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Preparing for a Digital Future: Cloud Strategy at Continental AG

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Completed Research Paper

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Abstract

This paper is directed towards IT executives aiming to promote the adoption of cloud computing (CC) within their company. We conducted a longitudinal case study on the evolving CC strategy and its implementation at the multi-national company Continental, based on a previous case study by Loebbecke et al. (2012). We narrate Continental's pathway towards CC adoption, which comprised the experimentation, professionalization, and utilization of CC, and discuss current and previous barriers encountered during the implementation. We derive five lessons learned that can serve as practical guidance for executives aiming to accelerate CC adoption within their own organization: (1) differentiate the CC strategy by delivery model; (2) drive proof of concepts to generate reusable blueprints; (3) pre-invest in the integration of IaaS and PaaS providers; (4) implement CC gradually, transforming applications during the transition to the cloud; and (5) disseminate knowledge within the organization to enable change.

Keywords: Cloud computing, strategy, implementation, adoption, knowledge transfer

Introduction

This paper is directed towards IT executives aiming to promote the adoption of cloud computing (CC) within their company. We conducted an exploratory longitudinal case study on the evolution of a CC strategy and its implementation at Continental AG, a German multi-national company. We based this on a previous case study by Loebbecke et al. (2012) and narrate Continental's subsequent pathway towards CC adoption. We illustrate the experimentation, professionalization, and utilization of CC at Continental and discuss current and previous barriers encountered during the implementation. We derive five lessons learned that can serve as practical guidance for managers aiming to accelerate the adoption of CC within their organizations.

Continental is a publicly listed German automotive supplier, which was founded in 1871. In 2018 its total revenue amounted to EUR 44 billion (bn) with an EBIT of EUR 4 bn. As a multi-national company, Continental consists of two groups: The Automotive Group and the Rubber Group. The Automotive Group includes the divisions Chassis & Safety, Interior, and Powertrain. The Rubber Group consists of the divisions Tires and ContiTech. Geographically, Continental's 243,000 employees are spread across 60 countries with 544 locations. Germany / Europe is its primary region but a sizeable number of employees (19% each) are located in Asia and North America (Continental 2018). The choice of Continental as a case example makes our findings interesting and relevant for many corporations: Traditionally, Continental is a corporation with a focus on manufacturing. However, the proportion of hardware products that require sophisticated complementing software (e.g., for steering in a powertrain) has been increasing over the last decades – sometimes these need more lines of code than are required for smartphone operating systems. Now, digital solutions are considered the primary driver of growth for Continental (Continental 2018). For example, remote vehicle diagnostics can allow car manufacturers to identify patterns within the movement data of cars that previously had defects. This then allows, manufacturers to order cars with comparable patterns back to the repair shop before a similar fault occurs, i.e., to conduct predictive maintenance. For reasons of innovative potential and cost-effectiveness, Continental intends to increasingly develop such digital solutions for its customers using CC delivery models such as Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS). Therefore, the adoption of CC by its decentralized units is a strategic imperative for Continental.

Continental's IT organization consists of global, centralized functions and local, decentralized units. A central corporate IT function provides infrastructure, global IT services, and IT services to other decentralized corporate units. 3,400 IT-related employees, of which 320 are dedicated to Corporate IT infrastructure, run three major data center hubs in Germany, Singapore, and the US. About 20,000 servers are up and running at any time in the data centers and across all locations. Local IT units additionally manage their own (small) data centers within their locations and have a high degree of autonomy. The IT organization at Continental has always been cost-centric, historically it has aimed primarily at enabling operational efficiency and, to a lesser extent, at fostering innovation. Software development sourcing mainly took place within the divisions. Software development resources were primarily sourced from the outside, with 20,000+ external software developers engaged. CC has been a game changer for the provision of infrastructure and IT services at Continental: Hundreds of cloud accounts are active. More than 2,000 servers have been migrated from corporate data centers to Cloud Service Providers (CSPs), storing around two petabytes of data.

In 2011, Continental developed a method for assessing which of its IT services should be migrated to the cloud (Cloud Readiness Method, Loebbecke et al. 2012). At that time, Continental assessed that 15 out of 29 IT services were "likely cloud ready." However, Continental had virtually no experience with the application of CC at the time of this case study.

Continental's CC strategy must be considered in the context of the CSPs. *The Wall Street Journal* reports on a trend towards consolidation of the CSP industry (Loftus 2019), with CC appearing to transform into a market with two main competitors: Amazon Web Services (AWS) and Microsoft's Azure. In 2015, Continental conceptualized a multi-cloud approach to make both providers accessible organization-wide. This makes the situation of Continental typical for traditional multi-national companies that aim to leverage the opportunities presented by CC based on a multi-cloud approach.

In this study, we investigate Continental's state of the CC strategy, strategy implementation, and the challenges that surfaced when it executed the defined cloud strategy. The paper at hand is structured as depicted in Figure 1. First, we present Continental's cloud strategy along its evolutionary stages. Second, we provide an overview of the strategy's implementation. Therefore, we explain the implementation work conducted and discuss the development of adoption barriers over time. Third, we synthesize lessons learned from the presented case study that serve as recommendations for practitioners. In that sense, we position this research paper as an exploratory case study, which generates claims by induction for the target audience (Sarker et al. 2018) of practitioners.

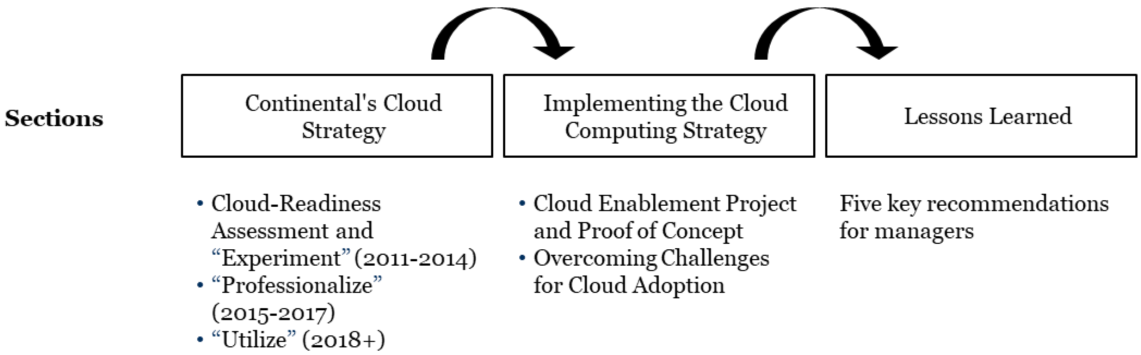

Figure 1. Paper Structure. Source: Authors' own illustration

In the first half of 2019, we developed five main topics and a corresponding questionnaire in two interactive sessions with I_6. The five identified topics were:

1. Recap of the 2011 readiness assessment (Loebbecke et al. 2012)
2. Enablement
3. Strategy
4. Implementation
5. Outlook

With the help of our co-author working at Continental, we then invited executives involved in the facilitation of the CC adoption at Continental and conducted a series of nine semi-structured interviews with them. Interviewees could either dwell on all topics or deep-dive into their specific subject area of expertise (see Table 1 for the topics covered by each interviewee).

Table 1. Interviewees			
Index	Position (prior, if relevant for case study)	Topics covered	Length, in minutes
I_1	Manager Server and Provider, Data Center	2, 4, 5	58
I_2	Head of Connectivity Services	2	62
I_3	Service Owner Secure Cloud Access	2, 4, 5	46
I_4	Head of Corporate IT Strategy – Enterprise Applications & Platforms	3, 4, 5	34
I_5	Head of Divisional IT Infrastructure	3, 4	33
I_6	Head of Cloud Consulting & Prototyping @ Corporate IT Infrastructure	3, 5	52
I_7	Strategist Cloud	3, 4, 5	56
I_8	DevOps Engineer	2, 3, 4	57
I_9	Head of Corporate IT Strategy & Innovation	1, 3, 5	53

Table 1. List of Interviewees for the Case Study. Source: Authors' own representation

Executives with more technical responsibilities primarily covered Enablement and Implementation (topics 2 and 4), whereas executives holding more strategic roles focused more on Strategy and the Outlook (topics 3 and 5). As many of Continental's executive positions dedicated to CC were created over the course of the last few years, I_9 was the only interviewee who also contributed to the prior case study of Loebbecke et al. (2012). We analyzed the interview transcripts strictly following a four-eyes principle to aggregate the implicit corporate knowledge accumulated within Continental's eight years of CC adoption.

We analyzed the interview transcripts in five steps. First, we transcribed the 7.5 hours of interview recordings (see Table 1 for the length of each interview). Second, the text fragments were coded using the five topics of the interviews (1. Recap of the 2011 readiness assessment, 2. Enablement, 3. Strategy, 4. Implementation, and 5. Outlook). Sub-groups were built to differentiate the sub-topics discussed, e.g., for “3. Strategy” the phases “experiment,” “professionalize,” and “utilize.” Third, the topics were analyzed one by one. Further material from presentations of the CC strategy from 2015 and 2017 was used to triangulate the topics and to ensure consistency. Clarifying questions were posed within the interviews in cases where responses on one topic conflicted with previous responses from other interviewees. The descriptive part of the article was subsequently drafted for each of the sections, including the artifacts of tables and figures. Fourth, findings were derived from the information provided and summarized in the section “Lessons Learned.” Fifth, the tables, figures, and Lessons Learned from the early interviews were combined with the later interviews and shared in a presentation session open to all interviewees to validate their accuracy.

Continental's Cloud Strategy

Continental's cloud strategy evolved in three stages: Experimentation, professionalization, and utilization. Each stage pursued different strategic targets, as Figure 2 illustrates.

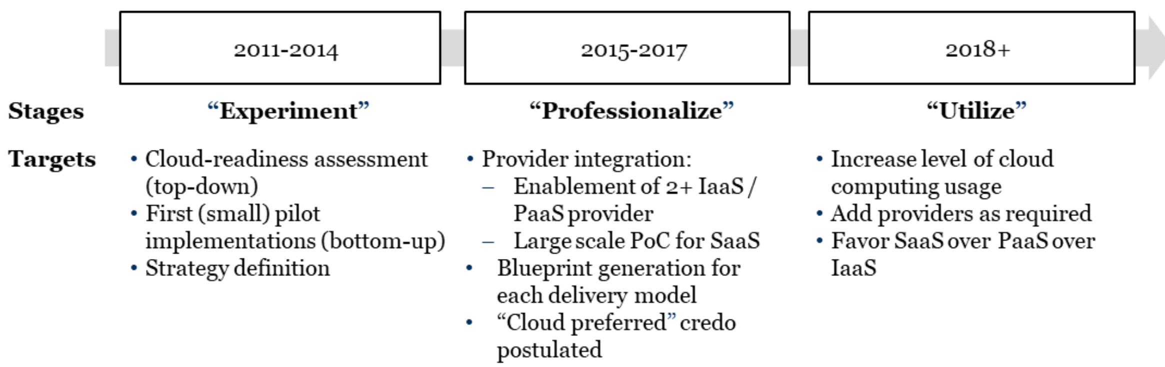

Figure 2. The Evolution of Continental's Cloud Strategy over Time. Source: Continental

Cloud-Readiness Assessment and “Experiment”

Below, we first summarize Loebbecke et al. (2012)'s analysis of Continental's cloud readiness in 2011. This allows us to ground our analysis on prior research as well as the company's CC adoption path.

Recap of Continental's Cloud-Readiness Assessment after Loebbecke et al. (2012)

In its first structured effort to assess the potential to apply CC, Continental developed a three-step process to identify, evaluate, and categorize IT services regarding its cloud-readiness (for more details see Loebbecke et al. 2012). First, it identified 29 IT services that the corporate center IT provided to internal clients for consideration. Continental derived a list of seven criteria with two parameters each as a basis for evaluating the 29 IT services in a series of 16 expert workshops. Second, Continental evaluated all IT services based on expert judgment and informed guesses according to the defined criteria. Third, IT services were categorized based on the evaluation. A soft threshold was defined for all seven criteria. An IT service needed to be evaluated respective to all criteria above this threshold to be considered as cloud-ready.

In 2011, Continental considered 15 IT services provided by the Corporate IT, especially those that are commonly provided in a standardized fashion, as “likely cloud ready.” Back then, business critical and complex services such as ERP Services were assessed as “not cloud ready.” Table 2 illustrates the results of the initial cloud-readiness assessment showing all 29 services categorized by assessment outcome (Loebbecke et al. 2012).

Table 2. Cloud-Readiness Assessment Results for IT Services			
IT services assessed as likely cloud ready		IT services assessed as not cloud ready	
Intranet	Patch Management	ERP Services (SAP)	Mobile Device Management
Internet	Virus Protection Management	Redundant Infrastructure	2nd WAN & WAN Accelerator
Finite Elements	Vulnerability Management	Continental Application Framework	Project Management Suite
Supply Chain Management	IT Asset Management	Storage	Internet Access Gateway
Office & File Viewer	Realtime Collaboration	Data Compression for Storage	Internet Mail Gateway
DMZ Operations	Service Desk	Information Life Cycle Management	Archiving Service
Managed Server	IT Service Manager Tool	Messaging	Meta Directory Services
Managed User Workstation			

Table 2. Continental's 2011 Cloud-Readiness Assessment. Source: Loebbecke et al. (2012)

The remainder of the paper is dedicated to the case study conducted at Continental in the first half of 2019.

"Experiment" (2011-2014)

After the cloud-readiness assessment, Continental started to operationalize the outcome – at that time it had virtually no experience in applying CC. Continental still had to define fundamental prerequisites such as security requirements of cloud providers, data classification rules, internal procurement and accounting processes, and responsibilities for overseeing cloud accounts – to name just a few.

Continental's line organization seemed yet unprepared to "consume" cloud services. Its decentralized organizational set up and culture made an effective centralized, top-down approach, as implied by the "cloud readiness assessment," challenging. Interviewees I_6 and I_9 stated that Continental began a period of decentralized bottom-up experimentation on a use-case by use-case basis – aiming to prove that CC would be beneficial for the organization and to convince decision makers in its decentralized units.

At that time, not all decision makers were fully convinced of the need to deploy CC within Continental, predominantly because the opportunities were not yet fully visible. Historically, Continental had a cost-focused IT organization. When decision makers considered replacing the current choice of sourcing, they expected either a clear cost advantage or benefits at the same cost level. Continental had matured its sourcing approach, which divided IT services into services sourced inhouse and outsourced services. Many decision makers considered this sourcing approach to be fully functional and cost-efficient. CC was also perceived to be difficult to handle. For instance, when considering using IaaS to source the services "managed server" or "managed operating system," the CSP could only partially deliver, as it did not deliver the operating system. Hence, the responsibilities of what ought to be managed by whom had to be allocated differently compared to conventionally outsourced services.

"One day in late 2012, I was invited to a workshop of a partner company on CC. I was myself not really convinced of the technology, because we did not really see the benefit of it. Then, in the workshop I saw how an AWS SharePoint environment was set up with five mouse clicks and destroyed with another click. I found this really amazing and thought, we need to have this at Continental as well. This is so much faster compared to the ticket order requests I would send to an outsourcing provider!" reflected I_6 on a trigger moment, which made the actual benefit of CC visible to him.

Subsequently, Continental experimented with the first pilot projects in 2013 and 2014 to expose more decision makers to similar trigger moments. The first pilots focused on narrow or easy use-cases as a back-up service and the set-up of a SharePoint environment. Then, the experimentation evolved to focus on further use-cases with increased complexity: A fleet management solution was developed on IaaS and an HR solution was rolled-out for the entire corporate HR function. The described use-cases succeeded in demonstrating the benefits of CC to a broader audience in the organization. However, the experimentation with CC showed the need to complement this bottom-up pilot use-cases with a top-down driven strategy: Continental found it challenging to provide services from the cloud to the organizations on a company-wide scale due to its high degree of decentralization. Moreover, it became evident that the broad and heterogenous landscape of service offerings for IaaS and PaaS required top-down decisions regarding how many and which CSPs Continental should use for service provisioning. Another lesson learned from the early pilots was that a profound knowledge of the specific CSP was necessary to use CC in an IaaS or PaaS delivery model. Hence, Continental defined a corporate cloud strategy in late 2014 (approved in 2015) as I_4 explained.

"Professionalize" (2015-2017)

Continental's first corporate cloud strategy enabled it to pursue CSPs for IaaS / PaaS and to increase the availability of Software-as-a-Service (SaaS) as an offering for the entire decentralized organization. To showcase the applicability of CC within the organization, Continental conducted a large-scale Proof of Concept (PoC) for SaaS. The expectation was to derive generalizable deliverables from these projects that could serve as blueprints for the consecutive integration of CSPs. A Cloud Enablement Project (CEP) was inaugurated for the integration of CSPs for IaaS / PaaS.

Meanwhile, Continental took the first measures to communicate migration towards CC within the decentralized and relatively autonomous IT organization: A council comprising all business unit CIOs communicated a new credo for sourcing IT services called "cloud preferred." This new credo was identified by three interviewees (I_5, I_6, and I_8) as an important step for Continental. The decision and its prominent communication into the organization constituted a form of role modeling by senior management.

Proof of Concept in SaaS

It is crucial to understand the context for the selection of a suitable IT service as Proof of Concept and to know who manages which resources in CC delivery models. The extent to which a Cloud Service User (CSU) manages resources itself varies between CC delivery models (Zhang et al. 2010). Figure 3 illustrates the relationship between the resources under management that depend on the CC delivery models. Services are composed bottom up, so that the provision of a SaaS service requires the CSP to provide and manage the subsequent level of resources or else outsource their management to another provider. Therefore, a CSU needs to manage the Application Layer resources itself if the consumed service is a PaaS. Consequently, a CSU who consumes IaaS needs to provide and manage both the Application and the Platform Layer. We can thus conclude that, from the perspective of a CSU, the easiest delivery model to implement is SaaS, as it entails the lowest level of self-provided and self-managed resources.

Continental had to choose a delivery model to serve as Proof of Concept. In the SaaS delivery model, the CSP manages the Application Layer and all other layers. Hence, the SaaS delivery model does not require any development resources. Moreover, SaaS systems constitute ready-to-use applications that allow for a fast roll-out. Because SaaS systems are a widely deployed IT service, choosing a SaaS as Proof of Concept could boost visibility within the organization. However, it also requires fast roll-out to numerous geographical locations. An additional disadvantage of SaaS applications is that they are usually highly standardized; they cannot be tailored to the purchaser's needs in the same way as applications built with PaaS or run via IaaS.

Ultimately, Continental selected Office365 as Proof of Concept. This was in line with the cloud-readiness assessment from 2011, where the IT service "Office & File viewer" was assessed to be likely cloud-ready (Table 2). As virtually every white-collar worker within Continental was a user of a deprecated Microsoft Office version and Lotus Notes (both at the end of their lifecycles), Office365 was the ideal candidate for a Proof of Concept with high visibility. It helped Continental to convey the message that CC had become available to the entire organization. However, it also increased pressure on the implementation team, as the entire organization experienced the ease / smoothness of migrating from the old Microsoft Office and

Lotus Notes environment to the new Office365. The wide roll-out required the implementation team to ensure accessibility across virtually all Continental locations.

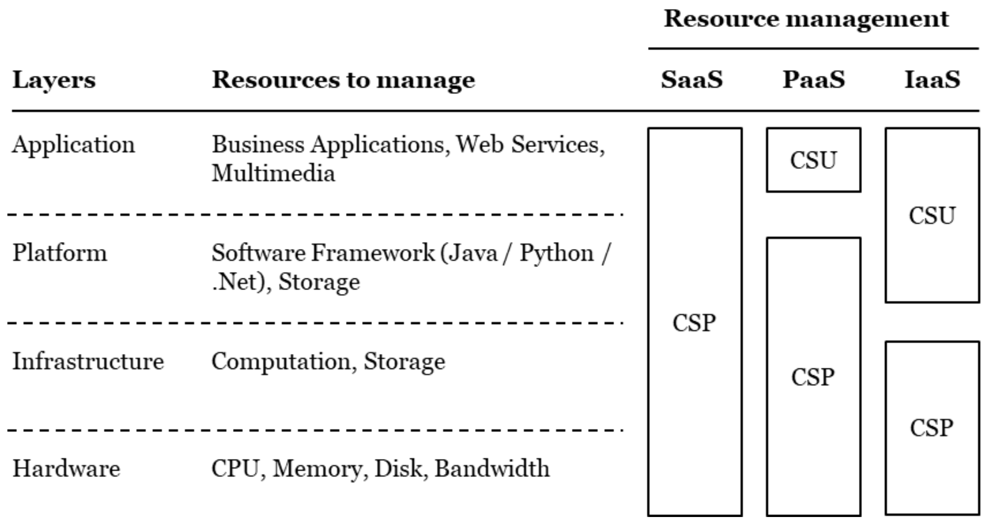

Figure 3. Exemplary CSP and CSU Managed Resources within the CC Delivery Models.
Source: Zhang et al. (2010), adapted

Cloud Enablement Project: IaaS / PaaS Provider Integration

One of the difficulties in the process of cloud adoption faced by Continental was that there was virtually no demand for IaaS / PaaS offerings by the business units. Hence, IT Infrastructure decided to provide a seamless connection to CSPs, pursuing a multi-cloud approach.

"It was like the old chicken and the egg problem: Nobody used IaaS / PaaS, because it was not seamlessly integrated, and we did not integrate it, because nobody seemed to be interested in using it. Hence, somebody had to make the first step to overcome this issue." reflected I_9.

In the case of Continental, the IT Infrastructure department decided to pre-invest into an enabling project that aimed to connect multiple IaaS / PaaS providers. Continental needed to decide how many CSPs should be enabled by this project.

Procurement pushed for the usage of a multi-cloud approach that comprised multiple providers for commercial reasons and to avoid vendor lock-in. Additional reasons also pointed towards this approach: In the beginning of 2015, the market of CSPs for IaaS and PaaS was still very heterogeneous, so it was not yet foreseeable which CSP would take the technological leadership. The challenge for Continental was to consider several effects when deciding on a set of CSPs that would serve the corporation. A larger number of CSPs would increase the number of use-cases supported by cloud infrastructure and platform but would also increase the complexity of managing multiple clouds in parallel. A larger number of CSPs would also be associated with reduced economies of scale from distributing cloud traffic over a higher number of CSPs. However, experience from the first pilots also indicated that knowledge building regarding the CSPs' specificities was needed to exploit their technological possibilities fully. Hence, for Continental the exploitation of technological possibilities would be more difficult with a higher number of CSPs. The procurement department advised contracting more than one CSP, said I_5. Therefore, Continental decided to focus on two CSPs. Due to their leading market positions and perceived maturity, Continental selected AWS and Microsoft Azure. The first CSP made available to the organization ("enablement") was AWS, because of its low entry barriers in terms of contractual pre-work.

"Utilize" (2018+)

The current focus of Continental's cloud strategy is to increase the usage of cloud delivery models within the organization. The current strategy foresees no strategic intention to enable further CSPs, unless the need arises due to a demand to support specific use-cases that can be better delivered with a new provider than with the current CSPs. This need could emerge through features provided by a CSP or the geographic coverage. Therefore, the strategy is directed to increase the usage of SaaS solutions and to foster development on the already enabled IaaS / PaaS providers. Part of Continental's current cloud strategy is also a hierarchization logic, which states clear preferences for the three delivery models IaaS, PaaS, and SaaS. Continental's cloud strategy favors the usage of SaaS over the usage of PaaS and IaaS, according to I_8. As the SaaS delivery model is the one with the highest degree of outsourced services, potential cost savings are the highest. However, such savings come at the expense of a limited flexibility regarding software individualization compared to IaaS.

After the successful Proof of Concept in SaaS and the integration of two IaaS / PaaS providers, Continental needed to think about the following: Now that it was proven that CC worked at Continental, the question was how to increase its usage within the organization.

Adoption Approach

In the following we illustrate the options for a CC adoption regarding IaaS / PaaS delivery models. In general, we conceptualize two approaches with different characteristics to implement CC. First, one could use a "big bang approach," by which a large amount of applications is migrated to the cloud at one point, or within a small period. Second, one could follow a "gradual implementation approach," by which applications are evaluated at strategic decision points to decide whether they should be migrated to the cloud. Which of the above-presented implementation strategies to apply depends on the individual advantages and disadvantages of the approaches. The subsequent paragraphs present these advantages and disadvantages.

The main advantage of the big bang approach is the speed of implementation. If one chooses to migrate the infrastructure of various applications, rapid migration of applications to IaaS aims to capture the cost benefits from CC as soon as possible. One important attribute of the big bang approach is that it requires a significant amount of capital to migrate a vast amount of applications in batches to the cloud, in addition to a large pool of human resources, both internal and external. As this approach would involve the migration of applications within their software development / hardware lifecycle, the approach follows a simple "lift-and-shift," without any transformational transition during the migration to the cloud. Such a transformational transition would redesign the application architecture to use the cloud's potential for innovation or options for cost savings. Another disadvantage of this approach is that the organization cannot gradually learn what works and what does not and, therefore, cannot adjust the approach to migrate applications to the cloud accordingly.

The gradual implementation approach aims to evaluate applications at strategic decision points of their lifecycle, which is either at the start of development for new applications, the beginning of another software development lifecycle, or when the underlying hardware is at the end-of-life and requires renewal. When deciding to migrate the application to the cloud, one needs to decide whether the application can be migrated with lift-and-shift, or whether a transformational transition is required to tailor it to the cloud. If the decision is taken not to migrate the application to the cloud, decision makers need to evaluate whether to insource or outsource the required infrastructure. Ultimately, Continental decided to follow the gradual implementation approach. Hence, for each existing application that was either starting a new development lifecycle or where the infrastructure was at the end-of-lifetime, the question was whether and how to migrate the infrastructure to the cloud within the next lifecycle of software development / infrastructure.

"We spent quite some time working on the business case. It is not easy to compare infrastructure costs on-premise to costs in the cloud, as the costs are based on different assumption, e.g., peak-sizing on-premise versus right-sizing in the cloud. However, we concluded that cloud infrastructure can come at lower costs under certain assumptions. These assumptions are that one makes use of the options we have in the cloud as right-sizing, reducing capacities, switching off, etc. This finding made us conclude that a simple lift-and-shift approach might not be enough in all cases to capture cost savings." noted I_4.

Seven interviewees acknowledged that a lift-and-shift approach would not be sufficient to explore the cloud's full potential. Hence, it required due diligence for each application under consideration to explore whether and how its infrastructure should be migrated to the cloud. These considerations involved cost savings, but also investigations into whether the potential for innovation could be captured with a lift-and-shift approach, or whether a transformational transition of the application would be required. Continental also uncovered a cost differential between the two strategies: Cost savings from CC resulted from an architectural redesign of the information system. Therefore, the gradual implementation approach, which foresees such an architectural redesign, would yield a cost advantage. The lifecycles of the purchased hardware span between five and ten years. Hence, Continental came to the realization that many of the cost savings anticipated in a direct comparison between on-premise and CC would take years to capture. Moreover, Continental even expected increased costs in rare cases, where a specific resource request could be fulfilled with already existing capacities.

Knowledge Management

Following the gradual implementation approach, assigned the decision regarding infrastructure and development platforms to software development project leaders who generally decide on sourcing at Continental. So, the question arose as to how to ensure that project leaders consider CC as a likely sourcing option. Potentially, Continental could have considered management-by-objective through target agreements. This approach was discarded, as it did not enable decision makers to reach an educated decision as to whether to cloud-source a specific service or not. Potentially, it could have induced false incentives and led to CC as a sourcing choice when it was in fact not appropriate.

"Target agreements could produce false incentives. Therefore, I think it is more meaningful to convince people that CC is beneficial for their specific project." responded I_6 when asked about how to foster the utilization of CC.

Moreover, Continental had no strategic intention to completely dispose of data centers at decentralized locations. Therefore, Continental chose to spread knowledge and capabilities regarding CC as an approach to CC adoption.

"We made CC services technically, operationally, and administratively available to the organization, but not everything is done with this. We must accompany every single colleague on their pathway to the cloud." stated I_7.

Continental uses and used various channels for the dissemination of knowledge on CC within the organization.

The primary instrument to spread knowledge and capabilities on CC within Continental were so-called "cloud consultants" within the corporate IT (centralized), which is currently headed by I_6, and within the business division IT (decentralized). Despite their geographic dispersion, the cloud consultants at Continental considered themselves as a virtual unit within the organization. Their task was to advise software development projects on the option to cloud-source the infrastructure or development platform for their project. Their role was to advise decision makers at the previously mentioned strategic decision points as to whether the application of CC was suitable in a particular context. This included demos of the potential offered by the cloud, so that decision makers could have their own trigger moment and understand the benefits of CC too. Moreover, pros and cons of the respective CSPs were outlined to enable the decision maker to select a suitable vendor. During the implementation, the cloud consultant then demonstrated the first steps on cloud accounts (e.g., how to set up servers). Additionally, they acted as agents for the change towards the cloud and therefore needed to convince decision makers across the organizations on a fact level, but also on a mental level to make the change happen.

I_7 stated that communications promoted general knowledge on CC to end-users (wide-dive), while targeted communication provided employees working in the software development context with more detailed information to (deep-dive). The amount of communication on CC received by an employee varied depending on the required CC knowledge the employee needs to perform her or his tasks. Additionally, the Proof of Concept contributed to spreading word of CC application at Continental. As Office365 was selected as Proof of Concept, virtually every white-collar worker at Continental became part of the roll-out and had first experiences as a CC user. Also, the prominent placement of the "cloud preferred" decision by the CIOs contributed to the communication efforts.

Employees who required knowledge on CC for their specific role received training. This training informed them about the IaaS and PaaS providers made available by the Cloud Enablement Project and explained the specifics that were required for implementation.

Implementing the Cloud Computing Strategy

Implementing the CC strategy comprised the execution of the strategized Cloud Enablement Project and Proof of Concept, as well as overcoming challenges that became evident and hindered utilization of CC.

Cloud Enablement Project and Proof of Concept

In 2015, Continental launched the Cloud Enablement Project to enable the at-scale implementation of CC. In line with its defined cloud strategy, this project primarily aimed to enable the usage of IaaS and PaaS from the providers AWS and Microsoft Azure. Hence, the Cloud Enablement Project rolled-out CC access to the entire organization. Broadly, the four interviewees reporting on the Cloud Enablement Project subject divided it into the work streams **network / connectivity**, **security**, and **operating model**. The Proof of Concept delivered guidelines for **data management**.

The **network / connectivity** work stream comprised multiple items. First, the infrastructure elements were built to connect the company's major data centers in Europe, North America, and Asia to the CSP. A network infrastructure provider then formed a gateway to the CSPs. The usage of an intermediary supplier to connect to the cloud made it possible to scale-up the number of CSPs being connected to, if required. However, Continental had to trade-off the ease of connecting to a multitude of CSPs via the intermediary against another potential source of service disruption. Further infrastructure elements created were broadband connection, switches, and firewalls.

The **security** work stream comprised the topics of role concepts, transparency, and network access. First, work was dedicated to developing an appropriate access role concept, which followed the least privileged principle. Hence, Continental aimed to balance the cloud's innovation speed with the increased risk of access rights. Second, the need to ensure transparency on account configurations over the lifetime of the cloud account necessitated the implementation of a suitable monitoring system, which was purchased on the market. Third, Continental defined categories for network access based on the type of use-case, according to I_2: Use-cases were therefore differentiated between internet facing-only, internal data center facing-only, or a combined type that interfaced internet and internal data centers (e.g., a web shop that integrated databases with customer data in the data center). These measures decreased the risk Continental was exposed in case of an incident.

Continental designed various components of the **operating model** to support cloud services as reported by I_8. This included the definition of roles and processes that administer cloud services in various areas: The process from ordering cloud accounts towards the provisioning also had to be defined. In addition, a monitoring system, which controlled the account status over the lifecycle, was required. Besides the provisioning of service, the internal accounting processes required adaption to support the billing based on a pay-per-use concept. The cost transparency of CC allowed for cost allocation and charging on an account level. Internal accounting processes did not yet support this granularity of internal cost accounting. Likewise, the budgeting processes required adjustment as CC users were charged for the consumed services. Additionally, Continental entered frame contracts with the CSPs for IaaS / PaaS.

Besides the targeted Cloud Enablement Project, Continental developed foundational work that enabled the implementation of the cloud within the Proof of Concept. An important foundation for the resolution of compliance challenges was the definition of **data management** procedures in the cloud. Specifically, a data classification clearly defined which categories of data were eligible for storage in the cloud and which were not.

"At the time we had the discussion, it was decided that the data owner has to assess by his- or her-self what type of data is potentially moved to the cloud." stated I_1.

A four-categories approach to data classification distinguished between "strictly confidential" data, which must not be stored in the cloud, and "confidential" data, which could be stored but only with approval from the data protection and security function. The two further classes were eligible for cloud storage.

This classification of data was a fundamental factor to determining whether an application was suitable for cloud sourcing across delivery models. Hence, Continental established data management procedures in advance of the regulatory imposition by the General Data Privacy Regulation (GDPR).

The artifacts generated in the Cloud Enablement Project and Proof of Concept now served as physical resources, operating model blueprints, and survey questionnaires, which enable integration of further CSPs at a faster pace at Continental. For example, the data classification described above provided clear guidelines for data owners as to whether data is suitable for usage in a CC context.

Overcoming Challenges for Cloud Computing Adoption

In 2011, Continental identified barriers to the adoption of cloud within the assessment process (Loebbecke et al. 2012). However, as CC technology became more mature over the following years and Continental undertook efforts to become more cloud ready, so did the ecosystem of suppliers and customers. Hence, one could assume that the challenges for cloud adoption had changed from what was identified in 2011. Likewise, new challenges for organizations arose that required attention in order for CC to be applied successfully on a large scale. The following sub-subsections address these two aspects.

Change of Previous Adoption Barriers

There is a connection between the cloud adoption barriers assessed in 2011 and the topics tackled by the foundational Cloud Enablement Project and the Proof of Concept between 2015 to 2017. CSPs improved their product offerings to overcome adoption barriers, too. Additionally, perceptions about CC changed as well, leading to a paradigm shift and the lowering of adoption barriers in some cases. As a result, the barriers to CC adoption changed quite significantly over the course of eight years between the two case studies.

In 2011, Continental ranked factors that hindered the migration of IT services to the cloud (Loebbecke et al. 2012): Compliance issues were found to be the biggest challenge for most IT services. Degree of Distribution ranked second in the list of barriers to CC adoption for the IT services under consideration, followed by Standardization, Network Connectivity, Importance / Availability, Identity Management, and Core Business / Competitive Position. Table 3 illustrates the barriers perceived in 2011 and highlights the reasons why these lowered over time. The left-hand-side of Table 3 illustrates how often a criterion was identified as a barrier for cloud-readiness within the initial assessment of 29 IT services in 2011 (Loebbecke et al. 2012). The right-hand side of Table 3 illustrates the reasons why the respective criteria represent a lower barrier for cloud adoption today compared to 2011, according to the input of the interviewees. The subsequent paragraphs will explain how these barriers changed over time.

Merits of the Cloud Enablement Project mainly focused on Networking / Connectivity, which aimed to increase bandwidth and achieve a latency as on campus for the larger locations. Effectively, these efforts also increased the stability of the infrastructural components, and thus enhanced overall availability. Identity Management barriers were resolved by the integration of Continental's Active Directory for the two IaaS providers. The data classification of the Proof of Concept provided clear guidelines on what could be moved into the cloud and what could not.

Barriers to cloud adoption also fell due to the improved service offering by CSPs. Parametrization of service provisioning on an account level allowed the migration of locally managed applications and adaption to company-specifics. While Importance / Availability was previously perceived as a barrier, the 24 / 7 customer support provided by CSPs enhanced availability compared to on-premise solutions.

A paradigm shift occurred regarding how Continental and its ecosystem view CC, so that some previous barriers are now *perceived* differently. Core Business / Competitive Position was mentioned as a reason to stay away from the cloud in 2011. New business ideas that have the potential to build a competitive advantage over competitors such as mobility services were recently considered to be heavily reliant on the application of CC.

"If now applications are built to be integrated in cars that leverage hot trends like autonomous driving and inter-connectivity, nobody would think of using something apart from CC as the infrastructural component. In that respect, the technology changed quite a lot. I believe our future competitive advantages will be based on CC." remarked I_8.

This statement is remarkable, because low contribution to competitive position was defined as increasing the cloud-ready value in the cloud-readiness assessment back in 2011.

Likewise, Continental employees participating in the case study perceived a paradigm shift in views upon compliance. In 2011, part of the compliance barrier was that the ecosystem of customers considered CC as a compliance issue: Nowadays, with other players in the automotive industry intensifying the engagement with CSPs, or even partnering with them, this argument has become less valid.

"In reality, we found that contracts with our partners rarely contained clauses that prohibited moving data to the cloud." stated I_2, which made the compliance argument less compelling.

For compliance, the paradigm shift consisted of a change in how security is ensured within the organization. Traditionally, security requirements were defined, and controls set up and carried out. In a cloud setting, Continental's role in ensuring information security changed. Controls on compliance and security-related topics are not set up and carried out by Continental itself anymore. Now, Continental has defined what type of data is allowed in the cloud and relies on certifications and the judgment of independent third-party auditors regarding the CSP's compliance and security standards.

Table 3. Reasons for Reduction of Barriers to CC at Continental					
Barriers to cloud-readiness for IT services at Continental in 2011		Reasons why barriers have decreased since 2012			
Criterion	Identified as barrier for cloud-readiness	CEP	PoC	CSP	Paradigm shift
Compliance	9 times		x		x
Degree of Distribution Within Continental	8 times			x	
Standardization	6 times			x	
Network Connectivity	5 times	x			
Importance / Availability	4 times	x		x	
Identity Management	4 times	x			
Core Business / Competitive Position	3 times				x

Table 3. Reasons for Reduction of Barriers to CC at Continental. Source of barriers: Loebbecke et al. (2012); Source of reasons why barriers have decreased: Authors' own analysis

Current Challenges in Cloud Adoption at Continental

Today, compliance considerations are still a challenge to CC adoption at Continental. However, the challenge of compliance conformity has declined for two reasons, as reported in the interviews. Interviewees reported that the supposed compliance conflict imposed by CC is, at times, only a perceived issue, because there are no clauses in contracts or respective laws that would hinder data storage in the cloud. Hence, the problems that Continental is aiming to overcome are myths of compliance challenges that in fact do not exist. Therefore, according to Continental, it not only needs to enable cloud usage from a technical perspective, but also to evoke a mental change at its IT and business side to thoroughly adopt cloud solutions.

According to Continental, the biggest current challenge to CC adoption is the migration of existing information systems to cloud infrastructure. Continental maintained a broad and heterogeneous landscape of IT and business unit-owned applications that, at the time of their making, were not designed to be run on cloud infrastructure. Therefore, a simple "lift-and-shift" approach that attempted to migrate existing applications to cloud infrastructure without redesigning the application was perceived as insufficient.

"If we only lift-and-shift existing applications to the cloud, we neither capture the potential benefits regarding innovation nor achieve a reduction in costs." stated I_2.

Hence, a redesign of the application's microservices, server lists, and utilized databases was required to capture the benefits of CC when migrating existing information systems to the cloud. Interviewees noted that this in turn prompted Continental to attract internal and external resources skilled in CC and capable of redesigning applications.

Another challenge Continental faces is the transfer of knowledge on CC within the organization. Decision makers need to select CC as a sourcing option when it is beneficial for the use-case under consideration and can choose a suitable CSP.

"For my division, the current approach is that one has to make the point why the cloud should not be used. We turned it around because the "new normal," the de-facto standard has to be the cloud." contributed I_5.

Lessons Learned

From the case study, we derive five recommendations for IT managers aiming to apply CC in their own organizations.

- Envision **differentiated, delivery model-specific** cloud strategies. From a corporate planning perspective, few use-cases of the SaaS delivery model can be strategically planned but are demanded from business departments for their respective use-cases. Guidelines established in a Proof of Concept can help with the evaluation of whether a SaaS from a new CSP can be implemented. For the IaaS and PaaS delivery models, strategic planning from the IT department should involve the selection of CSPs, a technical enablement of each provider, and a strategy to foster knowledge about the technology. Regarding the IaaS and PaaS delivery models a multi-cloud approach can be beneficial from a cost and technology perspective. Communication of the cloud strategy by senior management generates buy-in for the employees tasked with implementing the strategy.
- Create **reusable blueprints for following use-cases** from early use-cases as Proof of Concept for CC within the organization. Key to the successful implementation of cloud technologies is to start the at-scale (in the sense of a company-wide) application of cloud technology with a substantial Proof of Concept. This Proof of Concept should ideally be a SaaS delivery model, as this is the easiest one to implement, given that it exhibits the highest degree of outsourcing of the three cloud delivery models. Even services delivered on an organizational scale through the SaaS model require the CSU to manage a distinct set of resources, listed in Figure 4. Therefore, the Proof of Concept should be equipped with a large enough budget to establish network / connectivity, define security requirements, data management guidelines, and the operating model. The Proof of Concept acts as a lighthouse project with visibility for the entire organization.
- **Pre-invest in the enablement** of the CSP(s) chosen for the IaaS / PaaS cloud strategy, to overcome the chicken and egg problem of interdependence between low usage and upfront investment costs to enable the provider. Selection of a multi-cloud strategy for IaaS / PaaS is beneficial to support a broad variety of use-cases. This allows the internal use-case owner to select a suitable provider based on its strengths, such as technical configuration options or geographic reach. However, the usage of IaaS / PaaS requires an organization to be capable of managing the application layer, as shown in Figure 4. Hence, software development talent (either internal or external) needs the relevant skills to work on CC platforms and infrastructure.
- Follow a **gradual implementation approach** to adopting cloud infrastructure and platforms at the strategic decision points of application development: New development, new development lifecycle, end-of-life of infrastructure. The gradual implementation of cloud infrastructure and platforms requires less up-front investment and allows the organization to learn and build knowledge with the CSPs, compared to the alternative big bang approach. Hence, gradual implementation allows the decision maker to decide case-by-case whether an application's infrastructure should move to the cloud and whether a transformational transition is required to utilize the innovation potential or achieve cost-reduction. This comes at the cost of a multi-year project to shift workload to the cloud. On some occasions, a simple lift-and-shift approach may be enough to capture cloud benefits. More often,

applications require a transformational transition to the cloud, which necessitates a redesign of the application's architecture.

- Foster the **dissemination of knowledge** on CC within the organization. The scale at which CC is utilized in the organization is the result of decentralized decisions made by individual software development or infrastructure project leaders. Therefore, stringent communication, training, and advice is required for these decision makers to form an educated decision on the sourcing options for their respective projects. This requires showcasing the benefits that come with the application of CC to the entire organization. People will be more likely to make the change happen if they learn from demos, success stories, or own experiences about the advantages that are associated with the cloud. Change agent roles (e.g., cloud consultants) are required to spread the organizational knowledge on CC. Smooth roll-out of a Proof of Concept project is a suitable way to generate positive user experiences for a broad base of employees within the organization.

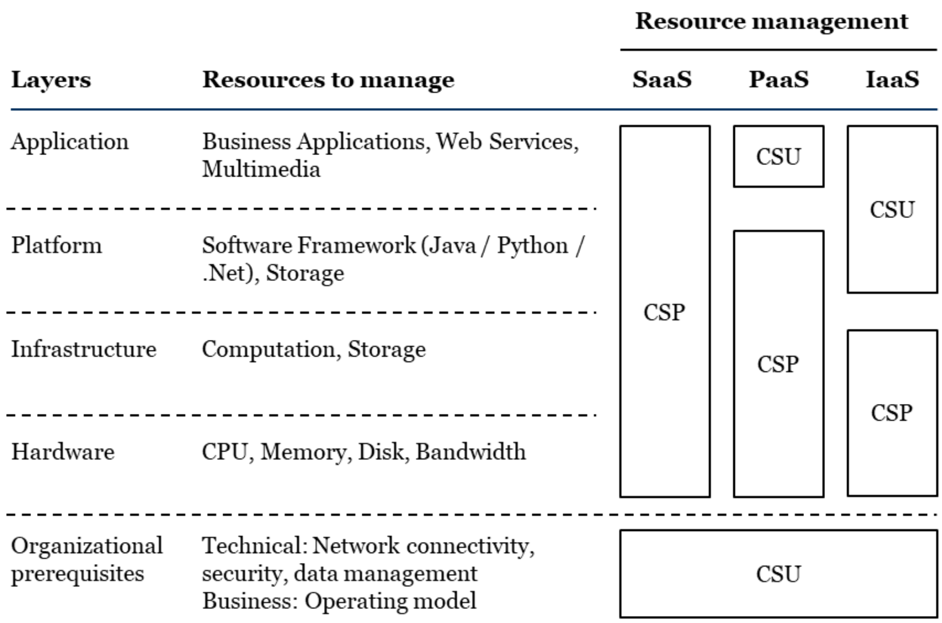

Figure 4. Updated Model of CSP and CSU Managed Resources by CC Delivery Model. Source: Zhang et al. (2010), adapted

A potential issue of any case study is that the derived conclusions may lack generalizability and that they may be valid only for the context in which they have been derived – here large multi-national companies. However, we find support for these recommendations in the literature on information systems regarding cloud / information systems strategy, legacy system integration, and knowledge management. Therefore, we argue that the lessons learned from this case study are relevant practical guidance for practitioners in a variety of industries, geographies, and contexts.

The differentiation of cloud strategies by delivery model is supported by the literature on cloud-sourcing decisions. The key client for the CSP of SaaS is the business department, whereas the key client for IaaS / PaaS is the IT department (Schneider and Sunyaev 2016). Hence, the strategic focus on IaaS and PaaS is a direct result of this characteristic. The IT department function takes the role of a service integrator (Schneider and Sunyaev 2016). This translates to the recommendations to provide blueprints for SaaS and invest in the integration of IaaS and PaaS as an IT department.

The importance of integrating legacy systems into the cloud is also discussed in the literature (Kathuria et al. 2018): A firm's ability to connect legacy systems to the cloud is positively correlated with firm performance (directly, and additionally mediated by business flexibility). Thus, the gradual implementation approach for cloud adoption can be recommended for integrating the existing application landscape.

Due to the limited amount of literature directed towards knowledge-sharing on CC specifically, we draw on the literature on knowledge management in information systems to position our findings. A minimum of four basic knowledge management processes can be differentiated: Creation, storing / retrieval, transferring, and application (Alavi and Leidner 2001). The core knowledge process targeted by Continental's CC strategy is the transfer of technological knowledge in the organization. In our case study, we find that Continental conducted various activities to foster knowledge transfer. This is in line with previous research, which argues that it is important to provide multiple channels for knowledge sharing to address diverse needs and preferences (Pan and Leidner 2003).

Conclusion

The adoption of CC within a large-scale organization is no doubt a multi-year process. We have showed that this stretches from the first experimentation with the new technology over the technical and operating model integration until the at-scale usage of CC. This is a challenge, especially for large organizations with a rich tradition of manufacturing, but stepping up to the cloud and thus enabling the growth of digital solutions remains crucial. Key aspects to successfully achieving this are the dissemination of technological knowledge around employees, the attraction of further talent with knowledge of CC and other modern technologies, as well as consequent consistent change management within the organization.

CC is still a maturing technology with a multitude of features being added by the large CSPs every week. It is thus not possible to determine all the potential use-cases to be expected from this technology in advance. Specifically, the authors expect a multitude of compelling use-cases to be unlocked by the combination of technologies such as 5G, blockchain, and data lakes with methodologies such as machine learning, artificial intelligence, and advanced analytics on cloud platforms.

With the corporate urge to cover more and more use-cases with IaaS and PaaS, the amount of organizations that pursue multi-cloud approaches will increase to either maximize exploitation of technological possibilities or to expand geographic coverage. Hence, virtualization across CSPs and the automation of administrative tasks will become more relevant.

Another technological trend that will change views on CC is edge computing (also known as "local clouds"), which carry out computations "on the edge" of a network. Acknowledging the trends of connectivity and autonomous driving in the automotive industry, the demand to develop cloud-native applications that run on edge computers will facilitate mobility services. Likewise, the application of the internet of things within production areas will increase importance of edge computing even further and, hence, cloud-native software development, even for non-cloud applications.

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