Z4, 23:40-23:52).*

By doing so, the orchestration of business processes and data integration from external stakeholders, e.g. in supply chain partners, is facilitated:

> *"The other thing that we are doing is that we are integrating ourselves to supplier ERP systems, which enables the use case [of a direct connection with the supplier's ERP system]" (Z4, 24:53-25:01).*

Yet, the technical capabilities of Zalando's CNA platform are not shared by a large part of the supply chain. Therefore, even though CNAs facilitate the access to external capabilities such as partners, it is limited by the technology stack of the respective external parties, e.g. traditional fashion designers:

> *"The problem here are the [missing] functional capabilities of external parties. I think the bigger fashion designer companies may be even quite advanced, comparatively to smaller brands, but overall they are not known for their IT department" (Z4, 25:38-25:58).*

Thus, the implementation of CNAs on Zalando's side alone is not sufficient to extend the companies scope towards external parties.

In conclusion, the standardization with Zalando's centralized container orchestration layer in combination with the re-usability from independent microservices impacts the scope of Zalando, since e.g. the exchange of services and functions is made possible. The implementation of standardized tools and processes moreover facilitates the hiring of IT employees. Since large parts of the central IT infrastructure are streamlined in the CNA platform, product teams can focus on the business value of their applications. Additionally, the standardization and re-usability of CNAs allow Zalando a seamless integration of application modules from third-party developers. This facilitated access to external capabilities is also related to the integration of Zalando's applications with those of partners and suppliers. Yet, the modern CNAs at Zalando cannot compensate for the lack of standardization and re-usability on the external parties' end.

4.3. Scale of Digital Business Strategy at Zalando

4.3.1. System Availability

In Zalando, a central benefit of scaling on CNAs was that of availability. Defined as up-time minus down-time (Ranjita et al., 2003), the availability of customer-facing services is a central metric to measure IT performance. Z2 reflects on the importance of ensuring a high availability rate:

> *"Availability is always interesting. [...] We measure what impact our incidents have in terms of money lost. For at least the bigger Incidents, we have a way to measure the lost revenue or lost gross merchandise value (GMV). So availability is definitely something that we monitor" (Z2, 19:47-20:10).*

Generally, system down-time can emanate from technical issues or traffic overload. Regardless of the root cause, for an e-commerce company like Zalando it is self-explanatory that the unavailability of systems presents a business risk to the company. For an online business, transactions can only be made if the website is available for the customers. Therefore, there is a direct financial impact from a lack of availability. In extension hereof, the automated up- and down-scaling characteristics of CNAs become a competitive advantage. Z1 uses the shopping event Black Friday as an illustration of Zalando's automated scaling of computing capacity through its Kubernetes platform:

> *"Black Friday is the biggest annual event for Zalando, where we are really pushed to something that is not normal. Normally we scale up and down during the day, but it's manageable with AWS and this we did before the Kubernetes platform. Now we do it on the Kubernetes platform automatically" (Z1, 27:37-28:00).*

Scaling of server capacity on a daily basis was not an unknown approach before Kubernetes. However, it was managed manually. With Kubernetes, scaling of server capacity is automated, which benefited the important Black Friday sales in Zalando, as Z1 continues:

> *"The cloud is not infinite. When every company wants to do Black Friday, they all scale up a bit before to get compute capacity and you can risk that you don't get the capacity you need. [...] What we did this year [Black Friday 2019] was our team requested all the capacity needed and then the Kubernetes infrastructure is smart enough to do this based on preferred server type and price" (Z1, 28:03-29:03).*

As the supply of server capacity from cloud providers eventually reaches a limit, it constitutes an availability risk for Zalando that e-commerce competitors also seek to scale up their server capacity for Black Friday. Fortunately, the automated Kubernetes platform ensured that Zalando got the compute capacity required to fully reach the potential revenue from Black Friday. Further, cloud-native architecture provides a solution to the problem of limited cloud resource capacities as noted by Z1. The advantageousness of CNAs mainly relates different concepts of scaling:

> *"[To increase] computational power on your machine, you can either scale the machine up [vertical scaling], making it bigger by increasing CPU or RAM, or you can scale out [horizontal scaling], making it wider, having more machines distributed working in parallel" (Z4, 06:33-06:58).*

Z4 elaborates how the horizontal scaling capabilities of CNAs present an advantage compared to monolithic applications, which are limited to vertical scaling:

> *"But this [horizontal scaling] you cannot do with a monolith. You can scale the whole thing, you make the whole thing bigger. But you cannot do the scaling per use case [with monolith]. But this is something that cloud-native allows you to do" (Z4, 06:33-06:58).*

With automated scaling, Zalando is capable of utilizing its unused infrastructure at website traffic peak events such as Black Friday. By connecting the dispersed server capacity to one logical unit, Zalando can effectively respond to temporary traffic spikes on its platform. The approach employing automated scaling through CNAs used on Black Friday 2019 stands in contrast to the process of securing the required compute capacity ahead of Black Friday, as managed in the year before. To fully appreciate the advantages of automated scaling through CNAs, Z1 compares both models:

> *"The previous year [Black Friday 2018], teams had to scale individually for their applications. They had to plan and figure out how much they [individual team] needed. But this year we could do much more from the infrastructure side and hide all of this complexity, which saved a lot of time compared to if you needed to do this with every individual team" (Z1, 29:03-29:36).*

In addition to temporarily scaling, the use of CNAs also accommodates the scaling of IT infrastructure required to achieve Zalando's ambition to grow its business. Z3 reflects on how the Kubernetes platform enables Zalando to scale its business through the use of IT:

> *"Scaling on Kubernetes tends to be a lot easier than it was before. And as we get more customers, as we get more partners, our ability to scale up needs to improve as well and needs to be faster. And that's what Kubernetes brings, it brings us that ability to meet these business goals from an infrastructure perspective" (Z3, 27:17-27:42).*

Firstly, scaling Zalando's reach through CNAs, such as the automated Kubernetes platform, is seen as an advantageous approach to accommodate a rising number of customers. Secondly, Z3 also mentions the possibility to increase the number of partnerships with other organizations through CNAs. This is an indication that scaling through CNAs can facilitate cross-collaboration between firms, thus extending Zalando's business ecosystem. Z1 describes how the easily scalable Kubernetes platform changes the perception of what IT infrastructure ought to provide:

> *"For applications [in Zalando], they need to be built the cloud-native way by being scalable horizontally. And by having Kubernetes, the infrastructure is more dynamic than before" (Z1, 03:21-04:36).*

In summary, with the example of Black Friday, automated scaling on Kubernetes has proven a valuable capability in Zalando. This is because automated scaling allows Zalando to accommodate large spikes in traffic, ensuring availability to services and no lost potential revenue. Further, Kubernetes allows Zalando to be frugal whilst ensuring that Zalando attains the server capacity needed for occasions where other e-commerce sites also request extra server capacity. Moreover, the Kubernetes platform is seen as a facilitator to realize the business opportunities related to scale by providing a dynamic infrastructure. This is because Kubernetes easily allows for horizontal scaling to accommodate more customers and partners.

4.3.2. IT Cost Efficiency

Scaling on CNAs has brought a possibility to achieve cost savings in Zalando. Specifically, with the Kubernetes platform in place, Z3 could centrally observe that the individual development teams in Zalando often bought more server capacity than needed:

> *"We saw that teams with orientation towards development work didn't really care too much about their operations. They would have tons of EC2 instances [server capacity on AWS] that were going completely un-utilized and which was very inefficient for Zalando. Now we don't need to worry about this anymore" (Z3, 03:56-04:18).*

For development teams in Zalando, operational management was not always an obvious priority. High utilization of server capacity was not of vital importance for the development teams, since the teams' self-interest was concerned with development, not the cost-effectiveness of the application. The centralization of infrastructure management with container orchestration streamlines the processes of achieving oversight, which results in overall lower spend on IT infrastructure. Therefore, automated scaling through CNAs served as a technical response to increase the low resource utilization in Zalando. Moreover, the centrally manageable Kubernetes platform had a positive effect on operational overhead costs, as Z3 states:

> *"Another key benefit [in relation to cost of scaling] is operational overhead. [Usage of] Kubernetes results in less operational overhead, because now we have a central team that's running the underlying infrastructure underneath it. It is economies of scale" (Z3, 22:19-22:35).*

Scaling on Kubernetes reduced the fixed costs associated with IT infrastructure. As infrastructure is centrally managed, Zalando can leverage economies of scale. The infrastructure cost per team is lower with Kubernetes, as server capacity is bought and allocated centrally. However, while scaling on Zalando's Kubernetes platform has increased the utilization of infrastructure in the company, determining the isolated financial impact of cloud-native in Zalando is not a straightforward task, as Z1 express:

"We spend the same amount [of money] on compute capacity in 2019 as in 2018, but we made a lot more money into those, in 2019. So we are more efficient" (Z1, 30:01-30:12).

Therefore, while the effects from scaling on CNAs in terms of increased output in Zalando are evident for the those working with IT infrastructure management, it has proven difficult to document the financial impact of the CNA's scalability. Z4 further express the challenges around measuring the direct financial impact of CNAs:

"If we take the amount of money that we invested in infrastructure, and then compare the monolith to the cloud-native solution, then it's not comparable. Because the entire system is growing in capabilities over time [...]. The problem is to define the necessary data" (Z4, 32:00-32:49).

Because of changes in requirements, Zalando's IT capabilities are constantly changing. Therefore, gathering the data required to create the equation that financially compares Zalando's CNAs to its previous traditional monolithic development approach is not feasible.

All in all, CNAs brought two dimensions of cost savings in Zalando. Firstly, automated scaling centrally monitors customer traffic on Zalando's applications and adjusts the capacity to provide the necessary compute capacity at the lowest cost possible. This improves the utilization of server capacity. Secondly, Zalando spends less on overhead expenses dues to the attainable benefits of economies of scale. These cost savings are attributed to the centrally managed infrastructure on Kubernetes. However, as the capabilities of CNAs are not directly comparable to Zalando's previous monolithic applications. This makes it impossible to benchmark the cost savings of introducing CNAs in Zalando.

4.3.3. Compliance

Lastly, the scalable quality of CNAs has eased Zalando's efforts to stay compliant with demands from relevant regulatory authorities. The most obvious example of ensuring compliance with CNAs comes from the European Union's General Data Protection Regulation (GDPR). The GDPR brought several requirements for companies concerning how personal data is processed, stored, and documented. Failure to comply could result in severe penalties (European Commission, 2020). As Zalando holds personal data such as name, address, telephone number, and credit card details on millions of individual customers, the GDPR brought significant implications for Zalando's operations. The regulation was passed in 2016 and came into effect in 2018. Between these time points, Zalando realized that the company at that time would face challenges in documenting that the software engineers only handled personal data to which they had a legitimate business purpose to, as the GDPR requires:

> *"STUPS was set up in a way to allow teams to act as autonomously as possible, which meant that every single team had kind of their own way of operating [...]. That [autonomy] led us to the point where we just couldn't keep up with the demands of GDPR, because we just didn't have any central levers to understand what people were running on their [cloud] accounts, as one example" (Z3, 02:21-03:43).*

The predecessor to the current Kubernetes platform, STUPS, proved an inadequate tool for Zalando to document what customer data teams were using and how it was processed. Fortunately, the Kubernetes platform provided the option for Zalando to establish an "Ingress", which is an API resource to centrally manage both internal and external access to the services in a cluster. This allows Zalando to centrally configure the conditions required to access a cluster's data. Z3 describes the benefits of utilizing an Ingress in Zalando:

> *"GDPR compliance is now easier [because] all data within a cluster is going through the same Ingress. It's much easier to make sure that people [software engineers] are authorized properly, as there is a standardized way to authorization. [...] People cannot intercept stuff they should not be able to intercept" (Z3, 39:03-40:02).*

An Ingress thus works to ensure the authentication of the data requester, which helped Zalando reach GDPR compliance. Moreover, continuing with the example of GDPR, Z1 addressed how the scalability feature Ingress comes into play with regards to compliance:

> *"With the Ingress, we can do more centrally. We can enforce much more [than on STUPS] in terms access rights and so on which is relevant for the whole GDPR topic. It's helpful in a lot of ways because there's a lot of things that we can integrate it [Ingress] with" (Z1, 33:12-34:05).*

In sum, the precautionary measure of the Ingress is a centrally managed API resource that is scalable on the Zalando's Kubernetes platform. It ensures authentication of the data requester, ensuring that data processing in Zalando is GDPR compliant. Manual enforcement of access rights is no longer required, as on the previous STUPS platform. This is a significant step to ensure that only a rightful Zalando employee can access a cluster network and the data it contains.

4.4. Speed of Digital Business Strategy at Zalando

4.4.1. Agility

Time is often a scarce resource in software development. This condition poses an ongoing challenge Zalando, especially if compromising on the quality of the software should be avoided. To ensure an output with high quality at a fast pace, the response for Z4 was to modularize applications in Zalando:

> *"Due to time pressures in the software development process, good engineering practices tend to be ignored. The need to always do things faster is basically in conflict with thoroughness. Therefore, we modularized our applications. That means that certain pieces of our application are responsible for certain functionality and that functionality only" (Z4, 02:36-03:22).*

A modularization of applications in Zalando was achieved with the implementation of microservices. As mentioned, microservices only provide a single functionality to a system, yet is coupled to other microservices that together provide an application with functionality. In extension of modularization, a continuous integration and deployment (CI/CD) pipeline automates the software delivery process from microservices in Zalando:

> *"Microservices require smaller changes that is safer and with less business impact. It's easy to roll out, and you get features out faster. And by migrating to Kubernetes we got a CI/CD pipeline, which allows our developers to push and deploy things faster and more safely" (Z3, 24:30-24:49).*

As each microservice evolves independently, microservices does not rely on updates or releases of other microservices. Therefore, the usage of modular iteration through microservices means that software engineers deploy more often, although with features that have a smaller business impact. This reduces the risk of an update to disrupt the entire system. Further, a CI/CD pipeline streamlines the development process as it takes care of e.g. test and configuration. This streamlining allows for a continuous delivery approach in Zalando, which can eliminate manual work through automating processes, as Z4 states:

> *"The Kubernetes platform automatically sets up continuous delivery pipelines for our individual systems. It's configurable and allows us to highly automate the deployment process" (Z4, 20:40-21:04).*

Through the automation of the deployment process and separation of functionality due to microservice-based architecture in CNAs, Zalando's ability to quickly modify its applications improved. Another way CNAs in Zalando works to speed up software development processes is to ensure that only decisions, information or requests related to software engineering, is presented to the software engineers:

> *"With the transition to the Kubernetes platform, we have basically abstracted a lot of this [operational burden] away from the individual teams. We [Digital Foundation] take care of the operational burden, including infrastructure, on our agenda. Software engineers have a smaller space that they need to care about, and that helps us do things faster" (Z1, 07:48-08:50).*

Zalando's Kubernetes platform works as a tool to simplify the workload for software engineers. Non-value adding work such as operational and infrastructure management is moved centrally to the "Digital Foundation" team facilitated by Kubernetes. Therefore, software engineers can increase their focus on developing software.

However, while the interviewees can identify how the cloud-native software development process has increased the agility, e.g. through automation, this is not the same as documentation that the overall process of software development is faster than before the usage of CNAs. Z1 explain the factors that can distort the measurability of determining the software development time:

> *"The idea behind the Kubernetes platform is to provide much more. So once development teams are moved, they can work faster on their features. But getting the documentation is super complicated. [...] Because you have to analyze things like incidents types and severity. And this is very hard to do automatically. It is a complicated thing" (Z1, 16:00-17:28).*

Individual opinions and unique circumstances, e.g. to determine the reason and place the responsibility of a root cause to an incident, makes it difficult to establish the specific time savings resulting from developing and operating software through the Kubernetes platform. As a consequence, when Z3 as the project manager of the Kubernetes migration project approached development teams, the strategy was to remain careful in what was promised:

> *"The time-saving is a tricky thing to gauge [...]. And so telling [teams] something like "if you just move to Kubernetes you will save three percent of your time per engineer per week which amounts to x amount of euros" - It doesn't work like that. So instead we give teams a rough estimation based on examples from other teams" (Z3, 22:35-23:14).*

To ensure support from the up to approximately 300 development teams of Zalando in the migration process to Kubernetes, Z3 made no promises of time-savings and the derived effects on cost savings hereof. Instead, he presented the results from already migrated teams, and let them interpret the results themselves.

Overall, the implementation of CNAs has increased digital agility in Zalando. As applications are built from microservice-based architecture, updates and releases to applications can be achieved faster and more frequently. Moreover, Kubernetes has removed non-software development work off development teams, as this is now centrally managed. This organizational arrangement works to further increase the responsiveness of software engineers in Zalando. However, documenting the time reducing benefits of CNAs effectively remains a manual task. Therefore, despite having a beneficial impact on software output in Zalando, the documentation process leaves Zalando in a somewhat unresolved situation in terms of proving the speed benefits of CNAs.

4.5. Sources of Value Creation and Capture of Digital Business Strategy at Zalando

4.5.1. Technology Openness

The architectural elements of CNAs allow for the implementation of new value sources in Zalando. With a system design based on independent microservices, software engineers have a high degree of freedom in their choice of technology:

> *"This is always the idea, and this is also cloud-native. The way it was done was that [the software engineers] can pretty much choose whatever language you want. [They] are very free to choose" (Z1, 25:47-25:59).*

By enjoying this flexibility, Zalando's developers can tailor the respective microservices to the specific business problem. According to Z4, this technology openness presents a crucial benefit of microservices. Z4 exemplifies the customization of services with the use of database technology:

> *"What [microservices] do for you is the freedom to use the technology that is used to store the data. You have this abstraction layer in between, where the data is sent somehow, and you could store it in PostgreSQL database, a NoSQL database, or in some kind of business analytics database. This allows you to optimize for different use cases" (Z4, 19:16-19:41).*

Another example of technology openness through CNAs is the diversity of programming languages. The modularization into microservices, which are delineated from the rest of the system, allows implementing the coding language most appropriate for the service. In Z2's experience at Zalando, this becomes evident when comparing to monolithic application design:

> *"[...] If you have smaller size services, you can choose new technologies for the different services. So if you would have a certain monolith that's based on some PHP [programming language], you would always have to develop on top of PHP" (Z2, 41:04-41:21).*

Besides the freedom to choose the database technology or programming language most suitable for the specific business case, the technology openness further facilitates the hiring of software engineers. In a monolithic application, the know-how of the technologies used throughout the system is indispensable for its further development. Therefore, the pool of qualified IT employees is narrowed down. With its flexible CNA design, Zalando's IT recruiting has fewer limitations:

> *"If you diversify and have more [programming] languages, you not only have the more fitting programming language in the technology […] for your use case, but you would also be available to be a little more open for hiring talent for different areas, instead of being limited by C++ Developers for example" (Z2, 41:25-41:58)*

Z1 affirms the impact of technology openness on the sourcing of software engineers (Z1, 26:51-27:02). Besides enabling the use of technologies that fit the respective business case best and allowing for broader recruiting sources, CNAs facilitate the integration of state-of-the-art technology:

> *"This is definitely one of the bigger advantages of microservices, that you are able to use new technologies more simply" (Z4, 30:01-30:03).*

The integration of modern technologies includes also the execution of system updates. Within a monolithic application, the introduction of updates poses a risk to the availability of the overall system. As system disruptions resulting from an update are possible, the entire application needs to be restored, even if these disruptions are concerning only minor system parts:

> *"[Imagine] you [are] using a framework, and its […] two or three versions outdated. And if you want to upgrade this now, you have to make sure that all of your product [versions] works at once. [...]. If there are breaking changes between these versions, you have to fix them all at once" (Z4, 30:04-30:17).*

On the contrary, CNAs enable the roll-out of the most recent software versions only in certain microservices. Thus, the risk of jeopardy of the overall system's functionality is minimized.

Furthermore, the loosely coupled architecture of CNAs makes the experimentation with novel technologies possible. Thereby, Zalando can tap into new sources of value creation, as Z4 states:

> *"We are able to experiment much faster. […] For smaller applications, you can build them quicker, you can use all technologies. I think this is something that really goes through the entire development cycle" (Z4, 28:23-28:42).*

Ultimately, the high freedom regarding the choice of technology enables Zalando to incorporate state-of-the-art technologies for new applications.

> *"When you are more flexible in the architecture, you can also spin out more applications that use newer technologies themselves. That will certainly also help with innovation" (Z4, 30:46-31:01).*

Thus, the increased technology openness through CNAs ultimately increases Zalando's innovation capability.

Overall, the technology openness resulting from the flexibility of CNAs enables Zalando to access new sources of value creation and capture. These include the targeted optimization of IT according to business needs, an enlarged pool of IT employees, and a more secure and updated system. Besides that, the modular CNA design facilitates experimentation with new technologies while further enhancing Zalando's capability to develop innovative applications.

4.5.2. Ecosystem Sharing

The modular design of CNAs allows Zalando's platform team to collect knowledge from various ecosystem sources, i.e. in the form of shared software code:

> *"We do contribute a lot to each other's code. When we need to things change, then we just go and do it on someone else's code. And it's also encouraged" (Z1, 45:46-46:04).*

While Z1 refers to the sharing of knowledge within the platform team, Zalando also employs company-wide open knowledge communities. One of these initiatives is dedicated to generating knowledge related to the adoption of new technologies. Technology recommendations are published on the so-called "Technology Radar", which represents an overview of recommended technologies This overview is available for all IT employees in Zalando:

> *"It's [managed by] an internal community called "Guilt", and it's mainly made up of volunteers. But basically, each of the teams, if they want to […] use a new technology,*

can present to it and argue for including the technology on this radar" (Z2, 46:23-46:54).

Z2 describes how the internal knowledge sharing process via the Technology Radar leads to the adaption of new technologies:

"[Software engineers] can for instance do a proof-of-concept, and afterwards go into an 'assess mode'. If they want to use it for production services, they would need to go to 'trial mode', and then it can be decided if we should move to it, invest more on it and adopt it, or move it back on hold" (Z2, 46:55-47:15).

Besides the use as an internal platform of crowdsourced technology adaptations, the insights generated from the Technology Radar are shared with the public IT community as open-source content (Z2, 43:38). Yet, the engagement with a wider developer audience does not represent a formally defined strategy at Zalando. Rather, it is utilized to share the created knowledge, as Z2 clarifies:

"That's all part of open source work, but it's only for transparency purposes. There's no dedicated interaction with the community" (Z2, 47:40-47:52).

Although not specifically managed, the involvement with open source projects is not limited to the sharing of Zalando projects with an external audience. On the one hand, CNA architectures and tools, such as the container orchestration platform Kubernetes, are based on open-source software. On the other hand, the widely used open-source software facilitates the integration of Zalando's technology with its partners and customers. Thus, Zalando's product teams also prefer to use open-source software for the development of their own products. In line with the impact of technology openness described previously, open-source code allows tapping into already existing value sources. Yet, the open-source services often require customization according to specific company needs. Z1 illustrates this with Zalando's version of the open-source service Kubernetes:

"Kubernetes is about providing a platform that can do what the users need. And we prefer to go with open source in our team if we can. But some things [that we need] are not there. We need to make a more customized [version] so that it fits better to Zalando infrastructure set-up" (Z1, 24:14-24:35).

All in all, the modular design of CNAs allows Zalando's IT teams to collaborate on software projects. Additionally, new sources of value creation and capture are used by the participatory crowdsourcing of technology recommendations via the Technology Radar. While Zalando also shares the Technology Radar via open-source, it also integrates externally developed open-source tools into their own CNA products. Yet, the IT teams regularly customize the services provided by the extended ecosystem to realize Zalando's business and IT requirements.

4.5.3. IT Complexity

While technology openness and ecosystem sharing first and foremost presents beneficial impacts of value creation and capture through CNAs, the resulting IT heterogeneity leads to an increased complexity at Zalando. The internally developed self-service platform STUPS provided the open access to CNA solutions across Zalando's independent product teams and resulted in an increased heterogeneity of the IT portfolio, as Z3 reflects:

> *"What ended up happening was that every team went in all these different directions. […] we ended up trying to create a system [STUPS] that did everything, but nothing particularly well" (Z3, 03:06-03:23).*

With the freedom and self-governance allowed on STUPS the complexity of the application landscape in Zalando increased radically (Z1, 46:42). In comparison with monolithic systems, CNAs are more complex in terms of system architecture. Within the modular design of CNAs, the overview over mutual dependencies, e.g. on mutual data sources, becomes increasingly challenging. Z4 describes the complexity of microservice architectures:

> *"[…] you're having this one-to-many relationship that spreads out too many parts of the system. […] Furthermore, what you also introduce the so-called n+1 problem, where [one service] calls another service. And you don't know what that service has to call either to fulfill your request" (Z4, 16:57-17:35).*

The missing overview over service dependencies may lead to a decreased application performance, e.g. by lengthy service feedback chains:

> *"So maybe that service is calling another service, and that service is calling another service, and you end up having these huge cascades of chains. Which then have to all finish to come back to you, and that connection is very slow" (Z4, 17:35-17:50).*

As a result, the flexibility advantage of CNAs over monolithic applications with high dependencies is diminished when CNA modules and its data are largely synchronized, as stated by Z4:

> *"Let's say a request comes in to service A and that service A [requests] service B for data, gets the data back and gets the answer out. [...] you will end up with a distributed monolith. So, you basically have none of the availability upsides, but you will get all […] complexity downsides with it" (Z4,14:04-14:32).*

As a mitigation for the problem of this synchronous communication, Z4 mentions the introduction of asynchronous communication, which employs the duplication of the necessary data for each service. Thereby, the independency of every service will be increased (Z4, [00:18:08]). Yet, the creation of duplicate data leads to further complexity especially at a higher scale, as illustrated by Z4:

> *"But it has a downside: it's significantly more complex. You have much more moving systems; you need to replicate the data into your own database. If, for some reason, this other service just starts sending thousands or millions of events, you might bring your own system down doing that. You need more data storage, but you have this data not one time, but many times" (Z4, 18:48-19:13).*

Despite the complexity arising from dependencies and duplicates in modular CNAs, Z4 mentions the complexity to manage application changes within distributed CNA architectures (Z4, 14:56-15:16). More general, the freedom to use different technologies for different microservices comes with an increased management effort compared to a monolithic application with consistent technology:

> *"On a monolith, you just deploy one application. For microservices, you deploy many. If you have to do this manually, the effort scales linearly with the amount of systems that you have and the amount of the problems that you need to do" (Z4, 20:24-20:37).*

Therefore, Zalando's CNAs must integrate automation, e.g. with continuous delivery tools. Yet, the addition of a continuous delivery layer further increases the IT complexity (Z4, 20:38-20:39).

The flexibility to use the "best-of-breed" technology for CNAs entails that product teams may also integrate less standardized technologies:

> *"It also leads to the problem [...] that there's too much freedom when it comes to technology. You have small islands of things that not a lot of people know about" (Z2, 42:02-42:19).*

Since the knowledge required to develop and operate applications based on less popular technologies are very specific, it becomes difficult to manage them in the long run. If the skills to manage and maintain applications are bound to specific teams or even single software engineers, it becomes challenging to support these services when the necessary knowledge leaves the company:

"For instance, we have a small community that builds their services in Rust, but if those people leave, then you would need to either refactor that service or hire someone who knows how to run a Rust service" (Z2, 42:20-42:35).

Z2 further illustrates how "knowledge islands" emerge in manifold technology areas:

"The same thing happens with other technologies. We have a lot of Cassandra-based applications. Cassandra is a database technology, and applications are running on top of it. Over the years, we lost a lot of Cassandra expertise. Now, we basically have teams running the services on top of the technology that they don't really know" (Z2, 42:51-43:17).

The creation of siloed knowledge presents a contrast to the benefits of ecosystem sharing as outlined previously. Senior software engineer Z1 further adds on the emergence of "knowledge islands":

"If everyone [developers] are doing different programming languages, different frameworks, [have] different ways to deploy, if people change teams - it gets very complicated" (Z1, 26:17-26:32).

In order to limit the development of IT complexity while still benefiting from the flexibility of CNA, Zalando's IT management introduced efforts to mitigate the negative impacts. As a result of Zalando's learnings with the STUPS platform, these efforts include the limitation of technology openness:

"Now we are also working a little bit the other way now to make it more restrictive, to have a more coherent way of doing things because it makes it very hard to understand what's going on in the whole infrastructure" (Z1, 26:04-26:15).

By defining certain "best-practice" technologies, Zalando fosters a less fragmented IT landscape without compromising the performance of services, e.g. through the Technology Radar. With this approach, Zalando manages to benefit from the manifold sources of value creation and capture of CNAs while mitigating the impact of complexity resulting from "too much" freedom:

"You can see the different technologies that we use both in terms of framework, data management, infrastructure and languages and then the different states. If you want to create a new service, we prefer if you use the technologies that are actually proven in Zalando or that are already in the adopt stage" (Z2, 45:30-46:00).

Conclusively, the introduction of CNAs brought complexity to Zalando's IT landscape. The freedom of teams to implement the technologies of choice via STUPS combined with the inherent complexity of microservice architectures led not only to a lack of transparency but eventually difficult application maintenance and slowed down system performance. Further, the technology openness and the thereby emerged technology islands created dependencies on the know-how of specific employees. Altogether, these drawbacks resulting from the CNA implementation led to the restriction of technology for the benefit of more control and standardization at Zalando.

With IT complexity representing the final empirical observation within Zalando, the analysis further continues with the presentation of the second case, which is Adidas.

4.6. Case presentation: Adidas

4.6.1. Company Background on Adidas

Since its founding in 1949, Adidas has become a globally recognizable brand with approximately 60,000 employees worldwide. Adidas sells a wide collection of sports apparels, i.e. mainly shoes and clothing for both sports and leisure activities. In the fiscal year of 2019, Adidas increased its net profit by 8 percent, resulting in a net profit of 12 billion Euros (Adidas, 2020). This result should be seen in extension of the Adidas' steady growth over the last decade, placing the company in the top 10 global fashion companies measured in market capitalization (FashionUnited, 2020).

Adidas' current corporate strategy, "Creating the New", is built from three strategic choices (Adidas, 2020): Firstly "cities", which is Adidas' response to the global megatrend of urbanization. With an over-proportional marketing investment in the global cities where fashion trends arguably are developed, Adidas aims to grow its market share globally. Secondly "speed", reflects the effort to serve customers better with a higher frequency of product launches as well as a faster-operating model end-to-end to strengthen competitive advantage. Thirdly, "open-source" is the theme aimed to broaden the collaboration between Adidas and its ecosystem. Innovation, inspiration, or co-creation to Adidas' products can come from e.g. external partners, athletes, or the consumers themselves. Shared between the three themes in the corporate strategy is that when possible, the initiatives under the themes are digitally based. This has resulted in the need for a digital transformation process, working in parallel with the corporate strategy (Adidas, 2020).

Traditionally, Adidas has focused its sales channels from own retail outlets and wholesalers. However, since 2012 there has been a strong corporate eager to boost Adidas' e-commerce platform, consequently giving it the status as the third leg of the company, with retail and wholesale being the other two (Digitale Leute, 2019) In 2019, Adidas' e-commerce platform saw revenue growth of 34 percent making it the fastest-growing sales channel in the organization. Further growth of the platform is aimed at increasing the sales efficiency and enable digital self-tailoring of products by the consumers (Adidas, 2020). The ambition to grow Adidas' e-commerce platform is manifested in an annual target revenue of 4 billion euros from e-commerce sales by 2020 (Digitale Leute, 2019).

4.6.2. Cloud-Native Transformation at Adidas

Until 2013, Adidas' IT infrastructure relied on physical servers externally operated by a third-party hosting provider (du Preez, 2018). On an application level, the core systems consisted of self-developed monolithic software based on Java, consisting of *"[…] sometimes a couple million lines of code"* (Eichten, 2019, p. 443). Further, large-scale enterprise resource planning systems, externally provided by the software provider SAP, were part of Adidas' IT portfolio (Eichten, 2019). From the perspective of software engineers, the set-up of development resources presented a highly manual process:

> *"[…] just to get a developer VM [virtual machine], you had to send a request form, give the purpose, give the title of the project, who's responsible, give the internal cost center a call so that they can do recharges" (CNCF, 2020c)*

This custom approval process involving multiple IT and business stakeholders led to lengthy waiting times for developers before they could start working on their software projects:

> *"[…] eventually, after a ton of approvals, then the provisioning of the machine happened within minutes, and then the best case is you got your machine in half an hour. Worst case was half a week or sometimes even a week" (CNCF, 2020).*

In 2013, Adidas decided to shift its externally hosted IT infrastructure to self-operated internal data centers. The extensive customization of IT provisioning, combined with the monolithic application design, caused high costs related to the migration of applications. To decrease the migration costs as well as to organize the set-up of IT resources more developer-friendly in the long-term, Adidas decided to move part of its system from VMs to containers as an alternative (du Preez, 2018).

Adidas imposed the criteria for running the containerized infrastructure within its on-premises data center. Yet, the shift from the VMs to containers did not result in the anticipated outcome which would be a developer-friendly, self-service infrastructure (ibid.). Furthermore, Adidas imposed specific criteria on its future IT platform, e.g. the ability to run in its internal data centers with open-source software. These criteria led to the conclusion of implementing a cloud-native platform at Adidas. (Eichten, 2019) In 2016, the initial containerization was therefore complemented by the orchestration platform Kubernetes, which was yet rolled out for only minor workloads (CNCF, 2020c)

Besides the implementation of Kubernetes, Adidas' IT complexity grew further. On the infrastructure side, data centers were gradually complemented by cloud instances, resulting in a hybrid IT infrastructure. On the application level, different maturity levels evolved, consisting of self-developed and external monolith next to newly established microservices (Eichten, 2019). After the initial tests in smaller environments, Adidas then decided to migrate the whole e-commerce-platform to Kubernetes.

With the learnings provided by this test phase, Adidas rolled out 100% percent of its e-commerce-platform on to Kubernetes by November 2017, only six months after the initialization of the project. Thereby, Adidas could successfully test its new cloud-native platform during high-peak traffic, e.g. the Black Friday and Cyber Monday shopping events (CNCF, 2020c).

Summarizing, Adidas cloud-native journey took offset in 2013 with the migration from the externally hosted IT infrastructure to internal data centers. On this infrastructure, Adidas operated externally developed ERP system by SAP as well as its own core IT systems, both presenting monolithic applications. In order to organize its IT infrastructure more developer-friendly, parts of the system were migrated from VMs to containerized microservices. After the initial experience with containers and microservices and first testing of Kubernetes on a small scale, the whole e-commerce-system of Adidas was migrated to a cloud-native platform based on Kubernetes. Figure 11 shows this transformation below.

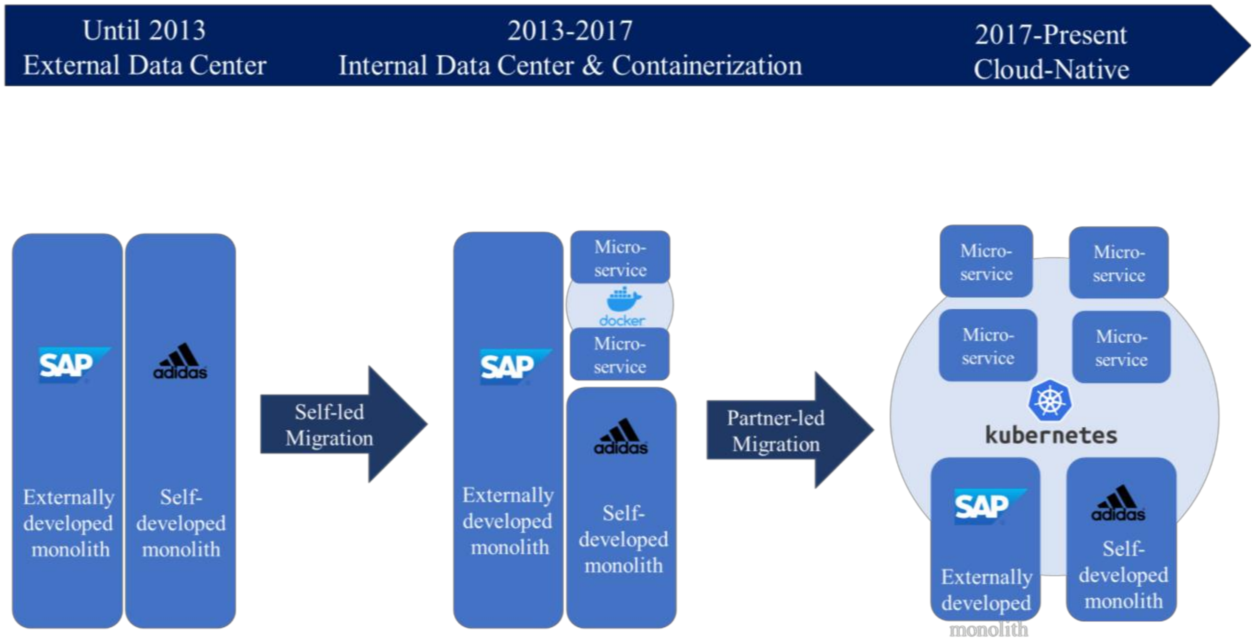

Figure 11: CNA-Transformation in Adidas (Own representation).

Currently, Adidas operates Kubernetes environments in five globally distributed data centers for multiple monolithic as well as microservices application workloads. Furthermore, a large-scale CI/CD process was implemented in Adidas' cloud-native platform to facilitate development and operations processes for the more than 600 employees in IT (Eichten, 2020). Overall, 20-30 percent of Adidas' applications are CNAs (A2, 14:25-14:32). In the course of the following analysis within Adidas, the effect of CNAs on the Digital Business Strategy as suggested in the thesis' conceptual model will be investigated.

4.7. Scope of Digital Business Strategy at Adidas

4.7.1. Fusion of Business & IT

Before the transformation from a monolithic to a cloud-native IT environment, the organizational design within Adidas followed a clear split between business and IT units (A3, 00:11). The centralized IT department followed a clear segmentation of the software development lifecycle, as A3 explains:

> *"[The IT units] were all central units to a certain degree. So, we had a central development unit, central integration, central test and central infrastructure" (A3, 00:26-00:41).*

The centralization of Adidas' IT led to inefficiencies specifically in software development. Instead of developing solutions hands-on, software engineers found themselves in a managerial role, overseeing projects from in-sourced software engineers (A3, 00:17). A3 further describes how this led to an organizational inflexibility, leading to the wrong assignment of positions:

> *"With this approach, you will find resources to a certain organization and you have less flexibility to reassign them [...] It's a very inflexible design, and [Adidas] ended up [with] team leads or people leads, who are actually not skilled in a certain [IT] practice" (A3, 01:51-02:25).*

Based on these observations from this centralized organization design, Adidas decided to shift its software development and operations organization towards a product-oriented approach (A3, 03:03). This included the convergence of business and IT through DevOps-related organizational structures. For Adidas, the IT traditionally first and foremost fulfills a support function for the business goals. Therefore, the IT needed to be adaptable to the demands of the business organization:

> *"[...] after all Adidas is not an IT company [...] Adidas is a retail company. IT is a driver to achieve the retail goals. So we need to fully support what the business needs, that's the most important thing. And in IT we need to be flexible enough to adjust to this demand" (A1, 41:18-41:43).*

A1 mentions the enhanced collaboration between both functions as the main driver of the cloud-native transformation at Adidas:

> *"[...] this is the whole point of this transformation. You basically remove some of the barriers that we have between business and how business wants to react to changes, react to where the demand is going to" (A1, 13:48-14:06).*

As a result of the fusion of business and IT, DevOps teams can directly implement solutions for the related business process. The deeper integration of both functional areas also led to a better understanding of the possibilities that software provides for business teams:

> *[...] you have to make these benefits visible to the people who are in business. [Business stakeholders may ask:] 'What does it help me now if I have [...] databases in Aurora [...]?' And then you can connect it to problems they have today: 'Have you ever sat in front of your marketing application waiting two minutes? How about you wait 10 seconds?" (A2, 26:47-27:05).*

According to A2, this extends the scope of problem-solving not only towards Adidas' internal but also external business stakeholders:

> *"And it might be for some applications our marketing colleagues or it might be consumers who are using the app or the web shop as well. Might be […] wholesale partners we sell products to, might be the government" (A2, 27:39-27:53).*

In the implementation to reach the merger of business and IT functions, Adidas moved away from its central IT units called Centers of Excellence (CoE) towards a product-oriented approach. As an extension of cross-functional product-teams, functions are loosely organized as "chapters" outside the product level. With this reorganization applying the DevOps methodology, Adidas reached not only a higher business focus in IT initiatives but also increased the organizational flexibility:

> *"[Adidas is] organized more around products. In the managerial reporting line, the most senior person of a certain skill with managerial skills, or chapter lead develops the people in the assignment. Therefore, you can rotate the people quicker, you can ramp up a product or down without changing reporting line. And this is the flexibility" (A3, 03:04-03:29).*

Yet, since Adidas is a large organization, the shift from a centralized towards a more distributed IT is fundamental and needs to take place gradually. A1 suggests that Adidas underwent a learning process to realize the benefits resulting from the organizational design in line with the characteristics of CNAs:

> *"Hopefully things will become smoother with time with when this transformation is more mature. In the meantime, those barriers [between business and IT] are being removed. You can see that in some parts of Adidas. I think that the rest will come with time. You cannot do this kind of transformation from one day to the other" (A1, 37:12-37:44, 2020).*

All in all, Adidas shifted its scope of IT by integrating product teams into the more dominant business organization and breaking up organizational barriers in line with the DevOps methodology. As a result, Adidas was able to react more flexibly to the demands of the retail business.

4.7.2. Product Ownership

Along with the transformation from central IT units to de-centralized product teams, evidence from the qualitative data suggests that the product ownership in Adidas increased (A3, 49:34). According to the DevOps methodology, Adidas' teams are supposed to share the responsibility for development and operations:

> *"[…] our ambition is that teams share the responsibility between operations and development of new features, which includes consulting with their colleagues. This is also how the teams are set up" (A2, 48:32-48:48).*

Further, teams are encouraged to collaborate and foster the development of own innovation initiatives (A2, 48:48). In Adidas, the teams' ownership not only encompasses the respective services but is also exemplified by the responsibility for the onboarding of new team members or external developers. A3 describes how the teams' ownership for their IT know-how influences on-boarding:

> *"We have skill ownership. Every team has to have a skill owner. They say 'okay this is the skills required in team, this is the material we want you to study yourself. This is the information we give you in the onboarding, and with that in a couple of weeks, you should be 100 percent productive" (A3, 13:39-13:55).*

In summary, Adidas' product teams are now responsible for the end-to-end software development life cycle rather than only specific technology areas. The resulting increase in ownership is not only transferred to software development and operations but also innovation projects as well as employee onboarding.

4.7.3. Standardization

While Adidas initially followed the de-centralization of its IT organization, the learnings from this shift led to the re-introduction of a central layer which oversees certain operational areas. Cross-functional teams focusing on products still share certain services, e.g. IT security:

> *"It doesn't make sense for most teams to employ a full-time security person. Maybe in one product area, if it's a lot of security exposed features, but very rarely. The same goes for technical things like network, monitoring, database" (A3, 04:16-04:29).*

Thus, the rationale for the centralization was an increased efficiency through the standardization of such shared services. A3 further reflects on the return to central teams:

> *"From a company efficiency perspective, having multiple of these people will lead to multiple solutions, multiple islands of expertise and those people who don't have them they always suffer because they have no central person to go to […] So that's why we*

created a central team on the most common use components to steer and control" (A3, 04:31-05:01).

While at first, it seems that Adidas re-iterated towards the prior model of Centers of Excellence, the centralized teams implemented with CNAs serve as a company-wide platform rather than detached organizational units. Since the central layer employs standardized APIs, de-centralized product teams can connect through centrally standardized technology solutions via self-service:

"The target there is to do it in a way that people can pull things from them. In the past, you had to create a ticket, you had to call them and now they have to create a service that you can pull them or even automate them, or you can pull them by an API" (A3, 06:13-06:25).

For A2, the enablement of a self-service platform presents an advantage of standardization with CNAs, since it allows IT teams in return to focus on the business functionality of their products while reducing the operational overhead:

"One benefit is, [...] we are reducing the need for internal personnel to focus on the value and you try to take all of the burden away of "how can I get my workload to compute?" [or] "How can I get access to the data?" (A2, 45:30-45:53).

Because of the standardization of data sources across Adidas, software engineers can set up projects very quickly:

"When you want to tap in a certain data source, you can explore it in the catalogue and you will find API access, automation, the tools, everything included for you. So, as a developer, you can get access to data super-fast, and this allows you to play around with the stuff" (A2, 30:54-31:08).

This self-service not only concerns Adidas' internal IT teams but facilitates the access to Adidas' technology for external developer teams (A2, 30:17). Since Adidas relies on external partners for their CNA implementation projects as described, a central platform was introduced. Thereby, the external developer teams can be aligned with Adidas' internal technology standards. This facilitates the on-boarding of the in-sourced developers:

"We have also [an in-] source portal, which is very important for us. It shares all the information inside of the company with our partners. We are 1,400 people in IT, and about 6,000 people are working for us from other companies. So, you can imagine when moving people in and out, it is important to learn all the time" (A2, 11:10-11:31).

Another key step towards standardization and re-usability at Adidas was the standardization of the technology portfolio. If not governed, the responsibility and ownership over technology choices arising from decentralized teams lead to a lack of transparency and complexity. Thus, Adidas' central layer is designed to balance *"[...] autonomy versus standardization"* (A3, 26:36-26:37), which is further discussed in the analysis of the sources of value creation and capture (section 4.10.)

In summary, the standardization through the introduction of a centralized technology solutions department aimed at improving the efficiency of commonly used technology resources, such as IT infrastructure. With this central platform providing re-usable operating technologies, Adidas' product teams were now able to focus on the creation of value through new software, while accessing the operative resources from the central platform. The standardization of the CNA environment further supported the integration of Adidas' internal IT with its many in-sourced, external employees. As a further step towards technology standardization, Adidas introduced further governance regarding the openness of technology for the distributed product teams.

4.7.4. Cultural Adaptation

The process of a stronger embedment of digital capabilities into Adidas' overall firm strategy through CNAs revealed challenges related to the adaptation of cultural aspects. Traditionally, Adidas is not an IT, but a retail company which is *"[...] not born in the digital age."* (A1, 15:17-15:26). A1 states the difficulty of Adidas' cultural change towards a digital company:

> *"I would say that the transformation at on an organizational level or at a people level, it's much more complex [than the technological transformation]. I think that's the most difficult task" (A1, 18:25-18:36).*

Especially accustomed habits in IT development and operations, which were developed by Adidas' IT employees over many years, present a challenge for the IT transformation towards CNAs:

> *"Adidas is a 70-year-old company, with a lot of people that have been in the company for a long time. They were basically creating and building these applications according to how they saw the market, and suddenly the market changes and they are confronted with something that is not the way it used to" (A1, 18:46-19:16).*

While being in the lead for the shift to a microservices-based IT architecture as part of Adidas' CNA-environment, A1 confirms that the technological change comes with an organizational change since different know-how and processes are required:

"[…] this is the most complex topic about this transformation that we are undergoing. The transformation is affecting the teams a lot. Because we had a different structure, things are changing. And this this change into agile way of doing things. The intention is to remove a lot of barriers between what's business and IT" (A1, 36:28-37:00).

While IT units were accustomed to working in a waterfall-based methodology on monolithic applications, the shift to a DevOps-oriented methodology with cross-functional teams that develop microservices signified a fundamental shift in the firm culture:

"Employees were used to plan, their product in two to three years' time with all waterfall and that the end you'll be delivering something after two or three years, and suddenly the company tells you [that] you have to define incremental MVPs [Minimum Viable Product] and deliver them at the end of a 'sprint'" (A1, 20:21-20:45).

Furthermore, the implementation of requires new know-how, which forces also long-term employees to extend their knowledge base developed over the years:

"Not everyone is aware or has the techniques or the right tools the right experience, the right knowledge to actually do this […]" (A1, 21:00-21:11).

The fundamental changes on the technological side, e.g. the breakdown of monolithic into microservice applications or the introduction of container orchestrations, along with the introduction of DevOps methodologies led to the creation of an IT unit dedicated to the mitigation of the cultural impact of the transformation, which is supervised by A1:

"[…] we have a big budget inside Adidas because the [IT is] being transformed. One of them is a more than 20 years old product. […] It will be a big change for the users, which is for the best and that's mainly what I am doing here" (A1, 02:55-03:43).

Consequently, the side effects of CNA implementation on the culture of the IT organization require the investment of further human and monetary resources related to training and enablement to use the new technology set as well as the sharing of knowledge regarding the value of CNA.

As the analysis shows, the organizational, as well as technological transformation through CNAs triggered the need for a cultural adaptation of Adidas' IT organization. Since Adidas presents a traditional company with processes and techniques grown over a long time, the shift presents a hurdle for some of Adidas' IT personnel. To overcome these challenges, Adidas' invested in a dedicated team that supports this cultural change.

4.8. Scale of Digital Business Strategy at Adidas

4.8.1. System Availability

In IT, availability is generally understood as the time a system is functioning, i.e. available to perform the task it was designed for (Ranjita et al., 2003). However, availability also presented a business opportunity in a collaboration between Adidas' IT and marketing. By utilizing Adidas' already globally recognizable brand, the HYPE initiative was a strategy to boost Adidas' revenue from its e-commerce platform:

> *"We innovated a new business model, called HYPE. With HYPE, we shorten the availability of a product, and hype it with celebrities globally and then we put it on the market [e-commerce platform] for a very short time. Before [HYPE] our e-commerce platform could easily handle 300.000 hits per second. But HYPE got this up to 500.000 hits per second" (A2, 04:09-04:29).*

The marketing department in Adidas worked to immensely promote specific products to build up a high level of anticipation in the market. The product was then made available on Adidas' e-commerce platform, which resulted in a large spike in incoming traffic to the website. With the large effort put into HYPE across Adidas, and the anticipated revenue generated hereof, it was of great importance that the e-commerce platform remained available during this short time of significantly increased traffic. However, the task at hand for Adidas' IT was more complex than merely ensuring that the e-commerce platform could accommodate 500.000 visitors per second:

> *"The problem was also how it [the HYPE e-commerce platform] was connected to the [ordinary] webshop. An overload on it [the HYPE e-commerce platform] would completely shut down the [ordinary] webshop. We asked ourselves in IT: "How does it require us to build solutions differently?" (A2, 04:30-04:54).*

Since the HYPE initiative and the introduction of CNAs in Adidas occurred in the same period, HYPE brought an ideal opportunity for Adidas IT to leverage the benefits of cloud-native infrastructure. According to A2, these include the scaling and automation capabilities of CNAs:

> *"We moved a big element, e-commerce, to cloud-native. When got 300.000 hits during HYPE, the auto scale kicked in and the [Kubernetes] platform could now automatically handle 500.000 [hits]. We sold two million units in less than half an hour, and after that the system scales down" (A2, 12:43-13:12).*

With automated scaling, Adidas' e-commerce platform was able to accommodate the high volume of incoming traffic, ensuring that the additional revenue from HYPE sales could be realized.

Furthermore, the Kubernetes platform was also able to decouple the HYPE sales from the ordinary e-commerce website:

> *"Another important thing is you detach this kind of waiting room HYPE sales from the original web shop. So even in the case it would fail, the rest of the workshop is unaffected. Because it's designed with the principle "designed to be disabled", which is a very important principle" (A2, 13:15-15:20).*

The decoupling feature of services running on CNAs is an important feature for A2. In the case of the unavailability of the HYPE platform, it would be disabled independently from the ordinary e-commerce platform, allowing operations to proceed regularly. This a clear benefit of running applications through distributed systems such as CNAs. Moreover, from a customer-facing perspective, automated scaling also proved a contributing factor to improve user experience on Adidas' e-commerce website:

> *"Kubernetes automatically adjust the infrastructure we need according to the demands [...]. The customers do not experience downtime and we react much better to peaks of usage. So, the website is much faster, and the customers can experience a better performance" (A1, 33:40-35:00).*

From a user experience perspective, an increase in performance on Adidas' e-commerce platform is measured in availability and response time. Both have been improved on the CNA platform with Kubernetes, as compared to the virtual machines previously managed manually in Adidas.

In summary, the flexible scaling on Kubernetes constituted a business opportunity for Adidas. As the upper limit to user capacity was pushed, Adidas' e-commerce platform is capable to accommodate a large number of HYPE customers for a short time. Moreover, the HYPE platform was decoupled from the original Adidas e-commerce platform, allowing regular e-commerce operations to continue in the case the HYPE platform failed. Lastly, Adidas perceives the high availability from automated scaling and faster response time as a positive impact on the user experience of the website.

4.8.2. IT Cost Efficiency

By scaling applications with CNAs, cost savings are attainable in multiple ways. Therefore, achieving cost reductions in IT infrastructure is a fundamental driver in Adidas' CNA transformation. A1 expresses how legacy applications in Adidas are costly to keep running and why they ought to be replaced with more modern solutions:

> *"Of course, a main driver [in transforming to cloud native] is cost-reduction [...]. We are also trying to reduce the footprint of the applications, because we basically have large legacy applications that cost a lot to maintain in terms of licenses that you pay to software vendors, but also in the infrastructure they consume" (A1, 08:10-09:06).*

A1 is addressing the downsides of scaling monolithic applications, which has been the approach in Adidas until now. The inelasticity of monolithic applications means that its resource costs always rise as the capabilities of the application grow. Therefore, a significant portion of the costs associated with the legacy systems in Adidas comes from the overhead expenses, e.g. maintaining, licensing, and energy consumption of these applications. These represent service costs that are not contributing any value to Adidas. With CNAs, A2 see how overhead expenses related to the scaling of applications are reduced:

> *"With unpredictable consumer patterns, you don't know how many people will hit your site. And you don't want your site to break. Also, you only want to pay for what is used. This is where all of the benefits [of Cloud Native] begin" (A2, 13:55-14:24).*

In summary, scaling on CNAs offer two cost-saving potentials. Firstly, automated scaling automatically up- or down-scales the required server capacity based on website traffic. This ensures lower infrastructure costs for Adidas since only the needed resources are paid. Secondly, as CNAs monitor the dynamic pricing of server capacity, CNAs allows Adidas to execute code when the market price of the required server capacity is low.

4.8.3. Compliance

So far, the scaling advantages of CNAs in Adidas can be attributed to cost and performance. However, for a global company like Adidas, national data protection legislation can become a barrier to scale internationally. This constitutes a challenge for global scaling of CNAs, as A2 states:

> *"How you make the data secure or how you deploy the services is super simple with cloud-native. The problem is if you made it "too" cloud-native, if you are too much into a cloud provider, you can have a hard time moving something [cloud] natively developed to run elsewhere" (A2, 07:11-07:40).*

The problem with storing and processing of personal data in a distributed system became evident with "Runtastic", a subsidiary of Adidas based in Austria. Runtastic is a mobile fitness application that tracks personal progress and provides professional training services. Runtastic thus stores user data. When Adidas wanted to enter non-EU markets with Runtastic, they faced a challenge:

> *"For our own company Runtastic, it was working very well in Europe, and now they [Adidas] wanted to expand to China. So the server in Linz, Austria works pretty well for people in in Europe, but legally it doesn't work at all in China or Russia" (A3, [22:29-22:49]).*

A2 refers to the same example of Runtastic, yet more specific on the personal data issues of scaling the application to China and Russia:

> *"We had a big issue which were coming from China and Russia, where there are laws that states that data cannot leave the country. So we have to enter the data in for example Russia, but then the data needs to stay in Russia" (A2, 25:05-25:25).*

In a global context, requirements that personal data must stay in the country on origin conflicts with the distributed nature of CNAs, where data is sent between servers in different locations. However, a solution with Kubernetes was possible:

> *"[...] we developed a concept which allowed us to deploy any CNA with a hyper-scaler [large cloud provider] on-premise, by using a Kubernetes installation. Thereby we cloned it [the data] and connected only Russian traffic to it. And we also made sure that most of new application we do still runs on this installation type" (A3, 23:54-24:15).*

Therefore, both the problem and solution of scaling Runtastic globally was cloud-native. For Adidas, the workaround of scaling CNAs globally was thus to set up an on-premise server that sends the cloned data back to Adidas. However, with the expansion of Runtastic, a central learning around the scaling of CNAs was experienced. As national data legislation can become a barrier to leverage the scaling benefits of CNA, Adidas is able to make technical solutions to legal challenges without increasing the complexity of the application.

4.9. Speed of Digital Business Strategy at Adidas

4.9.1. Agility

The desire to respond to changes more quickly, i.e. increase agility, was a central driver for Adidas' transformation towards CNAs. However, before showcasing how increased agility is achieved in

Adidas, A1 stresses that organizational agility is not something that is merely “nice to have”. An ability to quickly react to changing demands is essential for the future success of the company, even survival:

> *“The times that we live in now, the fluctuation in business requirements changes a lot. If you are not able to adapt fast to those changes, you are not in business much longer. Therefore, if we don't have [the] systems that allow us to react fast to those changes, we are going to die. So this a main driver for us [Adidas]” (A1, 07:27-08:04).*

A requirement to respond to changes more quickly inevitably brings additional requirements to Adidas’ IT environment. Not only does the IT capabilities in Adidas need to be competitive, they further need to be able to adjustable if required. In this relation, A1 express the rationale in moving away from a monolithic application landscape:

> *“Basically [...] we want to have the ability to transform IT and adapt to business changes much faster, which is difficult when you are dealing with big monoliths. Every change takes a lot of time. So going to a microservice based architecture will allow us to react to changes much faster” (A1, 06:19-07:14).*

The flexibility of microservices reflects a digital response to the desire of increasing organizational agility, which monolithic application was a fundamental hindrance to. Moreover, in Adidas’ digital transformation, automation of processes plays a central role in speeding up software development, as A2 states:

> *“Speed isn't just quickly defining a feature and put it in production. Another way [to increase speed] is to automate. Everything you do that is cloud-native comes with an automatic access to APIs. You can put things into code. It's more adaptable and less interruptive to the existing process. It is tailored to speed” (A2, 05:48-06:24).*

Software development consists of a broad range of sub-processes such as testing, configuring, deploying, etc. Fortunately, CNAs bring the possibility for Adidas to automate sub-processes of software development, for example with APIs. The automation of the set-up of software test environments illustrates how CNAs automate sub-processes in software development:

> *“Imagine you have a standard system. It will take a lot of time to learn the system and read the process documentation, and even after doing so, you still cannot test software because you don't have a production environment ready. In cloud-native, you have the big benefit that you [can] automatically wrap up a cluster and try for yourself very quickly” (A3, 15:47-16.12).*

Under a monolithic, testing of software is limited to the system in which it is being developed. This stands in contrast to a cloud-native practice, where a software engineer does not need to be an expert on the underlying system, as the test environment is set up automatically.

Another way CNAs contribute to Adidas' ability to more quickly react to changing demands is related to the integration of real-time data. A1 describes how the process of sending product data from factories to the Adidas headquarters was a manual task before the process was transformed to CNAs. Previously, whenever a change happened to a product, e.g. price changes in materials, new product images, etc., the sales employees in Adidas had to manually update the presentation slides related to the updated product. As Adidas sells thousands of products and many of these experience updates on a weekly basis, the manual updating of sales material added up to a significant number of working hours per week. Moreover, sales employees were often left uncertain about the accuracy of the product data during client presentations (A1, 29:06). The solution to improve this sub-optimal process is based on CNAs:

> *"We created a tool for them [in sales] that eliminate the need to [manually] make those updates. We basically provided a product where they can create their presentations in a web application. Everything that is put in those presentations is connected in real-time to our systems. So it ensures that data is accurate at all times. This applies to everything that they can put in those presentations" (A1, 30:15-31:07).*

The time-saving benefits and simple setup of the real-time data tool based on CNAs are further described by A1:

> *"This is a very good example on how you can save not just time, but actually also ensuring accurate data all the time. And this comes with just a web application, a few microservices and a connection to some APIs to collect events in real time. So now Adidas avoids the redundancy of having to keep track of every change. Everything is automated" (A1, 32:17-33:04).*

In summary, CNAs play a central role in increasing digital agility in Adidas. This is reflected in two ways from the interviews. Firstly, automation tools from CNAs help to speed up the sub-processes in software development, as it e.g. relieves developers from the time-consuming task of understanding a system's process documentation. This also quickens the process of software testing. Secondly, the microservice-based architecture in Adidas allows for more accurate data relating to Adidas' products as the previously manual task of updating data is now provided in real-time. Both capabilities are made possible from cloud-native and works to make Adidas faster to respond to changes.

4.9.2. Productivity

When new software engineers join Adidas, the ambition with regards to the time necessary until the new software engineers are fully productive quite straightforward, as A1 states:

> *"Our aim is to make a new developer fully productive in within the first month. This is very ambitious but we are quite good at it" (A2, 11:53-11-58).*

The aim to make new software engineers as productive as his or her peers within a month is an ambitious target. Therefore, Adidas has created an onboarding program to accelerate the learning curve specifically for new software engineers. A2 describes what is necessary for new software engineers to know before they can reach the aimed level of productivity:

> *"Every new developer gets a full week of on-boarding. There he or she will learn about all elements, teams, components of the stack In Adidas. So they know who to talk to, how to use things. All this is meant to increase time efficiency" (A2, 11:34-11:52).*

A lot of new information needs to be communicated before new software engineers can reach full productivity. However, the principles of cloud-native play a role in ensuring a fast onboarding process for software engineers. A3 elaborates here:

> *"If you follow the principles of cloud-native, you have the benefit that a lot of the documentation is already in the code. Therefore, when people get onboarded, a lot of the documentation they need is written as code, instead of a separate document. So they can read the code, learn from the code and they can contest the code themselves very quickly" (A3, 15:02-15:46).*

As mentioned in the previous section concerning agility, the understanding of documentation of code or software can be a highly time-consuming task in standard systems. Yet with cloud-native principles, this documentation is moved into the individual code piece or microservice. As a result, the software engineer only needs to understand the system he or she is using. All other dependencies on that system can be ignored. In all, the integration of documentation into code helps Adidas reach the ambition of making new software engineers productive more quickly than with standard systems.

4.10. Sources of Value Creation and Capture of Digital Business Strategy at Adidas

4.10.1. Technology Openness

As touched before, the distributed product teams at Adidas have a high degree of ownership for the development and operations of their services. Since these services consist of independent microservices, the underlying technologies, such as the programming language or database, are delineated from the overall application logic. Thus, technologies can be selected according to the specific needs of the respective function. Adidas' implemented a recommendation system for the choice of technologies:

> *"We have what we call 'mandatory' and 'optional' [technologies]. So, of course the autonomy of teams is the freedom to pick how they want to run the [service]. We recommend things, so we provided the technologies" (A3, 49:34-49:45).*

The governance of the technology portfolio focuses on the blacklisting of certain technologies while leaving the freedom of technology choice within the allowed scope:

> *"We also tell them what not to use and so we deprecate things and tell them: 'Okay, you can choose this, but you cannot choose that'. If you want to ensure creativity in teams, you don't tell them what to do, you tell them what not to do" (A3, 49:45-49:59).*

As stated by A3, Adidas uses a centrally managed recommendation system as well as a technology blacklist. Thereby, Adidas' teams benefit from the technology openness of CNAs and the resulting business-technology-fit, but within a predefined scope. If the implementation of blacklisted technologies seems advantageous for specific services, teams still can establish a justified exception:

> *"[Teams] can think about how to solve the problem for themselves, and they know exactly what the boundaries are. If they then must do something they shall not do, they must ask for an exception. That's why we bring architecture exceptions down to 5 percent" (A3, 50:30-50:44).*

A3 mentions the term 'aligned autonomy' for this limitation of the technology. Even though this model imposes boundaries on the development and operations of applications, the authority of the central technology solutions unit is rarely exercised. The company-wide alignment of "blacklisted" technologies led to a common adaptation (A3, 27:30). While the limitation of technology openness resulting from CNAs may present a limitation of value sources in terms of technology at first sight, A3 mentions the increased overall efficiency resulting from this approach:

"It's a crowd intelligence topic. If you limit yourself a little bit on the technologies, you're more effective as a team" (A3, 29:00-29:07).

Yet, the limitation on the technology portfolio does not result in stiff IT structures at Adidas. Rather, the recommendations or prohibitions are based on experiences, e.g. with certain programming languages:

"It doesn't mean we all learn the same things. It doesn't mean we all code Java, of course we have versatility. We know that certain program languages have benefits over others. There's a good reason why we develop Python, Node, Java, React and all these other frameworks [...]" (A3, 29:12-29:27).

Subsequently, the portfolio streamlining via standardized technology allows the enforcement of "best-practices" at Adidas. Consequently, the scalability of the IT organization increases:

"This is where we are in Adidas. We are limiting autonomy for the benefit of scale, economies of scale basically" (A3, 26:38-26:44).

In combination with the central technology solutions team, Adidas leverages their value sources, e.g. employees skilled in a specific technology, across the company:

"We say: '[...] you want to use this [programming] language, but we urge you to use this one and the reason is the following: If you go with this database, we have 20 people who have skills. We also can tell you that people will help you, if you run into problems. We have also a managed service which helps to set it up" (A3, 26:44-27:11)

The economic effects of the technology standardization also manifest themselves in the flexibility of IT employees, e.g. when it comes to team rotation:

"And then we also make sure by selecting or limiting technologies that you can work in multiple teams. And that's why it is more attractive for you as a developer, because if I tell you if you learn that programming language, that database, you could work in eight different teams" (A3, 28:10-28:15).

Besides the limitation of technology openness, Adidas makes also use of its benefits. Through a gamification process, Adidas' IT employees can present their innovative ideas to a wider internal audience, which eventually decides on the funding for the realization of the project (A2, 48:48). The experimentation and implementation of the respective ideas are supported through the agility of CNAs:

"[…] it's important that you don't use the funding to just wait three weeks to ramp up a big server, which does nothing for you. That's why all of these technologies of cloud-native can solve innovation problems, that you can rightly start to work on your idea and you don't waste your time on something which just brings you to the idea" (A2, 49:23-49:51).

With CNAs, the ideas can be quickly transferred into prototypes. Thus, CNAs remove the barriers to innovation. CNAs facilitate the experimentation as they rely on flexible cloud infrastructure:

"[…] cloud-native has the big benefit that you can wrap up a [cloud or Kubernetes] cluster and try for yourself very quickly. […] You can create a production system for yourself just to try, because it automatically comes from code. And then you can see how that behaves very quickly" (A3,16:07-16:36)

On a strategic level, the open design of CNAs thus enables Adidas to test novel technologies more flexibly. This allows Adidas to react to emerging trends in various areas. Thus, CNAs directly impact the capability for long-term innovation through technology as a new source of value creation and capture:

"It's not just limited to making a product sale on the e-commerce site. You need different technologies as well. It even goes into edge-computing, IoT [Internet of Things]. We were in IoT, but stepped out. We will probably move in again. So, there's a couple of new technology fields which call for different ways of how software is delivered tomorrow" (A2, 28:04-28:29).

All in all, Adidas' enforced guidelines on the technology openness resulting from CNAs. The model of aligned autonomy leaves the technology choice open but implements recommendations as well as prohibitions of certain technologies via the central technology solutions department. The leverage of economies of scale, the enforcement of best practices as well as increased resource flexibility, e.g. in software engineer rotation, present the rationale for the limitation in technology openness. Thereby, the IT portfolio is aligned with the standardization and re-usability of CNAs. Yet, Adidas benefits from the technology openness of CNAs in experimentation processes. The availability of tools and resources decrease the barriers to create prototypes for new solutions as well as test emerging technologies. Thus, CNAs enhance the innovation capability at Adidas.

4.10.2. Ecosystem Sharing

Related to new sources of value creation and capture, the data from Adidas further revealed the importance of knowledge sharing. Adidas' digital strategy encompasses three ways to exchange IT knowledge:

"We have inner source just internally, open source with everybody else, and […] we work with a couple of partners where we will share that [knowledge] just within partners" (A3, 44:01-44:09).

The creation and capture of value through knowledge sharing ideas via open-source initiatives is a fixed component of Adidas' IT organization:

"We take open-source very literally in IT. Everything we do and see worth to share with the world, we put on our public co-development portal, where developers can put stuff we want to share with the outside world" (A2, 10:51-11:08).

At Adidas, this external sharing of e.g. software code is seen to be beneficial for the retention of skilled IT employees, since

"It's very rewarding for the software engineers, because a lot of them define themselves and their success not just by the monetary value, but also the way they expose themselves as an expert to the outside world. [...] So, to get a platform where all people can put things on the open-source platform of the developer portal, we are making a lot of people proud" (A3, 41:16-41:43).

Moreover, the publishing of software projects via external platforms is regarded to enhance the quality of Adidas' applications. Over time, the published code is validated and extended with the know-how of external developers:

"You also open up to share your knowledge with other companies and eventually when you give, you will also get something back. It might not be in the first place. We didn't expect if you put all of our code, that somebody will [for example look] in our automation tool, will take it, review it for us and make it better" (A3, 41:48-42:09).

Yet, this requires constant interaction with open-source stakeholders. According to A3, the open-source initiatives can be regarded as a long-term investment into Adidas' IT:

"If you start this and if you learn it from the open-source community, it takes a long while until you are there that you get something back, but you have to constantly fuel this and then, eventually, you will get something back" (A3, 42:11-42:19).

Besides the external sharing of knowledge with external developers on the open-source platform, Adidas implemented a shared platform within the internal ecosystem, including in-sourced employees that need to be aligned with Adidas internal IT specifics:

“The inner-source portal, is even more important for us [compared to the open-source portal]. It shares all the information inside the company and with our partners” (A2, 11:10-11:16).

Next to open-source and inner-source for knowledge sharing and idea creation, Adidas is furthermore in the regular exchange of IT initiatives with its partner companies. A2 illustrates how Adidas’ development process is accelerated through the partner-source model. The exchange of best-practices and company-specific IT skills shortens the time to develop internal know-how, as A3 illustrates:

“For example, we have a good collaboration with a big German automotive company. So, they learn a little bit from us how to do Kubernetes and our Digital Data platform and we learn from them great concepts on Big Data, [for example] how we could classify data. We did not think about that. They have a huge concept. They showed it to us, [and] we said: ‘Great, we copy 80% of that’. [This exchange] saved me and the team two [or] three months of time” (A3, 42:57-43:19).

Adidas’ manifold sharing initiatives are directly enabled through the implementation of CNAs. Especially for digital companies, software represents the firm's’ main asset. In a monolithic application, the sharing of the software code would signify the loss of the firm's’ value proposition:

“[…] if you […] have [for example] a huge logistic system, a monolithic, which creates knowledge in their own processes, you probably wouldn't share it. Because it's everything you have which defines the company” (A3, 44:40-44:52).

In contrast to monolithic application design, the design of CNAs facilitates the ecosystem sharing, since only minor parts of the application can be shared, thereby benefiting from the external know-how:

“With cloud-native, you have the benefit that the components work way much smaller. It's easier to share them. Just imagine you have to solve [only] one thing. Let's say a package tracker as part of the [logistic] system, where you say: ‘It makes a lot of sense, if I share that, others can develop that, I can benefit from that.’ You just share the component” (A3, 44:30-44:52).

This includes the legal aspects of sharing software code with external stakeholders. The breakdown of CNAs into delineated application modules also allows a different licensing for these parts, e.g. open-source licenses. A3 summarizes, how CNAs thus have a benefit over monolithic application:

"The benefit from cloud-native is you can share smaller components and put them on a different license. With whole big systems, you can't do that. So, your legal department is very much more willing to accept that" (A3, 45:05-45:32).

Overall, ecosystem sharing plays a vital role in the creation of new value sources and capture at Adidas, manifested through the implementation of open-source, inner-source, and partner-source schemes. CNAs facilitate Adidas to profit from the benefits of these ecosystem sharing initiatives, e.g. the shortening of development time through external know-how from partners. Whereas CNAs allow for the targeted sharing of minor application modules, i.e. microservices, a monolithic application needs to be shared as a whole unit. Thereby, the companies' main asset would be accessible and prone to imitation. Consequently, companies that employ monolithic applications cannot benefit from ecosystem sharing in the same way as companies relying on CNAs.

4.10.3. IT Complexity

Moreover, the limitation of technology openness as described above was implemented to prevent the loss of control over Adidas' IT environment and the emergence of technology islands (A3, 04:30-05:01). This is especially crucial in large organizations such as Adidas, as A3 notes:

"[…] I think this standardization and aligned autonomy play an important role. In a company of our size, if you don't do that, you have anarchy" (A3, 52:09-52:19).

These technology islands further present a risk related to application-specific know-how. As A3 explains, technology islands create dependencies on specific employees:

"[…] I have smart people and they might leave teams and then I don't have other smart people who can pick up what all these smart people left. This can put me in trouble" (A3, 52:27-52:41).

Adidas' IT management does not only want to prevent technology islands from a knowledge perspective. Services that are encapsulated from each other may also operate technology in different maturity levels, thereby introducing further complexity to the overall IT. Elements of CNAs, such as containers or microservices, present modern technologies, while Adidas' systems have grown historically and involved business-critical legacy systems. A1 describes the challenge of different IT maturity levels in relation to microservices:

"[…] [Adidas needs to] transfer those big legacy databases with a lot of business logic there, which was a pattern from the 90s and maybe even from the beginnings of the this

20th century. We have a lot of business rules inside those databases. Probably one of the biggest challenges when you want to migrate to microservices is all that business logic that you have there. The migration to microservices in those cases is not that easy because of that" (A1, 17:29-18:02).

With the implementation of distributed CNAs, a multitude of new services needs to interact with previously existing in-house applications. While these legacy applications are mostly relying on Adidas' on-premise infrastructure, CNAs operate on modern cloud resources and networks. The resulting complexity is further increased with the integration of manifold external applications, which again employ diverse technology maturity levels. By using the example of Adidas' webshop, A2 elaborates how the heterogeneity of different IT modules imposes complexity:

"You will connect to legacy systems, to commercial platforms, to databases. […] A negative example was on our website, it was hosted by an external provider. Then you went for the cloud-native user interface, which we develop ourselves. [For this], we went through AWS [cloud provider] in Ireland. Then you will proceed to the checkout process. [This was an] external provider" (A2, 09:19-09:50)

Thus, the new value sources brought by CNAs increase the complexity of the overall IT. When considering the total IT portfolio, the simple addition of CNAs does not automatically enable its benefits. The drawbacks of legacy applications cannot be offset if CNAs are operated next to them:

"This is also a disadvantage of cloud-native or distributed applications - things become not less complex, the complexity moves from the application layer into the network. […] So, a lot of components you need to learn. It doesn't help you if you make your cloud-native application very resilient if the rest of the process chain dramatically fails" (A2, 10:05-10:32).

According to A2, the complexity instills a transition period. The system heterogeneity arising of applications with different maturity levels needs to be overcome over time:

"[…] I wouldn't call it a complete disadvantage, but it is a timely disadvantage. Until you are at the stage where you either are resilient from your legacy applications, or you have control of the dependency in the network, it takes a ton of time" (A2, 10:33-10:55).

While A2's above statement refers to the complexity resulting from the embedment of CNAs within an existing application landscape, CNAs as such may present a complex network of application modules. Despite CNAs benefiting from the modular design of containerized microservices in various ways, it can create dependencies. Since their integration is effortless when compared to monolithic applications, cloud-native modules originating from other sources are often implemented in new contexts:

> *"[There is a risk of] dependency, and you have many of them, because it's so tempting to use all of these tiny little services from other companies: 'Oh, they have a great map service. Let's use it'. Developers like that" (A3, 19:55-20:07).*

Subsequently, the interplay of many software modules becomes hard to oversee. A3 elaborates, how the risk of unmanageable dependencies between cloud-native services risks the functionality of the application as a whole:

> *"[…] you create so many dependencies. And, that's the problem in cloud-native: You need to have somebody to oversee how all of these components in an end-to-end process work together. It's very tempting to say: 'Wow, we are very quick and fast. But you create so many dependencies that your order placement will not work. And then you ask yourself: '[…] what is the benefit of cloud-native again?'" (A3, 20:07-20:40).*

At Adidas, the mitigation of complexity arising from CNAs is the centrally organized technology solutions unit. Overseeing the complexity by limiting technology choice

> *"[…] has two reasons: to prevent too many technology islands and to leverage some efficiencies in terms of spend" (A3, 05:03-05:10).*

In order to support the distributed teams in their technology decisions while aligning the company-wide IT portfolio, Adidas' technology solutions team developed a recommendation system for the use of CNAs:

> *"[…] we try to provide a very simple decision tree for project teams and product teams to decide what to do. We call it Cloud Canvas. […]it tells you [the technology choice], based on your criteria of what you want to do" (A2, 05:31-05:50).*

The Cloud Canvas system takes the IT landscape into account, using a centralized perspective. As a concrete manifestation of Adidas' "aligned autonomy" strategy, the Cloud Canvas tool mitigates the risk of uncontrolled technology islands while leaving product teams the decision power over their toolset. Thus, but only if it makes sense in the context of Adidas' whole application landscape:

> *"It takes legal, procurement, architecture and technology-based decisions [into a] framework and guides you to the right solution. […] it asks a simple set of questions, and then it gives you a recommendation: Your use case for re-architecting the application, qualified for going cloud-native or just swapping technology" (A2, 06:00-06:22).*

Summarizing, the implementation of distributed CNAs as a new value source poses a risk of technology islands that are difficult to manage considering the sheer size of Adidas' IT. These technology islands moreover depend on the knowledge of specific IT employees, which becomes problematic if these employees leave the firm. Adidas' IT landscape is further prone to increased complexity since the combination of CNAs and legacy applications result in different IT maturity levels. This complexity is enhanced by the integration of external applications for specific business processes. Additionally, a loss of control over system dependencies can pose a challenge from CNAs, since the re-use of existing modules is facilitated and may thus lead to a fragmented landscape. Therefore, Adidas must undertake the transition towards CNAs gradually. In order to centrally overview the process while leaving product teams the freedom to operate, the recommendation system Cloud Canvas was introduced.

5. Discussion

The results from Zalando and Adidas show evidence for the interrelation between CNAs and each of the four themes of Digital Business Strategy as described by Bhardwaj et al. (2013). In the following discussion, the results from both case companies are contrasted and compared with the findings from previous literature related to CNAs.

5.1. Scope of Digital Business Strategies with CNAs

5.1.1. Synergies through Fusion of Business & IT

The fusion of business and IT with CNAs led to an extension of the digital business strategies' scope in both Zalando and Adidas, even though they differed in their baseline situation. While Zalando broadened its focus from a webshop technology provider towards an e-commerce-platform, Adidas re-organized the IT from a supporting role to the central driver of its emerging digital business initiatives. Yet, the introduction of CNAs led to the same organizational shift enforcing the fusion of business and IT functions.

In both case companies, the introduction of microservices replaced a siloed IT organization with product-based teams. Within the product teams, both Zalando and Adidas, fostered a cross-functional composition, e.g. with the direct cooperation of product owners and software engineers. At Zalando, it was evident that the fusion of business and IT functions led to increased transparency, e.g. through improved cross-functional data exchange. Subsequently, CNAs and particularly microservices led to increased business efficiency which supported Zalando to reinforce its business propositions via software. Within Adidas, the extension of the IT's scope towards business functions further led to the increased flexibility of Adidas' IT organization, i.e. regarding the assignment of teams.

The findings around the organizational shift from central IT to product teams reflect the organizational theory of Conway's Law (Conway, 1968; Fowler & Lewis, 2014). As found by prior literature, the fusion of business and IT through cross-functional teams results in the direct translation of business needs into software functionality (Dragoni et al., 2017; Hasselbring & Steinacker, 2017; Fowler & Lewis, 2014). As Dragoni et al. (2017) suggest, the increased organizational flexibility, as found in Adidas, goes in hand with the flexibility of microservices to change applications with respect to changing business contexts. In this relation, the evidence is consistent with Gienow et al.'s (2019) observation regarding the positive impact of microservices on the enforcement of business strategy execution**.**

Consequently, the findings supported by the literature suggest that the extension of the strategic scope enabled by CNAs leads to synergies through the fusion of business and IT, i.e. increased transparency, efficiency, and flexibility of the overall organization. Strategically, CNAs thereby support the organizations in the execution of the overall business strategy.

5.1.2. Increase in Product Ownership

Along with the fusion of business and IT, evidence for extended product ownership was found in both companies. Both Zalando and Adidas incorporate the DevOps methodology. Consequently, the oversight over software development and operations was transferred from large, functionally separated IT units to small, cross-functional teams in both companies. In Adidas, this increased product ownership facilitated internal innovation projects as well as onboarding of new employees. The implementation of CNAs further enabled the paradigm of *"you build it, you run it"* (Vogels, 2006). At Zalando, the increased ownership is found to increase the overall service quality.

The findings are supported by previous research, which relates the small size of microservices with the transfer of responsibility to autonomous product teams (Jamshidi et al., 2018; Dragoni et al., 2017; Fowler & Lewis, 2014). The coverage of the full software lifecycle with end-to-end responsibility is enhanced by the DevOps methodology and leads to increased product ownership, since the product teams are facing the operational reality of "their" services (Fowler & Lewis, 2014; Hasselbring & Steinacker, 2017).

As proposed by previous research, the high degree of product ownership ultimately results in increased service quality, thus a beneficial strategic impact of CNAs (Kratze & Quint, 2017; Hasselbring & Steinacker, 2017; Fowler & Lewis, 2014).

5.1.3. Facilitation of Standardization

In Zalando and Adidas, a central platform team was introduced to provide a shared pool of standardized IT resources. In both companies, the platform team manages the cloud-native orchestration platform Kubernetes. By sharing re-usable cloud-native services across product teams, the two firms increased the efficiency of the IT organization. Besides, product teams benefit from an increased focus on the development of new value, as the burden of operative tasks was taken away by the platform teams. Within the context of standardization, the companies further share the experience of a facilitated recruiting of IT employees, since the emphasis on standard technologies broadens the choice of applicable candidates. Particularly at Adidas, the in-sourcing of external software engineers was found to be facilitated through the streamlining of Adidas' IT platform. As found in Zalando, standardized cloud-native modules also facilitate the integration of external applications into Zalando's systems and vice versa. Thereby, Zalando's scope was extended to the supply chain management of fashion suppliers. Yet, the facilitated integration of Zalando's standardized CNAs is often undermined by the incompatibility of legacy applications operated by partners in the supply chain.

Overall, the results from the case companies reflect the findings from previous literature. Stine (2017), as well as Kratzke & Quint (2017), note that the pooling of shared IT resources is facilitated by the modularity of CNAs. As suggested by Jamshidi et al. (2018), the standardization through a centralized management layer can mitigate the lack of transparency of distributed microservices. In this relation, Gannon et al. (2017) note that the automation of standardized containers through a container orchestration platform enables facilitated IT governance, thus improving the overall IT efficiency. As proposed by Bharadwaj et al. (2013), the standardization of IT resources moreover supports the extension of the businesses' scope towards business ecosystems. The findings can be thus referred to the reference literature by Bharadwaj et al. (2013), which states that the emergence of digital dependencies in business ecosystems requires the pooling of IT resources beyond a single firm’s scope.

After discussing the facilitated standardization as an implication of CNAs in the light of theory and practice, several strategic impacts can be derived, namely, an increased organizational efficiency, facilitated IT recruiting, and facilitated integration with business ecosystems.

5.1.4. Need for Cultural Adaption

With the organizational transformation required with CNAs, the long-grown, monolithic IT organization of Adidas needed to adapt to its new role as the driver of the company’s digital strategy. In this relation, the transformation stressed the need to develop in-house knowledge related to CNAs. This posed a challenge for existing employees used to “their” legacy applications and a waterfall methodology in project management. The evidence from Adidas further showed that the introduction of individual cloud-native elements alone is not sufficient to benefit from the strategic advantages of CNAs. Rather, a company-wide cultural commitment is needed to enforce the fundamental shift from waterfall-based sequences to a continuous DevOps process. Adidas’ transformation experiences thus suggest the need for monetary and time investments. In contrast to Adidas, the need for cultural adaption to CNAs was not found in Zalando, which could be due to Zalando’s origin as a technology company.

The importance of diligent resource investments to culturally adapt large organizations as found in Adidas is stressed by the propositions of Gienow et al. (2019). Despite the cultural implications are challenging for established enterprises, an adaptation towards a cloud-native culture is crucial (Gienow et al., 2019). As Gienow et al. (2019) note, companies are prone to waste financial and human resources while essentially creating cloud-based monolithic applications when they neglect the cultural dimension of cloud-native (Gienow et al., 2019).

Thus, the extension of the company's strategic scope through CNAs needs to take the established firm culture into account, requiring the commitment to monetary and non-monetary resource investments from a strategic perspective.

5.2. Scale of Digital Business Strategies with CNAs

5.2.1. Increase in System Availability

With the implementation of CNAs and especially the container orchestration platform Kubernetes, both Zalando and Adidas make use of automated scaling of IT infrastructure resources. The automation of up- and down-scaling of IT resources reduced the service disruption related to changes in website traffic. This is particularly useful due to the volatility of customer demand in the e-commerce-industry. At Zalando, the elasticity and scalability capabilities of Kubernetes presented a solution for the challenge of allocating adequate IT resources for dramatic increases of website traffic, e.g. during seasonal shopping events such as Black Friday. Similarly, Kubernetes enabled a periodic up- and down-scaling of IT infrastructure to accommodate the short-term demand spikes resulting from the launch of highly anticipated products with the limited stock at Adidas. With CNAs, Adidas' so-called HYPE sales platform could be moreover decoupled from the standard webshop. Thereby, the availability of the regular e-commerce-business is secured, even during overloads due to special HYPE product launches.

Thus, the evidence from Zalando and Adidas corresponds with the findings from previous research, which emphasizes the elasticity and scalability of cloud-native platforms resulting from containers and container orchestration. Thereby, the close matching of IT infrastructure demand in the form of website traffic, and supply in the form of provisioned IT resources, is enabled. (Shen et al., 2019; Gienow et al., 2019; Kratzke; 2018) As a consequence, the risk of application downtimes resulting from under-allocated IT resources is minimized, resulting in continuous availability (Kratzke, 2018). Further, the IT infrastructure can be scaled independently from each other, thereby allowing for the targeted scaling of specific service parts without disrupting critical business services (Gienow et al., 2019).

Hence, the results are consistent with Bhardwaj et al.'s (2013) proposition that the ability to up- and down-scale the IT infrastructure to meet the demands of customers present a *"[...] strategic dynamic capability for the firm to adapt to the dynamic requirements of the digital marketplace"* (Bhardwaj et al., 2013, p. 475). This may imply direct strategic impacts on business performance. The increased availability of Zalando's and Adidas' services, including extreme seasonal fluctuations of demand, allows the companies to capture revenue from sales, which could not be realized if their platforms would experience downtimes. Further, since fewer service disruptions are experienced, end-customers experience an improved quality of service, resulting in a better user experience. As argued by Power & Weinman (2018), a better digital user experience impacts the creation of trust, which leads to increased customer loyalty in the long run.

5.2.2. Increased IT Cost Efficiency

In addition to enhancing system availability, the more efficient utilization of IT resources through the resource elasticity of CNAs resulted in cost savings at Zalando and Adidas. In the two companies, resource elasticity was realized through the implementation of Kubernetes with its auto-scaling capability. Thereby, both companies use CNAs to leverage economies of scale. Also, the evidence from Adidas proposes that the dynamic management of microservices enables fine-grained resource cost optimization at the level of the software execution. Despite presenting a crucial motivation for the adoption of CNAs, the cost efficiency was found to be difficult to measure at Zalando. As the findings propose, there is a lack of comparable benchmarks with monolithic applications, since the overall system capabilities fundamentally changed with the CNA transformation. The result is the lack of data related to the actual cost efficiency of CNAs. Still, apart from missing numerical evidence, Zalando's IT management sees its efficiency assumptions confirmed. Instead of a cost decrease, an increase in software capability and output can be observed while maintaining the associated costs at the same level as without CNAs.

Thereby, the practical findings comply with the results of previous research. As suggested by (Gannon et al., 2017) and Kratzke & Quint (2017), container orchestration platforms optimize the utilization of IT resources by the dynamic allocation and management of application containers. They argue that by only provisioning as much compute, storage, or network capacity as needed, the amount of idle resources is minimized. Thus, the waste of costs associated with unassigned IT resources is reduced (ibid.). Hence, CNAs fully exploit the well-established cost efficiency of cloud computing infrastructure, which is argued by Tofetti et al. (2017) and Weinman (2015). Moreover, as discussed by Kratzke (2018), containers and the microservices operated therein allow a higher density of computing resources compared to virtual machines or physical servers, thus being more cost-efficient. Yet, although there exist single studies that compare individual elements of CNAs with a monolithic approach, e.g. Forsgren et al.'s (2019) study related to the increased productivity with DevOps or Villamizar et al.'s (2016) cost comparison of microservice and monolithic applications, the establishment of clear cost-efficiency comparisons of CNAs and monolithic applications presents a research gap.

Ultimately, the cost-efficiency arising from CNAs can be linked to Bhardwaj et al.'s (2013) strategic proposition of enhanced profitability from decreased unit costs of digital products, thereby having a direct strategic impact on the overall business performance.

5.2.3. Facilitation of Compliance

The enablement of an increased scale of digital business strategy through CNAs facilitated compliance with data security requirements for both Zalando and Adidas. With their transformation towards distributed cloud infrastructures, both companies experienced challenges in scaling their applications while ensuring compliance with data protection legislation. At Zalando, the growing team autonomy and the self-service character of the CNA platform led to nontransparent processing of customer data in decentralized services. Hence, compliance with the GDPR requirements was jeopardized. As mitigation, Zalando introduced a centrally managed API for accessing customer data within its Kubernetes platform. At Adidas, locally different data storage requirements impeded the global expansion of a subsidiary business. The fulfillment of these requirements was at risk due to the storage of customer data in locally dispersed cloud infrastructure. As a solution, a hybrid cloud approach was implemented with Kubernetes. The container orchestration enabled the replication of data in local servers. Thereby, compliance with national data protection regimes was ensured while leveraging the flexibility of cloud computing.

In previous research, the interrelation between CNAs and the facilitation of compliance has received little attention. Gannon et al. (2017) propose the introduction of sophisticated management of access control in cloud-native architectures. This is realized through specific role-based access management offered by cloud-native technology providers (Gannon et al., 2017). Further, Gannon et al. (2017) mention the capability of CNAs to replicate cloud-based data in local data centers to facilitate the global scalability yet connect this benefit to performance enhancements rather than data security. Moreover, the facilitation of global scalability of CNAs due to the portability of containers and the underlying cloud infrastructure is also acknowledged by Gienow et al. (2019), yet also not related to data compliance.

In a wider sense, the safeguarding of data compliance can be connected to the reference theory, which notes the importance of *"[…] develop[ing] the organizational capabilities to harness the huge quantities of heterogeneous data […]"* (Bhardwaj et al., 2013, p. 475). Although further research is required, CNAs supported the strategic goal of companies to expand their business while mitigating the risk of compliance violations in the case of Zalando and Adidas. As a strategic impact, the business expansion was facilitated for both companies.

5.3. Speed of Digital Business Strategies with CNAs

5.3.1. Increased Agility

For both case companies, the ability to execute software changes in response to changing business demands more quickly, i.e. increase agility, presented a central driver for their cloud-native transformation. In both Zalando and Adidas, it was evident that especially the implementation of microservices in combination with the Kubernetes platform increased the agility of software development in several ways.

Primarily the modular design of microservices allowed for a faster release of software feature*s* at Zalando. Since Zalando's microservices have only limited functionality and thus a smaller overall business impact, the isolated capabilities can be changed more frequently without disrupting the overall system. Consequently, the modernity of Zalando's overall e-commerce platform benefits from these shortened feature release cycles. This is consistent with the findings at Adidas, which suggest that the agility of a modular microservices-based architecture presents a key advantage of CNAs compared to monolithic designs. Microservices provided Adidas with the opportunity to quickly react to changing customer demands.

Further, CNAs increased agility through automation. At Zalando, the development of an in-house tool for continuous delivery was connected to the centralized Kubernetes platform, which automated the software deployment for Zalando's product teams. The automation achieved with this CNA implementation sped up the development process, which also led to a quicker roll-out of new features. Additionally, the results from Adidas supplement the benefit of Kubernetes automation. With the fast access to IT resources and the quick set-up of test environments for developers, the automation with Kubernetes accelerated software development. Another example of automation is the elimination of lengthy coordination between different IT and business units through the constant provision of real-time data via APIs. Thereby, Adidas benefits from direct time savings while further ensuring a better service quality due to the higher accuracy of data.

Also, the definition of decision rights for shared IT infrastructure on Zalando's Kubernetes platform streamlined the decision-making process in IT operations. Combined with the independent DevOps teams with short lines of communications regarding product development, CNAs thus increased the speed of decision making in the software development lifecycle at Zalando.

While increased agility was observed at both companies, the data from Zalando shows that the interrelation of CNAs and a more agile software development process is difficult to measure with clear indicators. Since applications and underlying use cases significantly changed compared to the previous monolithic applications, Zalando lacks a comparative basis to undermine the perceived increase of agility with hard data from the company. Equally, no evidence for direct measurement of the effects of CNAs agility was found at Adidas.

Altogether, the data support the suggestions by prior literature on microservices, which emphasizes the accelerated feature release cycle enabled by modular microservices (Gienow et al., 2019; Jamshidi et al., 2017; Gannon et al., 2017; Hasselbring & Steinacker, 2017). Therewith, the findings are aligned with the reference literature's proposition of the speed of product launches as a driver for digital business strategies (Bhardwaj et al., 2013).

As noted by Jamshidi et al. (2017) and Dragoni et al. (2017), the agility of microservices is enhanced in the interplay with further elements of CNAs, such as application containers, CI/CD pipelines, and DevOps. The automation through continuous delivery and container orchestration is described by Dragoni et al. (2017), who suggest that *"By using automated continuous delivery pipelines and modern container tools, it is possible to deploy an updated version of a service to production in a matter of seconds which proves to be very beneficial in rapidly changing business environments"* (Dragoni et al., 2017, p. 7). Further, Kratzke & Quint (2017) and Perera (2017) note the acceleration of software releases using DevOps and automation principles. The practical findings around an accelerated decision making relate to the theory by Gienow et al. (2019) as well as Toffetti et al. (2017) as previously outlined in section 2.3.3.

Even though further research is needed to define clear indicators for increased agility resulting from CNAs, the agility arising from CNAs impacts the execution of business strategy. Specifically, the enablement of Bhardwaj et al.'s (2013) propositions of increased speed of product launches, as well as the accelerated decision making, can be directly seen as an impact resulting from the implementation of CNAs.

5.3.2. Accelerated Productivity

In the case of Adidas, the use of CNAs supported Adidas' goal of quicker onboarding for external software engineers. As the company relies on in-sourcing for specific software development projects, the achievement of full productivity within the unknown system is crucial for the overall efficiency of the companies' IT initiatives. The beneficial impact of CNAs on accelerated productivity was again linked back to its modular design. Adidas' microservices contain all necessary documentation in the form of software code, which eventually makes the lengthy study of additional application information in other documents obsolete. Further, the small size of microservices delineated the amount of required knowledge, thus limiting the time to acquire knowledge about the system design. In contrast, no comparable evidence was found at Zalando, which did not report the integration of in-sourced software engineers.

Yet, the concrete influence of CNAs on the acceleration of productivity is undertheorized in research. Studies such as Hasselbring & Steinacker (2017) or Forsgren et al. (2019) estimate the productivity of developers, but do not differentiate between newly hired or existing developers and focus only on DevOps. Besides, the fast onboarding of external developers could be linked to the standardization achieved with CNAs. As found in prior literature, cloud-native technologies emphasize the re-usability of individual technology modules (Dragoni et al., 2017; Kratzke & Quint, 2017). Eventually, this might further accelerate the productivity of external developers, who could be already familiar with the utilized technology.

While it supports Adidas to reach the aim of quick productivity for developers, Jamshidi et al. (2017) stress that the modularity of CNAs may result in a loss of oversight regarding the overall application. This could manifest in software engineers failing to recognize important dependencies with other services. Thus, a missing integration with the overall system could present a drawback when external developers are on-boarded too quickly.

Yet, although the findings from Adidas are not directly relatable to prior research, they can be related to the context of digital business strategy. As mentioned by Bhardwaj et al. (2013), Digital Business Strategy emphasizes the acceleration of supply chain orchestration by *"[…] extend[ing] interfirm networks and enhance efficiency."* (Bhardwaj et al., 2013, p. 477). Further, Digital Business Strategies increase the speed of network formation and adaption, since technology offers novel ways to integrate complementary capabilities between firms (Bhardwaj et al., 2013). Both concepts refer to the fast collaboration within ecosystems, such as the in-sourcing of external IT employees for Adidas' software projects.

5.4. Sources of Value Creation & Capture with CNAs

5.4.1. Increased Technology Openness

The openness of technology as an implication arising from CNAs can be observed in both case companies, yet in different forms. Before the cloud-native transformation, the inflexibility of monolithic applications limited the freedom of technology choice at Zalando. Software engineers were limited to utilize the technologies already incorporated by the monolith. With the shift to loosely coupled microservices, Zalando was able to utilize a wider technology stack. More restrictively, Adidas decided to constrain the freedom of technology by introducing blacklisted technologies. Adidas' rationale is to increase its organizational flexibility from CNAs, e.g. by rotating software engineers with specific programming knowledge to other product areas. Outside of the blacklisted technologies, product teams are still free in their technology choice for their respective services. For both companies, it was further significant that the technology openness resulting from CNAs allowed for experimentation with novel technologies. Consequently, cloud-native technologies support Zalando and Adidas in their innovation capabilities.

The observations concerning the openness of technology and microservices are coherent with the proposition of prior research. Dragoni et al. (2017) state that by implementing microservices, *"[…] developers can freely choose the optimal resources (languages, frameworks, etc.) for the implementation of each microservice"* (p.3). Thus, CNAs overcome the technology lock-in imposed by the technology dependencies in monolithic applications (Dragoni et al., 2017). With their bounded business context, microservices enable the integration of "best-of-breed" technologies (Jamshidi et al., 2018). Further, since the technologies can be tailored to the underlying business logic, business and IT capabilities become increasingly aligned (Gienow et al., 2019; Dragoni et al., 2017). As proposed by Dragoni et al. (2017), this may result in increased service quality.

Regarding the implications of CNAs on experimentation and innovation found in the case companies, a better understanding has yet to be established in the literature. In their study about the business value of cloud computing, Iyer & Henderson (2011) recognize a facilitated business model experimentation with APIs in cloud platforms. As a strategic impact, it leads to innovation in the long run. Yet, Iyer & Henderson's (2011) study concerns cloud infrastructure, thus being inconclusive concerning CNAs.

On a strategic level, the ability to implement the most appropriate set of technologies can be linked to the increased value from information, as stated by Bharadwaj et al. (2013). As discussed above, this entails increased service quality and increased innovation capabilities as strategic impacts following the technology openness arising from CNAs.

5.4.2. Facilitation of Ecosystem Sharing

Moreover, the value co-creation in shared ecosystems, as mentioned by Bharadwaj et al. (2013), was found to play an important role in both case companies. Particularly, Adidas' IT organization emphasizes the sharing of technology, e.g. software code, with an external open-source community, as well as with partners and internal stakeholders. By enriching the IT landscape with external applications, Adidas experiences faster development cycles. Adidas' ecosystem sharing is found to be facilitated through the modularity of CNAs. Additionally, CNAs enable Adidas to overcome legal challenges of software sharing, since only minor parts of an application can be licensed for third parties, as opposed to a whole business-critical system in monoliths.

While Adidas operates dedicated open-source programs around CNAs, the sharing with an external ecosystem takes place rather intuitively at Zalando. Since CNAs are often based on open-source technologies and easier to integrate, Zalando's proprietary technology often contains open-source elements. Yet, the software from the external developer community does not fulfill the specific requirements of Zalando and needs to be further customized.

As recognized by the theory, the modularity of microservices and the portability of containers facilitate the publishing of application parts from a technological perspective (Stine, 2017; Kratzke & Quint, 2017, Hasselbring & Steinacker, 2017). The need for customization of CNAs at Zalando is opposed to Fowler & Lewis' (2014) proposition of "battle-tested" open-source standards. Rather, the findings relate to Hasselbring & Steinacker (2017), who argue that the introduction of third-party technologies may introduce external dependencies which impede the product team's ability to tailor a service to the specific business needs. On the contrary, the sharing of code via open-source platforms may have a beneficial impact on service quality. Since software engineers expect the integration of their microservices in contexts outside the own firm, they may be more diligent in the development of microservices (Hasselbring & Steinacker, 2017; Fowler & Lewis, 2014).

Referring to the Digital Business Strategy, CNAs enable the capturing of value in business network*s* as stated by Bharadwaj et al. (2013) by facilitating sharing with an ecosystem. As strategic impacts, the acceleration of software release cycles by integrating external services and an improved serviced quality from integrating external feedback emerged from the research.

5.4.3. Increased IT Complexity

Lastly, the new value sources through CNAs resulted in an increased IT complexity as a drawback for both Zalando and Adidas. Following the establishment of autonomous product teams making independent technology decisions, the case companies observed the emergence of technology islands. The fragmentation of CNAs across many teams led to a plurality of different technologies. Due to the lack of oversight, hidden interdependencies between microservices impeded the overall application performance, as found in Zalando. For both Zalando and Adidas, technology islands moreover created dependencies of the knowledge from individual IT employees. Especially at Adidas, further IT complexity emerged through the different IT maturity levels of cloud-native services and legacy applications, which often need to run in parallel for the operation of business-critical processes. These disparities were further intensified through the use of external applications.

Both Zalando and Adidas iterated towards a more centralized, platform-based approach relying on the orchestration platform Kubernetes to gain back transparency over their previously fragmented cloud-native landscapes. In order to improve the governance of the complex IT landscape, Adidas further established a centrally managed technology recommendation called Cloud Canvas. At Zalando, a similar measurement was implemented with the Technology Radar, which fosters the implementation of best-practice technologies to reduce technology islands.

Prior literature around CNAs recognizes the complexity impact arising CNAs. CNAs, specifically microservices, promote independence and flexibility, as discussed by Dragoni et al. (2017) and Fowler & Lewis (2014). Yet, Gienow et al. (2019) describe CNAs as inherently prone to increase IT complexity due to their distributed nature. The design and maintainability of dispersed systems become increasingly difficult when the number and heterogeneity of cloud-native services grow (Gienow et al., 2019; Jamshidi et al., 2018). The findings further resonate with the assumptions of Kratzke & Quint (2017), who argue that the autonomy of engineering teams resulting from DevOps and microservices may impede the manageability of systems in the long run. Yet, none of the reviewed studies dealt with the complexity arising from different IT maturity levels in the combination of CNAs with internal and external legacy applications.

However, the mitigation efforts of Zalando and Adidas can be linked to prior research. As proposed by Hasselbring & Steinacker (2017), the complexity arising from CNAs requires the central management of IT operations. According to Gienow et al. (2019), the centralization via a platform team should rely on the orchestration and automation capabilities of CNAs itself to mitigate the disruptive impactive of IT complexity.

In combination with the existing literature, the learnings from the case companies suggest that a central management platform is crucial to effectively capture the new and diverse sources of value created by CNAs. Otherwise, the adverse impacts of the IT complexity, namely, an impeded application performance and dependencies on IT employees, may arise.

5.5. Summary of Strategic Implications through CNAs

Altogether, the empirical findings support the underlying assumptions of the research, which are proposed by the conceptual model presented in section 2.3.5. Accordingly, the implementation of CNAs enabled the four themes of Digital Business Strategy as described by Bhardwaj et al. (2013).

Firstly, CNAs enabled the extension of the organizations' scope of digital business strategy. The expanded scope of the organization with CNAs created **synergies through the fusion of business and IT**. These were found to support the execution of the overall business strategy. Simultaneously, CNAs brought **increased product ownership** in distributed teams, resulting in increased service quality. Along with the removal of organizational barriers, CNAs further **facilitated the IT standardization.** Thereby, firms may directly benefit from increased organizational efficiency. Moreover, the high IT standardization with CNAs was found to facilitate IT recruiting and integration with business ecosystems. Yet, these beneficial strategic implications face a drawback that intervenes in the scope of digital business strategy. For large organizations from non-digital industries, the shift to CNAs requires not only technological but also a **cultural adaptation**. This entails investments in the companies' organizational resources.

Secondly, the enablement of an increased scale of Digital Business Strategy through CNAs was unveiled. The characteristics of CNAs allowed **increased system availability** for the case companies, thus enhancing the reliability of their e-commerce-operations. Thereby, CNAs allow the firms to capture more sales revenue. A higher website availability moreover impacts the overall service quality and increases customer loyalty. Further, the higher scale of their digital business strategies included **increased efficiency of IT costs** though the scalability and elasticity of CNAs, resulting in increased profitability through direct cost savings. While the expansion of both companies' digital efforts was endangered by various data protection legislations, CNAs moreover allowed to scale by **facilitating the implementation of compliance**. By ensuring compliance, companies are supported in their efforts to expand their businesses. In the context of scale, no drawbacks from CNAs were observed in the study.

Thirdly, the assumptions of speed of Digital Business Strategy enabled by CNAs could be validated with the empirical findings. Most significantly, CNAs implied **increased agility** in both firms' digital business activities. As a consequence, firms can launch new products faster. Moreover, decision-making processes were accelerated. In addition, the increased speed of Digital Business Strategy by CNAs led to the **acceleration of productivity** for newly onboarded software engineers, impacting the speed of ecosystem collaboration. Within the theme of speed, CNAs were not found to present any drawbacks to Digital Business Strategy.

Lastly, new sources of value creation and capture were enabled by CNAs. Specifically, CNAs implied an **increased technology openness**, thus enhancing the possibilities to create and capture value through digital business initiatives with increased service quality. Higher freedom in technology choice further enhanced the firms' innovation capability. Moreover, the **facilitation of the ecosystem sharing**, e.g. of know-how or technology, was observed as an implication from CNAs. The fostered ecosystem collaboration through sharing was found to accelerate the software release cycle and reinforce the improvement in service quality. In contrast to these beneficial implications though new sources of value creation and capture, CNAs introduced the drawback of an **increased IT complexity** at both companies. The increased IT complexity was found to pose risks to the overall application performance. Additionally, firms could be prone to *dependencies on* individual IT employees that developed and operated complex systems.

5.6. The Cloud-Native Strategy Model

To provide an answer to the underlying research question *"What are the strategic implications of implementing cloud-native applications?"* with respect to the findings discussed above, a revised conceptual model coined the "Cloud-Native Strategy Model" is presented in Figure 12 and described below.

In line with the assumptions of the tentative conceptual model (see section 2.3.5.), the characteristics of CNAs, which constitute of principles, methods, architecture, and properties, enable the four themes of Digital Business Strategy according to Bhardwaj et al. (2013), namely scope, scale, speed and sources of value creation and capture. Each of the four themes relates to specific strategic implications from the implementation of CNAs, which are presented in bold text within the green and red boxes. Green boxes highlight strategic implications that are beneficial for the company, whereas red boxes signify drawbacks from CNAs. Further, the research unveiled that each of the strategic implications entails a direct impact on the firm's business operations. These impacts are detailed with bullet points below the respective strategic implications from which they arise. Ultimately, the revealed strategic implications from CNAs and their related impact are related to the firm's overall business performance, as proposed by the tentative conceptual model of the research. Yet, in contrast to the previous model, this impact is not necessarily found to increase business performance, as the research found drawbacks resulting from CNAs. Therefore, the quality of this impact is left to be investigated by future research.

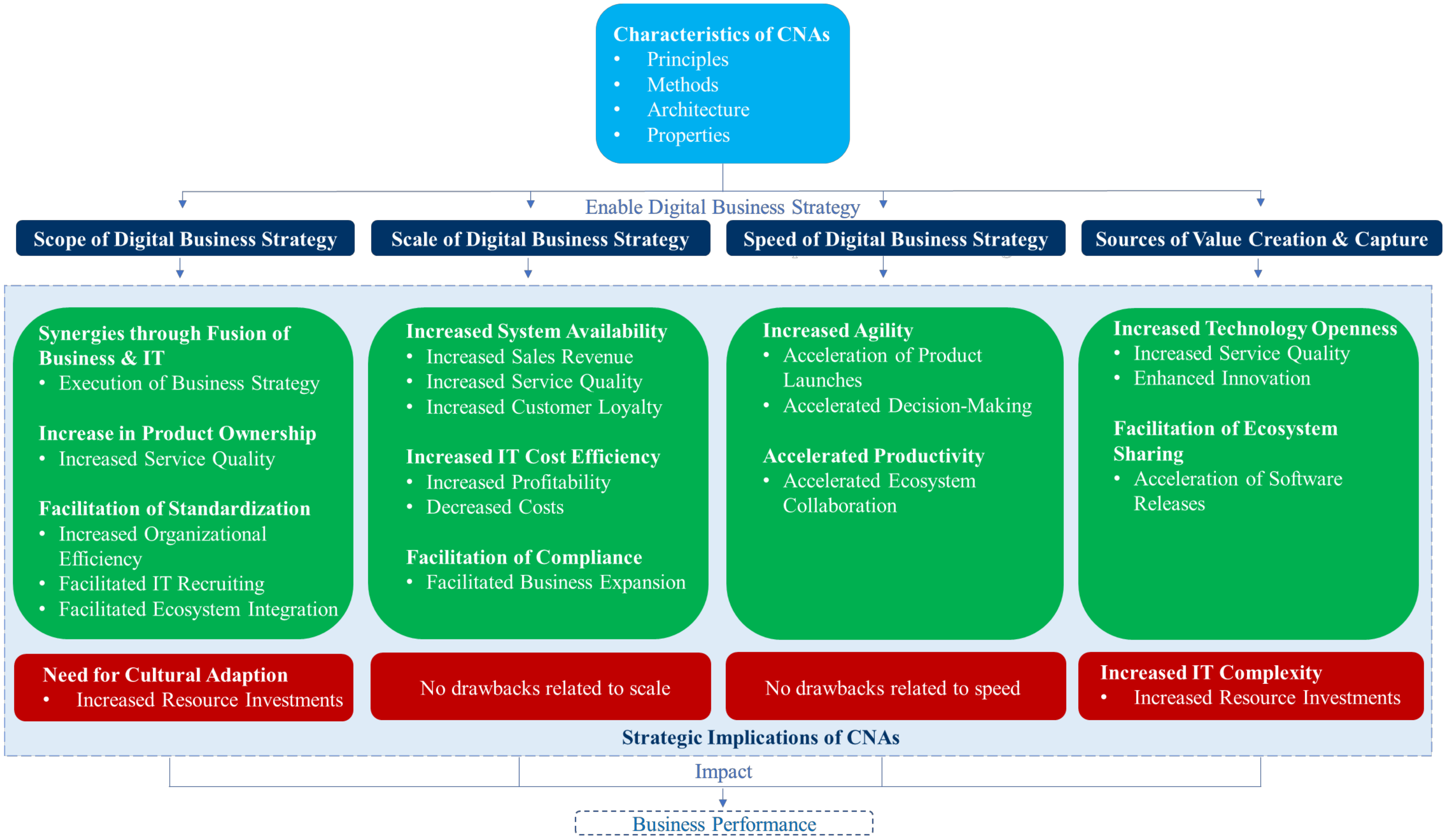

Figure 12: The Cloud-Native Strategy Model (Own representation).

6. Conclusion and Perspectives

6.1. Conclusion

As presented by the Cloud-Native Strategy Model, the implementation of cloud-native applications (CNAs) brings multi-faceted strategic implications from both a technological and an organizational perspective. First and foremost, the characteristics of CNAs enable companies to put Digital Business Strategies in the sense of Bharadwaj et al. (2013) into practice. The thereof arising managerial implications are manifold.

Predominantly, the firm's strategic aims were found to be supported by the implementation of CNAs. Companies benefit from an extended scope with synergies through the fusion of business and IT, increased product ownership, and facilitation of standardization. The increased scale enabled by CNAs implies increased system availability, increased IT cost efficiency, and facilitation of compliance. Another benefit is the accelerated speed of Digital Business Strategy, which comes with increased agility and accelerated productivity. Also, as new sources of value creation and capture, CNAs increase technology openness and facilitate ecosystem sharing. Thus, CNAs can be seen to enhance the transformative business value of cloud computing infrastructure (e.g. by Iyer & Henderson, 2012). Given the numerous potential benefits, business stakeholders entrusted with their firm's digitalization efforts are advised to evaluate the migration of legacy applications to CNAs. Further, the model provides IT stakeholders with a comprehensive tool to translate the technological benefits of cloud-native initiatives into strategic value and facilitates the discussion with respective business partners.

In contrast, the research also found strategic drawbacks from CNAs which require increased investments in the organization. The scope of Digital Business Strategy can be limited due to the need for cultural adaptation, while new sources of value creation and capture imply increased IT complexity. Depending on the digital footprint of the company's core business, i.e. the long-established retail business of Adidas in contrast to the digitally born Zalando, these drawbacks were manifested differently. Consequently, business as well as IT stakeholders need to carefully weigh out the benefits and drawbacks of CNAs based on the individual firm's digitalization level to establish a return on investment from CNAs in the long run. Yet, the multiple qualities of strategic implementations from CNAs make it difficult to measure its impact in comparable numbers, which requires firms to define individual performance metrics.

With their far-reaching strategic implications transcending IT and business, CNAs can be therefore understood as adjacent to other recent technology trends employing distributive systems, such as artificial intelligence, IoT, or blockchain (Kratzke, 2018). All in all, the research and the resulting model emphasizes the need for an integration of business and IT strategy to exploit the full potential of novel technologies and remain competitive in a digital era.

6.2. Research Quality

To assess the quality of the research, the applied methods of the research will be evaluated through the concepts of reliability, validity, and generalizability.

Predominantly two procedures have been utilized in the research to ensure the reliability of the research. Firstly, full documentation of the collected data is provided in Appendix 3, thus increasing research transparency. Secondly, explicit qualitative analysis via verbatim quotes provides the possibility to establish a "decision-trail", i.e. evidence that the conclusions made are well-founded based on data (Noble & Smith, 2015). Combined, these procedures increase the likelihood that independent research would arrive at a similar or comparable conclusion with the same data, which ultimately constitutes reliable research (Noble & Smith, 2015; Saunders et al., 2016).

Regarding the validity of the research, the central evaluation criteria are to firstly determine the appropriateness of the applied methods, and secondly the accuracy to which the findings reflect the data (Golafshani, 2003). Firstly, semi-structured interviews proved an adequate method to obtain detail-rich descriptions of the informant's experiences with CNAs. The research does not perceive it likely that other qualitative means of the query, e.g. questionnaires, would yield the same in-depth understanding of the CNAs. Secondly, the applied iterative processes between theory and data in abductive reasoning, lead to abductive validation (Danermark et al. 2002; Saunders et al, 2016). The proposed Cloud-Native Strategy Model thus reflects the most accurate description of the strategic implications of CNAs based on theory and data.

The abductive validation is in alignment with the outlined critical realist research philosophy focussing on identifying causality between a phenomenon and its context (Egholm, 2014; Fletcher, 2017). The unveiling of causal relations between the cases and their use of CNAs extends into the question of generalizability from case studies, i.e. how transferable the findings are to other contexts

(Noble & Smith, 2015). In a critical realist case study, the aim is not to justify the conclusions to other hypothetical settings. Instead, the critical realist research philosophy perceives case studies as an approach to *"provide useful information regarding how the postulated mechanism* [CNAs] *operate under a set of contingent conditions* [the contexts of Zalando or Adidas] [..]*."* (Tsang, 2014, p. 180). Therefore, the suggested Cloud-Native Strategy Model may be used by others in its present form to explain the strategic implications of CNAs, or with modifications serve as a basis for further analysis of CNAs in different settings. This depends on the individual assessment of the transferability of the conceptual model (Tsang, 2014).

6.3. Limitations of the Research

Nevertheless, the research comes with limitations. Firstly, cloud-native and CNAs present a relatively novel research domain. Consequently, there exist only few academic definitions related to CNAs to date. The concept employed by the research at hand relies heavily on the results from Kratzke & Quint (2017), who establish a broad definition of CNAs. Thus, it must be noted that while the research focused on this high-level definition of CNAs, more detailed results could have been elaborated by focusing only on the strategic implications of the individual elements of CNAs, such as microservices or container orchestration. Further, the lack of prior research led to the application of research findings originally concerned with cloud computing infrastructure to CNAs to provide a theoretical starting point for the research at hand.

Secondly, the incorporation of data triangulation using quantitative data to compare results would have increased the validity of the research as it reduces measurement error. However, due to the novelty and the lack of comparative numerical measures to date, the application of quantitative research methods to investigate the strategic implications from CNAs remains difficult.

Finally, the sample size of the research constituted a limitation. Although the samples include interviewees with managerial responsibility related to cloud-native initiatives, the overall validity of the findings would be strengthened by a greater interviewee sample size. Yet, the outbreak of the Coronavirus in Europe affected the data collection process, as scheduled interviews had to be postponed indefinitely. Even with persistence, it was not possible to reschedule all interviews to a time that would allow for enough time to process the data before the submission of the research.

6.4. Future Research

Despite the limitations of the research presented above, the findings of this thesis provide valuable insights for further research in connection with the strategic implications, impact, and business value of CNAs. Whereas the previous literature in this research domain predominantly took a technological perspective on the implementation of CNAs, this research contributes to the domain by suggesting a multi-faceted model for the implications and impacts of CNAs on the overall business strategy. Thus, it serves as a starting point for further investigation of the topic.

In particular, the limitations of this thesis at hand present concrete subjects that are worth to be addressed by future research. This includes the validation of the proposed model within a more diverse set of case companies and industries. While the maturity of CNAs and its integration in practice will evolve, future research will benefit from more practical experience in this context and subsequently, better access to data.

Moreover, the establishment of a quantitative model to measure the implications and impact of CNAs on the business seems to present an interesting research array. While this seems challenging due to the lack of comparable numerical benchmarks to date, the authors expect the application of quantitative methods to be facilitated in the future due to the growing body of experience and data around CNA implementation.

Additionally, the model of this thesis could be further refined by detailing the strategic implications of specific characteristics of CNAs. Thereby, a more fine-grained understanding of the casualties between the constituents of CNAs and the respective implications could be established, thus enabling more differentiated managerial decisions.

Further, an important leap for the understanding of CNA's strategic business value presents the establishment of a better understanding of its impact on the overall business performance. Thereby, business and IT stakeholders could be provided with a better understanding of the value mechanisms resulting from CNAs.

Lastly, while this study mainly found beneficial implications of CNAs, future research could address the drawbacks more in-depth. Consequently, firms aiming for a digital transformation with CNAs could gain a more detailed picture of the involved risks to their business strategy.

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