# Cloud computing as digital technology – definition, models and use in enterprises

Diana Bednarčíková[1]

DOI: 10.32725/978-80-7394-976-1.20

**Abstract:** Cloud computing (CC) is a digital technology of Industry 4.0 and, together with digitalization, they digitally transform business entities. CC consists of many physical computers connected via the Internet, or is a distributed computing technology over a network, and enables the provision of information technology resources such as servers, databases, storage, applications, and others. The technological model of CC includes models of providing services over the Internet (Software as a Service, Infrastructure as a Service, and Platform as a Service) and models of various deployment methods (public cloud, private cloud, hybrid cloud, community cloud, distributed cloud, and multicloud). The scientific article contains: a theoretical definition of CC technology and a comparison of its use and adoption in enterprises, pointing out expenses, providers, and advantages of CC.

**Keywords:** cloud computing, digitalization, digital technologies, enterprises
**JEL Classification:** M15, O00

## 1 Introduction

Due to the influence of new and developing information and communication technologies (ICT), innovations come that digitally transform the economy and society through digital technologies. Digital technologies together with digitalization represent the main elements and driving forces of The Fourth Industrial Revolution – Industry 4.0, in which companies are intensively involved. Digitalization is the process of using digitization and integration of digital technologies in companies, which result in their digital transformation and thus change business activities, models, processes, products and services, and ultimately the company becomes digital. Digital technologies represent: a combination of information, computing, communication, and connective technologies enabling access to cyberspace and among the most famous are: Artificial Intelligence (AI), Big Data Analytics (BDA), Blockchain, Cloud Computing (CC), Internet of Things (IoT), Radio Frequency Identification (RFID), 3D printing, and others.

A growing trend in the field of information and communication technologies is Cloud Computing (Akhgar, Tafaghodi & Domdouzis (2015). The development of CC has made great progress in recent years, and the reason for its rapid deployment was digital transformation and Industry 4.0 (Loreth & Pickl, 2021). For Industry 4.0 is CC key and the basic platform behind many digital disruptions (Elahi & Tokaldany, 2021).

Cloud Computing is the most famous technology in the world (Tariq et al., 2020), which emerged as a paradigm for hosting and providing services over the Internet (Mahmoud & Xia, 2019). CC is a revolutionary development of running computer applications and saving data through the Internet platform, and it combines distributed computing and grid computing (Li, 2013). Cloud computing is defined by Kumar and Siddappa (2016) as the process of providing IT related computing capabilities on demand based on Pay as you use system. Alptekin and Alptekin (2018) define CC as an on-demand large-scale distributed network to provide and realize computational resources. CC is defined as a technology that consists of a large number of physical computers connected by using the Internet or it is a distributed computing technology over the network, and an essential part of this digital technology is: a large resources, database, applications, services and software (Kanaker, Saudi & Azman, 2017). CC is a technological model enabling the provision of IT resources (servers, storage, applications, etc.) on demand (Elahi & Tokaldany, 2021). CC providing a number of services to its users, and the key functions of CC include cloud storage (Tariq et al., 2020), and it is a key enabler of the distributed IT environment (Sturm, Pollard & Craig, 2017). The cloud has essential characteristics such as on-demand self-service, resource pooling, and rapid elasticity, which enables organizations to purchase IT services in a utility-based model, paying only for the services consumed (Elahi & Tokaldany, 2021).

Cloud computing environments have been constructed differently according to the services that the given environment offers (Hamed, Dara & Kremer, 2017). According to Laszewski & Nauduri (2012), Cloud computing service models indicate the type of service offered, which is a hardware/software infrastructure or a platform for developing, testing, and

[1] University of Economics in Bratislava, Faculty of Business Management, Department of Information Management, Dolnozemská cesta 1, 852 19 Bratislava, Slovak Republic, diana.bednarcikova@euba.sk

deploying applications, or enterprise software is ready-to-use on a subscription basis. Laszewski & Nauduri (2012), Sitaram & Manjunath (2012), Hamed, Dara & Kremer (2017), Teikerdogan & Oral (2017), Elahi & Tokaldany (2021) defined as follows:

1. Software as a Service (SaaS) is the earliest CC model that represents a software service containing a business model. A Cloud Service Provider (CSP) provides software to an end user/consumer/client over the Internet that is run and deployed in a cloud infrastructure. In this case, the user is not responsible for the management or maintenance of the cloud infrastructure, including the network, servers, OS or any other issues related to the application. In the SaaS layer, users use the software as an on-demand service and are not allowed to modify the lower levels (hardware resources and application platform.
2. Infrastructure as a Service (IaaS) as a model shares hardware resources between users/consumers and involves management of physical cloud infrastructure by providers. The CSP provides the consumer with processing, server, storage, network hardware, related software, and other basic computing resources that enable the consumer to run its software (OS and applications). Cloud providers typically charge for IaaS services based on users' use of hardware resources.
3. Platform as a Service (PaaS) is the basis for a computing platform based on hardware resources and represents a platform delivered as a service for the development and deployment of applications. It is usually an application engine similar to an operating system or a database engine that combines hardware resources (the IaaS layer) with software (the SaaS layer). The CSP provides a platform for the consumer to deploy consumer-created applications written in any programming language supported by the CSP. The consumer is not responsible for managing or maintaining the underlying infrastructure (network, application servers, databases, OS, or storage), but controls the deployed applications and host environment configurations.

Cloud technology provides a centralized location of data that can be accessed from anywhere, enabling better connectivity and collaboration across multiple data sources (Elahi & Tokaldany, 2021). According to the method of deployment, cloud computing is classified by the authors Sitaram & Manjunath (2012), Tian & Zhao (2015), Akhgar, Tafaghodi & Domdouzis (2015), Goralski (2017) as follows:

1. Public cloud - Services offered over a public network are provided by independent third-party cloud providers over a public network to anyone (the cloud environment is shared by some companies and users) who can pay the costs (e.g., usage fees, floating subscriptions, etc.). The cloud provider also serves to other users; these users share resources owned by the cloud provider. The basic architecture of virtualized data centers and the network connections between them within the cloud is still the same. However, public clouds require much more stringent security requirements, from secure data segregation to unauthorized access and more, so the ease of access to a public network only heightens these concerns.
2. Private cloud – In a private cloud scenario, the entire cloud infrastructure is owned and operated by a business or organization. The cloud environment is created and used by the enterprise/company independently, and users outside the enterprise or organization cannot access the services provided by the CC environment. A private cloud is considered private if it is: single-use, managed by a third party, or hosted on-premises or remotely. Users in a private cloud pay only for what they use (during downtimes in the current emergency these resources can be used by other users), and this disadvantage can be somewhat mitigated by compensation system between departments or divisions or business units of a large organization, but it is often more attractive to deploy cloud computing in some form of public cloud.
3. Hybrid cloud - It is composed of two or more clouds - usually public and private, but in some cases also including community clouds - which remain distinct but can be treated as one in most applications. It is also possible to connect a traditional, non-virtualized service to the public cloud. Hybrid clouds are very popular and have a way of minimizing ongoing costs while still allowing for scaling during peak business periods. The customer can choose to store sensitive client data in their private cloud and connect to the marketing application in the public cloud when needed. IT organizations can temporarily expand their internal capacity using the public cloud when needed - referred to as “Cloud bursting”. Cloud bursting allows a relatively compact IT business to support more users than pure physical resources would suggest.
4. Community cloud - The cloud shares its infrastructure among many organizations, but organizations from a specific community of interest (e.g., hospitals). These communities have common concerns (e.g., monitoring patients, purchasing medicines and others) that are not necessarily shared with other types of organizations. The cloud can be managed locally or by a third party and hosted on-premise or somewhere in the middle of the group. Typically, the cost is spread over fewer users than a public cloud, but more than a private cloud.

5. Distributed cloud - Collects resources in different places, but they are connected by a common network and sets aside some of their capabilities for a common purpose. This is where the distributed computing aspects of the cloud come to the fore and outweigh the vast amounts of data that are buried in huge data centers.

Cloud computing is defined as a model to access shared computing resources through network in a manner which is ubiquitous, on demand, requires less time for provision and release of resources and requires minimum intervention of management authorities (Jaiswal & Bhaise, 2018).

## 2 Methods

The main goal of the scientific article is to examine the use of digital technology Cloud computing and is based on the following partial goals: analyzing, synthesizing and comparing theoretical sources from foreign literature in order to identify the current state of knowledge in the field of Cloud Computing; identifying cloud computing service and deployment models; analyzing the use of Cloud computing in enterprises through the conducted studies; pointing out the providers, expenses and benefits of Cloud Computing and finally synthesizing a view of the digital technology of Cloud Computing.

The starting point for the development of a scientific article was the study of domestic and foreign literature, its analysis, systematization, synthesis, and comparison in the field of information technology and business entities in the form of professional articles from scientific databases, primarily from Web of Science and Scopus, books, studies, press releases of technology companies etc. The search for literary sources was carried out using key words a key phrases such as: "digital technology", "cloud computing", „CC“, "cloud computing models" and "cloud computing in enterprises", in scientific databases in the range of years from 2012 to 2022, and on professional portals in the range of years from 2020 to 2022. Given that the scientific databases contained several tens of thousands of sources for key words, we sorted the sources according to the most frequently cited and most up-to-date, and then examined them by evaluating abstracts. Another search was carried out through professional portals, where more than a thousand sources were identified, so we focused on the most current data, primarily from 2021 and 2022. When examining the use of digital cloud computing technology in business entities, we focused on information from surveys from companies: Gartner (2021), Synergy Research Group (2022), Cybersecurity Ventures (2020) and the Organization for Economic Cooperation and Development (2021) on specific business areas where CC is applied, used, and what the adoption of the technology is, and further attention was focused on evaluating the benefits that businesses have identified by integrating CC. The selected companies, from which the data came, did not indicate the number of investigated enterprises. We translated and converted data from the OECD into graphical and tabular formats through our own processing, and calculated average values based on descriptive statistics.

## 3 Research results

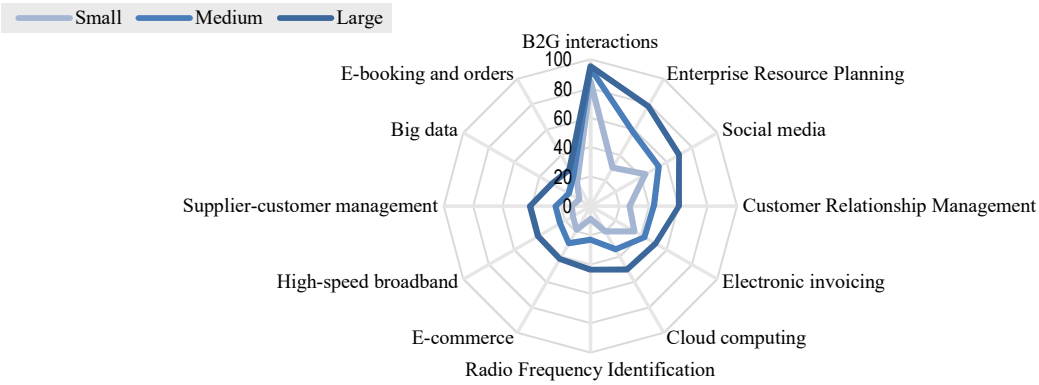
Gooasduff (2021) reports that Gartner's survey of 268 technology leaders found that Cloud Computing was the top investment in technology innovation. Gartner (2021) reports that expected spending on public cloud services should exceed 480 billion USD in 2022, an increase of 21.7 percentage points over 2021. New distributed cloud models are also expected due to the growth of hybrid, multicloud and edge environments. According to Gartner, worldwide public cloud services have an expected increase in usage with a total market of 482,155 million USD in 2022, and of this the main areas of expenditure are: SaaS (171,915 million USD), IaaS (121,620 million USD) and PaaS (100,636 million USD).

Synergy Research Group (2022) reports that enterprise spending in the third quarter on cloud infrastructure services exceeded USD 57 billion, with Amazon AWS (34%), Microsoft Azure (21%), Google Cloud (11%), the largest share Alibaba Cloud (5%), IBM Cloud (3%), and other companies.

Cybersecurity Ventures (2020) predicts that the total amount of data stored in the cloud – in public clouds (operated by vendors and social media companies such as Apple, Facebook, Google, Microsoft, Twitter, etc.), in government-owned clouds (accessible to citizens and businesses ) and private clouds (owned by medium to large corporations and cloud storage providers) will reach 100 zettabytes by 2025 - 50% of the world's data at that time. It is also predicted that the total global data storage will exceed 200 zettabytes by 2025 (this includes data stored in private and public IT infrastructures, in public service infrastructures, in private and public cloud data centers, on personal computing devices — PCs, laptops, tablets and smartphones — and on IoT devices).

The Organization for Economic Cooperation and Development (OECD) in its study from the year 2021, examined the digital transformation of small, medium and large enterprises within OECD countries: According to the OECD (2021), digital technologies, including Cloud Computing, are spreading quickly but differently among companies, by countries and industries (Table 1). As we can see on Figure 1, according to the OECD, large enterprises (LE) use digital technologies the most - they have a more proactive approach, and small and medium enterprises (SME) use them less.

**Figure 1** Average use of digital technologies by size category of enterprises during the years 2015 to 2018




Source: own processing according to OECD (2021)

Cloud Computing was used by half of the investigated large enterprises, 34.11% of the investigated medium enterprises and in small enterprises, it was used by 20.03% of the investigated companies. Big Data was the least used digital technology, on average it was used by 18.76% of the surveyed enterprises (30.48% large, 17% medium, and 8.8% small enterprises).The following Table 1 shows the percentage of use of Industry 4.0 digital technologies (Cloud computing, Big data, Radio Frequency Identification) broken down by sector: Accommodation and food services (ACC); Administrative and support services (ADM); Construction (CON); Information and communication services (INF); Manufacturing (MAN); Professional, scientific and technical services (PRO); Retail trade services (RET); Transport and storage services (TRA); Wholesale trade (WHO). According to the OECD (2021), the Information and communication services sector has the highest rate of use of digital technologies (avg. 46.40%), followed by Wholesale (avg. 35.62%) and Professional, scientific, and technical services (avg. 30.95%). Conversely, the lowest rate of use of digital technologies was recorded in the following sectors: Construction (avg. 22.37%), Transport and storage services (avg. 25.28%) and Manufacturing (avg. 27.23%).

**Table 1** Average use of digital technologies by individual sectors during the years 2015 to 2018 (values are in percent)

| **Digital technologies** | **Sectors** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **ACC** | **ADM** | **CON** | **INF** | **MAN** | **PRO** | **RET** | **TRA** | **WHO** |
| **Cloud computing** | 14.15 | 22.10 | 16.98 | 56.82 | 20.62 | 32.95 | 20.44 | 19.95 | 25.77 |
| **Radio Frequency Identification** | 6.07 | 11.44 | 5.72 | 24.31 | 13.82 | 12.92 | 10.07 | 13.26 | 11.97 |
| **Big data** | 8.40 | 10.84 | 8.10 | 25.32 | 8.33 | 13.53 | 10.95 | 13.60 | 11.55 |

Source: own processing according to OECD

According to the OECD (2021). cloud computing is used by 50% of large enterprises among the total number of large companies surveyed and 54.13% of SMEs among the surveyed small and medium-sized companies. The specific use of Cloud Computing digital technology can be seen in the following Table 2, where it is also quite visible that large enterprises progress faster in adoption in specific areas compared to SMEs. E-mail services are the most common way of using Cloud Computing in all investigated size categories of enterprises with an overall average of 22.82% namely: 32.12% in large enterprises, 13.98% in medium enterprises, and 14.12% in small enterprises. Storage of files is the second most used with 20.95% overall average use and the least used is Computing power with 8.75% average use in all enterprise types.

**Table 2** Median areas of use of Cloud Computing (CC) in selected small, medium, and large companies of the world during the years 2015 to 2018 (values are in percent)

| Types of Cloud Computing adoption | Enterprise type | | |
|---|---|---|---|
| | Large | Medium | Small |
| CC - Finance or accounting software | 10.95 | 9.64 | 7.08 |
| CC - Computing power | 13.61 | 7.90 | 4.75 |
| CC - CRM | 13.75 | 8.23 | 4.52 |
| CC - Hosting of databases | 19.91 | 13.78 | 8.04 |
| CC - Office Software | 24.19 | 15.51 | 8.93 |
| CC - Storage of files | 30.75 | 20.57 | 11.52 |
| CC - Email | 32.12 | 22.23 | 14.12 |

Source: own processing according to OECD (2021)

Chatterjee (2022) states that: more than 30 cloud services are part of the average employee's daily routines; 80% of surveyed companies saw operational improvements after adoption; 83% of the workloads of companies surveyed will be in cloud storage, and by 2025, 30% of enterprise workloads will be in the private cloud.

Howard (2022) states that: 76% of organizations worldwide use a multi-cloud operating model (at least one shared and one private cloud) and of these: 90% of large enterprises, 60% of small enterprises, and 76% of medium-sized organizations had a multi-cloud infrastructure; 42% use multicloud cost management tools, 38% use multicloud security tools, and 33% use multicloud management tools; 82% of enterprises use a hybrid cloud model; enterprises use an average of 2.6 public and 2.7 private clouds; 53% of IT decision makers say multicloud helps them achieve their business goals; less than half of traditional small businesses use cloud infrastructure or hosting services; 44% of traditional small businesses use cloud infrastructure or hosting, compared to 66% of technology-based small businesses and 74% of enterprise companies; 31% of enterprises spend more than 12 million USD annually on public cloud; The limiting factors preventing companies from adopting a multi-cloud infrastructure according to IT decision makers are: cost (51%), security (47%), lack of skills (41%), complexity (35%), and compliance (33%).

The advantages of CC according to Chaulya & Prasad (2016) are primarily: cost savings and their minimization, resource maximization, better collaboration in companies, mobile access to CC, independence from location, and equipment, highly automated technology and providing greater flexibility. Sales Force (2022) lists the advantages of CC as: cost savings, security, flexibility, mobility, insight, increased collaboration, quality control, disaster recovery, loss prevention, automatic software updates, competitive edge, and sustainability.

## 4 Conclusions

Innovations in the context of Industry 4.0 encouraged business entities to integrate and use digital technologies, including the most famous Cloud Computing technology. Cloud computing is an Industry 4.0 digital technology consisting of many physical computers connected via the Internet or distributed computing technology via a network and enables the provision of information technology resources such as servers, databases, storage, applications, and others. The technological model of CC includes the provision of services over the Internet (Software as a Service, Infrastructure as a Service, and Platform as a Service) and various deployment methods (public cloud, private cloud, hybrid cloud, community cloud, distributed, and multicloud).

Cloud computing has been the highest investment in technology investments and cloud services have increased, as evidenced by various statistics. It is mainly used in large companies, in the Information and communication services, and Professional, scientific and technical services sectors, and the most common way of use is e-mail services. Within the models, the most used is SaaS, and from the point of view of deployment it is hybrid cloud, multicloud, and public cloud. Although there are factors that prevent companies from adopting cloud infrastructure (cost, lack of skills, complexity, etc.), the benefits of adoption are noted, namely: cost minimization, resource maximization, security, flexibility, data loss prevention, sustainability, and others.

The adoption of CC in companies leads to digitalization and digital transformation, through which: processes are innovated, and made more efficient, businesses become more competitive, profitability is maximized, return on investment, and others. Cloud Computing has the potential for greater use in the future due to increasing digitization and Industry 5.0, which is a new model extending Industry 4.0 with more efficient and meaningful interaction between systems, people, and machines within their digital ecosystem.

**Acknowledgement**

The scientific article is a partial output of the solution of the project of the University of Economics in Bratislava for young teachers, researchers and doctoral students in the full-time form of study under the project number: IG-22-111-00 entitled „Information technology management in business entities“.

**References**

Akhgar. B.. Tafaghodi. A.. & Domdouzis. K. (2015). Chapter 15 - Cloud Computing. Sustainability. and Risk: Case Study: A Quantitative Fuzzy Optimization Model for Determining Cloud Inexperienced Risks' Appetite. *Green Information Technology*. 295–311. DOI: 10.1016/b978-0-12-801379-3.00015-2

Alptekin. S. E.. & Alptekin. G. I. (2018). A fuzzy quality function deployment approach for differentiating cloud products. *International Journal of Computational Intelligence Systems*. *11*(1). 1041–1055. DOI: 10.2991/ijcis.11.1.79

Chatterjee. S. (2022. October 12). *Top 50 cloud computing statistics and trends for 2022*. EPC Group. Retrieved November 1. 2022. from https://www.epcgroup.net/top-50-cloud-computing-statistics-and-trends-for-2022/

Chaulya. S. K.. & Prasad. G. M. (2016). Chapter 7 - Application of Cloud Computing Technology in Mining Industry. *Sensing and Monitoring Technologies for Mines and Hazardous Areas*. 351–396. DOI: 10.1016/b978-0-12-803194-0.00007-6

Elahi. B.. & Tokaldany. S. A. (2021). Chapter 15 - Application of Internet of Things-aided simulation and digital twin technology in smart manufacturing. *Advances in Mathematics for Industry 4.0*. 335–359. DOI: 10.1016/b978-0-12-818906-1.00015-2

Gartner. (2021. August 2). *Gartner says four trends are shaping the future of public cloud*. Gartner. Retrieved November 1. 2022. from https://www.gartner.com/en/newsroom/press-releases/2021-08-02-gartner-says-four-trends-are-shaping-the-future-of-public-cloud

Goasduff. L. (2021. November 1). *Cloud. AI and Software Are Top Investment Areas for Data & Analytics*. Gartner. Retrieved November 1. 2022. from https://www.gartner.com/en/articles/cloud-ai-and-software-are-top-investment-areas-for-data-analytics

Goralski. W. (2017). Chapter 29 - Cloud. SDN. and NFV. *The Illustrated Network*. 731–757. DOI: 10.1016/b978-0-12-811027-0.00029-1

Hamed. T.. Dara. R.. & Kremer. S. C. (2017). Intrusion detection in contemporary environments. *Computer and Information Security Handbook*. 109–130. DOI: 10.1016/b978-0-12-803843-7.00006-5

Howarth. J. (2022. August 29). *30 amazing cloud computing stats (2022)*. Exploding Topics. Retrieved November 1. 2022. from https://explodingtopics.com/blog/cloud-computing-stats

Jaiswal. R.. & Bhalse. N. (2018). A result evaluation based on privacy preserving using unified security methods (PPUSM). *2018 3rd International Conference on Communication and Electronics Systems (ICCES)*. 733–738. DOI: 10.1109/cesys.2018.8724099

Kanaker. H.. Saudi. M. M.. & Azman. N. (2017). Evaluation of EWCDMCC cloud worm detection classification based on statistical analysis. *Advanced Science Letters*. *23*(6). 5365–5369. DOI: 10.1166/asl.2017.7377

Kumar. N. L.. & Siddappa. M. (2016). Ensuring security for virtualization in Cloud Services. *2016 International Conference on Electrical. Electronics. Communication. Computer and Optimization Techniques (ICEECCOT)*. 248–251. DOI: 10.1109/iceeccot.2016.7955224

Laszewski. T.. & Nauduri. P. (2012). Chapter 1 - Migrating to the Cloud: Client/Server Migrations to the Oracle Cloud. *Migrating to the Cloud*. 1–19. DOI: 10.1016/b978-1-59749-647-6.00001-6

Li. L. (2013). 16 - The future of academic libraries in the digital age. *Trends. Discovery. and People in the Digital Age*. 253–268. DOI: 10.1016/b978-1-84334-723-1.50016-4

Loreth. T.. & Pickl. S. (2021). Chapter 5 - Digitalization and security: a new challenge for Mathematics 4.0. *Advances in Mathematics for Industry 4.0*. 115–130. DOI: 10.1016/b978-0-12-818906-1.00005-x

Mahmoud. M. S.. & Xia. Y. (2019). Chapter 3 - Cloud Computing. *Networked Control Systems*. 91–125. DOI: 10.1016/b978-0-12-816119-7.00011-3

Morgan. S. (2020. June 8). *The World Will Store 200 zettabytes of data by 2025*. Cybercrime Magazine. Retrieved November 1. 2022. from https://cybersecurityventures.com/the-world-will-store-200-zettabytes-of-data-by-2025/

OECD. (2021). The Digital Transformation of SMEs. *OECD Studies on SMEs and Entrepreneurship*. 275. DOI: 10.1787/bdb9256a-en

Richter. F. (2022. November 15). *CLOUD INFRASTRUCTURE MARKET Amazon. Microsoft & Google Dominate Cloud Market* . Statista Infographics. Retrieved November 1. 2022. from https://www.statista.com/chart/18819/worldwide-market-share-of-leading-cloud-infrastructure-service-providers/#:~:text=According%20to%20estimates%20from%20Synergy.Microsoft%20Azure%20and%20Google%20Cloud

Salesforce. (2022). *12 benefits of cloud computing and its advantages*. Salesforce. Retrieved November 1. 2022. from https://www.salesforce.com/products/platform/best-practices/benefits-of-cloud-computing/

Sitaram. D.. & Manjunath. G. (2012). Chapter 1 - Introduction. *Moving To The Cloud*. 1–21. DOI: 10.1016/b978-1-59749-725-1.00001-9

Sturm. R.. Pollard. C.. & Craig. J. (2017). Chapter 1 - Overview. *Application Performance Management (APM) in the Digital Enterprise*. 1–9. DOI: 10.1016/b978-0-12-804018-8.00001-2

Synergy Research Group. (2022. October 27). *Q3 cloud spending up over $11 billion from 2021 despite major headwinds; Google increases its market share: Synergy Research Group*. Synergy Research. Retrieved November 1. 2022. from https://www.srgresearch.com/articles/q3-cloud-spending-up-over-11-billion-from-2021-despite-major-headwinds-google-increases-its-market-share

Tariq. M. I.. Tayyaba. S.. Ashraf. M. W.. & Balas. V. E. (2020). Deep learning techniques for Optimizing Medical Big Data. *Deep Learning Techniques for Biomedical and Health Informatics*. 187–211. DOI: 10.1016/b978-0-12-819061-6.00008-2

Tekinerdogan. B.. & Oral. A. (2017). Chapter 8 - Performance Isolation in Cloud-Based Big Data Architectures. *Software Architecture for Big Data and the Cloud*. 127–145. DOI: 10.1016/b978-0-12-805467-3.00008-9

Tian. W.. & Zhao. Y. (2015). 1 - An Introduction to Cloud Computing. *Optimized Cloud Resource Management and Scheduling*. 1–15. DOI: 10.1016/b978-0-12-801476-9.00001-x

Tokaldany. S. A. (2021). Chapter 15 - Application of Internet of Things-aided simulation and digital twin technology in smart manufacturing. *Advances in Mathematics for Industry 4.0*. 335–359. DOI: 10.1016/b978-0-12-818906-1.00015-2