A middleware for creating physical mashups of things

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Abstract

Nowadays, "things" deployed in cities are crucial to gather data to support decision making systems. Unfortunately, there is a low level of reuse of "things" between smart city applications of different organizations because "things" were unknown to developers or because it was harder to reuse them than use new ones due to technical details. In this ongoing work, we propose to convert "things" into active entities capable of discovering and organizing themselves driven by the applications goals' satisfaction. Moreover, "things" are capable of collaborating between them in order to satisfy or maintain satisfied the published goals of applications. To validate the feasibility of our proposal, we are building *mashThings*, an Internet of Things (IoT) platform to build smart city applications as physical mashups, where the middleware layer is augmented by a multiagent layer of broker agents representing the available "things" in the city.

1 Motivation

The Smart City vision is to make a better use of the public resources, increasing the quality of the services offered to the citizens while reducing the operational costs of the public administrations [1]. IoT' devices are crucial for smart cities, because they are used to obtain data needed by decision making systems such as transportation or surveillance systems [2]. Almost 30 billions of connected devices (with processors enabling communication over a network interface) are forecast by 2022, where around 18 billion will be connected cars, machines, meters, sensors, wearables, to name a few examples of IoT' devices and 1.5 billion will have cellular connection [1]. Moreover, current simulation results using realistic large-scale IoT ' service scenario in a city showed that the 99% of devices located deep indoors could be reached with new cellular technologies for the IoT [2]. The connectivity is only the foundation to enable smart cities [3]. Ubiquitous and pervasive computing, sensing technologies and embedded devices are also needed [4].

Currently, there are several IoT' platforms [8] such as *OneM2M* [3] or the FI-WARE project [4]. Moreover, several architectural reference models had been proposed (e.g. *IoT-A* [5]), where typically, several layers had been considered (perception, network, middleware, application and business layers)[5]. There are proposals using known Web standards to wrap "things" as Web APIs [2] proposing that smart city applications should be built as Web mashup of "things" or physical mashups [12]. Other authors [6, 7] had proposed to use a microservice architecture in order to build a new application as a composition of a suite of small services, each running in its own process and communicating with lightweight mechanisms.

The IoT paradigm is the facilitator for real and digital worlds be continuously in a symbiotic interaction. "Things" are not only for collecting data from the environment and interact/control physical world, but "things" must be interconnected exchanging data

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[1] https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-june-2017.pdf

[2] https://www.ericsson.com/en/mobility-report/massive-iot-coverage-in-the-city

[3] http://onem2m.org

[4] http://fiware.org

[5] http://open-platforms.eu/standard_protocol/iot-a-architectural-reference-model/

and information between them [4]. Unfortunately, in the previous revised platforms, "things" were modeled as passive entities or simple data sources' providers.

Agents and Multiagent systems has been used in distributed problems where agents act as autonomous entities to achieve individual and/or collaborative goals. Unfortunately, even when they had been used for transforming common applications based on the Internet of Things on self-adaptive applications[10, 13], "things" were always modeled as passive entities.

In this ongoing work, we propose to wrap "things" as autonomous agents, making them capable of collaborating with other "things" in order to achieve and maintain satisfied mashups' goals. To do that, we propose to create a multiagent layer between middleware and application layers of the IoT's reference architecture.

The rest of the paper is the following. Section 2 presents the proposal. Section 3 presents implementations details. Section 4 presents conclusions and draws current and future works.

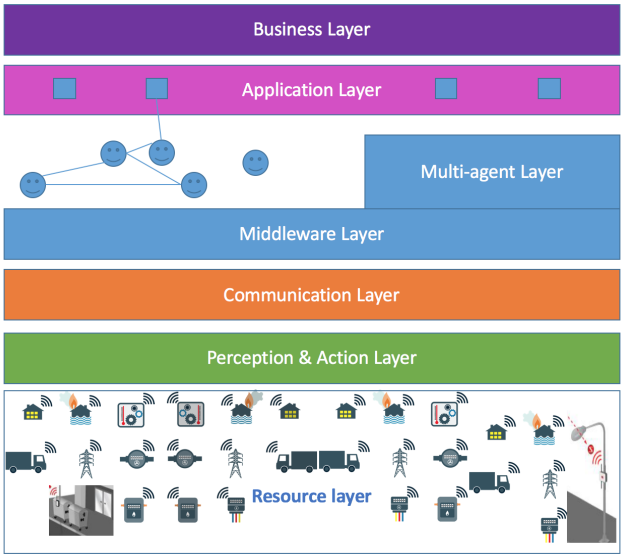

Figure 1: Layers of an IoT platform including the multiagent layer

2 Proposal

In this work, we reuse the concepts used in MACOCO++ [9] for service-based systems, where a market metaphor is used to allow agents representing Web services' requesters and providers negotiate to obtain the Web services' configurations. Specifically, we propose to add a multiagent layer to the basic IoT architecture [5] as Figure 1 shows in order to extend the middleware layer's capabilities with a new service that provides a living catalog of the available "things" in the city. In this layer, each "thing" is represented by a provider agent, who has the relevant data of the represented "thing" such as the available services, the error range, the maximum throughput, to name a few.

Each time, a "thing" is registered in the city, a provider agent is created. Indeed, the *Directory Facilitator (DF) Agent* is a dedicated agent for this task, which resides inside of the multiagent system. The provider agent allows to keep track of the availability of the "thing" as well as access to its data.

Each time, a developer publishes a mashup request, a request agent is also created. This agent is in charge of selecting a proper "things"' configuration to satisfy the request from the several possible offers received from different virtual organizations of agents from the multiagent system. Configurations are created by the self-organization of agents representing "things"; as in MACOCO++, agents communicate between them to achieve this aim negotiating and creating alliances.

During runtime, if there is evidence that a physical mashup is not satisfying its goals, then the same request agent may trigger a new request in order to obtain a new configuration of things.

3 Implementation and Evaluation

To show the feasibility of our approach we are building *mashThings*, an Internet of Things (IoT) platform to build smart city applications as physical mashups, where the middleware layer is augmented by a multiagent layer of broker agents representing the available "things" in the city. This extra layer is between the middleware and application layer of IoT' platforms and it was built using Jade 4.4.0 [6]. We built a Web prototype using node.js to facilitate its use. Independent of the IoT platform under use, each time a new "thing" is registered in this Web application, a broker agent is created in the multiagent layer and the "thing" is registered in the corresponding IoT platform. Then, when an application developer needs a configuration of "things" to achieve the application's goals, request is published into this Web application, where a request agent is published into the multiagent system in order to create a virtual organization with agents representing the needed "things" for the physical mashup in order to obtain authorized access to the data of the things if it applies.

The experiment setup is an application scenario that consists of to keep track that the temperature, humidity and/or pressure do not exceed a given threshold in an office hall as well as in each one of three near offices. Each one of the three near offices has a node comprised of a plug computer and three different sensors (temperature, humidity and pressure) connected

[6] `http://jade.tilab.com`

through an Arduino One. The office hall do not have a node or any sensor.

4 Conclusions and Future Work

In this ongoing work, we proposed *mashThings*, an IoT platform for building in the future, robust smart city applications. *mashThings* is based on extending the capabilities of the middleware layer of the IoT platform by adding a multiagent layer that provides a living catalog of functionally-equivalent things available over the city, where things discover themselves to mashups developers. Moreover, this middleware's service will abstract developers of physical mashups of the details of connections to these "things" in order to get the data. It will also enable the owners of the things to restrict their use only to authorized mashups if it is built over an XMPP-based IoT platform [7].

Currently, we are experimenting with different IoT platforms. We are using FIWARE complemented with Orion [8] to give broker agents access to the latest data by using the publisher-subscribe mechanism. In the short term, we will test a full XMPP-based IoT platform footnote`http://tno-iot.github.io/ekster/` in order to address also security concerns.

We believe in the short term that any user in the city could create its own mashup from the available infrastructure. Thus, as part of the roadmap, we will include proposals [11] where users may provide their goals and automatically obtain an executable workflow, in our case, representing the mashup.

Also, in the future *mashThings* will allow smart cities applications become fault tolerant mashups through the self-organization of configurations of things when goals are not being satisfied by adding them self-adaptation capabilities.

References

[1] A. Zanella, N. Bui, P. Castellani, L. Vangelista, M. Zorzi Internet of Things for Smart Cities *IEEE Internet of Things Journal*, vol 1, pp 22–32, 2014.

[2] J. Heuer, J. Hund, O. Pfaff, "Toward the Web of Things: Applying Web Technologies to the Physical World", Computer, vol. 48, no. , pp. 34–42, 2015.

[3] S. Li, W. Mackaness A multi-agent-based, semantic-driven system for decision support in epidemic management *Health Informatics Journal*, 21(3):195–208, 2015.

[4] E. Borgia, The Internet of Things vision: Key features, applications and open issues *Computer Communications*, 2014.

[5] R. Khan. Future Internet: The Internet of things architecture, possible applications and key changes *10th International Conference on Frontiers of Information Technology*, 2012.

[6] A. Krylovskiy, M. Jahn, E. Patti Designing a Smart City Internet of Things Platform with Microservice Architecture *3rd International Conference on Future Internet of Things and Cloud*, 2015.

[7] A. Krylovskiy, M. Jahn, E. Patti InterSCity: A Scalable Microservice-based Open Source Platform for Smart Cities *6th International Conference on Smart Cities and Green ICT Systems*, 2017.

[8] M. Zdravkovic, M. Trajanovic, J. Sarraipa, R. Jardim-Goncalves, M.Lezoche, et al. Survey of Internet-of-Things platforms. *6th International Conference on Information Society and Technology*, 2016.

[9] R. Torres, H. Astudillo A market-based approach to the dynamic reconfiguration problem of service-based systems *International Journal of Innovative Computing, Information and Control*, 10(1), 115–132, 2014.

[10] D. Weyns and M. Georgeff, "Self-adaptation using multiagent systems" *IEEE software* vol. 27, no. 1, pp. 86–91, 2010.

[11] M. Chechik, J. Simmonds, S. Liaskos, S. Nejati, M. Sabetzadeh R. Salay PWWM: A Personal Web Workflow Methodology" *Lecture Notes in Computer Science, The Personal Web - A Research Agenda*, vol. 7855, pp. 11–48, 2013.

[12] Y. Benatallah, F. Casati, and F. Daniel. "Understanding mashup development". *IEEE Internet Computing* 12(5):4452, Sept. 2008.

[13] N. Moraes, C. Pereira. "FIoT: An agent-based framework for self-adaptive and self-organizing applications based on the Internet of Things". *Information Sciences* 378: 161–176, 2017.

[7] `https://xmpp.org/software/servers.html`

[8] `https://fiware-orion.readthedocs.io/en/master/`