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A standardized approach to deal with firewall and mobility policies in the IoT

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HIGHLIGHTS

- A high-level description of new IoT standard named QLM is introduced.
- The QLM piggybacking property to deal with firewall and mobility policies is presented.
- A home automation case study dealing with firewall policies and using QLM is presented.
- A car automation case study dealing with mobility policies and using QLM is presented.

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ABSTRACT

Internet of Things (IoT) is intended to provide a network where information flows could easily be set up between any kinds of products, devices, users and information systems in general. This vision is getting closer to become real due to the continuous development of new information system concepts and technologies. Nonetheless, this new reality requires special attention on particular aspects of the IoT such as security and mobility. First, people and companies want to secure their assets/data using firewalls, which inevitably leads to a challenging conflict between data security and usability. Second, products are becoming increasingly mobile, operating in environments where it can be difficult to contact them directly using their IP address (e.g., due to the presence of NAT or to access restrictions). It might therefore be necessary in some IoT applications to enable two-way communications through any type of firewall, e.g. to enable real-time control and maintenance. Quantum Lifecycle Management (QLM) messaging standards have been designed to provide generic and standardized application-level interfaces for the IoT that make it possible, among other things, to achieve such two-way communication. This paper provides a high-level description of QLM messaging standards with a particular focus on this QLM feature, along with proofs-of-concept through real-life implementations in building and automotive domains.

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1. Introduction

In the so-called *Internet of Things* (IoT) and *Cyber Physical Systems* (CPS), mobile users and objects will be able to dynamically discover and impromptu interact with heterogeneous computing, physical resources, as well as virtual data and environments [1–4]. These visions are getting closer to become real due to the every day increase of concepts and technologies such as sensor hardware/firmware, semantic, cloud, data modeling, storing and reasoning [5,6]. Billions of

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devices are connected to the Internet and it is predicted that there will be 50–100 billions by 2020 [7]. As stated by Perera et al. [8], standardization is crucial in the IoT paradigm because it increases interoperability and extendability, but so far there is still a real need for sufficiently generic and generally applicable application-level IoT messaging standards. This is all the more true following the interpretation of the IoT given in [9], where the IoT is used in the sense of "*a generic information system for accessing and synchronizing any kind of product-related information, mainly over the Internet*". In this interpretation, the focus is given to the entire product lifecycle, in which the product operates through numerous business areas [10,11]. Within this context, the primary challenge is to provide standardized interfaces to enable complex business procedures and seamless information exchange among all product stakeholders and involved systems [12]. The design of such interfaces is an essential step to enhance product lifecycle management (PLM), while enabling the creation of a true IoT [13]. However, no proper agreement on a common standard for IoT data exchange between organizations has yet been reached or even proposed. Quantum Lifecycle Management (QLM) standards have been developed as a standard that would fulfill the main IoT requirements [14]. A fundamental requirement is to enable Peer-to-Peer (P2P) communication for all devices, even in mobile or secured environments.

The proliferation of mobile and pervasive computing devices over the past decade has made host and service mobility on the Internet a significant issue. Delivering data to a mobile host across a network address change (e.g., a NAT router) without disrupting existing connections remains a central challenge [15,16]. To compound this problem, people take proactive measures to ensure the security, confidentiality, and integrity of their assets/data using firewall and proxy systems [17–19] that inevitably leads to a challenging conflict between data security and usability; security making it more challenging to implement new services, while usability is required in order to achieve user acceptation of those services [20,21]. This is particularly true considering the entire product lifecycle since product-related data is a valuable resource for companies and should not be seen by other organizations [22]. Considering environments with firewall and mobility policies, it might be useful to allow information sharing in a P2P fashion despite the presence of firewalls, NATs, or similar systems (e.g., when developing real-time control or predictive maintenance services in the IoT [11,23]).

The QLM messaging standards propose a set of interfaces that enable, among other things, real-time communications as well as two-way communications with nodes located behind firewall/NAT systems. This property exploits the possibility to place further requests as a part of a response to an earlier request over the same connection. This concept is commonly referred to as "piggy backing" [24]. Section 2 provides the IoT background from a PLM perspective to understand the general interests of introducing such a new IoT standard. Section 3 provides a high-level description of the QLM specifications, followed by Section 4 that presents in greater detail the QLM piggy backing property. Two real-life applications implemented in the contexts of home automation and car diagnostics, each one dealing with different security and mobility aspects, are presented in Section 5; conclusions follow.

2. IoT background from a PLM perspective

Product lifecycle management (PLM), is commonly understood to be a strategic approach that incorporates the management of data associated with products of a particular type, as well as the business processes that surround it [22]. These product definition data typically consist of detailed specifications, user manuals, computer aided design (CAD) drawings, manufacturing instructions, service manuals, disposal and recycling instructions and so forth. For such traditional PLM, the product information generation process seems to end after production. When the product enters actual use, PLM mainly signifies providing access to the existing information but hardly any new information is generated about the products. This is, perhaps, a reflection of the point of view of the manufacturing industry that tends to see PLM mainly as a distributed knowledge management task of the "extended enterprise" [25] that created the product. With this view of PLM, there has been only slight interest in how the customer uses each individual product, or in how that product has behaved.

Inter-organizational data exchange is a pre-requisite for any kind of PLM in the context of the extended enterprise. In PLM, it usually signifies the transfer of electronic documents or business data from one computer system to another, i.e. from one trading partner to another without human intervention. Data exchange requires some kind of physical media for transmitting the data from one system to the other, a protocol that allows determining what a system should send when and where, one or more interfaces that send and/or receive data, and a semantic layer for understanding the data in a uniform way. The further up we go on the "protocol stack" towards the semantic level, the more challenging it is to create data exchange standards that are unambiguous, while providing a sufficient power of expression. When dealing with product instance-enabled PLM, the need for adequate standards becomes even more flagrant due to the presence of people, embedded devices, and mobile devices that need to communicate with each other in ad hoc and context-dependent ways. Concepts such as "Product Agents" and "Intelligent Products" [26,27] have been proposed as solutions for enabling such item- or instance-enabled PLM, as well as the IoT.

Such concepts were the cornerstones of the product instance-enabled PLM solutions developed in the PROMISE EU FP6 project.[1] QLM standards emerged out of this project in which real-life industrial applications required the collection and management of product instance-level information for many domains involving heavy and personal vehicles, household equipment, phone switches, *etc.* Information such as sensor readings, alarms, assembly, disassembly, shipping event, and

[1] http://promise-innovation.com.

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