

Understanding IoT Management for Smart Refrigerator

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Abstract—Lately the concept of Internet of Things (IoT) is being more elaborated and devices and databases are proposed thereby to meet the need of an Internet of Things scenario. IoT is being considered to be an integral part of smart house where devices will be connected to each other and also react upon certain environmental input. This will eventually include the home refrigerator, air conditioner, lights, heater and such other home appliances. Therefore, we focus our research on the database part for such an IoT' fridge which we called as smart Fridge. We describe the potentials achievable through a database for an IoT refrigerator to manage the refrigerator food and also aid the creation of a monthly budget of the house for a family. The paper aims at the data management issue based on a proposed design for an intelligent refrigerator leveraging the sensor technology and the wireless communication technology. The refrigerator which identifies products by reading the barcodes or RFID tags is proposed to order the required products by connecting to the Internet. Thus the goal of this paper is to minimize human interaction to maintain the daily life events.

Key words: IoT, Machine Learning, RFID, Smart House, Wireless Technology

I. INTRODUCTION

We must identify objects which include daily life items that we usually purchase from the grocery store. These objects must have some unique code to identify them. We know that most products having barcode to identify them.

1) *Barcode:*

Barcode is an optical machine readable data relating to the object it is attached to, like its manufacturing date, expiry date and price. But to be accurate, these barcode are not unique. Every product of the same type will have the same barcode as many products are being manufactured at the same time.

2) *RFID:*

There is still the need to have unique codes and for it the latest technology is of Radio Frequency Identification (RFID) also known as “electronic tag”. It has the capability to track and identify the products using radio waves.

RFID is actually a passive technology; i.e., it doesn't transmit the radio waves by its own but these ID can only be read by an RFID reader. Using this technology we can have each and every object identified and we can use connecting devices to connect these objects.

3) *Connected Devices:*

The IoT is a combination of the Internet and all kinds of information sensing devices such as radio frequency identification devices (RFID), infrared sensors, global positioning systems, laser scanners, etc.[1]

IoT semantic origin is from two words; internet and things. Where internet is the network of computers by some standard protocol TCP/IP and things here refers to two main categories of objects Identified objects and connected devices.

These devices are active devices usually requiring power source to operate and they have built-in network connectivity. These devices have the power to take over our daily life tasks in view of IoT making our life luxurious. In the near future, these connected devices will become a part of a digital grid, monitoring the networks and making decisions by themselves.

Examples of these devices can be smart phones, sensors, laptops and our smart fridge as well and we will discuss it further in this paper. The main objective of IoT is to connect everything with each other, D2D communication and also include human beings in this cycle. DHL courier services send our goods to other country in about 5 days. But, receipt of it duly signed will reach you in next 2 hours after delivery. It happens because of connecting printer with Internet and print instruction executed from remote location.

A. *Intelligent Refrigerator*

Applying the IoT technology to have a refrigerator, knowing what it holds in it plus amount of everything in it, such a refrigerator can be called as “Smart refrigerator” or “Smart fridge”.

It identifies the products by barcode or RFID scanning. The expectations are that fridge can maintain our food products and keep track of all the food items by scanning the codes and it is able to order the food item whenever it is about to finish. Moreover, it can detect the product's expiry time to notify us, image an LED screen in front of our refrigerator door telling us what we have in it and how much and when will it expires. In addition, it is preventing us from the need to open the refrigerator to check the things, keeping the temperature maintained and also saving the power.

According to Avil'tzkovitch, the devices will be able to tell us in real time what we have in our fridge so we don't have to create a shopping list before heading out to the supermarket.[2] But the idea we are proposing is omitting the person entirely

from the cycle. The central system is able to read the things getting low and is able to connect to person stored information, like a PayPal account, to order the things online as everything is connected by the Internet.

Our paper looks mainly into the data management and information extraction based on query processing from a database suitable for our IoT scenario and make order based on the data extracted from the database. Therefore we work on eXist DB to plan our query processing extracted from xml files where our refrigerator object information are kept.

eXistdb is an open source database management system. It is based on XML technology and stores XML data according to the data models. It offers index-based XQuery processing.

Its high performance engine stores textual or binary data and documents without requiring a database schema that makes eXistdb schema-less.[3] It works with Windows, Linux or Mac along with java installation, JRE/ JDK required running with administrative privileges required for full installation. It enables stand-alone java interface to make queries.

The major features of eXistdb making it a suitable database for IoT are listed below:

- Schema-Less XML Data Storage
- Collections: schema-less, nested, managed in hierarchical fashion
- Index-based query processing to speed up query uses fast path join algorithms. Moreover, the database automatically applies indexing to all the nodes and then provide quick identification of possible relationships between these indices
- Extensions for Full-Text searching: it supports document centric XML very well as opposed to Xpath providing search by keyword, proximity of terms or regular expressions.

The recent versions are providing web based application development tools, based on XQuery and related standards. eXistdb is providing a user friendly environment with many examples and rich documentation.

This sensor is provided just as an example for this scenario, we have not tested it ourselves but it is suitable for this kind of weight measurement.

B. Wireless Control

There is a need of wireless connection between the sensor in the refrigerator and the main control station. In the present scenario, only 1-way communication is needed as only the readability of sensor data is required. At fixed time intervals the channel will be activated by the controller, to receive data from the sensor and analyze it with the stored values and make the actions accordingly.

In the present case, Wi-Fi or even the Bluetooth connection is reasonable choice but when everything is connected to each other and the data is coming on millisecond basis then for this time-series data the connectivity needs to be highly reliable.

C. Remote Monitoring Center

The sensor inside the refrigerator is to be connected via a wireless channel to a central monitoring system using wireless technology and Internet. The database server, monitoring center and monitoring terminal together maintain the remote monitoring center.[1] If the central server acknowledges a certain critical condition reached, it will connect to the Internet to make an order for the product using the credit card information stored in the credit card database.

D. Internet Connection

According to Steve Leibson, who identifies himself as “occasional docent at the Computer History Museum,” the address space expansion means that we could “assign an IPV6 address to every atom on the surface of the earth, and still have enough addresses left to do another 100+ earths.”[6]

Whenever the controller decides to connect to the internet to order the product, it will use existing database of person’s credit card.

II. ALGORITHM STAGES

This paper explains an IoT scenario for a smart fridge and how it can have conditions on the data to maintain the food in the fridge. By maintain food, the food amount and its expiry date is meant here. The same idea can be extended to any other product to monitor in the fridge or to another device to connect to the internet.

A. First Stage: Data Generating

XML is the core of data exchange these days between different organizations so it is expecting that Internet of Things basis can rely on XML database system. The main benefit of XML is that it is self-describing and supports user defined tags so handling XML is quite easy. Moreover, it can automatically built applications and can change behavior of applications or optimize the performance by simply changing the way information is expressed without changing the code.

In this case we can generate a simple XML file without any schema definition to define our data. As the IoT environment is not available at present so it should be noticed that the data is imaginary only. So for preparing data the very first step for implementing our idea is to make a XML file which will contain the measurement of milk bottle on specified time every day in a week. Based on the xml we will do XQuery for getting the output. We plan to implement our idea by following the below mentioned steps:

- 1) First we take the measurement of milk bottle & store into the xml file the measurement of milk bottle on specified time of a day.
- 2) Create an XQuery on xml file which will show the measurement of milk bottle on specified time.
- 3) We assume that from above mentioned steps we can get the weekly measurement of our milk bottle which will be able to show us the weekly consumption of milk in a month. To accomplish that we can make another XML file.

- 4) We can make a web application for the user based on our query by using eXistdb which will help user to know about the measurement of milk bottle and also show whether it need to order for milk from the shop or not.

B. Second Stage: Data Storage

We have to manage our XML data in eXistdb and for that we used eXistdb collection feature. The process we can adopt is to create a new collection in eXistdb and put the XML file in that collection.

eXistdb offers to create new collections to handle different types of data efficiently. We can stored our data files in eXistdb collection. Collection feature provides efficiency in terms of storing large documents, which can be divided into small chunks and stored in a single collection to make access easily possible.

C. Third Stage: Data Query

As we generate the data, now the next part is to write XQuery for our scenario. We can use eXistdb platform to write the query. We can define our critical level with a simple algorithm as follows:

First, access the xml document then search for a specific where condition, this field can be modified by the user to set specific times at which user wants to check the status of milk bottle. After that, if-then-else statement may be use to print out specific message related to amount. This data is provided through wireless connection between the controller and the weight sensor. Based on this message the next decision will be made that either it is required to proceed further to order more milk or the amount is enough and the next process is not required.

For the next process, we can assume that the person's credit card information has been stored in the system and the system is capable of connecting to the internet to go to some specific online grocery store and identifying the barcode or RFID tag to make milk ordered successfully.

D. Fourth Stage: Web Application

In the present world, everything is connected to Internet somehow or is expected to be connected in near future, so as an additional part of the project, we plan to include a web application for our scenario by using eXistdb based on our query.

HTML can be use to implement the query, as HTML is the basic of information exchange applications in any web applications.

The application will enable the user to know about the measurement of milk bottle on a particular time so that user can check the measurement through the application from anywhere and anytime without opening the door of the fridge and thus saving the power.

We want to bring in notice that on average a person open fridge door at least 10 times a day and imagine if there are more than five person in a home then this application can save a good amount of power as no one needs to open the fridge door just to check what is in it and how much. This application can benefit also when you are at a grocery store and by chance you forget the grocery list you made at home, thus making your smart refrigerator accessible at anytime and anywhere.

Our application is mainly for the user to get a display of the refrigerator object updates to check and see the expiry dates and such others.

E. Finding Patterns

We can create an xml file where the total amount usage on a per day basis will be incrementally saved with the information taken by the sensor connected to the milk bottle. We can assume that data will be dynamically saved from the sensor devices.

This example can be extended to other objects in the fridge as well and also to other appliances.

III. E-SHOPPING

E-shopping or online shopping or e-store are all virtual types of stores which allow customers to directly buy products or services over the internet using a web browser. [8]

The best and the most popular online retailing stores are: Amazon.com, eBay, Gmarket, Alibaba. With the growth of online shopping, comes a wealth of new market footprint coverage opportunities for stores that can appropriately cater to offshore market demands and service requirements. [8]

A. Advantages and Disadvantages:

Online shopping facilitates customers by providing at home services most of the times cheaper and also providing a lot of options to choose from. Thus, it is convenient for most of the people to shop online without wasting their time in markets.

But, there is risk in ordering things online as you cannot guarantee the material, but most of the systems have good return policies also. But the greatest concern here is of privacy and security.

B. Business Scenario

It is obvious that like any new technology, the IoT has the potential to drastically improve our personal lives, work place and industrial capabilities as it is affecting our life directly. But end user acceptance is necessary for any new technology.

By the trends and the history of user acceptance, the expectation is that it may take time for users to adapt to new technologies and opportunities of the IoT, just as mobiles and e-commerce have taken years to be successful.[7]

Once IoT establishes its ground, we can imagine a totally new environment in our future; it will be user friendly and more users independently. One can imagine what ads companies will do with IoT, how everything will be flourished.

IV. SECURITY ISSUES

Data exchange is critical in today's networked world. We already are facing the cybercrime challenges and now if we are expecting to have a huge interconnected world of devices and humans we have to look at our security systems requirement.

Our emails can be hacked so now our intelligent refrigerator can also become a victim of this hacking. So being connected to the internet always would mean the possibility of more surveillance, both good and bad. It also means the possibility for more fraud, scams and cyber- attacks. [4]

In order to ensure that the personal data collected is used only by the authorized service, solutions have already been proposed that is usually based on 'privacy broker'. [5]

One of the most important requirements in IoT is that of security. Here, the person's card information or account information are potential and attractive targets of hacking. Therefore it needs to be specially considered while designing IoT scenarios.

Another security issue is to have control over the smart refrigerator so that it can be deactivated and also activated again because there can be times when the user doesn't want to order a certain object any more or when the user is going to some place for a long time. In that case if the refrigerator keeps ordering refrigerator food on its own then it's going to be a catastrophe.

V. CONCLUSION

The smart refrigerator in this paper is explained by a simple example of a daily product, milk bottle. We described an IoT refrigerator scenario and analyzed the data management for such a device. The same idea can be expanded to have each and every item of the fridge stored in the database to maintain the fridge without getting person to worry about maintaining a healthier lifestyle.

However the idea may or may not be applicable to all the objects with the same sensors and therefore the application of different kinds of sensors can be expected in this IoT scenario.

Ultimately the scenario can be devised for each and every device of home to have a 'smart home' system. And the results can be that each device in the world is connected together without the need for human intervention to have a global impact. In future we hope to extend our work by connecting our database system in very affordable and simple manner.

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