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Bahar Farahani, Farshad Firouzi, Victor Chang, Mustafa Badaroglu, Nicholas Constant, Kunal Mankodiya

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Towards Fog-driven IoT eHealth: Promises and Challenges of IoT in Medicine and Healthcare

Bahar Farahani*, Farshad Firouzi†, Victor Chang‡, Mustafa Badaroglu§, Nicholas Constant¶, and Kunal Mankodiya ¶
*School of Electrical and Computer Engineering, University of Tehran
†Department of Electrical, and Computer Engineering, KU Leuven
‡International Business School Suzhou, Xi'an Jiaotong Liverpool University, Suzhou, China
§Qualcomm Technologies
¶Department of Electrical, Computer, and Biomedical Engineering, University of Rhode Island

Abstract

Internet of Things (IoT) offers a seamless platform to connect people and objects to one another for enriching and making our lives easier. This vision carries us from compute-based centralized schemes to a more distributed environment offering a vast amount of applications such as smart wearables, smart home, smart mobility, and smart cities. In this paper we discuss applicability of IoT in healthcare and medicine by presenting a holistic architecture of IoT eHealth ecosystem. Healthcare is becoming increasingly difficult to manage due to insufficient and less effective healthcare services to meet the increasing demands of rising aging population with chronic diseases. We propose that this requires a transition from the clinic-centric treatment to patient-centric healthcare where each agent such as hospital, patient, and services are seamlessly connected to each other. This patient-centric IoT eHealth ecosystem needs a multi-layer architecture: 1) device, 2) fog computing and 3) cloud to empower handling of complex data in terms of its variety, speed, and latency. This fog-driven IoT architecture is followed by various case examples of services and applications that are implemented on those layers. Those examples range from mobile health, assisted living, e-medicine, implants, early warning systems, to population monitoring in smart cities. We then finally address the challenges of IoT eHealth such as data management, scalability, regulations, interoperability, device-network-human interfaces, security, and privacy.

I. Introduction

Internet of Things (IoT) is an ever-growing ecosystem that integrates hardware, computing devices, physical objects, softwares, and animals or people over a network enabling them to interact, communicate, collect and exchange data. There is an increased number of users, services and applications associated with IoT across different disciplines [1], [2]. IoT has been evolved from Radio Frequency Identification (RFID) [3] and Wireless Sensor Network (WSN) technologies [4], [5], [6], [7], [8], [9] to more advanced integration with cloud computing, Internet services, cyber-physical systems and interconnections between hardware and software devices [3]. A typical IoT system consists of sensors, communication interfaces, advanced algorithms, and cloud interface. Sensors are used to collect data from different devices. RFID technology and WSN technologies provide the means of communications and network infrastructure. Advanced algorithms are used to process data and analyze anything meaningful through Application Program Interfaces (APIs) or apps. Thousands of client-server requests can be exchanged between mobile devices and services in the cloud and Internet, thus allowing users to get access to different types of services at the same time [1], [2], [10], [11].

There are different major types of IoT services as follows [1], [10], [12], [13], [14], [15]. First, smart wearable devices can be used for patients who need to collect data about their health status such as heartbeat, blood pressure and glucose level through sensors on the wearable technologies, which are sent to smartphones. The health status of patients can be monitored at the same time. Second, smart homes can be enhanced by IoT. While sensors can detect the changes in temperature, air-conditioning systems can be monitored. Home security cameras can capture any intruders and send the warnings to the home owners by mobile apps. Third, traffic and transport systems can be monitored by IoT to achieve smart cities. Data can be collected and analyzed to understand the updates in traffic networks and transportation systems. Forth, supply chain system can work with IoT that all the deliveries can be recorded and tracked in real-time. When goods have been shipped to the destination, the delivery records can be kept up-to-date. Fifth, the Internet banking can work with trustworthy third-party payment systems on the smartphones. Examples include Apple Pay, PayPal, Taobao and Alibaba that customers can purchase and pay within seconds. Customers can have more varieties of options for their purchase and have a more convenient way to complete their transactions more easily without a need to go the vendor directly. These use cases of IoT can be mapped to a generic model where this generic model is to provide an easier integration with different services seamlessly, ranging from sensors to network infrastructure, and from APIs to big data processing, and finally from analytics to predictive modeling [1], [16], [17]. This approach ensures that users can have easier access to services, can monitor the progress of the service delivery, and can compare prices and ratings offered by service providers. Moreover, service providers can be more exposed to more customers, check their business performance and track the market trend more easily [10], [16], [17].