IoT and Big Data Technologies for Monitoring and Processing Real-Time Healthcare Data

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ABSTRACT

Recent advances in pervasive technologies, such as wireless, ad hoc networks, and wearable sensor devices, allow the connection of everyday things to the Internet, commonly denoted as the Internet of Things (IoT). The IoT is seen as an enabler to the development of intelligent and context-aware services and applications. However, handling dynamic and frequent context changes is a difficult task without a real-time event/data acquisition and processing platform. Big data technologies and data analytics have been recently proposed for timely analyzing information (i.e., data, events) streams. The main aim is to make users’ life more comfortable according to their locations, current requirements, and ongoing activities. In this article, combining IoT techniques and Big data technologies into a holistic platform for continuous and real-time health-care data monitoring and processing is introduced. Real-testing experiments have been conducted and results are reported to show the usefulness of this platform in a real-case scenario.

KEYWORDS

Complex Event Processing, Connected Health, Context-Awareness, Context-Driven Services, Experiment and Case Studies, Predictive Analytics and Control, Smart Cities Applications, Stream Processing

INTRODUCTION

More than 3 billion of the world’s population have access to the Internet (Curran, Fenton & Freedman, 2016). As the Internet evolves, a new vision of the Internet embracing everyday objects comes into focus, which is the Internet of Things (IoT). The IoT could be built on the pervasive deployment of a variety of things, such as Radio-Frequency IDentification (RFID) tags, sensors, actuators and mobile

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phones that can interact with each other and cooperate with other services to reach common goals (Atzori, Iera & Morabito, 2010). The integration of data generated by sensors with other data, such as location and social media data, allows the development of context-aware applications that could help users in taking more informed decisions regarding their daily activities. The IoT is considered as an enabler for developing new intelligent applications and services that can be deployed to different domains. For instance, developing services for better management of the transport issues (i.e., traffic routing, automatic logistics chain optimization) is now possible by allowing instantaneous reactions to contextual changes and external triggers. The IoT is also used in the healthcare domain by enabling the development of numerous connected health applications, from remote patients’ monitoring to smart medical devices. Connected health can be defined according to Taylor (2015) as “the collective term for telecare, telehealth, telemedicine, mHealth, digital health and eHealth services” (p. 1). Connected health can capitalize on the IoT technologies to improve healthcare delivery and services to patients. In fact, some healthcare conditions and chronic diseases require continuous monitoring, which can be enhanced by IoT technologies.

Recently, diverse IoT technologies have been developed to perform real-time device monitoring, collect sensors’ data and analysis of large size of streaming data. The growth of these data creates what is named the “Big Data” phenomenon with the main four V’s – Volume, Velocity, Variety and Value (Oracle, 2013). The Big Data technologies aim to timely extract the ongoing and future contexts in order to anticipate changes and tailor services that better fit the users’ needs. Several Big Data technologies have been developed and could be classified according to the data processing concepts as defined by Shahrivari (2014) and Sun et al. (2015): (1) batch processing technologies and (2) real-time processing technologies. Batch processing technologies, such as Hadoop, are more suitable for high throughput data processing by first store data and process later on (Turner, 2011). Real-time processing technologies, such as Storm and S4, have been developed to process data in motion and get as fast as possible valuable insights from it. The objective is to enable the development of real-time or near real-time applications for data processing. These applications operate in scenarios with tight requirements, such as high data rates (more than 10000 event/s) and low latency (up to a few seconds) (Heinze, Aniello, Querzoni & Jerzak, 2014). In parallel to this progress in developing Big Data technologies, several IoT platforms such as ThingSpeak (2017) have been developed for data monitoring and analysis. However, there are no guarantees on time transmission and processing, which are required for the development of context-aware applications. In fact, streaming the data from an embedded device into a data analytics cloud and performing analysis based on these data can easily take tens of seconds.

This paper presents the architecture of a holistic platform that combines tools from IoT, complex event processing and Big Data technologies. The aim is to provide a platform that allows processing large scale sensor data that can be used to develop context-aware applications and services. This study is mainly based on the pioneering work by Kaaproject (2017) aiming at combining Kaa and Storm technologies into a holistic platform. In fact, Apache Storm is a distributed event stream processing that allows distributing the processing and input data streams into several processing units (i.e., bolts and spouts) to reach real-time processing and make mitigation action as quick as possible (STORM, 2015). A prototype combining the Storm and Kaa has been developed to allow distributed real-time computations of integrated IoT devices into one platform. A small-scale healthcare scenario has been tested to show the usefulness of the developed platform for real-time monitoring and processing. The main contribution of this paper is to investigate the platform usefulness on scenarios related to health. We show how our platform provides a valuable tool allowing the monitoring and processing streams of data using IoT tools and Big data technologies. The work carried out so far provides a solid ground for the development of more complex applications and services. For instance, in Kharbouch et al. (2018) under the framework of SELFSErV project, funded by the Belgian VLIRUOS agency, the developed platform was used for preventing severe hypoglycemia episodes. The obtained results showed the efficiency of the platform in early detection of hypoglycemia episodes while handling
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