![iscte INSTITUTO UNIVERSITÁRIO DE LISBOA]

EDGE-CoT: NEXT GENERATION CLOUD COMPUTING AND ITS IMPACT ON BUSINESS

Veronika Koltyukova

Master in International Management

Supervisor:
PhD, Nelson Jorge Campos Ramalho, Associated Professor,
ISCTE-IUL

November, 2020

Marketing, Operations and General Management

EDGE-CoT: NEXT GENERATION CLOUD COMPUTING AND ITS IMPACT ON BUSINESS

Veronika Koltyukova

Master in International Management

Supervisor:

PhD, Nelson Jorge Campos Ramalho, Associated Professor,

ISCTE-IUL

November, 2020

Acknowledgements

"Modern technology has become a total phenomenon for civilization, the defining force of a new social order in which efficiency is no longer an option but a necessity imposed on all human activity"

– Jacques Ellul

Resumo

Objetivo- O objetivo deste estudo consiste em analisar o potencial impacto das tendências futuras de cloud computing na gestão das empresas, a partir da visão de especialistas da área.

Metodologia- Abordagem qualitativa que engloba revisão de literatura e nove entrevistas semiestruturadas com proclamados influencers e lideres globais em cloud computing, destacando-se Jeff Barr, o Vice-presidente da Amazon Web Services.

Resultado- As redes 5G possibilitarão o surgimento da arquitetura Edge-CoT, que consequentemente impulsionará o aumento da aplicação de Inteligência Artificial (AI) e robótica. A combinação de Edge-CoT, Robótica e AI desencadeia o desenvolvimento de Smart Cities e Industry 4.0. Simultaneamente, a Cloud sozinha beneficiará do aumento da conectividade e será a arquitetura preferida comparativamente a Edge-CoT. Novos setores e negócios resultarão do Edge-CoT, e as empresas existentes beneficiarão principalmente de uma melhor experiência do cliente. Os principais desafios organizacionais desencadeados pelo Edge-CoT incluem a requalificação da força de trabalho, a adoção da abordagem agile e uma mudança cultural que estimule experimentos tecnológicos.

Restrição da pesquisa- O processo de recolha de dados foi limitado a 9 especialistas em cloud computing, dificultando assim uma possível generalização.

Originalidade/ Valor- Este estudo utiliza uma abordagem qualitativa para ouvir os especialistas do mercado e cruzar com os resultados teóricos até o momento, aproximando assim a teoria da prática.

Palavras-chave- Cloud computing, IoT, Edge-CoT, Hybrid Cloud Edge, Edge computing

Sistema de Classificação JEL:

O32 - Gestão de Inovação Tecnológica e P & D
O33 - Mudança Tecnológica: Escolhas e Consequências • Processos de Difusão

iv

Abstract

Purpose – The main objective of this paper is to analyze the potential impact of future cloud computing trends on business, from the perspective of specialists in the area.

Design/ methodology/ approach – Qualitative approach that includes literature review and nine semi-structured interviews with proclaimed influencers and global thought leaders in cloud computing, highlighting Jeff Barr, Vice President of Amazon Web Services.

Findings -5G networks will enable the emergence of the Edge-CoT architecture, that will consequently drive the increased application of Artificial Intelligence/ Machine Learning (AI/ML) and Robotics. The combination of Edge-CoT, Robotics and AI/ML triggers the development of Smart Cities and Industry 4.0. Simultaneously, Cloud alone will benefit of increased connectivity and will be the preferred business architecture comparing to Edge-CoT. New industries and businesses will result from the Edge-CoT, and the existing companies will benefit mainly from an improved customer experience. Major business challenges triggered by Edge-CoT include workforce re-skilling, promotion of the agile approach and a cultural shift towards risk-taking.

Research limitations/implications – The research study was limited to the analysis of a selected set of cloud computing trends. Moreover, the data collection process was limited to 9 cloud experts, hindering a possible generalization.

Originality/value – This study uses a qualitative approach to listen to market experts and cross with the theoretical findings to date, consequently bringing theory and practice closer together.

Keywords: Cloud computing, IoT, Edge-CoT, Hybrid Cloud Edge, Edge computing

JEL Classification System:

O32 Management of Technological Innovation and R&D
O33 Technological Change: Choices and Consequences • Diffusion Processes

Table of contents

Glossary of acronyms

Acronym	Meaning
AI/ ML	Artificial Intelligence/ Machine Learning
AWS	Amazon Web Services
CapEx	Capital Expenditure
CPS	Cyber-Physical system
Edge- CoT	Convergence between the technologies Edge computing, Cloud Computing and Internet of Things
IaaS	Infrastructure as a service
IoT	Internet of Things
IT	Information Technology
ITC	Information and communications technologies
OpEx	Operational Expenditure
PaaS	Platform as a service
PC	Personal Computer
QoS	Quality of Service
SaaS	Software as a service
VM	Vitrual Machine
5G	5th generation mobile network
VPN	Virtual Private Network

x

1. Introduction

"If someone asks me what cloud computing is, I try not to get bogged down with definitions. I tell them that, simply put, cloud computing is a better way to run your business."

-Marc Benioff, Founder, CEO and Chairman of Salesforce

According to Bryne (2000) and Scott (1999), an organization will be at a competitive disadvantage if it is unable to adapt to the speed and instability caused by technological change. Technology can be a powerful tool to gain competitive advantage, as it supports the cost-efficient business processes and allows time savings, through the improvement of productive yields (Hussain, Sushil & Pathak, 2002).

Cloud computing revolutionized the way information is stored, accessed, and processed, forever transforming the global technological paradigm. By re-energizing productivity, efficiency and competitiveness of the companies, cloud computing is considered a driver of the global economy, especially the ICT industry (Gai & Li, 2012). Large upfront investments in physical datacenters were replaced by an unlimited amount of internet space, allowing managers to focus on their customers and leverage the uniqueness of their business. As a result, organizations of all sizes, geographies and sectors are developing their own private cloud or purchasing public cloud services from cloud service providers, such as Microsoft Azure and Amazon Web Services (Stein et al., 2020). In fact, U.S. study showed that, in 2018, only medium-sized businesses were likely prefer cloud over on-premises solutions, while small business segments continued to prefer on-premise solutions. Nonetheless, in 2019 — just 15 months later — small businesses were reported to be more likely to prefer cloud (IDC, 2019). Cloud computing became especially relevant in 2020, after the global outbreak of COVID-19 pandemic, as it was proved to be a paramount ally in the effective development and implementation of healthcare surveillance and control systems (Gong et al., 2020; Kaplan et al., 2020). Despite the massive impact of cloud on the economy and organizations, its future promises to be even more dynamic: from one side, the adoption of cloud technology is increasing to a global level. According to Gartner (2020), the public cloud services market is projected to reach a staggering USD364 billion in 2022, representing a 50% growth in comparison to 2019 (Table 1). From the other side, technologies enabled by

the cloud, such as Big Data, are emerging and changing the high-tech paradigm. Lastly, the cloud itself is undergoing changes, that anticipate the emergence of new opportunities and challenges for businesses.

Table 1: Worldwide Public Cloud Service Revenue Forecast (Millions of US Dollars)
Source: Gartner (2020)

	2019	2020	2021	2022
Cloud Business Process Services (BPaaS)	45,212	43,438	46,287	49,509
Cloud Application Infrastructure Services (PaaS)	37,512	43,498	57,337	72,022
Cloud Application Services (SaaS)	102,064	104,672	120,990	140,629
Cloud Management and Security Services	12,836	14,663	16,089	18,387
Cloud System Infrastructure Services (IaaS)	44,457	50,393	64,294	80,980
Desktop as a Service (DaaS)	616	1,203	1,951	2,535
Total Market	**242,697**	**257,867**	**306,948**	**364,062**

= infrastructure as a service; PaaS = platform as a service; SaaS = software as a service

Note: Totals may not add up due to rounding.

1.1 Research Gap

Although the future of cloud is a very popular theme in the technological environment, it seems as if this topic is generally ignored by the managerial and organizational journals, even though the impact of cloud computing on organizations is immense and is in need of investigation (Bayramusta & Nasir, 2016; Senyo et al., 2018). The existing articles tend to use a technological language and focus on aspects of cloud that are outside the domain of a common business administrator without prior background in tech industry. Hence, company managers and administrators are unlikely to find clear and condensed academic information about the future of cloud technology and its impact on organizations. In addition, the majority of cloud computing studies used experiment and simulation as methods of enquiry, disregarding the qualitative, quantitative, and mixed methodologies (Senyo et al., 2018). Addressing the literature gaps mentioned above, the present research aims at applying qualitative methodology to explore and explain the links between different technologies

2

related to the future of cloud computing, through business concepts and terms. Furthermore, it will clarify the future impact of cloud computing on business' strategies and processes, as well as provide recommendations from industry experts on the key elements to consider for a smooth technological transition.

1.2 Research Problem

Cloud computing helps businesses to leverage their unique features and traits, and can be critical for creating and maintaining a competitive advantage in the market. According to Deloitte (2019), "Executives extend the enterprise every time they use a cloud service, outsource a business process, or otherwise spread operations beyond the traditional four walls of their organization.". To assure the survival of the organizations, business managers are forced to address technologies that are becoming continuously more complex and fast changing. The pace of technological evolution drives a growing need to equip business managers with tools that would allow them to navigate the multiple technological waves. Nowadays, cloud computing is a dominant theme in the tech environment, and, despite the existence of vast amount of literature on the future of cloud, none of it addresses business audience, and very few attempt to describe this new paradigm using business concepts, or explore its effect on the organizations. More research involving both academic and industry experts must be conducted to support managers with the optimal strategies to reap the full benefits of emerging technologies. To cover this gap in previous strategy and business literature, this research aims to answer the following research problem:

Clarify the future trends in cloud computing industry, their interdependencies, as well as the impact that will be brought to business at a global scale, and advise them on how to better navigate this technological transition.

1.3 Research Questions

The purpose of this research is to estimate the future trends in cloud computing and its effect on business. The research questions aim to specify the emerging technologies related

to cloud, and its respective relationships and interactions. Finally, this study will test the validity of academic literature predictions on the trends dominating the future of cloud computing. Hence, the research questions are the following:

1) *Is the forecasting of future cloud trends by academic literature in line with the considerations of cloud experts?*
2) *What links exist between the technologies of cloud computing, internet of things, mobile cloud computing and edge computing and the concepts of smart city, industry 4.0 and green cloud, according to cloud experts?*
3) *According to the cloud experts, how will the Edge-CoT paradigm impact business?*
4) *According to the cloud experts, how can businesses prepare for the Edge- CoT paradigm?*

This study is beneficial to both the practical and the theoretical perspectives. From the theoretical point of view, it validates the forecasts predicted by the academic community with the industry experts, as well as increases knowledge in this academic territory. From the practical standpoint, it provides real-word insights on what can businesses expect from the technological evolution, anticipating the opportunities and challenges that will arise from this transition. Moreover, a practical guideline including the recommendations of some of the most recognized global cloud experts will aid the businesses in their strategy planning.

1.4 Research Objectives

The key objective of this research it to aid businesses to navigate the evolution of cloud computing by exploring the main trends in cloud industry and how they will influence businesses processes. This study aims at combining valuable knowledge from both academic and cloud industry communities, to ensure a holistic view on the expectations regarding the future of cloud computing. Furthermore, it will shed light on the links that tie several emerging technologies, allowing to draw a general and simplified picture of the interdependencies between cloud-related technological trends. The objective of this research is to familiarize business administrators with this technology and its advantages for the organizations, in a simplified and business-oriented language and structure. Moreover, this

4

study aims at providing a practical guideline on how to better adapt to the evolution of this technology and to create successful strategies with the aid of cloud computing.

Despite the existence of many academic articles exploring the future of cloud computing, there is little or no business-oriented literature using industry experts to validate the academic arguments and findings. Hence, this study aims at filling the research gap existing in the academic literature, by listening to the viewpoint of industry specialists on the main academic hypothesis and assumptions regarding the future of the cloud computing technology. In detail, this study aims to validate the cloud computing trends developed by the academic community, such as Green Cloud, Smart Cities, Industry 4.0, Mobile Cloud computing Hybrid Cloud and the Edge-CoT hypothesis. The latter will constitute the main object of analysis, as it encompasses the convergence of three key technologies: Internet of things, Cloud computing, and Edge computing.

1.5 Structure of the thesis

This thesis comprises six chapters. The second chapter of this paper provides a concept overview on the term of cloud computing. Moreover, it defines, and reviews earlier literature related to cloud computing, with the aim of providing background to the empirical study. The third chapter outlines the methodological choices of this study. The research methods will be described while justifications on the chosen data collection and analysis methods will be provided. In the fifth chapter, the findings will be discussed and analyzed in the context of the previously reviewed literature. Finally, in the sixth chapter, this thesis will conclude the research and provide recommendations on future research, while acknowledging the limitations of this study.

2. Literature review

This chapter is divided in two main sections. The first part defines and describes cloud computing, its characteristics, main benefits and challenges. The second section explores main academic assumptions regarding the path cloud computing will take in the future.

2.1 Cloud Computing

According to the U.S. National Institute of Standards and Technology (NIST), Cloud computing is a "model that enables a ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources, such as networks, servers, storage, applications and services" (National Institute of Standards and Technology, 2011). These resources can be provided in a prompt manner, and released with minimal management effort or service provider interaction. The term Cloud computing became particularly popular when Amazon Web Services released its Elastic Compute Cloud product, in 2006 (Daylami, 2015).

2.1.1 Characteristics of Cloud Computing

The National Institute of Standards and Technology (2011) further defines five essential characteristics of cloud computing, which include:

• On-demand self-service: A cloud computing service user can leverage computing capabilities whenever necessary without needing cloud provider's supervision.

• Broad network access: Cloud computing service users are able to access datacenters resources online using different devices such as workstations, laptops, smartphones, or tablets.

• Resource pooling: Multiple cloud computing service users share the cloud provider's resources in a multi-tenancy manner, where each user can run and stop these resources as required.

• Rapid elasticity: Depending on the consumer's needs, resources are elastically supplied and released automatically or manually. This means that, from a consumer point of view, the cloud resources and capabilities are often unlimited and can be used anytime.

• Measured services: Cloud service providers charge consumers based on a pay-as-you-go pricing model. The service usage is monitored and reported in real-time, ensuring transparency between the cloud service provider and its users.

2.1.1.1 Service Models

The main service models of Cloud computing are Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). These models determine the degree of control the consumer has over the cloud. In the IaaS model, the consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications. In the PaaS model, the consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment. Lastly, in the SaaS model, the consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, except for limited user specific application configuration settings.

2.1.1.2 Deployment models

The four main deployment models are public, private, community and hybrid cloud. The public cloud is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government institution, or some combination of the three. It exists on the premises of the cloud provider. The private cloud is provisioned for exclusive use by a single organization comprising multiple consumers, such as business units. It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises. The community cloud is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance

8

considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises. Finally, the hybrid cloud is structured by two or more distinct cloud infrastructures (private, community, or public) that are bound together by standardized or proprietary technology.

2.1.1.3 *Benefits of Cloud Computing*

One of the main advantages of cloud computing is cost saving (Aljabre, 2012). Cloud provides cost allocation flexibility for customers wanting to move their capital expenses (CapEx) into operational expenses (OpEx). Costs are also reduced due to operational efficiencies. Cloud's elastic nature allows for a rapid allocation and de-allocation of massively scalable resources with immediate access, enabling a faster deployment of new business services (Bhardwaj et al., 2010). Moreover, the fact that cloud computing has no fixed costs results in a lower investment, reduced risk, and greater flexibility for the businesses. As cloud services are accessible from any location, all the important company operations become available anytime, anywhere. The IT personnel is no longer required to keep the software updated, or other computing issues (Bhardwaj et al., 2010) Finally, customers can enjoy specialized support and advanced security procedures available by the cloud providers with in-depth experience and knowledge in this area.

2.1.1.4 *Challenges of Cloud Computing*

The main challenges of cloud computing explored in this research are the energy-inefficiency of datacenters and the data security of applications and data in the cloud.

2.1.1.5 *Energy-efficiency*

One of the main vulnerabilities of cloud computing is the inefficient energy usage. Datacenters are not only expensive to maintain, but also significantly detrimental for the environment. Cloud computing worldwide consumes more energy than most countries, and only the four largest economies (USA, China, Russia, and Japan) surpass clouds in their annual usage of electricity (Buyya et al., 2018). The rapid increase in cloud's energy consumption and in the relative cost of energy in the total cloud expenditures demands an

increased attention from the academic community on how to minimize cloud's energy usage (Buyya et al., 2010).

2.1.1.6   Security

Security is a major concern in Information Technology (IT) industry, and cloud computing is no exception. As enterprise boundaries have been extended, traditional security structures and processes are no longer appropriate for applications and data in cloud. Considering cloud's openness and multi-tenancy, the major security concerns are software, infrastructure, storage and network security (Singh et al., 2016). Software security deals mostly with bugs, buffer overflow and designed flaws, as these constitute a critical issue when building a cloud environment (Sun et al., 2011). Storage security is a key aspect of cloud providers' Quality of Service (QoS), as the data stored in the cloud is no longer owned by the user that stored it in the first place. The major concerns of storage security are data leakage, cryptography and malware. As cloud's network is the backbone of the entire cloud environment, it represents a key security concern for cloud providers. Network security is associated to both internal and external attacks, that can either occur in the virtual or physical network (Singh et al., 2016). Overall, cloud vendors must continuously demonstrate the security and reliability of both virtual and physical infrastructure of the cloud, as it constitutes a key element of vendor's value proposition and reputation.

2.2 Future trends in Cloud Computing

Cloud computing is growing on a daily basis, hence, it provides a vibrant technical environment where innovative solutions and services are created (Ardagna, 2015). According to Varghese and Buyya (2018), the resources and services offered on the cloud have rapidly changed in the last decade. This chapter will summarize the main academic assumptions regarding the path cloud computing will take in the future.

Varghese and Buyya (2018) divide the trends and directions of the next generation cloud computing in four different branches: emerging architecture, changing infrastructure, impact areas and directions (Fig. 1). Most of the trends explored in this research relate to either two or more technology integrations, or a deviation of the cloud itself. The main trends describe a convergence between cloud computing and other emerging technologies, namely Internet

of Things, Edge/fog computing and Grid computing. Moreover, different variations of cloud computing are expected to develop, such as the Green cloud, the Volunteer cloud, the mobile cloud, and an increased popularity of the hybrid cloud /multi-cloud. Lastly, the concepts of Smart City and Industry 4.0 are related by many academics relate cloud computing, therefore, they will be included in this analysis.

Figure 1: A snapshot of trends and directions in next generation cloud computing
Source: Varghese & Buyya (2018)
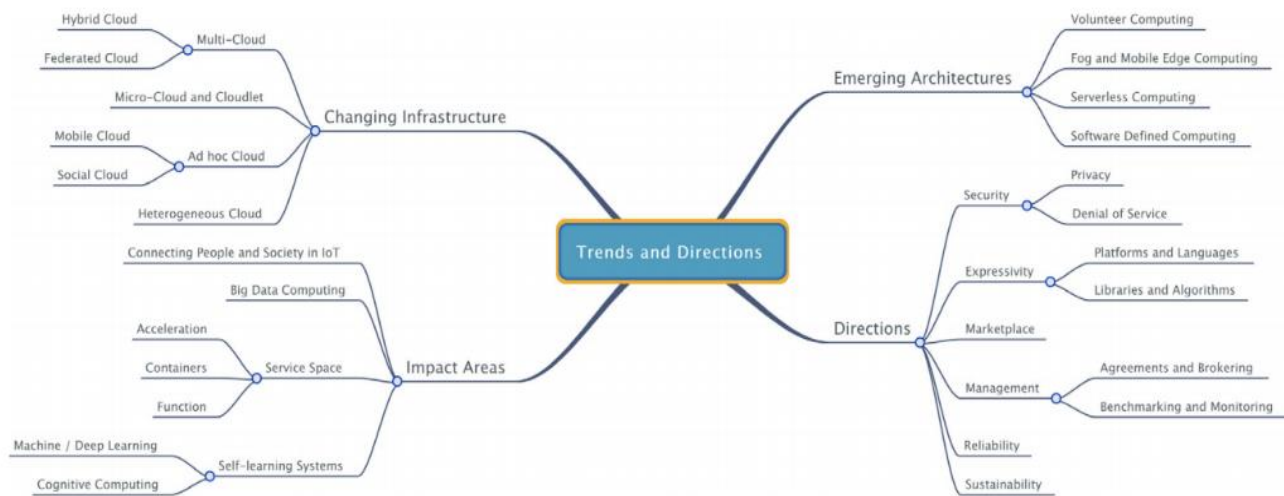
2.2.1 Cloud and Internet of Things

Nowadays, Internet of things (IoT) has been gaining increasing attention (Yu et al., 2018; Ray et al., 2019). In IoT, smart and self-configuring devices and sensors are interconnected in a dynamic and global network infrastructure. This enables increased scalability, flexibility and agility mainly in fields of massive scale multimedia data processing, storage, access and communications (Kobusinska et al., 2019).

Xia et al. (2017) and Belcastro et al. (2017) argue that the future development of cloud computing systems is more and more influenced by IoT. Therefore, Cloud-assisted Internet of Things (Cloud-of-Things or in short CoT) has recently emerged as a groundbreaking model that enables smart IoT devices and sensors to be connected with the cloud through the Internet (Abawajy et al., 2019). CoT enables IoT devices to benefit from both cloud's

powerful and scalable high-performance computing and massive storage infrastructure for real-time processing and storing of the IoT data. Nonetheless, the CoT paradigm is currently facing increasing difficulty to handle the Big data that IoT generates. According to Abawajy et. al (2019), "As billions of previously unconnected devices are now generating more than two exabytes of data each day, it is challenging to ensure low latency and network bandwidth consumption, optimal utilization of computational recourses, scalability and energy efficiency of IoT devices while moving all data to the cloud".

Consequently, in recent times, this centralized CoT model is undergoing a transition towards a decentralized model termed as edge computing. The edge computing model offers cloud's computing and storage capabilities, on a smaller scale and in real time. This is achieved by moving data computing, storage and service supply from cloud to the local edge devices such as smartphones, smart gateways and local PCs. Thus, edge computing complements CoT paradigm by providing high scalability, low delay, location awareness, and allowing of using local client computing capabilities in real time. The convergence between these three technologies results in a new technological paradigm: the Edge-Cloud-of-Things (in short, Edge- CoT).

Figure 2: Technological constitution of the Edge Cloud-of-Things (Edge-CoT) model

12
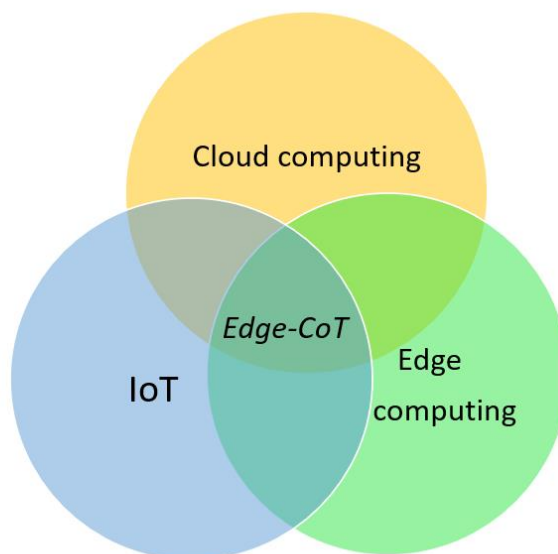
2.2.2 Cloud and Edge/Fog Computing

Edge Computing, also referred to as Fog computing (Bonomi et al., 2012) is a computing concept which performs computation on distributed edge devices, enabling the data collection over network (Singh & Chana, 2015). Edge computing processes large amounts of data at the edge devices instead of cloud server, hence, it improves the QoS and reduce latency, as well as the transmission cost (Bonomi et al., 2012; Dawoud et al., 2018; Ali & Alam, 2019). The time sensitive applications, such as autonomous cars, can take more advantage from edge computing, nonetheless, this technology needs continuous Internet connection to perform the appropriate functions within a given time. Fog computing, on the other hand, is the denomination of the architecture that provides services at the edge of a network (Bonomi et al., 2012). Fog computing also supports IoT devices, such as mobile phones, sensors and health monitoring devices (Gill et al., 2019). Some academics see Fog as a supplement to the cloud, instead of replacement. Fog would find it challenging to replace cloud completely as cloud is still needed to handle big or complex data problems (Gill et al., 2019). Fog only provides services which are not offered by cloud, in the same time limit or latency requirements (Rao & Clarke, 2020). The applications demanding low response time (as real-time applications i.e., traffic system, emergency system, healthcare system etc.) go for fog services instead of cloud services. Nonetheless, if the application is not time sensitive, then use of cloud computing services is more beneficial.

2.2.3 Mobile Cloud Computing

The concept of mobile cloud computing differs from the traditional mobile computing model mostly by offering on-demand, self-service, measured, elastic, and broad access mobile services. (Noor et al., 2018). The mobile cloud computing model attempts to combine the benefits of both mobile computing and cloud computing (Dinh et al., 2011; Fernando et. al.,2013) From one side, mobile devices are designed with constrained hardware, software, and communication capabilities. From the other, enormous computing capabilities are delivered as services by cloud to reduce cost, improve performance, or allow remote access.

The combination of both mobile and cloud computing therefore allows mobile devices to perform complex computations that require more powerful computing resources. (Noor et al., 2018).

2.2.4 Cloud and Industry 4.0

Commonly referred to as the fourth Industrial Revolution, smart factory and intelligent factory, the concept of Industry 4.0 was introduced by the German Federal Government to refer to the current trend of establishing smart products and production processes (Brettel et al., 2014). This trend leverages up-to-date automation and data exchange technologies, such as Cyber-Physical Systems (CPS), Internet of Things (IoT) and Cloud Computing (Pedone & Mezgar, 2018) Industry 4.0 is particularly relevant in its potential to address economic, social and ecological problems (Kagermann, 2015; Schneider, 2018; Gisbert et al., 2014), From an economic viewpoint, the implementation of Industry 4.0 has potential to enhance value creation and competitiveness (Porter & Heppelmann, 2014), improve production flexibility and efficiency (Hossain & Muhammad, 2016), improve the time of reaction to critical events (Civerchia et al., 2017), and reduce of logistics costs (Zhong et al., 2015). From an ecological viewpoint, Industry 4.0 has showed reductions in greenhouse gas emissions (Peukert et al., 2015), and waste (Berman, 2012) in the organizations where it was implemented.

2.2.5 Green Cloud

Data centers are known for their massive environmental impact due to large carbon footprints (Varghese & Buyya, 2018). In 2014, it was reported that the US data centers consumed about 70 billion kilowatt-hours of electricity, constituting approximately 2% of the total energy consumed in the US (Datacenter Knowledge, 2016). While datacenters are an essential element of the computing ecosystem, innovative architectures are required for its sustainable progression. Hameed et al. (2016) and Duan et al. (2017) argue that useful contributions in this space can be achieved by developing algorithms that rely on geographically distributed data coordination, resource provisioning and carbon footprint-aware and energy-aware provisioning in data centers. These are expected to minimize energy consumption of the data center and maximize the use of green energy while meeting the application's QoS expectations. Incorporating energy efficiency as a QoS metric has been

14

recently suggested (Singh et al., 2017). Current Cloud systems primarily focus on consolidation of Virtual Machines (VMs) to minimize energy consumption of servers. However, cooling systems and networks consume a significant proportion of the total energy consumed. New techniques need to be developed to manage the degree of servers' energy efficiency, networks and cooling systems (Varghese & Buyya, 2018). These techniques can leverage the interplay between IoT-enabled cooling systems and data center managers that dynamically make decisions on which resources to switch on/off in both time and space dimensions, based on workload forecasts. If the energy consumption is not minimized, Cloud's increasingly pervasive front-end client devices interacting with back-end datacenters will cause an enormous escalation of energy usage. To address this problem, datacenter resources need to be managed in an energy-efficient manner to drive Green Cloud computing (Gill et al., 2019).

2.2.6 Multi-Cloud and Hybrid Cloud

Traditionally, the notion of multi-cloud refers to leveraging resources from multiple data centers of a provider. Nonetheless, applications soon were hosted to utilize resources from multiple providers (Petcu et al., 2013). A multi-cloud can also take the form of a hybrid cloud - a combination of public and private clouds or a combination of public and on-premises infrastructure (Bernstein et al., 2009; Zhang et al., 2011). It gives an organization the ability to scale its on-premises infrastructure, and consequently handling workload spikes that demand more resources than available locally. A hybrid cloud brings the "best of both worlds" in terms of security, resilience, cost saving, scalability and reliability (Varghese, 2018). Security-wise, a hybrid cloud enables organizations to split the data into sensitive and insensitive for storing respectively in the private and public clouds (Mansouri et al., 2020). It allows organizations to add/remove resources to/from their pool of resources as workload changes, while offering higher reliability in the case of natural disasters as users can recover data from backup if data was replicated in both clouds. Finally, a hybrid cloud mitigates capital expenditures to handle short-term spikes in workloads that require resources beyond the available ones in a private cloud. Nevertheless, a connection between private and public clouds can be costly. These features can be achieved through a secure, resilient and cost-free Virtual Private Network (VPN) that connects the private and public clouds involving in the

hybrid cloud. Being no exception, a hybrid cloud arises several challenges in two dimensions. The first one is implementation of hybrid clouds for which robust, automated, secure and cost-effective connection, network routing, and provisioning cloud infrastructure should be figured out (Varghese, 2018). The second dimension is the deployment of applications in hybrid clouds for which automated resource discovery and optimized QoS– such as monetary cost and response time for running applications on a hybrid cloud–should be addressed.

2.2.7 Grid and cloud computing integration

Despite the rapid growth of cloud computing, its underlying technology is based on models like cluster computing, distributed computing, utility computing and grid computing (Sadashiv & Kumar, 2011). Foster (2002) defined grid as a "system that coordinates resources which are not subject to centralized control, using standard, open, general-purpose protocols and interfaces to deliver nontrivial qualities of service". From one side, Grid computing shares the same vision as cloud computing, which is to reduce the cost of computing, increase its reliability and flexibility (Foster et al., 2008). Nonetheless, Grid differs from Cloud to the extend that it coordinates resources that are not subject to centralized control, and uses standard, open, general-purpose protocols and interfaces (Foster, 2002). According to Gai and Li (2012), the integration of grids and clouds will become one of the trends of clouding development to optimize cloud-base services, grid services and e-infrastructures. The approaches that integrate grids and clouds can be operated through both "grid on cloud" and "cloud on grid" models (Keahey et al., 2005; Foster et al., 2006).

2.2.8 Volunteer computing

Volunteer computing is a crowd funded model in which spare resources from user computers or devices are volunteered and an ad hoc cloud is created (Varghese & Buyya, 2018). Such computing model may be especially useful to support applications with a societal or scientific focus (Gai et al., 2012). Volunteer cloud computing can take different forms. For instance, users of a social network may share their heterogeneous computing resources in the form of an ad hoc cloud. This particular model is referred to as 'social cloud computing' (Chard et al., 2010). The most reliable owners are compensated through a reputation marker within the social network. For instance, the Cloud@Home project rewards volunteers though

16

a payment for their resource donations (Distefano & Puliafito, 2012). The challenges that need to be overcome to fully benefit from volunteer cloud computing are mainly minimizing the overheads for setting up a highly virtualized environment given that the underlying hardware will be heterogeneous and ad hoc. Moreover, the security and privacy concerns will need to be addressed to boost confidence in the public to more readily become volunteers for setting up ad hoc clouds. Finally, the development of a consistent platform that can integrate social networks with cloud management is advised (Varghese & Buyya, 2018).

2.2.9 Cloud and Smart cities

In the last few years, the rapid growth of urban areas is causing the emergence of social problems, such as traffic congestion system, inefficient urban management, imperfect environmental monitoring systems, uneven educational resources and a non-satisfactory emergency response system (Han et al., 2014; Robbins et al., 2019; Yao et al, 2014).

The concept of smart city centers on next-generation technologies such as the Internet of Things and cloud computing and has become a new model for future urban development (Creutzig et al., 2015; Zhang et al., 2014). Jiang (2020) argues that smart cities are the inevitable result of the development of urban models. The construction of smart cities can significantly solve the dilemma related to urban development, improve the level of urban information management, and promote the development of high-end industries nationwide (Xu et al., 2015). It can collect information comprehensively and transparently, transmit information widely and safely, and processing formation intelligently and efficiently. Not only it has the potential to promote urban management and operational efficiency and improve urban service levels, as it's a valuable ally for sustainable urban development.

The emergence of the smart city concept goes hand in hand with the growth in internet application. Internet of things, big data and cloud computing are the main technologies driving the emergence of Smart cities: while internet of things gathers large amounts of data (also known as Big Data), the cloud computing model is responsible for the Big Data processing through the widely distributed computing resources in the cloud.

2.3 Literature review outline

The literature review clarified the position of the academic community in relation to future trends in cloud computing. After considering the limitations of this research, only a few trends were chosen for further analysis. Mobile cloud computing and Green cloud, as well as Edge-CoT model, that describes the integration of cloud with IoT and edge computing, were considered the trends of greatest impact and relevance, for which they will be the object of a future in-depth analysis. Moreover, the impact of cloud computing on industry 4.0 and smart cities will also be investigated in the following chapters. During the analysis of academic literature, attention was drawn to the premise of Abawajy et al. (2019) and Varghese & Buyya (2018), stating an integration between cloud and internet of things (Cloud-of-things, or in short, CoT). The argument continues that, in the face of an increasing difficulty in handling the Big Data that IoT generates, the CoT model will shift towards the decentralized approach of edge computing. This model will allow data computing, storage and service supply to be moved from the cloud to the local edge devices, such as smartphones and local PCs, that can offer computing and storage capabilities in a smaller scale and in real-time. Thus, edge computing is believed to complement the CoT paradigm in terms of high scalability, low latency, location awareness, and allowing of using local client computing capabilities in real time. The Edge-CoT hypothesis will thus become the main object of this research, and its validity will be verified via semi-structured interviews with cloud experts, in the following chapters.

3. Methodology

This chapter aims to describe and explain how the research was conducted, highlighting the methods and strategies that were used in order to answer the research questions and achieve the objectives. Data collection was conducted via interviews, which have a semi-structured nature. Cloud Computing experts have been chosen as interviewees, due to their vast experience in dealing with cloud technology.

3.1 Theoretical viewpoint

Firstly, the theoretical viewpoints of this study will be analyzed. A business research study can be built on three different epistemological grounds: the positivism, the subjectivism, and the critical realism (Eriksson & Kovalainen, 2016). The positivist viewpoint assumes that reality is composed by easily observable and concrete materials.; the subjectivistic viewpoint presumes reality as a socially constructed phenomenon; and the critical realism, assumes that people interpret experiences in different manners due to their individual backgrounds. Critical realism provides subjectivity to the research by highlighting that the perception which we have of our world, is dependent upon our own beliefs (Gray, 2013). Based on the analysis by Eriksson and Kovalainen (2016), this research assumes a critical realist starting point as it is believed that people interpret situations differently based on their socio-cultural backgrounds and individual beliefs.

3.2 Case-study methodology

This section specifies which of case study method this research will follow. Eriksson and Kovalainen (2016) further divide case study research into two approaches; the intensive and extensive case study approaches. The intensive case study approach focuses on the uniqueness of a particular case, while an extensive approach uses several individuals or cases as the objects of the study. Yin (2003) outlines that the intensive case study approach, also referred to as single case study method requires extensive investigation into specific events and contexts while focusing on a unique individual case. Hence, focusing on just one single case would allows to study the phenomenon in-depth. Nonetheless, as this study focuses on the collection of experiences and aims to explore the future trends in cloud computing, and

furthermore compares the findings with the academic literature, a single-case study would be limited in its ability to explain several phenomena simultaneously. On the other hand, a multiple case study, allows the researcher to focus on the phenomena, while making comparisons between the cases and identifying any existing common patterns (Eriksson & Kovalainen, 2016). Therefore, as the answering of the research questions requires the viewpoints and contributions of several individuals, this study has been constructed as an extensive business study through multiple case analysis, applying the theories of Eriksson and Kovalainen (2016) and Yin (2003). Relying on multiple case studies also enhances reliability and validity of the research, as it allows to test the theoretical framework of this research with cloud specialists, to draw out better managerial and societal implications.

3.3 Data analysis strategy

Eriksson & Kovalien (2016) distinguish two main strategies of data analysis. The first is based on a pre-formulated theoretical proportion and a respective coding system. The second is based on development of a case description, which would then form the basis for emerging research questions and a framework for organizing the case study. The latter is preferred, as it means that the research questions are either formulated or at least refined and refocused in the process of the analysis procedure.

3.4 Research design

To date, not much research has been conducted on the business viewpoint on cloud computing trends. Thus, the primary purpose of this study is to fill the gap of business oriented literature on cloud computing. Furthermore, this study focuses on validating academic literature on cloud computing with recognized real-world experts in cloud computing. Finally, this thesis attempts to increase business knowledge on the world's main technological trends to the businesses, by drawing an interdependency model. The exploratory nature of this study makes qualitative research method an appropriate choice.

Qualitative research is recognized by providing better grounds for studying phenomena with little prior knowledge (Eriksson & Kovalainen, 2008). As this research requires the analysis of an extensive phenomena, while still keeping the focus on theory-building throughout the study, a qualitative research will provide the necessary methods to find

answers to the research questions. Connecting with the critical realist viewpoint of this study, individual opinions and experiences play a key role in the construction of conclusions and therefore this study is prone to be qualitative (Eriksson & Kovalainen, 2016). Lastly, qualitative study also allows the researcher to collect context-sensitive data, while providing an holistic view (Eriksson & Kovalainen, 2016).

3.5 Data collection

For this research, the data was collected through qualitative interviews. Interviews are beneficial to all qualitative researchers as they provide a considerable amount of data collection both in quantity and quality (Kvale, 1996). Since the individuals interviewed are experts in the technologies being studied, a pragmatic approach presented by Creswell (2007) was adopted.

3.5.1 Semi-structured interviews

Semi-structured interviews were chosen for this study to keep the discussion as open and flexible as possible. Brinkmann and Kvale (2015) discuss how this type of interview will give the informant the time to answer both the set questions along with any follow-up, probing, specifying, direct, structuring, and interpreting questions. Therefore, the interviews can be defined as Research Interviews, where knowledge is produced primarily by the interviewee. In addition, semi-structured interviews were chosen for this study as they allow the researcher to adjust the flow of the interview according to each particular situation while providing the opportunity to ask additional questions throughout the interview. Semi-structured interviews entail that the questions are the same for each interviewee, however the order of the questions can change based on the responses of each individual interviewee (Rabionet, 2011).

Considering the research conducted by Kvale (1996), we scripted the interview through dynamic or thematic questions and stressing the roles of the "why", "what", and "how". The interview questions were structured to be concise and straightforward, and categorized into introductory, probing, specifying, indirect, direct, structuring, interpreting, and follow-up questions. Furthermore, scientific and journal articles which are publicly available were

incorporated into the research to provide an extensive description of the case. Yin (2003) advises the use of multiple sources to achieve strong evidence through triangulation. Alongside supporting documentations and literature review, we conducted several interviews to gather the necessary knowledge.

3.5.2 Interviewees

According to Eriksson and Kovalainen (2016), in an extensive multi-case research, the chosen cases should be similar enough to produce new theory, while having some different cases to allow for interesting comparisons from which the theory can be verified. Applying this guideline, the selection criteria for the interviewees followed an approach which allowed to gather viewpoints of cloud specialists with different background and geographical location Thereby, it was determined that nine cloud experts should be used to represent the cloud experts in this study. Nine was determined as an optimal number as it provided an in-depth data collection process, while still taking into consideration the resource constraints of this study. The requisites to comply with the expert status include a proven expertise in cloud computing and related technologies. Furthermore, the subject had to be deeply familiar with the terms Cloud computing, Edge computing, Internet of Things and Mobile Cloud Computing, which was clarified at the beginning of the interview. Finally, interviewees experienced in public speaking were preferred, due to their ability of easily share technological knowledge using business terminologies and concepts. The interviewees were selected from ranks listing the global influencers and thought leaders in cloud computing for the years of 2019 and 2020 (Table 2).

Table 2: Description of the interviewees

Name	Current company	Current position	Type of organization	Current Location	Global cloud expertise validation	Additional Information
Lee Atchison	Atchison Technology LLC	Owner and Consultant	IT consulting	Washington, US	Ranking as 13th at Top 50 Global Thought Leaders and Influencers on Cloud Computing (January 2020) according to Thinkers 360	Author, Speaker, Advisory Board Member at Tombolo Institute (Bellevue College)
Sarbjeet Johal	Self-employed	Cloud Consultant	Cloud consulting	San Francisco, US	4th position in the Top 100 Cloud Influencers according to Onalytica (as of 4th of February, 2020)	Founding Investor and principal advisor at the Batchery
David Linthicum	Deloitte Consulting	Chief Cloud Strategy Officer	Consulting	Ashburn, US	6th position in the *20 Cloud Influencers You Should Be Following In 2020* rank, according to TotalCloud	Best-selling Author, Speaker, Radio, TV and Podcast Personality
Omid Mahboubi	Founder and Cloud Evangelist	MENA Cloud Alliance	Cloud Community	Dubai, UAE	20th position at Top 50 Global Thought Leaders and Influencers on Cloud Computing (January 2020) according to Thinkers 360	International Speaker, Entrepreneur and Community Builder
Lawrence Dignan	Journalist and Vice President	ZDNet, TechRepublic and TechRepublic Premium (business technology online journals owed by Red Ventures)	Technology journals	Morrisville, US	16th position at the Top 100: Cloud Influencers rank by Onalytica (as of 4th of February 2020)	Technological Writer, Social Media Personality
Jeff Barr	Vice President & Chief Evangelist	Amazon Web Services	Cloud vendor	Seattle, Washington, US	2nd position at the 20 Cloud Influencers You Should Be Following In 2020 rank by Totalcloud	Public Speaker, Blogger, Social Media personality
Imtiaz Adam	Founder, Director of Machine Learning and Digital Strategy	Deep Learned Strategies Limited	Digital transformation	London, England, United Kingdom	8th position at the Top 20 Artificial Intelligence Influencers on Twitter by The Awards Magazine (as of May 2020)	Public Speaker, Social Media personality
Bernard Golden	Chef Executive Officer	Navica	Cloud consulting	San Carlos, California, US	Member of the Top 10 Cloud influencers and thought leaders according to WIRED (as of 2018)	Business mentor, best-selling author
Danilo Poccia	Chief Evangelist (EMEA region)	Amazon Web Services	Cloud vendor	London, United Kingdom	More than 8 years of experience with Cloud at AWS	Public Speaker, Social Media Personality, Blogger

3.5.3 Interviews' overview

Global thought leaders and influencers in cloud technology, listed in global rankings on cloud expertise by Thinkers 360, Onalytica, WIRED, Totalcloud and The Awards Magazine, were contacted via LinkedIn Direct. The Sales Navigator tool, integrated in LinkedIn, allows contacting the highest levels of the corporate hierarchy, such as business owners and C-levels. A contact from AWS, with extensive knowledge in Cloud computing, already existed prior to the conduction of this study. The researcher was granted nine interviews with world-recognized leaders in cloud computing, IoT and edge computing technologies. All the interviewees work with these technologies daily, advising their customers on the best strategies to leverage cloud computing.

After the initial contact via LinkedIn, a date and time was set for a meeting. The interviews were conducted during the year of 2020, having an average duration of 38 minutes. The communication platform used was Zoom, and all the interviews were conducted in English. Lastly, it is of relevance to mention that no questions were sent to the cloud experts prior to the interviews.

3.6 Data analysis

The data analysis process of this study started with the transcription of the interview records and then moved on to categorization and coding through predetermined themes (refer to Table 2).

Further comparison and synthesis allowed the theoretical interpretation of the findings (Hirsjärvi & Hurme, 2004). The data was divided into three main sections, with subsequent sub-groups, constituting the research questions of this study. The *Technological links dominating the future of Cloud Computing* section focused on the validation of the academic literature, and analysis of the dynamics between the technologies Cloud Computing, Internet of Things, Edge Computing and Mobile Computing. Moreover, this section attempts to connect the Edge-CoT theory to the rise of Smart Cities, Industry 4.0, Artificial Intelligence and Machine Learning. The *Edge-CoT and its impact on businesses* section analyzes the

impact of these trends on businesses, while the *Expert's Recommendations* gathers expert advice on how to better navigate this new technological paradigm.

Table 2: Data analysis process

Phase 1	*Phase 2*	*Phase 3*	*Phase 4*
Interview record transcript	*Individual case coding and analysis*	*Cross-thematic analysis*	*Comparison to existing theory*

3.6.1 Interview record transcript

Brinkmann and Kvale (2015) introduce the analysis of the recording by transcription. The interviews were all conducted through video calls on Zoom. The videos were recorded using a videorecorder called ActivePresenter and Zoom Recording option. Furthermore, the smartphone voice recorder was placed next to the speakers in order to have two versions of the audio file. At the end of the interview, both audio files were duplicated as a means for recovery and backup in the event of an accident. The recordings were used to transcribe the interviews. According to Brinkmann and Kvale (2015), the process of transcribing interviews means to transform them from audio to text. This can lead to the abstraction of body language and tone, nonetheless, it was proved imperative if the data will be studied and analyzed. Each transcription was written word for word with a few modifications added to make the interview more fluent on paper. Brinkmann and Kvale (2015) advise researchers to avoid tedious transcriptions and advise the researcher to conduct a fluent and concise transformation.

3.6.2 Individual case coding and analysis

After the interview record transcript, each case was analyzed separately to understand the background, opinion, and position of each expert individually. The categorization and coding allowed to identify patterns in expert's position regarding the predetermined themes. The important or key statements in the transcription were marked in light blue, then categorized according to their main themes (refer to Table 3). The findings will not only validate the academic literature and increase our understanding of these technologies, as they

will provide a guideline for business administrators on how to better prepare their organizations for this new technological paradigm.

3.6.3 Cross-thematic analysis

Thematic analysis provides freedom for the researcher and can be used in several different theoretical backgrounds (Braun & Clarke, 2006). The themes used in this research were based on the findings of prior literature, while maintaining the connection to the research questions and objectives. Nonetheless, during the data collection process, the predetermined themes were revised, and any new emerging themes were added to the data analysis process. The final thematic coding has been outlined in more detail in the table 3 below, encompassing the Thematic Analysis.

Table 3: Thematic Analysis

Thematic Analysis		
Technological links dominating the future of Cloud Computing	*Edge-CoT and its impact on businesses*	*Expert's Recommendations*
Edge-CoT hypothesis as the future of Cloud Computing	Changes brought by the Edge-CoT hypothesis	Expert advise for businesses
Mobile Cloud Computing as part of the Edge-CoT hypothesis	Business opportunities brought by the Edge-CoT hypothesis	In-house IT workforce training versus hire of external consultants
Smart Cities and the Edge-CoT hypothesis	Business challenges brought by the Edge-CoT hypothesis	Cloud versus on-premises: security comparison
Industry 4.0 and the Edge-CoT hypothesis	No. years for Edge-CoT hypothesis ro reach maturity in the market	
Green Cloud and the Edge-CoT hypothesis	First country/ region to adopt the Edge-CoT hypothesis	
AI/ML and the Edge-CoT hypothesis		

3.6.4 Comparison to existing theory

Finally, the data analysis process included the comparison of the empirical data to previous literature and existing theory to conceptualize and interpret the studied phenomena.

3.7 Scientific Quality and Ethical considerations

According to Eriksson and Kovalainen (2016), a qualitative research is traditionally evaluated by the quality and trustworthiness of the study. Thus, the overall quality of a research can be improved by preparing proper interview guides and transcribing the interviews in an appropriate manner, and moreover by conducting these quality measures throughout the data collection process, rather than at the end (Hirsjärvi & Hurme, 2004). These measures were applied in this research, as interview guides were prepared beforehand, and the interviews were transcribed right after the interview took place, which also allowed making adjustments to the data collection measures throughout the process and not just at the end of the research (Eisenhardt, 1989).

Eriksson and Kovalainen (2016) further outline that research that is based on the critical realist viewpoint should be evaluated based on reliability, validity, and generalizability. Validity and reliability are often mentioned as the key criteria for a trustworthy study (Hirsjärvi & Hurme, 2004). Validity refers to the study of the phenomenon with previously proven reflections of the phenomenon, while reliability is essentially the ability to repeat the study with the same unit of analysis (Yin, 2003). Generalizability then refers to the ability to apply the findings of the study to different contexts than the one applied in the research itself (Eriksson & Kovalainen, 2016).

The reliability of this study stems from the well-planned method, which provides the opportunity to conduct the same research again. However, it should be noted that due to the fact that this study utilizes experiences and opinions as the basis of analysis, these opinions and reflections on experiences might differ as time progresses. Validity of this study can then be proven by the previous academic literature, on the grounds of which the empirical research has been constructed. Thus, the data collection measures have followed a path predetermined by prior academic knowledge. Furthermore, it is important to evaluate the bias that is present in this research, which can affect the validity of the study. Therefore, it should be highlighted that the interviews are biased to the specific opinions of the interviewees. Furthermore, as the industry experts represent the views of their respective industries, they might be more biased towards their own profession. In addition, the coding and analysis of the interviews is also subject to some bias as the process is purely based on the researcher's interpretations.

The thematic patterns that will be evaluated are also based on researcher's conclusions. Thereby, some unavoidable subjective bias can be found in research design.

The data collection is limited to the nine industry experts. Hence, the generalizability of the results in a different context is limited even though the selection of an appropriate method reduces these limitations. Due to this limitation in the extent of the research data, the study cannot be considered applicable to every Cloud expert. Furthermore, as already previously stated, this research follows a critical realism foundation and thus due to the critical realist viewpoint, this study will provide an example of interpretations of a selected sample but should not be taken as the only truth of the phenomenon applicable to every context.

Finally, the ethical considerations of this research need to be evaluated as the ethical issues of a research affect the whole research process. In terms of the ethical concerns of this study, the guidelines of Eriksson and Kovalainen (2016) are followed. More specifically, the guideline stating that every researcher should treat other researchers and participants of the study with respect has been followed in this study. This has been ensured by proper citation of previous work, and by ensuring all research participants were informed and granted anonymity if wished upon. All interviewees have voluntarily participated in this research and permission to record the interviews have been asked prior to the interview. Moreover, any sensitive data was left out as the interviewees will not reveal such information of their own companies and employers. Finally, all prior secondary data has been appropriately cited and credit has been given to work, which has not been the product of this research.

4. Empirical Findings

4.1 Technological links dominating the future of cloud computing

The cloud experts confirmed that the integration of Cloud computing, Internet of Things and Edge computing, also known as the Edge-CoT paradigm, plays a major role in the future of cloud Computing. The rise of 5G will improve network connectivity, empowering both Edge computing and Internet of Things, and all the unexplored opportunities these new technologies will bring. Nonetheless, many experts argue that, besides the convergence trend, cloud computing alone will still be predominant in our lives, as the 5G networks also improve cloud connectivity. Not only will these two trends coexist, as cloud computing alone will be preferred, due to its familiarity, ease of use and relatively low cost. The main use cases where the convergence technologies will be chosen are situations in which a low-latency would be unacceptable, or when the data processing time should be as low as possible, like in the example of autonomous cars. Finally, the convergence theory has been declared as an already existing but very recent concept– the *Hybrid Cloud Edge*.

Mobile Cloud computing was considered by all interviewees as an element of the convergence premise, instead of a trend on its own. Due to its blurred nature, Mobile Cloud computing falls between the IoT and Edge computing category. 8 out of 9 cloud specialists confirmed the Edge-CoT hypothesis as being the main driver for the emergence of Smart Cities. The computational power provided by cloud is the foundation of this trend. The smart sensors empowered by IoT and edge technologies spread across the city to collect data will allow for a more efficient city. By measuring and analyzing data, smarter choices can be made in all city life aspects. Nonetheless, according to Jeff Barr, the whole purpose of cities will suffer a change in the eyes of the society, as the 5G connectivity and cloud technology enabled remote work, which eliminates the distance issue and allows people to live and work in remote areas of the country. Similarly to Smart cities, the convergence hypothesis was confirmed as one of the main drivers of Industry 4.0. other important technologies supporting the growth of Industry 4.0 are cyber-physical systems, AI/ML, and smart sensors.

The impact of the Edge-CoT hypothesis on the emergence of the green cloud was equally disputable by all experts: from one side, the Edge-CoT technologies will increase compute energy needs, leading to the increase in the number of datacenters, and consequently, of Cloud's carbon footprint. On the other hand, the integration of smart and technologies such as AI/ML, IoT and edge computing has potential to be significantly more efficient than manual processes. This way, it is argued that the convergence theory will in fact contribute to the rise of a more sustainable cloud infrastructure. Moreover, cloud datacenters are known by being more energy efficient than traditional on-premises infrastructure. Following this logic, an increase in cloud usage will result in less on-premises datacenters and a higher rate of utilization of cloud's datacenters, leading to a lower carbon footprint. Lastly, companies have profit incentives in the development of a more efficient cloud, and are actively investing this domain, with the example of Microsoft's underwater datacenter experiment.

The Edge-CoT technologies were also recognized as the driving factor for Artificial Intelligence and Machine Learning by all experts. The ease of access to compute resources is the main AI-enabling opportunity brought by cloud. Moreover, the increase in edge devices will create an exponential rise in the amount of available data, that is a key component for the successful training of AI/ML. In fact, the more quality data is fed to the machine during its training, the better predictions and responses you are going to get. Finally, some experts argue that AI cannot be scaled without Cloud, edge computing and IoT. Other drivers for the development of AI and ML include increased academic research and relatively easy-to-use Machine Learning tools.

4.2 Edge-CoT hypothesis and its impact on business

All experts agree that the impact of the Edge-CoT hypothesis on businesses will be tremendous. According to Lee Atchison, the convergence will drive the emergence of new industries and businesses, that are expected to leverage AI and ML. Furthermore, a dramatic change in all existing industries is inevitable. Sarbjeet Johal believes these changes will deeply affect the main factors of an organization: People, Processes and Product. The paradigm of people management will shift as communication boundaries are removed, and 3D and Virtual Reality technologies gain ground. 3D and 5G will allow to produce goods closer to the customer, resulting in less shipping and package utilization. Digitalization and

3D printing will also affect all factors of the Products' dimension. According to Omid Mahboubi and David Linthicum, the convergence will bring the ability to leverage technology strategically, instead of just automatic the manual tasks. As a result, businesses will have to re-think what new values they bring to the table and how better can they do the job they have always been doing. Lawrence Dignan argues that the convergence will force businesses to undergo digital transformation, and to be more agile. According to Jeff Barr, the convergence will enable to focus on aspects that are unique to the business, instead of the underlying technology. Bernard Golden argues that, as fewer people will be operating, businesses can displace that investment into more applications. Danilo Poccia adds that these technologies will shift the workforce paradigm, as they will not only allow employees to work remotely, but also in a better and smarter way. Finally, some experts agree that the next 3 to 4 years will bring more change to businesses, than over the last 200-250 years.

Customer experience improvement is the main opportunity brought by the Edge-CoT. Form one side, businesses gain more customer data, which will allow them to make better decisions and improve their customer feedback loop. From the other side, the merge between the physical and the digital world will generate a more sophisticated customer experience. If done correctly, this will allow businesses to grab and additional market share and improve their revenue models. According to Lee Atchison, healthcare and insurance industries leverage Cloud and IoT technologies for the integration of devices into an automatic data coordination system, while the automobile industry has leveraged these technologies to build self-driving vehicles able to self- diagnose. Imtiaz Adam and Danilo Poccia highlighted the emergence of new products such as Virtual Reality glasses, that will possibly replace the smartphone. Lastly, Bernard Golden points out that this trend allow businesses to start thinking about "where are the places where you could use these capabilities within your business, that in the past you either could never afford it, or could never imagine you could do it."

According to the experts, the number one challenge brought by these technologies is the re-skilling of existing employees and managers and finding new talent with the required skillset. David Linthicum also points out the need for a cultural change and a flatter organizational hierarchy as a major challenge faced by the companies. The existence of

sufficient capital, as well as the understanding that, inevitably, there is going to be a lot of wasted spending in the beginning, is another challenge pointed out by Omid Mahboubi. The high pace of technological change constitutes a challenge to the extent that it requires fast learning and adoption. In that sense, legacy companies with their legacy data and technology infrastructure face a major risk of being whipped out. Legacy companies usually come hand in hand with businesses' high technical debt. According to Lawrence Dignan, "The enterprises are settled with a lot of infrastructure they don't need and don't want, and it makes it hard for them to adopt these new technologies of scale". Aligned with adversity to change, risk-aversion and short-termism of some company managers, the survival of a business in the era of new technologies constitutes a substantial challenge.

4.3 Cloud experts' recommendations

Some experts agree that businesses should only adopt the technology if they plan to improve some specific business outcome. Whether they want to grow their customer base, improve the satisfaction of their customers, or even reduce the internal cost, the technology should always have a purpose. It is vital that companies set a business outcome first, and then learn how technology can help, in innovative ways. Imtiaz Adam goes further and advises companies to view technology not as a tool to improve the core competencies, but as a core competency itself. This demands a considerable degree of reflection on the uniqueness of each business, and how it can be enriched though technological tools. Next, it is imperative that everybody at the company understands the new direction the organization is following, and why.

Once businesses get the leadership on board and have the funding in place, Jeff Barr, Danilo Poccia and Lawrence Dignan advise businesses to familiarize themselves with these technologies though experimentation. Is it is crucial that the first projects are sufficiently small, to avoid incurring in considerable losses if the outcome is not the one desired. Accepting failures as a natural step towards great results and "failing fast" are the key suggestions at this stage. Furthermore, experts advise to foster a risk-taking mentality at the organization: quoting Lawrence Dignan, "It can't be all about the ROI (Return on Investment)". For reference, at Amazon, experiments are a common practice and are deeply encouraged.

Next, companies need to make sure their data story is clean and accurate, and that architecture is adaptable. Lawrence also advises to avoid getting comfortable with a specific model, as companies need to constantly disrupt themselves. Sarbjeet Johal recommends to start learning about these technologies as soon as possible, and to bring experts from outside from different backgrounds and industries, to foster cross-creation of ideas.

When choosing between investing in the in-house IT talent or hiring external consultants, the experts argue that the type of required support depends on the organization. From one side, in-house talent owns business domain knowledge that no consultant possesses. From the other side, technological specialists and can fasten your pace of adoption, as they bring valuable knowledge and fresh ideas to your company. Thus, a combination of both trained

in-house talent and external technology specialists would be the preferred strategy. Most experts agree that it is crucial that you focus on your employees with formal and on-the-job training and, when needed, support them with external specialists, particularly during the transition stage.

Lastly, all experts agree that cloud providers invest heavily in security, as their reputation is at stake. When security is seen as a cost by other businesses, for cloud providers, the security is a core competence. Considering cloud's shared responsibility approach, businesses data in the cloud is only safe if those using it got the appropriate training. According to Danilo Poccia, cloud provides complete visibility, full control and automation opportunities, in comparison to on-premises infrastructure. Despite the fact that some experts chose to avoid arguing that cloud is more secure, everyone recognizes that cloud's security system is at least as good as, or much better, than the ones of individual companies.

5. Discussion and Analysis

The following chapter will analyze the findings in more detail by using the following subtopics: the future of cloud computing, the impact of Edge-IoT trends on businesses and the cloud experts' recommendations. The theoretical framework will also be revisited based on the findings of this study. Furthermore, the findings of this study will be compared to existing literature to make valid conclusions at the end of this research paper.

5.1 Validity of academic assumptions on the future of cloud computing

This research explores the future cloud computing trends identified by the academic community, and further contrasts them with the opinion of cloud specialists. The results of this research validate the premise stating that the future of cloud computing will consist of an integration of cloud computing with internet of things and edge computing, as suggested by Abawajy et al. (2019) and Varghese and Buyya (2018). Despite the blurred nature of some technological concepts, these trends were proved to dominate the future of cloud computing. The findings also suggest addressing mobile cloud computing as a constituent of the convergence paradigm, instead of as a separate trend.

Gill et al. (2019) argues that energy-efficient data centers, also referred to as Green Cloud, are crucial for a prosperous future of cloud computing. Nonetheless, no consensus regarding the relationship between the convergence paradigm and the Green Cloud was established, as the experts' opinions diverged. The increase in the need for computational power will only increase the number of required datacenters, yet, cloud datacenters were highlighted to be more energy-efficient than traditional enterprise datacenters. Furthermore, some cloud datacenters were mentioned to be zero carbon print, nonetheless, its not enough to source renewable energy to designate cloud as sustainable or green, as the energy consumption must be minimized.

Finally, Zhang et al. (2018) and Celesti et al. (2019) refer to the Edge Cloud-of Things paradigm as Hybrid cloud-edge, reinforcing the academic validity of term introduced by Imtiaz Adam during the interview process.

5.2 Technological links dominating the future of cloud computing

This research identified that future of cloud will be dominated by a convergence between cloud computing, edge computing and IoT, along with mobile cloud computing, called the edge-CoT or Edge Hybrid Cloud. Together with robotics, AI / ML and cyber-physical systems (CPS) the edge hybrid cloud constitutes the main driver of Smart City and Industry 4.0. The smart sensors, empowered by IoT will collect the required city and factory data, that will be processed and further analyzed by the cloud's computational power. Likewise, the data will be collected and processed directly in the edge devices, in the cases where latency is considered an issue for the normal functioning of the devices and processes.

Despite the emergence of Edge-CoT, most experts agree that cloud computing will prevail over edge computing. Cloud's its ability to process large amounts of data, its low cost and familiarity will make it the preferred computing option, while edge will be reserved to singular situations where low-latency is of uttermost importance.

 Furthermore, the role of 5G in both enhancement of cloud computing and enablement of the convergence paradigm cannot be overstated. 5G is the coming fifth generation wireless broadband network which will provide better speeds and coverage than the current 4G. It will be designed to support a variety of applications such as the IoT, connected wearables, augmented reality and immersive gaming (Bongard et al., 2020). This technology was mentioned by the majority of cloud experts, suggesting that the existence of 5G networks is a natural component for the evolution of cloud computing. 5G networks can therefore be considered as one of the main pillars that support future of cloud computing. An important consideration is that the integration of 4G and 5G technologies is almost impossible considering the big difference in terms of throughput, latency and architecture. Thereby, telecommunications operators must think how to easily switch from current 4G to the new generation 5G (Bongard et al., 2020).

Figure 3: Cloud-related technological interdependencies
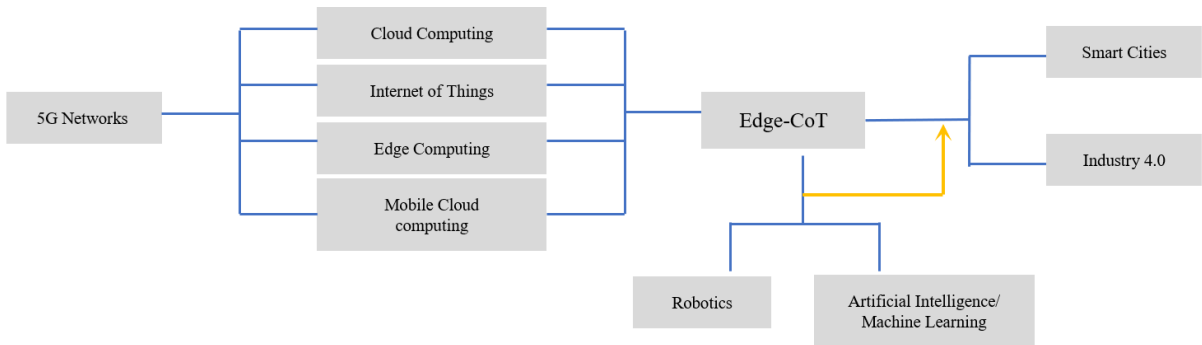
Description:

The 5G will enhance the capabilities of cloud, IoT, edge computing and mobile cloud computing, thus, enabling the emergence of the edge-IoT architecture. This novel architecture will drive the AI/ML and Robotics. The combination of Edge-CoT, robotics and AI/ML will cause the development of smart cities and industry 4.0. Simultaneously, Cloud alone will benefit of increased connectivity and will be the preferred business architecture comparing to Edge- CoT.

5.3 The impact of edge-CoT trend on business

In the near future, all industries will be touched by the Edge-CoT trend business professionals can expect the emergence of new industries driven by the evolution of the cloud. Similar to the social media and e-commerce industries, these new industries will bring significant changes to the way business is conducted. Likewise, new business opportunities will be created as the convergence boosts other technologies, in particular AI and ML. the internal aspects of all organizations, such as the people, processes and products will be affected. The paradigm of people management will shift as communication boundaries are removed, and 3D and Virtual Reality technologies gain ground. 3D and 5G will allow to produce goods closer to the customer, resulting in less shipping and package utilization. Digitalization and 3D printing will also affect all factors of the Products' dimension. the convergence will bring the ability to leverage technology strategically, instead of just automatic the manual tasks. As a result, businesses will have to re-think what new values

they bring to the table and how better can they do the job they have always been doing. as fewer people will be operating, businesses can displace that investment into more applications. technologies will shift the workforce paradigm, as they will not only allow employees to work remotely, but also in a better and smarter way.

Customer experience improvement is the main business opportunity that will arise from the convergence paradigm. As businesses gain more customer data, they become better equipped for decision-taking, improving their customer feedback loop. Furthermore, the merge between the physical and the digital world will generate a more sophisticated customer experience. If done correctly, this will allow businesses to grab and additional market share and improve their revenue models. Healthcare and Insurance industries leverage Cloud and IoT technologies for the integration of devices into an automatic data coordination system, while the automobile industry has leveraged these technologies to build self-driving vehicles able to self- diagnose. The emergence of new products such as Virtual Reality glasses, that will possibly replace the smartphone.

In terms of security, Cloud was considered more secure environment that on-premises data centers, to the extent that cloud providers invest a relatively higher amount of resources in up-to date, modern and effective security technologies. Furthermore, cloud vendors have access to a broader pool of talent in the datacenter security industry. Nonetheless, the security of cloud data is a shared responsibility of both cloud vendor and the customer, thus, the appropriate training of IT personnel from the customer side is essential for a secure cloud environment.

Even so, as in all major technological shifts, businesses will be facing considerable challenges. The re-skilling of existing employees and managers, as well as finding new talent with the required skillset will constitute a significant challenge for businesses. Moreover, business professionals need to understand that, inevitably, there is going to be a lot of wasted spending in the beginning of the implementation process. The high pace of technological change constitutes a challenge to the extent that it requires fast learning and adoption. In that sense, legacy companies with their legacy data and technology infrastructure face a major risk of being whipped out.

A consensus in the number of years for the maturity of the Edge-CoT technology in the market was not reached. According to David Linthicum, this trend is already here and was only boosted by the pandemic. Nonetheless, according to Jeff Bar, it will take another full generation of employees for the convergence to reach it's full maturity. Some experts argue that the acceleration part will take place in 2 to 4 years, and is particularly dependable of 5G network implementation. Sarbjeet Johal and Bernard Golden agree that around 10 years are needed for this trend to mature. In terms of global landscape, 7 out of 9 experts argue that United States will be the first to adopt this trend. Europe usually follows US in the technological adoption, with a delay of 1 to 3 years. Within Europe, the economies that stand out more are UK and Germany. While some experts argue that the financial sector of central Europe is relatively slow in the adoption of cloud technology, others believe that central Europe has shown great will in the adoption of cutting-edge technologies. Additional strong economies in cloud computing are APAC, in particular China, Australia and South Korea. Finally, several countries in the Middle East, such as United Arab Emirates, Saudi Arabia and Bahrain were also pointed out as candidates for first-mover position in these technologies. Nonetheless, Danilo believes this is a global trend, and while some regions have better infrastructure, other regions can compensate with other factors, such as creativity.

Table 4: Summary of the impact of Edge-CoT on business

Impact of Edge- CoT convergence on business		
Opportunities brought by the convergence		Business challenges brought by the convergence
Macro level	Micro level	
Emergence of new industries, specially related to AI and ML	Customer service and support improvement and potential improvement in the customer feedback loop	Fast pace of change will oblige companies to act fast in their digital transformation
Emergence of new businesses	Revenue model improvement	Companies with legacy technologies are in risk of being left behind
Change in all existing industries and businesses	The production process will shift to closer to the consumer, decreasing the amount of shipping and package needed.	Capacity to find new skilled talent, and to re-train the existing workforce
Merge of physical and digital world together	The constitution of business workforce will change, as fewer people will be operating. This enables businesses to displace that investment into more applications	Wasted spending in the beginning is inevitable Necessity to change the organizational culture dominated by risk-aversion and shot-termism, as well as to promote a flat hierarchy
	Employee experience improvement	Difficulty in adopting new technologies of scale due to businesses' technical debt
	Businesses will have more data to measure and evaluate their performance	Absorbing the capabilities of cloud computing and use it as part of the business design.
	Removal of communication boundaries, driven by Edge-CoT, VR and 3D	Inevitability of wasted spending in the initial phase of the technological adoption
		Difficulty in finding the capital required for a digital transformation
		Ensuring the security and reliability of cloud
		The management of IT infrastructure running on cloud will be more complex

5.4 Expert recommendations for a successful transition

As global competition intensifies, organizations find that it is necessary to increase the focus on their core competencies. Technology roadmapping is viewed by practitioners in the field as a strategic planning tool to visualize and formulate the linkage between a business and technology strategy (Groenveld, 1997).

This section will address the key elements pointed out by cloud experts, that are required for a successful technology roadmap implementation. These elements will lead people and organizations though the stages of a technological transition. This chapter divides into two main factors of a successful technological evolution: the organizational structure and culture, and the technology. Note that these elements do not constitute all the necessary steps towards a successful technology implementation, instead they comprise the key recommendations of industry specialists for an effective shift towards Edge-CoT.

Table 5: Summary of experts' recommendations

Experts recommendations	
Organizational structure and culture	*Technology*
Promotion of a flat organizational hierarchy	Avoid technical debt promoting behaviours, such as heavily investing in IT systems that soon become obsolete
Encourage a culture of experimentation and accept failing as a natural part of the learning process	Experiment - Experimentation is key to learn a new technology and to understand how it can empower your business
Avoid short-termism and risk-avoidance attitude within your company	The architecture is advised to be flexible and agile, capable of adapting to future technological waves
Bring external experts to boost innovation and support your internal IT department, but avoid relying too heavy on outside specialists and invest in developing in-house expertise instead	Small projects are preferred over large ones in the beginning of the technological implementation to avoid incurring in significant losses
Avoid getting comfortable with a specific model – businesses should be constantly disrupting themselves	Guarantee a clean and accurate data story
	When used correctly, cloud at least as or potentially safer than on-premises infrastructure
	Do not underestimate the power of AI/ML for your business

5.4.1 Organizational structure and culture

In order to collect the benefits brought by these new technologies, businesses must start by understanding the impact of technologies on the structure and culture of their organizations (McMillan, 2003). Structure-wise, David Linthicum advises to shift to a flat hierarchy. The success of this process is largely dependent on people and their individual contribution (Cosner et al., 2007), thus, David argues that it is crucial to inform the whole organization on what is being implemented, why, and what are the expectations held of every individual in the company. In terms of organizational culture, experts advise the encouragement of a risk-taking, long-term orientation, innovation and cross-creation of knowledge. Lawrence advises to inspire experiments and accept failures, as long as the appropriate lessons are drawn, and fast. it is crucial to train the internal IT department.

When choosing between investing in the in-house IT talent or hiring external consultants, the experts argue that the type of required support depends on the organization. From one side, in-house talent owns business domain knowledge that no consultant possesses. From the other side, technological specialists and can fasten your pace of adoption, as they bring valuable knowledge and fresh ideas to your company. Thus, a combination of both trained in-house talent and external technology specialists would be the preferred strategy. Most experts agree that it is crucial that you focus on your employees with formal and on-the-job training and, when needed, support them with external specialists, particularly during the transition stage.

Lastly, Lawrence advises to avoid getting comfortable with a specific model, as companies need to constantly disrupt themselves.

5.4.2 Technology

Firstly, it is crucial that the business professional decided and plans a specific desired business outcome. Whether it is improving customer service, increasing revenue streams, or cutting internal costs, businesses must establish a desired result before adapting any technology. According to Bernard Golden business managers must reflect on *where are the places where I could use these capabilities within my business, that in the past I either could never afford it, or could never imagine I could do it.* Afterwards, Sarbjeet Johal argues that

businesses managers should aim to learn about the technology as soon as possible, and consider bringing experts to understand how technology can help you in innovative ways. All experts agree on the importance of prototyping and experimentation with relatively small projects, to understand the technology and the functioning of tools without incurring in significant capital losses. Lawrence Dignan advises to avoid incurring in technical debt, as it traps companies with legacy systems, hence, hindering its technological agility in the long-term. As the success of an AI project depends largely on the quality the data presented, businesses are advised to keep their data story clean and accurate. An adaptable architecture was also highlighted as a best practice for the induction of new technologies. Despite the paramount importance of having the project capital in place, businesses were advised to avoid focusing on the Return on Investment (ROI) in the short-term, as the process of learning and becoming familiar with new technologies plays a vital role for the long-term success of the technological transition.

On the topic of cloud security, all experts agree that cloud providers invest heavily in security, as their reputation is at stake. When security is seen as a cost by other businesses, for cloud providers, the security is a core competence. Considering cloud's shared responsibility approach, businesses data in the cloud is only safe if those using it got the appropriate training. According to Danilo Poccia, cloud provides complete visibility, full control and automation opportunities, in comparison to on-premises infrastructure. Despite the fact that some experts chose to avoid arguing that cloud is more secure, everyone recognizes that cloud's security system is at least as good as, or much better, than the ones of individual companies.

6. Conclusion

The aim of this research was to explore the technologies linked to the future of cloud computing, and their consequent impact on businesses. Thereby, the purpose of this study was to find answers to the following research questions:

1) *Is the forecasting of future cloud trends by academic literature in line with the considerations of cloud experts?*
2) *What links exist between the technologies of cloud computing, internet of things, mobile cloud computing and edge computing and the concepts of smart city, industry 4.0 and green cloud, according to cloud experts?*
3) *According to the cloud experts, how will the Edge-CoT paradigm impact business?*
4) *According to cloud experts, how can businesses prepare for the convergence Edge-CoT paradigm?*

Thus, this study has successfully analyzed the future trends in cloud computing, as well as it confirmed the validity of the academic community literature. It provided an overview of the links between different cloud-related trends, supported by evidence of industry specialists. Furthermore, it filled the literature gap by focusing on business-relevant information of the cloud computing technology, utilizing easily understandable concepts and theories for the corporate community. The second part of this research shed light on the business impact of the future cloud computing trends, focusing on the opportunities and challenges that will emerge. Finally, this study gathered recommendations from some of the world's most proclaimed cloud specialists, not only on how businesses should prepare for these trends, but on how to maximize the value creation in the era of technological convergence.

Businesses' competitive advantage is largely dependent on its ability to adapt to the technological change (Scott, 1999; Bryne, 2000). The ability to prepare for future technological waves is therefore essential for the survival of businesses in all industries. This research represents significant practical implication as it embodies a potential prediction on the future technological paradigm related to cloud computing, and the dynamics surrounding the latest technologies in the global market. Moreover, this paper equips business managers with significant knowledge relatively to the impact businesses will be facing with the

emergence and growth of the edge-CoT technology, as well as the opportunities and challenges that will arise with this trend. Finally, it gathers key insights and best-practices from global cloud experts that allows to reap the benefits of this technological transition. The factors above can play a significant role for businesses due to its ability to influence future strategies and plans at both technological and business level.

The present study was limited to a selected set of future trends in cloud computing, as not all the trends were analyzed and validated. Moreover, the academic literature was not reviewed using a systematic approach. This study also was limited in its data sample to nine cloud experts interviewed and thus cannot be stated to represent the truth for all cloud specialists in general. The sample of interviewees also represent a predominantly western view on this topic, as most of the experts were form the United States and the United Kingdom. Moreover, all the experts interviewed were male. The volatile nature of technological predictions must also be considered, as emerging new trend have the capability of altering the current direction of cloud computing. The next chapter will outline recommendations for future research based on the limitations of this study.

Due to this study limitations, future studies on this topic should consider opting for a bigger pool of data sample. Furthermore, researchers are advised to explore other trends such as volunteer cloud and multi-cloud, and their impact on business processes. It is also recommended to search for a more diverse sample of specialists, particularly in terms of gender and culture. The realization of a systematic review on the topic of cloud computing trends is also proposed. Finally, qualitative studies encompassing the impact of different variations of cloud computing on businesses are encouraged, to fill the current academic literature gap.

7. References

Abawajy, J., Chen, M., Hassan, M., Qiu, M., & Chen, S. (2019). Special Section on Cloud-of-Things and Edge Computing: Recent Advances and Future Trends. *Journal of Parallel and Distributed Computing*, 133, 170-173. DOI:10.1016/j.jpdc.2019.07.004

Ahmed, A., & Sabyasachi, A.S. (2014). Cloud Computing Simulators: A Detailed Survey and Future Direction. *IEEE International Advance Computing Conference.*

Ali, A., & Alam, M. (2019). SecOFF-FCIoT: Machine learning based secure offloading in Fog-Cloud of things for smart city applications*, Internet of Things*, 7. DOI: 10.1016/j.iot.2019.100070

Aljabre, A. (2012). Cloud Computing for Increased Business Value, *International Journal of Business and Social Science,* 3(1), 234-239.

Ardagna, D. (2015). Cloud and Multi-Cloud Computing: Current Challenges and Future Applications. IEEE/*ACM 7th International Workshop on Principles of Engineering Service-Oriented and Cloud Systems*, 1-2. DOI 10.1109/PESOS.2015.8

Ardagna, D., Gibilisco, G.P., Ciavotta, M., & Lavrentev, A. (2014). A multimodel optimization framework for the model driven design of cloud applications, in *Search-Based Software Engineering - 6th International Symposium, SSBSE 2014, Fortaleza, Brazil*, 61–76.

Ardagna, D., Nitto, E. D., Petcu, D., Mohagheghi, P., Mosser, S., Matthews, P., Gericke, A., Ballagny, C., D'Andria, F., Nechifor, C. & Sheridan, C. (2012). MODACLOUDS: A model-driven approach for the design and execution of applications on multiple clouds. *MiSE 2012 Workshop Proceedings*.

Bayramusta, M., & Nasir, V. A. (2016). A fad or future of IT?: A comprehensive literature review on the cloud computing research. *International Journal of Information Management*, 36(4), 635-644.

Belcastro, L., Marozzo, F., Talia, D., & Trunfio, P. (2017) Big data analysis on clouds, *Handbook of Big Data Technologies,* 101–142.

Berman, B. (2012). 3-D printing: the new industrial revolution, *Business Horizons*, 55 (2) 155–162. DOI: 10.1016/j.bushor.2011.11.003

Bernstein, D., Ludvigson, E., Sankar, K., Diamond, S., & Morrov, M. (2009). Blueprint for the intercloud-protocols and formats for cloud computing interoperability. *Proceedings of the 4th International Conference on Internet and Web Applications and Services,* 328-336.

Bhardwaj, S., Jain, L. & Jain, S. (2010). Cloud computing: A study of infrastructure as a service (IAAS), *International Journal of Engineering and Information Technology,* 2(1), 60-63.

Bongard, M., Grunert, K. & Aleksic, S. (2020). Techno-Economic Analysis of Deployment Options for Converged 5G Wireless-Optical Access Networks. *Conference: 43rd International Convention on Information, Communication and Electronic Technology (MIPRO 2020).* DOI: 10.23919/MIPRO48935.2020.9245174

Bonomi, F., Milito, R., Zhu, J., & Addepalli, S. (2012). Fog computing and its role in the internet of things, *Proceedings of the First Edition of the MMC Workshop on Mobile Cloud Computing,* 13-16. DOI:10.1145/2342509.2342513

Brettel, M., Friederichsen, N., Keller, M., & Rosenberg, M. (2014). How virtualization, decentralization and network building change the manufacturing landscape: An industry 4.0 perspective, *International Journal of Mechanical, Industrial Science and Engineering* ,8 (1), 37–44.

Brinkmann S. & Kvale, S. (2015). InterViews: learning the craft of qualitative research interviewing. 3rd Edition. London: Sage.

Burmeister, C., Luettgens, D., & Piller, F. T. (2015). Business model innovation for industrie 4.0: why the 'industrial internet' mandates a new perspective on innovation, RWTH-TIM Working Paper.

Buyya, R., Beloglazov, A., & Abawajy, J. (2010). Energy-efficient management of data center resources for cloud computing: A vision, architectural elements, and open challenges, *Proceedings of the 2010 International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA'10),* 1-12.

Buyya, R., Srirama, S., Casale, G., Calheiros, R., Simmhan, Y., Varghese, B., Gelenbe, E., Javadi, B., Vaquero, L. M., Netto, M.A.S., Toosi, A.N., Rordiguez, M.A.,Llorente, I.M.,Vimercati, S., Samarati, P., Milojicic, D., Varela,C, Bahsoon, R., Assuncao,M.D., Rana, O., Zhou, W., Jin, H., Gentzsch, W., Zomaya, A.Y., & Shen, H. (2018). A Manifesto for Future Generation Cloud Computing: Research Directions for the Next Decade, *ACM Computing Surveys,*51(5), 38. DOI:10.1145/3241737

Byrne, J. (2000). The Corporation of the Future. *Management Perspective. Chicago: Coursewise Publishing.*

Caton, S., Bubendorfer, K., Chard, K., & Rana, O. F. (2012). Social cloud computing: a vision for socially motivated resource sharing. *IEEE Transactions on Services Computing*, 5(9), 551-563. DOI: 10.1109/TSC.2011.39

Chard, K., Caton, S., Rana, O., & Bubendorfer, K. (2010). Social cloud: cloud computing in social networks. *IEEE International Conference on Cloud Computing*, 99–106.

Civerchia, F., Bocchino, S., Salvadori, S., Rossi, E., Maggiani, L., & Petracca, M. (2017). Industrial internet of things monitoring solution for advanced predictive maintenance

applications, *Journal of Industrial Information Integration*, 7, 4–12. DOI: 10.1016/j.jii.2017.02.003

Cosner, R.R., Hynds, E.J., Fusfeld, A.R., Loweth, C.V., Scouten, C. & Albright, R. (2007). Integrating roadmapping into technical planning. *Research Technology Management* 50(6), 31-48.

Creswell, J. W. (2007). Qualitative Inquiry and Research Design: Choosing among 5 approaches. 2nd edition. London: Sage Publications

Creutzig, F., Baiocchi, G., Bierkandt, R., Pichler, P. P., & Seto, K. C. (2015). Global typology of urban energy use and potentials for an urbanization mitigation wedge. *Proceedings of the National Academy of Sciences of the United States of America,* 112(2), 6283-6288. DOI: 10.1073/pnas.1315545112

Datacenter Knowledge (2016, June 27). Here's How Much Energy All US Data Centers Consume [Press release]. Retrieved from https://www.datacenterknowledge.com/archives/2016/06/27/heres-how-much-energy-all-us-data-centers-consume

Dawoud, A., Shahristani, S., & Chun, R. (2018). Deep learning and software-defined networks: Towards secure IoT architecture, *Internet of Things*, 3, 82-89. DOI: 10.1016/j.iot.2018.09.003

Daylami, N. (2015). The Origin and Construct of Cloud Computing, *International Journal of the Academic Business World*, 9(2), 39-44.

Deloitte. (2019, January 15). *Extended Enterprise Risk Management to be a Focus in 2019* [Press release]. Retrieved from https://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/deloitte-poll-extended-enterprise-risk-management-to-be-2019-focus.html

Dinh, H.T., Lee, C., Niyato, D., & Wang, P. (2011). A survey of mobile cloud computing: architecture, applications and approaches. *Wireless Communications and Mobile Computing*, 13(18), 1587-1611.

Distefano, & S. Puliafito, A. (2012). Cloud"@Home: Toward a volunteer cloud. *IT Professional*, 14(1), 27-31

Duan, H., Chen, C., Min, G., & Wu, Y. (2017). Energy-aware scheduling of viral machines in heterogenous cloud computing systems, *Future Generation Computer System*, 74, 142-150. DOI:10.1016/j.future.2016.02.016

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review,* 14, 532-550

Eriksson, P. & Kovalainen, A. (2016). Qualitative methods in business research. 2nd Edition. London: Sage.

Fernando, N., Loke, S.W., & Rhayu, W. (2013). Mobile cloud computing: a survey, *Future Generation Computer Systems*, 29(1), 84-106

Foster, I. (2002). What is the Grid? A Three Point Checklist. Retrieved from *https://www.researchgate.net/publication/215757948_What_is_the_Grid_A_Three_Point_Checklist*

Foster, I. T., Freeman, T., Keahey, K., Scheftner, D., Sotomayor,B., & Zhang, X. (2006). Virtual clusters for grid communities, in Proceedings of Cluster Computing and Grid. *IEEE Computer Society*, 513–519.

Foster, I., Zhao, Y., Raicu, I., Lu, S. (2008). Cloud Computing and Grid Computing 360-Degree Compared. *IEEE Grid Computing Environments.* DOI: 10.1109/GCE.2008.4738445

Franceschelli, D., Ardagna, D., Ciavotta, M., & Nitto, E.D. (2013). Space4cloud: A tool for system performance and cost evaluation of cloud systems. *Multi-Cloud 2013 Workshop, Proceedings*, 27–34.

Gai, K. & Li, S. (2012). Towards Cloud Computing: A Literature Review on Cloud Computing and its Development Trends. *IEEE Computer Society.* DOI: 10.1109/MINES.2012.240

Gartner. (July 2020). *Public cloud revenue to grow 6.3% in 2020 — Gartner* [Press release]. Retrieved from https://www.information-age.com/public-cloud-revenue-to-grow-6-3-in-2020-gartner-123490499/

Gerdsri, N., Assakul, P., & Vatananan, R. (2010). An activity guideline for technology roadmapping implementation. *Technology Analysis & Strategic Management,* 22(2), 229-242. DOI: 10.1080/09537320903498553

Gill, S., Grraghan, P., & Buyya, R. (2019). ROUTER: Fog enabled cloud based intelligent resource management approach for smart home IoT devices. *Journal of Systems and Software*, 154, 125-138. DOI:10.1016/j.jss.2019.04.058

Gill, S., Tuli, S., Xu, M., Singh, I., Singh, K., Lindsay, D., Tuli, S., Smirnova, D., Singh, M., Jain. U., Pervaiz, H., Sehgal, B., Kalia, S., Misra, S., Aslanpour, S., Mehta, H., Stankovski, V., & Garraghan, P. (2019). Transformative effects of IoT, Blockchain and Artificial Intelligence on cloud computing: Evolution, vision, trends and open challenges, *Internet of Things*, 8, 100118.

Giove, F. Longoni, D., Yancheshmeh, S., Ardagna, D., & Nitto, E.D. (2013). An approach for the development of portable applications on paas clouds. *Proceedings of the 3rd International Conference on Cloud Computing and Services Science,* 591-601.

Gisbert, J.R., Palau, C., Uriarte, Prieto, M,G.., Palazón, J.A., Esteve, M., López, O., Correas, J., Estañ, M.C., PGiménez, P., Moyano, A., Collantes, L., Gozálvez, J., Molina, B., Lázaro, O., & González, A. (2014). Integrated system for control and monitoring

industrial wireless networks for labor risk prevention, *Journal of Network and Computer Applications,* 39 (1), 233–252.

Gong, M., Liu, L., Sun. X., Yang, Y., Wang, S., & Zhu, H. (2020). Cloud-Based System for Effective Surveillance and Control of COVID-19: Useful Experiences From Hubei, China. *Journal of Medical Internet Research.* DOI: 10.2196/18948

Gray D.E. (2013). Doing research in the real world. SAGE.

Groenveld, P. (1997). Roadmapping integrates business and technology. *Research Technology Management* 40(5), 48.

Hameed, A., Khoshkbarforoushha, A., Ranjan, R., Jayaraman, P. P., Kolodzijei, J., Balaji, P., Zeadally, S., Malluhi, Q.M., Tziritas, N., Vishnu, A., Khan, S.U., & Zomaya, A. (2016). A survey and taxonomy on energy efficient resource allocation techniques for cloud computing systems. *Computing*, 98(7), 751-774. DOI 10.1007/s00607-014-0407-8

Han, L., Zhou, W., Li, W., & Li, L. (2014). Impact of urbanization level on urban air quality: a case of fine particles (pm2.5) in Chinese cities. *Environmental Pollution,* 194, 163-170. DOI: 10.1016/j.envpol.2014.07.022

Hossain, M.S., Muhammad, G. (2016). Cloud-assisted industrial internet of things (IIoT)—Enabled framework for health monitoring. *Computer Networks*, (101), 192-202. DOI: 10.1016/j.comnet.2016.01.009

Hussian, Z., Sushil & Phatak, R. D. (2002). A Technology management Perspectives On Collaboration in The Indian Automobile Industry: A Case Study. *Journal Eng. Technology Management,*19, 167-201.

IDC (October 2019). IDC FutureScape: *Worldwide SMB 2020 Predictions.* Retrieved from *https://www.idc.com/getdoc.jsp?containerId=US45587619*

Jiang, D. (2020). The construction of smart city information system based on the Internet of Things and cloud computing. *Computer Communications*, 150, 158-166. DOI:10.1016/j.comcom.2019.10.035

Kagermann, H. (2015). Change through digitization—value creation in the age of Industry 4.0. *Management of Permanent Change*, 23–45.

Kaplan, M., Shinn, D., Kneifel, C., Orlikowski, V., Dorff, J., Newton, M., Howard, A., Bishawi, M., Chidyagwai, S., Balogh, P. & Rendles, A. (2020). Cloud Computing for COVID-19: Lessons Learned From Massively Parallel Models of Ventilator Splitting. *Computing in Science and Engineering,* 22(6), 37-47. DOI: 10.1109/MCSE.2020.3024062

Keahey, K., Foster, I.T., Freeman, T., & Zhang, X. (2005). Virtual workspaces: Achieving quality of service and quality of life in the grid. *Scientific Programming*, 4(13), 265–275

Kobusińska, A. Leung, C., Hsu, C., Raghavendra, S., & Chang, V. (2019). Emerging trends, issues and challenges in Internet of Things, Big Data and cloud computing. *Future Generation Computer Systems,* 87, 416-419. DOI: 10.1016/j.future.2018.05.021

Kvale, S. (1996). Interviews: An introduction to Qualitative Research Interviewing. Thousand Oaks: Sage Publications.

Liu, Y., Wang, L., & Wang, X. V. (2018). Cloud manufacturing: latest advancements and future trends. *Procedia Manufacturing*, 25, 63-73. DOI: 10.1016/j.promfg.2018.06.058

Mansouri, Y. Prokhorenko, V. & Babar, M. A. (2020). An automated implementation of hybrid cloud for performance evaluation of distributed databases. *Journal of Network and Computer Applications,* 167(1), 1-14. DOI:10.1016/j.jnca.2020.102740

Markoff, J., & Hansell, S. (2006). Hiding in Plain Sight, Google Seeks More Power. *New York Times.*

McMillan, A. (2003). Roadmapping – agent of change. *Research Technology Management* 46(2), 40–47.

Murad, M., & Thomson, J. D. (2011). The importance of technology diffusion in Malaysian Manufacturing SMEs. *3rd International Conference on Information and Financial Engineering,* 12.

National Institute of Standards and Technology (2011). The NIST Definition of Cloud Computing. Retrieved from https://csrc.nist.gov/publications/detail/sp/800-145/final

Noor, T. H., Zeadally, S., Alfazi, A. & Sheng, Q.Z. (2018). Mobile cloud computing: Challenges and future research directions. *Journal of Network and Computer Applications,* 115, 70-85. DOI: 10.1016/j.jnca.2018.04.018

Pedone, G, & Mezgár, I. (2018). Model similarity evidence and interoperability affinity in cloud-readyIndustry 4.0 technologies, *Computers in Industry*, 100, 278-286. DOI: 10.1016/j.compind.2018.05.003

Petcu, D., Macariu, G., Panica, S., & Crciun, C. (2013). Portable cloud applications: From theory to practice. *Future Generation Computer Systems*, 29 (6), 1417-1430. DOI: 10.1016/j.future.2012.01.0095

Peukert, B., Benecke, S., Clavell, J., Neugebauer, S., Nissen, N.F., Uhlmann, E.,Lang, K.D., & Finkbeiner, M. (2015). Addressing sustainability and flexibility in manufacturing via smart modular machine tool frames to support sustainable value creation, *Procedia CIRP*,29, 514–519. DOI: 10.1016/j.procir.2015.02.181

Porter, M.E., & Heppelmann, J.E. (2014). How smart connected products are transforming Competition, *Harvard Business Review*, 92, 64–88.

Rabionet, S. E. (2011). How I Learned to Design and Conduct Semi-Structured Interviews: An Ongoing and Continuous Journey. *Qualitative Report*, *16*(2), 563-566.

Rao, A., & Clarke, D. (2020). Perspectives on emerging directions in using IoT devices in blockchain applications, *Internet of Things*, 10. DOI: 10.1016/j.iot.2019.100079

Ray, B.R., Abawajy, J.H., Chowdhury, M.U., & Alelaiwi, A. (2019). Universal and secure object ownership transfer protocol for the internet of things, *Future Generation Computer Systems*, 78, 838–849. DOI: 10.1016/j.future.2017.02.020

Robbins, R.N., Scott, T., Joska, J.A., & Gouse, H. (2019). Impact of urbanization on cognitive disorders. *Current Opinion Psychiatry,* 32(3), 1.

Sadashiv, N., & Kumar, S. M. D. (2011). Cluster, Grid and Cloud Computing: A Detailed Comparison. *IEE: The 6th International Conference on Computer Science & Education*, 477- 482.

Schneider, J.W. (2018). Concept symbols revisited: naming clusters by parsing and filtering of noun phrases from citation contexts of concept symbols, *Proceedings of, Springer*. 573–593.

Schuh,G., Potente, T., Varandani, R., Hausberg, C., & Fränken, B.(2014). Collaboration moves productivity to the next level, *Procedia CIRP,* 17, 3–8. DOI: 10.1016/j.procir.2014.02.037

Scott, G. (1999). Top Priority Management Concern about New Product Development. *Academy Management Executive,* 13(3), 77-84.

Senyo, P. K., Addae, E., & Boateng, R. (2018). Cloud computing research: A review of research themes, frameworks, methods and future research directions. *International Journal of Information Management*, *38*(1), 128-139.

Singh, S. & Chana, I. (2015). QoS- aware autonomic resource management in cloud computing: a systematic review, *ACM Computing Surveys* 48(3), 1-46. DOI: 10.1145/2843889

Singh, S., Chana, I., & Singh, M. (2017). The Journey of QoS-aware autonomic cloud computing. *IT Professional*, 19(2), 42-49.

Singh, S., Jeong, Y. & Park, J. H. (2016). A survey on cloud computing security: Issues, threats, and solutions. *Journal of Network and Computer Applications*, 75, 200-222. DOI: 10.1016/j.jnca.2016.09.002

Stein, M., Campitelli, V. & Mezzio, S. (2020). Managing the Impact of Cloud Computing: Perspectives on Vulnerabilities, ERM, and Audit Services. *The CPA Journal*. Retrieved from https://search.proquest.com/docview/2420174077?pqorigsite=gscholar&fromopenview=true

Sun, D, Chang, G., Sun, L., & Wang, X. (2011). Surveying and analyzing security, privacy and trust issues in cloud computing environments. *Procedia Engineering*, 15, 2852-2856. DOI:10.1016/j.proeng.2011.08.537

Varghese, B., & Buyya, R. (2018). Next generation cloud computing: New trends and research directions. *Future Generation Computer Systems,* 79, 849-861. DOI: 10.1016/j.future.2017.09.020

Xia, Q., Liang, W., Xu, Z. (2017). Data locality-aware big data query evaluation in distributed clouds, *The Computer Journal*. 60 (6), 791–809.

Xu, H., Wang, X., & Xiao, G. (2015). A remote sensing and gis integrated study on urbanization with its impact on arable lands: Fuqing city, fuijan province, china. *Land.Degrad.Dev,* 11(4), 301-314.

Yao, S. M., Zhang, P. Y., Cheng, Y. U., Guang-Yu, L. I., & Wang, C. X. (2014). The theory and practice of new urbanization in china. *Scientia Geographica Sinica*, 34(6), 641-647.

Yin, R.K. (2003). Case study research design and methods. 3rd Edition. Thousand Oaks: Sage

Yu, W., Liang, F., He, X., Hatcher, W.G., Lu, C., Lin, J. & Yang, X. (2018). A survey on the edge computing for the internet of things, *IEEE Access*, 6, 6900–6919. DOI: 10.1109/ACCESS.2017.2778504

Zhang, K., Zhou, X., Chen, Y., Wang, X., & Ruan, Y. (2011). Sedic: Privacy-aware data intensive computing on hybrid clouds. *Proceedings of the 18th ACM Conference on Computer and Communications Security*, 515-526.

Zhang, Y.J., Zhao, L., Zhang, H., Tan, T. D. (2014). The impact of economic growth, industrial structure and urbanization on carbon emission intensity in china. *Natural Hazards*, 73, 579-595.

Zhong, R.Y., Huang, G.Q., Lan, S., Dai, Q.Y., Chen, X., & Zhang, T. (2015). A big data approach for logistics trajectory discovery from RFID-enabled production data. *International Journal of Production Economics*, 165, 260–272. DOI: 10.1016/j.ijpe.2015.02.014

Appendix A: Interview guide

Interviewee Background

1. Could you tell me about your own role in the company, your past career and experience?

Opinions on technologies

The academic literature points out 2 main trends in cloud computing: the 1st one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing.

Looking at the first trend: integration between Cloud computing, Internet-of-Things and Edge Computing: what literature argues is that Internet-of-Things and will integrate cloud , however, the centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices speed across the world, improving speed and performance of data processing.

2. Do you agree that this will be the future of cloud computing?
3. Would you argue that mobile cloud computing is not a separate trend, but its actually part of this trend?
4. Do you agree that this combination of technologies is the main driver of smart cities and industry 4.0?
5. Can we argue that this combination of technologies will make cloud more energy efficient, and therefore drive the emergence of Green cloud?
6. Do you agree that this combination of technologies is the main driver of Artificial Intelligence and Machine Learning?
7. would you argue that cloud is more secure than on premises infrastructure?

Opinion on business impact

8. In your opinion how will the integration of these technologies change the environment in which businesses are managed?

9. What are the main challenges that business managers will be facing with this trend?

10. What are the main opportunities that will arise with this trend?

11. Would you advise businesses to invest in training the inhouse IT department or hiring consultants that are experts in cloud computing?

12. In how many years from now do you think this trend will reach its peak of acceptance in the market /mature?

13. Which country or region will be the first to adopt this trend?

14. What advises would you give to business managers to allow them to reap the full benefits of this new trend?

Appendix B: Interview transcripts

The following section contains all the transcripts derived from the conducted interviews with the following cloud experts: Lee Atchison, Sarbjeet Johal, David Linthicum, Omid Mahboubi, Lawrence Dignan, Jeff Barr, Imtiaz Adam, Bernard Golden and Danilo Poccia.

1. Lee Atchison

Interview duration: 43.37 minutes

L= Lee Atchison
S=Student

S: Could you tell me more about your role in your company and your past experience?

L: Sure. I started my own company as a consulting company, I am the owner of that and essentially, what I am doing now is the same thing I was doing for New Relic. I'll give you more details: my last job was at New Relic, I worked for New Relic for about 8 years and I was brought in as a cloud expert. New Relic was a startup at the time when I joined, total slice of the company was probably around 100 people, it was not a small startup, but it was a small enough company. My job there was, as I said, I was a cloud expert and I brought in to help them and guide them into growing and scaling their applications. I had previously come from Amazon Web Services and had significant experience of work with cloud and scaling applications so that was the expertise I brought in. I spent the first few years helping to build their infrastructure product and to manage IT systems and processes to help them to become a much more stable production-oriented company that could keep their systems up and running. As they grew, they were started to have product damages, so I used my expertise at amazon to help them keep those things from happening as well as if they happen, to try and minimize the impact. After some years I wrote a book about my experiences at amazon and New Relic, in scaling and building applications, architecting for scale. With that book I changed jobs at New Relic, what they decided to do is they wanted to use my expertise as a tool to talk with the customer and show them how neuralgic could help them. So, I spent the next 4 years speaking with CEOs, CTOs, VPs, and Directors of all our customers, I did a lot of presentations. Basically, I spoke to a wide variety of companies and hearing a lot of their problems and tried to help them to solve those problems.

S: So, a little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture

will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and performance of data processing. Do you agree that this will be the future of cloud computing?

L: Yes, I think there is a lot of evidence confirming that. I think that what made cloud successful in the first place was the centralization, the ability for someone to build an application without having to build their own infrastructure, but I think the feature of the cloud is much more its ability. Technologies are running across the globe and bring them under common set of data, a common set of construction to make things work. And that's the advantage of cloud and that's very consistent with making IoT "cloudaquian" but using edge computing as a way to increase the performance because the obvious disadvantage of having a centralized cloud is the latency requirement, and for some things that is not a problem, for other things it is paramount. So I think what you are going to find is going to be multiple edge, basically bring parts of the cloud closer to our key devices, closer to mobile devices, and having some of our computing and data storage in those edge locations that are closer to the users, and they are "cloudaquian", then it is more of a choreography of these edge locations and they back a repository. It's a lot more than caching but you can think about it like sophisticated caching if you want.

S: Do you agree that this combination of technologies will be the main driver of Smart Cities and Industry 4.0?

L: Those new terms, Smart city and Industry 4.0 are so new that it's hard to say for sure exactly what we are going to turn it into, so it's a little bit hard to say yes they will be the things that drive those trends, and we really don't know what those trends are, but certainly the belief of what those trends are going to be, yes, I would definitely agree that it's going to be cloud, it's going to be edge, its going to be IoT and its going to be mobile. I don't separate those four things into two separate things, I would put mobile into edge and IoT and kind of lump them all together. Those four technologies working together are going to be the things that drive the industry of tomorrow, the city of tomorrow, all those things would be driven by those technologies.

S: It's very interesting that you put mobile cloud computing not as a separate trend, but as a part of the main trend containing cloud computing, iot and edge computing. Could you please develop that thought?

L: Actually, IoT and mobile they are parallel, they work together obviously but they are at the same level, and both mobile and IoT will depend on the edge as well as on the cloud to make things work out. Mobile is just a type of IoT device. Maybe even the first IoT device

if you will. So, if you want those 3 together, you would say the trend is cloud leading to edge leading to mobile and IoT, I think that is probably the way I'll describe that.

S: Can we argue that this combination of technologies will make cloud more energy efficient and therefore will drive the emergence of Green Cloud?

L: I think by itself no, I think its going to take a lot more effort and a lot more fields to derive the green cloud, I think, if anything it might be opposite. I think using the edge, using IoT using mobile isn't decreasing the complication requirements for cloud and the complication in data storage driving energy consumption. They are not decreasing the need for those things (energy), they are just moving where those needs are located. It's taking it out of a centralized location and put it into more distributed locations. But, at the same time they are increasing data storage and that is driving up energy needs. I think those 4 technologies are not driving down out energy needs, but they are driving the need for us to having to work towards the green energy consumption. Other technologies like alternate energy forms are what we can do to drive the green innovation, but I don't think those technologies per se are making it easier or more likely, if anything they are doing the opposite.

S: Now we will shift to the world of business. In your opinion, how will the integration of these technologies change the environment in which businesses are managed?

L: These technologies will bring significant changes. We are already seeing new businesses being created because of these technologies, but also you will see major changes in existing industries and how they do their business. I could think of hundreds of examples, one that instantly comes to mind is healthcare. The healthcare industry has changed dramatically, primarily because of cloud and iot:cloud for coordination of records and coordination of data between multiple hospitals and doctor offices, and IoT for the integration of healthcare devices into the automatic elaborated coordination of all this data. So, I think these two technologies just changed healthcare in massive ways. And related to that, insurance industry was changed the same way because of the same trends. I think automotive industry is also changed dramatically also because of these trends. IoT and automobiles go hand in hand, its kind hard to find a new car nowadays that doesn't have connection to the cloud. The way that cars are operated, the ability to have your car to self-diagnose problems and inform you ahead of time and lets you coordinate with a mechanic for repair, those sort of uses of cloud and IoT devices are massively changing that industry. Obviously, agriculture is changing dramatically. But also, research is going to be affect by all of this too. Financial industry also saw a huge impact primarily by cloud, not as much by IoT but by cloud and mobile. Those two technologies have led to dramatic changes in the way that financial industry works It's hard to find an industry that hasn't been dramatically affected by the cloud. And the ones that haven't been yet, are going to be very soon. And there lots if new industries that are being created, so the effect is tremendous.

S: Could you give me an example of a possible industry that you believe that will be created in the future because of this trend, if you have any.

L: Sure, it's easier to come up with ones that have been created recently. E-commerce didn't exist before there was cloud. It was a mere idea. Yes, there were some ecommerce before cloud but certainly the industry grew into its current size because of the cloud. Social media, the way we communicate with each other. You look at the current virus outbreak right now and the way people are working from home and the way we are conducting business. The communication industry has had huge changes. The whole idea of zoom conferences 10 years ago has never been heard of. We could have imagined doing what we are doing today 10 years ago, as far as the amount of working at home that we are doing in general, it just would have been impossible. So that is another industry that is growing because of the cloud, that is created because of the cloud. As far as what's going to come, I think we are going to see some new industries that are going to rely on artificial intelligence and machine learning, as these technologies will become much more possible and will be coming into existence because of the cloud. If you want to add a new technology to these 4, the next technology that is going to revolutionize the way we do business is machine learning and AI.

S: Looking at the ways businesses are managed internally, what challenges will the managers be facing because of this trend?

L: No.1 spot is security. The way that businesses think about security has changed dramatically comparing to before the cloud and I've delt with this for the last many years talking to companies. The No.1 complaint against going to the cloud is around security. How can I possibly take my data that is in my own secured datacenters and move it into a public datacenter. How can I possibly do that and trust that my data is secure? And what I have been finding and telling people is that its actually easier to keep your data secure in a public datacenter that it is in your own datacenters. Keeping your data secure in the cloud is actually easier than keeping it secure in a datacenter. And the reason for that is: when you store data and systems in your own datacenters, you are 100% responsible for keeping that data secure. Nobody helps you with that. You have to have the right knowledge and the right expertise in house in order to keep that data secure. When you use a cloud to do that, cloud vendors have at stake at keeping your data secure either, because if clouds aren't secure and safe, the vendors will go out of business. So they are just as motivated to keep your data secure as you are and all of the major cloud vendors provide significant tools, processes, systems, advice expertise, best practices and guidance in order to keep your data and systems secure. They provide you tools to make that happen and they provide them using the industry best security techniques. So, you are leveraging their advice and expertise to keep your data systems secure. I stared to say that argument about four years ago and a lot of people were very skeptical about it, I think nowadays most people believe that and I'm starting to see those trends in action. If you hear a lot of the major security vulnerabilities that have been exposed, almost all of them involved on-premises datacenters and very few of them involved cloud.

S: Do you have any other advice?

56

L: As the cloud grows, there is going to be significantly more competition. The cloud market has been dominated mostly by a single vendor AWS, that's changing. And that is going to create challenges for the companies to decide which capabilities of the cloud they want to take advantage of, because then you are going to start thinking about things like lock ins, or " do I want multiple vendors or a single vendor?". So I think the decision-making process for which tools to use is going to be significantly more complicated and is going to require a lot of high-level expertise and foreshadowing of needs and of what is the available today. So the industry is going to make the management of IT infrastructure running in cloud significantly more complex, so I think that partner relationships are going to be significantly more complicated. I think that one of the early rise is what I call the "rogue development group" and this is the group within a company that is building something new and innovative and don't want to be slowed down by all the processes within the IT infrastructure of a large company. So, they just create very easily and quickly an account on the cloud, start some servers and do some connections up and running without being bogged down by the requirements of their company for how to build a new system. Those groups move faster but also by bypassing a lot of existing policies and processes it makes it more out of control. So, the job of the IT organization now becomes much more than just managing technology, it becomes managing the swarm of other groups that are trying to do their jobs for them.

S: Would you say that another challenge that may arise from this trend is the lack of people with cloud knowledge that will support the transition and management of cloud inside the companies?

L: I think there is always the problem of shortage of people with the proper skillsets for every new technological trend and that problem exists with cloud too. I think we have seen a turning point in the last couple of years where the problem used to be " hey the cloud is taking jobs away from my IT team" now it's " the cloud is creating opportunities for people to do more and bigger things". So I think people are realizing the opportunities of cloud, and the IT person recognizes that they need to have the skills to work in the cloud in order to keep their job in the future. That is generating a need for much more training and education, but I think that people are starting to fill those roles. So even though there is a shortage, I don't see it as a long-term problem, it is a short term problem.

S: What advice would you give to business managers that would allow them to reap the full benefits of this new trend?

L: "Don't underestimate the value of machine learning" would be the No.1 It's the place where people are just starting to see the value in it. AI and ML has been around for decades but it's been missing capabilities to make it happen. A few things it has been missing is 1) large datasets and 2) is large quantities of centralized computation. The cloud provides both of them. That is why you see a huge increase in AI and ML in recent years, it is because cloud has enabled it. So I think that ,as you are trying to figure out how the cloud fits your company, the answer to that question almost certainly will include answering the question "how ML and AI fits into your company".

The question isn't any more "if" the cloud can help you, the question is "how" each individual company can leverage cloud in new and innovative ways. Understanding this shift from "if" to how" which has occurred in the last couple of years, you will be better off. Don't even ask the "when" question, the when is now. So, the more you can think about innovative ways

S: would you advice hiring a consultant of training the in house IT department to help with these decisions?

L: even though I am a consultant I would focus on the training side. In order to be successful with the cloud, mobile, IoT and edge, ML, you have to be intimately knowledgeable about these technologies and intimately knowledgeable about how then can be used for your industry. Outside consultant can't provide you with that kind of expertise. So it's critical that you gain the expertise in house.

S: Would you argue that the cloud is safer than on-premises architecture?

L: Yes, the cloud is safer than on-perm. The reason for this is because cloud vendors, such as AWS & Azure, have strong motivations to provide a secure environment, and they invest heavily in tools to make your applications secure in the cloud. As such, you can leverage their expertise by using their services and recommended best practices in their cloud environments. When you run on-premise, you are on your own. You have to provide all the expertise to make your environment secure, nobody is there to help you and nobody else is motivated to make sure your application is safe

S: In how many years from now do you think this trend will reach its peak of acceptance in the market?

L: I think we have already moved out of the early majority into the mainstream majority, I think we are entering the majority stage already. I don't think we are anywhere near saturation, but I think we are in the point where cloud and cloud acceptance in most industries is mainstream. I think we're plateauing as fat as the acceptance standpoint, but not plateauing from the standpoint of the opportunities. I think we're getting near the peak now and in a few years will reach the peak of acceptance. More like 2 or 3 years.

S: In your opinion, which country or region will be the first to adopt this trend?

L: That is a good question, I have actually written on this topic. Certainly, US is the leader in cloud technology, period, end of story, that is definitely true. But then APAC, Asia pacific so Australia is way of the world in cloud computing Japan is way ahead. The slowest places are certainly in Europe. Europe has been the slowest to adopt, but I also think that certain industries and certain regions are slower to adopt. The slowest industry to adopt is certainly the financial industry in central Europe. I spent some time in Switzerland, talking to the representative of a private bank in Switzerland and they are still figuring out if they can avoid cloud. This specific area has been extremely slow at adopting these trends. While various high-tech industries in west cost of US have been extremely fast to adopt.

S: From my side that would be all, thank you so much this was a very informative talk. Have a great day, bye!

L: Yes, I enjoyed it. Good luck, bye bye.

2. Sarbjeet Johal

Interview duration: 53 minutes

V=Veronika (Student)
S=Sarbjeet Johal

V: Could you tell me more about your role in your company and your past experience?

S: Sure. I am an independent consultant and I work with C-level executives of large companies to do the cloud/digital transformation strategy. I have worked for world's biggest brands like Oracle and Visa as an employee. So 25 years of tech and for last twelve years I've been doing cloud computing.

V: So, a little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and performance of data processing. Do you agree that this will be the future of cloud computing?

S: I think it is, especially because of the amount of data we will be producing almost everywhere. I always say this is the age of miniaturization: we have been miniaturizing hardware for the last 30 years and now we need to miniaturize e software. On that note, I always say that cloud is nothing more than infrastructure as code, and anything we turn into code grows exponentially, anything we turn from physical to digital grows exponentially. It's not that fast of a change s some industries think. Any technology that takes off is always a convergence of few other technologies, it's never alone. So mobile take off because the network and computing got better, the touchscreens and processors got better, and they are always miniaturized. I will give you an example: VR will take off big time in maybe 4 or 6 years, as we miniaturize it. Similarly, in this case, I think edge will take little longer. For edge to happen I think we need really strong 5G network, which are not there yet but they will be. I think 5G will fuel edge, as it is a faster wireless technology. Keeping that in mind I think there will be more of regional datacenters that we can call edge datacenters. But edge is very relative term

V: So basically, you agree that this will be the future, but you are saying that we are still in a very phase, so it is too soon to say something definitive?

S: No, no, I am certain that it will happen but I'm not certain about the market size for edge and where are the boundaries between a traditional datacenter and edge. It's all a latency problem, you don't need edge for anything else. Thus, as networks get stronger and its speed gets better, we can do more with cloud. I keep saying that to anybody who says that edge is going to be huge, but do not rule out the growth of cloud. One of the main reasons why cloud took of is its centralized processes, that are better processes. With centralization you can get economies of scale working in your favor, as well as the division of labor. We always compare cloud to electricity: people used to have generations outside of their homes for electricity, but now it's all centralized and distributed by electricity companies. So, I think that having that central management will reduce costs. Also, it's always about the price to performance ratio, so if cloud is cheaper and it gives you good performance, even if it's a little bit lower than the one of the edge locations, people will still chose cloud. Edge is going to be a very expensive proposition for many companies to put in place and to maintain, so I see cloud getting stronger at the same time.

V: So basically, you would say that both cloud and edge coexist, and cloud will be preferred?

S: Yes, cloud will be preferred.

V: Would you argue that mobile cloud computing is not a separate trend, but it is actually a part of this trend that integrates cloud computing, IoT and edge computing?

S: A cell phone is an edge device. My apple watch connects to my phone though local connectivity, I don't need internet on this (the watch), so these are both edge devices. Mobile is part of edge and 5G is going to be part of mobile, so they are all technologies are again coming back to the convergence. So the technologies are converging: 5G, which is networks, are converging into mobile and then cloud, AI and ML. By the way, we already have Edge. We have been doing edge computing for the last 20 years we used to call it CVN. Most of the cloud companies are doing edge computing: if you take a look at amazon outpost solution and Microsoft azure in your datacenter, those are all edge solutions, I think.

V: Can we argue that this combination of technologies is the main driver of Smart Cities and Industry 4.0, which are other trends also addressed by academic literature?

S: Yes, that is so true. They are the basis of smart cities. I think education and public transportation will be changed big time with the convergence of these technologies, self-driving cars, I don't see buses in the cities, I think we will have cars that fit 2 people and that will be owned by the city, so they can provide public transportation in that sort of way. Many times, you see buses running empty in San Francisco.

V: Another trend that I see a lot in academic literature is green cloud. Can we argue that this combination of technologies that we spoke about will make cloud more energy efficient and therefore drive the emergence of green cloud?

S: That I am not sure about. I think energy efficiency is going up as we improve out servers, minimalization on the hardware and software side, but I think we will be consuming more energy in cloud datacenters, but for the same amount of compute we will consume less energy in the future.

V: So, from one side we will be doing it more energy efficiently but from the other side we will be doing more of data processing, so the impact will not be much relevant am I correct?

S: Hold up: at the macro level it will be a huge positive change I believe. I gave you the example of the micro transportation, right? So a big bus moving people from point A to point B is taking a lot more energy and CO_2 emission. Just imagine if you deploy a smaller bus based on the data coming from the route of the bus, like " ok, from this point to that point only a maximum of 5 people travel a day", you don't need a bus to carry 50 people. So, in that way, it is good for the environment, but when you talk about a datacenter being green, I don't believe it. Cloud will be more grayer than greener. You can put a solar panel on top of a datacenter and cloud it green cloud, yes. But overall we need more and more computing, and we are concentrating more and more computing into the cloud providers, like AWS, Google, Alibaba and the consumption of electricity per server will go lower, but the demand will be skyrocketing for servers that means more energy for servers, but per server it would consume less. Forget about all these trends, Edge is just a tool to do automation of other things like buses, factories, airplanes and cars, so it will save us a lot more in other areas: the buildings, the cars, the trains will be efficient, because we have more servers in the cloud, more edge devices.

V: In your opinion, how will this this integration of technologies change the environment in which businesses are managed?

S: I think it will bring huge changes. There are 3Ps in every business, they are people, processes and products. So, it changes people management. Though this pandemic we have seen people can work from home there are on remote work, there is less cars on the road and like, it changes the whole paradigm. As we can connect remotely and we have the holograms and we can see people 3D and the VR hitting us in a couple of years... the boundaries which we have in communication these days will be removed and the communication will improve as networks improve. I think from the "people" side it will change, and processes side of course it will change. We will bring the 3D printing into the mix with 5G and I think it can change the way we are producing things, like, you can make things closer to the consumer that means less shipping needed, less packages and materials needed… it has a big impact. So, on products side we can see products are digitized so … it falls under the 3D printing, 3D printing falls on the product side as well as processes side. So on the products side we have been digitalizing everything, right? So the healthcare is digitalized, if you want to send documents to somebody to sign, so we are digitalizing every aspect of our life. I sometimes challenge people by asking name one industry which is not touched by digitalization,

including agriculture, everything is going to pass by digitalization. We are doing (experimenting) agriculture without land these days. We have multi store buildings here in NY macro area. You don't need dirt or land to grow mushrooms and things like that. It's just done by robots blowing gases, oxygen, whatever they need, and it works. At least 1/10 of the water, it's crazy.

V: That is interesting because you touched the topic of AI. Would you say that Cloud computing, IOT, Mobile cloud computing, edge computing, they are also drivers of AI and ML?

S: Yes, yes they are, for artificial intelligence we need more compute, faster compute, better networks, storage is less important I believe in AI, I mean it is important in a way because data is the food for AI or ML so ML eats data to grow, but I think also on AI front, the numbers are over blunt by industry experts saying " no this % of jobs will disappear" and I think they do that because they want to crease some sense of urgency for governments and regulators to take some actions so that we don't leave some people behind. But I think its going to be a gradual change, its definitely a change but its digestible.

V: What in your opinion are the main challenges that business will be facing with this trend?

S: I think the way we manage people will change, we are a gig economy in many ways. To do the job will be a challenge, we will have to re-train our people so there is a challenge in finding those people, a challenge to train them. The managers themselves will be challenged into knowing how to operate robots, they will not have people to work for them, they might have haft of the work being done by a machine and half being done by a person. From the people side it's a training issue, it's an income issue, it's a control issue in a way that people don't want to change. From these things I mentioned: people, processes and product, people are the hardest thing to change and the next thing is processes, but products are easy to change.

V: From the people side, you mentioned training, my question is : do you think it is better to train the in-house IT department in new technology or would you advise to hire a consultant to help companies to leverage these technologies.

S: I think it depend but mostly you should invest in bringing people form outside, don't rely on your internal people to speed up that training. You have a sense of urgency to move fast right? For example, you want to do electronic vehicles: will you hire someone from Toyota or from tesla? Of course, you will get the best out of free talent from outside, to do things faster yourself. So: we are a knowledge economy, knowledge is everything, but I think it will be like, you hire someone with cloud knowledge and hire them for 5 hours and you pay them 1000$/ hour and you are not stuck with that person for years, but you get to know how to do stuff because he or she has done it in other companies. Like for example, I will pay 500$ an hour to somebody who is senior at facebook, for 10 hours, and that will save me 5 years of

time to go to market. I think this is the age of specialization and micro-consumption, how I usually call it.

V: What will be the main opportunities for businesses that will arise with this trend?

S: There are huge opportunities to serve customers better using these technologies, though mobile and then go to VR and self-service. Yes, there are huge opportunities to delight your customer and have better customer service and have better feedback loops. I always say that the best companies are the ones that have better feedback loop. It means you are listening to your customer every time, getting your feedback and adopting the processes and products according to new customer's needs.

V: What would be the main challenges for businesses

S: I think human capital is a problem. Finding people who are trained in these things. Capital itself is a problem. Money is a problem. Also, businesses don't want cannibalization meaning they don't want to kill their existing business to start a new one, so that's a huge problem. I think people who are not willing to take the risk, there is a huge problem for them, they will be crushed sooner or later. People who are more reactive to the stock market, share prices of the companies and stuff like that – short-termism will kill many of these companies

V: What advices would you give to businesses to allow them to reap the full benefits of these new trends?

S: My advice is to start learning about these technologies as soon as you can No.2 bring the people, experts from outside from both your industry and adjacent industries, like if you are a car company bring someone from a software company, something that would lead to cross-creation of ideas and stuff like that. If I contacted the CEO of the company, I would tell them to do stuff like that, but at a lower level it's another discussion.

V: In how many years will this trend reach its peak of acceptance in the market?

S: Different Parts of the world will move at a different speed: for example, if you are in the silicon valley most of the stuff is cutting edge technology, but if you go to Bangladesh they are way behind.

V: Think about US as a market.

S: Yes, yes, so US, Germany, UK, China those kind of economies, they are already in the mix of it, but we are talking about multiple technologies right? So Cloud is already happening for the last 12 years, more and more and more. Normally the technology cycle is about 7/8 years long, but the cloud cycle is going to be 20 years, I think. And edge will be also pretty long, but not longer than cloud, AI and ML will be long cycles because they are waiting for the technology shift and business model shifts, and you cannot see technology in isolation from the business world meaning how the businesses are doing, how the countries are operating, so the money is cheap these days. As we become more global economies, the economies go hand in hand. So, there are so many factors in the adoption of technologies in

different nations. But I think the peak will be .. <mark>we are just in the very beginning of edge, so I think it will be more in than 5 but less than 10 years.</mark>

V: Perfect, that would be all from my side. Thank you so much for your time, this was super interesting and insightful.

S: Thank you, good luck with your studies, bye.

3. David Linthicum

Interview duration: 22 minutes

D= David Linthicum
S= Student

S: Could you please tell me more about your role in the company, so I know you work at Deloitte. Just a little bit about your experience.

D: Yes, I have been in the industry for about 35 years then multiple roles different technologies faced as mostly CTO roles I did that with a number of companies that have been mostly sold in the 90s and early 2000's. then focused on cloud computing for the last 15 years, I started a cloud computing consulting firm in 2006 that was sold I'm at Deloitte ever since. 13 books on computing last couple on cloud, I do a lot of writing and speaking, talk to a lot of reporters and a lot of radio and TV.

S: So, a little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and performance of data processing. Do you agree that this will be the future of cloud computing?

D: I think it's going to be about different architectures, at the end of the day its computing provides us the architectural alternative which allows us to place the data analysis closer to the stores. So, while we will use some instances, typically its not going to be as widely used as people think (edge). So I use it, in my IoT deployments, dealing with drones, sensors, that part frankly can work in a disconnected world and therefore they work at the edge, they work better at the edge, but you are also giving up power, performance to be able to integrate and you're adding complexity, <mark>so its situational,</mark> I think, it's never a good thing when you consider an architecture that is all or nothing: that we are moving towards the edge or towards

64

IoT, it's going to be a balance for a long period of time. Because both of them have legitimate advantage and use.

S: Would you argue that mobile cloud computing is not a separate trend, it is actually part of this conversion trend?

D: Yes, obviously mobile computing wouldn't be possible without backend system to support it, that does the sorting and information processing. We realized quickly that the data was too big to live on the devices, so we put it in the backend systems so it's absolutely integrated. The majority of mobile systems out there, the applications leverage backend cloud storage, backend cloud analytics and they are married on to another. So they are right when they say the lines are blurred, it's very hard to make the distinction between these two right now.

S: Do you agree that this combination of technologies is the main driver of Smart Cities and Industry 4.0?

D: Oh, absolutely. So in other words like we talked about cloud provides centralized processing and storage, while its centralized knowledge base, the ability to leverage AI and ML centrally, and edge based system will be in reason to put some of the processing to the closest place of the data collection. And smart cities is lots of things operating in orchestration one to another and whether it's a traffic light or a security camera, a smog and air quality detection system and things like that, those are all edge based but they communicate back in cloud and they deal with IOT because they deal with sensors. And obviously mobile computing is part of the deal because in many essences smart cities are looking at the location of the citizens in terms of whether determining their safety issues or where police needs to be located things like that. So, it all comes into place and I believe this is what a smart city is.

S: Cloud more energy efficient and thi way drive green cloud?

D: Yes, the more we use cloud, the more energy-efficient you are. While edge and IoT can actually be less energy efficient if we are putting a special device that is out there on its own power supply, basically leveraging its own network device and connectivity and things like that. So, the thing is, the more we are leveraging cloud computing, the more we are sharing resources. And the more we are sharing resources, the more green it is. So, many instances… I live in Virginia, and there is datacenters all over the place, they are building 5 every month. And, the reality is, if you go in those datacenters, the level of utilization is fairly low for an enterprise datacenter, in other words they own the building they own their equipment, they employ the people that are in there taking care of. Well if you move those workloads to cloud, we go from say 3 to 5% of utilization on average to 95-97% of utilization on average and therefore we are leveraging the same compute systems with the same power supplies, same use of water, same real estate that we have to cool and we're getting much more out of it. So, this share ability allows us to increase the optimization and efficiency of those things.

S: Can we argue that these trends driving Artificial Intelligence and Machine Learning?

D: Yes, they (AI/ML) are economically viable now. You know in 1958 I was an AI analyst, just got out of collage when I was 22. They were not economically viable for businesses because they costed multimillion dollars to set up a very rudimentary system. Now you can set the same system for 10-15$ per month to run it. And obviously that allows us to leverage ai, technology ml technology as a force multiplier. Not only is the technology better than it was 30 years ago, but also it is thousand % cheaper and that is the perfect storm: economic viability, power of technology and also the ability to leverage the technology as a force multiplier for the business, whether its analytics, inventory reorder systems or something that is basically running a process.

S: Would you argue that cloud is more secure than on premises infrastructure?

D: Yes, it is. It has been more secure for about 5 years, and the reason is because cloud based security systems, whether they are owned by the providers or not, so its 80% of their R&D dollars are sunk into cloud-based security. So, we're not working on on-premises security anymore, haven't been for the last 5 years. So therefore, if the R&D dollars are shifted into the cloud, then the cloud is going to have better security mechanisms and better opportunities to be secure. So that is why you have more capabilities on the cloud and therefore the cloud, generally speaking, is more secure.

S: In your opinion how will this integration of these technologies change the environment in which businesses are managed? In other words, what changes will this bring to businesses?

D: I think they will bring the ability to leverage the technology strategically, instead of just basically allowing it to automate operations, you know, counting, payroll, inventory control, things like that, just basically to keep the business running, to automate what used to be manual. The ability to do things such as generate more sophisticated and better customer experience and therefore the ability to kind of grab the additional market share because very much like Netflix and uber and lyft, those folks are basically providing great customer experience and therefore they are going to be better than taxi cabs or movie theaters. Ultimately, in essence they will be able to do things for the pharmaceutical and manufacturing or resell industry. We have already seen Amazon moving that direction right. Technology is not something that enables their business basically to automate what used to be manual, but the ability to step up the customer experience, and logistics and allows the business to run in such a better way, that people view it as a better alternative to competitors out there. And I think that is where the technology is going to merge in the next couple of years.

S: What are the main challenges that business will be facing with this trend?

D: I think the challenge is going to be the ability to get the personnel in the company trained up and on the line. The people has always been the biggest challenge, it's never the technology, its fairly easy to do things with the technology. People and personalities and

politics and all those things that exist in large enterprises these days are very much difficult to overcome, so you have to be able to change the culture, it has to be a very flatter organization that we are going to manage and ultimately the ability to train people to have the skills to make the stuff work, it's the hardest thing to do.

S: What advises would you give to businesses to allow them to reap the full benefits of this new trend?

D: You have to get leadership on board and investors on board before you can more forward. So, it has to be funded, that is No.1, everybody has to be signed up for it, and it has to have the funding in place to make it work, and it has to have a cultural imperative that everybody understands why we are doing it. That doesn't mean we can't have people who disagree, but ultimately everybody has to be on the team of moving this stuff forward and that is the only way you are going to leverage the technology correctly. Then, leverage the cloud computing technology needs to be discussed to find a way of it being the most efficient, and missing that, its just not going to happen. Keep in mind that technology is easy. So, the problem is not just the technology stuff, but the idea of getting the business behind it, and the operational models and people behind it, the leadership on it.

S: Speaking of people, would you advise to train the in-house IT department in these new technologies or is it better to hire external consultants?

D: I think it's really both, everybody should have an opportunity to reinvent their skillsets, and certainly today the training is on demand, as you need it, then people have the opportunity to accelerate their careers themselves. But you need to be prepared to understand that a certain amount of those people aren't necessarily going to step up. In the essence you can retrain them to do other things, it doesn't have to be too tyrannical, but you will have to infuse the skillset you already have with the skillsets that are able to provide leadership and mentoring as to someone who has done it before. And that is why people are bringing mentors and may hire outside, to drive those engagements. By no means you are getting rid of everybody in the company that doesn't have the necessary skillsets, you provide them with the opportunity to change their skillsets and step up.

S: In how many years from now will this trend reach its peak of acceptance in the market?

D: Oh god its already there, and if it wasn't there prior to the pandemic, it is now. Everybody is onboard with cloud and you can't have a virtual work environment without leveraging mobile computing and the ability to provide all these virtual services and move out the existing datacenters into the cloud. they realize that the vulnerabilities that they didn't know they have, with the pandemic at work, people who had on-premises systems and datacenters that couldn't get into because of the quarantine, and now being stunned by that, many of my clients lost a million dollar/ an hour for a week, so of because they are going to move as quickly as they can to cloud and paying everything to move forward and that's IoT, edge

computing, mobile computing, cloud-based system, AI/ML, analytics, everybody is kind of brought into it so that is a good thing.

S: What region do you say would be the first to adopt this trend?

D: obviously US, and then second would be Europe, then from there I would say, UK is part of Europe, then it's going to be the APAC region, including china and japan, south Korea and Australia. So it's probably going those sorts of ways. I've notices that Asia APAC has the tendency to be 3 years behind, where Europe has a tendency to be a year behind.

S: Some of experts mentioned that central Europe is rather slow in adopting there trends, specially the financial industry, in countries like Switzerland. What do you think about this?

D: I think Europe is not slower than Asia APAC, so it is faster than other parts of the world, certainly slower that the States.

S: Can we get back to the question related to Green cloud: you mentioned that cloud will become greener from the perspective that more companies are sharing resources and obviously less energy is being consumed, however, the datacenters, even the ones of the cloud providers, are very energy-inefficient, at least that what the academic literature is saying. What people are trying is making the datacenters more energy efficient. Do you think that it is something cloud is moving towards to?

D: Yes I mean, the cloud datacenters are more energy efficient, for the reason of multiple sharing but also their ability to process power and alternative energy sources, solar, wind, deal with water in a different way, they are more optimized, they are better built to be more energy efficient. Certainly, the ability to share resources would be the main advantage, but if you could replace those with traditional and inefficient datacenters, what you just mentioned is true. Every datacenter that I see around here uses more power than a small town, and they are ugly, they are 3 store buildings without windows. So they really don't do anything to us other than dry energy based on the value we get from it and so the more cloud datacenters we're able to open, the more potential we have in shutting that datacenters. I did notice that a big trend of my clients has been not just keeping the datacenters open and use them more sparingly before shutting them down. So, there is a big push to get out of the enterprise datacenters and that's because of its inefficiency.

S: From my side that would be all, we were very efficient- in 22 minutes we're done. Thank you so much for agreeing to do this, it was really insightful. Thank you so much David.

D: Sure, let me know how things go with your studies. Thank you, cheers, bye bye.

4. Omid Mahboubi

Interview duration: 36 minutes

O: Omid Mahboubi
S: Student

S: Could you please tell me more about your role in the company you founded and your past career experience?

O: I am the founder and executive director of MENA Cloud Alliance. The Alliance is the only neutral not for profit industry association focused on cloud computing in the Middle East and North Africa, particularly in fourteen countries, and what we do is, I think is an integral part of any ecosystem, is that we bring trust to the table. See the problem with cloud computing consumption in many ways can be reduced down to the problem of trust. If you don't trust cloud ser vice provider, if you don't trust the government, the policymakers and the integrity of cloud based systems and security, then, we will have no adoption, so my role was to create this platform, bring all the big vendors and users, government agencies even as far as universities to the table, so that we can have a unified voice in the industry.

S: So, a little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and performance of data processing. Do you agree that this will be the future of cloud computing?

O: I would say yes, but I wound not characterize as the future of cloud computing per se. this is the future of us, this is the future of technology, its interesting that you have chosen this path Veronika to get into Cloud computing and the future of cloud computing, but the beauty of this is, the more mature a technology becomes, the more abstract it is going to be, so five years down the road, we're not going to hear the work cloud computing, because it is going to be abstract and nobody will be even notice it doing wonders as foundation of all these emerging technologies. It is true that... and I have one word for you, that is convergence. We have IoT and we have edge computing, of course we're then introducing cloud computing for many different reasons... there is also another very important technology here and that is 5G. the whole idea of this is, you know cloud computing initiated a new way of consuming IT. So, we were thinking, let's not build our own datacenters, lets trust somebody who's got datacenters without data. They can do a better job, we don't do our electrical plans anymore, we just go to a utility company and get out business subscription- based. And then people started to open up to data and started to see the advantages in cloud computing, especially

after COVID I would argue it is becoming even more clear what cloud computing is enabling everybody to do. And then we had IoT of course, because we wanted to create new IP- based devices and notes in our networks because we thought "hey, why not to have a traffic control span on the network. Why not even connect our fridges to the network, maybe there is a processing possibility? And then we realized, ok , so there is massive and huge implications of that, if you're talking about autonomous cars, and things that really need instant, real time processing, as fast as cloud is, we don't get to go to the cloud and come back to the device, in time enough to avoid disasters or to actually to provide services as they are expected to be provided. So then everybody though, what will we need to do is we need to create some sort of a processing capability like on those devices, so we don't have to go to the cloud and back. And now we have all sorts of emerging tech, we are talking, OK, fog computing- lets have notes on the network, closer to the devices but not necessarily on the devices. these days we're looking at Kubernetes and adoption of open source technologies basically creating mini datacenters on those notes, so my thinking is, there are applications of this convergence of cloud, IoT and 5G, that we haven't really contemplated just yet, so there things will surface in near future and become part of our lives like they've always been there and our kids are going to be completely accustomed to these things.

On this note, would you argue that mobile cloud computing, a separate trend according to academic literature, it's actually a part of this trend.

O: Actually, it is very difficult to give distinct descriptions on these trends, partly because they have a few overlapping areas that point to each other, in fact that is why I will go back to the convergence point. There are different technology trends and there are different protocols, different implementation processes, but these things actually come together to provide a service. See, it's not about technology, it's all about the problem we are trying to solve, and I always do this analogy, see technology is not a single even, technology is the backend and it shouldn't even be visible, it's just in the background, these technologies, mobile cc, IoT, edge, they need to handshake at some point to be able to provide the service that we are trying to provide. So, it's very hard to argue for and against the differences between these trends, let's just say these are all part of a unified growing trend, and that is the convergence of these new technologies.

S: Do you agree that this combination of technologies will be the main driver of Smart Cities and Industry 4.0?

O: Oh , absolutely, there is no doubt in that. When we talk about smart cities, we are talking about scale. We're not just talking about little bits of problems to solve, we're talking about massive, population wide, statewide problems to solve. And these are all pieces of that big puzzle, and certainly, it's inevitable, we're going to be taking a lot of IoT and edge computing applications and deployments that are running on the cloud, to be able to make a city smarter. And look, I sometimes think about this: what makes a city smart? Cause I think it's important to understand, when we talk about smart cities, how can we characterize a non-human city with the human characteristics, and my answer to that has always been: if you can start an emotional relationship with the city, then that city has become smart. That relationship can

have different degrees, we have smarter cities and there is obviously a massive room for improvement, but if we really going to make a city smart, that city needs to understand you, it needs to establish a genuine relationship with you, and for that to happen, we are going to have a combination of all of these technologies, but we are going to have a harmonized combination of technologies.

S: Can we argue that this combination will make cloud more energy efficient and therefore drive the emergence of green cloud.

O: Let's be honest: more cloud means more datacenters, and datacenters are no environment friendly creatures. We are trying to make them more environment friendly. We have seen, for god's sake, we have seen Microsoft dipping a whole datacenter underneath the ocean, or we've seen completely solar powered datacenters. But see, more processing means more cardon footprint, there is no argument in that. I don't necessarily correlate these two together. So I wouldn't say more cloud means more environmentally friendly attitudes, I think we need to be conscious and we need to understand the impact of cloud computing or any technology for that matter, on what we are doing to the planet, and I think it's a different trend. And I'm so happy to see that this is an exponentially growing trend because of consumers, you know enterprises and governments are certain about this: cloud system providers and the whole ecosystem is trying to be less pollutant but hey more cloud means more datacenters, and more datacenters is, we're going to need some very creative ways of increasing our compute power, but at the same time, be a friend for our planet.

S: Would you argue that cloud is more secure than on-premises infrastructure?

O: Yes, the answer to that is definitely yes. And the reason why is usually that big cloud service providers, they do this for a living. They have state of the art datacenters, they are exclusively trained for this, they know exactly what they are doing, so chances are, they run a better datacenter security wise that you do on premises. But there is also point that I think is highly underappreciated, and that is, look, for security, one vendor or one government for that matter, we should rely on an ecosystem that provides security for the environment, enterprise environment, start ups and so. So, leveraging the cloud, which by definition means redundancy right? We're not in just one location, there is a distributed nature in cloud computing. So that, by itself, the fact that you are not putting all your eggs in one basket, it increases your security, and it creates redundancy. And folks need to understand that, cloud vendor ecosystem is working so hard at becoming interruptible, and ecosystem of security. Not just one product, not just one vendor, but an ecosystem protecting our data. And there are of course issues and challenges, so we're not saying it's all vanilla, there are so many issues that we need to tackle, but cloud is generally safer.

S: Can we argue that these trends that we spoke about are driving artificial intelligence and machine learning?

O: Absolutely. The reason why is, how can you have AI, without the accumulation of good quality data? you can't. There is this old saying, I use it from time to time in conferences. There was this guy who lost his keys in an alley, and he couldn't find it. So he went under this streetlight and started looking for it so there is this guy and he asks him " is this where you lost the key?" and he goes " no, but this is the only place where the light is". This to me represents what so many of these big data cloud-based systems are producing. They are looking into the only type of data that they can get their hands on, it's not necessarily good quality data. That is why you end up building systems where is rubbish in and rubbish out. For ai to work properly, we need to feed it the right data. Now, to accumulate and process that, and to filter that, we need cloud computing and so many of these technologies. For that ai ml to happen ,they need to start somewhere, and its very important the foundation we provide these systems with, and we can't possibly do that without the power of compute power, and the right algorithms, to get our hands on the right type of data to feed it AI and to let AI do its magic, and god knows what we are in to see in a few years, but we are getting there little by little.

S: In your opinion, how will the integration of these technologies change the environment in which businesses are managed?

O: Right. As far as cloud IoT and edge computing is concerned, I'm going back to the point that I made earlier about solving the problems. Real actual unsolvable problems, important problems. I think we really need to focus on what new values businesses can really make, leverage this technology. and this remains to be seen because I think we are about 5-7 years off from a time where we see actual application of IoT, edge plus cloud, 5G combination. But when we get there, I'm pretty sure it will have a huge impact on A) what values businesses are bringing to the table, so there is new values based on new capabilities that are in the market, the opportunities that arise and B) how better can they do the job that they have always been doing, but now leveraging IOT. For example you are an engine production company for planes and for cars, of course you are looking into all these things, its just that, have you been able to identify the new value that you can bring to the table and or the new way of providing your previous core values. So that is the impact that you are going to be seeing, I don't know what is going to… I don't profess that I know exactly what these companies are going to become. If I did, I would be a billionaire. But yes, it's interesting to see where businesses are going with that.

S: To understand how businesses can bring value with these new technologies, would you advise a) hiring an external consultant or b) investing in training of the in-house IT department to leverage these technologies

O: That a good question. A lot of folks are really deal with these things on a daily basis. I would say there has got to be a combination of both. One is, when cloud computing first came out, IT folks within the organization they became second class citizens. They were afraid of losing the jobs, they thought "ok, everything that I have been handling is going to be put on the cloud in a few years and I'm going to be redundant". Well, that didn't happen because hybrid came along and then companies realized "hey, you don't have to put everything on the cloud, you still need your IT folks". It's just, you need to understand your workload better, you need to understand your environment better, so you need to actually equip your workforce with the latest cloud technology and the trends, so that they can understand how to deal with these things in terms of external environments that are going to be handshaking with them, and APIs and all those economies around them, but at the same time I have always advocated injecting fresh ideas into a company if you can afford it. And the beauty of this is, and the trend that I'm seeing is that, as opposed to 10 years ago you had… oh you still have the Big 4 right? Nothing against them, they are great companies, excellent consultant force and they have brought a lot of value but I think in the future, and this is near future, we will see the power of community, not just one day, we're going to see companies and consultants that arise from a community-wide collaboration, and that "crowd-wisdom", sort of speak, is going to be injecting the fresh look and the fresh insights. I don't think companies no matter how big they are, in fact the bigger you are, the more problems you are going to have, I don't think they can always have 100% inhouse talent, you need outsiders as well.

S: What are the main challenges that businesses will be facing with this trend in your opinion?

O: Look, as is the case with other technology trends, in the beginning, there is going to be a lot of spending that will go to waste, inevitably. And that is because we are just getting acquainted with what these technologies are capable of. New things they require some time for us to get acquainted with, not just technologically, but also culturally, financially, we need to understand what they are and IOT and Edge computing absolutely fall under that categories as well, so my answer to that is, there will be challenges and there will be a lot of spending going to waste, but if you as a company or a first mover, you lose a little bit of financial resources, but you gain a first mover advantage in return. So, obviously, another example of that is how folks started using public cloud but they just didn't know how to switch it off or how to manage the virtual issues and ended up paying a lot more. So its is going to happen to these technologies just like to anything else, of course there is a learning curve that everybody needs to go through, but in time, as these technologies mature, I think we understand them a lot better, and the other thing, there is going to be a lot tools out there helping decision makers make better decisions as well.

S: Looking at the advices that you would give to businesses, to allow them to reap the full benefits of these technologies, we are looking at combining in-house training with external consultants, we are looking at investing in the development of these technologies without fearing the first financial losses, is there any advice that you like to give to business managers to succeed in this new trend?

O: Absolutely, there is one word that comes to mind, and that is agility. Look, all these things are here for us to be able to experiment with them, and more importantly, for us to fail fast. I mean if we were to experiment with edge computing, put up an environment, the backend cloud computing, create a devise that has the ability to processing data information, to solve a problem. Using cloud computing and using IOT protocols that we have today, it allows us the privilege of failing fast. Setting up an environment, testing it, if it doesn't work with minimum cost, you can spend on something else then. And that is the beauty of this, it injects agility into our product development environments, and teams and departments. It allows us to experiment fast and to fail a lot and then learn how to succeed, so to me folks who have the courage and the resources, by the way, because it's really different from company to company, but if you fail, if you leverage these things to solve an actual problem and fail fast, you will arrive at something gold .

S: What would be the main opportunities that will arise with this trend? I know you already mentioned that each company must find what problems it can solve with this technology, but, do you think there are a general set of opportunities that will cover all industries and businesses?

O: Sure, while you were asking the question I actually started thinking, and I'm just thinking out loud here: this to me is the future. See if we were to go back to 20 years ago, nobody would see people, like human beings as data sources that could be commoditized. Nobody would knew that there would be Facebook, there would be social media and I think we are not realizing the gravity of introducing things as sources of data and this is going to be the future because there is a whole a lot more of them than there is of us. Back then we were 5 billion? Today there is more devices connected to the internet than there were people back then, so I wouldn't be surprised to see new opportunities from understanding and analyzing this huge surge of data, and if they can do it right, the good thing about it is, these devices are not going to be protesting their rights to privacy, that's for sure, so that's a huge opportunity right there.

S: Which country or region do you think will be the first to adopt these trends that we mentioned?

O: That is hard to say, especially because we are living such a fluid geopolitical environment these days, that it is practically impossible to foresee something like this. If we were talking about this last year, I'd be telling you certain countries in the middle east, certainly Europe, but this is changing on a daily basis and what I see in the market now, there is this willingness, this ambition to become first movers in so many underappreciated markets like middle east

for instance. And they are trying to leapfrog a lot of the countries and regions that actually initially opted by technologies like cloud, then IoT, edge computing, it's probably the same case. So there will be an uptake, I wouldn't be surprised to see an uptake of IoT and edge in smart city applications, say in the middle east, certainly in UAE and Saudi, Bahrain, also, depending on the applications in autonomous vehicles certainly we're seeing the US and that remains the hot spot for that, but again it's very hard for me to say as this world we're living in today? Is very different as you and I both know from what we used to know 6 months ago.

S: Absolutely. Well, it was a pleasure to know your opinion on this topic, that would be all from my side.

O: Let me just give you a piece of a compliment here, and that is, the way your reach out to people. I try to explain this to a lot of folks, we get approached by folks on LinkedIn, but the way you formulated your message, to me was flawless. I think it's a lesson for people to know how to engage people. I think you were a quick learner at AWS, AWS being one of our top partners, but hey, keep up the good work and never lose the energy and enthusiasm.

S: Thank you so much, your words mean a lot specially because this has been not an easy process. And have a good meeting a wonderful day!

O: Thank you, have a wonderful week!

5. Lawrence Dignan

Interview duration: 33 minutes

L= Lawrence Dignan
S= Student

S: Could you tell me about your own role in the company, your past career and experience?

L: I'm a journalist, Vice President of Editorial and Red Ventures, which is the company that owns ZDnet, Tech Republic. I have been covering cloud since amazon had their cloud unit, so I've been writing about it for a long time now. So basically, since like 2008 or so, I've been covering cloud computing and watching it develop overall.

S: So, a little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and

performance of data processing. Do you agree that this will be the future of cloud computing?

L: I see it as something that is intertwined, not necessarily the future of cloud computing. The big reason is, cloud computing is still going to be there, it is going to be part of a centralized data processing, datacenter, hybrid cloud kind of approach. Companies are going to run their own datacenter whilst multi cloud will enable companies to switch between Google Cloud, AWS, Alibaba Cloud, Microsoft Azure. So, edge computing, the theory is, the centralized, it processes more of the data at the edge, largely because its challenging to upload that data back and forth to the cloud process, the more you can do with the edge, the faster, and that said, there will be certain types of data, like batches that you might to once or twice a day, whatever, so the output from what happens on edge computing, that may be transferred to the cloud, which is why 5G is so important, because it is what will be the connection to the cloud in many ways. So I don't think it's a zero- sum game, like its one or the other, I think there are going to be two different things that are highly overlapped, so frankly it's just going to depend on the workloads so in some cases, AI ML, that's better off being processed at the edge, and other times that is better off in the cloud. it just kind of depend of what you are doing, what the workload is, and how fast you need to make decisions. With something like autonomous vehicles, you want as much processing as possible inside the car, because you don't want a network outrage to screw up the braking system for instance. Now if it's something like autonomous vehicles and you don't have to worry about latency as much, that may connect to some edge server sitting on a billboard somewhere on the highway, and maybe that goes up to the cloud. So, the idea that one is going to be the future of the other, I see it as being two things that run in parallel and they intersect a lot.

S: Interesting, because I've been talking with some experts and most of them argue that there is going to be this convergence where all these technologies are going to be used, depending the purpose, but basically they argue that this is one big trend instead of many different trends.

L: I see it converging at some point, before the foreseeable future, it's going to depend on the workload.

S: Ok, then your opinion must be different on the other question that I'm going to ask, would you argue that mobile cloud computing is not a separate trend, it's actually part of this trend that we are talking about, specially internet of things. Would you look at it that way?

L: Can you describe mobile cloud computing? I see internet of things a thing that is related to cloud computing and edge computing. Mobile cloud computing, I'm not sure I see it as a thing. Now if you are taking about edge centers sort of things, that is where commonly refer to the internet of things. That could be anything from a sensor in a winter bine, to a sensor

on a tire, to a sensor in a bulldozer, that's where I'd see internet of things. Some of that would be classified as autonomous driving. Honestly, if you were to draw this out , you'd have cloud as a circle, edge computing as a circle, and IoT as a circle, and frankly, all the stuff is going to be in the middle. So, the technologies are overlapped, which is why you've seen cloud computing vendors, like AWS, they have edge computing services, they have IoT services, they have cloud services, and they overlap a lot. Think in terms of building blocks: If you didn't have cloud computing, you probably wouldn't have edge computing. Without internet of things, you wouldn't have edge computing. It's all 5G and kind of goes to the connection issue, and the same it goes.

Would you agree that this combination of technologies, cloud computing edge computing and IoT, maybe mobile computing if you consider it, would you say that these technologies are the main driver of Smart cities and Industry 4.0?

L: Certainly, industry 4.0. smart cities, I have been writing about that for a while now, and there is so much that it just depends on. I guess there are Smart Cities but Smart Cities are probably more for some place like china, where its centralized control allow to though money at it, they can just do it. If you take a city like san Francisco, you know for a smart city you need premises, you need so many things that it's kind of hard to pull off.

S: I see. But you would also need the sensors, right?

L: And you need the sensors, yes.

S: So, that is Internet of Things, right?

L: So, yes, so that is all there, but the most impact I think it would be on Industry 4.0. like the industrial IoT, that is a big trend and I think its underappreciated.

S: Can we argue that again, this combination of technologies will make cloud more energy efficient and therefore drive the emergence of the green cloud?

L: I don't know if the green cloud is going to a category by itself. In my view of it is that cloud are going to become greener anyway and the reason is because if you can have a greener, less energy intensive datacenter, then you are going to make more money. So there is a profit money to have green cloud, therefore, all clouds are going to be green, because it just makes sense. If you can pay less on electric power, your profit rate will improve, and you'll just make more money.

S: Interesting. And these Green clouds are not going to be driven by these technologies that we were talking about?

L: They may be on some level, but I don't know… you know it becomes an issue of tracking. So how do you track energy consumption at the edge? Because it's much easier to track in your hyperscale datacenter. So I don't know if green cloud will be a category, but I do know

everybody is in line for profit motives and yea you know it saves the environment and all that, at least in America. So as long as these things are aligned, you are going to have profit anyway.

S: Can we argue that these trends are driving Artificial Intelligence and Machine Learning?

L: Yes, across the board. That brings me to the building blocks analogy, you can't do ML and AI at scale, unless you have the cloud, edge computing, IoT all that kind of stuff. They all go kind of hand in hand.

S: In your opinion, how will this integration or convergence of technologies change the environment in which businesses are managed?

L: I think it will give businesses a lot more data. I think companies are going to have to be more nimble, one thing we've seen with the COVID pandemic is that every business is trying to go cloud first, and the ones that already went cloud, are doing way better than other ones. So all these companies have had their digital transformation projects and stuff like that, are all doing well.

S: Would you argue that cloud is more secure than on premises infrastructure?

L: Yes, and the reason its more secure is very simple. Google, Amazon, Microsoft, these companies have more security resources. So that is the argument. And the average company is not going to have security footprint better that the cloud does. Now that may change if you are a regulated industry as healthcare or financial services that kind of thing. You know you find a lot of those folks building their own cloud, and cloud providers have specific clouds just for governments, so that is something that happens too. That statement used to be challenged a lot, I don't think it is challenged as much anymore.

S: What would be the main challenges that businesses are going to be facing with these new trends?

L: I think the biggest challenge companies have is, they have so much technical debt. And technical debt is stuff they have already invested, and they are still paying for it and I just think technical debts are a big issue. So, I think enterprises are really settled with a lot of infrastructure they don't need and don't want, and it makes it hard for them to adopt these new technologies of scale. Like if you were to start a company from scratch today, you would be cloud first and you would be more likely to adopt these technologies because you don't have all this other stuff. It is the difference between building a new house, the way you want it and buying a house that has already been around for a while and you have to re-do it.

S: What would be the main opportunities that will arise with this trend?

L: Well we have seen it in COVID. The companies that use these technologies well deliver better experiences for customers, employees, basically everything, right? And I think that is where the cloud storage is getting reframed. Its about the business company being able to adjust to whatever. And that is why you see the investment going through the roof. And this will do everything from driving more efficiency to better customer experiences, to better revenue models to business capability to be able to like, any aspects of returns within the company is going to be improved by the cloud. cloud, IoT and edge computing. I kind putted them all in the same category.

S: On that note, what advice would you give to businesses, to allow them to reap the full benefits of these trends?

L:I would think though the data models, you have to have your data story correct, you have to have clean data, if you do not have your data story right and an architecture that works, none of this stuff is going to reap the benefits described. It really comes down to making sure you have your own data, the other thing is, don't get too wedded to anyone's model, you cant get too comfortable, you have to be able to disrupt yourself. And the other thing is, just take some shots. We saw it in COVID. There were things that the companies were doing for digital transformation and IT projects that weren't paying off immediately, and one example would be hospitals that were experimenting with iPad's and tablets in the patient's room. I talked to the CIO of a Nebraska Medical, and they basically had this project, they did it, they just wanted to see how the technology worked, they were experimenting. And I think they said like 1% of the doctors and nurses and patients used those tablets. So, if you look at that project now, you would say that was a failure. But, fast forward, COVID hits and that became a lifeline for patients to be with their families. It became a key to keep first respondents healthy. So, this wasn't all planned out and wasn't really paying off, but then you have a disaster or something, and it kind of set the stage. So, you have to experiment a little, and it can be all about ROI. The other thing is, just make sure you have an architecture that allows you to adapt.

S: Looking at the training and people part inside and organization, would you advise training the in-house IT department or having consultants that would be experts in these new technologies?

L: I think you have to do both, but you do have to train your employees and you do have to do it often. You have to set up a system where you have employees who want to learn and can adopt these skills. Now you may need external consultants to help you with that, but, ultimately, I have covered so many IT failures and they almost always include a consultant. They include consultants, vendors and customers and they're all pointing the finger to each other. So, for me, bring consultants when you can or when they are necessary, but you can't rely entirely on consultants for this stuff. You have to develop your in-house talent.

S: In how many years from now, do you think this trend that we are talking about will reach its peak of acceptance in the market?

L: I think cloud has already reached its peak. Edge, I would say it's still kind of early, because so much of edge computing is dependent on 5G, and those networks aren't fully badged yet. So, I would say edge, there is a lot of stuff that is not quite developed just yet. But I think it will gain pretty quickly. I would put edge computing in a 2-3-year timeframe. There are too many benefits to it, for it not to happen pretty quickly, and the cloud providers are already in the edge computing space and there are partnering with people, so I think it will be sooner than we think.

S: What country or region do you think will be the first to adopt this trend?

L: I find its usually the US, like if we look at the cloud adoption, US has been fast to the cloud, china is catching up, and then you have Europe. Europe tends to be a little slower, slower than china. And then edge computing, I definitely see that's the case: It's going to be US then China then everywhere else. Europe has good resources and things like that, but they tend to be behind the adoption curve, and china has moved so fast, so I think china and the cloud is behind where US is, but their market is so big, and they can scale up so fast, I have no doubt they'll catch up pretty quickly.

S: I have spoken with some other cloud experts and this was actually mentioned: how central Europe, countries like Switzerland, are very skeptical with the cloud specially in the financial industry.

L: That is not a country per se, that is more about the industry, right? So, Switzerland is known for its banking and personal finance. Banks have such a treasure trouble with data, that they are more inclined to build their own cloud than necessarily use… you know a lot of big banks don't use google cloud and things like that, they are not using it for its core data processing. So I would say that's less about Switzerland and more about the industry that dominates Switzerland.

S: But cloud is safer than having on premises infrastructure so what would be the problem?

L: The problem is customer data and what happens if you move it. The other issue is, remember, and one thing that slows down cloud adoption in Europe data sovereignty laws, right? So data in Italy can't leave Italy, data in Ireland has to stay in Ireland, so Europe doesn't move like one, its not one thing. It's one union for certain things, but, when it comes to cloud their sovereignty laws and regulations operate more like at a bunch of different countries, so that's why you see like a lot of cloud providers building cloud specifically for regions, like oracle just built a UK government Cloud that its staffed by UK people, the data never leaves UK, it's totally engineered there. So that is why, because the US is a bigger territory, and you can adopt cloud without a lot of interstate regulatory issues. Europe is a bunch of different countries.

S: From my side that would be all, we covered all the questions I had. Thank you so much for joining me!

L: Sure, send me a link when this get published.

S: Sure, it was a pleasure talking to you.

L: You too, good luck!

6. Jeff Barr

Interview duration: 29 minutes

J=Jeff Barr
S=Student

S: I would like to start with your background: could you tell me about your role at AWS and your past career experience, focusing on cloud computing?

J: sure. So, I have been at Amazon for a little bit over 18 years. I have joined when we were first getting started with Web Services. I had some earlier experience at Microsoft, also some experience as web services consultant. And way back then in 2002, web services were a brand-new kind of technology, I was really excited to see Amazon getting into that. I joined a team that was basically doing part of that very, very early web services effort. I took on one of the first speaking roles when they had some conference talks, they asked me to go out and speak at some conferences and events, I was happy to do that, and then, within about 6 months after starting my job, they gave me a new title, they called me web services evangelist. From then util now that was the first effectively, a really interesting bridge between technology side and the customers and I have a really strong technology background, I have a degree in computer science, I have worked in tech for… really, all my life. But I love to understand things and then to explain them. And that turns out to be just a really interesting role that you are… kind of one side on the tech and one side that is on the business or the customer side, so I really loved that hybrid role that I occupied for a very long time.

S: So, a little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and performance of data processing. Do you agree that this will be the future of cloud computing?

J: I would agree with that, I think there is a lot of really interesting details: starting from the device and getting to the cloud. We are seeing that the power and the kind of variety of devices at the edge, I think it's going to get more and more interesting overtime. The different kinds of sensors that we can measure all different kinds of things out in the real world. We

can generate this tremendous amount of raw data, but because these devices were at any given point in technology and communication, there is always going to be more data we can generate that we actually have the bandwidth to actually transmit. So I think there is always going to be probably a couple of filters or summaries along the way that would take all this raw data and then... so how can we... take maybe a tremendous amount of raw data and then figure out what is the most interesting part and then just send that up. Maybe it goes directly from the device to the cloud, or maybe there is just a few steps in between. But I suspect that IOT and edge and cloud , it will be kind of blurry, that is my thinking, because there is going to be a lot of different ways to solve the problems. Someone who is really skilled at this is going to probably chose between a lot of different options in the course of a couple of different projects.

S: Speaking of the blurry part, would you argue that mobile cloud computing is not actually a separate trend, but it is a part of this major convergence trend, let's say?

J: Well, to me mobile… I often think that a lot of technologies are the same and lightweight and low power and small devices, but to me mobile always involves a telecommunications provider, so it's a 4G or 5G provider and I think there is a lot of really exciting things that are happening there. Will they blur? In the sense, can you imagine IOT devices having 5G radios in them at some point? Probably.

S: Do you agree that this combination of technologies will be the main driver of Smart cities and industry 4.0?

J: I don't think I know enough about those two to really say this. I do think smart cities are important and I think right now, in this very interesting time of quarantine and coronavirus, the whole idea of what is good about a city is probably about to change. I don't think we've realized that as a society yet, but cities are better in a way because of this, but they are also a little bit scarier and you can see like is there a role for… what kind of health monitoring can we do if we have smart cities and smart devices and can we, while paying a lot of attention to security and privacy, are there ways of making the city more healthy with smart devices? There probably are, and I think that cities are… if you are a mayor of the city and you have a lot of big businesses in that city and you attract the people to come to the city because it's a wonderful place to work, people are now saying " what is the use of a city and why do I need to actually go there versus I can live out in the countryside if I want to". I really think there is some really big changes that are going to happen and we have to kind of rethink the density of people and the services, entertainment and of data, that is probably going to be one of the interesting things that will be a benefit of a city going forward.

S: That is an interesting point. What about industry 4.0?

J: So I don't know exactly what defines the different numbers along the way, but when I do speak to manufacturing customers and they actually, for sure, they want to monitor production lines, there is a lot of concern about "ok, we make something on the production line, we put it in boxes, we ship it out though a carrier that takes it to customer, we need accountability, we need tracking, we need to make sure that as we do it we are safeguarding

the environment, we need to understand what emissions are we generating, what raw materials are we taking in, are we paying attention to politically sensitive conflict materials, things like that. So, different ways to measure and track and improve quality and just kind of... again, not being in that field, it just always kind of comes down to like " how do you serve your customers better?" and "you've got so much data, what do you do with this massive amount of data?" though the sensors, like, are you doing machine learning training? Are you inferencing to find the properly built devices from the ones that have manufacturing defects? Can you analyze data from your production lines to figure out where the production line went wrong? Lots of opportunities there.

S: Next question: can we argue that, again, this combination of technologies will make cloud more energy efficient and therefore drive the emergence of Green cloud?

J: I don't know if green cloud is a specific term that we want to really share on that, in fact, probably not. Every cloud provider is asked a lot about their energy efficiency. And the interesting thing is, when you are a hyperscale cloud provider, because you run at such a gigantic scale, you have the social responsibility to do that, to consume energy efficiently, but you also have the technical opportunity to do it really well, because you are running the biggest datacenters of any organization on the planet, so you should have access to the best technology. And also, the thing that I find encouraging is, if you are an individual company, maybe you build a datacenter, I don't know, every 10 or 15 year, at most. If you are a cloud provider and you are growing rapidly, you are building them all the time. So each one has the opportunity to learn from what you understood in the past: ok we built it, we used these technologies, now 3 months later we're ready to do another one, what did we learn from doing the 3-month old one that we can apply? So, I think the cycle of innovation should be a lot faster for a cloud provider than for a private industry.

S: Absolutely, but we cannot say at least for now, that these are the technologies that are going to help to bring the sustainable datacenters to life?

J: I don't think there is a specific set of technologies, as much as, every point within the datacenter, how you make the individual elements? The cooling, the water distribution, the power distribution, the servers, you can continue to make each of those more efficient, but there is also this very strong argument that, if you look at the actual utilization of servers in a private datacenter versus servers in a cloud datacenter, I don't have accurate numbers to share with you, you can probably look for those up but the utilization within a cloud datacenter may be many times higher for a given amount of power consumption, the amount of productive work that you are doing in the cloud, may be two, three, four times higher. So rather than saying "is this particular server energy efficient"? You might say "is the overall workload being run, and is the cloud, considering the amount of work that it does"? Another way I think about that is, in a traditional datacenter model, you need to have enough server capacity for whatever it is your maximum expected utilization, so you are paying for all these servers in space and in power, whether you use them or not. But if you are cloud-based, you are only effectively turning on servers when you need them, if no one is using them then the

cloud provider has the opportunity to turn them off, use them for other customers, put them in low power mode.

S: In your opinion how will this integration of these technologies change the environment in which businesses are managed? In other words, what changes will this bring to businesses?

J: At Amazon, as you know, we always focus on customers first, and what I hear from our customers and I speak with them pretty regularly, the massage hasn't really change a lot in the last maybe 10 or 12 years, they really see that, by putting more energy… by just saying " we're not building datacenters, we're not buying servers, we can do more things that are actually unique to our business and that are customer impacting". So, they are able focus at a higher level of abstraction and work on things that are more unique to their own business.

S: What in your opinion would be the main challenges the businesses will be facing with these trends?

J: So, security I think is well understood and there are lots of materials and lots of training that is there to help customers to build very secure systems. By far the biggest challenge I'm hearing from my customers is getting people with the right cloud skills. It's a new set of technologies, and the most enlightened customers are really talking about this model, and even some countries and cities, they are talking about upscaling, where you take a set of people you already have and you say " let's give you some additional training, let's take you from where you are, let's give you some training to help you to progress to the next level of your career. So, I think education and training and having a highly qualified workforce, is the biggest challenge I'm hearing from the customers I talk to.

S: Now that we mentioned training, I have another question for you: would you advise to invest in training of the inhouse IT department or hiring external consultants that are experts in cloud computing?

J: I think that is going to really depend on the organization but for the most companies I know that, in situations in which they have leaned very heavily on outside expertise, it has really taken away a lot of the skills from inside of the organization, in most cases. I think maybe in old-school IT, a decade or two ago, you built some applications, and you deploy them, and use them for a really, really long time. And so, it was ok to just hire a company to build it, deploy it, and you are kind of stuck with it for 5 or 10 years. The customers I speak to, they want something that is a lot more fluid, a lot more dynamic and they don't want just to build and deploy, they want to get a first generation out there, they want to very very quickly learn from the feedback and they want to keep improving and iterating, which I was going to say, you need long term in-house development to make it happen.

S: You mentioned security. Can we argue that cloud is more secure than on-premises infrastructure?

J: Well, I don't think you can simply say that the cloud is more secure, the way I look at it is that cloud provider has this responsibility to protect all of the customers, and a lot of the security systems and practices, they scale really easily. So if you are a individual customer

and you have to achieve compliance for some particular regulation in a country or in a market, every compliance is often a very long list of what is called "controlled", where we have to say "check check check" with a lot of different things to protect our systems and our customer data. The amount of work to o though your practices and check all those boxes is the same if you are a 10-person company or if you are a cloud provider serving millions of customers, so there is this incredible economy of scale that says that the cloud provider can make a bigger investment to do this. And also, the cloud provider's entire reputation is on the line with security. We all of course realize this, and we say that we need to do every conceivable way we can think of to, not just protect the customer data but to educate customers. Coming back to education, how do we educate customers on how to use the cloud properly, to keep everything as safe and secure as possible.

S: What advice would you give to these businesses to allow them to reap the full benefits of these trends? So, we're talking about cloud computing, edge computing, IoT and mobile cloud computing

J: Well, I always advise investing in your employees. Get them educated, get them trained, give them opportunities to try some new things, to experiment, and, the way we always like to think at amazon is: we try a lot of new things, some succeed and some don't, and we love to just conduct experiments. I think there is a bit of a mindset shift that has to happen to make it really ok within a company to test and experiment and to not assume that everything you try is going to succeed. To have this experimenter mentality that says: let's try this, and maybe it's going to work. If it works will ramp it up and we'll make that little fire an even bigger fire; and if it doesn't, we'll step back and learn a little bit and say "ok, let's try something different and let's see what we have learned from having done that".

S: In how many years from now do you think this trend will reach its peak of acceptance in the market?

J: Oh man, it's hard to predict the future. We are 12 to 14 years in the cloud at this point, I don't know. Probably another full generation of employees. We probably have to think that employees are not in the workforce yet. When they have been working for a while and at some point they say "hm, a datacenter, that's a weird thing. Why would anybody build their own datacenter when its so easy to do things in the cloud?". I think we have a long, interesting path ahead of us.

S: What country or region would be the first to adopt these new trends in your opinion?

J: Oh its actually global. There is certainly some differences from country to country, and region to region, but I'm really encouraged, I think one interesting thing I've seen in the last months of quarantine and working from home, I see people all over the world reaching out and saying "we're ready for cloud and we want to learn" and just a lot of parts of the world, I had the opportunity of speaking before, and if anything this quarantine was kind of an equalizer in a way, the advantage of location isn't necessarily as strong as it once was now. This isn't to say there isn't huge economic disparities across different parts of the world, for sure, and we need to figure out ways to address those, and part of the way I think we're seeing

this address is that in some of these markets, they are full of young, new, energetic developers, they are now saying " I don't need to go somewhere to learn something, if I have got connectivity I can find anything I want online and I can learn in at my own pace". I'm incredibly encouraged by that and I think back to the really early days of my career where, a college degree was an absolute necessity and sometimes you need a person that actually has achieved quite a bit but have not earned a degree, and you can have a different.. "oh, I'm really sorry you didn't have opportunity to go to college" and now I'm meeting so many people that are entirely self- thought and self-motivated. It's absolutely fascinating and its really encouraging and heartwarming to see people saying " oh, you know, I didn't have the opportunity to go to college but I sat down with my laptop and my phone and I thought myself python and cloud and EC2 and SQL and Serverless and I'm just as skilled as anybody who went to college. I actually love that. I think college is a wonderful institution, but still this idea that you can be motivated and you can learn on your own, is still really amazing, and I think we're only starting to see the consequences of that.

S: Absolutely. Now, out of curiosity, would you argue that the financial sector will the last to adopt these new trends?

J: Probably not, we have seen wonderful adoption withing the financial sector and I think that, what we talked with security, they are of course very security conscious, but then they look at the investments we've made in security and they can look and say " this cloud provider made this huge investment and the different certifications and accreditations and, when they can speak to the cloud provider and they can learn in detail all the precautions that we put security-wise, the financial sector is actually a very healthy consumer of cloud resources.

S: Interesting, because we were talking about the financial sector in central Europe, so the banks in Switzerland and all, and they were trying kind of to avoid Cloud, according to what some experts have shared, so we have mixed opinions here.

J: Yes, it's going to be different from location to location, but we just announced a new AWS region that will be opening up in Switzerland in 2022, and, I don't know what news cases were anticipated but clearly there is a large, financial services sector in Switzerland and its pretty surprising to see, when you talk with these companies and I've given several talks this year from this very office and this desk to different financial services companies in the last couple of months, and they are very eagerly embracing cloud and the security part is almost a checked box. We see this scale and success of AWS, it must be secure because we see the competition using it already and what attracts them is the richness of the services and the ability for them to go from ideas to production very, very quickly.

S: Would you say that these trends are also driving the emergence of AI and ML?

J: Absolutely, for sure. The interest thing is, once you have this vast amount of data, its often too much to be processed by humans. So, the idea that you can generate all this data from, lets say, vehicles factory floor or from air quality centers all over the city. It flows perfectly into training Machine Learning models, and then to use that to detect anomalies and to detect

positive and negative trends, so I think they all go together. The mode data you can feed into your machine leaning training, the better predictions they are going to get. And there is nothing better than sensors and IOT to give you that incredible viable data.

7. Imtiaz Adam

Interview duration: 45 minutes

J=Imtiaz Adam
S=Student

S: Could you tell me more about your role in the company and your past experience?

I: So, let's start with my past experience. I used to work here in this area (London) as an investor, I was a director at Morgan Stanley, of technology financing, clean infrastructure financing. For various reasons, I left, did a master's in computer science where I specialized in Artificial Intelligence. So I'm familiar with edge computing, 5G etc. I now own my own startup, right now a bit of consulting projects in different sectors, that has included manufacturing with predictive analytics, retail, and a bit fintech. I'm also building my own products with my own team which we'll have to finance to be able to put in the market hopefully… that is liked to robotic and IoT and edge computing.

S: A little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and performance of data processing. Do you agree that this will be the future of cloud computing?

I: Yes, and lets break that down a little bit. One of the trends that has been occurring in the market is something called hybrid cloud edge, and that's where I think you are leading to. Basically, we do the training and testing on the cloud and then the inferencing on the edge. That is called the hybrid cloud edge model. So that is becoming quite common, I have worked with that architecture myself.

S: Just to specify, is the hybrid edge cloud the same thing that I am talking about?

I: Yes, yes, pretty much. Microsoft and others will tell you that is a huge trend in the last two years. You could use cloud as a big data resource but ultimately if you keep transferring lots of data back and forth over the internet, you are going to get a lot of latency, all that traffic, all those computational resources, is not efficient. Therefore, it is more efficient to have the intelligence closer to where the data is being produced, which is on the edge device. This

way you can not only reduce traffic but also reduce latency. For example, the new 5G network, which is exponentially faster and that is great, but it's not just about the speed, it's the lower latency. And the significance of a lower latency is the following: A) virtual and augmented reality. Companies struggle with 4G because of latency. The other thing is IoT. When we come to autonomous devices and senses etc., if you are an autonomous car, you can't wait for that signal coming from a cloud server to tell you what to do. Therefore, we need edge computing for that.

S: Would you argue that mobile cloud computing is not actually a separate trend, but it's a part of this trend?

I: Yes, I think that is probably a fair thing to say. The reality is that most of the data has really come by the mobile (article: data never sleeps). You can also see that a lot of data come from the social media and ecommerce, and a lot of those are very popular on mobile. So, I think in particular during this COVID-19 pandemic, we are relying on the digital.

S: Do you agree that this combination of technologies is the main driver of Smart Cities and Industry 4.0?

I: It is one of the main drivers. Industry 4.0 is basically just convergence between cyber systems, merging between physical and digital, iot, AI,ML, Smart sensors, internet connected devices, all those things coming together, that would be industry 4.0 by definition.

S: What about smart cities?

I: Yes, sorry the smart cities, absolutely. There are a number of initiatives around the world, and the plan is so being able to leverage IoT, to measure and evaluate, and have near real time interactions, so we can manage traffic more efficiently, reduce pollution, etc. so yes, absolutely, edge computing is going to be, AI on the edge is going to be very important for that.

S: Can we argue that this combination of technologies will make cloud more energy efficient, and therefore drive the emergence of Green cloud?

I: I have to say, there is a lot of research going on about how we can optimize... essentially a good example is what google did, how they managed to use ML, deep learning algorithms to reduce energy consumption and therefore the cloud of that datacenter is using AI to do that.

S: So, we can actually argue this, am I correct?

I: Yes , I mean, Google and Deepmind did it.

S: Can we argue that these trends are driving Artificial Intelligence and Machine Learning?

I: Yes, absolutely. They are not the only thing driving it, but they certainly have a big impact. If you look at the state of the world before, let us say the last decade, from 2015 to 2019. AI was really being driven by the tech managers, they had huge social media platforms. But now, edge computing is driving a lot of demand for AI. Statista forecasted that by 202, there will be 75 point… I forget what comes after the point but that is not relevant. 75 billion

internet connected devices by 2025. That is approximately an average of nine per person on the planet. Let us say Statista are correct, that's massive, exponential increase. And this is going to create a huge increase in data being generated. Which will mean, that we will have no choice but to use ML and deep learning AI, to make sense of that data. So yes, I think it will be the dominant theme for AI in this decade.

S: How in your opinion, this integration of technologies changes the environment in which businesses are managed? In other words, what changes will this bring to businesses?

I: Massive, we are going to a period of unprecedent change. The next 3 to 4 years, let's say from 2020 to 2025. This change will be bigger than the change we've had over the last 200-250 years in those 4 years alone. As we scale edge computing, 5G networks and AI, and we develop what's called AI- IOT. This will bring huge changes in society and businesses. It will create brand new business opportunities with AR VR. We might be wearing our VR glasses. Apple, Facebook, Microsoft, are all racing to launch that product, Samsung as well, I believe that these will actually replace the mobile phone.

S: So, we can say that the main changes that will be brought by these trends are new businesses being created and new products.

I: The whole customer experience will change. We're talking about merging the physical and the digital world together.

S: In your opinion, what are the main challenges that business will be facing with this trend?

I: The pace of scale will change. So many businesses are being slow to adopt digital technology let alone edge computing and AI. There are also the legacy companies, with their data and technology infrastructure that are being whipped out. We've seen it with COVID-19 right? A lot of companies that didn't have a strong digital footprint suffered this proportionally. So that is going to be a big challenge for them. And also, skills. Getting people with the right skills, this is going to take massive re-skilling.

S: Now that you mentioned the topic of training, I have a question for you: would you advise training the inhouse IT department or hiring external consultants that would be experts in this technology?

I: I think you need both, I don't think you should be exclusive.

S: What advises would you give to businesses ..

I: Well, you want internal core capabilities, right? So, companies are going to have to view technology as a core competency, which many of them see as alien territory. And the C-levels have to view technology as an opportunity, not just a to improve the cost space and not only to improve the core competencies. The C-level have to jump in it entirely and they have to build these capabilities to have technology as a revenue generator, not just a cost space.

S: Would you argue that cloud is more secure than on premises infrastructure?

I: As long as you use proper security protocols, yes, and as long as you have your staff trained appropriately, because a lot of breaches often happen from people. But essentially, yes, I think cloud providers have a lot of good in-built security.

S: Which country or region will be the first to adopt this trend?

I: Well, we've seen china being very powerful at that but I think south Korea is very strong in these areas, I think part of the Asian region, Japan has been a little bit slower on 5G etc, but I think japan will probably catch up. So I'd say it's really between Korea and China and then after that we're probably looking at Germany, I think it's going to be very strong, UK makes noises but we have to see if actions really match that, when it comes to scaling the 5G network. 5G networks are going to be very expensive, you see 5G is going to be very powerful for edge computing. I think US will still be there, but someone is going to have to pay for that infrastructure in the US, will it be the telecom companies? Will it be the new administration of US?

S: In how many years from now do you think this trend will reach its peak of acceptance in the market?

I: I think 2021 is going to be a year of considering built, but I have something about 2022-2023, we'll start to see a lot of interesting products. Intel commission ordered to conduct a research that showed that by 2028, 5G and kind of mixing edge computing into that, would account for 1.3 trillion dollars of revenue for the media sector alone. The acceleration part is 2022 to 2025. I use those years as a proxy for internet of things etc. because that was based on the scale of 5G networks, well I think it would be the same for IOT, cause the IOT will need those 5G networks to accelerate its scale and enable the device connectivity that is needed. So, I think the 2022 to 2025 would be the rapid growth race.

S: That would be all from my side, thank you so much for agreeing to do this interview.

I: Not at all. Feel free to reach out if you have any more questions. Bye.

8. Bernard Golden

Interview duration: 58 minutes

B=Bernard Golden
S=Student

S: Could you tell me more about your role in the company and your past career experience?

B: Yes, so I am located in Silicon Valley, I've worked in the software area my entire career. So, I've been a software engineer for local telecommunications companies and then was

recruited into a vendor, and I pretty much stayed on the vendor side through most of my career. Although I just recently spent a couple of years at capital one, which is a very large financial institution. Then I went independent and was doing a lot of writing as part of just exploration and doing new things. And I was approached by dummies press to write Virtualization for Dummies, which I agreed to do.

S: So, a little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and performance of data processing. Do you agree that this will be the future of cloud computing?

B: Let's start with the IOT stuff. I agree that there are use cases for which the computing needs to be in a non-centralized environment. But I think the thing one must consider and appreciate is how important those factors or constraints are on a given workload, on a given application, versus the cost of that certain application, because traditionally decentralized computing environments are more complex to manage, they are more expensive to manage and they tend to be more fragile in terms of, the stuff breaks or some sort of component breaks.

S: so, basically, what you are saying is that, yes this convergence will happen, but at the same time we will have the cloud that we have today and they will kind of go in parallel and both be coexisting?

B: Definitely, there are people who proclaim that "edge computing is going to be the end of cloud computing", which I don't agree with, at all.

S: Would you argue that mobile cloud computing is not a separate trend, but it's a part of this trend.

B: Well I'm not really sure I understand what mobile cloud computing is. I think IoT is… they all fall under the bucked of edge computing. Whether it is a specialized device, like we have a thermostat, that is a smart thermostat. To me, there is an element of edge computing, its just not very smart edge computing. And I mean, a sort of a mobile device that is very smart, you can say the smartphone is that. I still, sort of, gussy it up with the name of mobile cloud.

S: Do you agree that this combination is the main driver of smart cities and industry 4.0

B: Well, yes, and the way I would describe it is cloud computing and all of these other things... I mean I draw fewer distinctions between these things like "oh is it a special thing?

Is it edge computing?" I mean you look at AWS outpost, well it kind of is, cloud be. And then there is people that do things that are similar to that who say, "I'm going to give you Kubernetes installed in a box next year, next to an oil pump". So, I think of it as more of a continual, not a separate category. But I do agree that all of that computing capability, is the substrate for smart cities. So, I do agree that smart city and the... what was the other example?

S: Industry 4.0

B: Yes, is that the world economic forum something?

S: Yes, yes, that is it.

B: Well, I agree that, that sort of… that vision is based on…basically easy access to scalable compute resource. And, once you have that, you can start saying "how can I apply…". I sort of. when you hand a new technology to people in silicon valley, they treat it like a Rubik's cube, they go " what if I turn it this way? What can I have?" and that is what… that experimentation enables smart cities, industry 4.0, etc. etc. "how can I run the heating and the cooling in my building more efficiently?". and I think the technologies you described are the foundation of that, yes.

S: Can we argue that this combo will make cloud more energy efficient, and therefore drive the emergence of green cloud?

B: Well, I would say, certainly comparing to getting one compute unit out of a cloud provider is certainly less costly and less energy consuming than getting the same amount of compute unit from a company running their own datacenter, there is no doubt about that. The big cloud providers, they are the Henry Fords of running datacenters. You know Henry Ford was a fanatic for driving down cost, and they do the same thing. So, they are certainly more efficient than the alternative.

S: And do you think these technologies can contribute to make the cloud datacenters more sustainable?

B: I mean, I guess. You can have a smart thermostat that really figures out what to do , and that's probably more efficient than a person going " oh, I feel warm" and going up and turning it down themself. And it would keep the energy use for keeping the environment comfortable. It would do it better than a person would.

S: would you argue that these technologies are driving Artificial Intelligence and Machine Learning?

B: well, yes, I think there is no doubt about that, because its now easy to get sufficient compute resources to do model training and to execute models. I would not have been impossible to do in the past, but it would have been really really expensive and really difficult because you sort of have to hire somebody to go install two thousand computers and connect them to the network and all that. So, its very labor intensive, difficult to figure and all that. Now you sort of go "AWS I'd like two thousand instances" and then minutes later, you got them. Which means you can start focusing on the workload.

S: How will these techs change the environment in which businesses are managed?

B: Well, I mean, the application of computing into aspects of life is virtually limitless, people come up with things all the time. Businesses have used information technology for a long time, right? 40 or 50 years. One obvious example is that it will change the make-up of their technology workforce, because you will have fewer people racking and stacking sort of speaking. That will enable you to displace that investment into more applications. It also enables you to start thinking about "where are the places where I could use these capabilities within my business, that in the past you either could never afford it, or could never imagine you could do it. So it makes marginal use cases more accessible. And so, it enables a lot of companies to do lots of different products. Thanks goodness to this pandemic happened. Not that I think the pandemic is a good thing, but it's a good thing its happening now, not 5 years ago, not 10 years ago, because the world, many parts of the business world fairly seamlessly shifted to " oh now I'm going to work virally from home". 10 years ago, and certainly 20 years ago, that would have been impossible. And zoom and google hangouts is all based on cloud, so it has a profound impact in that aspect. Rethink your business processes and then you can rethink the products or services that you build. It is all based on that compute substrate.

S: Would you advise for companies to invest in training the in-house IT department or hire consultants that would be experts in these technologies?

B: I guess my feeling is: it's not an either/or. Your staff may not have those skills but first of all, they have a lot of domain knowledge. They know your business. So, thinking that "I'm going to get rid of those people and bring the specialists", then you will have to train them (the specialists) about your business. And I will say that everybody can learn new skills, human being is a learning species, so I believe that people can pick up new skills. So I think educating your workforce and helping them to develop the skills to work in these sorts of environments is very important and very appropriate. Its also important to bring in those skills from the outside. Bring consultants and staff, whoever experiences this, and have them be peers and colleagues, as a way of diffusing knowledge.

S: Would you argue that cloud is more secure than on-premises infrastructure?

B: Well, I think that is a question with a lot of nuance or elements to it. So first, I would say, it's important to understand if you are a cloud user. And… security… and this is where AWS, I think they sort of started with it. It is a shared responsibility, and it's important not to think that if you are using cloud, you don't have to pay attention to what's in your area of responsibility. So, if you look at the piece that the provider is responsible for, I think there is no doubt, they are at least as good or significantly better than companies-owned datacenters. Most companies treat security as a cost and an inconvenience, whereas, for cloud providers, it's a core competence. So, they invest more on it, they probably have more specialized skills on it. So, I think there is no doubt, they are as good as or much better than the alternative.

S: We already discussed the opportunities that will be brought with these trends, but what will be the main challenges that businesses will be facing?

B: Well, I think there is sort of a latter of challenges. The first is understanding it and having the right skills. And then really absorbing the capabilities of cloud computing and use it as part of your design. I often say that companies should not treat cloud computing as a datacenter at the end of a wire and use it in practice. Many do though. So, you have to sort of think "well, given these resources and that they are available in an automated fashion, how do I internalize that in the way I think about my applications?". So that is the next step up. Then the next level is, "how do I start to think about how I can apply computing into my products and services, to make it more useful for the consumer? More cheaper?" and so, that is the, what I call the 3rd level. How do I transform my business given these technical capabilities?" and that's a challenge.

S: what advice would you give to businesses? I know you already answered to this question in your previous answer, but if there is anything you would like to add to what can businesses do to be successful in this new trend that is coming?

B: They have to figure "out how do I make room for that kind of thinking?" How do I start to envision a richer job to be done?" "how do I start to experiment with that?". You are experts of what you have done. How do you now, become experts at what you can't do?

S: In your opinion, which country or region will be the first to adopt this trend?

B: I think it's fair to say its north America. Because it traditionally has been the leading adopter of information technology. the law used to be: it happened in the US and then two years later, it would happen in Europe, but I will say that Asia has been really aggressive about applying these kinds of things , and so, I think it's not lagging at all. The economies in the European Union are not as IT intensive as the US's, traditionally. And that is going to be a challenge because this isn't just about how your back office is, this is about customer facing progress. So, the European economies need to understand "how do I respond to this whole new category of my product?" so, you can't really afford to delay that because these changes are going to occur quite rapidly.

S: In how many years from now do you think this trend will reach its peak of acceptance in the market?

B: Probably ten years. This is a process you know. When I first got into this, there were people who just rejected cloud computing. They said it will never work, it's too expensive, not secure, and it was not an acceptable choice. Those days are gone, and in any company it's a serious option. But most companies are still in the process of "how do I do it? How do I migrate everything?" and that is going to be a decade long process. Which is good for you, if you get in the cloud now, you have a long runway for your career.

S: That would be all from my side, thank you so much for sharing your insights.

B: I enjoyed our discussion and I look forward to your thesis. Cheers, bye bye.

9. Danilo Poccia

Interview duration: 28 minutes

D=Danilo Poccia
S= Student

S: Could you tell me about your own role in the company and your experience, focusing on cloud technology?

D: So, I started working with AWS in 2012, I saw Cloud as a great advantage compared to traditional infrastructure management. I started as a Solutions Architect then, I moved into the Evangelist role and now I am the Chief Evangelist for Europe, Middle East and Africa.

S: So, a little background from my side: the academic literature points out two main trends in cloud computing: the first one is an integration between cloud computing, IoT and edge computing and the second one is mobile cloud computing. Looking at the first trend, what literature argues is that IoT will integrate cloud , however, a centralized cloud architecture will not be able to process all the data that is being created in a timely and low-latency manner. This is where Edge computing enters the scene: with edge computing, the data will be processed directly inside the devices spread across the world, improving speed and performance of data processing. Do you agree that this will be the future of cloud computing?

D: Making statements about the future is always difficult. I don't agree that it's really a problem of processing the data, cloud architecture can scale and can process almost any amount of data if you design it correctly, with AWS for example, it's relatively easy if you use the management sets that we provide and auto scale. There are three main reasons for edge computing: one is latency, so with edge computing you are closer to where the data is generated. So, you have low latency and that means that you can also reply faster. If you need to reply with a latency of a few milliseconds, then you need to be closer, you cant go to another country and come back. The other reason is the law of the land. Let us say that, depending on the country, you may be able to do things inside the country or not. So, for example, if you are taking personal information and you want to cross this personal information, maybe it's easier from a privacy and law perspective to process the data in the same country instead of sending it to another country for processing. These are the two main reasons to why edge computing is really fast and has no latency.

S: So basically, what you are saying is that we will still have cloud and it will still be probably preferred, but for these cases, we will have this type of convergence of cloud and edge computing, so they will coexist, am I correct?

D: Yes yes, and also I think you will see cloud computing be more distributed across different countries, for example at AWS last week we have now a second region in India, a new region is coming to Switzerland. So that means the fact that you don't have local cloud computing in the same country will be less of an issue. But there will be use cases for edge computing so, driving cars for example: if you lose the connectivity, you don't want the car to stop in the middle of a highway. So I think they will coexist, and edge computing will be very important for certain use cases, specially where you need low latency and privacy.

S: Would you argue that mobile cloud computing is not actually a separate trend, but it is part of this convergence trend that we are seeing?

D: yes, probably. Currently the mobile device is the device that we bring with ourselves everywhere so many applications should be, in this time of pandemic, help us understand if we get closer to people with the virus. So, the personal side of the mobile device is very important. If this keeps on, then this will be the interface for many applications that can be provided using edge or cloud. I'm not sure that this trend will go on forever, so I think things like virtual reality, augmented reality, maybe smart glasses, I already wore them, maybe this will replace the smartphone in maybe five years, ten years, twenty years. I think, if the smartphone is something, we still use a lot, probably yes, but I'm not sure that will be true in ten years, maybe.

S: Do you agree that, again, this combination of technologies, is the main driver of Smart Cities and Industry 4.0?

D: Yes, so these are two very abused trends, now everybody wants to say that mine is a smart city, that my factory is industry 4.0 but there is something very important, the fact that, traditionally, the was a lack of data that was collected and analyzed. So yes, I think cities and factories, they will start to collect and analyze data, and then they will deploy solutions that will allow them to act quickly. So, at the beginning, there is someone looking at the data, is writing reports and graphics, and then maybe it takes one week to process, or even more. Over time, we will start to have more, especially with edge and low latency devices, we will have many quick analysis and very fast reply. Yes, I think that is the trend, the problem is that this terminology has been abused, so now the people are not as enthusiastic as a few years ago, I think.

S: Can we argue that this combination of technologies will make the cloud more energy efficient, and therefore drive the emergence of the Green cloud?

D: So, I think cloud is already much more efficient that traditional datacenters. Because, normally, in a traditional datacenter it is very difficult to switch on the things that you really need, in the cloud this is one of the jobs of the provider, and the provider has advantages in consuming the minimum amount of energy and help customer to use only the minimum amount of the resources that they need. So, features like autoscaling, these kinds of things,

help a lot. I think this is a trend. Edge computing and mobile can help on top of that, I would say that to improve energy consumption, what you should do is to use the minimum amount of resources that you should need at any given point in time, and this is what normally the trend we see in the large customer and also in customers adopting new services so. And also, the fact that cloud resources are centralized you make it easier to improve the way power is generated. So, for example, for AWS, the regions that we have in Ireland and in Frankfurt, for example, they are carbon neutral because of the way we purchase and generate electricity for these regions, there is no impact on carbon emissions.

S: Can we argue that these trends are driving Artificial Intelligence and Machine Learning?

D: I think there are three trends here, one is the research in machine learning and artificial intelligence for example in vision and speech recognition, has improved a lot. And this has generated tools that can be used very easily. The third thing is computational power. So, normally, machine learning requires either a lot of computational power, or specific computational power for ML platforms, like GPUs. So, Cloud is really helping on this side. So, the fact that we have research, we have the tools we can use and we can get this power that we can this power that we need to train a machine learning algorithm , and again, you pay only for the hours that you use, you don't need to buy a datacenter and spend millions. These three trends together are working to improve… and then, there is a lot of use cases where, for example, machine learning is used with mobile devices, you take pictures, and this picture automatically cataloged for you based on its content.

S. So, we can agree that these trends are driving AI and ML, specially Cloud, as Cloud is the one technology making it happen. Correct?

D: Yes, its these three reasons working together.

S: In your opinion, how will this integration of technologies change the environment in which businesses are managed?

D: This is, again, very difficult to say. So, definitely, remote work is much easier, and it is something we all learned in this difficult period. One customer I was in touch recently created like nine hundred virtual workplaces for the employees to start working from home, and this is in the UK, but also in places like Manila or Singapore, so, it's a worldwide trend. So, I think these technologies can help us work remotely, work better and in a smart way, but, again, I think it's important to know that there are things not related to technology. So, I've seen companies that adopt technologies, but they don't work in a good way. You need to understand how to empower small teams to work independently so that they have no blockers. If you provide the tools and then the employees are just blocked by bureaucracy, this will not work.

S: What would be the main opportunities that will arise with this trend?

D: Yes, I mentioned remote working but definitely improvement of customer service and customer support. I think there is a trend where we are seeing the evolution of traditional contact center into something more smart, so you can use technologies like connect your contact center with your business systems and then you can use speech recognition to understand the questions that the customers are asking. And then this can triage and find the best feedback to give to the customer very quickly. So that you avoid explaining customer explaining the problem again and again, and maybe you focus your employees in customer support for those things that are really peculiar. So, the advantage is really that we are improving the way people can work also in customer support.

S: What would be the main challenges the businesses will be facing with this trend?

D: Yes, so, the challenges are that the environment is changing even faster than before. So, learning and understand the impact of technology on your business is really important. And it looks like the new trends happen faster and faster. It took like 50 years for the traditional old phone, since the invention, to be in many homes. It lok 10- 20 years for the mobile phone to be really popular, and just five years if not less, for smartphones to be popular, so we should expect that, new things that are invented can be dissipated very quickly, so your business can leverage that, you should act quickly. It's not the time where you can say " yes, my business is working, I don't need to do big changes, I can just manage what is happening" and definitely, going back to the question of industry 4.0 and Smart Cities, I think, analyzing data to improve what you are doing and your customers are doing is very important.

S: would you advise to invest in training of the in-house IT department, or hiring external consultants that would be experts in these technologies?

D: I think it should work in stages. Customers I have seen working better hire a little bit of external resources, and then they do formal training and also training on the job, with their employees. So that basically means that your employees will improve in this area, and during the transition phase you need support, not just training, but you need consultancy that can help you moving to the new way of working. A very large customer said that when they migrated to AWS, they did a very large scale training, on top of the consultancy that was managing the migration, and overall, they saw that the employees were happier, so the feedback from the employees were that they felt that they work was more productive now than before, because they could avoid doing manual tasks and they cloud automate things easier. So training is better, and training your employees also improves their morale, the way they work and the wat they feel.

S: Would you argue that cloud is more secure than on-premises infrastructure?

D: I think so, but it's important to hear this from a real customer, as I work for a Cloud provider. I think it's better because with Cloud you have three things, with security: you have complete visibility of what is happening, you have full control because every resource has an interface that you can use to manage that resource, and it's a standard interface, you don't need to send someone to change something physically and then you can automate. So, if feel

there is a possible issue, you can inspect and then build an automation to control that. So, visibility, control and automation are much better in the Cloud.

S: What advice would you give to businesses to allow them to reap the full benefits of this new trend?

D: So, that also depends on the business, but the idea is to think of what can be the business advantage that you need. Because you shouldn't adopt the technology for the sake of the technology, but you should adopt it because you are thinking or planning to improve some business outcome: you want to grow your customer base, you want to improve the satisfaction of your customers, you want to reduce your internal cost. So, set a business outcome, and then see how the technology can help, and then, try to work as much as possible with prototypes. So, instead of starting with a large project that takes half of your company as your first project with the cloud. So, build a small prototype, test the features, understand how they work, and then grow in this way quickly.

S: In your opinion, in how many years from now do you think this trend will reach its peak of acceptance in the market?

D: Again, it's difficult… I think it's growing steadily, as I said, technologies, especially on the consumer side can change quickly, but I think it's growing steadily for the next 3 years, definitely, so I think its years.

S: Like five years or ten years?

D: Maybe five, I think five years, yes three to five years, things are going to change. So, cloud is already evolving towards a more serverless approach, and the consumer side maybe will not have smartphones anymore, but other things like glasses.

S: And which country or region will be the first to adopt this trend?

D: I've seen innovating in the cloud in everywhere in the world. Maybe every country has its own priorities, but I don't think there is such specific countries. And, some countries maybe have a better infrastructure, but other maybe have better creativity so I think it's a global trend.

S: that would be all from my side, thank you so much for agreeing to do this interview.

D: I'm looking forward to see your thesis. Have a nice day, bye bye.