Chapter 13
Cloud Computing for Cytopathologists

Abraham Pouliakis
University of Athens, Greece

Stavros Archondakis
401 Military Hospital, Greece

Efrossyni Karakitsou
National Technical University of Athens, Greece

Petros Karakitsos
University of Athens, Greece

ABSTRACT

Cloud computing is changing the way enterprises, institutions, and people understand, perceive, and use current software systems. Cloud computing is an innovative concept of creating a computer grid using the Internet facilities aiming at the shared use of resources such as computer software and hardware. Cloud-based system architectures provide many advantages in terms of scalability, maintainability, and massive data processing. By means of cloud computing technology, cytopathologists can efficiently manage imaging units by using the latest software and hardware available without having to pay for it at non-affordable prices. Cloud computing systems used by cytopathology departments can function on public, private, hybrid, or community models. Using cloud applications, infrastructure, storage services, and processing power, cytopathology laboratories can avoid huge spending on maintenance of costly applications and on image storage and sharing. Cloud computing allows imaging flexibility and may be used for creating a virtual mobile office. Security and privacy issues have to be addressed in order to ensure Cloud computing wide implementation in the near future. Nowadays, cloud computing is not widely used for the various tasks related to cytopathology; however, there are numerous fields for which it can be applied. The envisioned advantages for the everyday practice in laboratories' workflow and eventually for the patients are significant. This is explored in this chapter.

INTRODUCTION

Cloud services (in modern tech jargon often referred as "the cloud") refers to a network of servers connected by the Internet or other network that enables users to combine and use computing power on an as-needed basis. Cloud computing is a novelty that rapidly showed tremendous opportunities for application in medicine and health care improvement (Eugster, Schmid, Binder, & Schmidberger, 2013; Glaser, 2011; Kuo, 2011; Lupse, Vida, & Stoicu-Tivadar, 2012; Mirza &

El-Masri, 2013; Patel, 2012; Rosenthal et al., 2010; Waxer, Ninan, Ma, & Dominguez, 2013; Webb, 2012). Actually it is forecasted that there will be an increase in the US cloud computing market for medical images approximately 27% by 2018 at a Compounded Annual Growth Rate (CAGR). This is mainly due to the growing volume of medical images and the increasing costs of the ownership for owning Picture Archiving and Communication Systems (PACS) (GlobalData, 2012).

Within this chapter, we analyze the state of the art related to the application of cloud computing services and infrastructure for cytopathology, identify and propose potential applications, explore possible solutions for potential problems and finally promote the benefits of transforming traditional applications of the cytopathology lab into cloud based services. The main areas related to the application of the Cloud for cytopathology include data storage with an emphasis on image archiving and access, the shift of traditional Laboratory Information Systems from laboratory or hospital hosting to cloud hosting, the benefits of cloud based services for the support of population screening and especially for cervical cancer screening that represents the major work load for cytopathology laboratories, the application of cloud applications for the support of Quality Control and Quality Assurance (QC and QA) of the modern cytopathology lab as well as the trends to shift the traditional proficiency testing for cytopathologists and the need for continuous medical education to e-services and why the cloud would be an appropriate choice. In this chapter, primary diagnosis and tele-cytology and tele-consultation issues are analyzed and finally we present research highlights for cloud based cytological image analysis and cytogenetics and genome analysis. Finally, issues and principles for virtual slides for cytopathology are presented, being a driving force for the application of cloud based services for cytopathology, both for the everyday practice and research purposes.

BACKGROUND

A cloud system is actually a network of computer servers offered under demand as a service. The system is designed to be flexible, scalable, secure and robust. Cloud systems usually provide software, data access, and data storage services provided by this interconnected grid of computers that permits sharing of resources through the Internet and works on a pay-per-use model.

Cloud systems are categorized into three different groups according to the offered service type:

- Infrastructure as a Service (IaaS), which means offering hardware, storage and physical devices over the Internet.
- Software as a Service (SaaS), which means offering software and hosted applications over the Internet.
- Platform as a Service (PaaS), which means offering the capability to deploy applications created using programming languages, libraries, services, and tools owned and supported by the provider.

For cloud computing, the user/consumer does not manage or control the underlying cloud infrastructure, but has control over the deployed applications. Clouds, according to their location of hosting, may be public, private, hybrid, and community, especially adapted to the medical field:

- **Public Clouds:** Are for general use. The cloud owners are responsible for information hosting; public clouds are rarely used in the field of medicine and in case of use, data are encrypted.
- **Private Clouds:** Are only for in-hospital use and are dealing with confidential patient data. The owners or the hospital premise are responsible for information hosting.

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