Digital Object Memory

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INTRODUCTION

The Internet of Things envisions new roles for physical objects in everyday life. So-called "Digital Object Memories" address one of these roles – the collecting of data, about the objects as well as object-related information such as tasks, processes and even people that came in touch with the object.

Definition. *A Digital Object Memory (DOMe) denotes a repository of digital data, which is linked with a physical artifact, and which is continuously enriched with data from entities that interact virtually or physically with the artifact.*

Technically seen, this repository may exist at the artifact itself, outside, or both. From a content point of view, it offers access to data about a history of events up to the current point of time. The Digital Object Memory forms a building block of the Internet of Things with approaches dedicated to data models, architectures and interaction methodologies for object-centric data collection.

BACKGROUND

The Internet of Things promises radically new ways of interacting with physical objects, empowered by various kinds of digital extensions ranging from digital media linked with an object to sensors and actors attached to the object. Actually, related technology makes its way into various kinds of industry-strength applications. These are typically "closed" in some way, i.e., they are limited to a well-defined process with environment, actors and data known in advance - as it is common, for instance, in automated manufacturing, and logistics processes. However, outside of its predefined setting, uses of the aforementioned digital extensions to a "thing" are limited.

Imagine a product where tracking temperature is of relevance, e.g., a packing of frozen pizza. Would it not be helpful if the kitchen at home could inform you, the buyer, if the retailer's logistics (stock keeping, freezer) as well as your personal logistics (your car, cooling box, fridge) were able to protect the product, so consumption is not needed right now? Conceptually, this could be easily achieved by integrating a battery-powered monitoring device into the packing. However, such a packing is a cheap single-use product, which does not justify the use of complex technology. Thus, in terms of this example, it would be more desirable for the pizza box to be associated with temperature logs from external monitoring technology. Again, this could be enabled by means of automated identification (e.g., radio frequency identification). However this approach can potentially fail because of the closed nature of the data logs, as the linked monitoring technologies will usually rely on temperature logs different in structure, syntax, and semantics.

Enabling Technologies

Research related to DOMe comprises a broad range of activities focused on collecting data about objects in application scenarios, which have in common that some scenario parameters are not known during setup of the data collection. Such parameters may include, e.g., aspects of the technical infrastructure the object

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is exposed to, the data to be associated with the object, and the application accessing the data.

Conceptually close to the Digital Object Memory is the so-called Digital Product Memory (DPM), a notion coined by Wahlster (2007). Focused on collecting and exploiting information concerning physical instances of a product, the DPM explicitly seeks to leverage value-added services along the value chain. Schneider et al. (2011) summarize technical foundations of a DPM infrastructure, which aims at enabling objects to function as communication tool between business partners, provide immediate access to up-to-date data concerning the product, and acquisition and exploitation of object-related real-world data. Wauer et al. (2010) illustrate how to exploit object-related data collections as a building block for semantic federation of comprehensive product information. Kröner et al. (2010) and Schief et al. (2011) report on the potential of object-specific data collections for so-called process memories – which can, for instance, be employed for monitoring and revising processes involving objects of the same kind.

Outside academic contexts, state-of-the-art supply-chain management frequently employs infrastructures for the automated identification of physical objects. Label technologies such as RFID allow for linking an object with a unique identifier, which can be employed by business partners along the supply chain for object-related services. A prominent example is the Electronic Product Code (EPC), and the EPCglobal Architecture Framework, both specified by GS1 (2012). This framework defines a middleware layer to support communication based on the physical exchange of objects, peer-to-peer exchange of data about EPCs, and EPC Network Services for shared service interaction. Such an ecosystem provides tools that can be employed for realizing a DOMe, and/or object-related data that may be linked with a DOMe. Beyond, emerging technical infrastructure platforms for the Internet of Things provide facilities for storing, retrieving and analyzing object memories. Examples include Xively[1] and Evrythng[2], which have recently been launched as commercial products.

Applications

DOMe-related applications can be found in manifold areas, such as logistics, retail, healthcare and digital cultural heritage. In line with the open nature of a DOMe, such applications often combine aspects of several scenarios, using physical objects as anchor or even data collector. For instance, Stephan et al. (2010) investigate the benefits of DPMs for controlling and documenting a highly flexible production and logistics process. Similarly, Kröner et al. (2011a) report on a retail scenario, where DPMs are applied to inform customers about various products' individual manufacturing and logistics processes. If desired, then the customer may exploit this data for configuring value-added services such as product recommendations and personal logistics.

Sustainable energy consumption and enabling cities and citizens to make smarter decisions are at the core of many research and political long-term agendas and policies like the EU Smart Cities and Communities program[3]. DOMe applications have the potential to enable and support many of these transformations and are thus of interest to wider audiences. However, currently only a few consumer-facing products that make use of digital object memories have been established in the market. A notable exception is the Nest Learning Thermostat[4]. Nest is fitted with a number of ambient sensors that observe and record people's behavior in their homes over time. The product aims to save energy through adjusting the temperature in homes based on what it "learned" from the data history.

Barthel et al. (2011) argue that linking objects with personal experiences may stimulate discussion and leverage socializing in user groups. In contrast to the process-oriented DPM, the Tales of Things Electronic Memories (TOTeM) project does not constrain quality and quantity of memory contents – it is up to the user to decide about contents he or she finds appropriate for a linking with an object. For this setting, it is crucial that people not in possession of the object are enabled to discover contents created by other people, and to comment on existing contents. Consequently, the TOTeM service employs a web-based infrastructure, which provides a single access point to all information linked by its community with some object. Beyond, discovery of objects (and their memory) is possible without having the object or even without its identifier. Examples of applications TOTeM include the augmentation of (second-hand) goods through digital media stories about their origin from previous owners, designers and producers and the enabling of collective records of people's interactions with cultural heritage artifacts in museums and heritage sites[5].