Chapter 62
An Approach to Data Annotation for Internet of Things

Ivaylo Atanasov
Technical University of Sofia, Bulgaria

Anastas Nikolov
Technical University of Sofia, Bulgaria

Evelina Pencheva
Technical University of Sofia, Bulgaria

Rozalina Dimova
Technical University of Varna, Bulgaria

Martin Ivanov
Technical University of Varna, Bulgaria

ABSTRACT

The increasing number of connected devices which use Internet of Things (IoT) technology and variety of associated services is a real challenge to interoperability. There is a need of an abstraction layer which hides the technology heterogeneity. The paper presents an approach to data modeling in the domain of home energy saving which extends existing solutions with context-ware concepts and relationships. Requirements to data annotation are identified by use cases. Problem-solving principle is applied to data annotation which defines the vocabulary related to a certain task or activities. An observation and actuation models which show how data annotation works are proposed and formally verified. As a proof of concept, the server model includes web services that illustrate the usage of the proposed data annotation. The potential of home appliance power control is estimated.

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INTRODUCTION

Internet of Things (IoT) is pervasive technology which allows connected devices like household appliances, medical devices and cars to share data. Nowadays, the number of connected devices is growing tremendously and the associated services enabled by the device are growing even more rapidly. Services include all of data applications that may be necessary to connect a device over the network, from wearable devices for healthcare monitoring, through smart meters for temperature, energy consumption or pollution levels to telematics devices for vehicle tracking. One of the problems with IoT applications is how to manage the device heterogeneity in terms of different hardware requirements to data rates, form factor, computing and communication capabilities. Developing of customized embedded software for each device costs higher engineering efforts and extends time to market. In order to provide interoperability, there is a need of semantic annotation that can provide a level of abstraction in device description. The raw sensory data captured has to be structured with semantics in order to produce information and then to abstract relevant knowledge. Efficient set of actions may be created having interoperable and semantically described data.

A semantic support is essential to foster collaboration among different vertical IoT applications by providing specific mechanisms which allow the construction of complex services from elementary building blocks (Fortiş et al., 2015). Semantic modeling increases interoperability of diverse devices connected to the cloud (Amato et al., 2015a), (Amato et al., 2015b).

There are already standards such as Sensor Web Enablement (SWE) that provides some interoperability, but it is envisaged that semantic technologies will be key enabler for integration of IoT data. Semantic technologies provide modeling primitives and describe the meaningful relations between different elements. Semantic Sensor Web is an extension of SWE which annotates sensor data with semantic metadata. Resource Description Framework (RDF) provides metadata about uniquely addressable web resources with properties also addressable. In semantic network, ontology is a formal specification of concepts in a domain and relationships between concepts. Ontology Web Language (OWL) provides powerful means for ontology description.

In this paper, we present a structural approach to data annotation for home energy saving domain based on identified requirements. The proposed approach extends existing semantic models with concepts and relationships that strength on how the sensor data can be used and situation or context-awareness, which is the basis for development of applications that respond to the dynamics of the environment and make intelligent decisions.

The paper is structured as follows. First, use cases that illustrate the usage of data annotation are presented and the requirements are identified using a standardized template. A structural approach to representing physical entities within the digital world is proposed, which considers the context in which the entities can be used. In addition to sensor and actuator models, the approach includes observation and actuator models, which are formally verified. The usage of data annotation is illustrated by service model. The service model includes web services for power control. In Section Related works, state-of-art in semantic approaches for IoT is presented and discussions on how the suggested approach extends the existing semantic models are provided. The conclusion outlines the course of future research and highlights the benefits of usage data annotation for home energy saving.