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Review Article

Future internet: Application of internet of things to libraries

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ABSTRACT

This paper explains the technical perspective of Internet of Things (IoTs) with definitions and the evolution of IoT. The characteristics like interconnectivity, heterogeneity, dynamic change, safety and connectivity are emphasized with IoT architecture. Different layers like the perception layer, network layer, middleware layer, application layer and business layer are explained. Application of IoT in different disciplines like in healthcare, agriculture, transportation is discussed. Emphasized the developments of smart cities with smart homes interconnecting the appliances, smart buildings for their operations from remote, smart environment and smart governance. Smart healthcare is also included under smart cities with parking lots in cities. Then IoT applications in libraries are discussed from entry of users, circulation desk, restoration of books, virtual library and book tracing, information literacy, cloud computing for the e-resources stored and accessed from publishers' website and fire detection and protection for the safety of documents in libraries. The challenges and issues faced while implementing the IoT like privacy and security, accuracy, transaction, hacking, expenditure, system development and user training are mentioned. It has been concluded that IoT is in infancy stage for library professionals and they should try to implement and the future lies on their interest in latest technological applications.

1. Introduction

With the rapid development of the Internet, the earth has been transformed into a global village. Information technology has penetrated into all walks of life and all fields of the world. Currently, the applications of information technology have a great impact on all aspects of people's social life. The Internet of Things (IoTs) is an "internet of things" based on the traditional Internet, using technologies such as RFID and wireless sensor networks to build an "internet of things" that connects things and senses each other (Kramer and others, 2020). A library may be an assortment of knowledge, sources, resources, books, and services, and also the structure within which it's housed. Apart from books several libraries square measure currently additionally repositories and access points for maps, prints, or alternative documents on numerous storage media like microform (microfilm/microfiche), audio tapes, CDs, LPs, cassettes, videotapes, and DVDs. Libraries materials are organized as per a library system, so that collections are browsed with efficiency.[1] Some experts assert that: once a micro sense is embedded in whatever objects such as watches, keys, trains, automobiles, buildings, the object can "talk" automatically. With wireless network technology, people can "talk" directly with objects, and objects can "communicate" with each other at any time. At the same time, with the improvement of people's ideological awareness, the borrowing volume of books is also increasing. As an important carrier of books, the difficulty of book management in libraries has increased, and the traditional manual management method is no longer

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suitable for the needs of modern book management. In recent years, the concepts of "smart campus" and "smart learning" in domestic universities have also been proposed, and the research of smart library, as an integral part of smart campus, has become more and more the focus of modern library research. As libraries explore and develop their next generation library catalogue, cloud computing has emerged as a critical component of these new system. Cloud computing improves the service efficiency and visibility of libraries' collection and management services (Christine, 2011). IoT helps the libraries to act in a smart way for many of the activities / services for the users. This article deals with IoT, structure and applications to libraries.[2–8]

2. Internet of Things

According to Techopedia "The Internet of Things is a computing concept that describes a future where every day physical objects will be connected to the Internet and be able to identify themselves to other devices". As per Whatis "The Internet of Things is a scenario in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS) and the Internet". In simple terms, Internet of things enables, any natural or man-made objects to communicate each other and transfer data using assigned IP address with or without human interventions. In essence, according to the European Telecommunications Standards Institute (ETSI, 2013), the IoT can be considered as a superset of connecting devices that are uniquely identifiable by existing near-field communication (NFC) techniques.[9–14]

Internet of things (IOT), known as the Internet of objects, refers to the networked interconnection of every object, which is composed of all kinds of information sensing devices, such as radio frequency identification (RFID) devices, infrared sensors, global positioning systems, laser scanners and various other devices. When embedded with chips and sensors, these objects can "think", "feel", and "talk" with each other. Together with the infrastructure of the Internet and mobile networks, these objects can communicate with humans, and enable us to monitor and control them anytime anywhere and enjoy their intelligent service, making the idea of a "Smart Planet" a dream come true. It is described as a self-configuring wireless network of sensors whose purpose would be to interconnect all things. The concept is attributed to the former Auto-ID Centre, founded in 1999, based at the time at the Massachusetts Institute of Technology (MIT). Its original definition is very simple: connects all kinds of objects through radio frequency identification and other sensor equipment to the Internet, to achieve intelligent identification and management. In 2005, in Tunis World Summit on the Information Society (WSIS), the International Telecommunication Union (ITU) formally proposed the "Internet of Things".

The growth forecast of Internet of Things is very high as number of objects connected to Internet is rising year after year. Even though the concept emerged in early 2000s, sudden surge of interest in IoT has happened owing to multiple factors viz., introduction of new version of Internet protocol i.e., IPv6, support of major network providers (Cisco, IBM, GE and Amazon) and decreasing connectivity costs. The evolution of IoTs is shown in Figure 1 below:

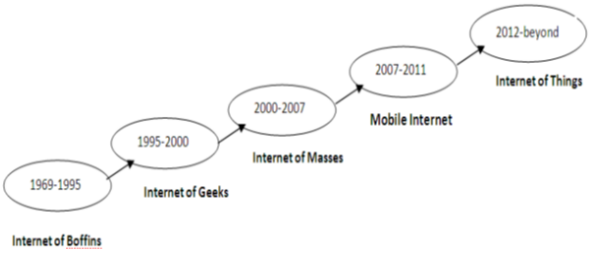

Fig. 1: Evolution of internet of things from internet

2.1. Technical perspective

Technically, the IoT works at three levels for its three basic functionalities. It includes: (a) Identification; (b) Sensing; and (c) Communication. The identification at first level is carried out through a 'transponder' available on the identifiable object. This is more or less like an RFID tags most commonly used on the books in libraries. It is an electronic chip carrying coil and a microwave antenna. The next level in the architecture is 'Sensing'. The sensor reads the transmitted data which is the low power radio signal. The last level is the communication. It talks to the deliverable and act as an interface for the mobile-to-mobile communication. These three levels constitute the basic work carried out in the IoT. Lot of other technologies are also involved in the IoT. Another important component is a software layer between the technology and the application layer which is a middleware.

2.2. Characteristics of IoT

The general characteristics of IoT are as follows:

1. Interconnectivity: With regards to IoT, something can be interconnected with the overall real factors and conversation establishment.
2. Things-related to administrations: IoT is productivity offering related organizations necessities of things, private affirmation, flexibility between physical issues,

and related virtual things.

3. Heterogeneity: gadgets and contraptions in IoT are heterogeneous and it implies it varies as far as equipment and correspondence frameworks. They can draw in with different gadgets and stages of suppliers over computer networks.
4. Dynamic changes: objects involved in IoT can change dynamically. For instance, automobile industry.
5. Safety: The creators and recipients of IoT must ensure safety. It can be achieved by protection of our personal information, securing the endpoints and the networks.
6. Connectivity: Connectivity enables accessibility and compatibility. Accessibility is the receiving on a community whereas compatibility offers frequent capacity to secure and protect things.

3. IoT Architecture

An international community inter connects specific sorts from anywhere every time through Internet protocol (IP). The following section discusses the architecture of IoT contains different layers, namely the perception layer, network layer, middleware layer, application layer, and business Layer as appeared in Figure 2.

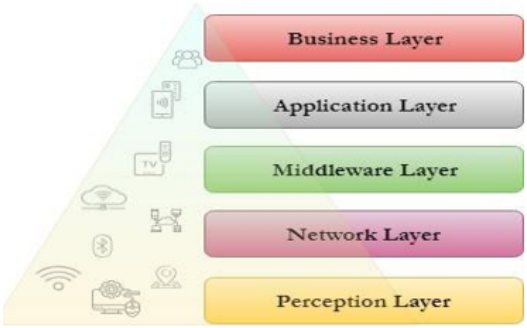

Fig. 2: Architecture ofIoT

3.1. Perception layer

It is also called as awareness layer to perceive things and accumulate information. It involves social affair of physical things (Lin and others, 2017). It is good responsible for data and acquainting real factors and the commitment to ensure how estimations is accumulated, saved and transmitted. The layer includes Radio-Frequency Identification, sensors; camera relies upon qualities of segment, for instance, shows or verbal exchange developments used.

3.2. Network layer

Network layer is a neutral system that considers efficiency insight of IoT, which is liable for communicating and handling proceedings with the guide. It has an enormous job in managing records identified with IoT managements. Community and correspondence innovation utilized right now as wired, wireless depends on the systems embraced through the network. Wi-Fi, Bluetooth are the examples of the network layer.

3.3. Middleware layer

It is viewed as handling or processing layer, over the network layer. It offers an Application Programming Interface to place in power applications. Also, it affords many numerous administrations, example, records investigation, records handling, notice and control gadgets, records assortment, and revelation of information by Object Naming Service or Electronic Product Code. It utilizes general protocols such as COAP, MQTT, XMPP, and HTTP.

3.4. Application layer

The utility consumer interface applications are part of the product or software layer for internet providers as an application-programming interface inside the layer (Anzelmo and others, 2011). This is answerable for transport giving a number of purposes in numerous territories where IoT discipline sent and applied, for instance, cunning homes, shrewd urban areas, astute wellbeing, and others. The main aim of this layer is to associate IoT clients and applications.

3.5. Business layer

This layer deals with complete IoT frameworks, for example, application, plans of action and, a record has gained from the utility layer. It creates IoT capacities adding to the improvement of effective adventure designs for the support of IoT related advancements. Also, it must control and protects the security of clients, which is crucial to the internet of things (Rose, E and others, 2015).

3.6. Applications of IoT in different industry

The applications of IoT in health industry, agriculture, transportation and smart cities are discussed below, even though it has applications in many more areas.

Healthcare - In case of healthcare, IoT has given birth to remote patient care and monitoring thus helping in reduction of health costs and better treatment for patients. From the smart devices attached to human bodies, doctors would be able to monitor the state of health of patients and can avoid emergency hospitalizations by having early interventions. The convergence of IoT and healthcare bring in rich dividends by giving real time information about patients' health and greater understanding of their behaviour, which are key factors in treating chronic illnesses (digital service cloud). The devices that are connected to

humans, to the Internet and to each other help doctors in broadening patient care and can bring in potential benefits such as scaled expertise, ongoing monitoring and hospital prevention (Hollander). For example, with the help of IoT, a person having heart disease can be better monitored by doctors by receiving constant reports on the status of health, effect of medication and able to know early signals of any distress, so that emergencies can be avoided.

Agriculture - India predominantly pursues agriculture. 69% of the Indian populace has agribusiness as a significant occupation. The advancement of the IoT innovation will assist farmers with augmenting their farm yield. As IoT application in horticulture keeps on creating, farmers will greatly benefit.

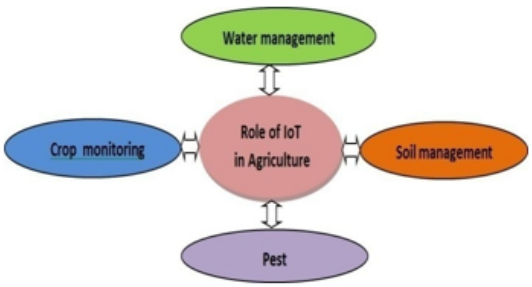

Fig. 3: Application of IoT in agriculture

Offer excellent solution to produce and market Agricultural Products. The essential applications of IoT in agribusiness will help to checking on availability of water, screen soil constituents, and manage water systems (Figure 3).

Automotive sector – With the introduction of Industry 4.0 or Industrial Internet of Things (IIoT), digital transformation has begun to show its profound impact on the transportation and logistics industry. The implementation of IoT in automotive sector has brought in a huge development in the field of fleet management. Trucks nowadays are integrated with weight measurement, location tracking, and several other sensors. The volume of sensory data gathered from a large fleet of such trucks is stored into a cloud application. This data is then processed through different analytics features and conceptualized into a visual format. A fleet operator can easily go through this information to monitor different parameters associated with its fleet. Some of the benefits that an IoT infused fleet management system offer to a fleet manager are: i) Real-time location monitoring of the fleet ii) Weight / volume tracking of cargo that the fleet is carrying iii) Truck's performance statistics like fuel and mileage iv) Tracking traffic conditions on the road v) Route management and vi) Time and driver management.

Smart Cities - The IoT utilizes the Internet to interconnect heterogeneous contraptions with one another, to improve the receptiveness, and every single open machine should be related to the Internet. The connected sensors, light and meters are the devices that are used in the smart cities to gather and analyze the data. Figure 4 demonstrates the essential usages of the IoT for reasonable city networks. These data were gathered from the devices used to improve the infrastructures, public utilities, services, etc.

In smart homes, the various electric and electronic devices that are wired up to a centralized control system. So, they can be either switched off or on remotely at particular times. But it has to buy a lot of things such as sensors, smart bulbs and security cameras and so on.

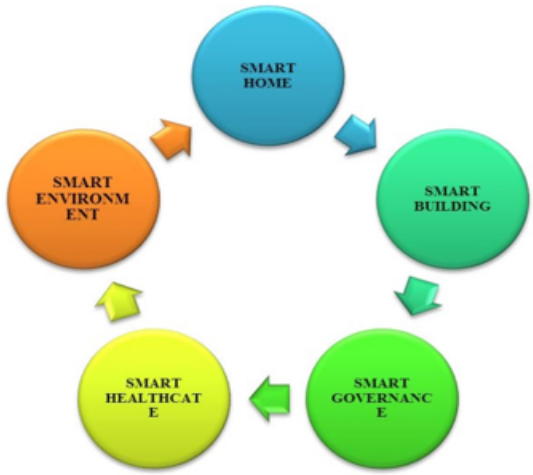

Fig. 4: Smart city and its applications

Smart parking lots - By empowering sensible stopping and touchdown vehicles can be monitor towards a variety of parking areas disseminated in the metropolis. Thus, sensible parking garages ought to be composed in a method to think about the quantity of automobiles in every zone. Similar to that IoT applications are there for smart Governance, healthcare, environment and buildings and many more. Let us discuss some of the applications of IoT in libraries.

4. Internet of Things: Libraries Perspective

Even though IoT is still in its infancy, it has a huge potential for libraries. As library is a complex organization which has embedded constituents linked together and a large number of interactions take place be it with man to man or man to machine, machine to man, and with IoT object with object interaction has a great possibility. Librarians are already familiar with this in libraries owing to the use of RFID, which

does the similar thing of interacting with machines, tags and updates library management system with entries of

books issued to a user, but in case of IOT, only the difference is, it is the Internet interacting with a thing or object such as book. Libraries have books, journals, CDs/DVDs and many more physical objects and IoT can be a blessing in disguise to overcome some of the perennial library problems such as misplacement of objects and their usage. It can even help in strengthening the ties between the books and readers thereby realizing Dr S.R. Ranganathan's 2nd law of library science "Every Reader his or her Book." Since most of the patrons in present days have smart phones, using a mobile app, libraries can enable them to access and use library resources through virtual library card. It has the great potential for libraries to market their services.

5. IoT implementation in Libraries

1. Access to library and its resources - Libraries, using a mobile app, may provide a virtual library card to its members, which will enable members to gain access to library and use its resources. When a user accesses the library catalogue to locate the required resource/s, the library app stored on his or her mobile, will provide a map of the library guiding user to the location of resource/s. It can also provide additional information about a resource by connecting to a site such as Amazon.
2. Circulation Desk - But with IoT, online connectivity can be provided through mobile apps to the users, which can automate rest of the circulation jobs such as records' maintenance, creation and updating of library cards, overdue, reminder. With IoT, the users need not stand in the queues on circulation desk, can check for the books
3. Overdue on his/her mobile. Also, if someone has demanded any book which is already issued, when the book is returned then with IoT an automated message will be received by the demanding user. In case of eBooks, the required book will be issued automatically. So IoT will help not only save efforts of the staff but also will save the time of the users.
4. Reservation of Books - One potential use of the IoT can be that the patron can search the desired book from the OPAC of the library available on internet through his smart phone and reserve the book through smart phone. Then the desired book, available in the shelf of the library, which is enabled with sensors through network can show its presence through a beep or may start flashing light. This way the book itself will identify its location.
5. Virtual Library and Book Tracking - IoT through the mobile apps will allow its users to not only have the virtual tour of the library on their mobile devices, but also keep and track the availability of the book on the respective shelves or check the other resource availability despite the location wherever they are.
6. Information Literacy - IoT may help libraries in providing self-guided virtual tour of the library. Libraries having setup beacons like wireless devices at various sections
7. Of the library, when users visit the particular section, their mobile phone will play a video or audio explaining more about that section and how one can get maximum benefit out of it. It may even able to provide enriched experience of special collections
8. Such as manuscripts by providing digital format of it on their mobile phones (Potter, N).
9. Fire Detection and Prevention – In case if there is fire in the library and there is no one to notice it, then the fire detection devices may alarm and sensors in the library with the associated networks will automatically send the message to the Fire.
10. Department. And not only this but the concerned person of the library (say Fire Officer) who could be available anywhere and is responsible for taking action can also receive a message. This way IoT will help in taking action automatically at early stage and prevent further damages.
11. Cloud Computing – It is nothing more than the collection of computing software and services that can be accessed via the Internet. It describes the software applications or other resources that exist online and are available to multiple users via the Internet, rather than being installed on a particular user's local computer. Cloud learning occurs on the basis of cloud technology as it supports the use of software in the cloud to learn by providing data, storage & software that can be accessed in an online environment. Libraries were loaded with various expenses. On the other hand, "with cloud computing there is little or nothing to finance". "Pay-as-you-go" & "Subscription" methods are two modes of payment in cloud computing. "91% of the organizations in US & Europe agree that the reduction of cost is a major reason for them to migrate to cloud environment" (Mayank, 2013). Under consortium environment, libraries are accessing the different types of e-resources (publisher's websites). If there is some app developed to interact simultaneously with users and librarians and informs the resources, problems faced by the users, so that librarian /publisher may take action quickly due to IoT. Therefore, it is time for libraries think seriously before clubbing libraries services with cloud-based technologies and provide reliable and rapid services to their users. There are many more applications of IoTs to libraries, but not all are listed here.

5.1. Challenges and issues

Some of the probable challenges and issues that may arise with adoption of IoT for libraries could be:

6. Privacy and security

For availing best of the IoT, the users may have to keep the mobile data always enabled. This enabling may track its location, as well as may intrigue its privacy by having access control on device as well as contents available on phone such as photographs, documents, etc. Hence the privacy of individuals may get compromised.

6.1. Accuracy in understanding

It is very essential that the IoT is highly accurate and the system understands the semantics clearly. It needs a clear understanding of the requirement of the user without any ambiguity; else the whole system can fail.

6.2. Transactions

These days people largely depend on mobile transactions. One can sync his/her credit/debit card with Google wallet (for android) and can simply buy things simply by peaking phone in front of a sensor at checkout. Same way the transactions for overdue charges, payment for services of library can be done.

6.3. Hacking

As with IoT, mobile apps can have full control on the data and personal information of the users, so it can track and hack the sensitive information and make it available for the unauthorized use.

6.4. Expenditure

IoT involves tagging the items of the inventory of the library, so this may involve additional expenditure on the library budget. Other expenditures involved are: sensors, actuators, communication devices, internet connectivity, etc. These may need huge investment. This issue could be another challenge for the IoT.

6.5. System development

The libraries have to understand and identify where and how the IoT can be used. Different applications will require different inputs from the librarians and staff. To create a highly reliable and accurate system it is important that all the requirements are given in a highly accurate manner and deep involvement of the librarian and staff is necessary.

6.6. Standardization

It is vitally important in the development of IoT. Its goals include lowering the entry barriers to new service providers and users; improvement of interoperability; and to enable products or services to compete for better outcomes at a higher level. Standardization of IoT is difficult due to its rapid growth. Particular problems experienced in IoT standardization include interoperability, radio access level, semantic interoperability, plus security and privacy issues (Keoh and others, 2014).

6.7. User training

For smooth running of the IoT in libraries, basic training has to be provided to the staff for IoT's better implementation. The library staff may not be comfortable to use it in the beginning, so apart from convincing him/her demonstration tools needs to be created to automate the assistance to the users.

7. Conclusion

IOT has a great potential for libraries. If implemented in the desired lines, may bring in desired results and make value addition to library resources and services. The library professionals are always at the forefront in adopting the new technologies. IoT being new, librarians are trying to learn about this new technology and wait until the technology is more widely accepted, adopted and available for better implementation. However, it would be also interesting to learn from early adopters and devise better ways to maximize the benefit of IoT adoption in libraries. Libraries are prone for change and it has been witnessed over a period of history, hence IoT would be the next big thing after Internet, which is going to bring in plethora of changes to the library arena particularly the way library connects and communicates with its patrons. IoT once fully evolved, may bring in sea change in a way how libraries function and provide services to their patrons. It may turn library buildings in to smart buildings, wherein patron can interact with various things in the library and get virtually all kinds of information using devices having communication capabilities. Libraries by taking their patrons into confidence, informing them about privacy and security of data and providing the required training and infrastructure would be able to implement IoT to enrich their services and patron's library experiences. They are very smart and active in implementing and getting benefits of the technology for their work. IoT will help the libraries and their users in a big way.

8. Source of Funding

None.

9. Conflict of Interest

None.

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