An Overview of Internet of Things (IoT)-Based Healthcare Services: Lesson Learnt from BLESS U Joint Project

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Abstract

Internet of Things (IoT) has been a promising technology to automate the tasks or services that involves human works in many areas of life. One of services that is crucial to enhance a quality of life is healthcare services. The gap of healthcare services in many countries over the world has been a challenging issue. University of Lampung, Indonesia and University of Bradford, United Kingdom (UK) have an on-going joint project funded through Newton Fund Institutional Links Scheme addressing the use of IoT and wide area communication infrastructure to automate the healthcare services in Bandar Lampung, Indonesia, so do the project is called as BLESS U standing for Bandar Lampung Enhanced Smart-health Services with Smart Ubiquity. The ultimate goal of the project is to lessen the gap of healthcare services between urban and rural or very extreme rural area in both Bandar Lampung of Indonesia and Yorkshire region of UK. To achieve this challenging goal, the project has some sub-projects which are part of the BLESS U project. This paper presents an overview of those some on-going works related to the BLESS U project. The paper starts with the concept of BLESS U system at the top level to realize the goal of the project. Some on-going works have been focused to build the hardware component using sensor and communication technologies supporting the healthcare related issues, to build a smart clinic based on IoT, and to build semantic smart service gateway. Overall, the paper identify the stages to achieve the goal of BLESS U project.

Keywords: *automation, healthcare services, Internet of Things, BLESS U Project, sensor technology.*

1. INTRODUCTION

Indonesia is the latest country in the Asia-Pacific region to adopt smart city initiatives, with many major cities such as Jakarta and Bandung already benefiting from government support and investment. The 24-month project, BLESS U (Bandar Lampung Enhanced Smart-health Services with Smart Ubiquity), will complement existing smart city projects in Indonesia by developing a proof-of-concept Internet of Things (IoT)-enabled smart clinic to automate primary healthcare services provided by clinics in Bandar Lampung, Indonesia and to address the inequitable distribution of healthcare services between urban and rural areas through potential integration of IoT and satellite technologies for remote healthcare service delivery in rural extremes. BLESS U will transform current paper-based clinical services with smart technologies in Bandar Lampung. It will assess the rural-urban divide in healthcare provision in both the Yorkshire region of UK and in the Lampung province of Indonesia to provide recommendation on how resources in urban cities can be shared with rural areas. BLESS U should therefore be seen as an initial phase in establishing Bandar Lampung as one of major smart cities in Indonesia and the Lampung province as an exemplar province to lessen the rural-urban gap in healthcare provision. It will also help catalyse the digital rural development in the UK. BLESS U will base its system architecture design on existing patient pathways and clinical processes to minimise service disruption and the hardware/software platforms will be associated to a semantic smart service (3S) framework,

identified as vital to the successful outcomes of the work.

A multidisciplinary team of communications and electronics engineers, computer scientists, and process management scientist from the University of Bradford (UoB), UK and University of Lampung (Unila), Indonesia with support from Institute of Technology Bandung (ITB) Indonesia, industries, local governments and non-profit research organisations will ensure project goals be reached. BLESS U project has some objectives, those are: 1. To develop an IoT-enabled smart clinic demonstrator for automated and ubiquitous access to healthcare services and validate the smart clinic concept through laboratory trial and evaluation; 2. To identify gaps in healthcare provision in rural extremes and investigate the use of IoT and satellite technologies for rural healthcare delivery; 3. To define a semantic smart service (3S) framework to model semantically the patient pathways and clinical processes including the delivery of associated information, the interactions between clinic, hospital and pharmacist, etc. for secure healthcare provision, taking into account security and patients' own mobility and access to mobile technologies; 4. To build institutional capacity for researchers' professional development to maintain research excellence; 5. To disseminate BLESS U activities and outcomes through workshops, research seminars, conferences, high quality publications and media.

One most related work in the literature has been found in [1]. This paper has been based on the talk in [2] which has been presented in the workshop held in University of Bradford.

2. ARCHITECTURE OF BLESS U

Fig. 1 shows the architecture of BLESS u (Bandar Lampung Enhanced Smart-health Services with Smart Ubiquity) at the top level. The lower layer in the BLESS U architecture, it has the physical system and sensors layer. The sensors sense the parameters from the physical systems and it results in the raw sensor data. Each device could be equipped with Radio Frequency Identification (RFID) to indicate the

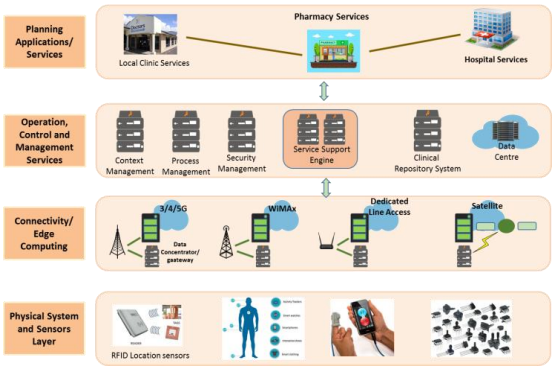

Fig 1. The Architecture of BLESS U

position of the sensor. To implement the monitoring of health conditions for the patient (s), Wireless Body Area Network (WBAN) can be applied and a collector node functions to collect the patient health parameter. In this case, the data security of patient and the production of the precision sensor devices are issues in the implementation. Every sensor node and the data collectors have to be connected one to another. It forms what it is called as Wireless Sensor Network (WSN). In order to data from WSN can reach the distance data centre, a global network are needed. Therefore, it is connectivity/edge computing at the second layer of BLESS U architecture. The connectivity for the global accesses can be 3/4/5G networks, WorldWide Interoperability for Microwave Access (WiMAX) networks, a dedicated line access (such as broadband Public Switch Telephone Network (PSTN), etc), and/or satellite network. Two upper layers of BLESS architecture are more to support the intended applications with its supporting functionalities.

A. Semantic Smart Service Gateway

To implement the BLESS U at the application level, Semantic Smart Service (3S) gateway is necessary. Fig. 2 depicts the conceptual of 3S gateway. Basically, it functions as the processing from the raw data sensed by the sensors to the information that can be translated to the actionable information. The diagram of 3S gateway that can be implemented is shown in Fig. 3.

Semantic Smart Service gateway is purposed to: make use of World Wide Web Consortium (W3C)'s semantic web standard; define common data formats and exchange protocols on the web;

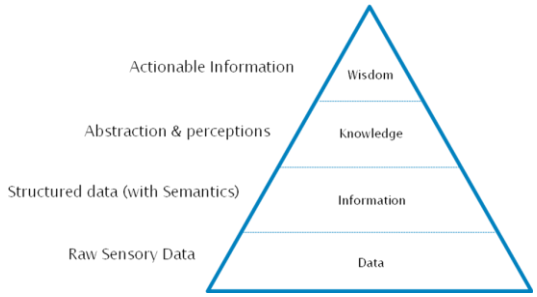

Fig. 2 The Conceptual of Semantic Smart Service Gateway

enhance usability and usefulness of the web and its interconnected resources.

On the diagram, Resource Description Framework (RDF) are describing the information; expressing data models (resource and their relationship); consisting of triples or sentences (<subject, property, object> and <"sensor", has type, "Temperature2">). RDF Schema (RDFS) is to extend RDF with standard ontology vocabulary that are class and property; type and subClassOf; and domain and range. Related to BLESS U project, the basic idea of RDF can be related into four requirements. First, related to resources: every resource has URI (Universal Resource Identifier), an URI can be an URL (Universal Resource Locator) or other kinds of identifier. Second, an identifier does not necessarily enable access to a resource. Third, a resource is an object to be described such as car, person, place, etc. Fourth, SPARQL is a query language for RDF data.

Furthermore, ontologies on the diagram describes a set of concepts in a domain, consists of a finite list of terms and relationships between terms. In addition, Web Ontology Language (WOL) provides more concepts to express meaning and semantics than XML and RDF(S), provides more constructs for stating logical expressions. Both in ontologies and OWL, the terms denote important concepts of the domain. For example, in a hospital setting, hospital staff, patients, hospital departments, patient age, etc. are important concepts.

B. Semantic IOT-based Healthcare Information System

Fig. 4 shows the healthcare informasion system based on Semantic IoT. The Figure is implementing the concept that is described in the previous sections.

3. THE CLINICAL PROCESS AND PROCEDURES

To identify the clinical processes and procedures, the University of Bradford collaborates with National Health Service (NHS) Bradford Teaching Hospital Renal Unit. The tasks is to identify gaps in procedures and processes through questionnaires and interviews, to define patient pathways including elderly renal patients, to use Business Process Execution Language (BPEL) or Unified Modeling Language (UML) to describe processes, and currently in ethical approval stage. At the University of Lampung side, it

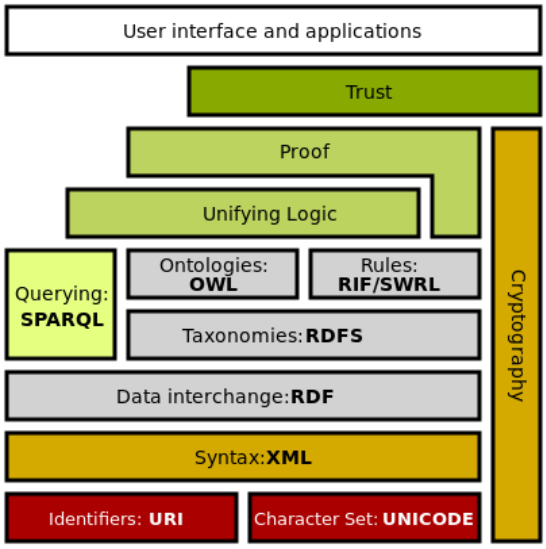

Fig. 3 The Diagram of Semantic Smart Service Gateway

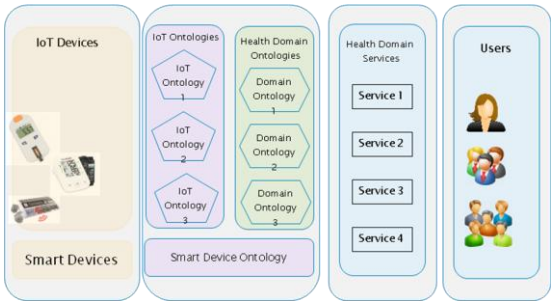

Fig. 4 Semantic IoT-based Healthcare Information System

collaborates with Kosasih clinic and it needs the similar procedures and processes as the University of Bradford side.

4. CONCLUDING REMARKS

This paper has presented an on-going collaborative project funded by Newton Fund Institutional links. The university partners are University of Lampung, Indonesia and University of Bradford, UK. The project addresses the use of IoT and Communication Infrastructures as well as process and procedures modeling to achieve the goal of the projects. The system architecture and its requirements have been identified and its related issues to make it as real system also have been presented. As future works, the project teams have some planned works and approval processes to be carried out.

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