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BPMN Extensions and Semantic Annotation in Public Administration Service Design

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Abstract. Internet of Things (IoT), and in general the Internet of Everything (IoE), are deeply influencing the business processes Digital Transformation, also in the Public Administration context, introducing new actors and interactions among People, Process, Data and Things. Therefore, a re-design of the processes or the creation of new ones is necessary, in a way that the design of a public service meets needs and skills of different end users (citizens, business managers, experts, etc.). This paper presents a framework for the design of public service user interfaces that, on the basis of domain ontologies and BPMn extensions, support the modeling of new interactions with IoT and bot services, in particular Telegram Bots, in the context of public administration processes. A service semantic annotation model can be shared with and reused by other organizations, thus reducing the user interface design and implementation time, and consequently the overall service development time.

Keywords: Business Processes, Internet of Things, Bot, BPMN, Ontology, UI design

1 Introduction and Motivation

In the Smart Cities context, the revolution triggered by Internet of Things (IoT) and, more generally, by Internet of Everything (IoE), enables new processes and modifies the existing ones, such as signaling of inefficiencies via APP, geolocalized tourist information service provided via OpenData, thus creating new value and new business opportunities for the involved communities. People and new types of information are increasingly connected, autonomous and semi-autonomous things are now active participants in digital processes. The four pillars of the IoE (People, Things, Process and Data) are being increasingly crucial factors in the Digital Transformation of Public Administration (PA) processes, which move from traditional document workflows to processes that involve both human and non-human actors.

Effective Business Process (BP) digitalization is essential to provide efficient services, and to quickly respond to the citizens' needs. Smart City actions aim to enhance city performance by using data, information and information technologies, such as IoT, in order to provide a more efficient service to citizens, monitoring and optimizing existing infrastructure, increasing collaboration among various stakeholders and encouraging innovative business models in the public and private sectors.

The potential value of a Smart City is fully exploited when data from multiple IoT networks are combined to enable new knowledge in a process, and even in a different application domain. In addition, social media, instant messaging platforms, chatbots, Artificial Intelligence, and OpenData have transformed the communication between PAs and citizens in an increasingly "smart" way, enabling new processes, also through citizens' involvement. We can identify three different communication types between PAs and citizens:

- broadcast (1:N): via different institutional communication channels (web site, Facebook page, etc.) to inform the citizenship;
- direct (1:1): via email, Instant Messaging, user identification;
- participative (N:M): via social platforms, active citizenship platforms, etc.

However, there are several gaps introduced by the implementation of IoT/IoE in business processes, and generally by the BP Digital Transformation in Smart Communities contexts:

- the Business Process Management notation (BPMn) 2.0 [1], used for modeling processes, does not provide classes and artifacts able to model the interactions with IoT/IoE elements;
- in IoT-based processes and in Public Administration contexts the same data (possibly provided by a smart device, such as a sensor) may be of interest in multiple processes and application domains. This introduces semantic issues about assigning the most appropriate meaning to data and information;
- technical interoperability issues due to IoT devices heterogeneity, which affect the of device description;
- different types of end users interacting with the processes, who are characterized by different skills and have to be provided with graphic layouts and semantics representations suitable to their skills.

To address these issues we refer to the KSM - Knowledge Stratification Model framework [2], which guides technical experts in designing IoT and IoE based public service interfaces with a user centered perspective and semantic approach. This paper introduces a PA service interface design framework, based on ontologies to describe the three KMS layers and an extended BPMn process modeler able to manage the specificities of IoT and IoE. The framework aims to contextualize data in PA processes and public service user interfaces (UIs) from a semantic point of view, through ontologies and controlled dictionaries, in a multi-stakeholder - user-centered - development process. In fact the interaction and knowledge sharing among all stakeholders (technicians, process analyst, domain experts, end users) is necessary both in the process modeling

and in service design phases, in order to ensure usability and user experience of the final PA service UI.

This paper is organized as follows. Section 2 provides a brief overview of the existing studies on BPMn extensions and on semantic approaches in IoT and IoE contexts. Section 3 illustrates the proposed BPMn extension for IoT and bot-based processes. Section 4 introduces the proposed framework to support PA service UI design by means of a semantic approach. Section 5 reports conclusions and future work.

2 Related Work

Traditionally, IoT-based information and events are represented via web services in BPM systems (BPMs) [3], because BPMn 2.0 supports modeling URI-based service tasks. This approach simplifies the systems for business process management and is compatible with existing BPM tools. Unfortunately, many IoT devices do not work as regular web service entities. For example, there is often the need of intermediary services to enable systems to access the devices; or tasks such as sensor data streaming are continuous tasks that cannot be explicitly represented by standard BPM notation [4]. A common solution is to extend the notation introducing specific IoT elements, thus differentiating the tasks in which they are involved from those with standard BPM services [5].

In the literature, there are several proposals of introducing IoT elements in existing modelling standards as BPMn, according to different perspectives: as Events [6], Resources [7], Services [5], Participants [8]. They define new notations in order to represent IoT elements in the models, i.e., an IoT process is described as a Pool and IoT device activities are modelled in Lane [7], real world Physical Entity are modelled through Participant notation [9], etc.

Some research projects [10, 7] propose frameworks for theoretical IoT-driven business process modelling, others for practical system integration in order to involve IoT elements in the intra-organisational or in the inter-organisational level [5]. The IoT-A project [11] focuses on designing IoT-driven BP models, proposes a meta-model of BPMn extensions, and provides a guidance for the (re)design of processes.

To the best of our knowledge IoE elements have not been much investigated. Only *social media* have been deeply explored and BPMn extensions and design patterns have been defined to represent their behavior [12].

Finally, semantic technologies are applied both to IoT domain [13] and BP modeling in order to re-use and include semantic models, as IoT-BPO or IoT-Lite. In Italy, several ongoing initiatives are coordinated on digital and technological transformation of PAs, promoted by AGID¹ (Agency for Digital Italy) and the Department For Digital Transformation of the Presidency of the Council of Ministers. In this frame, the OntoPia project² defines a common language for data exchange among Italian PAs. By means of shared ontologies and controlled vocabularies, the project aims to the standardization and semantic interoperability of Italian PAs' knowledge, data integration, sharing and

¹ <http://www.agid.gov.it>

² <https://github.com/italia/daf-ontologie-vocabolari-controllati>

reusing of public data. The *Designers Italia*³ project is developing guidelines for Italian PA service design.

3 Extending BPM notation to IoT and Bot-based processes

Integrated tools and approaches, such as BPM, are needed to support the Digital Transformation of public process. BPM is a structured approach to process modeling and management, which can be extended in order to include other constructs, for modelling and managing new relationships and interactions enabled by technology.

We have defined BPM extensions for IoT and Telegram Bot according to Stroppi's approach [14], which defines a procedure to transform a conceptual domain model to a BPMn compliant extension model through mapping and transformation rules. The approach is based on the following steps: 1) definition of a conceptual domain model of the extension as UML class diagram; 2) transformation of the conceptual domain model into a validable BPMn extension model (BPMN+X); 3) transformation of BPMN+X into an XML Schema Extension Definition Model; 4) transformation of XMLSchema Extension Definition Model into an XML Schema Extension Definition Document (XSD).

3.1 BPMn Extension for IoT

We consider IoT elements as process Participant, and we start from the domain model defined by the IoT-A project [11]. This model was modified and extended according to ISO/OGC Observation and Measurement (O&M)⁴ and to the IoT Ontology defined in OntoPIA project⁵. In the UML conceptual model we propose for the IoT-domain (see **Fig. 1**), *IoTService* is a generalization of the *Performer* class that defines the resource performing an *Activity* (SendTask, ActuationTask, etc); *IoTDevice* is a pool, its features are assigned using the *IoTSpecifications* relationship, and is referred to a DeviceType (sensor, actuator, gateway, etc). In this way future extensions are possible. Moreover, the *Observation* class describes observations, results and sampling features; the *Measurement Quality* class represents the observation quality or measurement parameters defined by the IoT ontology, such as Latency, Accuracy, Replicability, etc.

³ <https://designers.italia.it>

⁴ OGC 10-004r3 and ISO 19156:2011

⁵ <https://github.com/italia/daf-ontologie-vocabolari-controllati>

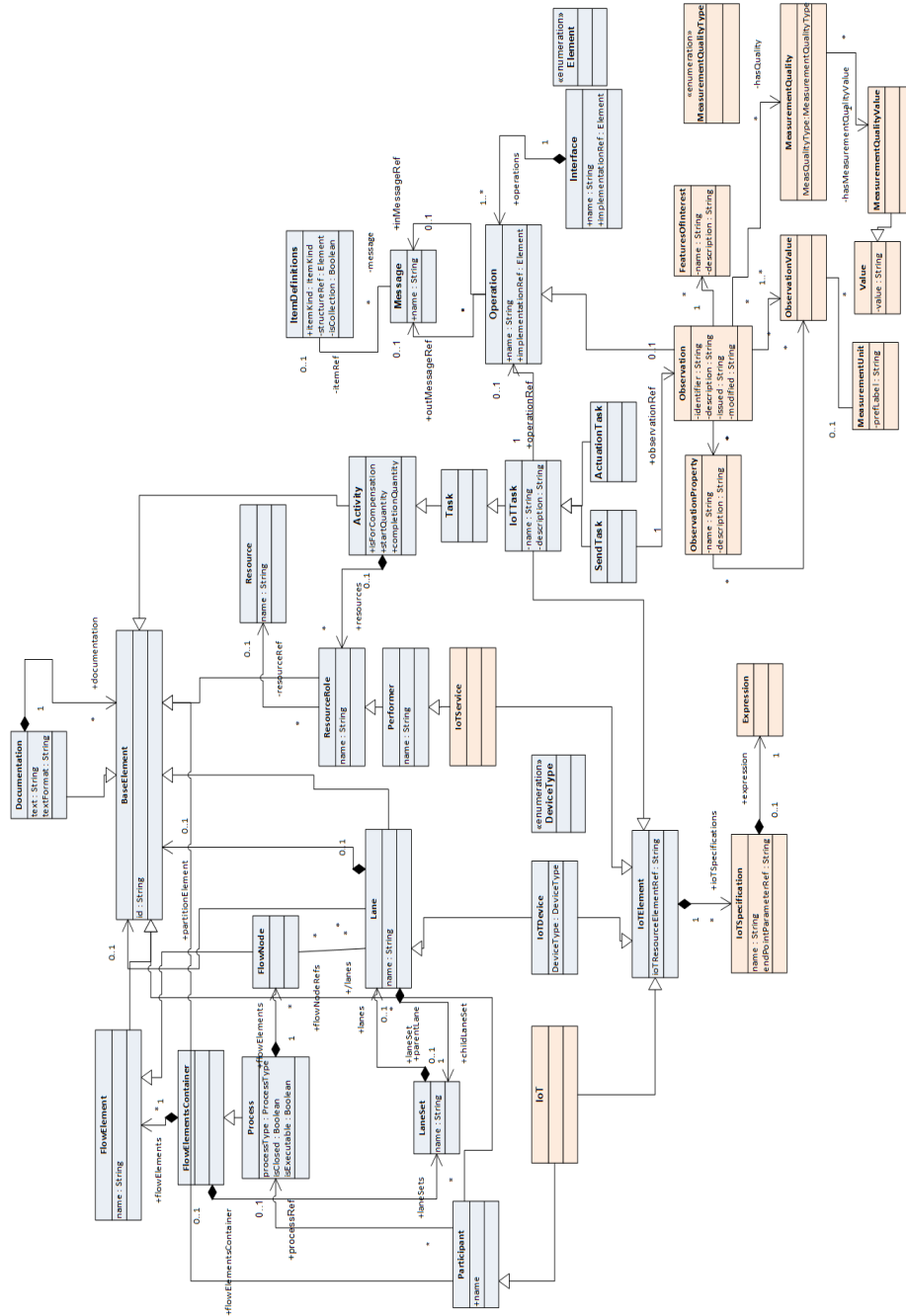


Fig. 1. UML representation of the BPM conceptual model of the IoT-domain; classes in blue are a subset of those proposed by the IoT-A initiative [11], classes in pink are the proposed extensions. High-resolution image available at http://tiny.cc/HCSE2020_material

Then, according to Stropi's methodology [14], an XML-schema extension model was defined and finally an XSD with the BPMN+X model transformation was generated. The XML schema is used into a process modeler tool in order to design processes with new extensions that are visually represented by new graphic constructs (**Fig. 2**).

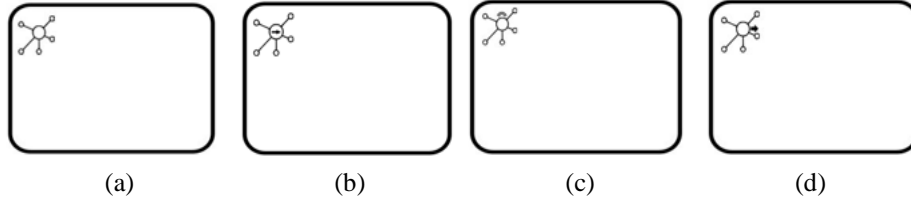


Fig. 2. IoT-extension graphic constructs: (a) Sensing Task; (b) Actuation Task, (c) Gateway Task, (d) Stream Task.

3.2 BPMn Extension for Bot

To the best of our knowledge, there are no BPMn extensions modeling bot interaction, although these bot services are widely spreading in Open Government context.

Bots are programs that can perform autonomous actions or execute commands when receiving inputs; their applications are various (marketing, customer care, search engines, etc.), good or bad (fraudulent), but all share the same capability to imitate human behavior. For example, chat-bots mimic human conversations; bots programmed for search engines or for fraudulent purposes copy the way human browse the Web. Telegram Bots, in particular, have spread, also in Public sectors, because they exploit the potential of the Telegram instant messaging platform, thus improving user's requests response and taking advantage of mobile device popularity. In the PA context, bot usage scenarios are various: personalized news, virtual desks, Open data browsing, alerts from citizens, etc. These services allow targeted communication from the PA to the citizen or to a community. From the other side, they enable citizen's interaction with the internal processes of the PA: for example, the bot can start specific PA processes for managing a problem reported or a claim submitted by citizens.

The Telegram Bot is configured as an active participant in the PA process, able to interact with other actors, to automate some steps of a traditional process, to call up external services or other bots, to activate social services, custom tools, payments and games⁶. The UML domain conceptual model provided in **Fig. 3** shows an excerpt of BPMn meta-model classes, highlighted in blue, extended with bot classes.

⁶ <https://core.telegram.org/bots>

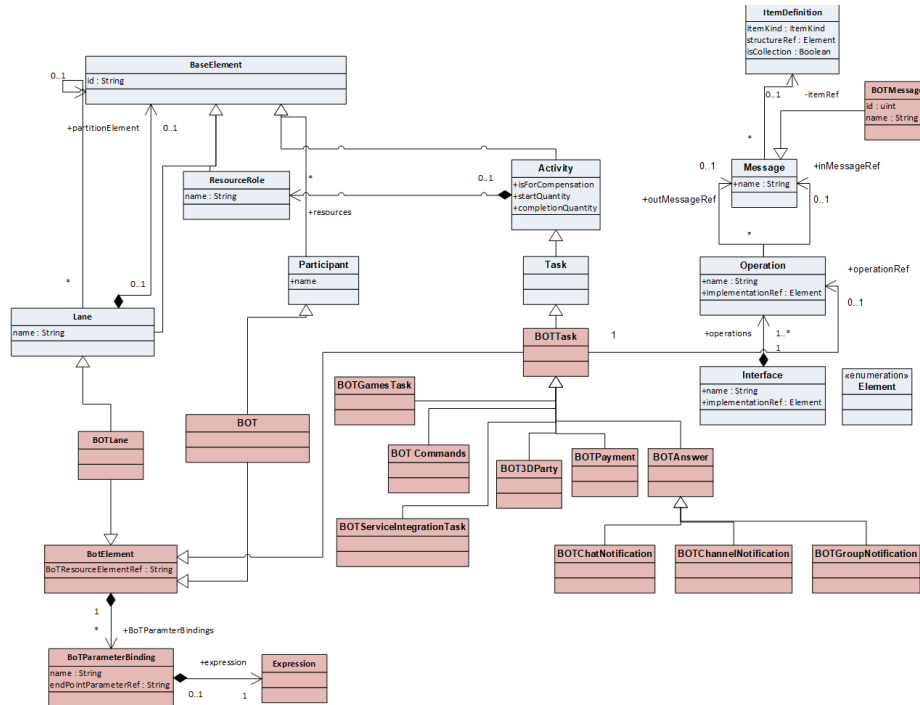


Fig. 3. UML representation of the BPM standard meta-model (classes in blue) extended with Telegram Bot classes (in pink). High-resolution image available at http://tiny.cc/HCSE2020_material

The *BOT* class is a generalization of *Participant* class, because BOT has a role in the process, i.e., it is responsible for performing tasks. Its graphical representation is a Pool. The *BOT Lane* is a generalization of the *Lane* class, because bots can interact with other bots. The *BOT Task* class represents a program that resides in the Telegram server; it is specialized in other classes: *BOT Commands* is the communication task to execute activities scheduled for the command; *BOT answer* is the activity for posting a response via chat, group or channel, represented by the corresponding classes; *BOT Game* allows users to play with another user or in a group by receiving a game message; *BOT Payment* allows to accept payments from Telegram users; *BOT Service Integration* combines responses from external services, third-party REST services or other bots (*BOT Inline*⁷). The *BOT Message* is a generalization of the *Message* class that represents different bot message types: voice, text, audio, video, document, game.

Errore. L'origine riferimento non è stata trovata. shows our proposal of graphic constructs to be embedded in process modelling tools in order to model bot behaviour.

⁷ Inline bots are embedded in other bots that cite them through the “@<inlineBotName>” call.

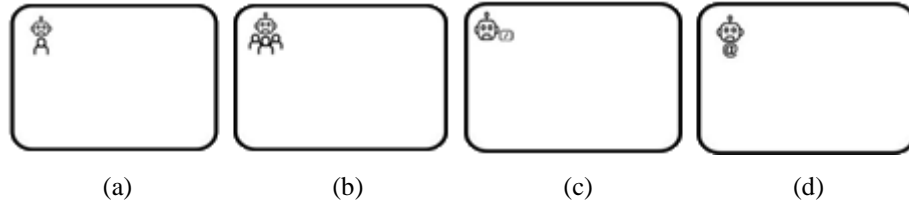


Fig. 4. Graphic constructs to model bot behaviour: (a) Chat notification, (b) Group or Channel Notification, (c) Commands, (d) Inline.

3.3 IoT and Bot BPMn Extensions: a case study

The proposed IoT and bot extensions have been used for modelling already existing PA processes and to define new ones. The Municipality of Lecce (Italy), for example, has implemented a process, managed by the municipal police via a Telegram channel ([@polizialocalelecce](https://t.me/polizialocalelecce)⁸), to deliver communications to citizens. The channel has 6378 subscribers (data referred to March 2020), who, through messages, photos, links, receive weather alerts, traffic and road incidents information, and any other relevant communication for the community (**Fig. 5a**).

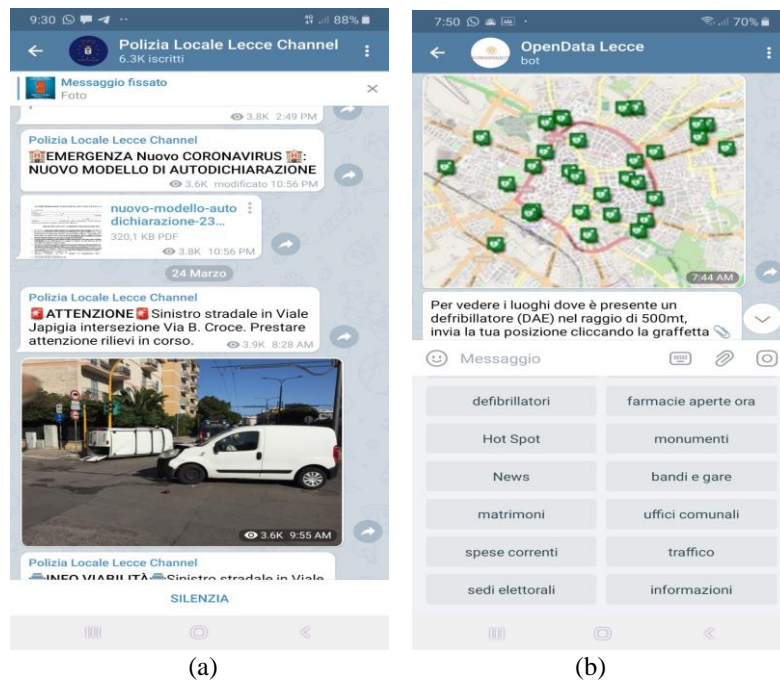


Fig. 5. (a) Telegram channel of the municipal police of Lecce. (b) Telegram Bot to explore OpenData of Municipality of Lecce.

⁸ <https://t.me/polizialocalelecce>

When the municipal police receives a report of an event from a citizen, it is verified and inserted in the internal information system; then, after complementing the event with further details, the alert is possibly broadcasted to citizens via the Telegram channel. These data are organized in datasets, published on the OpenData website⁹ that, as shown in (Fig. 5b), can be explored by means of a bot telegram (@opendataleccebot¹⁰) [15].

The alerting and management process of the municipal police, as outlined in Fig. 6, has been designed with the Bpmn.io¹¹ open source process modeler, extended with the IoT and IoE graphic constructs we have presented in the previous subsection.

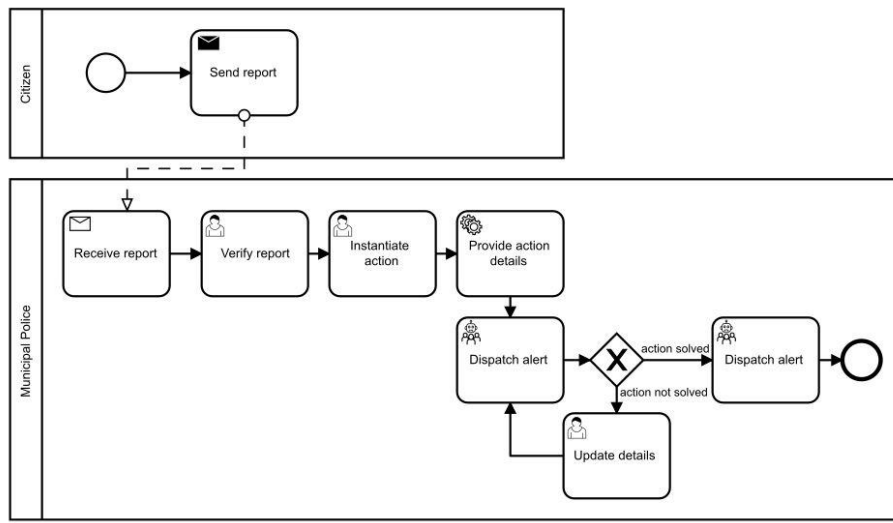


Fig. 6. Citizen-report management process by the municipal police.

4 A semantic framework to public service UI design

The proposed framework adopts the typical approach of *service design* [16], an approach to design according to the needs of customers or participants, so that the service is user-friendly (for participants), competitive (for organizations) and generates a quality experience for both parties involved allowing to achieve the desired goal.

In the PA context it is important to focus on the citizens' needs: it means to investigate, through user research activities (such as web analytics or interviews and focus groups), how the user uses the system, and to ensure that all features are designed around her needs and mind models, allowing her to get easily and quickly what she requires, also by means of new technologies, without unnecessary steps and with un-

⁹ <http://dati.comune.lecce.it/>

¹⁰ <https://telegram.me/opendataleccebot> (<https://www.piersoft.it/i-miei-bots-telegram/>)

¹¹ <http://www.bpmn.io>

derstandable instructions. Through a multidisciplinary approach, services must be designed around the citizens' needs and not on the basis of the requirements of the organization that provide them. This affects the semantic constructs to be used, the graphic design and the implementation on the different devices.

We are creating a tool that supports the design of the public user interfaces of a service through a semantic annotation of the service management processes, the graphical constructs adopted and the intended users. By involving domain experts, technicians, PA employees and end users, the semantic annotation is performed according to the three layers of the KMS [2], i.e. real world data provided by IoT/IoE resources, domain knowledge embedded in the business processes and user needs to be satisfied by the final application.

The framework is composed of three main elements (see the top layer of **Fig. 7**):

- 1) the *Semantic Annotator tool*. It provides a BPM modeler, extended to visualize the IoT or IoE based process that manages the resulting service; an *Annotator* that enables the annotation of the process by means of the concepts available through the *Ontology Visualizer*; a *UI modeler*, based on open source Rdf forms library¹², that creates RDF descriptions of public service user interface.
- 2) the shared *Ontologies* (e.g., Ontopia, BPM, domain), which contain the concepts to be used into the service annotation activity performed by means of the Semantic Annotator tool.
- 3) the *Ontology Adapter*, which allows the Semantic Annotator tool to access via REST services the Ontologies.

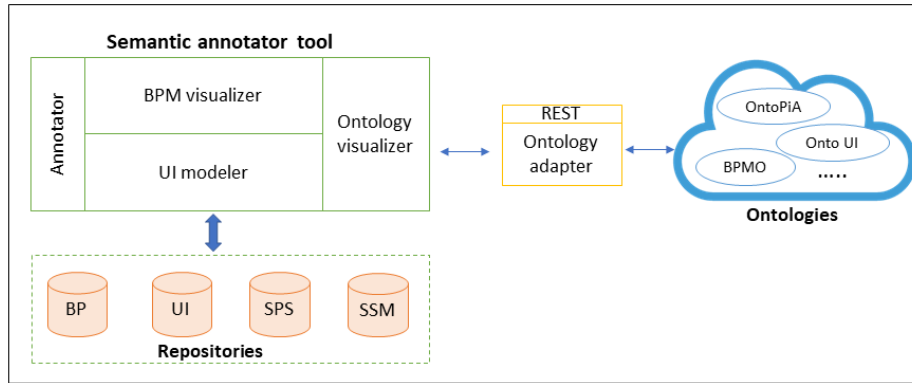


Fig. 7. High level overview of the semantic framework.

The data layer consists of four *Repositories*. The *Business Process (BP)* repository stores metadata and references to BP models that manage services; the *UI template (UI)* repository includes the specifications of UI patterns; the *Semantic Public Service (SPS)* repository stores service metadata descriptions, the included BP and UI components references and semantic annotation model references; the *Semantic Service Model (SSM)* repository stores service semantic annotation models defined with the Semantic

¹² <http://www.rdforms.org>

annotator tool.

The framework enables the semantic annotation of a UI-Process-IoE triad and the definition of public service metadata, which will be used for software development by programmers. The Onto adapter facilitates the introduction of new ontologies, thus to guarantee extensibility over time.

The framework generates a semantic annotation model and a RDF description of Public service UI, that can be browsed, shared, or reused by other PAs, in order to reduce UI-design time, and consequently development time, according to the code sharing and reusing objective of the Open Government approach.

5 Future work

In this paper, we presented a framework to support the design of user interfaces of a public administration service. Such services use increasingly pervasive technologies such as IoT and IoE and are characterized by a multi-stakeholder design process, typical of Smart City initiatives, involving technical experts, PA domain experts, and citizens. The processes that manage such services are new or redesigned to include the interactions of non-human elements such as IoT or bots; for this reason, an extended process modeler tool with BPMn extensions for IoT and Telegram bots has been presented. A semantic tagging of service interfaces and business processes that manage it will allow, in the development phase, to identify the UI constructs and the most appropriate semantics in relation to the end user, to use a semantics shared throughout the entire PA community, and a correlation between interfaces and processes within the organization. Moreover, semantically annotated interface models can facilitate the reuse and sharing of the same models within the community, exploiting the potential of the semantic web. As future work, we are in the process of assessing the quality of the proposed framework. We are working with an ENAC accredited European laboratory for software product certification based on ISO 25010 standards. A qualitative and quantitative analysis has been defined, which can respond to two hypotheses: do the notation and process patterns introduced improve the usability in use, i.e. the user's understanding of the model both in terms of aesthetic layout and model interpretation time? Do the introduced patterns improve the quality of the model, in terms of comprehensibility, modularity? A study will be defined to investigate the understanding of the process model and the patterns by the end users, i.e. the technical experts who model the processes. For this reason, participants will be recruited among the employees of an IT company, who are the final recipients of what has been achieved with this research work.

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