Cloud Computing in Public Administratione

Ioannis Nanos* and Amalia Stafyla

International Hellenic University, Thessaloniki, Greece

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*Corresponding author: Ioannis Nanos, International Hellenic University, Thessaloniki, Greece

Abstract

Cloud computing is a new paradigm for the provision of ICT services, with appropriate deployment and service models. The aim of this paper is to highlight the potential of cloud computing adoption in public administration and more specifically in local government authorities (municipalities), identifying the associated benefits-advantages and problems-challenges. Moreover, through an empirical research in a sample of 211 Greek municipalities, this paper explores cloud computing adoption in Greek municipalities and analyzes the cloud services and models applied, as well as the factors that influence the decision about proceeding or not to cloud computing adoption. The outcomes of our study can serve as a roadmap for local government authorities that consider cloud computing adoption as part of their digital transformation strategy.

Keywords: Cloud computing; Public administration; Digital transformation

Abbreviations: MIT: Massachusetts Institute of Technology; IaaS: Infrastructure as a Service; Platform as a Service: Platform as a Service; SaaS: Software as a Service; HaaS: Hardware as a Service; DRaaS: Disaster Recovery as a Service; XaaS: Everything as a Service; SLA: Service level agreement

Introduction

The origin of the term cloud computing can be traced back in the 60's, where John McCarthy in a lecture at the Massachusetts Institute of Technology (MIT) argued that in the future, computing infrastructure and services would be provided in a form of a public utility services, such as electricity, water, telephony etc. (Abelson, 1999). Practically and outside the fields of the academic community, the term cloud computing was introduced in 2006 by Eric Schmidt (former Google's CEO), who used it to describe a new business model that would provide services through the internet Regalado [1]. According to this model, computing and storage resources as well as software, are provided as a service Voorsluys [2], something that was innovative and very different to the existing philosophy and practice.

In the literature there are numerous cloud computing definitions, each of them focusing on different aspects. By combining some of the most indicative definitions Chellapa [3]; Foster [4]; Marston [5]; Regalado [1]; Sultan [6]; Vaquero [7]; Wyld & Maurin [8], we can say that cloud computing is a model for on demand and according to the needs provision of IT services and resources. These resources are shared, flexible and scalable and are acquired through the pay-per-use model. The main characteristics of cloud computing are resource pooling, broad network access, rapid elasticity, measured service, on demand self-service, scalability, flexibility, independency, ignorance, reliability, cost efficiency and sustainability Mell & Grance [9]; Rountree & Castrillo [10]; Sosinski [11].

The models of cloud computing can be classified in two main categories: a) deployment models, that refer to the structure and property of the cloud, its characteristics and users' access and b) service models, that refer to the type of services offered. As far as the deployment models are concerned, we can find the public cloud, the private cloud, the community cloud and the hybrid cloud Hsu [12]; Robinson [13]. As far as the service models are concerned, we can identify the Infrastructure as a Service (IaaS), the Platform as a Service (PaaS) and the Software as a Service (SaaS) Hsu [12]; Robinson [13]; Sosinski [11], while some authors add also the Hardware as a Service (HaaS) model, the Disaster Recovery as a Service (DRaaS) model and the Everything as a Service (XaaS) model Busch [14]; Firdhous [15]; Mladenow [16].

The adoption and use of cloud computing is an opportunity for public administration and can lead to digital transformation and more effective and efficient electronic government. With cloud computing, public administration authorities can have access to powerful IT resources, without the need of purchasing them Bansal [17]; Bellamy [18]; Liang [19]. Also, they get specialized IT support from cloud service providers, something that is very

important since many public administration authorities have limited budgets for ICT services and they lack experienced IT personnel Ali [20]; Hashemi [21]. Moreover, they can have tools, systems and applications that are flexible and scalable according to their needs Nasr [22]; Smitha [23]. Furthermore, they can have a solid and safe disaster recovery plan, since backups are stored in the cloud and can be easily restored at no delay Ali [24] and at no extra cost Hashemi [21]. Finally, with the use of cloud computing, public administration authorities can reduce their carbon footprint, since they require less in-house resources (servers, air conditions etc.) and less power needed Zissis & Lekkas [25]; Bansal [17].

On the other hand, cloud computing adoption in public administration authorities faces potential problems and challenges. First of all, it requires the compatibility and interconnectivity between the existing ICT infrastructure and the systems and services that will operate in the cloud Hofmann & Woods [26]. Other problems-challenges that are found in the literature refer to the protection of data security and privacy Ali [20]; Almarabeh [27], the lack of control over systems and personal data Alshomrani & Qamar [28], the dependency on internet speed and the operational issues concerning cloud providers Sahu & Tiwari [29]. However, many of the above-mentioned challenges can be solved with a service level agreement (SLA), which clearly and specifically describes the role and responsibilities of the cloud provider.

Apart from realizing the opportunities and challenges of cloud computing adoption, public administration authorities should proceed into a requirements analysis and a detailed mapping of current IT workload and their backup and recovery policy Wang & Feeney [30]. Moreover, they should decide about the appropriate model that they will apply (deployment and/or service) and consider issues about security and privacy of data and systems, according to existing regulations (e.g. General Data Protection Regulation - GDPR). Furthermore, they should prepare a detailed cost-benefit analysis and an action plan for the selection of services that will be migrated to the cloud and the alignment of cloud features and capabilities with the existing operations and culture of the organization Wang [31].

As far as the selection of the cloud model is concerned, Zwattendorfer & Tauber [32] suggest that the appropriate deployment models for the public sector are the private and community models, since they allow enhanced control and they have more powerful safety and security measures comparing to the other models. However, the authors argue that the solution of public cloud could also be considered, since it has low cost and high availability. Especially in small public administration authorities with limited budget and IT requirements, the economic advantage of public cloud is higher, compared to the private cloud Zwattendorfer & Tauber [32]. On the other hand, the adoption of public cloud has disadvantages, such as low level of control, lack of common standards among various cloud providers, cost

of cloud services customization (if needed), dependence on the cloud provider and cost of switching to another cloud provider Gongolidis [33]. Despite the disadvantages, public cloud can be an appropriate and economic solution for a public administration authority, especially in the case that the authority does not handle sensitive personal data and the applications are low cost and low risk Gongolidis [33]. The hybrid model (combination of private and public model) could also be considered, provided that sensitive data and critical systems are hosted in a private cloud and the rest in a public cloud. Finally, another model that is which is increasingly applied in recent years, is the governmental cloud (G-cloud). This model is a combination of private and community cloud and has a greater level of compliance with existing laws and regulations compared to the public cloud Zwattendorfer & Tauber [32].

Finally, as far as the adoption of a cloud service model by a public administration authority is concerned, Zwattendorfer & Tauber [32] suggest that all models (IaaS, PaaS, SaaS) are applicable. For example, the IaaS model can be applied for the storage and backup of data and systems of public administration authorities. The PaaS model can be applied for the development of customized applications in the cloud, while the SaaS model can be used for a variety of applications, such as workflow and document management, office automation etc. The aim of this paper is to explore cloud computing adoption in Greek municipalities and to analyze the cloud services and models applied, as well as the factors that influence the decision about proceeding or not to cloud computing adoption.

Materials and Methods

The research was conducted with the use of an online survey among local government authorities (municipalities) all over Greece. The total number of municipalities is 325 and their contact details were found at official resources, such as the Ministry of Interior and the Central Association of Greek Local Government Authorities (Municipalities). Every municipality was contacted firstly by phone, informing about the aim and scope of the research and then an email was sent, containing the link of the electronic questionnaire and instructions for the survey. A total number of 211 municipalities participated in the survey, thus forming the sample of our research. The responses came mainly from the managers of the IT departments. The demographic characteristics of our sample refer to the size of the local government authority (municipality), measured with the total number of employees and categorized into the following categories: i) very small (less than 40 employees), ii) small (41-90 employees), iii) medium-sized (91-200 employees), iv) large (201-600 employees) and v) very large (over 600 employees). The participation of municipalities in our research, according to their size, is presented at the following table. From the above table, it is evident that our sample is representative of the survey population (total number of municipalities), since the participation percentage of municipalities in each category was from 27,40% to

100%. Especially in the last category, all very large municipalities participated in our survey, while in the other categories (except from the first one), the majority of municipalities responded to our questionnaire. It should be noted that in the questions that will be analyzed below, respondents could select more than one answer.
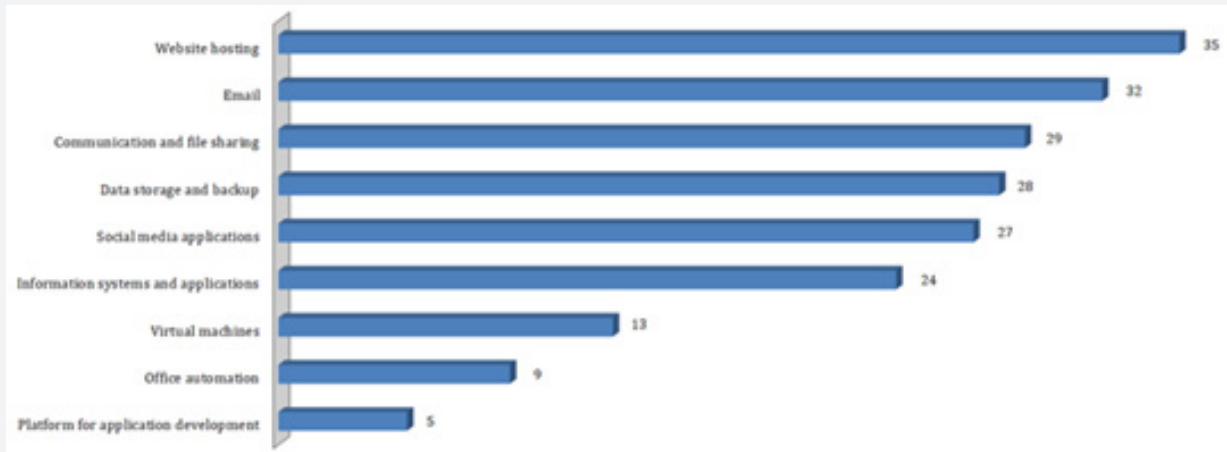

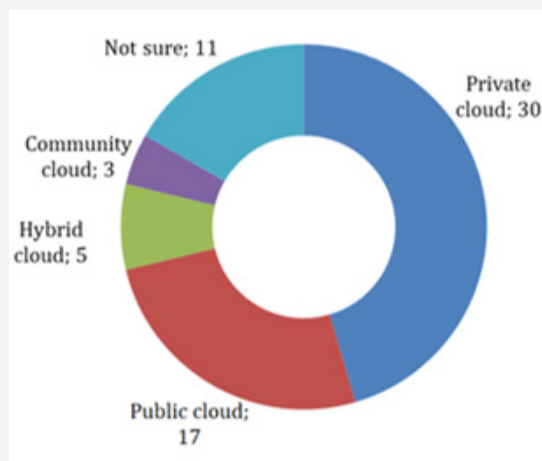**Figure 1:** Cloud services used.

Figure 2: Cloud deployment models used.

Results and Discussion

In the beginning of the survey, participants were asked if cloud computing is adopted and used in their municipality. From the 211 municipalities, the percentage that uses cloud computing in everyday operation is 26%, while in the remaining 74% cloud computing is still in an exploratory stage. As far as the cloud services used, the most common are website hosting and email, followed by communication and file sharing, data storage and backup, as well as social media applications. Half of the municipalities responded that they use cloud-based information systems and applications, such as document management and workflow systems, fleet management systems and financial management systems. The use of virtual machines is limited, mainly to large size municipalities. Finally, few municipalities use cloud-based office automation applications and cloud-based platforms for application development (Figure 1).

As far as the cloud models are concerned (Figure 2 & Figure 3), private cloud and software-as-a-service models are the most popular, although there is a quite large number of "not sure" responses, probably due to the fact that the respondents were not aware of the exact cloud models names and categorization. Proceeding to the reasons that led municipalities to cloud

computing adoption (Figure 4), the access from any place and with any device is the most important reason, followed by the need for better backup and recovery. Reasons such as the improvement of existing processes, the use of systems without the need of installing hardware and software and the cost reduction, follow. Other reasons, according to the respondents, are the need for providing more and better services to citizens, the flexibility and scalability of IT resources as needed, the outdated IT infrastructure of the municipality and the fact that the use of cloud computing was recommended by other authorities. Finally, reasons less popular among the responses were the need for more efficient allocation of human resources, the need for easier maintenance of IT infrastructure and the need for reduction of carbon footprint. We should highlight the limited answers for reasons related to more efficient allocation of human resources and to reduction of carbon footprint. This may be explained by the fact that cloud computing is not yet perceived as something that can lead to more efficient human resource management and to environmental sustainability.
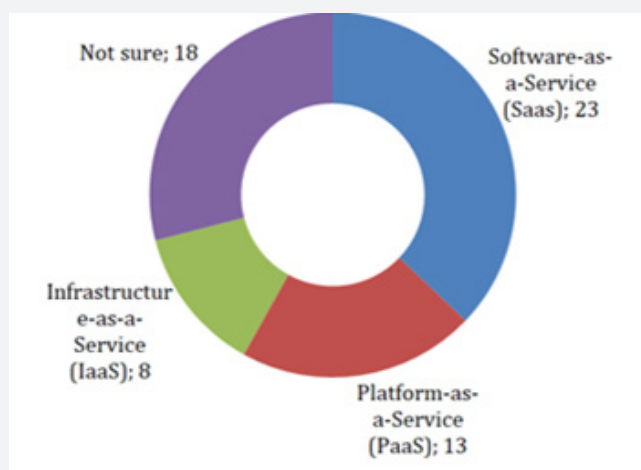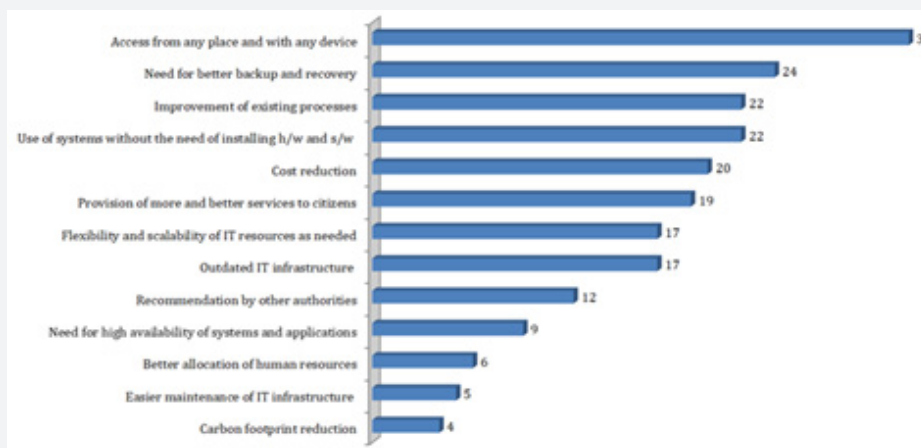

Figure 3: Cloud service models used.

Figure 4: Reasons for cloud computing adoption.

In the municipalities that our research showed that they have not adopted yet cloud computing, we attempted to explore the issues that hinder or delay this decision. According to the answers presented in Figure 5, the most important reasons are the lack of IT personnel and the lack of knowledge and relevant information. Reasons that follow are low internet speed and bandwidth, lack of best practices from other municipalities, concerns about data and systems privacy and security, possible problems in compatibility and interconnectivity with existing systems and applications and lack of funding. Other reasons mentioned are the risk of dependency on the cloud provider, the reluctance to adopt new technologies, the risk of adopting cloud computing, the unclear

charges of cloud computing services and the limited number of cloud service providers in the Greek market. Also, in several cases, it is argued that, at the moment, cloud computing adoption is not considered as a priority. Finally, some respondents stated that their municipality is waiting to enter the governmental cloud (G-cloud), while some others indicated operational problems, lack of time and resistance to change as prohibiting factors for cloud computing adoption. Finally, in the question "if your municipality proceeds to cloud computing adoption, which of the following services you would like to use", the preferences of the respondents refer to data storage and backup, website hosting, email, cloud-based information systems and applications, communication and file sharing, office automation applications, virtual machines, cloud-based platforms for application development and social media applications (Figure 6).
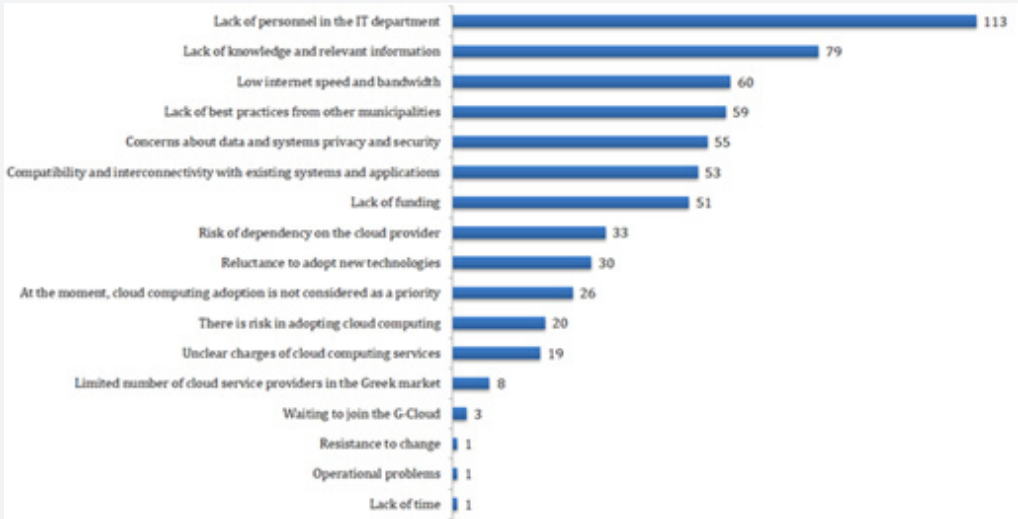

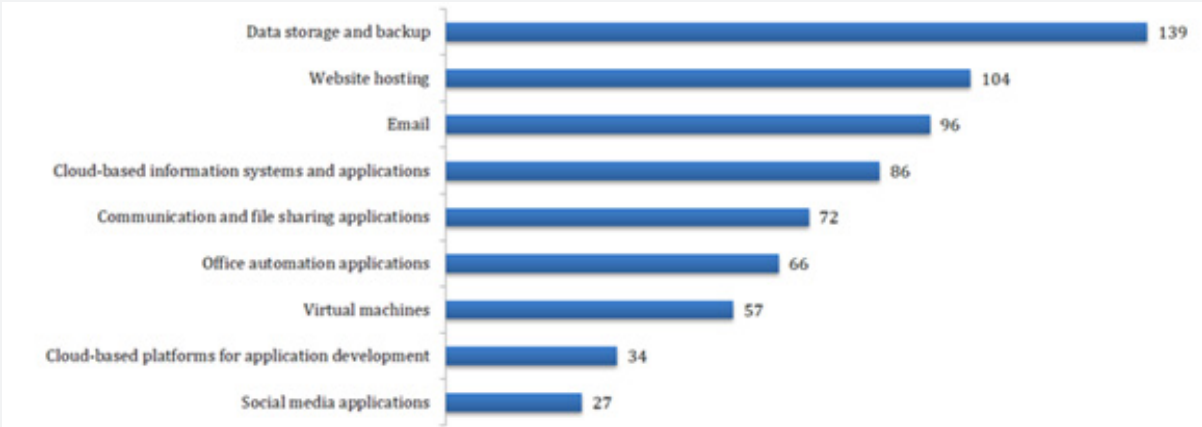**Figure 5:** Reasons for not adopting cloud computing.

Figure 6: Preferred services in the case of cloud computing adoption.

Conclusion

From the literature review it is evident that cloud computing adoption in public administration and more specifically in local government authorities (municipalities) has several anticipated benefits and challenges. The decision for proceeding in cloud computing adoption requires a detailed mapping of current ICT infrastructure and a requirements analysis, in order to identify the services that will be migrated (or not) to the cloud. A critical issue is the selection of the appropriate cloud deployment and/ or service model, since each of them has several advantages and disadvantages. More specifically, the most widely used

deployment models in public administration are the private cloud and the community cloud, as well as their combination in the form of governmental cloud. The choice of public cloud can also be considered, especially in cases of small-sized municipalities and for services that refer to citizens. Also, the solution of the hybrid cloud can be a choice, which, however, requires the separation of systems and data into those that will be hosted in the private cloud and those that will be hosted in the public cloud. As far as the service models are concerned, all models (IaaS, PaaS, SaaS) can be applied, according to the needs and requirements of each municipality. However, it should be mentioned that the IaaS and PaaS models require specialized knowledge from the municipality's personnel. The cloud services that can be applied by a public organization authority according to the selected cloud model(s), can cover a wide range of applications, from web hosting and data storage to virtual machines and to all information systems that can be used in a municipality.

Table 1: Participation of municipalities according to the number of employees.

Municipalities	Number of participating municipalities	Total number of Greek municipalities	Participation
Very small (<=40 employees)	20	73	27,40%
Small (41-90 employees)	38	74	51,35%
Medium-sized (91-200 employees)	62	79	78,48%
Large (201-600 employees)	78	86	90,70%
Very large (>600 employees)	13	13	100,00%
	211	325	

The empirical research conducted in the present study showed that cloud computing adoption in local government authorities (municipalities) is at a low level and in an exploratory stage. The most widely used services among municipalities that have adopted cloud computing, and the most preferred services among municipalities that have not yet adopted cloud computing, are web hosting, data storage and backup, email and file sharing. The cloud models that are mostly applied are the private deployment model and the software-as-a-service model. Finally, the factors that influence the decision about proceeding or not to cloud computing adoption were identified and analyzed, through the answers of the respondents. Our study can serve as a roadmap for local government authorities that consider cloud computing adoption as part of their digital transformation strategy. However, more empirical research is needed, in order to further analyze factors that influence cloud computing adoption, as well as the correlations between them and their impact on the final decision.

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