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Research Article

"LIDO" FOR MEDICAL THINGS

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ABSTRACT

This article deals with the application of an Internet of Things (IoT) universal modelling language called "LIDO" to model the Internet of Medical Things (IoMT). "LIDO" has six (6) different view each represents an aspect of the IoT domain. A first View is interested to the user. This can be doctors or hospital staff. The second view, the "Human-Object" view represents the main objects of IoMT namely Medical Things. The Third view, the network view represents the aspects of Remote Health Monitoring (RHM) and the use of "Fog Computing". The fourth view, the service view encapsulates the capabilities of a Medical Thing in a service that can be integrated with enterprise medical processes. The fifth view, the context-time view represents the information about a situation of a patient relevant to his health state. The sixth and the last view, the localization view represents mainly the geographic position of a patient. The modelling of IoMT by "LIDO" will expand the space and the scope of IoMT and its applications.

Keywords: "LIDO", Modelling language, IoT, Internet of Medical Things, E-Health.

INTRODUCTION

Model Driven Software Development (MDSD) [2] is a branch of model driven engineering applied to software engineering. The characteristic of MDSD is that the model represents the objective and the product. The interest lies in the fact that a model is expressed in terms of concepts that are neutral and independent of any implementation technology likely to change. As part of our research, we worked on a meta-model called "MODIDO" [5]. It is a generic meta-model formed by a selection of concepts from the Internet of Tings domain (IoT). It complies with MOF which represents a super-layer [3]. This meta-model is intended for any developer, having any particular culture. The meta-model is of elevated level of abstraction to strengthen its scope along its universality. Indeed, "LIDO" was designed as a universal language that can be used for all IoT application domains [7]. "LIDO " is based on the meta-model called "MODIDO" which constitute the abstract component of "LIDO". A textual notation constitutes the concrete part of "LIDO". Internet of Things (IoT) plays a vital role in the field of healthcare. The development of smart sensors, smart devices, advanced lightweight communication protocols made the possibility of interconnecting medical things to monitor biomedical signals and diagnose the diseases of patients without human intervention and termed as Internet of Medical Things (IoMT) [1]. This paper is interested in adapting "LIDO" specifically to medical objects. The reminder of this paper is organized as follows. The section II deals with the "LIDO" language, its principals and its role in a development process. The section III presents briefly, the internet of medical things. The section IV describes how IoMT can be modeled with "LIDO". The section V summarize the modelling of IoMT using "LIDO language" and its benefits on the space and scope of the first.

"LIDO" A UNIVERSAL MODELLING LANGUAGE

What is "LIDO"?

To answer this question, we can say that a development team is usually made up of a multitude of actors with different profiles and concerns. To collaborate, these actors need to understand each other and to share a common language [7]. This language must support an IoT culture that is sufficiently horizontal to bypass the differences in the profiles of the actors. "LIDO" is such a language. "LIDO" is made of an abstract part which is a meta-model of IoT domain and a concrete part which is a textual notation. Guillemin P. and Friess P. postulate: "The Internet of Things allows people and things to be connected Anytime, Anyplace, with Anything and Anyone, ideally using Any path/network and Any service» and have deduced that the IoT has six (6) views [8]. A first View is interested to the user, the man and its applications. Man as a user is an entrepreneur of interactions with its local or remote environment. The man's environment is, here, a virtual space to which it has an interest. This space is composed of a number of physical objects capable to ensure an active life on the net through digital counterparties. Storage, calculation and communication capacities support these digital counterparties. A second view puts the light on these objects. A service is a normative unity of treatment. One of the contractors of the interaction invokes it. A service represents a choice of composition for the integration of these contracts. Services are the purpose of a third view. An interaction occurs in a given context. A context is made of facts, conditions and events accompanying and influencing such an interaction. A fourth view is interested with contexts. The man and his objects interact using network infrastructures and communication protocols. A fifth view is concerned with these means of interaction. Mobility of men and objects poses a problem of localization, which is a subject of a sixth view [5].

"LIDO" in the development process

"LIDO" is a language that allows the entire development team, including the end users, to discuss and exchange design and implementation ideas about an IoT solution. The approach foresees that, in a first phase, the development team derives a generic meta-model called "MODIDO" formed by a selection of concepts from the IoT domain. This meta-model constitutes the abstract component of "LIDO". The team then obtains a solution model made up of draft and unfinished objects. This is a kind of meta-design. The second phase

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consists in furnishing the objects of the solution by describing them in detail through a textual notation constituting the concrete part of "LIDO". In a third phase, the noted solution will be transformed by code generation to arrive at a draft of a feasible solution. The different phases are carried out in cascade. Each phase, like a pipeline architecture, represents the source, the raw material, for the phase that follows [7].

Internet Of Medical Things (IOMT) a dedicated IoT for medicine

A series of technological and cultural revolutions are allowing technology and people to be better connected to one another, leading to the development of a network of connected, smart devices and objects that can communicate with each other and automate key tasks. This leads to the invention of Internet of Things (IoT). IoT technologies are increasingly benefiting the health care sector, as advances in computing power, wireless technology and miniaturization are driving innovation in connected medical device development. The large volume of data created, along with the devices themselves, IT systems and software, connectivity technologies and services, are combining to create the Internet of Medical Things (IoMT). IOMT is defined as the medical things that can transfer data over a network without human-to-human or human-to computer interaction [1]. IoT, in healthcare, offers several benefits such as enabling doctors and hospital staff to do their work more precisely and actively with less effort and intelligence [2]. During the COVID-19 pandemic, there has been an increase in telehealth practices due to physical distancing guidelines that require healthcare professionals to operate patients remotely via IoMT devices [4]. This allows the medical technology (Medtech) industry to design and manufacture a wide range of medical products that help to diagnose, monitor, and treat diseases and health conditions. There are more than 500,000 medical technologies currently available, which all share a common purpose – having a beneficial impact on people's health and quality of life [9].

MODELLING MEDICAL THINGS WITH "LIDO"

"LIDO" offers six (6) views to model a reality, a present reality or a future reality. The models of these views are made using Unified Modelling Language (UML) notation [14] and Star UML tool.

The "User View"

The first view of "LIDO" is the "User View". A user is someone (a human being) or something (application, augmented object: physical object with ICT capabilities) that takes advantage of the digital capabilities of a physical object to interact with it [7]. The human being through a simple browser or through one of its applications will be able to interact with a physical object (real world object) and take advantage of its services. Examples of interaction consist in accessing the capture services of an object, or accessing the actuation services of an object. The interaction between users is only a sequence of accesses to the services offered by physical objects. Figure 1 illustrates this view.

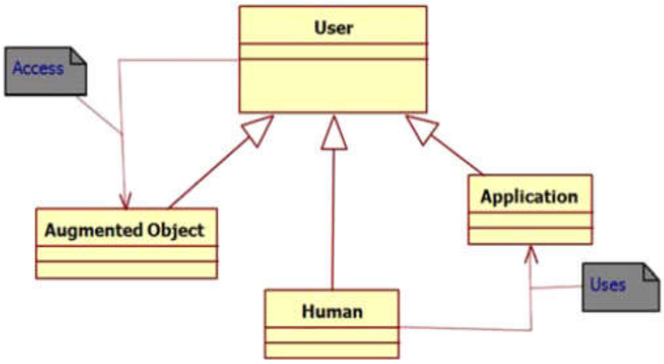

Fig. 1: The "User View" of "LIDO"

To apply "LIDO" to medical objects, just take the doctors and the hospital staff for humans, the ICT[1] applications for application and the augmented object for a medical thing. Thus, we obtain the diagram illustrated by figure 2.

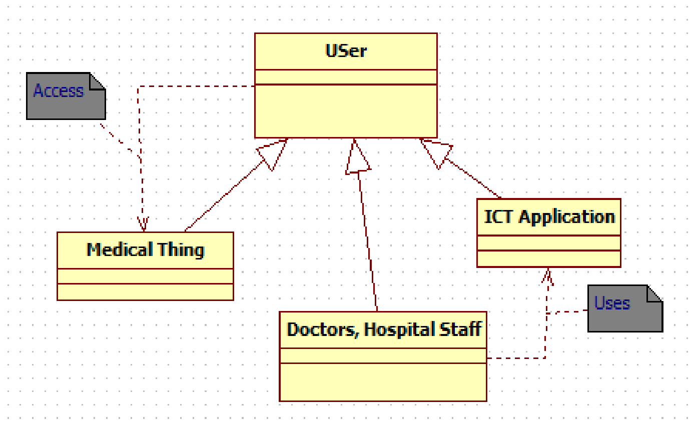

Fig. 2: The "User View" of "LIDO" applied to Medical Things

The "Human-Object View"

The progress and convergence of micro-electromechanical systems, wireless communications, and digital electronics have allowed the development of miniaturized devices with the ability to sense, compute and communicate wirelessly over short distances. A device is considered, here, as a Black Box whose composition details are hidden. A device can have information capture, processing and communication capabilities that allow it to augment a physical object and that it can itself be part of a more complex device. These devices have the advantage of providing a "ubiquitous sensing capability". This is essential to the realization of Weiser's global vision [10]. The awareness capability of an augmented object is its consciousness of its environment. This awareness of the environment testifies to an intelligence. For this it is called smart object and which together with similar objects form a smart space. Figure 3 illustrates these concepts.

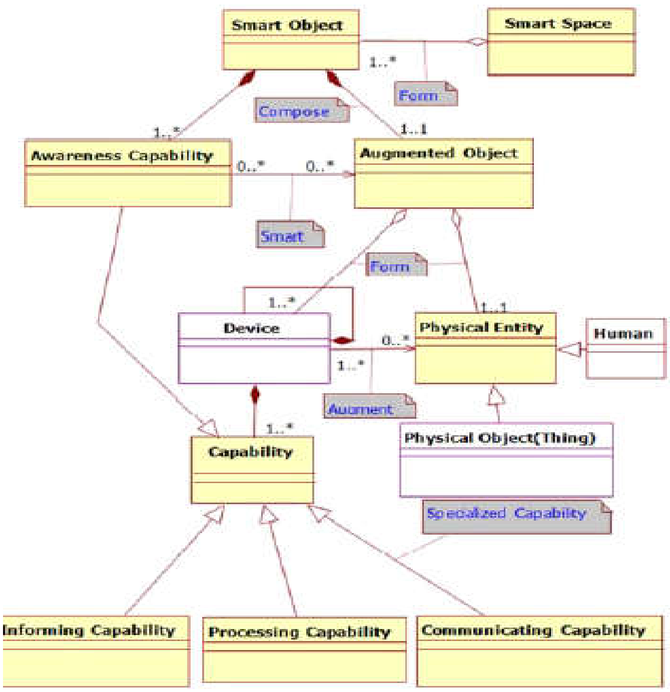

Fig. 3: The "Human-Object View" of "LIDO"

To apply the "Human-Object View" of "LIDO" to IOMT, we consider that a device (sensor or other electronic component) augments an element of a human body by providing ICT capabilities to it. An awareness capability makes a Medical Thing even smarter. Smart Medical Things make for example a hospital a smarter one. Figure 4 illustrates all these transformations.

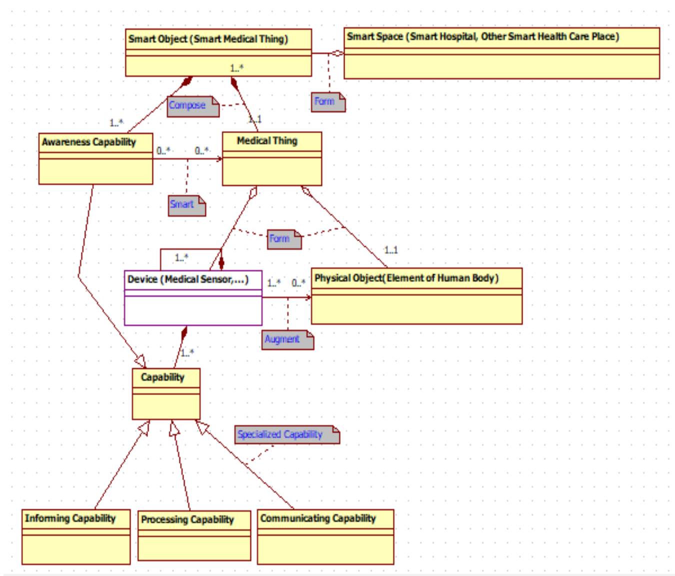

Fig. 4: The "Human-Object View" of "LIDO" applied to Medical Things

The "Network View"

A human or an application user access an augmented object which is a physical object with a device attached to it or imbedded in it through a local network generally a wireless one using one or more protocols. From local-to-local network with same or different topologies a bridge plays the role of a relay. Remote connections are provided by a gateway.

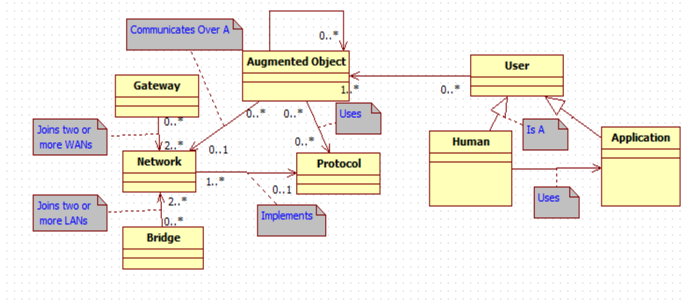

Fig. 5: The "Network View" of "LIDO"

Due to the advancement of fifth-generation wireless networks, the Internet of Medical Things (IoMT) has developed into a game-changing approach which offers a plethora of features and applications. It enables the connection of a large number of devices in order to form a unified communication architecture. Remote Health Monitoring (RHM), also referred to as Remote Patient Monitoring (RPM), is the process of using Network technology to monitor patients in non-clinical environments, such as in the home especially for monitoring heart conditions and diabetes. This is often done by using 4G or 5G medical devices. Mobile-based health care is well established among the people because of the influence of smartphones in their day-to-day life. The era of mobile health is starting from the simple footstep counters to real-time physiological signal monitoring system. The wearable such as smart watches, smart t-shirt, etc. can be paired with the smart-phones via Bluetooth or NFC (Near Field Communication) to provide visualization of their vital signal status in real-time [1]. Cloud computing for medical purpose is based on a mobile device, cloud servers, and a network which provides real-time access to the resources in anytime and anywhere. "Fog computing" is a distributed structure of cloud computing that aims to make the data processing closer to the network edge which provides more suitable options to overcome the limitations of cloud computing [11]. To apply the "LIDO Network View" to IOMT we have to consider that physicians, doctors and medical staff are kind of users of RHM software to access medical things. Medical things are accessed via local wireless networks. "Fog computing" infrastructures are reached via gateways.

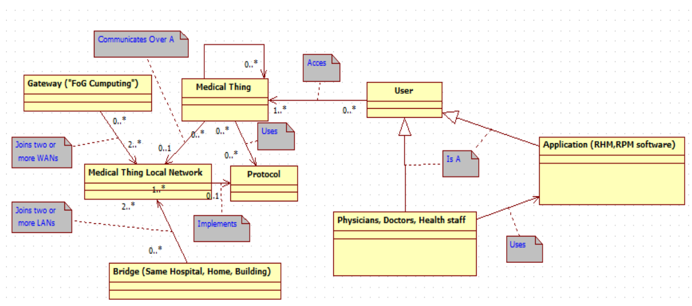

Fig. 6: The "Network View" of "LIDO" applied to Medical Things

The "Service View"

The "Service View" model illustrated in figure 7, uses the concept of a physical object augmented by a device whose functions are encapsulated by a service. This device service extends a generic service. It can be a service operating independently of the enterprise business services. Such a service can be bundled with other device services to form an independent "mega-service" or it can be part of an integrated service grouping together device services, enterprise business process services and mediators or communication facilitators. Independent and other integrated services are deployable on nodes (processor-based machines).

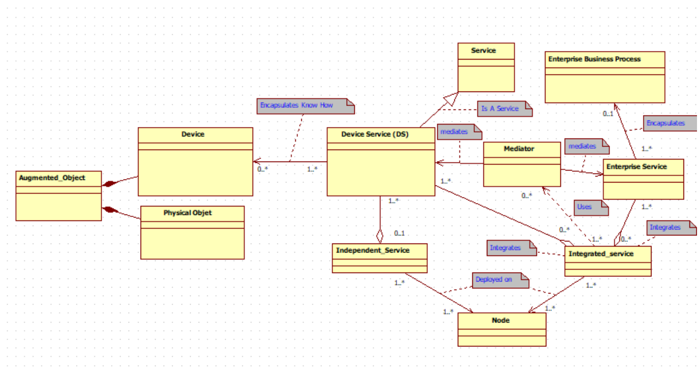

Fig. 7: The "Service View" of "LIDO"

To apply the "Service View" of "LIDO" to Medical Things, we consider that the enterprise process is a hospital or an E-Health company process. This process can integrate one or more medical things services. A medical Thing service encapsules the ICT capabilities of one or more devices attached to or embedded in that thing. Independent Medical Things or integrated ones can use "Fog computing" capabilities for storing or calculating medical data in a secure manner.

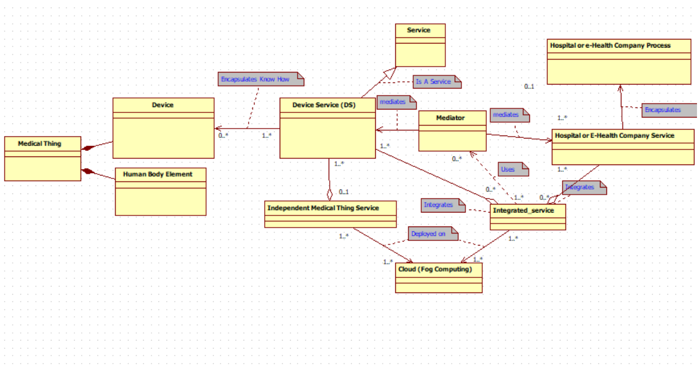

Fig. 8: The "Service View" of "LIDO" applied to Medical Things

The "Context-Time View"

To understand any scene, such as an interaction between a human and a system, one must understand the rules that govern this interaction and the behaviors of the human and the system. To deduce these rules and the reasons for the behaviors or attitudes of the participants in an interaction, one must know the context in which this interaction took place. At this stage, we can confuse context with information to situate an interaction and its participants. This information can be taken from a human or a device surveilling a physical object. In order to evaluate the situations in which these participants act, one must know the context and the period of time during which the situation and its interpretation is valid. In the other hand, a context attribute is an element of the context model describing the context. A context attribute has an identifier, a type and a value, and possibly a collection of properties describing specific characteristics [12]. This introduces the notion of template, which considers that a context model is formed of context attributes. Figure 9 illustrates these concepts. To apply this "Context View" to Medical Things, one can say that the physical object is a human body element and that a Human is a doctor, a patient's family member, a patient's friend or a patient itself. All these people can inform on the patient situation. A physical entity is the entity to situate. Figure 10 illustrates the application of the context view of LIDO to Medical Things.

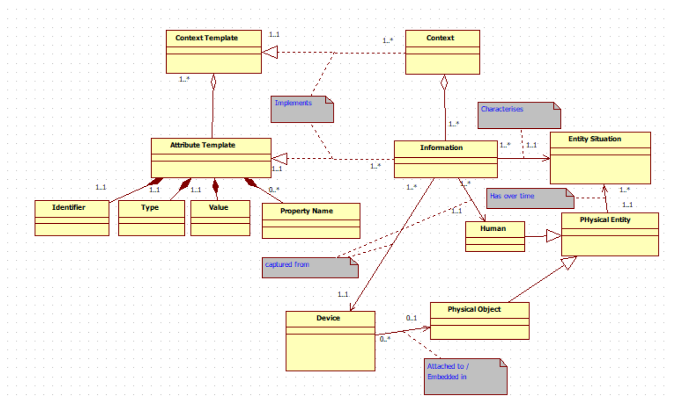

Fig. 9: The "Context-Time View" of "LIDO"

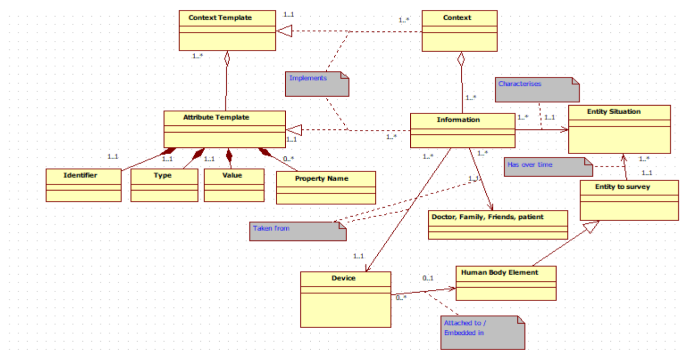

Fig. 10: The "Context-Time View" of "LIDO" applied to Medical Things

The "Localization View"

Location plays a key role in determining the type and nature of human activity. Location can determine consumers' information needs and their choices of products and services. If a mobile service provider knows the exact location of the user, and is able to target useful (and billable) information based on the user's location and time space, the interest can be shared. Thus, one of the contributions of location is the targeting of specific needs and the offering of the studied solutions. The techniques and means of location are many and varied. The Global Positioning System (GPS) is the most widely used satellite positioning system, which offers maximum coverage. GLONASS is the Russian equivalent of the United States GPS. GalilEo is the European version. Today, many cellular or wireless networks exist. These networks communicate with mobile equipment by radio. Location based services are any service that takes into account the geographical location of an object using sometimes different generations of RFID (Radio Frequency IDentification). These localization techniques and means are intended to provide a location service. Figure 11 illustrates all these concepts.

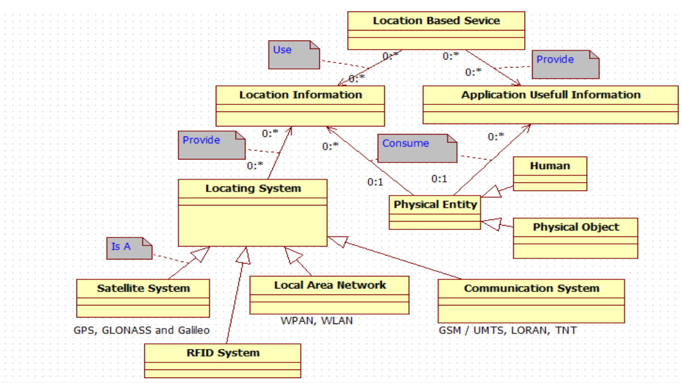

Fig. 11: The "Localization View" of "LIDO"

To apply the" Localization View of LIDO" to Medical Things we have to consider that the location information is about a patient or a medical thing and that this information and other useful information are used by RHM or other E-Health Software. Figure 12 shows this application.

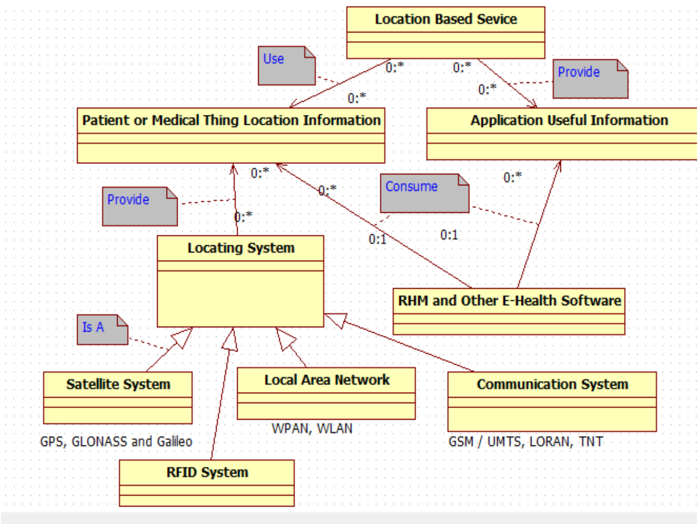

Fig. 12: The "Localization View" of "LIDO" applied to Medical Things

CONCLUSION

This research work presented in this article is a vision coupled with a modeling language called "LIDO" of how Electronic Medicine should be represented. A well-structured articulation between the medical knowledge of man and the intelligence of the machine, whether it is a machine with a processor, or equipment fitted with electronic chips will make the internet of medical things a success. Networks and communication equipment are there to expand the space and scope of E-Health applications. LIDO is the subject of the author doctoral thesis [13]. "LIDO" is a modelling language for the internet of things composed of six (6) views each representing an aspect of what we want to model. These views are: The user view, the human object view, the network view, the service view, the context-time view and the localization view. Internet of Medical Thing is a special case of the internet of things. Therefore, IOMT can be modeled by an IoT universal, multi-domain language such as "LIDO". In continuity of this work, we can specialize the textual notation of LIDO, generated thanks to Xtext [15], for the medical field and Medical Things. Once this is done, we can then program a "Python" code generator to help in the development of Medical Things applications.

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