MechDesk - An ontology solution to troubleshot vehicles problems

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Abstract. Semantic Web is extension of the existing World Wide Web, providing tools and technologies to support the transparent exchange of information and knowledge among organizations. Nowadays, multiple areas can be approached by ontologies, part of the W3C standards stack, and the semantic web world, as the subject of this project, mechanics. Mechanics have been accentuated in a visible way, where the reality of living without means of transportation is not feasible in people's lives. The development of new methods to increase the knowledge of drivers and everyday people about automated vehicles is essential. Regarding cars, revisions, maintenance, inspections, among others, are necessary and "mandatory" subjects and due to this, it is possible to prevent future damage by prolonging the life of the car. In certain cases, this doesn't happen, either due to wear of parts or unforeseen events, and despite being a busy market, drivers are not always informed about the best cares to take or the problems that may arise. As such, the theme of this project is to make a relationship between mechanical details, issues, and solutions. For that purpose, the defined ontology was exposed via a mobile application, with it providing to the user, several details that he can or not relate, and trough them, provide a connection with a certain problem and solution. The semantic web ontology was developed in Protégé, exposed into Apache Jena Fuseki server, and was running in an Azure Virtual Machine, allowing it to be available into the OutSystems application.

Keywords: Semantic Web · Ontology · Vehicles Maintenance.

1 Introduction

The internet as it's known today, has come a long way in a short period, from its origin as an exclusive technology for military use, to its current status as one of the developed world's primary sources of information and communication.

The Semantic Web is a vision about an extension of the existing World Wide Web, providing software programs with machine-interpretable metadata of the published information and data. In other words, further data descriptors are added to otherwise existing content and data on the Web. With this, computers can make meaningful interpretations, like the way humans process information to achieve their goals [5].

As in several cases, a normal user to achieve a goal, p.e information about a problem, doesn't need to have technical knowledge neither from the domain of the problem, neither from the technologies being used. The world is evolving in a way that creates a new reality, where everyday people can interact with multiple systems that they know a minimum or nothing, since those systems can grab the minimum information the user provides and process it.

Having this, the areas that can involve semantic web are various, such as health and medicine with medical diagnosis, higher education with assessment fraud, industrial environments or public spaces vehicle maintenance, business-level schedules with their management, chemistry, human resources management or maintenance [6].

The specific number of vehicles worldwide is a little hard to obtain, what with all the different bodies responsible for counting them, but the best estimate put the figure at around 1.32 billion cars, trucks, and buses in 2016. It continues to grow at an astonishing rate If the staggering rate from the previous years of growth continues, the total doubling every 20 years, then we can expect to see some 2.8 billion vehicles on the planet in 2036 [2].

Maintenance keeps the vehicle running smoothly and safely down the road for a much longer distance compared to never doing upkeep. Observing the number of vehicles nowadays and the predictions for further years, ways of maximizing a vehicle or a certain component life span are needed. In certain cases, the drivers are not aware of what they should do or where is the cause of a certain problem when an unforeseen occurs.

As main scientific contribution, the authors present at this paper an ontology-based system to diagnosis car problems and suggest solutions. The diagnostic is done based on the reported symptoms, that can be detected and characterized by any conventional driver, does not requiring any kind of expert, helping it to a better perception of the situation he encounters at hand.

The remainder of this report is organized as follows: chapter 2 presents the concepts and basics of the semantic web; chapter 3 presents the defined ontology; chapter 4 presents the architecture and implementation; chapter 5 presents the conclusions and future work.

2 Semantic Web

Semantic Web technologies aim to define and interconnect data in a way similar to that in which traditional web technologies define and interconnect web pages. In the case of the traditional Web, each web page can be considered a unit of information or entity and pages are explicitly linked using HTML links [7, 1].

The Semantic Web requires interoperability on the semantic level as well as semantic interoperability requires standards not only for the syntactic form of documents but also for the semantic content. To allow a computer to understand the information at semantic web level, machine-readable information is needed, being Extensible Markup Language (XML) and Resource Description Framework (RDF)/RDF Schema (RDFS) two core solutions [3].

3 Ontology

In this section the ontology developed will be discussed and every component of it will be exposed and explained. During the development of this solution, two web semantic approaches were explored: ontologies and graph databases, being the first approach chosen to be continued and aborded. This was heavily due to the fact of the reasoner provided by the ontologies. The software used to develop this ontology was the Protégé ontology editor.

3.1 Classes

The ontology developed is constituted by the following eight classes: Vehicle, VehicleBrand, VehicleFuel, VehicleType, MechanicalComponent, Detail, Issue and Solution.

Since the main objective of this ontology was to associate mechanical problems with causes and identify possible solutions to solve these problems, the classes Detail, Issue and Solution were created. The class Detail represents a detail related to a mechanical component (MC) that is a symptom of an issue like p.e. motor noises or instability. The class Issue represents an issue that a vehicle can have in a specific MC, p.e. malfunctions in the gearbox or discharged battery. The class Solution represents a solution for an issue that a vehicle can have in a specific MC, p.e. charge battery or replacing a specific component.

To identify different types of vehicles and their MCs the classes Vehicle, VehicleBrand, VehicleFuel, VehicleType and MechanicalComponent were created. The class Vehicle represents a vehicle model, the class VehicleBrand represets a vehicle brand, the class VehicleFuel represents a vehicle fuel type, the class VehicleType represents a vehicle type and the class MechanicalComponent represents a MC of a vehicle.

3.2 Data properties

A common data property that every class has is an identifier, used to identify the instances of these classes, and something to describe them, such as a name or a label. Adding to that, some specific properties were also defined depending on the class. Regarding the characteristics of the data properties of these classes, they are all functional. This is due to the fact that these data properties cannot have no more than one value for each individual.

3.3 Object Properties

Regarding the object properties of this ontology, they were defined to associate classes, relating them.

The HasMechanicalComponent is the association between the Vehicle (domain) and the MechanicalComponent (range), the VehicleHasBrand is the association between the Vehicle (domain) and the VehicleBrand (range), the VehicleHasFuel is the association between the Vehicle (domain) and the VehicleFuel (range), the VehicleHasType is the association between the Vehicle (domain) and the VehicleType (range), the MechanicalComponentHasDetail is the association between the MechanicalComponent (domain) and the Detail (range), the IsPartOf is the association between the MechanicalComponent (domain) and the Vehicle (range), the IssueHasDetail is the association between the Issue (domain) and the Detail (range), the HasSolution is the association between the Issue (domain) and the Solution (range), the AssociatedWithIssue is the association between the Detail (domain) and the Issue (range), the AssociatedWithMechanicalComponent is the association between the Detail (domain) and the MechanicalComponent (range) and the HasIssue is the association between the Solution (domain) and the Issue (range).

These object properties represent the association of the classes of this ontology and some of them are the inverse of other object properties. In Table 1, the corresponding inverse object properties for each object property are presented.

Table 1: Object properties - Inverse Of.

Object property	Inverse Of
HasMechanicalComponent	IsPartOf
VehicleHasBrand	(-)
VehicleHasFuel	(-)
VehicleHasType	(-)
MechanicalComponentHasDetail	AssociatedWithMechanicalComponent
IsPartOf	HasMechanicalComponent
IssueHasDetail	AssociatedWithIssue
HasSolution	HasIssue
AssociatedWithIssue	IssueHasDetail
AssociatedWithMechanicalComponent	MechanicalComponentHasDetail

In Table 2, the characteristics of the object properties mentioned previously can be observed.

Table 2: Object properties - Characteristics.

Object property	Functional	Inverse functional	Transitive	Symmetric	Asymmetric	Reflexive	Irreflexive
HasMechanicalComponent	No	No	No	No	Yes	No	Yes
VehicleHasBrand	Yes	No	No	No	Yes	No	Yes
VehicleHasFuel	Yes	No	No	No	Yes	No	Yes
VehicleHasType	Yes	No	No	No	Yes	No	Yes
MechanicalComponentHasDetail	No	No	No	No	Yes	No	Yes
IsPartOf	No	No	No	No	Yes	No	Yes
IssueHasDetail	No	No	No	No	Yes	No	Yes
HasSolution	No	No	No	No	Yes	No	Yes
AssociatedWithIssue	No	No	No	No	Yes	No	Yes
AssociatedWithMechanicalComponent	No	No	No	No	Yes	No	Yes
HasIssue	No	No	No	No	Yes	No	Yes

3.4 SPARQL Queries

To demonstrate that the ontology fulfils her purpose, two SPARQL queries can be observed in Fig 1 and 2. The first query, given details/symptoms of a specific vehicle, gets all the issues associated with the given details/symptoms and the details/symptoms that also are associated with the issues found. The second query gets all details/symptoms of a specific vehicle.

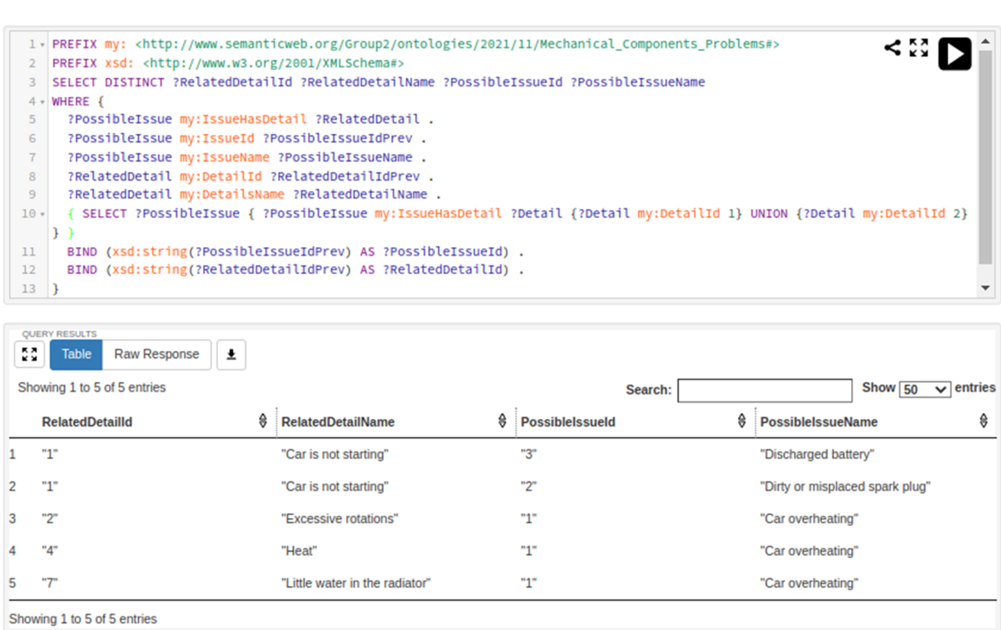

Fig. 1: Return all the issues related to the details provided.

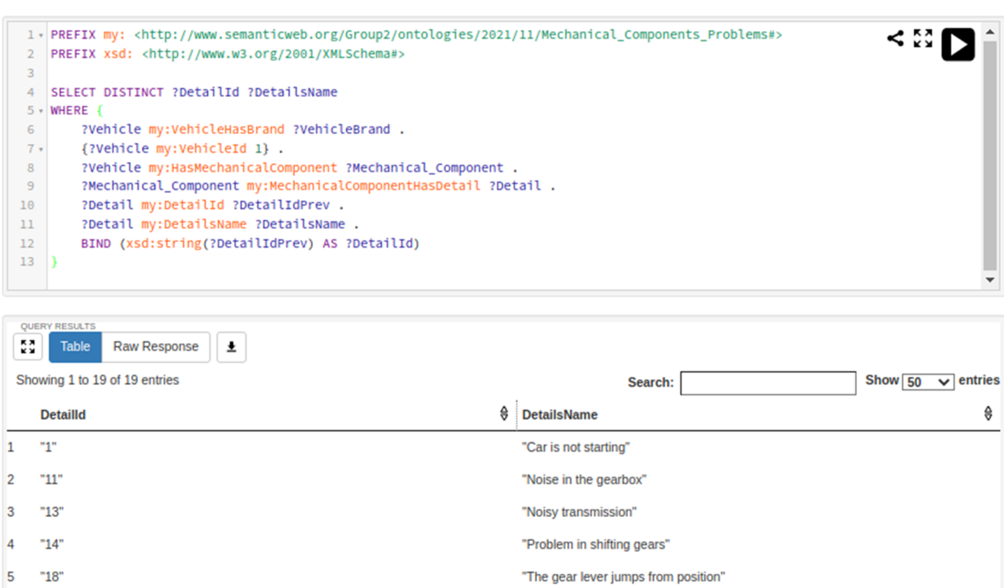

Fig. 2: Return all the details for the vehicle provided.

4 Architecture and implementation

As referred, the main contribution of the project is the ontology. To make use of it, several ways to expose it into the user are possible, where in this case, a mobile application makes an everyday driver, with or without mechanical knowledge, provide information (Details) related to the vehicle or the occurrence. Based on these Details, and through the defined queries, the ontology makes a match with Issues and Solutions. In Fig. 3, it's possible to analyze the overview of the built architecture, consisting of 3 elements:

- An ontology that is responsible for having all data to be processed, being this data described in the previous chapter.
- An Apache Jena Fuseki Server, that is holding the ontology model and is responsible to make the ontology data accessible worldwide.
- A mobile application, developed in OutSystems, that making use of the developed ontology, provides the user with information about vehicles, to help him find a solution or solutions, plus the price to fix it, for a certain problem that it has.

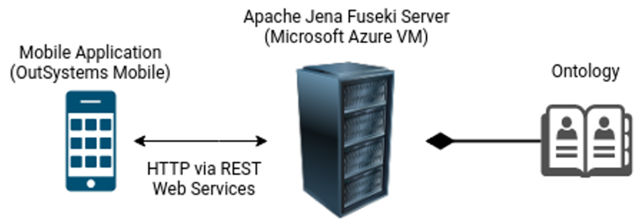

Fig. 3: Architecture Overview.

4.1 Apache Jena Fuseki Server

Apache Jena Fuseki is a SPARQL server developed in Java. This technology made use of the ontology developed in Protégé, storing it in a server, being possible to access it through a REST API [4]. The first phase of the development was having the Jena Fuseki Server running at Microsoft Azure, following the upload of the owl file from Protégé. The last step was the setup of the reasoner since by default, Fuseki doesn't come with one.

4.2 OutSystems Mobile Application

OutSystems, a low-code platform, it's possible to accelerate the delivery and production of a project, since its implementation was intended to that. Since the main goal of the project is a user to find the cause and solution for its status, a portable and practical application was needed, being it better if developed in mobile. Nowadays, and specially while driving, a portable cellphone is the standard device that is present. Every data related with the ontology that is present in this mobile application, it's coming directly through a REST API, making full use of the previous components.

The main view, Figure 4 left, allows a user to search by car brands and associated models. The user in terms to proceed, must select both fields. After that selection, the user will be redirected to a new view, where, a list of all details is shown, as visible in Figure 4 right. These details are associated with the vehicle chosen previously and the user can select one or multiple details or search by a specific name. After that, it can click in "continue" and advance to the issues view.

In this issues view, Figure 5 left, there are presented all issues/problems, associated with the details provided by the user. In this way, the user can observe related problems that he may have and start understanding where the problem could be. Inside each issue, there are all details associated with the details selected previously. It's possible to click an issue, where the user will be redirected to the solutions view.

The last view, Solutions, all solutions related with the issue that the user choose are shown, where a problem can have one or more ways to solve it. Inside each one of them, it is a price associated. This price can range from 0€, where

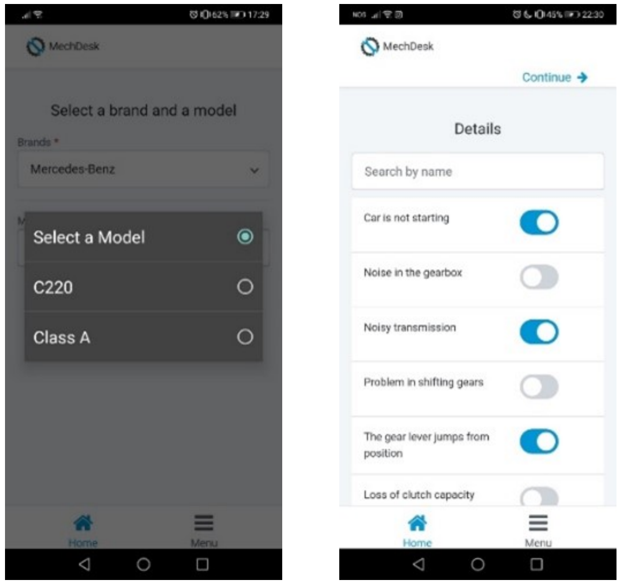

Fig. 4: Layout of the developed application (1).

nothing needs to be changed, until the full price of a new mechanical component. This is visible in Figure 5 right.

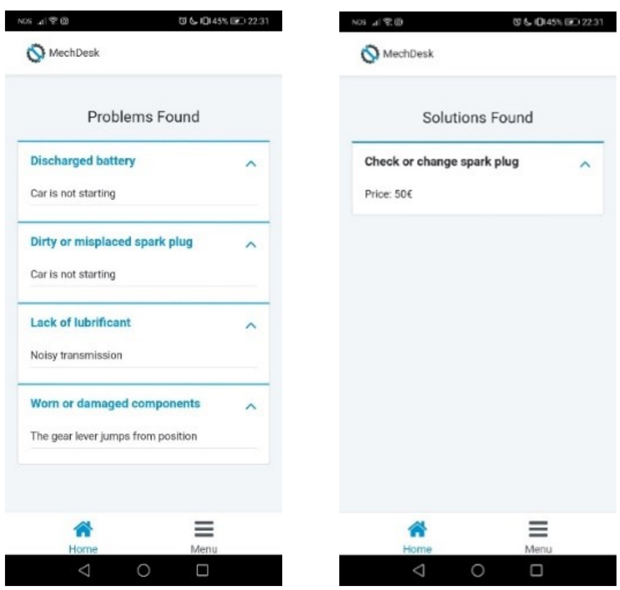

Fig. 5: Layout of the developed application (2).

5 Conclusions

This paper presents a resume about semantic web, as well as, the ontology, the queries, the architecture used and the mobile application. The software that was used to develop this project were Apache Jena Fuseki and OutSystems. With them, it was possible to upload the OWL, previously defined in Protégé, to the server, accessing it through the application. The reasoner was also added since, by default, it didn't come defined in the Apache Jena Fuseki. The SPARQL queries that were considered relevant for the application, demonstrating the application needs, were developed and shown. With this project, a relationship between car problems, causes and solutions was obtained, self-satisfying the primary goal of this project. Providing this kind of solution to users, becomes increasingly important, not only because the vehicle sector is growing increasingly, but also due to the driver's impartiality about the vehicle itself.

5.1 Future Work

For the future work, we have:

- Improve the ontology model, adding new concepts that were already identified and will allow to supply a better service.
- Improve the modulation with more realistic data.
- Improving the application to add features to the registered users.

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