Arquitectura de software basada en microservicios aplicados en un entorno Smart Campus

Software architecture based on microservices applied in a Smart Campus environment

Recibido: enero 18 de 2019 | Revisado: febrero 15 de 2019 | Aceptado: junio 17 de 2019

Eiriku Yamao[1,2]
Norma León Lescano[1,3]
José Luis Yapor Vallejos [1,4]

ABSTRACT

The present work is aimed to describe the microservice based architecture used in macetamascota, part of a smart campus project in Universidad de San Martin de Porres (Peru). A microservice architecture was successfully implemented in a smart campus environment to improve the self-sufficiency and sustainability of the flowers and ornamental plants inside campus. Results show the key components and interactions for a microservice architecture for smart campus, setting the groundwork for further studies and scaling into a larger city- wide implementation

Keywords: Microservice Architecture, Internet of things, smart campus.

RESUMEN

El presente trabajo tiene como objetivo describir la arquitectura orientada a servicios utilizada en el proyecto "macetamascota", como parte de las soluciones que integra el campus inteligente en la Universidad de San Martín de Porres (Perú). Se implementó con éxito una arquitectu- ra de microservicios en un entorno de campus inteligente para mejorar la autosuficiencia y la sostenibilidad de las flores y plantas ornamentales dentro del campus. Los resultados muestran los componentes e interacciones clave de la arquitectura para el campus inteligente, estableciendo las bases para futuros estudios y ampliando a una implementación más grande en toda la ciudad.

Palabras clave: Arquitectura de microservicios, Internet de las cosas, campus inteligente.

[1] Applied Research Laboratory, San Martin de Porres University Lima, Perú

[2] Eyamao@usmp.pe

[3] Nleonl@usmp.pe

[4] Jose_yapur@usmp.pe

DOI: http://dx.doi.org/10.24039/cv201971330

Introduction

Technological convergence demands universities to apply methods and technologies to transfer knowledge using practical examples. A popular solution of a learning platform for IoT and smart cities is the smart campus approach. Higher Education Institutions are effectively mini autonomous cities with their own governance, economy and socio-cultural system (Pavez & Agrawal, 2019). The smart campus is used to test and demonstrate the implementation of a smart city solution in a relatively smaller, more controlled environment to serve as a mode of transition for a city's journey to becoming a smart city (Zhuhadar, Thrasher, tMarklin, & Ordóñez, 2017), (Bruneo, y otros, 2019).

IOT solutions offer opportunities to create and capture value for a wide range of people, places and products, so they must have solid and agile architectures according to the business problems that are solved and the creation of real commercial value.

Microservices is a way of decomposing complex, monolithic applications into tasks running as independent processes, enabling updates and scaling of the services in isolation, even to be written in different coding languages (Banica, Stefan, & Hagiu, 2017). The microservices approach is considered to help in IoT to deal with multiple connected devices, handle demand peaks, allow remote and automated deployment, flexibility in the technological stack and programming languages (Banica, Stefan, & Hagiu, 2017) (Götza, y otros, 2018); are all considered as beneficial, especially in large scale implementations as in smart cities and smart campuses, where multiple solutions coexist.

In this paper we present the software architecture based on microservices for a smart campus solution in the form of a smart gardening system for the flowerpots in the Faculty of Engineering and Architecture Campus of the Universidad de San Martin de Porres.

Related Work

Multiple IoT and smart city projects has been implemented in a smart campus environment. Studies about smart grid and energy management (Seidita, Chella, & Carta, 2016), (Filimonova, Barbasova, & Shnayder, 2017) smart mobility (idell'Olio, Borda, & Barreda, 2014), (Lim, eKim, & Maglio, 2018), sustainability (Hashim, Haron, Mohamad, & Hassana, 2013), (Mehta, y otros, 2017), (Yasin, Rasul, & Khan, 2017) were presented.

A four-layer model is proposed as a case to demonstrate the viability and advantages of using a microservice architecture in IoT. The tasks executed by the "things" (authentication, data transmission/ reception, interaction with other devices) are handled with the microservices in a scalable, independent and collaborative manner (Banica, Stefan, & Hagiu, 2017).

Another microservice based framework is presented by (Kousiouris, y otros, 2019) for integration of IoT management, semantic and AI services for supply chain management. The framework enabled the integration between diverse and complex systems using a three-layer system architecture.

In 2019 StoRM, a social, distributed and hybrid reputation model bases on microservices for IoT is presented (Kravari & Bassiliades, 2019). The microservice architecture was used for the implementation of services and device handling. Each device microservice is related to an IoT device, where complex devices are represented with multiple microservices.

Another study is about a Cyber-Physical microservice and IoT-based framework for manufacturing assembly system, where a cyber-physical microservice layer is placed between the application layer and the IoT devices layer. Microservice architecture provides the framework with flexibility for the assembly workers and assembly process in an Industry 4.0 compliant manufacturing process (Thramboulidis, C.Vachtsevanou, & Kontou, 2019).

Smart campus FIA USMP

Smart Campus FIA USMP is a Project implemented in the Faculty of Engineering and Architecture campus of "Universidad de San Martin de Porres" in Lima, Peru. It's a multidisciplinary collaborative project between researchers, students and faculty members to improve campus life by developing multiple solutions to achieve some of the characteristics of a smart city, to carry out studies and proof of concepts.

MascoMaceta

MascoMaceta (pet flowerpot in Spanish) is one of the projects of the Smart Campus FIA USMP. It is aimed to make the flowers and ornamental plants inside the campus self-sufficient and sustainable. Each flowerpot is equipped with sensors to detect soil moisture and sunlight. A default parameter for the sensors is set depen- ding of the type of the plant. When the moisture level becomes lower than the threshold level, an automatic watering system is activated. A similar mechanism is in place for the sunlight sensor, where a daily required amount of time under sunlight is set and a motion mechanism for some of the pots are installed to move within a set perimeter to receive more sunlight if necessary.

Microservice based architecture

The three-layer, microservice based architecture is shown in Figure 1. The device layer is composed of sensors and actuators, controlled by a microcontroller or a Single board computer; The Application Layer is hosted in a cloud environment accessed by the devices via the campus Wi-Fi network; and the presentation layer consists of the interfaces the end user can use to interact with the system.

Device Layer

a) Sensor Module

Each flowerpot will be equipped with a YL-69+ YL-38 soil moisture sensor and a Light dependent resistor. The sensors measure real-time values for soil moisture and sunlight intensity and is converted by a 10-bit Analog Digital Converter to values ranging from 0 to 1023. A manual calibration of the sensors upon installation on the flowerpots is required to assure proper func- tioning. An error detection mechanism for the sensors is also programmed to detect unexpected values registered to send alerts to the user for possible sensor failure.

b) Motion and collision detection module

Some of the smaller flowerpots is placed on top of a moving platform with collision detection mechanism using HC-SR04 ultrasonic sensors. During daytime it will search for the best place to spend the established amount of time under sunlight and at late afternoon/ evening it will go back to an assigned space. In the initial versions of the project the movement are relatively simple (forward and backward for a limited distance) and is planned for a later instance a geo space localized platform using GPS to improve the control of the movement inside an established perimeter.

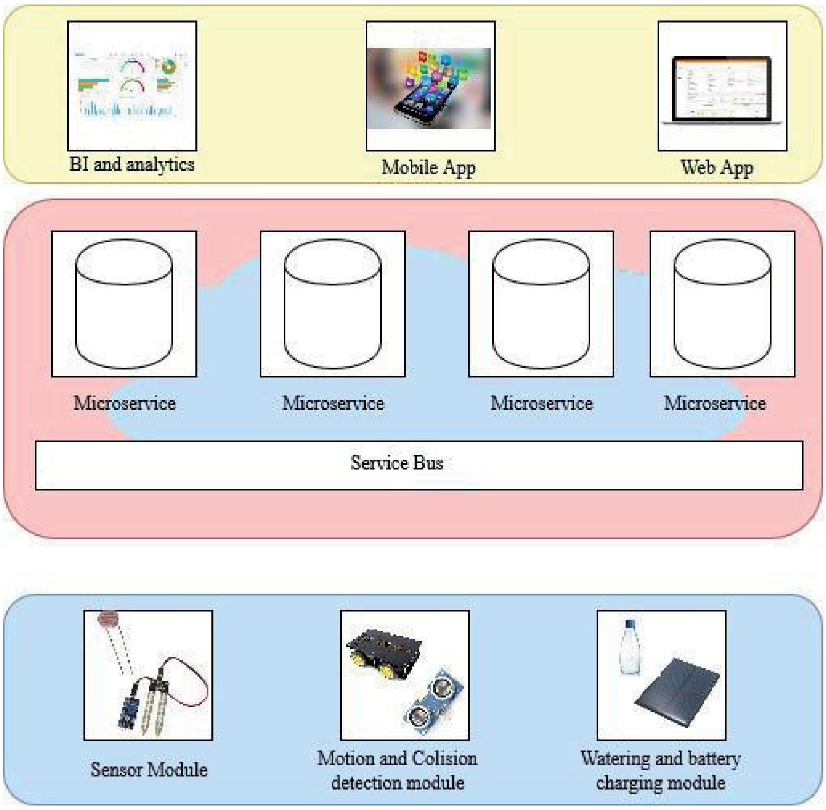

Figura. 1. The three layer microservice based architecture

c) Watering and battery charging module

To improve self-sufficiency and sustainability of each plant, an automated watering system is under development, activated when the soil moisture of the plant reaches a threshold value. The first version of the watering device is a small container of water activated by a solenoid valve equipped in each flowerpot.

Also, in the works is an automated battery charging system with two options being considered. First, a solar panel based recharging system, given that most of the plants are outdoors or in a place where sunlight is present, is the most obvious one; second, a wireless battery charging system, similar to what is found for mobile phones is being studied as an alternative for indoor plants with low sunlight requirement.

Application layer

The application layer is where the business logic and algorithms are executed inside the cloud. Given the continuous growth of IoT, from the number of devices to be connected and the different types of things that can be turned into an IoT application, a traditional, monolithic software architecture, where one of the main issues is the scalability is inadequate for these kinds of solutions.

A Microservice based architecture has been selected based on that many of the advantages of this architecture: easy to scale, easy to deploy, ability to use different technologies; are a great fit for IoT and smart campus projects. For mascomaceta, a service is implemented for each of the main entities of the system: plant, flowerpot, location and adopter. The microservices are deployed in the Microsoft azure cloud environment using a serverless deployment.

Presentation layer

There are three ways the end user can interact with mascomaceta. First, a mobile app is used for the registration of new plants by the adopters, where the plant type, flowerpot code, location and information of the adopting parent is registered. Upon registration the default parameter according to the plant type is set for the flowerpot and data collection begins. In case of any trouble happens to the flowerpot, the user is alerted via this app with the type of error.

Secondly, there is a web app for the system administrators where they can perform data management operations for plant, flowerpot, location and adopter.

The default parameter of sensor values is also configured via this app which can also be set to have specific values for each flowerpot if necessary. A simple alert tracing option is also included where the administrator can see the current state of the flowerpot present inside the campus and handle error alerts, which can be fixed remotely via this app or might require sending someone to physically check on the sensors.

Finally, a business intelligence and analytics option give each person access to the current state of their plant and its location in campus. Historic data of sensor values is also accessible if the user requires some deeper analysis, with a detailed view of any active or past alerts. The business intelligence app is developed with Microsoft Power BI, accessible through the university office 365 account, as shown in Figure 2.

Conclusions

This paper presented a microservice based architecture for IoT applied in a smart campus context. A microservice approach was successfully implemented for the mascomaceta, a project aimed to automate the flowers and ornamental plants maintenance process. The main functionalities of the three-layer architecture used is presented, with the elements of each of the layers: device application and presentation layers are described.

The microservice implementation lays the groundwork for future works inside the smart campus, where projects for access control with facial recognition, library administration with RFID, Virtual reality and augmented reality powered campus touring system, and others are in the works.

Finally, it is planned to apply machine learning and artificial intelligence algorithms to all the generated data inside the smart campus to improve the campus life experience for students, teachers and faculty staff. Also, a cooperation agreement with a local municipality is being explored.

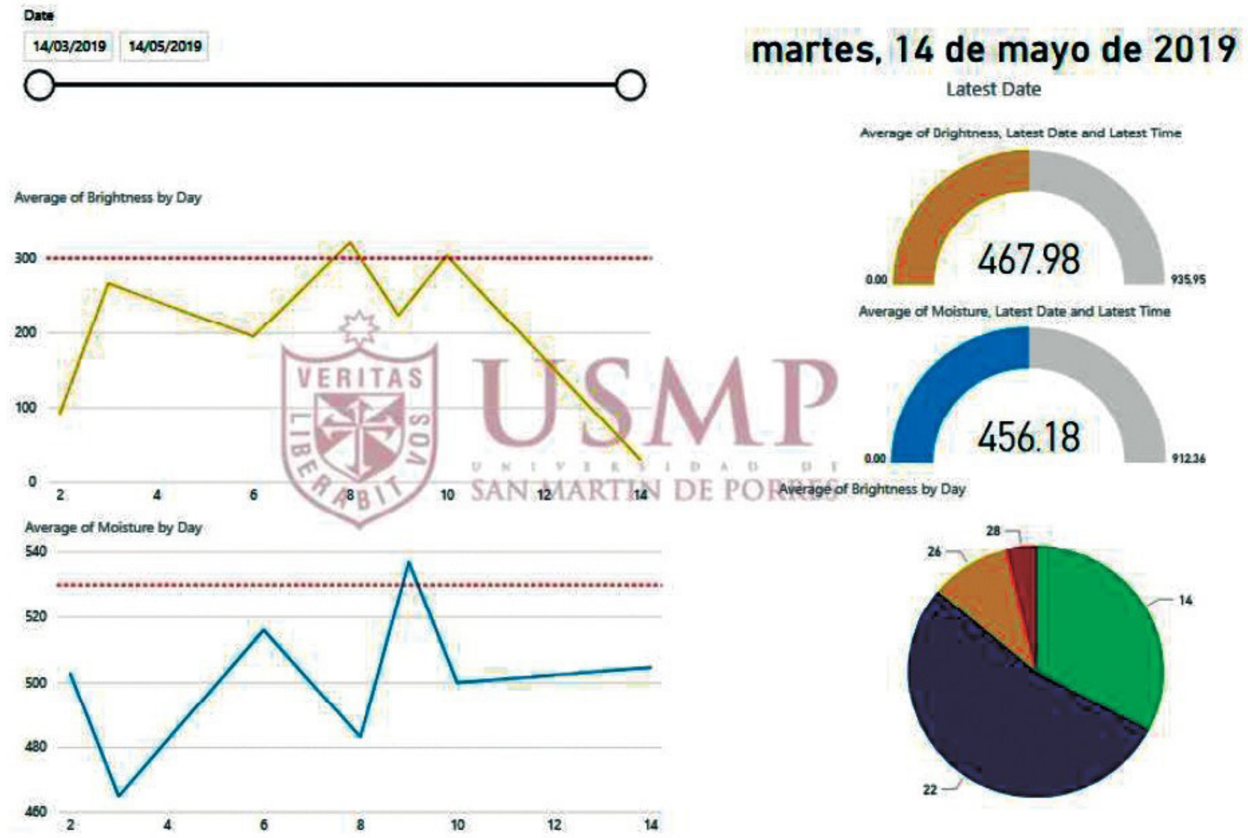

Figura 2. Sample of BI report in macetamascota

References

Banica, L., Stefan, C., & Hagiu, A. (2017). leveraging the microservice architecture for next-generation iot applications. Scientific Bulletin: *Economic Sciences*,, 26-32.

Bruneo, D., Distefano, S., Giacobbe, M. L., Longo, F., Merlino, G., Mulfari, D., ... Tapasa, N. (2019). An IoT service ecosystem for Smart Cities: The #SmartME project. *Internet of Things*, 12-33.

Filimonova, A., Barbasova, T., & Shnayder, D. (2017). Outdoor Lighting System Upgrading Based on Smart Grid Concept. *Energy Procedia*, 678-688.

Götza, B., Schela, D., Bauera, D., Henkela, C., Einbergera, P., & Bauernhans, T. (2018). Challenges of Production Microservices. *Procedia CIRP*, 167-172.

Hashim, R., Haron, S., Mohamad, S., & Hassa- na, F. (2013). Assessment of Campus Bus Service Efficacy: An Application towards Green Environment. *Procedia - Social and Behavioral Sciences*, 294-303.

idell'Olio, L., Borda, M., & Barreda, R. (2014). A Methodology to Promote Sustainable Mobility in College Campuses. *Transportation Research Procedia*, 838-847.

Kousiouris, G., Tsarsitalidis, S., Psomakelis, E., Koloniaris, S., Bardaki, C., Tserpes, K., ... Anagnostopoulos, D. (2019). A microservice-based framework for integrating IoT management platforms, semantic and AI services for supply chain management. *ICT Express*, 141-145.

Lim, C., eKim, K.-J., & Maglio, P. (2018). Smart cities with big data: Reference models, challenges, and considerations». *Cities*, 89-99.

Mehta, P., Zhang, D. X., Thomas, R., hJadhav, N., Lee, J., Conaghan, C., & Rawte, R. (2017). Harvesting 3D Multiphysics Modeling Techniques for Smart and Sustainable University Campus. *Energy Procedia*, 851-858.

Parvez, N., & Agrawal, A. (2019). Assessment of sustainable development in technical higher education institutes of India. *Journal of Cleaner Production*, 975-994.

Seidita, V., Chella, A., & Carta, M. (2016). A Biologically Inspired Representation of the Intelligence of a University Campus. *Procedia Computer Science*, 185-190.

Yasin, G., Rasul, M., & Khan, M. (2017). The Integration of Day Light with Advance Fuzzy Based Controllers for Institutional Buildings in the Region of Central Queensland, Australia. *Energy Procedia*, 2429-2437.

Zhuhadar, L., Thrasher, E., tMarklin, S., & Ordóñez, P. (2017). Leyla Zhuhadara Evelyn Thrasher a, Scarlett Marklin b, Patricia Ordóñez de Pablos c. *Computers in Human Behavior,* 273-281.