Investigating the Role of Internet of Things in Knowledge Management Systems (Case Study: Offering a Resource Description Model Based on Ontological Study of Smart Store Management (Smart shopping cart))

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Abstract:
Rapid changes in the knowledge management (KM) area are substantially dependent on the considerable progresses made by the mankind in the information technology (IT) during these years. In fact, Internet of Things (IoT), as part of the applied technologies in the IT world, has rendered feasible the fast growth and sharing of knowledge. IoT records the data pertinent to the natural phenomena and classifies and calculates them for the purpose of facilitating a better and easier perception thereby to enable the human beings better perceive the phenomena. The quality of achieving an integrated source in regard of resource description is an important challenge in IoT for a large number of heterogeneous devices.
According to the absence of an integrated description model for IoT devices, the present article tries proposing an ontology-based resource description model (ORDM). These resources in IoT include the description of such classes as specifications, statuses, controls, situations, performances, histories and privacies inherent of the things. The ontology-based description model (ORDM) can be completely implemented for the performance optimization of a smart store through its offering of a smart shopping cart. The experiment results indicated that the proposed model is of a considerable applied value and prospect in the optimization of devices' access and business performance in IoT.
Keyword
IoT, ontological study, smart store

1. Introduction

The scientific effort that led on the 20th of January, 1969, to the stepping of the first American on the moon can be considered as the most successful attempt made ever up to that point in time. The necessary knowledge and technology for the accomplishment of the extraordinary projects had to also be flourished and blossomed. The power to make use of Apollo computers in their first mission in space was lower than the power of the desktop computers currently being used in the airports. The computer used in Apollo 11 that was well-known as state-of-the-art in 1960 was composed of a 4-kn RAM and no disk drive and contained only 74 kilobytes of extra memory. From the perspective of KM, it was a big question that how the remarkable management of the project's knowledge could have controlled and operationalize the developing knowledge in such a short period of time and with such limited facilities (the knowledge required for the space trip, rockets and missiles, aerodynamic, control systems, communications, biological issues and various scientific fields of study that had to be developed and experimented before the expedition). From the viewpoint of knowledge production, as well, the project was also deemed as an extraordinary example of an effort. But, on the other hand, it can be concluded in a more precise look that the efforts for the extraction and discovery of knowledge from this project have been in vain to a great extent and even some studies show that NASA has indeed lost a large percentage of such knowledge [1].
The experience was indicative of the lesson that the lack of essential solutions for the management of knowledge causes the loss of very crucial information and knowledge the compensation of which is almost improbable. This is while one can dare to say that the IoT of the recent years is no less important than the then Apollo 11 project in terms of KM and the increasing pace of the technology's growth and its role in the future of the internet.
The future of the internet and the initiatives in this area are intertwined with the growing trend and influence that is required for IoT in making applications and this has resulted in the attraction, relationship, storing, accessing and sharing of the real world data. It has provided for a new opportunity in various extensive fields like electronic hygiene, retailing, green energy, production, city, organization, houses and smart stores as well as customized applications for the users [2].
The exploitation and extraction of knowledge from IoT dramatically depends on KM and methods of rendering things smart the objective of which is better and more perception of the periphery.
However, the diversity in the devices (things) and the necessity for their cooperation under such conditions

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cause challenging problems hindering the offering of world-scale solutions for the communications in this technology. The volume, speed and the fluctuations of the IoT data bring about important challenges for the information systems of this technology. The web semantic community has underlined the combining of knowledge engineering with the used techniques for the introducing, blending and creating the data obtained in the past decades. In addition to the abovementioned cases, the semantics has considerably contributed to the creation of auto-interpreting and auto -describing machines. However, the dynamic nature and the limited resource of IoT needs appropriate redesigning so that the semantic technologies could be executed in the real world.

Internet of things (IoT) was first introduced in 1999 by Ashton, a professor in MIT Auto-ID center, for the investigation and study of RFID technology. With the development of technology, the concept is subjected to a constant process of updating. For the time being, the broad definition offered by the international union of telecommunications in ITU internet report is as stated in the following words: two-dimensional reading equipment, radio frequency identification devices (RFID), infrared sensors, global positioning systems and laser scanners and other assessing tools, agreed on in the protocol, that can connect to any things equipped with internet for achieving and gaining access to the information and establishing communication for the smart identification of positions, tracking, supervision and management [3&4].

Based on the abovementioned definition, it is evident that IoT is a network comprised of various things. These things function as the antennas of the gigantic IoT system and form the basis of various programs [5]. Broadly speaking, things in IoT incorporate any devices and equipment served to perceive, control and process. For now, things encompass various kinds of sensors, stimulators and labels; although the equipment and the information collected by them enlarge the access circle, the IoT complicacies are also drastically increased due to the types' heterogeneities. Therefore, the quality of achieving an integrated resource description for the things in IoT, besides being a precondition for the actualization of information and sharing of data between the devices, is a foundation for various IoT's programs. To confront the above-cited problem, the present article suggests a new ontology-based resource description model (ORDM) for the internet of things. The proposed model overcomes for the heterogeneity of IoT devices through provision abstraction. In the smart store scenario, the current research paper takes advantage of ORDM architecture to perform the modeling and there are two sources, position and performance, added to the model presented in [10] so as to optimize the performance of a smart store. The experiment results indicated that the proposed model can be of a considerable value and prospect in optimization of store management as well as in business performance in IoT. The remaining parts of the article are organized as follows: section two gives the prior research and ORDM is explained in section three. The applications designed for smart shopping cart of the smart store are explicated in section four. Finally, the article is concluded in section five.

2. Prior Research:

So far, there are offered many comprehensive studies regarding semantic modeling by the researchers and a number of results have been obtained.

Liu et al in [6], Erinica et al in [7], Ghoreyshi in [8] and Yang in [9] have applied ARM algorithms that are predominantly dependent on the natural language processing (NLP) techniques for feature extraction. ARM algorithms extract the human features without performing preprocessing, for example, the manual preparation of the instructional datasets. However, the extracted features are most often repetitive characteristics adding twice the incorrect features and, this is while, the feature extraction call can be reduced. Moreover, the repetitive features can be characteristics outside the knowledge background and this lowers the accuracy of the extracted features.

Jang et al in [11], Hua et al in [12] and Agrawal in [13] have implemented ML approaches requiring a large collection of instructional data for accurate implementation. ML approaches obtain considerable results in feature extraction when the instructional dataset is described manually by a human expert. However, this is a time-consuming task because the required instructional dataset should be large enough so that the learning algorithms can be automatically launched.

Jao and Lee in [14], Penalo in [15] and Agrawal in [16] used SKB methods that are predominantly based on knowledge background. SKB approach exhibits a more advanced performance for the extraction of features when the intended knowledge background is applied to the extraction of features.

Nambi et al suggested a unitary semantic knowledge set in [17] that is drawn on multilayer architecture of IoT and incorporates resource ontology, place ontology, background ontology, cognitive ontology and service ontology.

Wang et al proposed an ontology-based resource description model in [10] concerning smart office scenario that encompasses descriptions of characteristics, statuses, controls, historical data and the privacy protection classes extant in things.

The abovementioned researches pertain to IoT devices' resource description that has been investigated in various respects. However, there are limitations found in some of them. On the one hand, the majority of these studies are limited to a certain application domain and, on the other hand, there are large differences in resource description model classifications. The model offered in [10] has been taken as the baseline model herein but there are at the same time added two resources to suggest an optimum solution for the mobile things existent in the smart store scenario (smart shopping cart).

3. Architecture of ORDM:

A device in IoT needs to be recognized as an authentic source through a series of abstract processes. The way a device characterized by various attributes is described is considered as a key and essential issue. The present article proposes an ontological theory to make a resource description model for IoT; the model can perceive and identify the integrated semantic descriptions of different heterogeneous devices in IoT. Based thereon, various types of resource-based services can be attained in application layer. Figure (1) illustrates the abstract process in IoT.

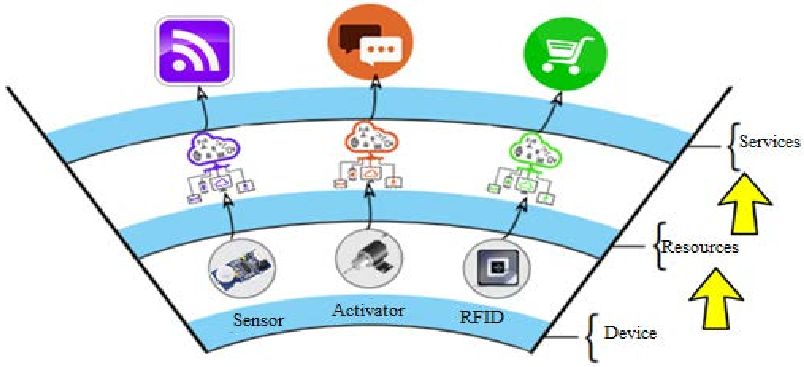

Figure (1): abstract process in IoT devices

A) Ontology-Based Modeling Process:

Ontology was first introduced in the realm of philosophy; it speaks of a systematic explanation for the existence of the entire things. Ontology blends the offered solutions and organizes the knowledge in a specific area to solve such problems as knowledge sharing and knowledge reuse and present a standard model [18]. The current research paper takes advantage of classification method suggested by Perez to make an ontological pattern. The method divides the modeling elements into five basic modeling languages: classes, relations, functions, principles and samples. An ontological model, say O, is demonstrated as below:

$$O=\{C, R, F, A, I\} \quad (1)$$

C denotes class or concepts and it can be further categorized to an initial class, Ci; R designates a collection of relations that are predominantly embracing four major types: part, type, sample and attribute. F refers to a collection of functions that can be formally shown as below:

$$F= C1* C2\ldots{}.* Cn\text{-}1 \quad \text{to } Cn \quad (2)$$

A denotes a set of rules and I designates a collection of samples. Based on the aforesaid ontological model, the present article analyzes the main elements of class and the relations with attributes and characteristics of devices in IoT and they constitute a large part of resource description model for IoT.

B) Resource Description Model for IoT Devices:

The contents of the IoT devices' descriptions and explanations can be classified into several groups:

1) The inherent device information: the information mainly includes the classifications of ownership information and the task interface of the device itself.
2) Production information: it primarily incorporates the obtained information.
3) Feedback information: it prevalently encompasses the appropriate decision-making and reaction according to the work status, history information and spatial position information.
4) Identity confirmation and privacy information: every device offers different access and control levels for various classes of users.
5) Based on the above-presented analyses, the present article posits seven classification attributes, including status, control, characteristics, history, privacy, performance and position that are used for the description of resources' information of an IoT. Amongst them, the position information is mostly composed of the recorded information pertaining to the device place and time.

Performance information, as well, elicits feedback from the control source in respect to the information obtained from the status, position and history of the device. The ontology-based resource description model has been displayed in figure (2).

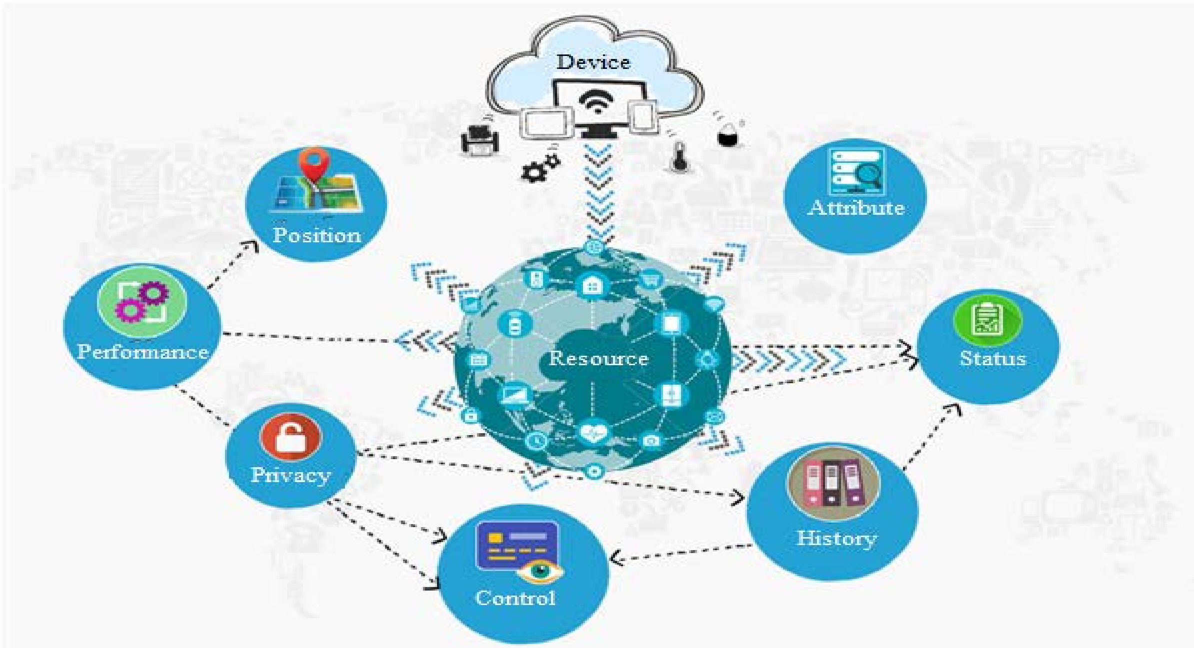

Figure (2): the proposed ontology-based resource description model

1) Designing the Attribute Class: attributes' class explains the inherent information of the device. This part includes information related to the main features (device type, device model, etc.).

2) Designing the Status Class: the status class incorporates two following subclasses: functioning status and obtained information.

3) Designing the Control Class: according to the fact that the device is easily controlled by the users, the control class is comprised of two subclasses: control type and control parameters.

4) Designing the Position Class: the position class is composed of two subclasses: global position and local position.

5) Designing the Performance Class: the performance class is consisted of information pertinent to performance type, performance number and performance parameters.

6) Designing the History Class: according to the fact that the users have access to historical information, the history class specifies the information pertinent to status history and control history.

7) Designing the Privacy Class: to protect the device from unauthorized access or control, this part supervises and controls the access authorization, power control and date validity confirmation.

4. The Applied Design of Smart shopping cart:

A) An Overview of the Design:

The smart store has been converted to a more popular concept comprised of IoT technology and store environment with the constant improvement of the people's lives. In comparison to the traditional stores, smart store can provide a more comfortable and less costly and, generally, more optimum environment. At present, huge stores, like hypermarkets, are incurred with large costs for instructing and waging their staff and human workforce solely for getting done such tasks as guiding the customers, advertisement and sale. Furthermore, the existence of a faster and easily operated smart system can be more useful for the customers, as well. The current research paper presents a smart shopping cart in this scenario featuring such capabilities as product introduction, spatial guidance based on the product type selection, smart purchase system and mobile phone-based bill payment, RFID calculation and security system and smart motion detection system. Besides being innovative and attracting customers, the smart purchase wheel offered herein considerably contributes to the business process, as well, through making savings in the recruitment and instruction of the human workforce in such a manner that the store and management costs will be reduced to half the usual costs with the omission of the human workforce.

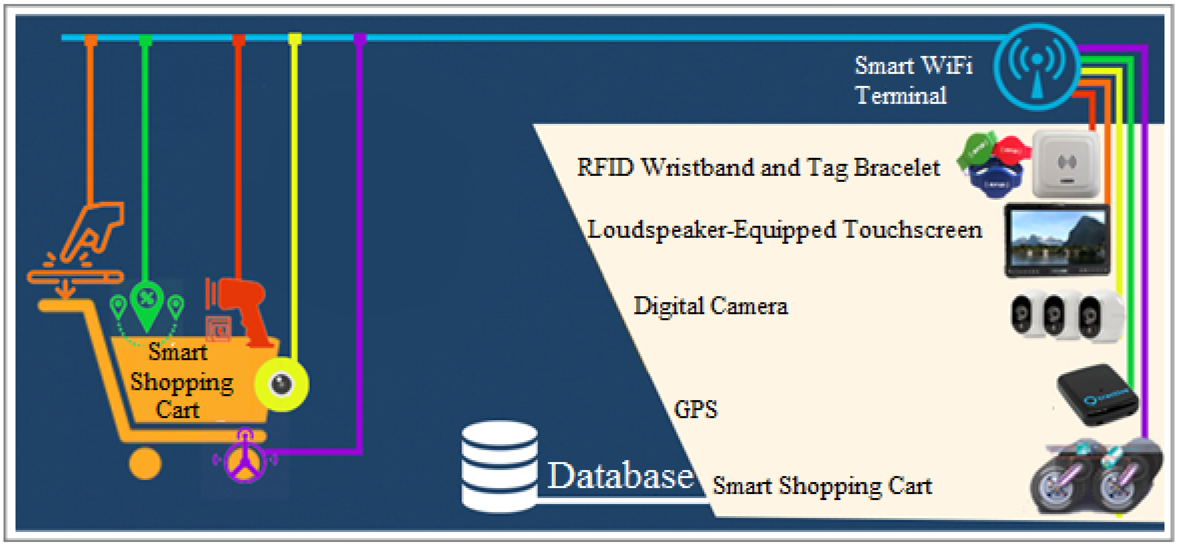

Figure (3): the applied scenario

As it is shown in figure (3), various types of devices required for acquiring information and exhibiting an appropriate performance can be connected to the smart shopping cart (such as GPS, RFID, camera, monitor, electronic wheels' automatic systems) and they can support the data storing using external equipment. In addition, the smart terminal can disperse and share the information through Wi-Fi or G4 and make use of RFID technology to calculate bills and provide for purchase security in an automated style.

B) Integrated Resources Description:

As it can be observed in figure (3), the software incorporates sensors, devices and digital cameras all of which are considered incongruous in terms of the user interface and data format. To overcome the heterogeneity problem hence providing for an integrated management of the whole system, the integrated resources are explained in the upcoming sections for the devices used in this scenario based on ORDM.

First of all, various classes are specified for every device depending on the device type. The class designs have been listed in table (1).

Based on the analyses presented so far, the resources need precise designing of the classes and subclasses for every device used in this scenario. As an example, consider an RFID smart bracelet (tag-reader) featuring its own specific attributes concerning characteristics, status, privacy, history, position, control and performance. Each class is composed of various subclasses like type, model, precision, range and response time for every attribute class. The explanations pertinent to the precise resources required for a smart bracelet have been illustrated in figure (4).

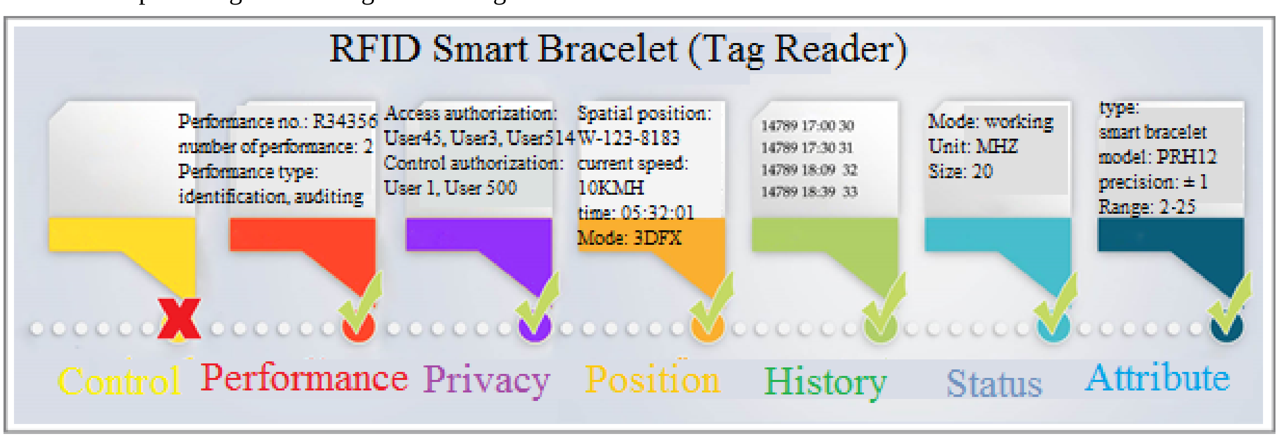

Figure (4): the explanations of the precise resources for an RID tag-reader sensor

Table 1: class designing for the devices

Device name	Model name	Attributes	Status	History	Position	Privacy	Performance	Control
RFID smart bracelet	PRH12	✓	✓	✓	×	✓	✓	×
RFID wristband	CIT3K	✓	✓	✓	×	×	×	×
Touchscreen monitor	M34	✓	✓	✓	×	×	✓	✓
GPS	GP8F9	✓	✓	✓	✓	✓	×	✓
Smart Wheel	WLL9	✓	✓	✓	✓	✓	✓	✓
Camera	E17	✓	✓	✓	×	✓	✓	✓

In the end, it is necessary to describe the information using a standard language and an appropriate format in order to be able to store and transfer the resource description information. Currently, the most common languages include either of the following sets:

XML (Extensible Markup Language): a markup language defining a collection of rules for encoding the documents. It is a format that is capable of being read by the human and the computer.

JSON (JavaScript Object Notation): a standard open-text format using the human-readable texts for the transferring of the data produced by things that are comprised of value-attribute pairs. This data format is the most common information data format that is applied for non-concurrent browser/server connections.

{"Device_ID": "ID_num",
”Attribute":{
"type_1":"value_1",
“type_2":"value_2",
“type_3":"value_3"
},
......
}

{
"Device_ID":1000201605070067,
"Attribute":{
"Type":11,
”Mdoel":"PRH12",
“Precision":"+_ 1 ",
"Range":"2-20",
"Response time ":"10s "},
"State":{
"Mode":1,
"Value":28,
“Unit”:"MHZ "},

1) YAML: it is a human-readable language in a serial format that has been drawn based on concepts from such programming languages as C, Perl and Python and borrowed ideas from XML and receives data in an email format. According to the features of teh foresaid language and the model proposed in the present study, JSON was applied as the ORDM implementation language herein. JSON is, on the one hand sufficient for the description of the entire ORDM elements and, on the other hand, it is simpler and more effective in comparison to the other languages. For the various types of resources involved in the proposed model, the following specifications have been designed for the formulating the JSON’s design.

"History":{
”Date-Time-value":[
"14789 17:00 30 ",
"14789 17:30 31 ",
"14789 18:09 32 ",
"14789 18:39 33 "},
"Privacy":{
“Access_authority":
["Libo", "Alex", “John"],
"Control_authority":
["Alex", "Jone"],
"History_authority":
["Libo", "Alex", "John"] } ,
"Location":{
”Place_location”:
[“w-123.8186 “],
”Speed”:[
[“10”],
”Time”:
[“05:32:01”],
”Mode”:
[“3D FX”]},

The temperature sensor file description based on JSON takes the following form:

A) Executing the Function 7:

In practical use, the system needs to store an explanations’ file specific to every device. To do so, it is necessary to regularly update the information related to status, history and position of things; as for the performance and control parts, there is a need for coordinating the system’s performance in no time. Based thereupon, the system can actualize various types of applied functions for smart shopping cart. The ordinary functions are as given below:

"Reaction":{
”Serial_Re”:
[“R-34256 “],
”Re-Namber”:[
[“2”],
“Re-Type”:[
[“Identify”
“Calculate”]},
"Control":{
”C-Type”:
[“P12 “],
“C-Parameter” : [“A,b,c”]},

}
}

1) Upon entry to the store, the customer picks up an RFID wristband from the counter and fastens it around his or her wrist as a result of which the smart shopping cart is activated and the wheel is identified through the radio wave emitted from the smart bracelet and the wheel follows the customer via detecting the radio waves.

2) When the individual chooses the type of products s/he is interested in from the monitor screen, the wheel guides him or her by means of a local GPS to the shelf wherein the product is placed.

3) When an individual selects a product and places it inside the smart shopping cart, the product, itself, introduces the price, nutritional value and amount of discount through RFID bracelet's sending of data to the loudspeaker-equipped monitor.

4) Upon the termination of the purchase, the smart shopping cart exits the store's product shelves and announces its current position using GPS and the bill is requested for the individual from the control unit.

5) When the purchase bill was confirmed by the individual on the monitor, a code will be displayed on the screen by which the individual can insert it to the store application installed on his or her mobile phone and pay the bill via a bank panel.

6) When the bill was paid, the RFID control unit verifies the payment and allows the customer to leave the store.

7) When the individual denies paying the bill and intends to rob the store of its products, the RFID unit makes use of the tag-reader control unit and GPS to reject the payment and the store's siren starts blowing and the smart shopping carts will be locked resultantly.

8) For instance, as specified in Function 7, the system gains access to the GPS status description and RFID status description file every 1000 ms.

9) When the GPS detects the exit from W-12.34 region or RFID bracelet realizes it has passed over the RFID tag-reading station, the field control system activates the siren and wheel lock files and this causes the siren to be blown as a result of which the smart shopping carts will be locked. The detailed work process has been illustrated in figure (5).

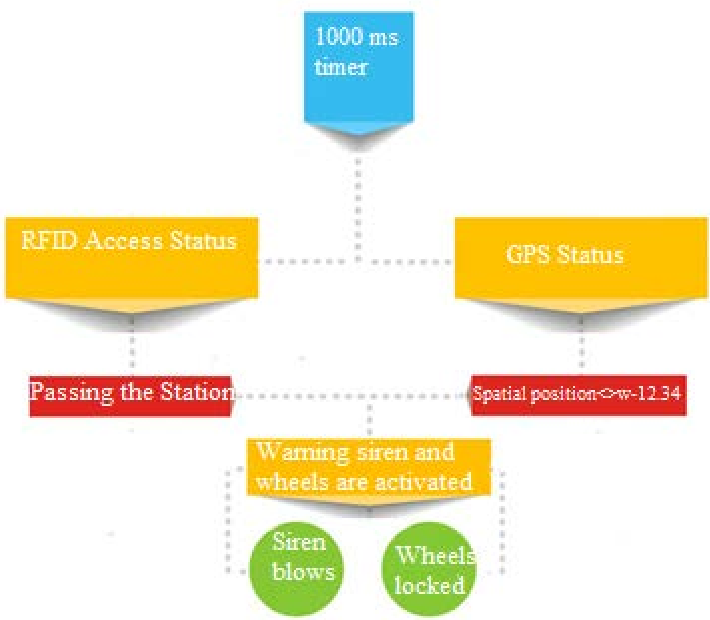

Figure (5): the implementation process of the Function 7

5. Conclusion:

The present article proposed an ontology-based resource description model for IoT. Resources are composed of characteristics, status, control, history, privacy, position and performance in IoT. The proposed model was practically executed using the smart shopping cart. In the implementation process, the description file formats were arranged based on JSON language. After a long round of operationalization, the system was tested in an applied scenario in practice and the results were found indicative of good performance. It has to be noted that there are many aspects that have to be covered in further research. As a specimen, the future studies can consider and investigate the energy consumption optimization, performance number minimization and effective blending of the resources in a format so that the reaction and implementation time could be maximally decreased.

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