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Modular and generic IoT management on the cloud

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HIGHLIGHTS

- We developed a Sensor Data Collection Service to support generic IoT data collection.
- The service separates IoT devices and cloud system with NoSQL data storage support.
- It supports vendor agnostic and on the fly data collection from IoT devices.
- It supports fast incoming traffic (POST data around 1.7 s per event).

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ABSTRACT

Cloud computing and Internet of Things encompass various physical devices that generate and exchange data with services promoting the integration between the physical world and computer-based systems. This work presents a novel Future Internet cloud service for data collection from Internet of Things devices in an automatic, generalized and modular way. It includes a flexible API for managing devices, users and permissions by mapping data to users, publish and subscribe context data as well as storage capabilities and data processing in the form of NoSQL big data. The contributions of this work include the on the fly data collection from devices that is stored in cloud scalable databases, the vendor agnostic Internet of Things device connectivity (since it is designed to be flexible and to support device heterogeneity), and finally the modularity of the event based publish/subscribe service for context oriented data that could be easily utilized by third party services without worrying about how data are collected, stored and managed.

1. Introduction

Over the years various services and applications have been developed in the concept of future Internet (FI) [1,2]. In particular such services are available by different cloud platform nodes such as FIWARE lab[1] that is a non-commercial sandbox environment. The services follow the form of RESTFul architecture [3] that allow to talk to each other easily and in a decoupled way. In addition, the Internet of Things (IoT) involves various sensors that are embedded to every day devices and monitor data produced by humans or by the environment in an automatic way [4]. The combination of cloud computing and IoT generates a new opportunity for wide discovery [5] and such data, since more and more FI applications are available. The development of such applications that are using cloud resources becomes more efficient (scalable storage) and creates a significant impact on the economic benefits e.g. because of cloud elasticity and pay on demand model [6]. In addition, the data transmission speed and the large volume of data (since cloud has the ability to store and process it) make it even more attractive.

In this work we focus on the FI concept and especially on the FIWARE platform[2] that offers public services followed by simple application programming interfaces (APIs) to facilitate the process of developing smart applications. FIWARE motivates new entrepreneurs and software developers to implement such applications in health, environment and smart city concepts by providing Generic Enablers (GEs) [7] that are the building blocks of FI applications [4]. In the general concept of a smart city many IoT devices and sensors are associated with cloud computing services.

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1 https://www.fiware.org/lab/.

2 https://www.fiware.org.

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For example in cases of data processing produced in order to avoid natural disasters (fires, floods, etc.), control of environmental conditions, energy saving, control of patient status and others. The sheer volume of data generated by sensors, has forced the transfer of the Internet of Things concept entirely on cloud computing since traditional systems could not handle the large volume of data as well as to guarantee remote access to other systems, e.g. for integration purposes.

The FIWARE lab[3] provides software to developers that use such services to develop smart applications/services within the smart city and thus including idea of the Internet of Things. Already in recent years, the community of FIWARE has taken important steps in the development of such services that help in creating more complex applications, however all these services are oriented with vendors, IoT devices and protocols. Having said that, this work proposes a Sensor Data Collection (SDC) cloud service that focuses on the problem of collecting data from different devices and their sensors, thus moving to a vendor agnostic solution. SDC developed as a gateway among IoT devices and cloud, enabling the collection of the different sensor signals that are eventually sent to various other services. The service is designed to be extensible and generalized, so IoT devices could be easily connected and communicated without any programming intervention. Also, it is modular based on the service oriented architecture [8], that allows (a) support of multiple sensors belonging to different domains (for example medical, environmental, etc.), and (b) support of network gateway devices.

The work is organized as follows. Section 2 presents the motivation and Section 3 the related approaches to this study, Section 4 demonstrates the architecture of the SDC service, Section 5 presents an analysis of the implementation aspects and demonstration of the service API and Section 6 presents the experimental analysis based on the simulation of two IoT devices that are (a) the Netatmo environmental sensor[4] and the Zephyr HxM Bluetooth Heart Rate Monitor medical sensor.[5] Finally, in Section 7 we conclude with the summary of this work and the future research directions.

2. Motivation

This work is based on FIWARE that is a non-commercial platform that offers general purpose services called Generic Enablers (GEs) that are in the form of APIs. In particular, GEs are provided by cloud computing infrastructure as SaaS [9] and if combined can constitute a special-purpose service called Specific Enablers (SEs), which could be used for developing solutions for more complex problem. FIWARE enables developers to obtain services as infrastructure (IaaS), creating virtual machines and allocating computing resources in the FIWARE lab [10].

FIWARE lab is based on the Openstack [11] platform that is an open source software, which allows the creation of a cloud computing systems. The latter are designed according to Openstack standards, thus consisting of a centralized architecture encompassing various smaller pieces of services that are responsible for controlling and managing the high volume computing resources [12]. In this work we utilize an OpenStack system and FIWARE GEs to propose an architecture for a sensor data collection service on the cloud. The solution is modular, decentralized and reusable [13] thus allows IoT devices to easily attach to the service. We are motivated by the works in publish/subscribe systems in clouds and inter-clouds as in [14–18] and [19]. The basic characteristic of the proposed service is the simplicity of use at any time requested by the user. Such reusable services are very important in a cloud computing because it allows developers to model complex systems. Another important advantage is the modularity, that is to say the replacement of one individual service (GE) in case of a new version or a failure.

We implement our service within the IoT concept based on a service centric architecture as in [20] that is based on the fact that a large problem can be solved optimally and efficiently if it is divided into smaller parts. The advantages of such modular architectures are:

i. The services are reusable and can be made available on a larger scale.
ii. It provides faster and more efficient debugging and leads to improved fault tolerance.
iii. It involves shorter time with regard to the distribution of new products and applications.
iv. The services are not bounded to the system, thus can be easily replaced.
v. In case of integrating to a new system it does not require changes to the internal procedures of the service.

The SDC service has been developed in the form of the so called protocol adapters[6] that are implementations developed specifically for communication protocol (for example Wi-Fi, ZigBee, Bluetooth, etc.) as well as for specific devices. These services provide APIs, with functionalities such as data sending and alerting in case that a stimulus is generated from the systems. Also, it is possible to retrieve the characteristics of a device. Usually, the resulting response in a method that calls the service API is a standard data JSON (JavaScript Object Notation).

In this work we aim to develop a more generalized service that will allow data collection and storage from various IoT devices without worrying about protocols or device specifications. Thus, we aim to "transform" sensors to flexible APIs so data could easily be flown over the Internet to other services. Two main issues that the SDC service is focused are as follows.

i. The issue of having many different communication protocols between devices and network gateway. The main communication protocols on modern sensors are the Wi-Fi, Bluetooth, ZigBee, etc. Thus there is a need for a service that implements interfaces according to these standards, so as to allow easy integration and communication between services and IoT devices.
ii. There is a huge variety of devices because companies provide proprietary APIs to collect data from the sensors, so the implementation of a service for commercial sensors seems quite tricky.
iii. The large volume of data produced by devices requires a new solution for scalable data storage. In addition, big data that are collected from different devices have different schemas thus a more sophisticated way is required for data storage.

The motivation of our work is based on the fact that to the best of our knowledge there is not a FIWARE service capable of managing, storing and sharing information in such way. Users who use this service may be persons, services and applications developed in FIWARE and other development environments. The proposed solution manages users and sensors for the immediate updating and subscribes users on data updates for each sensor. The basic functions supported are (a) add, remove and update sensors by the administrator, (b) add, remove and update user subscriptions, (c) add, remove and update user rights in sensors assistance from the administrator, (d) update subscribers' sensors,

[3] https://www.fiware.org.
[4] https://www.netatmo.com/en-US/site.
[5] http://www.zephyranywhere.com.
[6] http://catalogue.fiware.org/enablers/protocol-adapter-mr-coap.