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Cloud computing services – status and trends

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Cloud computing services gained in popularity in recent years. Cloud computing, the relatively new information technology discipline, has its roots in older technologies. The paper provides classification and a review of essential services being offered currently by a variety of vendors. Elastic-R environment for cloud enabled scientific calculation is described. Contents of certification under development in computer networks technologies, security, and cloud computing with laboratory exercises are provided.

Cloud computing

In last decade a cloud computing has been subject of an increasing interest of researchers and information technology practitioners alike due to its multiple advantages over legacy solutions. According to the National Institute of Standards and Technology (NIST) cloud computing is defined as […] *a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics: On-demand self-service, Broadband network access, Resource pooling, Rapid elasticity, Measured Service*[1].

The technology of cloud computing is rooted in technologies developed in previous decades and according to Kauffman cloud computing *originates from the telecommunications world of the 1990s, when providers began using virtual private network (VPN) services for data communication. VPNs maintained the same bandwidth as fixed networks with considerably less cost: these networks supported dynamic routing, which allowed for a balanced utilization across the network and an increase in bandwidth efficiency, and led to the coining of the term „telecom cloud*[2].

Present day cloud computing derived its roots from previously developed technologies of cluster computing and grid computing[3]. Cluster as in computing cluster is defined, after Buyya et al., as: *a cluster is a type of parallel and distributed system, which consists of a collection of inter-connected standalone computers working together as a single integrated computing resource*[4]. A computing grid is defined as: *is a type of parallel and distributed system that enables the sharing, selection, and aggregation of geographically distributed „autonomous", resources dynamically at runtime depending on their availability, capability, performance, cost, and users' quality-of-service requirements*[5]. Cloud, according to Buyya et al., is: *a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements established through negotiation between the service provider and consumers*[6]. Buyya et al. provided comparison of key characteristics and differentiating factors among cluster, grid and cloud computing. These key characteristics considered were the scalability, resource management, failure management, internetworking, areas where cloud computing offers distinct advantages over preceding technologies.

Gartner[7] lists cloud computing as one of the top 10 technologies which have *the potential for a significant impact on organizations within next three years*:

- Computing everywhere: mobile environment
- Internet of things

[1] *NIST Cloud Computing Program*, Information Technology Laboratory, http://csrc.nist.gov/groups/SNS/cloud-computing/, [22.04.2016].
[2] L.M. Kauffman, *Data Security in the World of Cloud Computing*, „IEEE Computer Society" 2009, Vol. 7, No. 4, pp. 61–64, http://doi.ieeecomputersociety.org/10.1109/MSP.2009.87.
[3] R. Buyya, et al., *Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility*, „Future Generation Computer Systems" 2009, Vol. 25, No. 6, s. 599–616.
[4] *Ibid.*
[5] *Ibid.*
[6] *Ibid.*
[7] *Gartner's Top 10 Strategic Technology Trends for 2015*, Gartner, 2015, http://www.gartner.com/smarterwithgartner/gartners-top-10-strategic-technology-trends-for-2015/, [07.11.2015].

- 3D Printing
- Analytics
- Context-rich systems
- Smart Machines
- Cloud/Client Computing
- Software-Defined Applications & Infrastructure
- Web-Scale IT
- Risk-Based Security & Self-Protection.

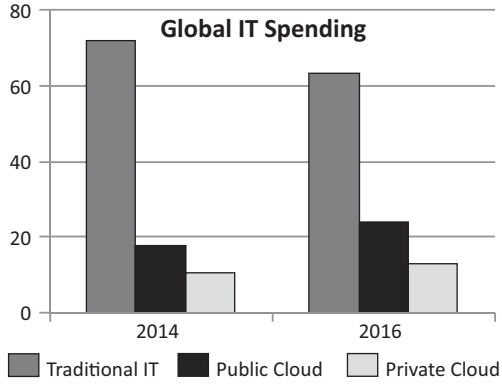
Cloud computing is increasingly being used by a variety of industries for multiple of reasons: reduction or elimination of legacy costs related to maintaining of computer networks, economics of scale or scalability, speed, agility, failure management, global access & reach.

Kizza[8] and Gapinski[9] provided analyses and information on cloud computing classification with respect to topology/architecture, information security standards, regulations compliance, and auditing attestation standards. Cloud types considered here include public, private, hybrid and community based entities, relative to ownership and who manages them. A public cloud is the most common form of cloud services where services are being accessed by users over the Internet, externally to their facilities. In a private cloud, an entity – a provider, provides cloud oriented facilities and services internally to the organization. Hybrid cloud is a composition of private and public types, where access to externally provisioned resources offers scalability to private cloud entities. In a community cloud, enterprises share their infrastructure and cloud resources based on common requirements and demand for such cloud services[10].

IT spending and cloud computing

According to „Bloomberg Businessweek"[11] the Information Technology (IT) expenditure worldwide will shift reflecting the growing demand for cloud computing services. A change in reallocation of funds will occur among traditional IT and various forms of cloud services. Here a traditional IT is understood as information technology environment where data, services, and applications are owned, controlled, operated and managed by the same organization. The IT environments may be hosted at data centers, server farms, mainframes or supercomputers or other non-cloud computing platforms. While the traditional IT spending took 71.9% of global IT spending, public clouds took 17.5% and private clouds 10.6% shares of total IT expenditures, respectively, in 2014 (see figure 1)[12]. It is forecasted that the numbers would change to 63.3% for traditional IT, 24% for public and 12.7% for private clouds, respectively, in 2016. See Figure 1 and Table 1.

Figure 1. Global IT Spending Shifts in percent



Source: I. King, *Networks. Cisco tries to make a Different Switch*, „Bloomberg Businessweek" 2015, November 9, Special Issue, pp. 46–48.

Table 1. Traditional IT – public cloud – private cloud

Traditional IT	71.9% (2014)	63% (2016 est.)
Public Cloud	17.5%	24%
Private Cloud	10.6%	12.7%

Source: I. King, *op.cit*.

The overall sales of cloud computing services are getting bigger. Cloud computing trailing 12-month sales rose to $18.7 billion in third quarter, up from $17.6 billion in second quarter of 2015[13]. Goldman Sachs forecasts the overall cloud computing platform sales reach $25.8 billion in 2016, $32.9 billion in 2017[14], and $130 billion in 2018[15].

Cloud computing: players' roles

Cloud computing does involve various players, or actors, who play different roles in providing cloud computing services. For clarity, we describe these players-entities as follows. Players called enablers enable appropriate hardware & software technologies including virtualization used in providers' cloud computing centers and services. Entities called cloud

[8] J.M. Kizza, *Computer Communications and Network*, 2nd ed., Springer, 2013.
[9] A. Gapinski, *Cloud Computing: Information Security Standards, Compliance and Attestation*, 13th LACCEI Annual International Conference *Engineering Education Facing the Grand Challenges, What Are We Doing?*, July 29-31, 2015, Santo Domingo, Dominican Republic, conference proceedings, http://dx.doi.org/10.18687/LACCEI2015.1.1.065.
[10] H. Jin, et al., *Cloud Types and Services*, [in:] B. Furht, A. Escalante (eds.), *Handbook of Cloud Computing*, Springer Science+Business Media, 2010, http://dx.doi.org/10.1007/978-1-4419-6524-0_19.
[11] I. King, *Networks. Cisco tries to make a Different Switch*, „Bloomberg Businessweek" 2015, Nov. 9, Special Issue, pp. 46–48.
[12] *Ibid.*
[13] P. Seitz, *Amazon, Microsoft Tighten Grip On Cloud Market*, „Investor's Business Daily" 2015, November 13.
[14] *Ibid.*
[15] J. O'Mahony, *The Road To Cloud Maturity*, „Bloomberg Businessweek" 2015, September 28, pp. S3–S11.

providers provide their infrastructure or cloud platforms to customers. Players called cloud customers, who are usually data owners, seek cloud services, and players called cloud users consume provided services. Clearly a user of cloud computing services may or may not be the data owner in those arrangements[16].

Cloud computing: classification of services

Cloud computing provides information technology (IT) resources to its users as a service. IT resources may include hardware, software environments and applications. The cloud services can be divided into following categories[17]:

- Infrastructure as a Service (IaaS), where essentially a hardware infrastructure is offered as a service. IaaS is subdivided into: Computation as a Service (CaaS) and Data as a Service (DaaS). In CaaS virtual machines with deployed software are offered. In DaaS service, a storage is offered to store user's data.
- Platform as a Service (PaaS) provides a software execution environment that specific application services can run on, where operating system is combined with programming language IDE and other API tools.
- Software as a Service (SaaS) offers licensed software to users. Occasionally, the software as on-demand offering may be deployed as part of PaaS or IaaS.

The IaaS, PaaS, and SaaS are essential three methods of delivery of various cloud computing services. Increasingly the boundaries among IaaS, PaaS, and SaaS services are being blurred. To determine the type of needed service and the level of engagement, IT manager has to answer essentially the following questions:

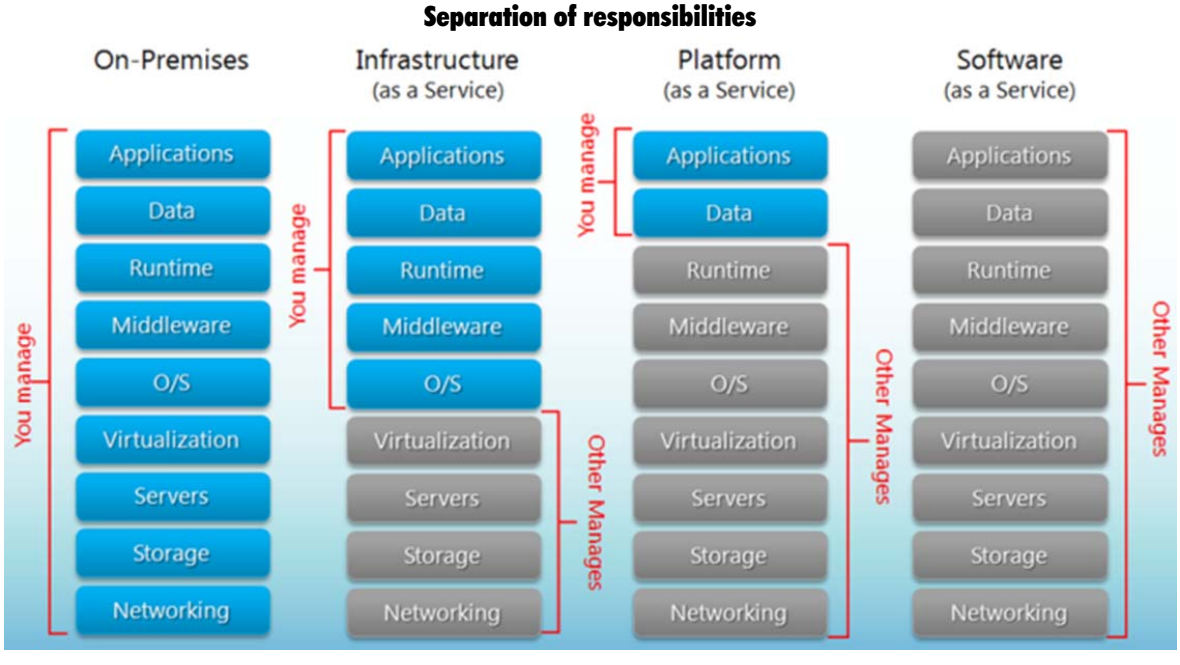
1. To what extent to own the hardware and software
2. If renting of space at cloud vendor data center is the option, then with whose software?
3. Who is responsible for information security?

So, in order to decide what level of cloud computing services is needed the user has to answer: who owns, controls, and manages what and where? The plethora of options can be summarized as on Figure 2, which specifies responsibilities of the user (blue) and provider (gray) in on-premises infrastructure, in IaaS, in PaaS, and in IaaS services with regard to application, data, runtime, middleware, OS, virtualization, servers, storage, and networking layer of engaged services (see Figure 2).

IaaS

In IaaS customer rents/buy a space, a „server in the cloud" (virtual machine), and controls & manages various software from operating system (OS) to specific application including third party software. In this type of service the customer controls the most aspects of the computing environment which demands the highest

Figure 2. General classification of responsibilities based on type of cloud computing & services



Source: technet.microsoft.

[16] J.M. Kizza, *op.cit.*
[17] *Ibid.*; H. Jin, et al., *op.cit.*

level of knowledge. Some most popular IaaS systems include Amazon Elastic Compute Cloud (EC2), Amazon Simple Storage Service (S3), GoGrid, Rackspace Cloud, Micrososoft Azure VM[18]. They offer many similar features, the differences are based on different business models and other considerations such virtualization platform, operating system, server RAM, load balancing, storage type (persistent storage). While Rackspace and GoGrid offer hybrid hosting, Amazon does not. GoGrid offers free inbound data transfers, etc. Hybrid hosting can mitigate the problems arising from multitenant server environment. Rackspace provides the security based on replication of three full copies of data across multiple of computers in multiple of zones[19].

PaaS

In this type of service the user provides the data and/or application and the rest is handled by the cloud provider. The cloud execution environment contains not only operating system but it may have a specific programming language platform for users to build their application. The current examples of PaaS include: Google App Engine (GAE), Microsoft Azure, Force, HeroKu. They differ in programming environments: Python/Java (GAE), Microsoft Visual Studio (.Net) (Microsoft), Apex programming (Force), Ruby (HeroKu), respectively; infrastructure, and hosted applications.

SaaS

Software as a Service is based on licensing the use of software, which is installed on cloud platform. The application might have been developed and run on IaaS or PaaS. SaaS substitutes for traditional software usage where user subscribe or rents the software itself or as a part of IaaS or PaaS.

SaaS has already a variety of offerings from many providers: Google Apps, Microsoft, Saleforce CRM, Amazon Web family which has multiple services: EC2, S3, SimpleDB, CloudFront, Simple Queue Service (SQS)[20].

IaaS & PaaS: Container as Service

A container provides the computing resources to run a single application. A container is a form of operating system virtualization that allows for running a single application. Container can be defined as isolation unit running in a single operating system. After M. Daconta *a container is a form of operating system virtualization that is more efficient than typical hardware virtualization*[21]. As part of IaaS, a container technology provides the necessary computing resources to run an application in isolation from other applications. Container creates a single isolated virtual space for an application as if it was the only application running in the operating system. The container architecture facilitates multi-container setup where each single application runs in a separate container on the same machine without conflicts and hopefully without security breaches. Currently containers are implemented on Linux, BSD and Solaris operating systems. At present many platform-as-a-service (PaaS) implementations, including HeroKu, OpenShift, dotCloud and CloudFoundry, use containers. Private cloud IaaS implementation providers such as Open -Stack and Cloudstack do offer support for containers. In this area various operating systems offer different boot-up time, space and storage requirements. It has been reported that Linux offers significant smaller boot-up times and smaller storage requirements than Windows platform[22]. As containers offer better isolation and consequently higher reliability than current technology of threads it is expected that a relatively new container technology will only grow in importance as part of cloud services.

Cloud computing: major vendors

According to recent data, the biggest cloud computing vendors are: Amazon with its Amazon Web Services (AWS), Microsoft (Azure), Salesforce, Oracle, Rackspace Hosting and Alphabet unit of Google. The three dominant vendors, Amazon, Microsoft, Salesforce corporations have share of 36.9%, 8.7%, and 4.6%, respectively, of overall market as of Q3 2015[23].

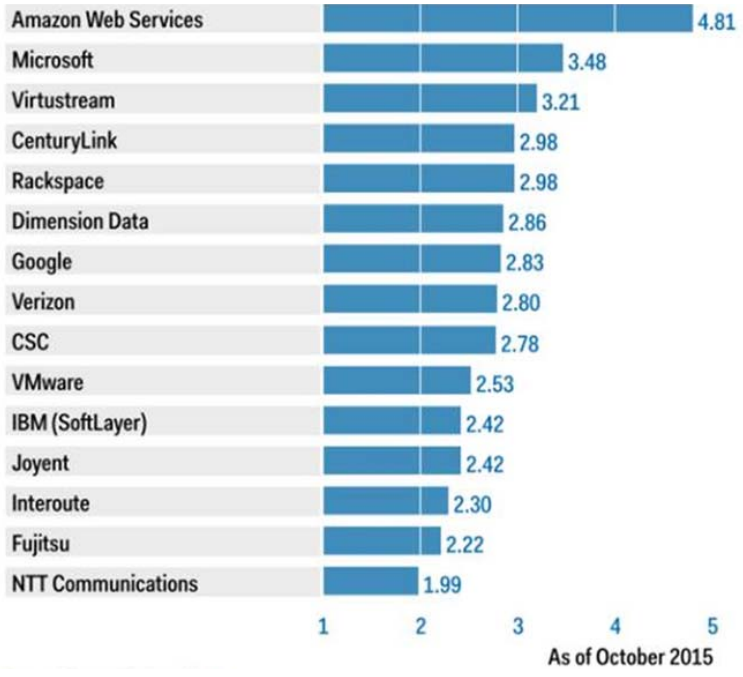
Major vendors are being compared with regard to product or service quality for application development with results given in Figure 3. Gartner[24] (Figure 3) shows major vendors' product scores for application development use.

Not surprisingly, AWS and Microsoft Azure took top spots in the ranking. Each of the major players offer multilayer platforms for cloud services. In the case of Amazon, AWS suite offers storage: Amazon Glacier, S3, EBS; relational and non-relational data bases: Redshift, Dynamo, ElasticCache, RDS; management: CloudWatch, FAM, CloudFormation Elastic Beanstalk; multiple of languages platform: PHP, Java, Ruby, Python, .NET, Node.JS, among others.

Increasingly, customers – software developer companies ask for an end-to-end service in order to build applications factories which would allow for access to cloud, mobile, sensors, large-scale data analysis within the entire life of their products. That relatively new demand forces companies to offer complete suite of services including mobile access. To illustrate the increasing importance of mobile access even for cloud computing one can mention the recent decision by

[18] H. Jin, et al., *op.cit.*
[19] *Ibid.*
[20] H. Jin, et al., *op.cit.*; Amazon Web Services, www.aws.amazon.com.
[21] M. Daconta, *Containers Add New Efficiency to Cloud Computing*, 2013, October 23, www.informationweek.com.
[22] *Ibid.*
[23] P. Seitz, *op.cit.*
[24] *Top IT Trends & Predictions in 2016*, Gartner, http://www.gartner.com/technology/topics/trends.jsp, [22.04.2016].

Figure 3. Various vendors' product scores for application development use case



Source: *Top IT Trends & Predictions in 2016*, Gartner, 2015, http://www.gartner.com/technology/topics/trends.jsp.

Microsoft Corp. to purchase a vendor in mobile service area. Namely, to compete with Amazon and Google cloud offerings in mobile applications, Microsoft recently bought Xamarin company, which would allow software developers to write applications for mobile devices[25].

Due to prohibitive costs of entering and expanding the cloud computing services, the smaller vendors, some not listed above, are about to lose gradually the market share. Thus, the future market may be even more consolidated with only a few major players present.

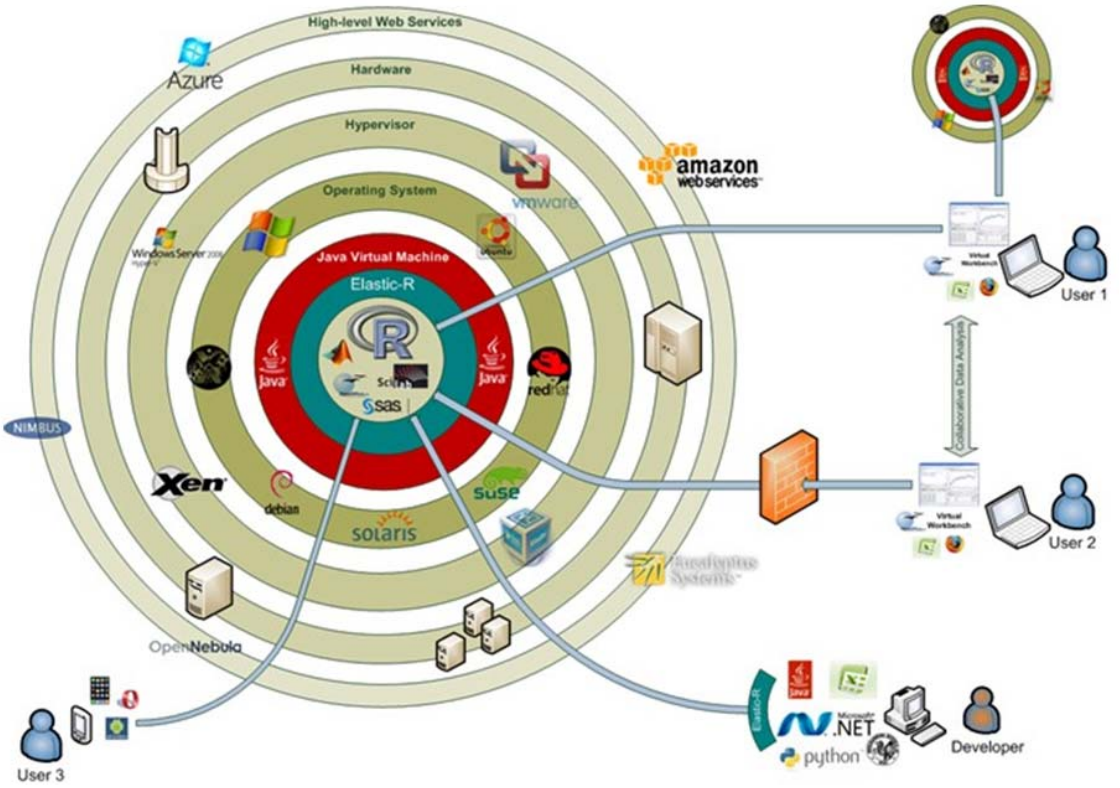
Cloud: Elastic-R environment for scientific and statistical computing

The computing grid[26] did not satisfy its expectations for efficient way of data transfer, connection of computers and people for scientific calculations. So, there was a need to develop a platform which would allow scientific community to access cloud services to scale their scientific calculations. Such a platform Elastic-R[27] was developed based on R programming language. Chine[28] describes Elastic-R (E-R) platform which provides environment for data analysis which can be linked to cloud as IaaS service. The E-R platform allows for assembling statistical/numerical methods and data on server, E-R virtual machine instance on the cloud. The Elastic-R offers a simplified facade portal to the cloud that allows a user to run a virtual machine using specific any scientific computing environment (Scilab, Sage, Root, etc.). Elastic-R Java workbench or Elastic_R Ajax workbench can be used to access cloud. The tool Elastic-R allows to install and use new packages, and perform any file and data processing. The R- platform can accommodate any of the programming languages such as C++, FORTRAN, Java, Perl, C#, etc. Elastic-R engine on server side can be controlled programmatically using Java, Perl, C#, C++, etc.[29]

Figure 4 shows Elastic-R used in IaaS environment-concentric circles[30]. Any layer can be accessed remotely. R engine can run on any operating system. Figure 5 shows users using Elastic-R environment connected to the same remote engine (server) and collaborating using spreadsheets and graphs with chatting enabled[31].

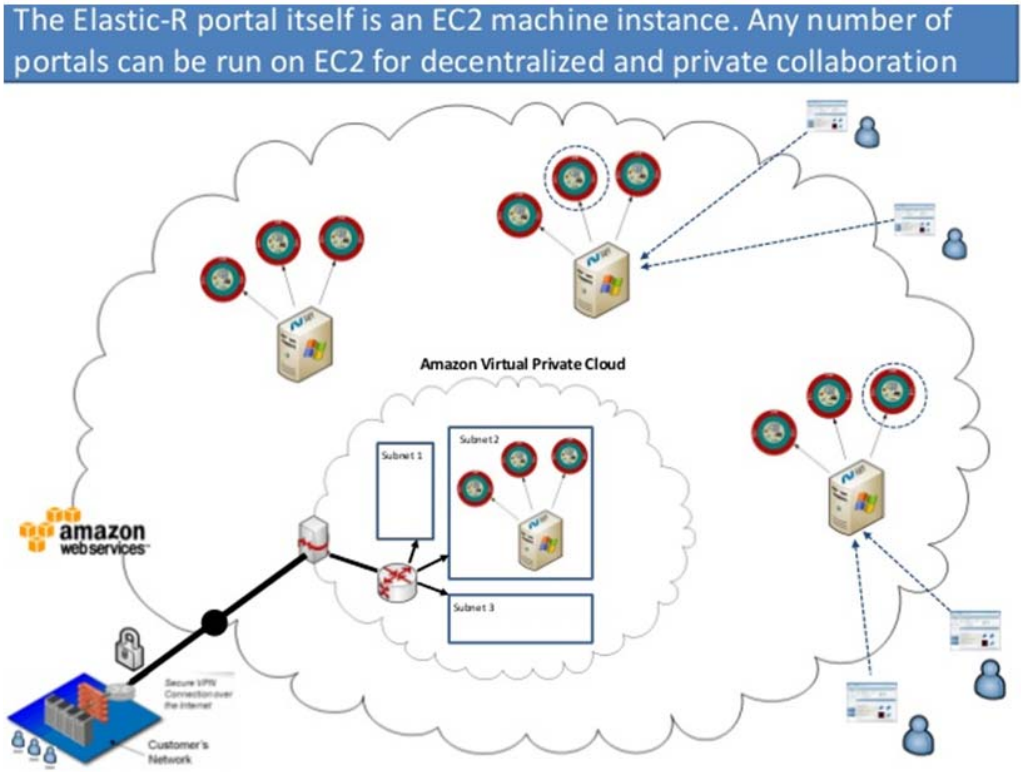
[25] Q. Hardy, *Cloud Computing Fight Intensifies*, „The New York Times" 2016, February 29, p. B5.
[26] I. Foster, *What is the grid? A three point checklist*, „Grid Today" 2002, Vol. 6, No. 1, pp. 22–25.
[27] *R: A language and environment for statistical computing*, R Development Core Team, R Foundation for Statistical Computing, Vienna 2009, http://www.R-project.org.
[28] K. Chine, *Open Science in the Cloud: Towards a Universal Platform for Scientific and Statistical Computing* [in:] B. Furht, A. Escalante (eds.), *Handbook of Cloud Computing*, Springer Science+Business Media, 2010, http://dx.doi.org/10.1007/978-1-4419-6524-0_19.
[29] *Ibid.*
[30] *Ibid.*
[31] *Ibid.*

Figure 4. Elastic-R and IaaS environment



Source: K. Chine, *Open Science in the Cloud: Towards a Universal Platform for Scientific and Statistical Computing* [in:] B. Furht, A. Escalante (eds.), *Handbook of Cloud Computing*, Springer Science+Business Media, 2010, http://dx.doi.org/10.1007/978-1-4419-6524-0_19.

Figure 5. Decentralized collaboration: Elastic-R portal in EC2



Source: K. Chine, *op.cit.*

Cloud computing: office tools

As an example of cloud computing available office productivity tools, Google for Works (GforW) is being compared to Microsoft Office 365 (MS O365)[32]. Tools such as email, office documentation, calendar and file sharing offered by Google Apps suite (Gmail, Hangouts, Drive, Calendar) is compared to Microsoft Office apps (Word, Excel, Outlook, PowerPoint) with respect to price, simplicity, flexibility, storage space. Each suite offers „unique strengths and weaknesses" which have to be taken into consideration in selecting the proper match for users. Table 1 lists differences between two suites with regard to price, storage options, plan choice, featured apps, and time commitments.

Table 2. Google for Works vs. Microsoft Office 365

	Google for Work	Office 365
Entry Price	$5 per user per month or $50 per year (plus tax)	$5 per user per month with a full-year commitment
Storage Options	300 GB per user, or unlimited storage for premium accounts with at least five users	1 TB per user, regardless of plan
Plan Choices	2 options; $5 or $10 per user per month	6 options; $5, $8.25 or $12.50 per user per month for business customers; $8, $12 or $20 per user per month for enterprise customers
Featured Apps	Gmail, Hangouts, Drive and Docs	Word, Excel, Outlook and PowerPoint
Commitments	Flexible month-to-month pricing or full year in an advance at a discounted rate	All plans require an annual commitment

Source: www.cio.com.

While prices are comparable, Google offer is simpler and more flexible with regard to time commitment. Naturally, the security safeguards and preferences with regard to user experiences and corporate IT culture have to be considered in selection. As Eric Schlissel, CEO of IT consultancy GeekTek IT Services firm points out: […] *we tend to recommend Google for Works to clients with a younger and more tech-savvy workforce*[33]. Organizations which traditionally uses Microsoft legacy software tools may prefer MS Office 365. Coexistence of two suites are possible and sometimes such a deployment inside an organization is encountered, where IT department may use Google for Works suite, and other departments, which are historically more accustomed to Microsoft Office tools may opt for Microsoft Office 365. In such case, however, some problems may occur due to lack of compatibility and other issues. Wiora reports of problems with Google for Works, which may place additional burden for businesses, such as *inability to transfer MS Excel formulas directly to Google Spreadsheets, shared calendar issues, compatibility issues, and others*[34]. Federal regulations may also affect the selection as in the case of Google past refusal to sign a HIPAA BAA (Health Insurance Portability and Accountability Act Business Associate) agreement for the healthcare industry, which most likely prohibits healthcare related businesses from adopting Google suite. Third party vendors are sometimes used to provide security and management services for cloud computing services. BetterCloud company provides such services for both Google Apps and Office 365[35].

Information security & compliance

Cloud computing information security and compliance conform to standards used by computer and computer network industry. The subjects related to information security were discussed and analysed by Kauffman[36], Solomon & Chapple[37], Schou & Shoemaker[38], and Gapinski[39]. Cloud computing serv-

[32] M. Kapko, *Google for Works vs. Microsoft Office 365: A comparison of cloud tools*, 2015, March 26, www.cio.com.
[33] *Ibid.*
[34] *Ibid.*
[35] *Ibid.*
[36] L.M. Kauffman, *op.cit.*
[37] M.G. Solomon, M. Chapple, *Information Security Illuminated*, Jones & Bartlett Publishers, Sudbary 2005.
[38] C. Schou, D. Shoemaker, *Information Assurance for the Enterprise. A Roadmap to Information Security*, McGraw-Hill, New York 2007.
[39] A. Gapinski, *Strategies for Computer Networks' Security*, „Kwartalnik Nauk o Przedsiebiorstwie" 2014, nr 3(32), s. 59–65.

ice organizations seek certifications and assessment by external agencies in mainly three areas[40]:

1. Information Security,
2. Compliance with regulations, and
3. Attestation / Auditing.

According to Kauffman[41] the companies which offer services to ensure data confidentiality, integrity, and availability (CIA), must offer capabilities that, at a minimum, include:

- *a tested encryption schema to ensure that the shared storage environment safeguards all data,*
- *stringent access controls to prevent unauthorized access to the data,*
- *scheduled data backup and safe storage of the backup media*.

Concepts of confidentiality, integrity and availability (CIA) are understood as:

- *Confidentiality, or secrecy – the concealment of information*
- *Integrity – trustworthiness of information or data/ resources; ensuring that data can be modified only though an authorized mechanism*
- *Availability – allowing authorized entities access to assets*[42].

Background information and analyses on information security, standards, and compliance issues as applied to cloud computing were provided by Kauffman[43] and Gapinski[44].

Companies offering cloud computing may seek reporting from the American Institute of CPA which offer Service Organization Controls (SOC) reports. The reports are supposed to help service organizations build trust and confidence in their service delivery processes and controls.

Certification in computer networks, security, and cloud computing

The author is in the process of developing the certification program in the area of computer networks, security, and cloud computing services. The certificate program under development will cover the essential concepts of computer networks (peer-to-peer and client/server local area networks (LANs), wide-area networks (WANs) technologies, including: planning, installation, server configuration, resource management, remote access, performance monitoring, and optimization); security (malware, attack tactics, data security, cryptography, wireless/mobile security, authentication/access techniques); and cloud computing (virtualization and virtual machines including Hyper-V, security, IaaS/PaaS/SaaS and clouds)[45]. Specific laboratory exercises will cover following subjects:

- Operating systems and Networking:
  a. MS Windows and Linux environments
  b. Basic concepts of networking: topologies, protocols, packet switching, routing
  c. Server – client services (Email service, Web server)
- Cybersecurity:
  a. Information Security
  b. Cryptography
  c. Virtual penetration (using Kali Linux)
- Cloud services:
  a. Creating a VM using Amazon AWS EC2
  b. Using Microsoft MS Azure
  c. Storage in cloud using Amazon AWS S3
  d. Infrastructure as IaaS – cloud computing security (using Apache CloudStack and OpenStack open source cloud middleware systems).

The goal of the program is to offer a certification to IT professionals and engineering personnel for variety of local industries which include manufacturing, high-tech, and healthcare sectors.

Conclusions

The purpose of the article was to review current status and trends in cloud computing offerings. Classification of services and present day developing trends in cloud computing services were described. Examples of IaaS, PaaS, and SaaS were provided. Information security concepts were reviewed. An example of cloud computing platform for scientific & statistical calculations Elastic-R was described. The certification program in computer networks, information security, and cloud computing with laboratory topics was proposed.

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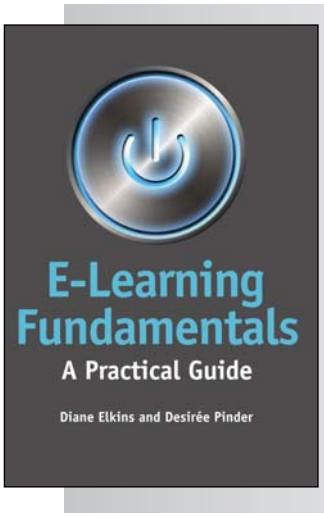

Polecamy

Diane Elkins, Desirée Pinder
E-Learning fundamentals. A practical guide
ATD Press, Aleksandria, VA, USA 2015

Zapraszamy do zapoznania się z podręcznikiem dostarczającym podstawowej wiedzy na temat e-learningu, którą powinna dysponować każda osoba zainteresowana prowadzeniem zajęć w tej formie. Pozycja opatrzona jest wieloma konspektami oraz checklistami i zawiera wiele praktycznych porad i narzędzi, które pomogą nawet początkującemu e-nauczycielami stworzyć profesjonalne i użyteczne kursy e-learningowe. Książka porusza wszystkie najważniejsze zagadnienia, począwszy od projektowania i rozwijania e-szkoleń (tworzenie scenariusza, tworzenie testów, dobór środków multimedialnych), poprzez proces ich realizacji, a skończywszy na ewaluacji. Publikacja dostępna jest na razie tylko języku angielskim.
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