PPROC, an Ontology for Transparency in Public Procurement

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Abstract. Public procurement or tendering refers to the process followed by public
authorities for the procurement of goods and services. Most public authorities in
developed countries provide online services to facilitate this process (e.g., available
at the buyer profiles of public authorities), as well as to ensure as much as possible
competitive tendering (for which an adequate advertisement of tenders is an
essential requirement). Besides, transparency laws being proposed in such countries
are making the monitoring of public contracts by citizens an essential right as well.
This paper describes the PPROC ontology, which has been developed to give
support to both processes (advertising and accounting), by semantically describing
public procurement processes and contracts. The PPROC ontology is extensive,
since it covers not only the usual data about the tender, its objectives, deadlines, and
awardees, but also details of the whole process followed from the contract initial
publication to its termination. This makes it possible to use the ontology both for
open data publication purposes (as others in the state of the art) and for the whole
management of the public contract procurement process.

Keywords. ontology, public procurement, open government data, legal institution

1. Introduction and motivation

In the context of public procurement, advertising has been always an essential part of the
process, as it fulfils a dual purpose: on the one hand, it is a resource to improve
competitive tendering and, on the other, it constitutes an instrument for transparency and
for the monitoring of the behavior of the contracting authorities [1]. This second purpose
is becoming increasingly important because one of the third-generation human rights is
free access to public sector information, which is now included in the laws of the majority
of developed countries [2].

With the progress of electronic government, the publication of information
regarding contracting procedures increasingly began to be performed using electronic
means. For instance, some European directives from 2014 created a specific mechanism
called the buyer profile: all public sector entities must have one and publish certain
information on it about the contracts that they put out to tender. Buyer profiles have
become the central information hub for companies and citizens when it comes to public

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procurement. However, its use has been severely limited by the major functional and technical differences between the different profiles of different public authorities and the lack of interoperability among them, what makes the integrated processing of the information published on them very hard (for instance, aggregating the total income for a specific company across all the public authorities in a group of countries)

One of the currently adopted solutions for this heterogeneity problem consists in forcing all public authorities to publish on a single website all announcements regarding tender procedures (e.g., the Public Sector Contracting Platform in Spain, https://contrataciondelestado.es). However, this solves only part of the problem; the part related to competitive tendering and, therefore, to economic efficiency since, in order to comply with this objective, it is enough to publish a limited set of announcements. However, transparency requires much more information, and transparency practices can be very different depending on the policies followed by each authority. Therefore, from the perspective of transparency, the solution involves preparing standards that could be used by administrations to publish all the information that they consider appropriate. To contribute to the development of these standards, we have created the PPROC ontology (http://contsem.unizar.es/def/sector-publico/pproc) with the aim to publish, in a structured and standardized manner, public procurement information on the buyer profiles of public authorities. This ontology has the potential to improve efficiency (for example, since it would enable computerized consultations of the profiles of the various administrations) and to facilitate access for all parties interested in information regarding public contracts. This means that not only contracting powers and tenderer companies, but also the general public as a whole has been considered in the design of this ontology.

The paper is structured as follows: we start with an analysis of existing ontologies in this domain, namely PCO and LOTED2 (§2) and a brief description of the ontology development method used (§3). The structure and main components of PPROC, as well as its relationships with other ontologies, are described in section §4. In section §5 there is a description of our experience with two Spanish public administrations that have been early adopters of this ontology and are now using it to publish structured information about public contracts in their buyer profiles. As a conclusion, we make some observations about the use of the concept "legal institution" in ontology development and its influence on the information structure.

2. Related work

Several projects have focused on public procurement processes within the scope of the Semantic Web. Among them we can highlight MOLDEAS, where authors describe a platform that retrieves, enriches and publishes public procurement data via a SPARQL endpoint [3]. Nevertheless, in our analysis we have focused on two works that have produced an ontology or a set of ontologies for the description of public contracts or processes, namely the Public Contracts Ontology (PCO), and LOTED2.

The Public Contracts Ontology (PCO) was published in 2012 [4]. One of its objectives was to demonstrate the application of Linked Data for contracts in the public sector, by emulating the market process of meeting supply and demand in order to produce a "business impact". With this purpose in mind, PCO models the main aspects of public contracts, although not in great depth. The ontology considers "only the information that is publicly available in existing systems on the Web […], mainly produced during the tendering phase". Hence, the result is a lightweight ontology that

reuses widely accepted ontologies and vocabularies such as VCard, Payments Ontology, schema.org, Call for Anything vocabulary and GoodRelations.

LOTED2 [5] extends the LOTED ontology [6] with the goals of (a) expressing the main legal concepts of the public contract announcements defined in legal sources, (b) supporting rich semantic annotation, indexing, search and retrieval of tender documents, (c) making possible the reuse of semi-structured data extracted from the TED system[2] and (d) enabling the integration with other ontologies and vocabularies about related domains. The ontology bases most of its content on the two directives that at the time of its development regulated public contracts in Europe (Directives 2004/17/EC and 2004/18/EC)[3] and is the result of a thorough study of legal documents. This means that the legal content of European procurement is heavily present and rigorously represented in LOTED2.

These two ontologies differ in two main aspects. One is the source of the ontology knowledge. PCO uses worldwide sources of information, trying to identify an information core of the domain of public contracts. It includes TED, DG Market (http://www.dgmarket.com/), and the national public procurement web site in the Czech Republic as information sources. In the case of LOTED2, focused on defining a complete legal ontology, its main sources of information are European directives. The second aspect—the complexity of the ontology—is closely related to the first one. PCO defines most of the information a public contract may need, but some specific relations, roles or behaviors are not strictly represented (e.g. the contracting body or distinguish between objective and subjective award criterions). On the other hand, LOTED2 represents almost every aspect of public procurement, including the properties needed to label information from the TED web site. The result is that the model is closely related to the text of the 2004 directives, which reduces its durability—in fact, this regulation has already been severely modified by the new directives that we have cited.

Consequently, as a starting point for the preparation of PPROC, we have taken PCO, because it is focused on the "institution" of public procurement and on the publication of information related to it.

3. Ontology Development Method

Our ontology has been developed following the method proposed by Noy [7], a widely accepted guide to developing ontologies. According to this method, the first step is to define the scope of the ontology. In a first approximation, it was identified by the knowledge required to express the information published on the buyer profile. This delimitation defined a clear scope of a size and complexity that was suitable to deal with the development of an ontology. And, in order to complete it, we used a set of competency questions (some of which are described in section 5.2). The following step was the study of the state of the art, the results of which have been shown briefly in the previous section, and which provided a basis for the development to be carried out.

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[2] The Tenders Electronic Daily (http://ted. europa.eu) is the online version of the Supplement to the Official Journal of the EU, dedicated to public procurement.

[3] Today replaced by the directives of the European Parliament and of the Council: 2014/24/EU, of 26 February 2014 on public procurement and repealing Directive 2004/18/EC; and 2014/25/EU, of 26 February 2014, on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC.

The enumeration of the relevant terms for the model was performed with two sets of stakeholders. On the one hand, the company iASoft, which has developed the buyer profiles of numerous Spanish administrations, compiled the fields included in the various documents published on buyer profiles. On the other hand, several legal experts analyzed the annexes of the European directives and Spanish legislation that specify the announcement models for their publication. Then, the ontology development team consolidated this information and used it as a basis to prepare an initial list of entities, including cardinality, domain and range for properties. This approach was completed and validated by the contracting managers of three public administrations, the Zaragoza City Council, the Provincial Government of Huesca and the Regional Government of Aragón.

At the same time, the classes and properties present in other ontologies that could be used to describe entities at a higher level were identified. Later, in order to link this set of entities to each other, in a joint task between ontology developers and legal experts, classes and properties were defined to organize the contents according to their nature and function. Therefore, although the strategy was basically bottom-up, as it started from the most detailed elements present in the buyer profiles and in the annexes to prepare an initial approximation of the ontology, an effort was also made to make them consistent with the highest-level concepts defined in other ontologies. Finally, the ontology was implemented in OWL.

These tasks were carried out during 2013 and the beginning of 2014. In April 2014, two of the aforementioned public administrations (Zaragoza City Council and the Provincial Government of Huesca) started labeling their buyer profiles according to the PPROC ontology, producing instances of the different classes and properties of the ontology. This ontology publication activity served as a basis for a review of the ontology, which was carried out jointly by the legal experts, the public administrations and the ontology development team. The objective of the review was to fulfil the labeling expectations of the public administrations whilst maintaining the legibility of the model.

4. Ontology description

4.1. Introduction

The PPROC ontology is built up around 12 main classes that describe the core concepts of a public contract (Fig. 1). The most relevant class of the ontology is `pproc:Contract`, which is connected to the classes `pproc:ContractObject`, `pproc:TenderRequirements`, `pproc:TendererRequirements` and `pproc:ProcedureSpecifications`. These classes allow describing the main characteristics of a public contract and its elements. Since we provide a separate class for each kind of element, it helps ontology users to better define the scope of searches. Some PPROC entities are aligned to PCO, and we define them as `rdfs:subClassOf` of their corresponding PCO classes.

The following subsections contain the definition of the main concepts of PPROC and their relation with existing ontologies. We explain the decisions made and compare our model with other ontologies as required.
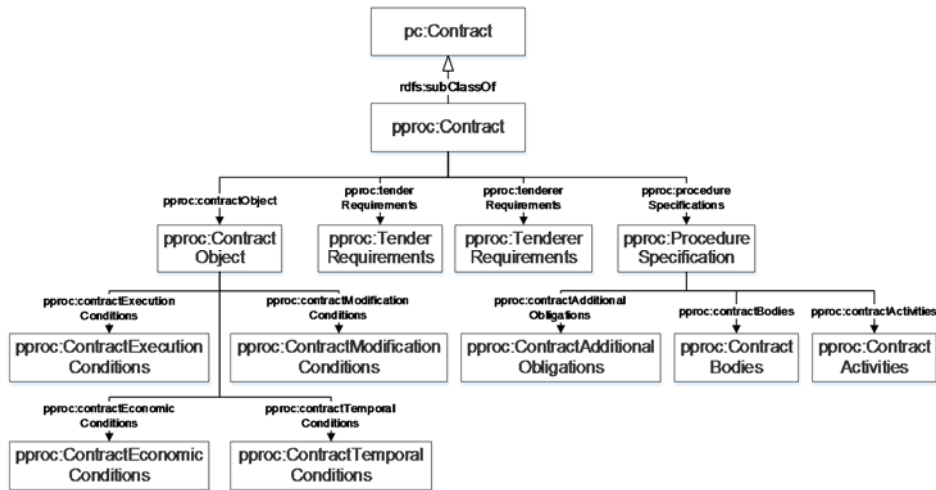
Figure 1. Contract "core" classes

4.2. Contract

As aforementioned, the class `pproc:Contract` is the main class for the definition of a contract. It contains the basic information about the contract and serves as an entry point to link to the other classes. We define `pproc:Contract` as a subclass of `pc:Contract`. The `pc:Contract` class is used as the domain of data properties such as `dcterms:title`, `pc:tenderDeadline` or `pc:actualEndDate` among others. Many of these properties are being reused in the PPROC ontology and thus do not require changes. However, many other properties are rewritten, as PPROC has specific classes to describe these properties, as explained below. Fig. 2 shows a diagram of the ontology, including the classes directly related to the concept of a contract. There we can see several external entities being reused, from PCO and also those related to prices from the GoodRelations Ontology.
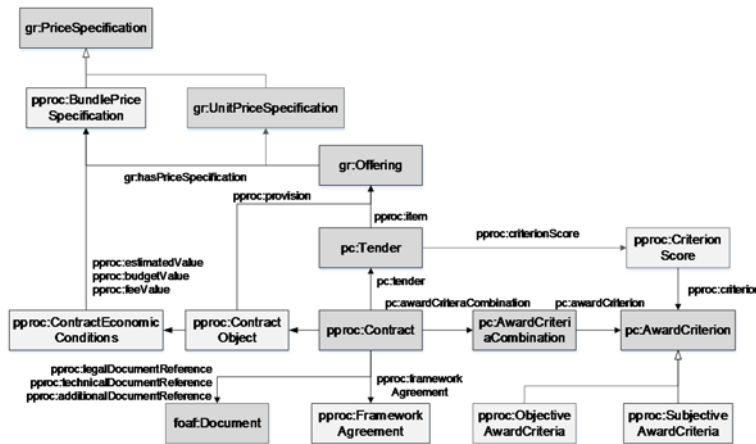

Figure 2. Contract-related classes

Public contracts may belong to many different categories (they can be contracts with and without lots, extendable, multiannual, etc.). Initially, we considered two different alternatives to categorize these types of public contracts: SKOS classification schemes [8] (e.g. the PCO ontology uses two of them for this purpose: `pc:ProcedureTypeScheme` and `pc:KindScheme`, to which `pc:Contract` is linked through the properties `pc:procedureType` and `pc:kind` respectively), or several class taxonomies for the different types of contracts. We have opted for the later option (creating several class taxonomies to replace the use of `pc:KindScheme`), because (a), we wanted to specify more clearly the different types of contracts that we may have to deal with and (b), we added some class restrictions relevant for some of these classes (e.g. `pproc:ContractWithLots owl:subClassOf pproc:lot some pproc:Lot`).

Furthermore, contracts are not only classified according to their administrative type. Contracts can be also extendable, harmonized (i.e. reaches the threshold of regulation of European procurement directives), private or multiannual, etc. (see Fig. 3). Besides, contracts may be subdivided into lots. Each lot is a contract in itself, with a defined object and that can be awarded separately, but that forms part of a main contract. PCO instantiates contracts, with or without lots, and lots as `pc:Contract`; that is, this class is the domain and range of the property used to relate contracts to their lots (`pc:lot`). In PPROC (as in LOTED2) specific classes for each of the cases are created.
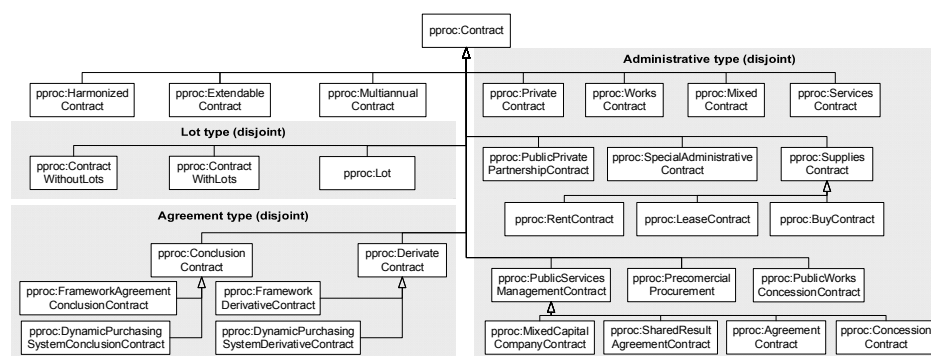

Figure 3. Classifications of the pproc:Contract class

4.3. Contract Object

Two different (non- exclusive) approaches can be used to define the object of the contract. The first one consists in using the `pproc:object` or `pc:mainObject` properties, which are especially appropriate for using the Common Procurement Vocabulary (CPV, http://simap.europa.eu/codes-and-nomenclatures/codes-cpv/codes-cpv_en.htm). It is exclusively used in EU procurement and consists of a main vocabulary for defining the object of a contract without entering into great detail, and a supplementary vocabulary for adding further qualitative information. There are also some implementations of this vocabulary in RDF, like the one available at http://cpv.data.ac.uk or the one described by Alvarez-Rodríguez and colleagues [9]. Besides, we proposed the use of GoodRelations [10] to describe products and services, prices and payment options in greater detail. PPROC includes two classes from GoodRelations: `gr:Offering` and

`gr:PriceSpecification`. The first one includes all properties needed to describe the object of the contract. However, when defining the price of a contract, a bundle of objects or a tender we find that `gr:PriceSpecification` and its known subclasses are not enough to describe some prices. Usually a `gr:Offering` contains a set of items the contracting authority is going to acquire. Its price can be set using the `gr:UnitPriceSpecification` class that defines a price of a single item of the offering (e.g. an offering contains 100 printers with the `gr:UnitPriceSpecification` specifying the price of a single printer). However, usually it also needs to define the prices of a set of objects as a whole, treating them as a single package, and to this end, PPROC includes the `pproc:BundlePriceSpecification` class.

4.4. Contract Parts

Besides describing the contract and its objects, we also need to describe the parts involved in a public procurement procedure. We use the Organization Ontology [11], which includes the classes and properties needed to describe organizational structures and their hierarchy, through the `org:Organization` class and `org:subOrganizationOf` property. The role that an organization plays in a given procedure or contract—contracting authority, delegating authority, the organization on whose behalf of a contract is being made, the contracting body, managing department and the specific supplier of a tender (tenderer)—is established by the property used to link it with the contract (see Fig.4). Note that in most cases we could use the `org:subOrganizationOf` property to describe the relation between the contracting body and the managing department belonging to a contracting authority.
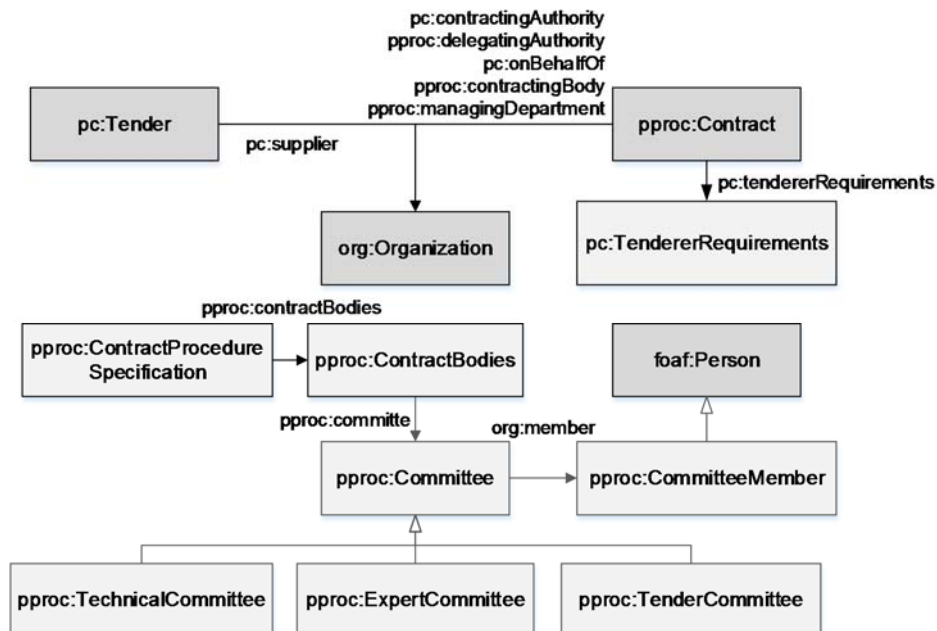

Figure 4. Parts-related classes

To describe the persons grouped together to perform a task of the procedure, we use the `pproc:Committee` class. These committees are known as contract bodies and could have different functions in the procedure. To differentiate them according to these functions, PPROC includes three subclasses of `pproc:Committee`. Members belonging to a concrete organization or committee are stated by using membership properties such as `s:member` or `org:memberOf`. Here we propose using properties belonging to other ontologies and vocabularies, such as the Organization Ontology itself, schema.org, Friend Of A Friend (FOAF, http://www.foaf-project.org/) or SKOS. There are several contents where the location or a specific place should be known (e.g. the office of the contracting authority or a tenderer, the location where the goods should be left or the place of a meeting), and to define them we propose using the `s:Place` class and properties of schema.org.

Next, the class `pc:Tender` is reused to describe proposals made by suppliers. PCO uses two properties to link tenders to their related contract: `pc:tender` and `pc:awardedTender`. Once again, we believe that the properties defining the nature of an object can be replaced by defining the `rdf:type` of such an object. Therefore, although we still use the `pc:tender` property, we created subclasses to further define a `pc:Tender` (`pproc:AwardedTender`, `pproc:AcceptedTender`, `pproc:ExcludedTender` and `pproc:FormalizedTender`). Finally, tenderers are also defined through the Organization Ontology and linked using the `pc:supplier` property from a `pc:Tender`.

4.5. Procedure

Another block of information is referred to the procedure followed during the procurement process. This includes the kind of procedure and all the information about it that could be useful to any party and the public, such as tender requirements, briefing meetings or information about remedies (see Fig. 5).
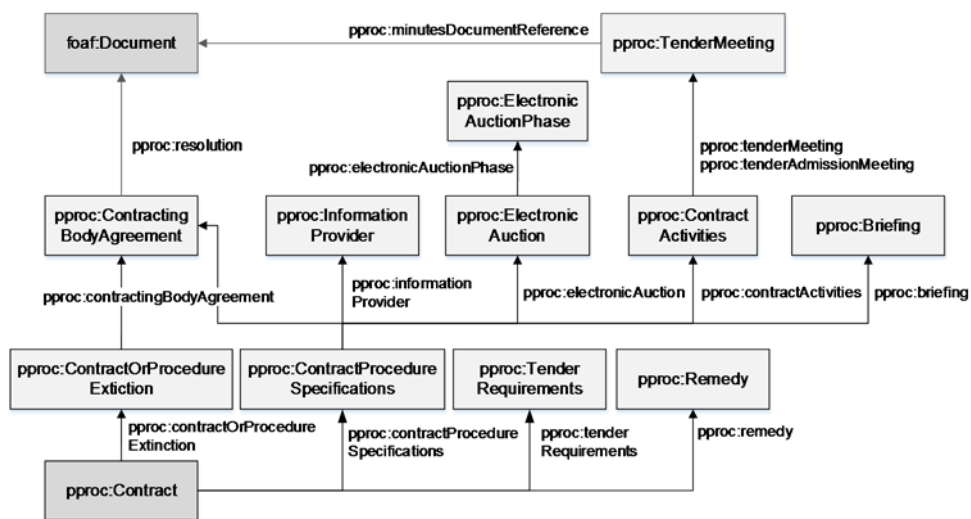

Figure 5. Procedure- related classes

In contrast to the decision made while classifying contracts and tenders, we use SKOS to define the procedure kind and its urgency, using two concept schemes (`pproc:ProcedureTypeScheme` and `pproc:UrgencyTypeScheme`). The use of SKOS is justified in this case because of its simplicity for this type of information where we do not have specific properties and property restrictions applicable to the different types of contracts and tenders. Both properties determining the procedure and urgency have `pproc:ContractProcedureSpecification` as their domain.

5. Usage of the ontology

As discussed in the introduction, this ontology is already being used by two public authorities of different size and scope (Zaragoza's City Council and the Provincial Government of Huesca), which are publishing open data about their public contracts so that they can be used not only by potential tenderers but also by citizens for transparency purposes. In both cases the corresponding PPROC-based RDF data is stored in a SPARQL endpoint (http://www.zaragoza.es/ciudad/risp/sparql.html and http://www.dphuesca.es/sparql respectively), which can be queried for complex information needs, such as those described in section 5.2. Additionally, in the case of Zaragoza, contracts are offered through their city API, providing data in JSON-LD (as described in section 5.1), as well as in other common formats like JSON, CSV, or XML. Finally, it is important to mention that this ontology is recommended as the ontology to be used by smart cities offering their public contract data according to the proposed technical norm at Spanish Association for Standardization and Certification (AENOR), PNE 178301 on Open Data for Smart Cities, which is at the time of writing in its public information phase. This technical norm is also proposing the use of other nine vocabularies for the publication of data on transport, tourism, air quality, businesses, etc., and has been jointly developed by a combination of private companies, cities and other regional and national public administrations in Spain.

5.1. A sample JSON-LD representation of a contract

In this section, we provide an excerpt of a Zaragoza city council's real contract description using JSON-LD. This contract description uses a good number of PPROC properties and classes and focuses on the most basic procurement data: title, procedure, notice, contract object and price, award criteria and, in this case, two tenders, one of them already awarded.

```
{
    "@context": "http://contsem.unizar.es/docs/context.jsonld",
    "@id" : "contzar:0308848-14",
    "@type" : [
        "pproc:Contract",
        "pproc:SuppliesContract",
        "pproc:HarmonizedContract",
        "pproc:MultiannualContract",
        "pproc:ContractWithoutLots"
    ],
    "dcterms:title" : "SISTEMA DE ENTRENAMIENTO CON FUEGO MEDIANTE PLATAFORMA
INDUSTRIAL PARA EL CUERPO DE BOMBEROS DEL AYUNTAMIENTO DE ZARAGOZA",
    "dcterms:identifier" : "0308848/14",
```

```
    "pproc:managingDepartment": {
        "@id": "orgzar:serviciocontraincendiosdesalvamentoyproteccioncivil",
        "@type": "org:Organization",
        "dcterms:title": "Servicio contra Incendios de Salvamento y Protección
Civil"
    },
    "pc:contractingAuthority": {
        "@id": "orgzar:1",
        "@type": "org:Organization",
        "dcterms:title": "Ayuntamiento de Zaragoza"
    },
    "pproc:contractProcedureSpecifications" : {
        "@id": "contzar: 0308848-14/ContractProcedureSpecifications",
        "@type": "pproc:ContractProcedureSpecifications",
        "pproc:urgencyType" :"pproc:Regular",
        "pproc:procedureType" :"pproc:RegularOpen",
        "pproc:notice": {
            "@id": "contzar:0308848-14/ContractNotice/anuncioDOUE",
            "@type": "pproc:ContractNotice",
            "pproc:noticeDate": "2014-05-14",
            "pproc:noticeSite": "DOUE",
            "pproc:noticeWeb": "http://ted.europa.eu/udl?uri=TED:NOTICE:161407-
2014:TEXT:ES:HTML&src=0"
        },
        "pproc:tenderDossierStartDate" : "2014-05-07",
        "pproc:tenderDeadline" : "2014-06-16T00:00:00",
    },
    "pproc:ContractObject" : {
        "@id": "contzar:0308848-14/ContractObject",
        "@type": "pproc:ContractObject",
        "pproc:mainObject" : "cpv:code-44212320",
        "pproc:provision" : {
            "@id": "contzar:0308848-14/Object",
            "@type": "gr:Offering",
            "dcterms:title": "SISTEMA DE ENTRENAMIENTO CON FUEGO MEDIANTE
PLATAFORMA INDUSTRIAL PARA EL CUERPO DE BOMBEROS DEL AYUNTAMIENTO DE ZARAGOZA"
        },
        "pproc:contractEconomicConditions" : {
            "@id" : "contzar:0308848-14/ContractEconomicConditions",
            "@type" : "pproc:ContractEconomicConditions",
            "pproc:budgetPrice" : {
                "@id": "contzar:0308848-14/priceWithVAT",
                "@type": "pproc:BundlePriceSpecification",
                "gr:hasCurrencyValue" : "1005656.00.00",
                "gr:valueAddedTaxIncluded" : "true",
                "gr:hasCurrency" : "EUR"
            },
            "pproc:priceReviewAllowable" : "false"
        },
    },
    "pc:awardCriteriaCombination": {
        "@id": "contzar:0308848-14/AwardCriteriaCombination",
        "@type": [
            "pc:AwardCriteriaCombination",
            "pc:AwardCriteriaLowestPrice"
        ],
        "pc:awardCriterion" : {
            "@id": "contzar:CriterionPrecioMasBajo,
            "@type": "pc:AwardCriteria",
            "pc:criterionName": "Precio",
```

```
                "pproc:evaluation": "Menor precio mayor puntuación",
                "pc:criterionWeight": "100"
            }
        },
        "pc:tender": [
            {
                "@id":"contzar:0308848-14/Tender1",
                "@type": [
                    "pc:Tender",
                    "pproc:AwardedTender",
                ],
                "pproc:supplier":{
                    "@type": "org:Organization",
                    "s:name": "DRAGER SAFETY HISPANIA S.A.",
                    "org:identifier": "A83140012"
                },
                "pproc:offeredPrice" : {
                    "@id":"contzar:0308848-14/Tender1/Item/PriceWithVAT",
                    "@type": "pproc:BudgetPriceSpecification",
                    "gr:hasCurrencyValue" : "1005653.99",
                    "gr:valueAddedTaxIncluded" : "true",
                    "gr:hasCurrency" : "EUR"
                },
                "pproc:awardDate" : "2014-08-20",
                "pproc:formalizedDate": "2014-09-18"
            },
            {
                "@id":"contzar:0308848-14/Tender2",
                "@type":"pc:Tender",
                "pproc:supplier": {
                    "@type": "org:Organization",
                    "s:name": "PREVENCIÓN DE INCENDIOS SEGURIDAD APLICADA S.L.",
                    "org:identifier": "B74024472"
                }
            }
        ]
}
```

5.2. Some sample SPARQL queries

As part of our ontology development methodology, we identified several competency questions that the ontology should solve. Some of these questions were defined with other stakeholders who wanted to make use of the data that was going to be published. In the following we provide some of these questions, which can be found in SPARQL format at https://github.com/pproc/pproc-sparql. All these competency questions can be solved through the Zaragoza's City Council SPARQL endpoint. In the case of Provincial Government of Huesca, due to the lack of additional information about their contracts, only the first four questions could be answered.

- First 50 contracts with most budget
- List of lasts contracts awarded
- Count of contracts by type
- Count of contract by procedure
- List of contracts grouped by managing department (i.e. water and sewer, gardening)

- List of suppliers that have worked with public authorities in the year 2014
- List of steps taken by a contract
- Number of formalized contracts between 11/11/2011 and the current date
- Actual price of all the contracts started, awarded or formalized in 2011, 2012 and 2013
- Total price of the formalized contracts with the supplier MULTITEC
- Id, subtype and date of the formalized contracts with the supplier URBANCO
- URI and names of managing department with most contracts

Besides these competency questions, we must note that public bodies must publish some indicators and data according to applicable freedom-of-information laws. Moreover, in some cases they have their own norms about this aspect, such as the Ordinance of Transparency and Free Access to Information of the Zaragoza's City Council. Even if it was not defined with this purpose, we have checked as part of our evaluation that the PPROC ontology also allows creating SPARQL queries that reflect literarily the text of the Ordinance, such as the following ones:

- A list of all contracts awarded by the City, classified by type and amount, indicating the object, the amount of the bid, the award and the final cost, the procedure for the award, the instruments through which have been published where appropriate, the number of participating tenders, the awarded tenders, the duration or timing of planned and actual implementation, modifications, and any other information of special interest to the public.
- Budget volume in percentage of contracts awarded by each of the procedures provided for in the legislation.

6. Conclusion and Discussion

In this paper we have described the PPROC ontology, an ontology for the description of public procurement that is already in use by two public authorities in Spain, and which has been recommended as the ontology to be used to publish open data about public contracts in Spain, according to the AENOR technical norm PNE 178301, what will ensure a higher level of uptake in the near future. The ontology has been developed following standard practices in ontology development, identifying competency questions with different stakeholders (public authorities, companies already working for them and legal experts), and published according to well-established recommendations for Linked Data vocabulary publishing. We have also provided examples of their usage, especially focusing on the generated JSON-LD context and a set of SPARQL queries that provide answers to the proposed competency questions.

In this process we have also considered carefully how to model legal knowledge related to contracts. Firstly, in the context of our public contract data publication process, we have started analysing the contract management applications used by the Zaragoza City Council and by the Provincial Government of Huesca so as to establish the equivalences between the information used in them and the PPROC classes and properties. In this analysis, we observed that the structure of the databases of these management systems was closely related to the temporal succession in which the information was being generated or received by the management bodies. This leads to

an organization of data that we could call "process-oriented", which often appears in the relational databases used by public administrations.

On the other hand, there are various initiatives whose purpose is to create standards for electronic procurement, including, within the scope of the EU, OpenPEPPOL[4] and CEN BII[5]. In both cases, XML formats that make it possible to structure the messages exchanged by the various agents involved in electronic procurement are defined. Also, as we have already mentioned, both the EU and national governments have created web sites whose function is to centrally publish information about public tenders. The announcements that are published on these web sites are among the first exchanges of information performed electronically using structured messages. However, to do this the administrations chose to create "de facto" standards, such as the one established for the TED eSenders and CODICE (https://contrataciondelestado.es/wps/portal/codice), defined for the Spanish PSCP. The objective of these standards is to achieve interoperability, which addresses communication between systems. Therefore, its domain is limited to the information that, at any time, is transmitted between the various organizations that are involved in the process. Moreover, the structure of the information is provided by the content of the documents that are exchanged. Consequently, we can call these XML standards "document-oriented".

Unlike the above situations, the development of ontologies is not based on elements associated with the proceeding—such as the sequence in which the information or communications actions are created—but with a general, all-encompassing view of the reality to be represented. In our case, this view is determined, because the objective of PPROC has not been the creation of models of general legal concepts, as happens in some core legal ontologies [11], but the modelling of a specific social mechanism, used to connect the contracting process of public sector entities. From the perspective of philosophy of law, this objective is related to the concept of a "legal institution" through which the physical, social and legal elements that comprise a given "social mechanism" are identified and described—such as marriage or contracts, for example—focused on the attainment of a defined objective. According to an approach based on the "theory of the institution" the central focus of the model would be public procurement, considered as a legal institution whose purpose is the attainment of a "product": a public contract [12]. This approach has appeared appropriate to us because this concept of a legal institution (or of the domain to be represented, which amounts to the same thing) as a group of resources focused on the attainment of an objective, is closely associated with the functional aspects of organizations, as is the case with computer applications or tools. For all these reasons, we can state that the PPROC ontology is "institution-oriented".

This perspective has determined the semantic relationships of the model. In systems of legal concepts, these can be organised vertically from the most general to the most specific. However, in an institution-based model, they can be organised according to the role that the concept plays within the "institution" that is represented. In the first case, the relationships are about belonging, but in the second—which is characteristic of what are known as operational families—they assume more complex forms [13]. In order to identify and define these relationships, the science of the law (legal doctrine) can be used,

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[4] OpenPEPPOL is an offshoot association of the Pan-European Public Procurement Online (PEPPOL) project (http://www.peppol.ue).

[5] CEN Workshop on Business Interoperability Interfaces for public procurement in Europe (http://www.cenbii.eu/) is an initiative of the European Committee for Standardization (https://www.cen.eu), an association that brings together the National Standardization Bodies of 33 European countries.

which is devoted to studying and organizing the legal elements that comprise institutions and the relationships between them. Therefore, the institution-oriented perspective is also appropriate to develop a model whose structure will be in accordance with that defined by legal doctrine. For instance, by following this organization in PPROC, it is possible to differentiate the objective elements—including the purpose of the contract—from the subjective elements—the parties—and the material elements—which are the elements related to the merits of the matter—from the formal elements—which are the ones related to the proceeding—and in accordance with these classification criteria, the ontology is divided into four blocks as shown earlier. As a practical result, this makes interdisciplinary work between engineers and legal experts easier during the development of the ontology and, once it is finished, the ontology is more understandable for legally-trained users and possibly for everyone else too.

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