Cloud Computing Architecture for digital services into Smart Cities

J.F. Hernandez, V.M. Larios

Abstract— Population growth, the use and evolution of the Internet and ability of minimizing response times and maximize user activities have allowed to generate any ideas are to improve the quality of services of the users around the world. In this case, the smart cities as an estrategy propose relevant trends to incorporate information systems, sensors and analytical of data to support a sustainable environment. In this paper, we propose an architecture for cloud computing and HPC as a platform to implement the smart city digital services. Some of the first services are related to parking, data processing, security and sensing pollution. For this study, we focused on the city of Guadalajara as a urban renewal model for other cities. Hence, we listed the characterictics of some services to analyze their behaviour and propose an estrategy for services based in a cloud infraestructure. This contribution is based on the review of other smart cities expereinces as Seattle, Montreal, Singapur or Amsterdam. Finally, we will show the importance of updating educational programs at the universities and a create cloud computing laboratory for the city in order to promote innovation in services.

Index Terms— Distributed Systems, software engineering, security, smart city.

1 Introduction

Cloud computing has become a preferred option in information systems because it can optimize, organize and maintain software services and hardware across the Internet [2]. The use of this technology has allowed companies to reduce costs of maintenance and support. In addition, the companies reach an efficient and flexible use and of hardware and software resources on demand. To provide one solution each sector, the cloud is divided into 3 main areas:
1) Public: as a service offered for general users with the ability to store, use hardware resources and execute software applications with restrictions. The cloud could be free or with a fee. 2) Private: enterprises have the control of the hardware and software resources and they are able to enable them on demand. 3) Hybrid: a mix of the two precedent areas.

All areas of cloud offer a service representing the use of a product accessible by vendor/client purchases (temporarily or permanently) through an exchange. The service usually is paid with money. In addition to these 3 areas, the cloud has different levels of service [5], see Fig 1. The service levels are: 1) IaaS (Infrastructure as a Service) and it contains servers, connections and switches that create a logical infrastructure through virtualization for different working sessions, 2) PaaS (Platform as a Service), it can be used to develop applications without the complexity of managening the underlying hardware and software, 3) SaaS (Software as a Service), it is an application or system in which mounted over Internet (cloud) and it provides some service for a specific client and 4) MaaS (Metal as a Service) proposed by Ubuntu whose attitude is to help to the developers to create and automate systems requiring high performance computational resources as big data workloads [7].

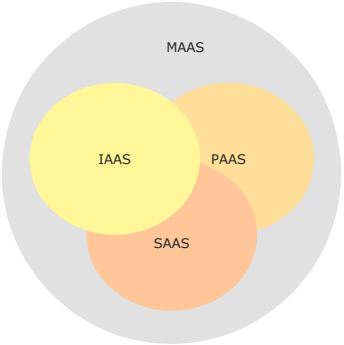

Fig. 1. Services of Cloud Computing.

These types of services in the cloud have allowed presenting different alternatives to improve the quality of computational systems and propose alternatives as portability, security, transparency and scalability that are basics by the users. We can find some examples of services in: Google Engine App [6], Windows Azure [4], OpenStack [8] and other tools with the same magnitude.

Hence, techonolgy is more accessible nowadays and it is possible to innovate optimizing resources in the cloud and improving them on demand. At this point, we intend to build an architecture using a cloud computing environment focused to support smart cities services to be responsive on time and events keeping a green sustainable compromise with the computing resources in the city computing facilities development.

A Smart city is an entity, which incorporates a techno-

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logical infrastructure to manage the everyday life inside of a real city [1]. In the next section we discuss about this topic.

2 SMART CITIES

Smart cities are a relatively new perception and as mentioned above, their basic goal is the efficient use of natural resources as water, electricity, air quality, waste management among many services to the citizens.

This type of environment has been adopted for several cities around the world as Seattle, Montreal or Singapur. Each one of them are creating new processes to increase the quality of life of the population to maximize resources and minimize the price. There is one property with major impact, cloud computing since it is a recently tecnhnology and it is a present trend to use resources located in different operating systems and architectures.

There is one smart city, Dublin, which was proposed as a smart city that supports cloud computing as a natural resource [17]. Pat Howlin [17] argues that cloud has led new employs, quickly adopt of this technology by the companies and the interest of the university of creating new curicula for planning courses about cloud computing.

The delay in completion of the issue requires knowledge to manage situations as: capture any physical variables present in the physical environment resulting in a flow of big data to analyze. Hence, in order to analyse and deliver results immediately to city digital services as for example, deal with traffic management; high computing is required on demand. It results in huge volumes of information analyze and characterize.

2.1 DIGITAL SERVICES

A digital service provides information related to a specific situation in the city interacting with their citizens [16]. For example, when a user access parking and need to find a slot, a digital service can manage to reduce pollution and time. Other digital services could be envisioned keeping a green engagement with the environment.

The goal of digital services is the mobility of them, ie you do not need a desktop computer to access these benefits, and it is only necessary to have some mobile device as a tablet, a smartphone or even from a car. Mobility is one of the factors to consider in digital services because they deliver real information of everything: traffic, government service, shortest path from origin to destination, bill payment and others.

Using a mobile technology, it is essential to create solutions to validate the authenticity of the user, such as iris recognition, voice or fingerprint. Another aspect is to preserve user confidentiality, services offered must not share personal information with the same, unless authorized by the aforementioned processes.

Each city has a specific logic to solve a problem or offer a public service. Then, we decided to incorporate a proposal of digital services for Guadalajara, México. This city has been recognized as model city to create smart cities [19].

TABLE 1
DIGITAL SERVICES FOR GDL

Type of Service
Cloud Data storage
Crowdsourcing traffic information
Cloud bases creative software for educational users
Intelligent urban security systems
Smart parking
Remote global education opportunities
Advanced consumer analytics

2.2 GUADALAJARA CITY DIGITAL SERVICES SUITABLE FOR CLOUD COMPUTING

During the process of understanding the concepts of smart cities, we chose to create a proposal for the city of Guadalajara (GDL) in Mexico. Since GDL will serve as a base model for other cities in the country looking to replicate the best practices applied for its smart city [9] [10].

Therefore, the digital services that will be implemented in GDL from its masterplan [10] are shown in Table 1.

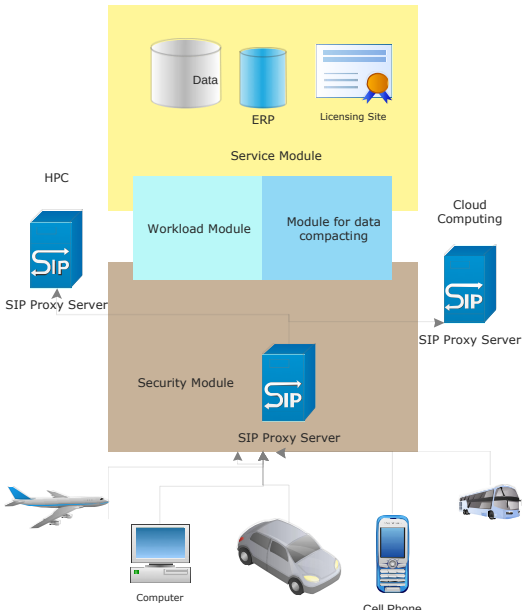

Fig. 2. Architecture proposal

These services, in general, need an elastic, flexible and economic infrastructure to support workflows that demand a high performance computing resources. We propose an intelligent model to classify the processes footprint (job) and schedule them to be processed in a local or remote cloud service. In the next section, we will explain how to add services and manage them using these technologies. We want to provide security and robustness properties to the city cloud infraestructure. An important aspect of this contribution is the incorporation of the

guidelines established by National Digital Strategy announced by the Mexican government to promote the adoption and development of Information Technology and Communication [18].

3 Cloud Architecture Proposal

In this proposal, we decided to separate by areas the solution as shown in Fig 2. Consequently, we can identify four modules as part of the architecture:

a) Security module, which will have proxies and allow access to services within and outside the city. It will determine intruder's pattern recognition, supported by an agent. The agent monitors the activities of each job in order to decide whether the service is linked to a valid user or process and can continue with his activity.
b) Services module, managing any process located in the city cloud with a specific processing demand.
c) Workload module, an agent C will be detected when a new job has arrived, the agent will check it and evaluate it for sending to cloud computing or HPC environment. This module has a great importance being the responsible of resources optimization as: energy consumption, memory, hard disk and software process.
d) Module for data compacting, when a job is submitted and finished, an agent D will take the data of him, to apply a new method of compression of data that will reduce the space disk and create new file whose data is identifical to the first one. The module will have the ability of processing data to get statistics for each service and restore one of them when presents an emergency situation as: hard disk or memory failure.

TABLE 2
Roadmap for Cloud Services over the GDL Smart City Development

	2014	2015	2016
Q1	Requeriments	Create resources to create a MOOC	Testing
		Interchange with universities to analyze data	
Q2	Conception and design	Install laboratories of testing	Define an use case
	Analysis metrics in education, government, health		
Q3	Define Architecture	Secure Cloud Tested	Proccess data and determine behaviour
	Collaborate with urban operating system	Define government policies	Publish a MOOC
	Determine roles (kind of users)		
Q4	Design a prototype	Update prototype	Conclusions
		Publish 2 MOOC	

The base idea is to generate any service regardless: programming language, operating system or hardware. This philosophy is applied to avoid in the future incompatibilities between operating systems or hardware.

4 Roadmap

Once generated architecture, , which is based on the concept proposed from CCD urban operating, which consists of a set of sensors, data collection mechanisms of classification and data analytics that allow to make decisions, for creating a smart city.

We have argued, the importance of creating a smart city that allows being a model for others to generate an expectation of success subsequently, it is necessary to modify the curricula of universities to train people and contribute with new ideas or innovations in an approach for the future.

The topics of big data, parallel processing, data analysis, Next Generation Networks, concurrency, etc. are relatively new to develop ina Latin Americas cities. Hence, It is strategic to prepare students and professionals dealing with the trends of smart cities. In addition, some laboratories to analyze results, test theories and generate metrics will be needed as the example of Dublin City [17]. Online courses (MOOC, Massive Open Online Course) are an ideal alternative to the academic worldwide to enhance the experience and promote innovation.

In Table 2, we propose a roadmap of activities to be completed in the next years.

A major focus to this paper, it is collaboratively works with the state government of Jalisco, to adapt this solution to their urban operating system, which was implemented to improve the quality of life of its citizens. Besides being pre-configured to support this feature, it is highly recommended to analyze the behavior of each architecture for each city in the world, to determine how to connect their services and propose a mechanism to be a reference model for other cities in need replicates these improvements. Therefore, the use of online courses could allow information sharing among all previous knowledge and enhance and build new concepts and ideas for a better use of one type of service.

5 Discussion and Perspectives

Cloud computing can be a mechanism to support an organization as important as a smart city with dynamic and flexible support of digital services. The architecture shown in this paper based in a scheduler to optimize the workload on the cloud could help to reduce energy consumption and increase the quality of the services.

Smart cities are analyzing new trends to optimize costs. Developing education and infrastructures, as laboratories are the best identified strategy to support innovation over the cloud services to develop and care. The support of cloud computing will do that the architecture shown in this paper is scalable, transparent and interop-

erable. As GDL will be a model city reference for others cities, organizations and educational institutions worldwide will provide of information and experiences to enhance the architecture.

Therefore, the collaborative work between different countries to establish metrics and standards for the interchange of data would encourage the cooperation between each of them.

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