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The role of smart data in smart home: health monitoring case

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Abstract

The smart data continuum refers to a series of increasingly semantically expressive definitions for data elements. With increased semantics we can achieve semantic interoperability, i.e., the ability of computer systems to exchange data with unambiguous and shared meaning. In context of smart homes it offers advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications. In order to achieve semantic interoperability in smart homes we have developed Smart Home Ontology, which gives semantics for the data that are exchanged by the systems and devices in a smart home. From technology point of view, we have studied the combination of cloud computing and Internet of Things as they enable ubiquitous sensing services and powerful processing of sensing data streams beyond the capability of individual “things”, thus stimulating innovations in both fields. Further, we will show how the principles of the Linked Data allow the integration of Smart Home data with other data sources, and thus increases the usability of Smart Home data. In particular we have restricted on health monitoring data.

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1. Introduction

A stovepipe system is a computer system where all the components are hardwired to only work together¹. So the term stove pipe system evokes the image of stovepipes rising above buildings, each functioning individually. The information only flows in the stovepipe and cannot be shared by other systems or organizations that need it.

The systems of a smart home should not be stovepipe systems. In a smart home there are many functions that can only be achieved by functioning together – among themselves or with external systems. Through functioning together we can also achieve synergy, i.e., we can achieve outcomes that would not be achievable in working independently.

The notion of smart data is a key for breaking down stovepipe systems¹. It refers to data that is application-independent, and part of a larger information ecosystem. Further, the smartness of data can be classified by a series of

increasingly semantically expressive definitions for data elements, which are also called as smart data continuum and ontological spectrum. At the low end of the continuum is a simple binding of a single word and its definition while at the high end is a full ontology that specifies relationships between data elements². With increased smartness we can achieve increased precision and semantic interoperability between communicating systems. As smart homes are comprised of a variety of communicating systems and tools, smart data should have a key role in the systems of smart homes.

Resource Description Framework³ (RDF) is a key for representing smart data. It is not a data format, but a data model with a choice of syntaxes for storing data files. In RDF we can express facts with tree-part statements known as triples. The subject identifies the thing being described, predicate is a property name, and object is property value. So, each triple is like a little sentence that states a fact.

However, RDF in itself does not bring smartness. It depends on the expression power of the used vocabulary. By a vocabulary we refer to a set of ontologies, which specifies the used terms and their semantics. Shared ontologies provide the ability of two or more systems to exchange information and to use the information that has been exchanged⁴.

We have developed an ontology, called Home Ontology, which gives the semantics for the data that are exchanged by the systems and devices of a smart home. We have also adapted the principles of the Internet of Things (IOT) in connecting the IOT devices of a smart home. By IOT devices we refer to the inter-connection of uniquely identifiable embedded computing devices within the existing Internet infrastructure. It is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications and covers a variety of protocols, domains, and applications.

In a smart home IoT devices can be used to monitor and control the mechanical, electrical and electronic systems, e.g., to control lighting, heating, ventilation, air conditioning, appliances, communication systems, entertainment and home security devices to improve convenience, comfort, energy efficiency, and security. They also suit well for remote patient monitoring where monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants. Specialized sensors can also be equipped within living spaces to monitor the health and general well-being of senior citizens, while also ensuring that proper treatment is being administered. Other consumer devices to encourage healthy living, such as wearable heart monitors, are also a possibility with the IoT.

It is also turned out that interesting challenges arise when IoT meets cloud computing⁵. The combination of cloud computing and IoT can enable ubiquitous sensing services and powerful processing of sensing data streams beyond the capability of individual “things”, thus stimulating innovations in both fields. For example, cloud platforms allow the smart sensing data to be stored and used intelligently.

Further the ability to share patient’s health data stored in clouds promotes the introduction of new emerging healthcare trends, such as patient-centered care. It emphasizes the coordination and integration of care, and the use of appropriate information, communication, and education technologies in connecting patients, caregivers, physicians, nurses, and others into a healthcare team where health system supports and encourages cooperation among team members.

The rest of the paper is organized as follows. First, in Section 2, we introduce the notion of knowledge centric smart home, and its cloud-based implementation. Then, in Section 3, we restrict to remote health monitoring: we describe how cloud-computing can be exploited in practicing patient-centered remote health monitoring. In Section 4, we deal with aspects of smart data: first we deal with ontology engineering in modeling smart data, and then we present the principles of the Linked Data, as well as their adaption to smart homes. We also illustrate the use of RDF in representing smart data. Finally, Section 5 concludes the paper.

2. Knowledge-centric smart home and cloud computing

Information integration and sharing are the key concept in any society, organization, as well as in smart homes. Knowledge management is a discipline which considers information: it concerns with acquiring, accessing and

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