WiP: Smart Services for an Augmented Campus

Work in Progress

Accepted version

Vincenzo Agate, Federico Concone, Pierluca Ferraro

4th IEEE International Conference on Smart Computing, Taormina, Sicily, Italy, June 18 2018

WiP: Smart Services for an Augmented Campus

Vincenzo Agate, Federico Concone, Pierluca Ferraro
{firstname.lastname}@unipa.it
Networking and Distributed Systems Laboratory
Università degli Studi di Palermo
Viale delle Scienze, ed.6, 90128, Palermo, Italy

***Abstract*—Technological progress in recent years has allowed the design of new intelligent learning systems in smart environments aiming to facilitate users' lives. As a consequence, besides making use of traditional sensors for monitoring the quantities of interest, such systems can also benefit from information obtained from the users' smart devices, which can now be considered as additional sensing tools. In this article, we present the design of a novel system based on the fog computing paradigm that can improve the services offered to users on a smart campus by using different smart devices, i.e., smartphones, smartwatches, tablets, smartcameras and so on. In particular, we will describe a system in which several smart devices will collect sensory and context information, whilst the cloud will aggregate and analyze this data to extract information of particular interest. The main challenge of this project is to create an intelligent platform that allows new software modules to be added without having to re-design the entire architecture, and that can provide new services to campus users or improve existing ones.**

***Index Terms*—Smart campus, smart devices, fog computing**

I. Introduction

In recent years, the huge diffusion of smart devices has had a dramatic impact on people's lives. Users are now accustomed to exploit these devices as a tool for web search and fruition of information, communication, collaboration, both for work and entertainment purposes. Moreover, smart devices are typically equipped with a wide range of heterogeneous sensors (e.g. GPS, accelerometer, microphone, camera etc.) that, by exploiting the existing network infrastructures, allow to collect and share a large amount of information about user's surroundings, thus providing context without requiring the deployment of expensive systems. All these features play a key role in a smart environment scenario, where data collected by embedded sensors of smart devices can be used to improve the quality of life of users. In particular, smart environmental systems apply data fusion techniques to combine information from different sensors, paving the way to new applications that would not otherwise be possible [1].

A university campus is a particularly suitable scenario for this type of analysis because it represents, on a small scale, a cross-section of the urban fabric of the city. In particular, thanks to the information collected and shared by heterogeneous sensors, it is possible to improve the services provided to students, teaching and administrative staff, while also making them more efficient. Moreover, a campus can be regarded as a social ecosystem in which different entities coexist and interact with each other, thanks to social tools allowing users to share information [2]. Different types of users normally inhabit a typical campus, and each of them has specific needs depending on the type of role played. In particular, it is convenient to separately consider the different roles of students, administrative technicians, teaching staff and external users (e.g. occasional visitors). Therefore, the main challenge is to provide services that are tailored to each type of users, and that allow the experience of people within the university campus to be improved. The University of Palermo fits within this scenario, having recently started a process of innovation that aims to overcome the limits of teaching, the divulgation of scientific knowledge, and the creation of new science and culture, in order to create a smart campus ready to accommodate students.

In this article, we propose an innovative system based on fog computing paradigm aiming to improve the services provided to users on the campus of the University of Palermo. In particular, our system leverages context information (e.g. location) and sensory data, and aims to provide a mechanism to improve access to university services, such as libraries, university cafeterias, museum collections etc, so as to manage university resources more efficiently. In fact, our smart campus does not just focus on the user experience, but aims to address such issues as the measurement and management of energy consumption within the university premises.

By means of innovative intelligent data analysis algorithms, the intelligent system will be able to elaborate an action plan by enabling specific actuators to set the environment to the desired state, satisfying both global constraints as well as any preferences expressed by the user [3]. Following this approach, energy consumption issue can be addressed using a set of sensors and actuators allowing to monitor and change the state of the environment, for example, by switching off the lights of a particular campus area when no students or technical staff are detected at some time.

The remainder of the paper is organized as follows. Related work is reported in Section II. Section III presents the architecture of the proposed system, whilst several application scenarios on smart campus are described in Section IV.

II. Related work

In recent years, several works in the literature have focused on the development of intelligent systems within a campus.

Clearly, teaching is one of the most important activities on a university campus, so early research has focused on developing systems that would aim to make classrooms smart.

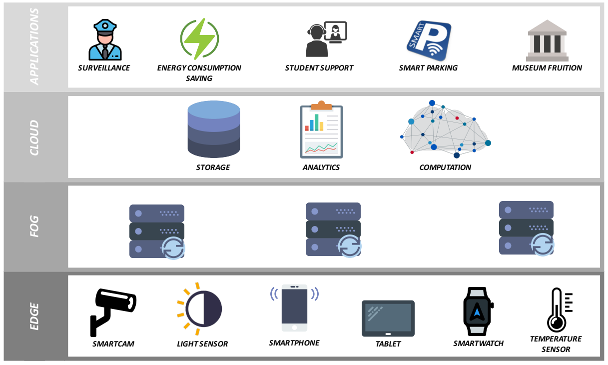

Fig. 1. Conceptual architecture of platform in the smart campus scenario.

In [4], the authors describe an application, useful both for teachers and students during the learning process, called Open Smart Classroom aiming to connect classrooms of different cultural background and languages with each other. This system inherits a multi-agent architecture and, consequently, is composed by a central server and several agents running on each of the host.

As already mentioned, the technological evolution has allowed the development of prototypes of smart campuses aiming at providing new services and improving existing ones. For example in [5], authors propose a system based on client-server architecture aiming to support social interactions between students in a smart campus scenario. On the client side, an application runs on user mobile devices and is used to collect and share with the server context information such as location, communication history, and so on. On the server side, such local data are merged in order to provide social services to facilitate social interactions among students. Another work is presented in [6]. Here, authors describe a framework based on the XMPP protocol exploiting the participatory sensing paradigm to provide a variety of services to the end customer. In a smart campus scenario, such framework is used to collect data from students' smart devices and exploit them in order to improve the services offered by the campus, for instance by suggesting activities to be carried out.

Unlike most works in literature, the platform we describe here will not focus on a single aspect of the smart campus but will instead attempt to provide a service as exhaustive as possible by addressing different aspects. To achieve such a goal, the proposed architecture will be highly scalable so that new modules can be easily added and will be based on a context-aware, multi-sensor data fusion paradigm in order to infer users activities, describe the environment through high level concepts and, consequently, plan the best set of actions to provide to people better services inside the campus.

III. System architecture

The main goal of the system we propose consists of collecting information from different parts of the campus, aggregating data, and offering a better service for improving the user experience within the campus. Since data are produced by a multitude of various devices located on different areas on campus, the system needs to support multiple network protocols to provide reliable and scalable communication across heterogeneous networks. In order to implement all these high-level features, it is possible to use different sensors and actuators that can be pervasively distributed on the smart campus with the aim of changing the environmental properties and/or providing a specific service to students or university staff. Because of all these factors, the system we propose adopts a fog computing paradigm as shown in Fig. 1. In particular, this paradigm was introduced to move data processing close to the sensors which collect the raw data, allowing resource expensive computing in lightweight servers placed at the fog level of the network.

At the lowest layer of architecture we propose, several heterogeneous sensors, i.e. smart devices, support analysis as they are responsible for collecting and sharing raw data with higher layer entities. In particular, our system makes use of two classes of sensors: wearable and deployed in the smart environment. The former refers to devices with embedded sensors that users use during their everyday lives, such as smartphones or smartwatches; whilst the latter are located within the various areas of the university campus in fixed-point to collect environmental information, such as temperature and light conditions.

At the next layer, there are several fog entities aiming to aggregate and analyze data received from the edge layer devices. Here, data transmission is carried out using existing communication infrastructures, i.e., 3G/4G/5G or WiFi, and is protected by encryption and authentication techniques, ensuring both data integrity and user privacy.

Finally, all the information obtained in the fog level is shared with the cloud that will perform expensive analysis in terms of computation and resource consumption. In particular, basing on the data received, the cloud will elaborate an action plan that will be transmitted to actuators, located within smart campus, to satisfy both global constraints as well as any preferences expressed by users providing a better service. Additionally, the cloud will be responsible for storing all relevant information in order to show the results and data collected later.

The main challenge of the system we propose will be not only to design and realize an intelligent system that allows to improve the user experience inside the campus, but also to modify the modules that compose it and add dynamically new ones without having to redesign the entire architecture. To address this requirement, the system, exploiting the technologies and access to the network provided by the University of Palermo, aims to be as general and scalable as possible for improving and modernizing the services offered to end users.

IV. Application scenarios

Nowadays, university campuses can take advantage of state-of-the-art technologies that, if used appropriately, can support and improve any type of service, such as the efficient management of energy resources or shared spaces inside the campus, i.e., parking areas, classrooms, school cafeterias and so on.

The University of Palermo is part of this evolution process, having recently embarked on a path of innovation for providing new services to students and staff. As an example, RFId Smart Cards have been introduced to provide a unique tool for accessing both cloud services to manage your files and campus resources, such as libraries, cafeterias, study rooms, print centers. Moreover, a further service provided to students and administrative staff was to simplify the secretarial tasks, such as enrolment procedures or the verbalisation of exams, by reducing to a minimum the interaction between students and administration.

A. Energy consumption saving

Much of the energy consumption measured on campus is due to poor energy management in lecture halls, laboratories and offices. It if often difficult to ensure that lighting system or unused electronic equipment are switched off correctly in the common areas frequented by different typer of users (e.g. students and University staff). Moreover, due to the high number of users present (passing or staying) in the Smart Campus, it is crucial to protect the infrastructure from malicious behaviours arising from insecure pervasive devices potentially attacked by malicious users. In order to achieve a significant reduction in energy consumption on campus, an ambient intelligence system estimates the occupancy levels of the different areas to optimize energy management both on individual buildings and on building complexes with similar characteristic.

For instance, low power-consumption motion sensors could be used to detect the presence of the users in some areas of the campus and the activation of advanced video-sensors is autonomously triggered by the framework to track specific users whose behavior is considered anomalous. In addition, by exploiting a set of ad-hoc sensors, the system would monitor the energy consumption of all the electrical appliances installed in the monitored environment and send an alert to security staff if consumption exceeds a certain threshold.

B. Virtual support to students

By embarking in the process of embracing the digital age, universities are investing in initiatives that bring them closer to the generation of so-called digital natives by using new technologies and media. In this direction, the creation of a virtual and interactive assistant would improve the user experience by supporting the students inside and outside the university campus. We plan to design a multi-platform IT module that can provide personalized information on each student's specific educational path, motivating and keeping them updated on the lesson calendar, indicating the route to the classrooms, allowing students to book their study stations at university libraries, providing access to digital teaching material stored in the cloud, notifying alerts and reporting news of interest. Moreover, the application also could allow students to share information through social tools [7].

As an example, consider a student who needs to run to her next class from her location in the city. The platform may infer how the user is going to travel to the campus by using sensory data collected from her smartphone [8] and suggest the best solution according to several parameters (e.g. traffic, chosen transportation, time constraints, and so on).

C. Augmented reality fruition of museum collections

Thanks to the the latest technologies in the field of augmented reality and the network, a new approach to sharing culture within museums is being introduced, aiming to transform a static cultural space into an intelligent one by defining innovative models of sensors and services.

According such a trend, the system aims to promote activities of this type through the numerous museum collections located within the campus. The idea is to design a multimedia totem for the augmented reality fruition of the assets of the *Collection of Historical Devices of Informatics*.

Such a platform will be allowed to access the university network, and will be equipped with appropriate sensors (such as a depth camera) and a graphical interface, in order to allow users to navigate through a multimedia catalogue containing the museum collections' assets. Moreover, in order to provide a high level of interaction with the visitor, the recognition device may detect specific gestures, interpreting them as commands enabling the exploration of the contents of the virtual portal [9]. Such systems could be introduced in specific places of the university to allow virtual visits to one or more collections, helping to improve sensory perception through information enhancement.

References

[1] A. De Paola, S. Gaglio, G. Lo Re, and M. Ortolani, "An ambient intelligence architecture for extracting knowledge from distributed sensors," in *Proceedings of the 2nd Int. Conf. on Interaction Sciences: Information Technology, Culture and Human*. ACM, 2009, pp. 104–109.

[2] S. Gaglio, G. Lo Re, and M. Morana, "Real-time detection of twitter social events from the user's perspective," in *IEEE Int. Conf. on Communications (ICC2015), 2015*, 2015, pp. 2810–2815.

[3] A. De Paola, S. Gaglio, G. Lo Re, and M. Ortolani, "Multi-sensor fusion through adaptive bayesian networks," in *AI*IA 2011: Artificial Intelligence Around Man and Beyond*, ser. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2011, vol. 6934, pp. 360–371.

[4] Y. Suo, N. Miyata, H. Morikawa, T. Ishida, and Y. Shi, "Open smart classroom: Extensible and scalable learning system in smart space using web service technology," *IEEE Trans. on knowledge and data engineering*, vol. 21, no. 6, pp. 814–828, 2009.

[5] Z. Yu, Y. Liang, B. Xu, Y. Yang, and B. Guo, "Towards a smart campus with mobile social networking," in *Int. Conf. on Internet of Things and 4th Int. Conf. on Cyber, Physical and Social Computing*, pp. 162–169.

[6] R. Szabó, K. Farkas, M. Ispány *et al.*, "Framework for smart city applications based on participatory sensing," in *Cognitive Infocommunications (CogInfoCom), 2013 IEEE 4th Int. Conf. on*. IEEE, 2013, pp. 295–300.

[7] S. Gaglio, G. Lo Re, and M. Morana, "A framework for real-time twitter data analysis," *Computer Communications*, vol. 73, pp. 236–242, 2016.

[8] F. Concone, S. Gaglio, G. Lo Re, and M. Morana, "Smartphone data analysis for human activity recognition," in *AI*IA 2017 Advances in Artificial Intelligence*, F. Esposito, R. Basili, S. Ferilli, and F. A. Lisi, Eds. Cham: Springer, 2017, pp. 58–71.

[9] G. Lo Re, M. Morana, and M. Ortolani, "Improving user experience via motion sensors in an ambient intelligence scenario." in *Pervasive and Embedded Computing and Communication Systems (PECCS), 2013*, 2013, pp. 29–34.