

Internet Refrigerator –A typical Internet of Things (IoT)

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Abstract - In a home the kitchen plays a major role in keeping the family alive and together, as the kitchen serves as the place where meals are prepared and also the meeting point where members of the family meet to eat. Amongst all the appliances or devices that are found in a kitchen, refrigerator is of great importance. This is due to the fact that the refrigerator house or keep intact food items that are needed in the home. Traditional refrigerators have been performing great task in preserving food items for a period of time, but there is need for more efficient ways of preserving and managing food items. With the innovations in technology came the Internet of Things (IoT) where divers appliance are connected together courtesy the internet, home appliance inclusive. Internet Refrigerator, which is a typical IoT also got innovated with the expectations to make life more convenient and comfortable by managing the kitchen more efficiently. It is expected to manage items or resources kept in it, save unnecessary cost, save food wastage, plan an organized menu, as well as organized shopping list. This research work looks at Internet Refrigerator as a typical Internet of things, its components, benefits and challenges as well as its acceptability.

Keywords----Internet Refrigerator, Internet of Things, RFID, RFID tags.

I. INTRODUCTION - HISTORICAL BACKGROUND OF INTERNET REFRIGERATOR

INTERNET refrigerator also known as Smart refrigerator is a refrigerator which has been programmed to sense what kinds of products are being stored inside it and keep a track of the stock through barcode or RFID scanning. This kind of refrigerator is often equipped to automatically determine when a food item needs to be replenished [20]. It also provides users with extra information about their products, their nutritional facts and consumption history. [1] An internet refrigerator can download recipes based on its content; communicate with a microwave oven to prepare the cooking power and time for the given mix of ingredients. It can suggest

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drinks based on what is stored inside, the ambient temperature and the time of the day. [6]

The first refrigerator connected to the Internet called Quantified Fridge was in a wired 100-year-old house in the Netherlands by Alex van Es in July 12, 1998; where it existed alongside networked lights, doorbell, mailbox, and, a toilet. There is a record and broadcast every time the fridge door opens. As of this writing, almost 16 years after inception; it has been opened for almost 70,000 times. [23]

In 1999, Electrolux Screenfridge, a connected refrigerator designed to allow users to order groceries over the Internet - but the product has yet to ship- was unveiled. In 2000, Whirlpool/Cisco refrigerator which allow users to watch a celebrity chef on the Web pad was launched. It has an integrated Web-browser to search for recipes that match the food items people have on hand. In 2002, the Whirlpool's refrigerator transforms into a multimedia communications centre such that the owner can surf the Internet, receive e-mails, listen to the radio, watch TV, videos and DVDs and even talk on the phone.

In 2003, LG's Digital Multimedia Side-By-Side Fridge Freezer with LCD Display came on board as the ultimate in kitchen technology with a built-in MP3 player for downloading and playing music from the internet, e-mail and video mail using a built-in camera and microphone. It has full internet access for re-stocking the refrigerator on-line or checking on the latest news and weather without leaving the kitchen. It is also great for storing food.

The Electrolux Screenfridge resurfaced in 2006 equipped with 15" touch screen and pop-up keyboard. It is connected to broadband and TV via wireless connection. In addition to Internet, email, phone, radio and MP3 player Electrolux adds highly advanced calendar and video messaging system so the kitchen truly becomes the center hub in the house. Whirlpool centralpark equipped with satellite radio, a Web tablet with interactive message board and family calendar, a digital picture frame, a DVD/CD player and other features came out in 2007. [13]

There have been so many other attempts at making internet refrigerator a success. In 2009 Samsung offered a fridge with a detachable LCD screen with a message board for "smart food management". In 2010 LG suggested a fridge with internet access that enabled users stay tuned to the internet. In 2011 Samsung again offered a new internet fridge, the Futuristic RF4289 with an 8in touch screen. One of the latest attempts is the LG Home Chat show cased at the International Consumer Electronics Show (CES) in Las Vegas in 2014 by Korea LG.

The proposition is that users will be text the fridge and ask it about its content. [3] Currently, the app can only be used to do this in South Korea, but LG planned to extend it to the US and other markets at a later date. LG's HomeChat appliances communicate with their users via Line, a popular chat app in Asia, and are designed to understand natural language requests. The refrigerator features an in-built wide-angle camera that takes a picture of its shelves' contents each time its doors are opened and closed. As a result, one of the requests it can handle is to provide the latest photo so its owner can check if they are missing an item while visiting a shop. In addition, the fridge's Freshness Tracker software can provide information about items that have passed their expiration dates. However, this feature requires the user to enter details of each product into the fridge when they were placed in it. [11]



Fig. 1 Internet refrigerator with built-in camera. Sourced from [11]

The focus of this work is to present an overview of internet Refrigerator as an instance of internet of things (IoT). The remaining part of the article is arranged as follows: Section 2 presents the components of internet refrigerator; Section 3 portrays the internet refrigerator as an IoT. Section 4 highlights benefits and challenges of IoT, Section 5 considers the user acceptance of internet refrigerator and Section 6 gives the conclusion.

II. COMPONENTS OF INTERNET REFRIGERATOR

Internet refrigerator has its own special features that distinguish it from other traditional refrigerator. These are:

A. An internet refrigerator could have an **IP address** that might support a function such as testing temperature [5]. A method of remotely controlling an Internet refrigerator having its own proper ID, includes transmitting a variable IP information assigned to the Internet refrigerator where the Internet refrigerator accesses the Internet, and the proper ID, to a server from the Internet refrigerator; storing the proper ID and the IP address information pertaining to the Internet refrigerator in the server; supplying the IP address information of the Internet refrigerator as appropriate, according to the proper ID address inputted by a user who has access to the server through the Internet, to a user terminal; and allowing the user terminal to access the Internet refrigerator, based on the IP information received from the server. Thus, a user in a remote place can access the Internet refrigerator by a remote control through a

terminal in the case of the refrigerator assigned a variable IP address.

B. Control Units: usually the IoT devices utilize a microcontroller as the main control unit. This can be considered as a small computer on a single integrated circuit, containing a processor, memory, and input and output peripherals [14]

C. Sensors: are devices that can measure physical quantity (like temperature, humidity) and convert to signals which can be read and interpreted by the control units.

D. Communication Modules: these are the devices that are responsible for communication with other devices or appliance that are on the IoT platform. They provide connectivity, either wired or wireless according to design. They consist of embedded electronics that transform information received in bits and bytes to radio waves or signals that are transferred by wire. [14]

E. Bluetooth/ WiFi: WiFi is the most common way to connect a device to the internet wirelessly. Fitted to the device is the WiFi interface that communicates with wireless router which provides access to the internet. Most IoT device has this fitted in them, the internet refrigerator inclusive.

F. RFID Technology: RFID is Radio Frequency Identification: A micro-chip in a label used to transmit data when the label is exposed to radio waves. In order to maintain an updated list of the products in the fridge, RFID is used. Each item gets tagged with an RFID card upon entering the fridge for the first time. Every time a product is placed in or removed from the fridge, the RFID antenna installed inside the fridge recognized the product's unique RFID tag, and registered it as either in or out of stock.[16] The RFID tag can either be passive or active;

1) *RFID tags Passive:* draw power from the reader, which sends out electromagnetic waves that induce a current in the tag's antenna. Passive tags have no battery. Passive RFID tags only transmit a signal upon receiving RF energy emitted from a reader in proximity of the tag. They are used for inventorying assets using handheld RFID readers

2) *RFID tags (Active):* this contains a transmitter that is used to send/ broadcast signal to the reader. It also has a battery that serves as the power source for the transmission and it runs the microchip circuitry. They are used with fixed RFID readers to perform real-time asset monitoring.

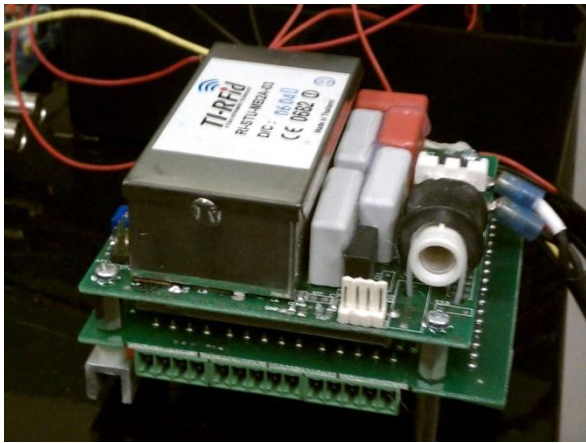


Fig. 2 RFID reader. Sourced from [16]



Fig. 3 An example of RFID tag. Sourced from [12]



Fig. 4 Future smart/internet refrigerator reading information of the contents. Sourced from [24]



Fig. 5 A WiFi enabled refrigerator Sourced From [25]



Fig. 6 Refrigerator Manager. Sourced From [26]



Fig. 7 Refrigerator manager. Sourced from [27]

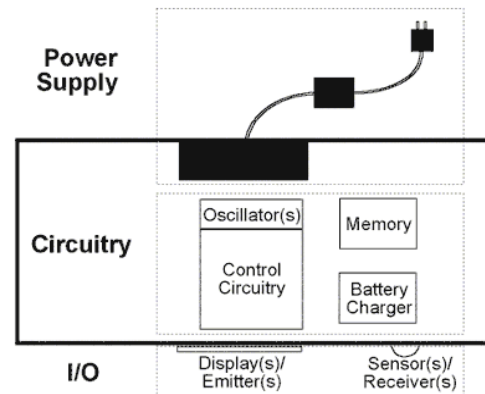


Fig. 8 the control Unit. Sourced from: [28]

III. INTERNET REFRIGERATOR AS IOT

The Internet of Things (IoT) is a novel paradigm that is rapidly gaining ground in the scenario of modern wireless telecommunications. The basic idea of this concept is the pervasive presence of a variety of things or objects – such as Radio-Frequency Identification (RFID) tags, sensors, actuators, mobile phones, etc. – which, through unique addressing schemes, are able to interact with each other and cooperate with their neighbors to reach common goals. [7]

The Internet fridge is probably the most oft-quoted example of the Internet of Things [15]. However, the IoT is much more than that. The Internet of Things includes the connected refrigerator plus thousands of medical devices in hospitals; smart utility meters; GPS-based location systems; fitness trackers; toll readers; motion detector security cameras; smoke detectors; and embedded systems etc. Each of those IoT end nodes requires connectivity, processing and storage, some

local, some in the cloud. This means scalability, reliability, security, compliance and application elasticity to adapt to dynamic requirements and ever-changing workloads. [2]

The proposition of internet fridge and its appearance in the market so far is a demonstration that IoT can be a success and is here to stay.

IV. BENEFITS AND CHALLENGES OF INTERNET REFRIGERATOR

The proposition of internet refrigerator comes with benefits and pitfalls or challenges attached to it. This section discusses some of the benefits and challenges associated with the acceptance of internet refrigerator. Regardless of the challenges, the benefits from this technology are incomparable, as its proposition is expected to make life easier by reducing daily hassles. Some of the benefits are explained below:

1.) *Smart Diagnoses:* In case a refrigerator develops a technical fault and stops working. Signals can easily be sent from the factory to the refrigerator to determine what part of the refrigerator has the problem, may be the fan, compressor, evaporator or thermostat. This makes repairs faster and easier as the technician sent from the factory already knows what component is to be changed.

2.) *Remote Monitoring:* items in the refrigerator can be monitored from whatever location one is. With the use of smart access one can with an IOS or Android phone check the status of items kept in the refrigerator.

3.) *Innovative Management:* items kept can be smartly managed and monitored. Expiration dates can be checked and sent to the user's smartphones to determine which item is expiring soon. This can also serve as a smart manager that coordinates what item is to be taken or cooked next, based on closeness to expiration. [9]

4.) *Energy Monitoring:* manufactures of internet refrigerators like LG, Samsung are making their wares more energy efficient by monitoring energy consumption. Monitoring Apps are placed on smart phones or mobile devices to see and monitor the energy usage of the appliance, in case the door of the refrigerator is left opened. [9]

5.) *Save Cost, save energy, save time:* another benefit associated with internet refrigerator is it saves cost of acquiring unnecessary or unneeded items, it save time spent on rearranging and checking dates of expiration by oneself, unnecessary energy spent can easily be saved. [22]

Also other benefits attached to intelligent internet refrigerator includes Better Food Management, No wastage of food, Efficient Shopping, Quick Decision for Cuisine. User Friendly Operation, Better Food Management, Improve Sales, Create new source of revenue, Target Marketing, Consumer Buying, Habits Information

Regardless of this benefits, there are some risks attached to this upcoming technology; internet refrigerator. As with any Internet-connected device, internet refrigerators have potential security vulnerabilities. Some of these include:

1.) *Hacking:* if the owner of a refrigerator can communicate or chat with it, so also can a smart skillful hacker. Appliances or devices like refrigerator connected to the internet are susceptible to hacking. The control of the refrigerator can be taking over by the hacker, and this can be used to generate spam email messages [19]. Cyber-attacks are likely to become an increasingly physical (rather than simply virtual) threat

2.) *Intrusion:* intrusion is certain as refrigerators that are connected to manufactures are susceptible to unwanted messages from the manufacturer and different related manufactures or business owners.

3.) *Privacy:* As the Internet of refrigerator spreads widely, it has a lot of positive views attached, but some of the downsides are also clear, and most involve privacy. Internet connects you to your refrigerator and every other thing in the internet of things. The world may go nosy and pick what you have and do not have in your fridge, even connect with your other appliances that are on the link. As connection to the refrigerator are controlled remotely.

V. USER ACCEPTANCE OF INTERNET REFRIGERATOR

One of the key clogs in the wheel of internet refrigerator is the user acceptance of the product. Factors such as ease of use, cost, household dietary pattern, technology anxiety to mention a few are to be considered. Some attempts have been made to determine the view of users about this smart product. Some users indicated that smart fridges are useful, easy to use and thus will be willing to purchase if only it can be available in the market. [17] Perceived usefulness and ease of use were considered to be the most important factors in smart fridge acceptance. The notion that smart fridges will be able to track items and expiry dates is found to be very appealing. [1] Presently users are not willing to own smart fridges due to its high price [8], [21] However, there is an increased intention to use a smart fridge in the future when the price would have been subsidized. Many people regard this kind of new technology as symbolic of wealth and a means of enhancing their sense of self-importance [18]. Generally, the users' reaction to smart fridge ranges from intriguing at its usefulness to disappointment about the apparent dullness of the smart fridge. [17]

VI. CONCLUSION

The internet refrigerator which is a typical IoT makes our daily life more convenient. Considering the positive side and the development this will bring to our daily life, convenience and comfort will be inevitable in our routines. This affects or impacts not the consumer or user alone but food manufacturers, food retailers, the product (refrigerator) manufacturers and even repairers or maintenance officers. According to [10], for users, it makes lifestyle easier, quick and efficient and of good quality as menu can be planed easily, short or no time is spent arranging item based on expiration, no food wastage, more efficient shopping and so on. For Refrigerator manufacturer, it saves the labor cost, easy plan can be made for future products based on the understanding

from the consumption pattern; this new technology becomes a new source of income, and so on. Food manufacturer gets to easily advertise their products to the right customers efficiently, cost of inventory and labor becomes reduce, origin of a food item can be traced easily. For retailers or distributors of items workload is reduced, better projections can be made on market conditions and sales also cost of product can be controlled.

Therefore there is no facet of life that embraces the internet refrigerator that will not benefit from its emergence positively regardless of whatever pitfalls attached to this. If embraced the potentials of nation's economy will definitely become greater.

REFERENCES

- [1] Alolayan Bushra (2014). Do I Really Have to Accept Smart Fridges? An empirical study. In the Proceedings of The Seventh International Conference on Advances in Computer-Human Interactions (ACHI 2014) pp186-191
- [2] Ben Rossi (2014). Why the Internet of Things is more than just a smart fridge Retrieved from: <http://www.information-age.com/technology/mobile-and-networking/123458485/why-internet-things-more-just-smart-fridge#sthash.C1hZfmQj.dpuf>
- [3] Charles Arthur (2014). Internet fridges: the zombie idea that will never, ever happen Retrieved from <http://www.theguardian.com/technology/2014/jan/07/internet-fridge-igces-2014>
- [4] DAN SAFFER 2014 The Wonderful Possibilities of Connecting Your Fridge to the Internet Retrieved from <http://www.wired.com/2014/10/is-your-refrigerator-running/>
- [5] Ellen Messmer (2014). Can TVs and refrigerators really spew botnet spam? Network World retrieved from <http://www.networkworld.com/article/2173783/network-security/can-tvs-and-refrigerators-really-spew-botnet-spam.html#> on 17th Jan. 2015
- [6] Fong B., Fong A.C.M. and Li C.K. (2011). Telemedicine Technologies: Information Technology in Medicine and Telehealth. Wiley Publishers.
- [7] Giusto D., Iera A., Morabito G., Atzori L. (Eds.), The Internet of Things, Springer, 2010. ISBN: 978-1-4419-1673-0. <http://dx.doi.org/10.1007/978-1-4419-1674-7>
- [8] Kim H. W., Chan H. C., and Gupta S., Value-based adoption of mobile internet: an empirical investigation, Decision Support Systems, vol. 43, February 2007, pp. 111-126. <http://dx.doi.org/10.1016/j.dss.2005.05.009>
- [9] Krissy Rushing (n.d) 5 Benefits of Internet Appliances, retrieved from <http://www.hgtv.com/remodel/mechanical-systems/5-benefits-of-internet-appliances> on 14th January, 2015.
- [10] Kwok Christy, Connie Chen, Ernest Wong, Joan Wong, Katie Leung, Kevin Chow (2003) IRefrigerator: Creative Key Intelligent Refrigerator System retrieved from <http://www.slideshare.net/walkthis/creative-key-intelligent-refrigerator-system-v24-2003> on 17th January, 2015
- [11] Leo Kelion (2014). LG launches fridges, washers and cookers that chat Retrieved from <http://www.bbc.com/news/technology-27308869>
- [12] MetalCraft (2013) RFID tags and Labels, retrieved from <http://www.idplate.com/category/rfid-tags-rfid-labels-and-asset-tags> on 17th January, 2015
- [13] Mike Kuniavsky 2008 Evolution of fridge computer Retrieved from http://www.orangecone.com/archives/2008/01/the_fridge_comp.html
- [14] Nicholas Negroponte (2014) Introduction to Internet of Things
- [15] Richard Macmanus (2009) Internet Fridges: State of the Market – ReadWrite Retrieved from http://readwrite.com/2009/07/27/internet_fridges
- [16] Renner Zach, Dan Jonik, Mario Admon, and Andrew Copp (2011) RFID Fridge: A Smart Refrigerator for the Home, retrieved from <http://www.personal.umich.edu/~zrenner/fridge/rfid.htm> on 17th January, 2015.
- [17] Rothensee M., User acceptance of the intelligent fridge: empirical results from a simulation, The Internet of Things, 2008, pp. 123-139.
- [18] Sarker S., and Wells J. D., Understanding mobile handheld device use and adoption, Communications of the ACM, vol. 46, 2003, pp. 35-40. <http://dx.doi.org/10.1145/953460.953484>
- [19] Stephen Bonner (2014). Hacked by your fridge? When the Internet of Things Bites Back, Guidian Media Network, Guardian Professional
- [20] Wikipedia(2015) Internet Refrigerator retrieved from http://en.wikipedia.org/wiki/Internet_refrigerator
- [21] Wu C. S., Cheng F. F., Yen D. C., and Huang Y. W., User acceptance of wireless technology in organizations: a comparison of alternative models, Computer Standards & Interfaces, vol. 33, 2011, pp. 50-58. <http://dx.doi.org/10.1016/j.csi.2010.03.002>
- [22] Zone Alarm (2014). The Benefits and Security Risks of Internet of Things retrieved from <http://www.zonealarm.com/blog/2014/11/the-benefits-and-security-risks-of-the-internet-of-things/> on 14th of January 2015.
- [23] <http://www.wired.com/2014/10/is-your-refrigerator-running/>
- [24] https://d262ilb51hltx0.cloudfront.net/fit/t/1200/504/0*Svi2mqXF-AbTYIEx.jpeg
- [25] <http://www.newlaunches.com/wp-content/uploads/2013/01/Samsung-WiFi-enabled-RF4289-fridge-2-thumb-450x307.jpg>
- [26] <http://uxmag.com/sites/default/files/uploads/itzkovitch-internet-of-things/internet-of-things-6.png>
- [27] <http://i.ytimg.com/vi/Uli9hvRVsTg/maxresdefault.jpg>
- [28] <http://standby.lbl.gov/images/42108.png>