RESEARCH ARTICLE

Migration of applications to the Cloud: a user-driven approach

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Abstract: During the last decade, there has been an increased interest on cloud computing and especially on the adoption of public cloud services. The process of developing cloud-based public services or migrating existing ones to the Cloud is considered to be of particular interest—as it may require the selection of the most suitable applications as well as their transformation to fit in the new cloud environment. This paper aims at presenting the main findings of a migration process regarding smart city applications to a cloud infrastructure. First, it summarises the methodology along with the main steps followed by the cities of Agueda (Portugal), Thessaloniki (Greece) and Valladolid (Spain) in order to implement this migration process within the framework of the STORM CLOUDS project. Furthermore, it illustrates some crucial results regarding monitoring and validation aspects during the empirical application that was conducted via these pilots. These findings should be received as a helpful experience for future efforts designed by cities or other organisations that are willing to move their applications to the Cloud.

Keywords: cloud migration, STORM CLOUDS, user-driven open innovation process, smart cities

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1. Introduction

Cloud computing has emerged as a key enabling technology to support more efficient, cost effective and quick deployment of IT services. It allows optimising service provisioning, automatically and seamlessly adjusting resources (bandwidth, infrastructures, data, etc.) to real-time demands, resulting in the optimisation of IT related costs while at the same time constituting an easier and more flexible alternative for service provision to citizens[1,2].

The European Commission eGovernment Action plan, the Digital Agenda for Europe and the Cloud Computing Strategy have set the effective exploitation of the benefits of information and communication technologies (ICT) as one of their main goals. After having highlighted the innovative character of public services migrated to the Cloud, the use of cloud computing is being promoted for the creation of more agile, trusted and transparent administrative services.

Under this context, STORM CLOUDS project (www.stormclouds.eu) was born, partially funded by

the European Commission within the CIP-FP7 Program. The main objective of the project focuses on exploring the shift to a cloud-based paradigm for deploying services that public authorities currently provide, based on their internal ICT infrastructure. The project aims to define useful guidelines on how to implement the process of moving applications to the cloud and it is based on direct experimentation with pilot projects conducted in three cities participating in the consortium.

Following this short introduction, the rest of the paper is organised as follows: Section 2 provides a brief literature review concerning the cloudification and migration processes. For Section 3, we show how cloudification process starts with the selection of the applications that will be migrated to the cloud based on a user-driven open innovation methodology. Municipalities' personnel work along with the cities' stakeholders were included in order to accomplish this selection. Once suitable technical actions were taken, an effective deployment of the applications on the cloud infrastructure was carried out.

Moving on, experiences and findings regarding the empirical implementation of this process on three pilot projects are thoroughly described in Section 4. The main goal of this section is to evaluate the adequacy of implementing an open innovation methodology in a strongly technical process like this one. We firmly believe that this methodology is highly suitable, provided that technical issues are communicated in the best way, so that all involved stakeholders are able to understand the implications of the migration process. This means that although a final user may not be aware whether an application is hosted on the City Hall server or on a public cloud, he/she will be concerned about the application's implications on costs, flexibility or duration.

In general, information provided in this article is particularly valuable for municipalities and public administration bodies, aiming to implement a migration process of their applications to a cloud infrastructure. One of the main findings suggested that this action was received as a positive policy movement for most stakeholders. These findings, along with a small discussion on the process and overall conclusions, are presented in Section 5.

2. Public Services on the Cloud: Literature Review

During the last decade, a lot of efforts have been made in order to define and in some cases portray the art of cloud computing. Starting from characterisations such as "*phrase du jour*"[3], "*perfect market buzzword*"[4] and moving on to "*a buzzword almost designed to be vogue*"[5], it became clear that cloud computing could not be ignored as an innovative methodological approach. Back in 2009, *The Economist*[6] stated that "the rise of the Cloud is more than just another platform shift that gets geeks excited. It will undoubtedly transform the information technology (IT) industry, but it will also profoundly change the way people work and companies operate". Furthermore, the diversified nature of applications that are gradually shifting into the Cloud constituted a crucial parameter which acts as a catalyst regarding the constantly changing definition of cloud computing[7].

Throughout time, the advantages offered by this innovative approach to internet-based computing stated to seem quite appealing to government agencies which gradually began adopting it. In general, cloud infrastructure is able to provide public administrations with mechanisms for improving their capability to fulfil citizens' demands. More specifically, advantages such as high levels of communication and collaboration effectiveness[8] are considered to be particularly appealing characteristics, which act as an essential comparative advantage when it comes to public sector agencies. Meanwhile, initiatives aiming to promote aspects of "smart city" evolution are gradually starting to accelerate as their policy design tool character is strictly interconnected with broader concepts of development, sustainability and inclusion[9–11]. The design and development of applications targeting certain domains of smart city advancement, such as energy and transport, resulted in the production of a large number of services which in many cases need to be redefined in order for their effectiveness to be improved[12].

Alongside the existence of practical benefits of the adoption of cloud based services, the recent economic crisis played an important role to their rapid expansion. Condon[13], referring specifically to the case of the U.S., characterises the combinatorial interaction between economic recession and web-savvy policies obtained by the government as the "perfect storm" that cloud computing is riding through its attempt to penetrate the public sector. He also pointed out that if cloud computing can work well for businesses, it should also be appropriate for the public sector[14]. A similar point of view was also adopted by a large number of politicians and scholars during the same period. Schatz[15] quoted Aneesh Chopra, the first Chief

Technology Officer (CTO) for the US government, who tried to promote a more extensive adaptation of applications based on cloud computing techniques by the US government. Hoover[16] quoted another important US CTO, Vivek Kundra, who highlighted another very essential advantage of cloud-based applications. Specifically, he pointed out the extremely less expensive character of such kind of applications compared to the expensive investments in infrastructure that should have otherwise taken place.

Apart from the undoubtedly high interest expressed by the US government on the extended use of cloud-based services throughout its public sector, there seems to be a large number of other international examples following a similar policy. Starting from the UK, the Digital Britain Report announced in June 2009, promoted a wide-raging digital strategy for the country through the improvement and migration of more governmental applications on the cloud[17,18]. Japan also constituted another important case of a major cloud computing initiative through the development of the "Kasumigaseki Cloud"[19,20], an initiative which aims to create a private cloud environment that would eventually host all governmental applications. In this case, the environmentally friendly character of such an innovative IT policy was also highlighted[21]. Other international examples referring to cloud computing initiatives are Thailand, New Zealand, Vietnam, Singapore and China.

Regarding the EU policy towards the creation of a cloud of public services, there has been a lot of effort during the last few years. In September 2012, the European Commission adopted the European Cloud Computing Strategy [EC14]. The strategy was designed to speed up and increase the use of cloud computing across European economy, as the gain in jobs and overall economy indicators was clearly identified. In particular, public sector organisations have much to gain by taking a cloud computing approach for service delivery in their information and communications technology environments[22]. An important number of research projects (eEnviPer, InGeoCloudS, OASIS, OpenDAI and SEED) were funded during a first call by the EU in 2011 whose initial success triggered a second round of projects in 2013 (CLIPS, CloudOpting, ECIM, STORM CLOUDS, STRATEGIC and Virgo). All of them target on experimenting with the migration of public services to the cloud, demonstrating possible interoperability and validating common specifications of cloud-based services. This process resulted in specifying the anticipated impact with respect to the Cloud Computing Strategy implementation.

Given the complexity of the process and the rigidity of public organisations, governmental strategies targeting a more cloud-oriented public infrastructure should be accompanied with a plan regarding the selection and migration of the appropriate applications to the Cloud, in addition to the technical transformations needed to fit in the new environment. A number of studies have been conducted in order to determine strategies referring to the process of organising the cloudification procedure, each offering a new approach to the challenges entailed by this movement towards a 'cloud of public services'.

According to Wauters *et al.*[23], the migration process should be conceived as a segmented procedure focusing on different sub-domains, targeting on a simplified implementation of the cloudification process. They also highlighted the fact that already existing public services should be used as a base upon which new ones could be added during the migration process. In addition to that, Seo *et al.*[24] viewed the whole process as a combination of three main sub-procedures that include (a) the definition of standards for selecting the applications to be migrated, (b) technical guielines regarding the cloudification process and (c) a set of instructions concerning an economic feasibility analysis. Concerning the selection of applications to be migrated, Bonneau *et al.*[25] moved to the creation of three general categories of services encompassing procurement and marketplace apps, resource pooling and standalone applications, respectively. Moreover, pilot projects were conducted in 10 European countries covering these categories[26].

Finally, KPMG's technical report[27] on the cloudification of public services stated some key points aiming to offer a better understanding of how governmental agencies could optimise the costs and positive impacts by this migration process. These included issues such as addressing the Cloud as a potential "ecosystem" incorporating diversified participants, applying strong initiatives, managing potential risks and collaborating with providers and private sectors. In this paper, we focused on a user-driven approach for migrating public services to the Cloud, promoting broad participation of stakeholders during the whole migration process.

3. Migration Process Design

Cloud computing characteristics are particularly inter-

esting in supporting the provision of *Smart City* applications provided to citizens by governmental authorities but the migration process is not always a smooth procedure. Several issues may arise when public sector organisations consider transitioning to cloud computing. Some prominent concerns are related to assuring control of ICT systems by public managers and quality of service, ownership and liability issues, security and privacy, trust in reliability and resilience of infrastructures and services, interoperability and standards, potential dependencies with vendors, regulation, risk management, governance and culture.

In general, the migration process consists of four stages which are illustrated in Figure 1. These stages include actions regarding (i) the selection of applications/services to be migrated to the cloud, (ii) addressing technical or procedural challenges, (iii) migration to the pre-production cloud and (iv) moving applications to the production cloud.

During this procedure, the involvement of a number of stakeholders was essential not only as a methodological requirement but also due to the fact that stakeholders' involvement would produce helpful feedback for the overall process to be closer to citizens and public employees. Moreover, another reason why this mechanism was adopted by STORM CLOUDS as compared to a mere selection of applications by the authority's technical staff is the fact that this involvement would strengthen stakeholders' awareness regarding the efforts made by local authorities towards a modernisation of the public sector.

During the first stage, potential services to be cloudified or deployed were selected. In the second stage, problems regarding technical, procedural or financial issues arising during the migration of services to the cloud were specified and enumerated. Stage 3 constitutes a pre-production stage where pilot projects, demonstration and other activities take place under the scope of service validation whereas stage 4 refers to moving the selected applications to the production cloud. Alongside these four stages, active participation of the stakeholders was an integral part of this procedure, promoting the user-driven character of this methodology.

The process of application selection was based on three main criteria: political priorities, technical specifications/restrictions and user driven aspects. Regarding the stakeholders participating during the whole procedure, their profile was carefully selected in order to derive a high quality input for the process. Generally, it is essential to select adequate stakeholders and keep them engaged in the project, thus groups or individuals with any interest in having publicly available services operated from the cloud were mostly preferred. The initial list of stakeholders that was proposed included citizens, local SMEs, municipality personnel, technicians as well as financial, managerial and political representatives.

Although it was important to involve a satisfactory number of stakeholders, their motivation to participate and stay active throughout the whole procedure was even more essential. In order to cope with this challenge,

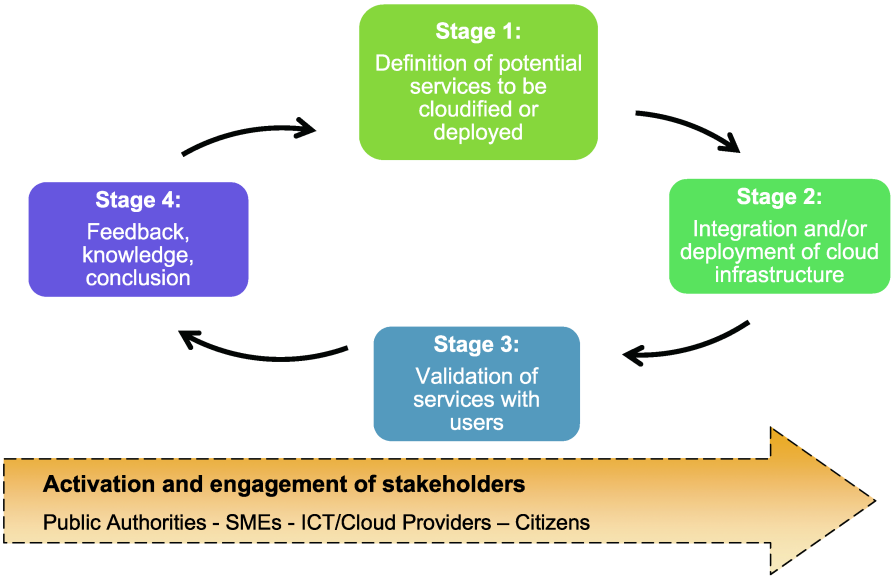

Figure 1. Four stages of a user-driven migration process.

some crucial elements were adopted while interacting with the stakeholders. These included first of all the selection of a meaningful number of people from each group and a detailed explanation of the project, as well as the proposed services. Furthermore, the use of non-technical language for a fluent communication to be achieved could give the end-users the opportunity to freely ask questions and be kept interested in the process. In addition, details such as providing enough time to fill in questionnaires and acknowledging the importance of end-users' opinion of the procedure's success played a crucial role for fulfilling this premise. Finally, in order to keep their engagement, it was important to provide stakeholders with short and mid-term rewards. In this sense, information about the progress of the whole process and the ways in which their involvement affected its formation were also given to them.

Another important methodological aspect of the project was the definition of a monitoring procedure in order to keep track of all activities related to user-driven open innovation methods. For this purpose, a mechanism consisting of three steps was endorsed. One of these steps included the identification of monitoring criteria and the definition of specific indicators, each depending on the task (stakeholder selection, application selection, etc.). Furthermore, the selection of information throughout the entire process of migration to the cloud, starting from the application selection until the adaptation of these applications to fit on the cloud, was an important part of the monitoring procedure for each one of the pilot cities. Additionally, an analysis concerning the extent of usage and acceptance of new applications and any possible variations on their usage patterns in the case of legacy applications was also considered to be essential for the monitoring process.

A summary of the process described above is given in Table 1. This table was completed by each one of the 3 pilot cities. In general, it constituted a practical roadmap for problem solving throughout the migration process of applications/services used in the public sector to a cloud infrastructure. These problems are usually recurring, thus the guide presented here might be perceived as an additional help to organisations facing future cloud migration processes in order to avoid loss of effectiveness through the deployment process. Nevertheless, the identification and suggestion of probable solutions referring to that kind of problems and situations were also the main objectives of the experiment.

4. Empirical Implementation

The above-described processes were followed in the cities of Agueda, Thessaloniki and Valladolid. Before examining each case separately, Table 2 provided a short description of the applications chosen to be migrated to the cloud during the STORM CLOUDS experiment.

4.1 Agueda

In the case of Agueda, the selection of services was guided initially by technical characteristics. These included criteria such as applications already owned by Agueda or open source applications for ensuring code availability. Moreover, the use of technologies known by existing Agueda technical staff was considered to be another crucial parameter for service selection.

The selected service for Agueda was *Eu Participo*. Several technical issues were identified including changes needed to be carried out in the application in order to reinforce its usability and change its logic to accommodate the requirements, preferences and expectations of a wider user reference group. Although

Table 1. Monitoring the migration process of public sector applications/services to cloud infrastructures

Stages	Details
STAGE 1: Application/ Service selection	How many different stakeholders participated in the service selection?
	How are stakeholders going to be activated and their participation maintained?
	How is the initial selection of services to be migrated to the cloud carried out?
STAGE 2: Technical adaptations	Problems found
STAGES 3 & 4: Cloud deployment	Analyse the technical experience and support provided by the cloud provider.
	Study how specific characteristics of the cloud could ease the process.
Feedback during the process	From stakeholders.
	From the Municipality's technical personnel.

Table 2. Applications chosen to be migrated to the cloud for each city

City	Name	Description
Agueda	Eu Participo	This WebGIS app allows citizens to express their opinion on a theme under discussion. Each topic is related to some geographic feature and users can upload photographs relevant to it. This application has an administrative interface to manage discussion topics. Privileged users (either from the local administration or community members) can add new themes for discussion.
Thessaloniki	Virtual City Mall (VCM)	Virtual City Marketplace enables the creation of a smart marketplace managed by the local shopping community. It empowers the city's local market by bringing together customers and merchants. Local shops are displayed over a city map, along with consumer reviews and promotional offers.
Valladolid	Urbanismo en Red (UeR)	Urbanismo en Red (UeR) was created with the purpose of publishing the municipal development plans across the Internet, enabling citizens to access them easily. It is designed to increase and enhance transparency in the public management of urban sectors. Moreover, it provides full interoperability between the various authorities and stakeholders.

the application was already available as an open source, its code files were transferred to Github and a new documentation was written in order to make it accessible to developers.

Regarding the selection of stakeholders, local authorities played an important role. The strong commitment shown by the City Mayor on technological progress in all aspects of the city was remarkable and extremely helpful during the whole process. This feature constituted a key parameter due to the fact that it facilitated the removal of a number of obstacles encountered, while at the same time it resulted in a diversified synthesis of municipality participants in the project.

Three main groups of stakeholders were defined—people working in the municipality, external stakeholders collaborating with the municipality and external users. These groups were defined using two main selection criteria; (a) the degree to which their decision affected the cloudification process (e.g., policy makers and politicians) and (b) the degree to which their everyday life was affected by this change (e.g., technical staff, accounting, procurement processes personnel). The widely diversified number of stakeholders selected for the city of Agueda resulted in the creation of a rich set of information that was used as input in the process of application/service selection. However, the difficulties on managing and consolidating the conclusions were received as a potential disadvantage of the wide range of stakeholders, whose activation and participation was stimulated by discussions, meetings and online questionnaires.

Most feedback received regarding *Eu Participo* was positive, despite the fact that citizens were not interested in knowing the technical details of the application. Generally, it was difficult to get feedback from users regarding the validation process as such technical issues were not clear to them. Regarding feedback coming from the municipality's technical personnel, these include the strong dependence on the municipality's internal IT units, arising from migrating public services to the cloud while a visible benefit was the possibility to deploy applications in a very fast and easy way.

It has not been possible to perform any technical or economic comparisons, as relevant comparable information was not available for the previously existing applications in Agueda. On the other hand, migration of an already existing application to the cloud was in practice a much faster and easier procedure than expected. Resources were ready to be used and all security threats were already handled by the cloud infrastructure. Besides that, there were no great benefits gained from this process since Agueda was using the cloud as an IaaS provider and the city already has an internal infrastructure of servers and virtual machines.

Two main indicators were defined for measuring the migration process: (1) users' acceptance degree which was measured by questionnaires filled in the meetings concerning the continuation of the user-driven open innovation process and (2) proportional change in the number of users. This latter aspect did not present any particular variation but the acceptance degree was particularly good as 89.23% of the stakeholders formed a positive/neutral view of the *Eu Participo* application (Table 3).

4.2 Thessaloniki

In the case of Thessaloniki, the whole migration process started with the user-driven dynamics for stakeholder/service selection. The municipality of Thessaloniki in the beginning organised general meetings with stakeholders and municipal services and later, training sessions and validation sessions with end users

Table 3. Monitoring results in Agueda – migration acceptance

Stakeholder group	Migration acceptance
Political representatives	Positive
External IT specialists related to the Municipality	Positive
Human resources staff	Positive
Administrative staff	Positive
Information Technology staff	Positive
Citizens	Neutral

as well as dissemination activities. During these meetings/events, the pilot partners distributed informative materials about the overall project and leaflets including the different candidates for migration. The municipality was particularly keen to select applications related to entrepreneurship and quality of life in the city. External stakeholders also selected applications for tourism promotion of the city.

During the second stage of the migration process, a number of problems were detected through feedback received and are explained in detail below. First, there were some organisational issues regarding the overall geographical coverage of the service, given that there was a strong interest from specific stakeholders to expand it to other areas of the wider metropolitan area of Thessaloniki and not only the city centre. These stakeholders were interested in sustaining the service after the end of the project. Another main issue referred to the entities that will be able to be present on the marketplace, the catalogue and the promotion pages. In general, it was decided that while professionals would be able to present themselves to the catalogue and be able to make offers, they could not be present on the marketplace which would be restricted only to shops and not service providers. Finally, a problem referring to the type of business model ensuring that the service would be sustainable after the end of the project also aroused. The most prevailing business model so far was one of multiple ownerships by different stakeholders managing different types of entities.

Regarding the monitoring process, a four dimensional group of indicators was established incorporating supply, demand, dissemination and level of validation (Table 4). Although four applications were selected to migrate to the cloud, only the Virtual City Mall was released early enough to complete the whole validation cycle, resulting in a complete dataset of monitoring indicator values.

Given that indicators were defined prior to the development of applications, no analytical record has been held beforehand which would give us a correct number of users providing feedback for the application (participants of the events and training sessions giving comments, individuals representing stakeholders and municipal employees proposing improvements, etc.). Furthermore, although a large number of stakeholders were involved in the whole process of services' selection, only a few of them were interested in providing feedback for this specific application—the Commercial Chamber of Thessaloniki, the Association of Professionals of Thessaloniki and the three departments of Thessaloniki Municipality, the Department of Entrepreneurship, the Department of Volunteerism and the Department of Tourism. Referring to the number of modifications based on the feedback received, these have been tracked after the first release of the application, when end users and professionals started using the application. In previous steps, feedback received and the respective modifications were somehow more informal and were not recorded in detail.

All applications that are either already or will be cloudified in the Thessaloniki pilot were new applications, thus any cost comparison would be inaccurate and could lead to erroneous conclusions. In general, a cost estimation task for an application's participation on the public cloud would require estimating separately the cost of buying hardware, software, operating systems and virtualisation software. In addition to that, the maintenance with personnel within the Municipality and with subcontractors, power consumption in case of hardware, telecom charges for Internet connection, system architecture and interoperability design should also be taken under consideration throughout the process. However, such a task would be infeasible and if tried it would provide very erroneous and questionable results.

4.3 Valladolid

In the case of Valladolid, four different applications were pre-selected by the internal staff involved in the project (Blue Parking, Ideal Innobarometer, LocalGIS, UeR) instead of presenting to stakeholders a wide range of candidate applications to be migrated to the cloud. In general, the field of applications/services was considered as a priority in the innovation strategy for the municipality. The criteria used to identify the list of applications included issues about citizens' demands and users' requests, as well as municipality strategic lines for developing both technical and public services.

Table 4. Indicators and monitoring results for Virtual City Mall, Thessaloniki

Supply	No. of shops participating in the app	62
	% of shops participating in the platform/shops in the area (total)	25.72
	No. of shops that have extended their online presence in the platform	27
	No. of shops making online transactions through the platform	0
	No. of offers per shop	0.24
	No. of synergies between two or more shops	0
Demand	No. of users – visitors (since 01.01.2015)	3893
	No. of registered users	41
	Sex	F: 45.85%
		M: 54.15%
	Total presence of the platform in third party websites (until 28.07.2015)	42
	No. of users providing feedback for the application	≈50
	No. of stakeholders providing feedback for the application	5
	No. of modifications based on the feedback received	3
Dissemination	Total presence of the platform in third party websites (until 28.07.15)	42
Validation	No. of users providing feedback for the application	≈50
	No. of stakeholders providing feedback for the application	5
	No. of modifications based on the feedback received	3

Project stakeholders were selected among two different groups, internal and external to the municipality. Also, the main criteria for the selection within each of these groups were diversified. In the first case, the main criterion was the extent to which migration of some applications to the cloud would affect their work. For instance, procedures followed by the procurement department were differentiated when contracting a cloud service, instead of buying hardware. Moreover, in the case of external stakeholders, the main goal was to achieve a diversified representation of groups of citizens living in the city—people from different age groups or professional skills, local SME, entrepreneurs, etc. This was complemented by choosing organisations that play a key role in the coordination of city actors.

After having defined the main selection criteria in each case, two groups were created. In the case of the internal group, municipal employees were mostly selected due to their good knowledge of each application and the fact that they could suggest improvements to be made, concerning the applications' functionality. The selected internal stakeholders were from the Department of Urban Planning, Traffic Management and Entrepreneurship. All staff working in some other key departments that usually provide support to the rest of the municipal units who thus have a comprehensive view of municipality needs and strengths was also selected. As a result, the additional internal stakeholders selected were from the Department of Information Technology, Accounting, Legal Services and Local Innovation Agency.

Regarding the external stakeholders' group, this was composed of citizens, small companies and associations clearly focusing on innovation. Using this criterion, members were selected from *Agile CyL*, a regional community of agile technologies developers; *ePunto*, a company devoted to fostering innovation in Castilla y León and linked to the local Chamber of Commerce; and *Geocyl*, a start-up in the field of geographic information systems consulting.

Stakeholders were contacted by email or phone, in order to get involved in the project while some regular short meetings were organised for applying the open innovation methodology. Additionally, as communication events were a strategic line, *Smart City* activities were presented in Valladolid and their participation to STORM CLOUDS project was evaluated as an important element.

During the service deployment, a number of problems have risen regarding the selected apps. Firstly, there were small delays in the planning of tasks and recruitment of external experts to cope with the cloud application installation. Another issue was ownership. The municipality was not the owner of the selected applications, as they were the property of the Spanish

Ministry of Industry and thus any implementation of additional features required a declaration of conformity from the Ministry. On a positive side, stakeholders were pleased by the current applications' functionality and modifications were not necessary.

A number of essential conclusions were recorded from the whole migration process. Initially, feedback coming from the final users of the cloudified version of *Urbanismo en Red* showed that the application's performance is similar to the existing one and the supplied information is exactly the same. Thus, it is absolutely transparent for users to use either the local or the cloudified version of the application. Moreover, there was no change in the number of users after the cloud-migration process. However, municipality technical staff mentioned that using a cloudified version of the application gave them more flexibility in the provision of services. Based on this approach, a temporal upgrade was feasible, cheap and easy to use during limited periods of time like urban plans submitted to public debate for a time. Furthermore, after the presentation and a testing period by specialised staff, positive reviews were received concerning the application.

Technical effort regarding system's maintenance has proven to be easier in the cloudified version, as most of the tasks being routine jobs, the staff can be devoted to more creative work. The relative ease of getting the service recovered from a crash by just restoring the instance in a short time and reducing downtime period is also remarkable for the technical staff. In addition, provision of telecommunications service is another major advantage, leading to a decreased number of new contracts with partners for using their services only for a few weeks.

At the political side, migration to the cloud was also perceived as a positive trend as it allows buying the application provision as a service which seems to be more feasible for the municipality than buying the required hardware and the service for its maintenance. Some feedback was also received by the municipality managers which showed that 80% of the interviewed managers characterised this application as very useful for the deployment of municipal policies and for enhancing transparency on urban projects. On the other hand, 20% of them expressed a sceptic attitude towards the impact of cloudification on citizens' lives. These conclusions are summarised in Table 5.

Table 5. Monitoring results for the city of Valladolid

Indicators	Before and after cloudification
Performance	No variations
Information supplied	No variations
Flexibility in service providing	Improvement
Improvement possibility	Improvement
Technical effort	Lower
Political management	Positive trend

5. Discussion and Conclusion

Table 6 summarises the main findings of *STORM CLOUDS* experiment regarding the four main steps of migration process followed here. In this integrated table, a systematic description of each city's results is attempted, corresponding to the categorisation proposed in Table 1. In all three cases, both similarities and disparities existed regarding the selection of stakeholders/applications, the encountered technical/procedural challenges and the monitoring indicators. Moreover, during the whole process a variety of methods were applied for activating and engaging stakeholders.

Starting from the selection of services/applications to be migrated to the cloud, a list of parameters affecting the final decision in each case was derived. As illustrated in Table 6, these components included various aspects such as technical considerations, political priorities and user-driven decisions. Although in the case of Agueda, technical restrictions were considered as the main driving forces for applications' selection; in the other two cases political priorities and user-driven criteria were used as the main selection incentives.

The selection of stakeholders is another crucial issue concerning the degree of effectiveness of this user-driven open innovation methodology. It was important to understand that the selection process should take into account not only the technical staff of the municipality but also a broader group of stakeholders whose everyday life might probably be affected by the migration process. A common pattern seemed to underpin all pilot projects, revealing the three main groups of stakeholders—an internal group of municipality departments, an external group of experts including academia, IT companies, commercial associations and a group of external users (citizens, local businesses, SMEs, etc.). In general, promoting the involvement of a wide range of end-users during the design process helps to better understand their needs. In this sense, involving external organisations and citizens was a wise decision leading to excellent results.

Table 6. Monitoring results for pilot projects

Monitoring Criteria			Agueda	Thessaloniki	Valladolid
STAGE 1 Stakeholder/ Service selection	*Selection of services*		Technical considerations: - Application owned by Agueda or open source applications - The code should be available - Use of a technology mastered by existing Agueda technical staff - Citizen personal data would not be managed	Political priorities: Thessaloniki Municipality decided to cloudify applications that are related to entrepreneurship and quality of life in Thessaloniki	Political & User-driven priorities: - Four different applications were selected by the internal staff of Valladolid municipality - City's most relevant problems were identified - Citizens' demands and users' request
	Selection of stakeholders	Internal members	Mayor and municipality dept.	Municipality and Dept. of Crowdfunding Volunteerism	Municipality departments
		External group	Academia, cities, IT companies	Commercial Association of Thessaloniki, Professional Chamber of Thessaloniki	Companies and associations with a clear focus on innovation: Agile CyL, ePunto, Geocyl
		External users	Citizens, professionals, SMEs	Local businesses	Citizens with different profiles
	Activation/ Participation		Direct contact	Meetings with stakeholders and municipal services	Direct contact (email or phone)
			Project brochure and STORM website	Training sessions	Regular short meetings
			Online questionnaires	Collection of comments and improvement suggestions	Small incentives to stakeholders (theatre tickets, invitations to cultural events)
			Discuss with stakeholders the name of the application		
STAGE 2 Technical adaptations	*Problems found* (Technical issues)		Change app logic to accommodate the requirements, preferences and expectations of a wider user community of international citizens from different municipalities Move code to Github and write new documentation	Thessaloniki Municipality servers are mostly running Windows instead of Linux Most are three- or more-tiered applications and are much heavier None of the existing applications is using Mysql In most cases, the applications don't use a web server	An unsuitable manual for the application installation procedure was only available The municipality wasn't the owner of the selected application
STAGES 3–4 Cloud deployment	*Study how specific characteristics of the cloud could ease the process*		Migration a much faster and easier procedure than expected All security threats were handled by the cloud infrastructure	A cost estimation task for the migration of an app to the public cloud would provide very erroneous and questionable results	Simple and routine jobs Easier to recover from crash Easier to telecommunications service providers relation
Feedback during the process	*From final users/ citizens*		Difficult to get feedback from final users about validating the services based on cloud computing as this issue was not clear in their minds	Expansion of the overall geographical coverage of the service, entities that will be able to be present to the marketplace, the catalogue and the promotions page	It is absolutely transparent using either the physical or cloudified version of the application
	From municipality technical personnel		Internal organisation made each unit highly dependent on the internal IT unit, regarding anything related with IT	The type of business model that will ensure that the service is sustainable after the end of the project	Using a cloudified version of the applications gave more flexibility in providing service
			The most visible benefit was the possibility to deploy an application in a very fast and easy way, independently of the municipality's internal IT department	The type of business model that will ensure that the service is sustainable after the end of the project	Technical effort for systems maintenance was lower with the cloudified version as most of the tasks that were routine jobs were eliminated and the staff can devote themselves to more creative work

Technical and procedural challenges addressed in this process also indicated an interesting variation throughout the pilot projects. It is particularly important to have a detailed technical plan in order to ensure that all required elements will be available prior to the migration process. This plan should incorporate aspects referring to (a) source code and documentation, (b) availability of technical support, either internal or external, (c) similarities/differences between the existing IT environment and the cloud environment and

ways to cope with any probable incompatibilities and (d) coordination of these activities with specific technical partners that could provide the necessary help and support to successfully complete the cloudification process.

Design and definition of monitoring indicators for assessing the output of the migration process constituted some additional key points of the proposed procedure. The choice of baseline indicators for evaluating public services that have been migrated to the cloud should cover multiple aspects, regarding the advantages of a cloud-based logic. These aspects include financial impacts, in addition to maintenance and security issues. Monitoring information targets a continuous improvement of cloudified services through feedback processes, as well as the detection of underlying multiplier effects, derived by a wide use of similar applications.

In terms of methodology, we firmly believed that the adoption of a user-driven open innovation approach under the framework of the STORM CLOUDS project was completely appropriate, providing satisfactory results. Stakeholders' involvement throughout the whole cloudification process was an essential characteristic of the proposed methodology. Nonetheless, their participation required an additional set of actions in order to maintain and reinforce their engagement during all stages of migration process.

Depending on the nature of the stakeholder's group, these actions should of course be diversified in terms of communication. For example, public servants ought to be informed about the ways in which cloudification of public services would benefit their group, in combination with appropriate training to adapt their competencies and abilities to withstand the new work conditions. On the other hand, a particularly effective tool for increasing citizens' involvement and encouraging them to stay engaged in the process is by including gifts and benefits related to the municipality. Mixing different types of stakeholders in common presentations and information sessions enriched the dynamic character of the process and increased the interest of stakeholders themselves.

These results should be received as a helpful experience for cities or other organisations that are willing to promote a strategy for migrating public services to the Cloud. In a user-driven approach, the selection of services/applications to be cloudified should take into account the opinion of a wide range of users. It is important to understand that when all users become an active part of the technological evolution of their city, they do realize that their city is essentially interested in covering their needs in the best possible way. This condition constitutes a particularly effective tool for increasing stakeholders' interest, by making them feel more deeply involved in the management of their city. After all, involving different types of users in the management process of a city creates positive interactions between them, resulting not only in higher quality public services but also in a more efficient way of management overall.

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