USE OF SEMANTIC TECHNOLOGIES IN THE DEVELOPMENT OF AN ONTOLOGY FOR THE MANAGEMENT OF URBAN PROJECTS. THE CASE OF THE SEVILLE CITY COUNCIL

USO DE LAS TECNOLOGÍAS SEMÁNTICAS EN EL DESARROLLO DE UNA ONTOLOGÍA PARA LA GESTIÓN DE PROYECTOS URBANÍSTICOS. EL CASO DEL AYUNTAMIENTO DE SEVILLA

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1.- INTRODUCTION

The implementation and start-up of economic activities that generate wealth and employment in any municipality require obtaining municipal licenses and authorizations for which the drafting of a technical activity project is mandatory. All the interested parties benefit from the regulatory compliance with the urban and environmental legal requirements established by the municipalities for this type of projects. However, the numerous non-compliances detected in the "a posteriori" inspections carried out by the municipal technicians are causing that in many Spanish municipalities a high percentage of these projects are not viable and are paralyzed due to non-compliances in aspects such as accessibility for people with disabilities, incorrect location of the machines of the different facilities, smoke and gas outlets, lack of acoustic insulation, etc. [1]. The consequence of this situation is the enormous delay in the opening of the establishments, or even that some of the promoters of these projects desist from undertaking the activity.

In response to this serious problem, a Knowledge-Based System (KBS) is proposed that would significantly improve the legalization system of economic activity projects processed by *responsible declaration*[1] in Spanish municipalities. The *ENIA*[2] of Spain recommends as a line of action for the period 2020-2025, the development of data platforms and technological infrastructures that support Artificial Intelligence, including resources (*data, ontologies, models*) and inference engines for its use and promotion from the Public Administration. The World Wide Web (W3C) has established standards to create the Semantic Web, an extension of the World Wide Web aimed at making Internet data readable by machines (intelligent agents). Along these lines, the literature includes a good number of ontology proposals developed to meet different user needs in a wide variety of domains. However, very few of them have been developed for the evaluation of regulatory compliance [2], [3] and [4].

The transposition into Spanish law of European Union Directive 2006/123/EC [5] brought about a drastic change in the processes of legalization of new economic activities supervised by Spanish municipalities. Since then, the start-up of a

[1]Document signed by the owner of a business or professional activity in which he/she declares, under his/her responsibility, that he/she complies with the requirements established in the regulations in force, that he/she has the documentation that accredits this and that he/she undertakes to maintain compliance during the term of the activity.

[2]National Artificial Intelligence Strategy. https://portal.mineco.gob.es/eu-es/ministerio/areas-prioritarias/Orriak/inteligencia-artificial.aspx

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large number of economic activities only requires the prior presentation of a responsible declaration, eliminating the a priori control that in many cases was carried out by the city councils and replacing it with a subsequent control by the administration of the activities in operation legalized by responsible declaration [6].

The origin of this proposal arises from the low quality of project documentation, which has led several studies [7], [8], [9] and [10] to recommend different strategies to improve it, among which we can mention: checklists, independent reviews, establishment of standards for the quality control of project documentation, improvements in the education of designers, etc. However, this article proposes a methodology that applies semantic technologies to determine the feasibility of activities and reduce their high failure rate after subsequent control. The ontology developed would facilitate the decision making of the technical authors of the projects, of the promoters of these activities and of the municipal technicians responsible for monitoring compliance with the regulatory requirements demanded by the municipalities, thus minimizing business failures due to erroneous designs or incompatible with the urban and environmental regulations of the city where the investment is made. In addition, this novel Knowledge Based System, KBS could be integrated into a management software oriented to smart cities or Smart Cities and reduce the carbon footprint by the implementation of activities in cities [1]. Although the case study has been particularized for the city of Seville, with *701,455 inhabitants*[3], it could be applied, with minimal adaptations, to any of the more than 8000 existing municipalities in Spain.

2.-PROBLEM STATEMENT

The model currently followed for the legalization of most of the activities in the Spanish municipalities, in accordance with the aforementioned Directive, is based on the trust in the administrator and the subsequent supervision of his actions. This model was intended to streamline authorization procedures, facilitating the start-up of economic activities that are a source of wealth and job creation. However, this legalization scheme is proving inefficient and causing problems that affect all parties involved (see Figure 1).

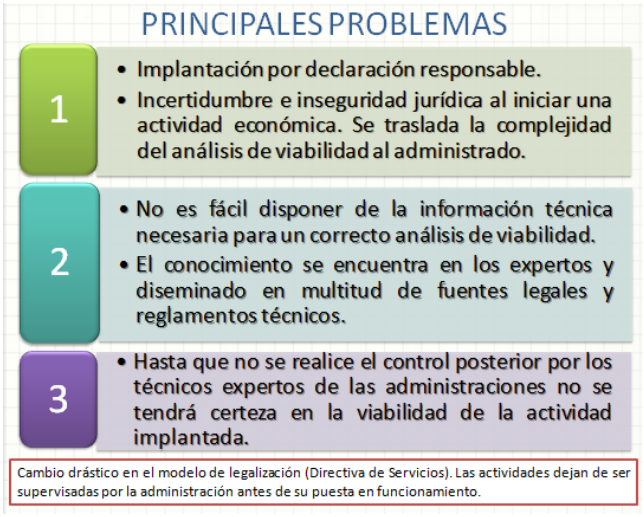

Fig. 1. Main problems in the implementation of activities by responsible declaration.

In the absence of prior control by the city council or legal support to allow it, it is found that a high percentage of activities, after its implementation and subsequent control, are unfeasible as they were initially designed and built. This circumstance means that many activities lose their operating authorization when their responsible declaration of commencement of

[3]Source: municipal census as of January 1, 2020.

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activity is rendered ineffective due to the deficiencies detected in the subsequent control, and have to be legalized again, and this is not possible in all cases, depending on the degree of unfeasibility detected. The degree of unfeasibility can range from slight to moderate, important or even complete unfeasibility. Cases of slight to moderate infeasibility have their origin in safety requirements, such as fire protection, safety in use, etc. or environmental requirements that are not met, but which can be remedied by carrying out works and installations to meet the unsatisfied requirements. The cases of significant unfeasibility have as an additional distinctive feature that some of the requirements that are not met are critical, as happens, for example, when the necessary works and installations require the permission of the owners of the rest of the property where the activity is located. Finally, cases of complete unfeasibility occur when, due to urban planning and/or environmental factors, the location chosen for the activity is a location that is not permitted or is incompatible with the territorial and urban model regulated by each municipality.

In addition to the frustration that the loss of the operating permit entails for the promoters of an activity, there are multiple disadvantages arising from the situation described above. In the first place, and in the best of cases, the loss of the operating authorization means that the activity has to be legalized again, which implies the execution of new works and installations (demolition of works carried out that are useless, reform works, reform of installations, etc.). Secondly, the operation of activities that does not comply with the requirements generally produces an impact on the environment that can affect the population, such as noise pollution, light pollution, smoke, odors, etc. Thirdly, the economic losses for all parties involved associated with the necessary actions, which in the case of an activity implemented in an unpermitted location, involves the loss of the investment made by the promoters of the activity and the social cost derived from the loss of jobs associated with that activity. All this, in addition to generating economic losses and delays in productive activity, slows down the economic development of cities.

In view of the above circumstances, this paper presents a solution based on semantic technologies. The problem posed is very complex, due to the large number of different types of economic activities that can be implemented and their particularities (*1011 types of economic activities*)[4], to the diverse urban planning of the existing Spanish municipalities *8151*[5], to the extensive technical regulations, to the environmental and sectorial legislation, which makes that an individual designer is not able to control all the aspects for the legalization of activities. Therefore, an ontology with a conceptual scheme of the domain of the implementation of economic activities is presented with the aim of supporting the realization of technical consultations prior to the implementation of activities, through the automation and recovery of prior technical consultations that help the agents involved in the implementation of activities, avoid business failures and improve the efficiency of the system of legalization and initiation of activities. Figure 2 shows the agents involved and the integration of the knowledge base in the municipal processing system, which aims to facilitate the legalization process, determining the feasibility prior to its implementation by checking the technical and regulatory requirements necessary for the correct start-up of activities to optimize the subsequent control procedures and minimize errors in the administrative authorization of such activities by responsible declaration.

[4]EU classification of economic activities (NACE Rev.2) https://www.ine.es/daco/daco42/clasificaciones/cnae09/nace11_nace2.pdf

[5]National Institute of Statistics - (01-01-2015) http://www.ine.es/daco/daco42/codmun/codmunmapa.htm

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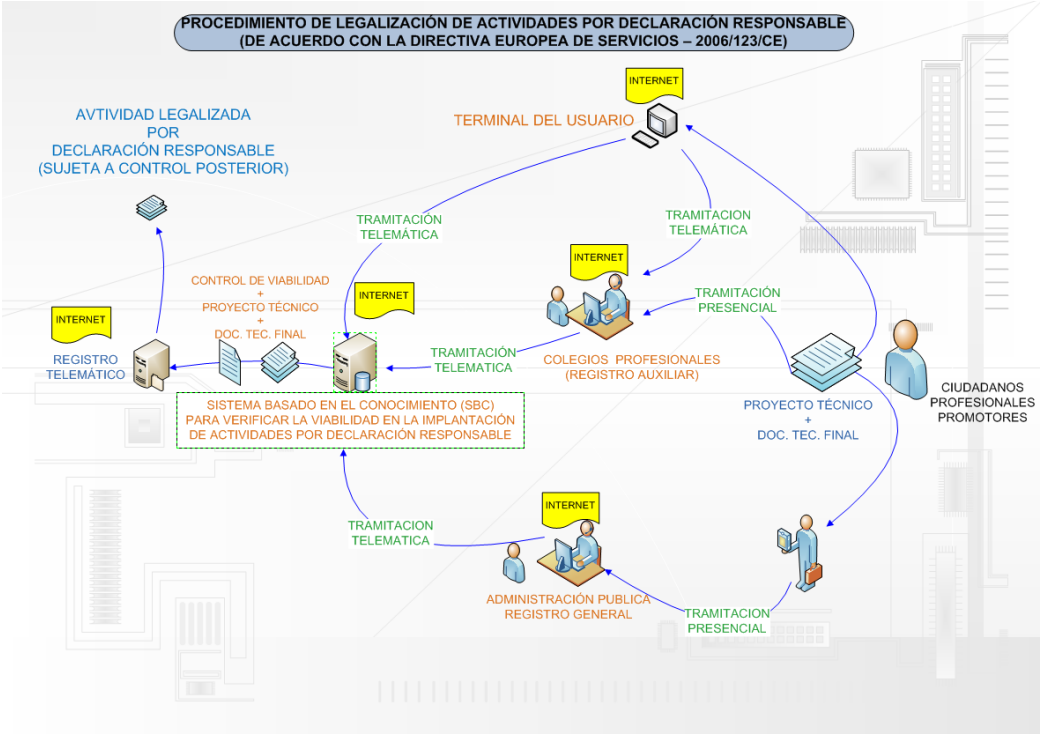

Fig..2 Model of processing system.

3. MATERIAL AND METHODS

3.1. Description of the legalization of activities.

The implementation of a new establishment or business in a city is governed, firstly, by the urban planning regulations established by the municipal urban development plan (PGOU) [11]; secondly, by environmental regulations, which in our country include both state and regional legislation, as well as municipal regulations drawn up by the city councils; and thirdly, by sectoral regulations relating to certain uses.

3.1.1. Analysis of the urban development regulation.

The general urban development plan establishes the catalogue of the uses to which the zones of a municipality may be put, defines the division of the land and assigns to each zone one or more uses. In this matter the differences between Spanish municipalities are usually minor, the PGOU of a city establishes the list of uses considered in the municipality and defines their content. This list of uses has a hierarchical organization with a first level, constituted by the so-called global uses. Each global use is specialized in one or more detailed uses, which are more specific and at their lowest level may refer to specific economic or non-economic activities whose names correspond, in many cases, to those of the types of establishments in which the activity is carried out. In urban land, the detailed use is generally the specific destination assigned to a plot of land by urban planning, which translates into the assignment of at least one use to each zone of these parceled spaces. However, there is no univocal correspondence between zone and use, given that practically all zonal use categories actually admit various other uses. This makes it necessary to establish criteria for dealing with conflicts of coexistence between different uses. The regulation of uses in the different zones of urban land is intended, on the one hand, to establish limitations on activities that may negatively affect the development of the main activity of the area, and, on the other hand, to guarantee the maintenance of situations of balance between uses that have proven to be satisfactory

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for the quality of life in cities. In each zone, or in general for the entire municipality, the plan may indicate prohibited uses (in certain cases they may be permitted uses).

The urban development plan, which is a regulation specific to each municipality, establishes a set of requirements to be met by each of the uses. In this way, the requirements to be met by a particular use or activity can be directly associated with that use or activity, and the same hierarchical structure can be used to organize and, through an inheritance mechanism, access all the requirements that affect a particular use or activity.

The requirements included in the urban development regulations are varied, being some of the most frequent, both for global uses and for detailed uses, those referring to urbanization and construction aspects of the plots and establishments destined for these uses.

3.1. 2. Analysis of environmental regulation.

Environmental regulation also imposes restrictions on the implementation of activities in a location; within the areas of industrial use, leisure use, recreational use, care use, etc., there are activities that are very different in nature, to the point that some may be allowed in buildings in spaces adjacent to dwellings, while others must be located in locations far from urban areas. In this context, environmental considerations become so important that the traditional urban planning regulation of uses in zones proves insufficient to guarantee the coexistence of uses with each other and, in particular, with housing.

In order to establish the conditions of compatibility between uses and, specifically, of the different uses and activities with housing, it is necessary to take into account the negative effects that these activities may have on the environment and people. The activities have problems of location insofar as they can be annoying, unhealthy, polluting or dangerous. The municipalities also have their regulations on activities, distinguishing, in general, between the building permit, regulated by urban planning regulations, and the permit for the establishment of activities, which implies agreement with the uses permitted in the area, but also with the municipal ordinances that affect the activities. The contents of these ordinances refer to constructive measures and installations that establishments must adopt, in addition to complying with the requirements included in the Technical Building Code and other regulations of general application in building. These ordinances are dictated, to a large extent, by the need to eliminate or mitigate the negative effects on health and the environment produced by all types of activities.

The spatial location of the activities is also regulated according to the level of tolerance that the area of location presents to some of the negative effects that the activities may produce. Depending on the dominant uses, the map of the municipality is divided into different areas of environmental sensitivity to the negative effect considered, establishing environmental quality objectives for each of them. A clear example of this is the acoustic zoning, which distinguishes a series of areas of acoustic sensitivity. In this context, the so-called Acoustically Saturated Zones (ZAS) or areas in which the concentration of activities and/or people causes the environmental sound indices to exceed or equal the required acoustic quality objectives are distinguished.

Due to the additive nature of these negative effects, municipalities that have the power to grant licenses and permits for the exercise of activities may not allow the establishment of new establishments that develop activities that may contribute to increasing the levels of a negative effect in those areas that require special environmental protection in relation to the same. For example, they may not allow the establishment of new bars, pubs, discotheques, etc., in acoustically saturated areas.

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3.2. DESCRIPTION OF THE ONTOLOGY

Among the many definitions of ontology, the most cited is the one due to Gruber [12], "an ontology is an explicit specification of a shared conceptualization". It is an ontology in the domain of activity implementation that configures a semantic model that includes the information resources available to be able to determine the feasibility in the implementation of economic activities and to promote reliability and efficiency in the process of activity legalization.

It is essential that the communication between citizens, developers, professionals, the administration and the information system allows a common understanding of the domain so that there are no errors of concept or terms when correctly identifying economic activities as well as locations incompatible with the uses allowed in the urban planning, which generate irreversible consequences since the activity could not be legalized. A common vision of the world with respect to our domain has to be shaped, for which an ontology is developed [13], [14], as a model of knowledge in this domain. This ontology explicitly describes and defines the concepts and organizes them hierarchically, forming classifications, so that software tools can use this information to automatically classify new concepts and individuals.

Broader classifications of concepts, such as those related to the types of economic activities and establishments, which are typical of the domain of the work we are dealing with, are particularly suitable for modelling knowledge. Knowledge acquisition has been carried out by consulting with experts in the domains of legalization of activities and by analyzing the regulatory procedures for legalization and start-up of economic activities, considering legalization, urban and environmental requirements, and identifying common characteristics and restrictions that determine feasibility.

In the conceptualization phase, the domain terms have been identified: concepts, instances, verbal relations or properties. In the implementation and evaluation phase, we use ontologies as a key technology to define the basic terms and relationships of a thematic area or application domain, the concepts are explicitly described and defined, organized hierarchically, forming taxonomies, so that the computer can use this information to automatically classify new concepts or individuals. The knowledge that describes the concepts of a domain is complemented by another type of knowledge that allows decisions to be made regarding some question of interest in the domain in the different situations that may arise. This other type of knowledge has traditionally been expressed in the form of rules.

The rules must also be expressed in a language that can be interpreted by the computer, so that it can derive conclusions or make decisions based on the data of the problem. Systems that make decisions or solve problems by applying knowledge expressed in this way, by means of an inference mechanism, are called Rule-Based Systems, and are the most common implementation of KBS. It is in the knowledge base where the knowledge necessary to solve the problems in the considered domain is concentrated. In addition, it will be composed of a fact base and a rule base. We could say that the fact base contains the data of the problem being solved and the rule base provides the information to solve it. The inference engine is the component in charge of providing answers to the queries made to the system, relating the information that exists in the knowledge base according to the situation that at each moment reflects the fact base and the established rules (see appendix of the supplementary material). Figure 3 summarises the structure of the proposed KBS.

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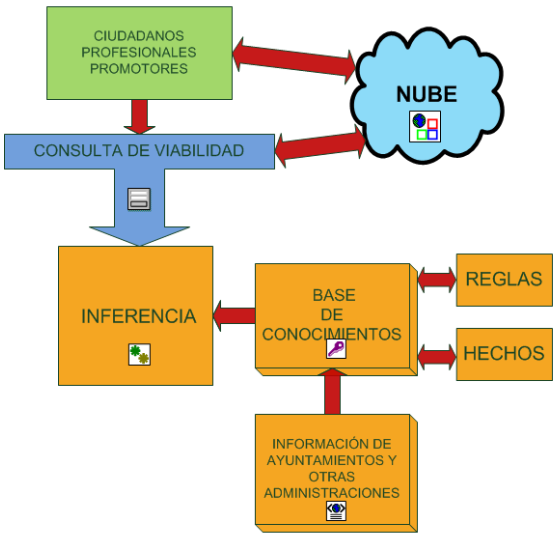

Fig. 3. Structure of the KBS

Next, Figure 4 shows the structure of the ontology created with Protègè [15], where the most general concepts and relationships of the domain of legalization of activities are represented, as well as its class hierarchy.

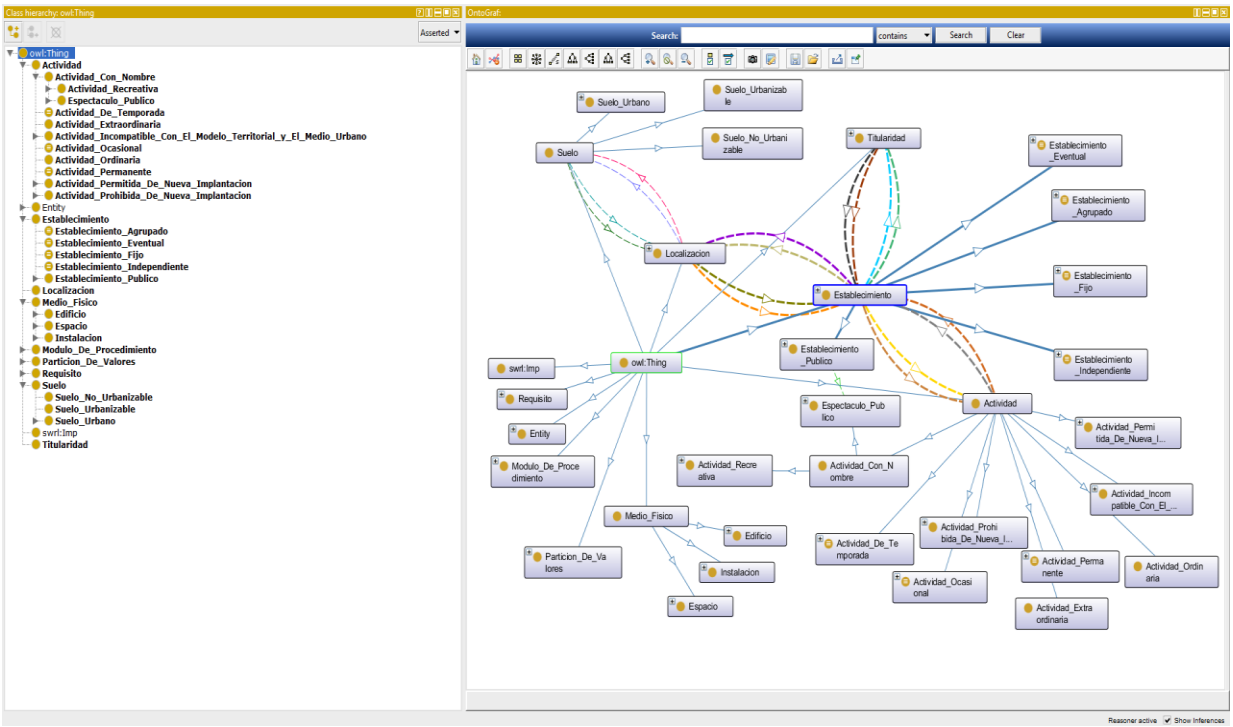

Fig.4. General ontology structure and class hierarchy

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4. RESULTS AND DISCUSSION

A case study to demonstrate the operation of the proposed ontological process is applied to determine the feasibility in the implementation of restaurant activity in a particular establishment and location in the city of Seville. The implementation has been carried out in the Protègè 5.2.0 platform. Protégé is a programming environment that allows by means of instances to perform user-defined queries that can be executed from the Semantic Web Rule Language (SWRL) rules included in the knowledge base.

We use the graphical user interface (GUI) shown in Figure 5, generated by the platform to enter the information of the instance we want to verify if its implementation is feasible. The restriction rule base is created from the rules, regulations and ordinances applicable to the domain of legalization of activities that we have already indicated above, formalizing it in the form of Web Ontology Language (OWL) axioms and SWRL rules [16].

In the Figure we can 5see that the Restaurant_1 activity that we have declared by means of class instances meets the requirements defined in the ontology knowledge base to belong to the "Restaurant" class (Restaurant_1 Type Restaurant) after the execution of the HermiT 1.3.8.413 reasoner. The triggering of the SWRL rules with the data entered when creating the class instances determines whether the instance "Restaurant_1" is viable in the chosen location.

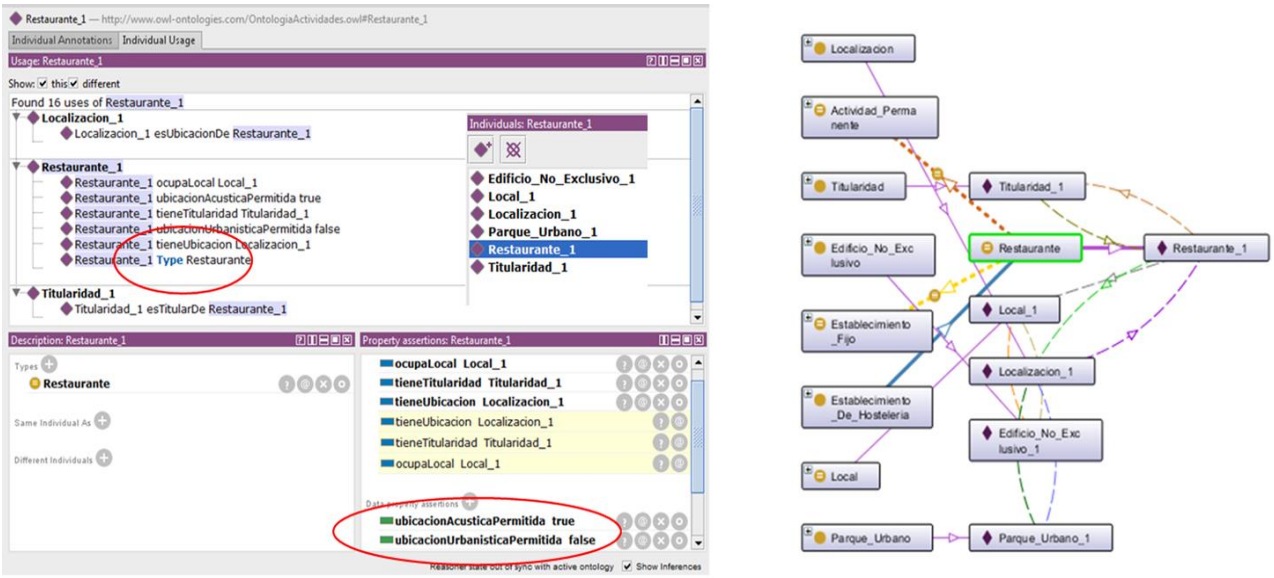

Figure 5: Result after execution of SWRL rules

In this example, the location chosen for the establishment is an urban park, since the PGOU does not allow restaurant activity in that land use, the result of the SWRL rule execution is "false" indicating that the activity is not feasible in that location. As the location coincides with an acoustic zone, and restaurant activity is not a prohibited activity in such zones, the result of the SWRL rule execution is "true" which would indicate feasibility for that condition. Since one of the conditions is not met, the activity is not viable. This KBS allows verifying if an activity establishment meets the conditions of the instantiated class and if so, if it can be implemented in a predetermined location. Specifically, this rule states that the location of a hotel establishment in an urban park is not viable, since it is not one of the permitted uses.

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5.-CONCLUSIONS

An ontology has been developed to support the process of defining and verifying the requirements for the implementation of economic activities by means of a responsible declaration in Spanish cities. It defines activities, establishments, types of land use, and critical urban and environmental requirements. The implementation of an KBS as an element of consultation prior to the implementation of activities by responsible declaration would minimize business failures, solving the problem described above.

The development of an ontology requires feeding the system with a large number of activity implementation cases stored as instances of the ontology for reuse, which will require a lot of time and resources, due to the large number of activities classified in the selected domain. As more patterns like the one in the example above are generated, more instances will be stored, so that the KBS implementation could progress more rapidly. In this proposal, only specific technical limitations are considered, but in practice, there are other types of conditioning factors such as the cost of system development or the requirements imposed by users. The applicability of the system in its current state of development is limited to a group or selection of activities that have served as a model for the proof of concept of operation of the prototype system, which requires implement all possible activities and use cases as well as its adaptation to the particularities of the different PGOU and provide them with a more friendly user interface that allows its implementation in the web environments of the municipalities.

The proposed system offers the local administration an alternative model that in future development should evolve to allow the realization of standardized and autonomous technical consultations without the need of expert personnel, from any place with an Internet connection with a friendly user interface. Among future developments, this tool could be integrated into professional associations as public law corporations, assuming delegated administration functions in the reception and verification of the feasibility of projects for the implementation of activities, improving the provision of the service. Likewise, the possible integration of the ontological proposal in Smart City management software should be explored.

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SUPPLEMENTARY MATERIALS

http://www.revistadyna.com/documentos/pdfs/_aduic/10383-1_en.pdf

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