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Performance Analysis of End-to-End Sensor-to-Cloud Personal Living Platform

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Abstract

This paper presents a performance analysis of the end-to-end sensor-to-cloud personal living platform. The analysis is based on a typical architecture starting from a single sensor and actuator and continuing to the virtualized services at smart dust, dew, fog and cloud level. The system is diverse and allows interconnection of different sensors/ actuators technologies directly or throughout gateways. The experiments in a living lab presented use energy harvesters and ZigBee PRO sensors. The results from sensor network are applicable for non-real-time and non-critical data connection. As a final conclusion, we claim that for critical and non-critical measurements that need to be supported in a typical living environment there is a necessity to use different priorities of the services and different sensors as well.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: sensor technology, cloud, performance analysis, living lab, non-real-time communication, critical and non-critical data

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1. Introduction

Nowadays, there are too many different devices and software interconnected in the network. The interworking capability of such a heterogeneous network and interoperability between network elements is a serious problem. Every new medical, fitness, wellness, active-aging, health-related device and software is usually supported by cloud based service. Due to the business solutions cloud services are not interconnected and do not share data. Possibility of data migration between different generations of the devices and nodes coming from different producers is still not well supported. The possibility to integrate multiple different devices into a personal living environment (PLE) that is context-aware is still a wish. When the PLE belongs to the person that is temporarily or permanently in care need it is not straight forward how the data could be shared and managed from different places and by different persons. In this paper, we try to define PLE that is end-to-end sensor-to-cloud solution and will allow easy integration of the devices, algorithms, software at smart dust, dew, fog or cloud virtual level. Platform virtualization allows easy application of the algorithms for big data analysis, data acquisition, data migration, context analysis, etc. regardless of the access part with specific traffic sources. The opposite is also true, i.e. being virtualized, the platform will allow adding/ removing/ reconfiguration, evolution, changing of the access network and traffic sources regardless of the cloud part of the network.

This work is organized as follows. We start with brief review on the state of the art in PLE. Then we present the architecture of the personal living environment mentioning the sensor part, gateways, smart dust, dew, fog and cloud computing parts keeping in mind that part of the nodes could be mobile and portable. The experiments done in the living lab are explained next as well as some results derived. We conclude with comments on applicability of the work and future research directions.

2. State of the Art

Internet of Things (IoT) and 5G are hot topics and there are many analysis and published research in this area. They concern different aspects like security, protocols, technologies, and advertise new platforms or frameworks. These activities are surrounded by a complex market of software and device vendors, telecoms and IT service providers. Under these circumstances, it is easy to be carried away from the main motivation for these technologies to come into existence – namely to provide good performance for the business and end-users and assist in their living[1,2]. As of some recent estimates (Forbes), it is expected that IoT market will double within the next 3 years, reaching 31 billion devices by 2020 and even quintuple by 2025 to more than 75 billion devices[3]. With the number of devices growing exponentially, we have hyper exponential expectations for the amount of data generated. All these data need to be turned into actionable and contextualized information and IoT realization success is highly correlated to our ability to gain insights hidden in seas of data[4]. There is still a gap between making IoT in general and making IoT workable. This is not possible without interoperability, big data analysis and sharing, data visualization, mapping, filtering, dependence analysis, accuracy of the presentation, machine learning and computer intelligence[5]. This could be done throughout open design and use of standard interfaces, protocols, data interchange formats, open APIs. Where necessary gateways could be applied for better connectivity and interoperability[6]. Conformance to the existing standard solutions like medical services standards, home appliances standards, home and business automation standards is considered at different levels of scale and design[7]. There is a good analysis of the ambient assisted living solutions used for further standardization in European Commission and ETSI[8,9]. The basic technical solution is having minimal requirements towards the infrastructure due to the price. Personal and smart weather stations are in high demand in US and in developed economies of European Union[10]. Medical applications and devices are very expensive due to the high accuracy requirements and specific features[11]. Part of the integrated solutions look like hobby-based and toys[12]. With the increased demand for compatibility, wireless communication and the utilization of open standards, these sensors and their controllers are becoming much easier to integrate.

Interconnection and reliability is another important issue in the PLE[13]. We already investigated peer-to-peer and client/server connections, backup and duplicated connections. Most of the solutions are mobile, i.e. connections are heterogeneous and comprise of 3G/4G/5G, Wi-Fi to communicate with the smart dust, dew, fog, cloud infrastructure. Gateways might be based on the Microsoft Azure IoT Gateway SDK with plugin architecture and will support a