Construction and Application Analysis of Information Model for Automotive Industry Test Equipment

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Abstract. Experimental data is an important resource for detecting and evaluating the performance and safety of automobiles. The current experimental equipment has a wide variety of data types and a large amount of data, which can be effectively managed and used through information models. Therefore, this article focuses on the field of automotive testing, dividing test equipment data into equipment, projects, results, and controls, and abstracting the categories, attributes, and association relationships of the data to construct an automotive test equipment information model. Based on this model, XML language is used to define semantic standards, which are applied to edge gateways to achieve semantic conversion and format encapsulation of collected data, ensuring the standardization and uniformity of test equipment data, Lay the foundation for the application of experimental data.

Keywords: Test equipment data;Information model;Edge collection

1 Introduction

Test equipment data is an important resource for detecting and evaluating the performance and safety of automobiles. Therefore, constructing an effective information model for automotive testing equipment can enable automobile manufacturers to better manage and use testing equipment data, in order to improve the quality and reliability of automobiles.

This article is aimed at the automotive industry's experimental business,This paper constructs an automotive test equipment information model by sorting and analyzing the categories, attributes, and correlation relationships of test equipment data, and uses XML language to define semantic standards. Finally, verify the effectiveness of the model in the edge gateway device to achieve unified data format.

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2 Information Model of Automotive Test Equipment

2.1 Data extraction and abstraction

An information model is an abstraction of the entity objects it represents. In this article, the first step is to classify the data of automotive testing equipment. Then, an information model is constructed through three steps: information extraction, information organization, and model representation[1].

Based on industry experience, this paper classify automotive test equipment data into the following four categories[2]:

(1) Test equipment. Test equipment is equipment used to test various performance of automobiles, such as engine test benches, chassis dynamometers, vehicle body test equipment, etc. The performance characteristics of the test equipment will have different impacts on the collection and processing of test data.

(2) Test items. The experimental project is a specific testing plan based on the experimental equipment. A pilot project involves multiple subject areas such as management, execution, resources, data, etc., as shown in the figure below, and may include multiple testing tasks such as acceleration, braking, manipulation, etc.

(3) Test results. The test result is the specific data generated by the test equipment based on the test project, mainly including the measured values of various performance indicators and other relevant information, such as the working status of the equipment.

(4) Equipment control. Equipment control refers to the operation control of experimental equipment and the collection and management of experimental data, mainly including the setting of programmed testing parameters, data collection and storage, and other elements of the equipment.

On this basis, this paper organizes all equipment data around the automotive testing business scenario[3]. Each branch can refine different attributes, objects, classes, etc. Downwards[4]. This paper uses the semantic similarity value method to classify the enumerated device information. The device information is distributed in a Tree structure to distinguish the hierarchical structure, as shown in the fig.1.

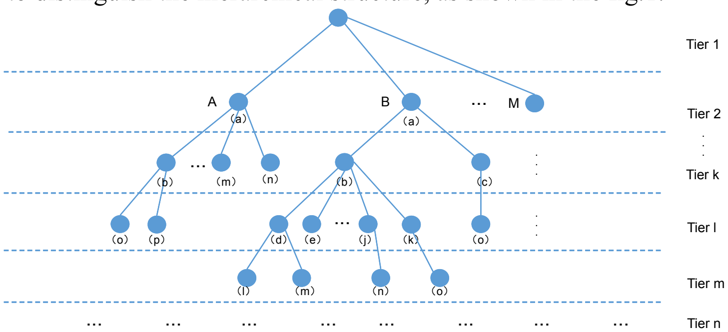

Fig. 1. Tree structure and Node Naming convention

Based on the tree distribution structure of the experimental equipment, we use the similarity value formula to estimate the similarity of each node[5]. The original value of each node is agreed to be the reciprocal of the number of layers it is in, and the present value is the result R obtained by multiplying its original value by the original values of other nodes. The similarity value calculation formula used in this article is as follows：

$$R(Am, Bn) = 1/k \times 1/m$$

Summarize the similarity values calculated from all nodes to obtain an affinity map between automotive test equipment information. On this affinity map, information with consistent similarity values is integrated and processed in conjunction with the actual business scenarios of automotive testing[6]. Thus extracting key information from the final testing equipment.

2.2 Information Model Modeling Based on Knowledge graph

Based on the key information of the testing equipment, the basic conceptual system of this type of equipment can be defined. The basic conceptual system of the testing equipment consists of two layers. The first layer includes the testing equipment, testing items, testing results, and equipment control. The second layer is a segmented item integrated through semantic similarity algorithm. The system architecture is shown in the following fig.2：

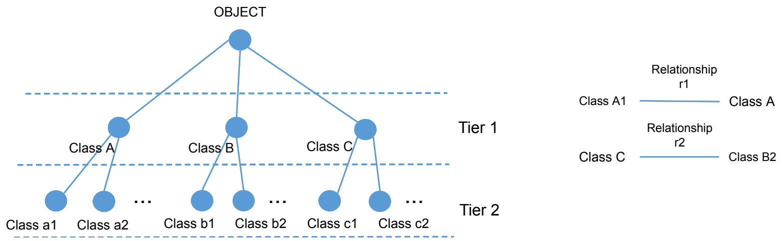

Fig. 2. Conceptual system of Knowledge graph business ontology construction

Based on the Knowledge graph concept system[7], combined with the key elements of the previous part of the test business, the basic architecture of the test equipment in the test field can be generated. As shown in the following fig.3.

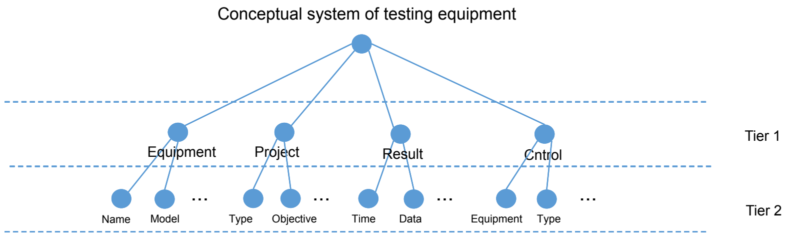

Fig. 3. Basic System Architecture of Experimental Equipment

On the basis of this system, in order to better express the connection relationship between key elements of automotive testing equipment and elements generated by integration and merging based on similarity values, this article uses OWL (Web

Ontology Language) to define the information structure of automotive testing equipment, and then abstracts the structure into a tree like information model. Finally, the information model is instantiated using XML language.

(1)Building an Information Model Based on OWL

OWL (Web Ontology language) is a language used to describe and organize knowledge. It can express individual entity elements such as A1, or triple groups such as (a2, r1, b1) (where a2 ∈ Class A, b1 ∈ Class B).

In this paper, we achieved the process of element extraction by constructing triplets of key elements in automotive testing equipment, and preliminarily constructed a knowledge connection diagram. But in the process of storing triplets, it is also necessary to consider the situation of entity disambiguation. For example, when (a1, r1, b1) and (a3, r1, b2) are stored, based on the characteristics of the "relationship" in graph theory, it can be considered that b1 and b2 are the same entity, so b1/b2 is merged into one in the knowledge connection graph.

In addition, this extraction method cannot connect all elements, that is, it cannot build the Knowledge graph by exhaustive method. The best way of element extraction is to extract feature samples that can Display rules[7]. As shown in the figure, because {a1, a2, a3} ∈ Class A, a1 and a3 point to the same entity, so based on the relationship deduction theory of Knowledge graph reasoning [8], a triple group (a2, r1, b1) is obtained, that is, knowledge completion is achieved, And finally build a complete Knowledge graph.

In the Knowledge graph of automobile test equipment, four basic branches such as automobile "test equipment" are defined as OWL classes, and the specific contents of the class are further divided into subclasses, data attributes and object attributes. The subcategories of experimental equipment include "temperature", "velocity", "noise", "material", "displacement", "power", "electromagnetic compatibility", etc., and the data attributes include "name", "model", "purpose", "state", "generated result", etc. At the same time, we define device components as OWL object attributes, such as "bench" which can be associated with a "bench" class. The following(fig.4) are some parts of the data structure of automotive testing equipment.

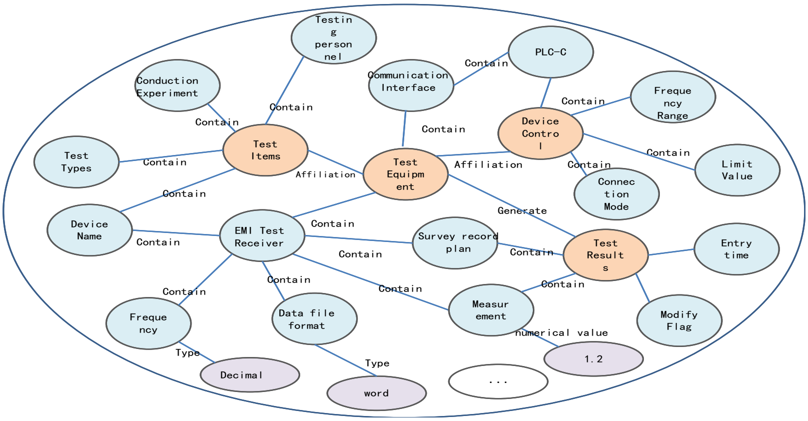

Fig. 4. Data structure diagram of automotive testing equipment

(2)Construction of Information Model for Automotive Test Equipment

Considering the characteristics of interconnection and interoperability of information models[8], we also need to abstract and adjust the models based on Knowledge graph. After fully considering the general characteristics and actual needs of the automotive testing business[9], this paper constructs an information model that conforms to the business characteristics[10].As shown in the fig.5.

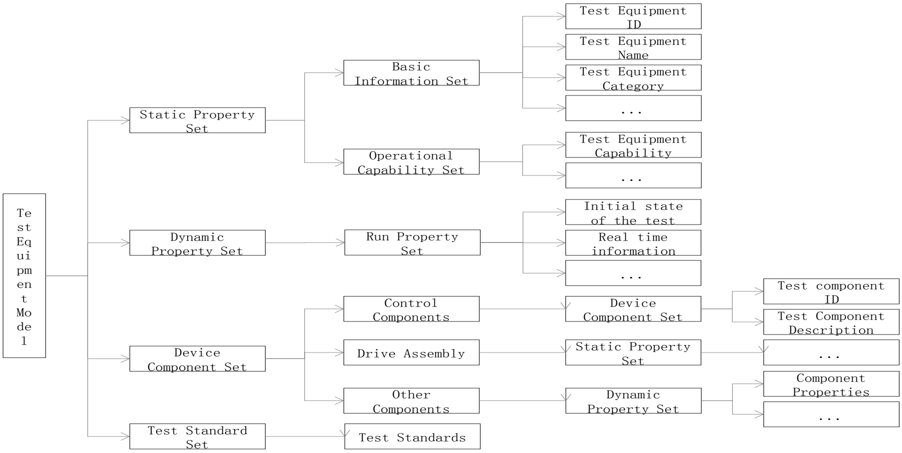

Fig. 5. Test Equipment Information Model

At the same time, using Extensible Markup Language (XML) to define model-based semantic standards[11], including device type<xs: complexType>, device element<xs: element>, device attribute<xs: attribute>, etc[12]. The following is a partial XML file content captured using EMI test receivers as an example.

```
<XMLSchema>
 <xs:complexType name ="dataEmi">
     <xs:sequence>
       <xs:element name="EmiFrequency"   type="xs:Decimal" />
       <xs:element name ="EmiSensitivity"   type = "xs:Decimal"/>
       <xs:element name ="EmiAccuracy"   type ="xs:Decimal"/>
     </xs.sequence>
   <xs:attributeGroup ref="ftr:OperateBaseClass"/>
 </xs.complexType>
 <xs.complexType name="dataEmiRef">
   <xs:attribute name="ref" type="xs:IDREF"/>
 </xs:complexType>
```

3 Example verifification

By combining model standard semantics[13], this paper utilizes edge gateways to encapsulate multi-source heterogeneous experimental equipment data formats, achieving structured data storage and application[14]. This paper applies the above automotive test equipment information model to the test equipment management system, achieving the collection, encapsulation, and unified data management of test equipment data. The data collection method of the experimental equipment management system is illustrated by taking a common AVL platform as an example. In this scenario[15], the application of data is facing significant difficulties due to multiple heterogeneous data sources. This paper will implement standard semantic expression of the experimental equipment information model in XML language[16]. And embed semantic standards into edge gateways in a programmatic manner to achieve automated data format encapsulation based on edge gateways, thereby achieving the goal of unified data format and interconnectivity. The experimental equipment data collection architecture based on the experimental equipment information model is shown in the fig.6[17].

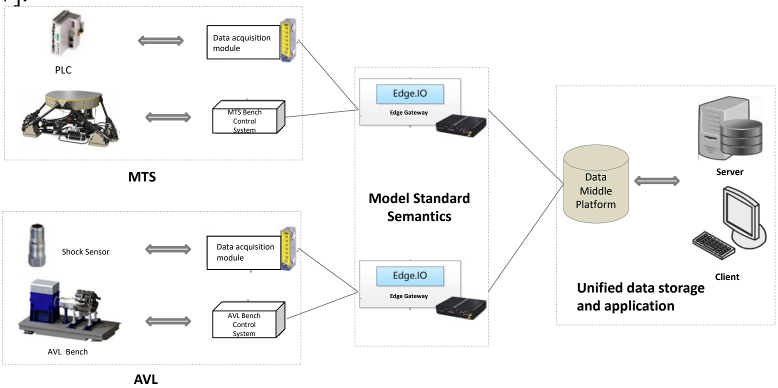

Fig. 6. Data Collection Architecture of Test Equipment Based on the Information Model of Test Equipment

4 Conclusion

To solve the resource intensive problem of conventional centralized data unification due to various types, complex formats, and large amounts of data in automotive testing equipment. This article proposes an edge layer data encapsulation method and information model framework based on the standard semantics of automotive test equipment information model, and applies it in the test equipment management system.

The information model involved in this method is a model architecture based on actual automotive business scenarios and highly abstracts the categories, attributes, and association relationships of test equipment data. The architecture is transformed into a standard semantic framework that conforms to the model specifications through XML language, embedded in edge gateways to achieve an integrated data governance approach of data collection, unified format encapsulation, and forwarding. The test data collected through the above method has a unified data format, which facilitates the management and analysis of test equipment data and provides useful information throughout the entire life cycle of the vehicle.

It should be pointed out that the model architecture designed in this article is oriented towards the current business situation in the automotive testing field, referring to the industrial internet information model standard, OPC-UA protocol standard, and QIF standard to construct an information model applied to the automotive segmentation field, and the types of testing equipment involved in this article are limited. In addition, the semantic transformation and data encapsulation of the edge gateway implemented in this article do not involve high concurrency and high real-time, and further optimization of the system is needed in corresponding scenarios. The above questions will be the focus of my future research.

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