Emerging Technology & Innovation : Internet of Things and its Applications in Libraries

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ABSTRACT

Network devices and Internet of Things (IoT) " IoT IS A NETWORK OF NETWORKS"

At the present time, we are living in the global changes. We should also aware with the changing times and achieve the new skills and technology in order to proceed. In this reference, Internet has a taken giant leap ahead from ICT to 'Internet of Things' which making it possible to connect devices and transfer data by with or without human intervention. In fact, today in the headway of innovation, Internet of Things (IoT) is a new era of computer technology that many people are calling the IoT. This IoT can be described as a network of physical objects could be anything like that contains embedded electronics, software, sensors etc. Which connect with the medium of internet using the IP addresses and those smart objects can exchange data among the network and create the decision which based on standard IoT protocols. Actually the Internet of Things (IoT) constitutes a network of embedded devices that incorporate sensors and communication functions . This Internet of Things (IoT) can connect the enormous offline world with people through the Internet . To achieve this developed sensors are used to collect data from connected smart objects in the physical world . The gathered data are then uploaded into the cloud and become big data . These data are then integrated and utilized for the development of intelligent systems . In this time , this intelligent system is continuously being developed to process to a big data through the IoT .

INTRODUCTION

Today in the headway of innovation , Internet of Things (IoT) is a new predominant technology for this advanced world because we are living in new era of computer technology . In actual, The Internet has occupied as a distinct position in various spheres of human life. It is developed by spearheaded by mobile devices, which has surprisingly become a part of modern living as everyone wishes to be connected to the Internet all the

time . This technological developments have made it possible for us to access any type of services to finding maximum information . This all resulted by the use of Internet for communication and accessing services by the use of devices .

It called "Internet of Things" whose connecting any object , which may include everything and probably anything else one can think of. For this objects using sensors and having networking capabilities would be able to communicate with each other by the access of Internet services and with the people. This new paradigm is can be binding on every person and his everyday life.

According to **Techopedia " The Internet of Things is a computing concept that describes a future where everyday physical objects will be connected to the Internet and be able to identify themselves to other devices".[1]**

 In present time, IoT is an emerging technology that can provide a variety of several possible potential services areas and innovation technologies , as well as presenting a beautiful and amazing result of networking of mutual networks which connect fast interconnected networked environment . In fact, the IoT presents a cumulative and pervasive nature with the high modern technology effect due to its wide trend .

Actually the Internet of Things (IoT) is a system of inter related computing devices, mechanical and digital machines provided with unique identifiers (UIDs) and ability to transfer data over a network without requiring human- to- human or human –to- computer interaction. IoT is emerging as the wave in the development of the internet and they are revolutionizing of the way we live.

In reference of libraries , this system is a step towards a smart library and also IoT enables traditional libraries to convert into digital libraries by RFID sensors. Today IoT is becoming a greater part of normal life and libraries are the knowledge centers at the forefront of providing necessary services to access and assist the community. Today libraries are an essential part of the education system to improve our knowledge. Because of the rapid changes and development in information and communication technology, it has impacting on libraries. In fact our library is also growing together with the development of human civilization and culture of any country or community from centuries, the knowledge acquired by humans have been managed, reserved and storage for future generations through the libraries. In the creation of any country or society, the importance of the libraries has been accepted universally. From the help of Internet and computer technology, the library managing and services has became universally and easy. Now with the help of information communication technology, the library is reaching to door step of the user community. Today the modern library is called 'Open Library' i.e. "Library for All". In present time, where the libraries are forefront to in use of new technologies and adoption of new trends – that's fact. Because libraries are essential in our life to improve our knowledge . The " Internet of Things " (IoT), which forms a network by sharing information of each sensing object , has recently been spotlighted over the world . This recent changed technology that libraries and library staffs should be friendly with as it may help improve the services, resources and experience those library can provide.

IOT HISTORY AND GROWTH

In 1999, the term " the Internet of Things" was **firstly coined by ' Kevin Ashton '** .Initially, the term referred to a type of computer network that which was can do gather a lot and a wide variety of data from all the physical things of the offline world . In order to obtain these data , these things have embedded sensors that record data and transmit through the connections to the Internet using IP networks which introduced as a new and powerful method to gather information which was not possible to be gathered in the past **."**

Today , IoT is becoming one of the core technologies of modern world . This is because the IoT creates the new values in the connected smart world by collecting big data , uploading data into clouds and processing data in intelligent systems . The newly created values in intelligent systems present the IoT which connects to the internet through incorporating sensors and communication functions in various smart objects . In fact in the IoT era , as application of IoT, it is possible to create a networked smart world with powerful new services and products that create new values .

Oyedeji (1980) describes a library as having " a machinery " for the use of the collection . **[2]**
**Dewy (1983)** posited that, " Libraries are schools and the librarians in the highest sense a teacher."**[3]** . **In the 1990s,** Internet connectivity became the norm for many applications and today is expected as part of many enterprise , industrial and consumer products to provide access to information . However , these devices are still depends by those things on the Internet that required more human interaction and monitoring through apps and interfaces . As early as 1995 , **Louis Rosenfeld** , **founder of the clearing house** for subject- oriented Internet resource guide at the **university of Michigan** ,   The term " Internet of Things " was popularized by the work of the Auto-ID centre at the Massachusetts Institute of Technology (MIT) , which in **1999** started to design and propagate a cross-company Radio frequency identification infrastructure **. (4) In 2002,** its co-founder and former head **Kevin Ashton** was quoted in **Forbs Magazine** as saying **" We need an Internet for Things , a standardized way for computers to understand the real world ." [5].**   Actually ,The concept of Internet of Things (IoT) was initially raised by **Kevin Ashton** in the **early 2000s while working on a project for Proctor and Gamble to improve their supply chain management by linking RFID data to the Internet.** [6].   Again in **2008 , IPSO alliance** was formed to promote the use of internet Protocol (IP) networked devices in energy , consumer ,. healthcare and industrial applications . **In current time , in 2012 IPv6 (Internet Protocol version 6) was launched** , which made it possible to assign IP address to every atom on this earth without having any constraints . Thus it could be possible to ensuring connectivity between across millions of devices . Actually **IPv6 has acted as a backbone to the IoT .** In fact , the above statement is a description of the IoT concept rather than definition . The term **" Internet of Things " is defined as the pervasive presence of a variety of things or objects through a unique addressing schemes to interact with each other and cooperate with their neighbors to reach common goals .(7). (Atzori et.al.,2010) . According to Linnik (2019), IoT is about connectivity between different objects and their ability to transfer the data over different networks . (8).**

The growth forecast of Internet of Things is very high as number of objects connected to Internet is rising year after year . **Cisco's Internet Business Solutions Group (IBSG)** predicts some **25 billion devices will be connected by 2015** and at this time , According to **BI intelligence report (2020)** , it has been predicted that up to **50 billion people will be connected with this technology . In today approximately about 100 things currently connect to the Internet every second and the number is expected to reach 250 per second by 2021 . (9).** Eventually **,** this IoT will encompass about 99 percent of all objects **.**

This complete IoT systems are represent the integration of four distinct components : sensors / devices , connectivity , data processing and a user interface .

CONCEPT & PURPOSE OF THE STUDY

Such our library has to provide a package of many rebated services with the help of computer networking which enable the interlinking of libraries and information centers to pull resources and services irrespective of their location . Library material can be controlled by applying sensors on them . By connecting the sensor to the internet, the movements of each item can be tracked. This can provide real time data , thereby providing better inventory controlled as well as help patrons easily find the item they are looking for .
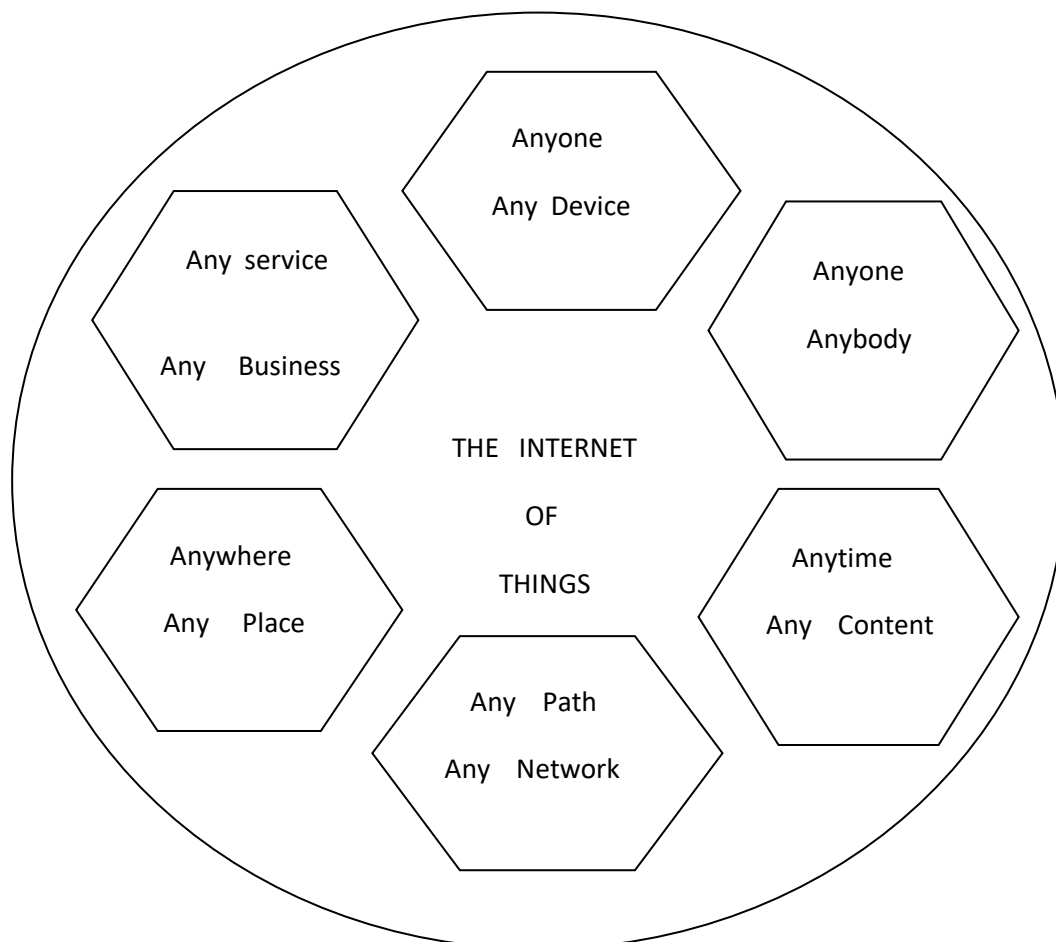
In libraries, IoT such as devices, people, processes and data are connected with one another in away that they can communicate with each other over internet. An attempt has been made to explain the potential impact of IoT on academic libraries and identify library areas where it can be implanted effectively**.** Libraries are essential part of education system to improve our knowledge**.** Because of the rapid development in information and communication technologies, it has and impact on libraries**.** Internet of things (IoT) is one of the most interesting concepts of recent years**.** The IoT has excellent potential in the education sector to create of library system and open new path for research and feasible solution by interconnecting multiple devices to improve operational efficiency, real-time visibility and user learning experiences**.** The IoT system architecture for library solution designed into four logical level including the physical level, communication level, system level and end-user level. Where the user is at center and can develop or enable the data in the libraries applications. **"**Actually IoT is a huge intelligent network that can establish connection between people, process, data and things therefore after the introduction of IoT technology in

the library, the sensor technology embedded in variety of objects can interact via more communication and multimedia system and provide the convenient efficient and improve services to the library users as 'assistive technology' with access and authentication". **(10)** In the libraries , IoT is a new system which has ability to be fastest, most efficient way to track and locate library services such as availability of connecting of the users to the library system that allows them to access the systems with higher level of authentication protocols . This IoT is a modern technology those such as RFID (Radio Frequency Identification Device) that allows for item identification and security, machine to machine (M to M) communication and which is device for such as self check or automated process. It is like a handling machines and semantic search technologies that include metadata and discovery tools. By the use of IoT, users could be directed to his specific reading material location by using if through this special app . IoT could detect the information via internet or Wi-Fi or Bluetooth and send the targeted communication to users. Users could connect their phones to sensors and receive notifications and to locate items from their favorite lists.

IoT Levels and Deployment Templates { 6 fact about IoT }

An IoT systems comprises the following components :

Device , Resource , Controller services , Database , Web service , Analysis Component and Application .

- **Device :** An IoT device allows identifications , remote sensing and remote monitoring capabilities .
- **Resource :** Software components on the IoT device for
    - Accessing , processing and storing sensor information ,
    - Controlling actuators connected to the device.
    - Enabling network access for the device .
- **Controller Services :**
    - Controller service is a native service that runs on the device and interacts with the web services .
    - It sends data from the device to the web service and receives commands from the application (via web services) for controlling the device .
- **Database :**
    - Database can be either local or in the cloud and stores the data generated by the IoT device .
- **Web Services :**
    - Web services serve as a link between the IoT device , application , database and analysis components .
    - It can be implemented using HTTP and REST principles (REST service) or using the Web Socket protocol (Web Socket service) .
- **Analysis Component :**
    - Analysis Component is responsible for analyzing the IoT data and generating result in a form that is easy for the user to understand .
- **Application :**
    - IoT applications provide an interface that the users can use to control and monitor various aspects of the IoT system .
    - Application also allow users to view the system status and the processed data .

EVOLUTION OF IoT IN LIBRARY

Technically, the IoT working 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. These three levels constitute the basic work carried out in the IoT **.**
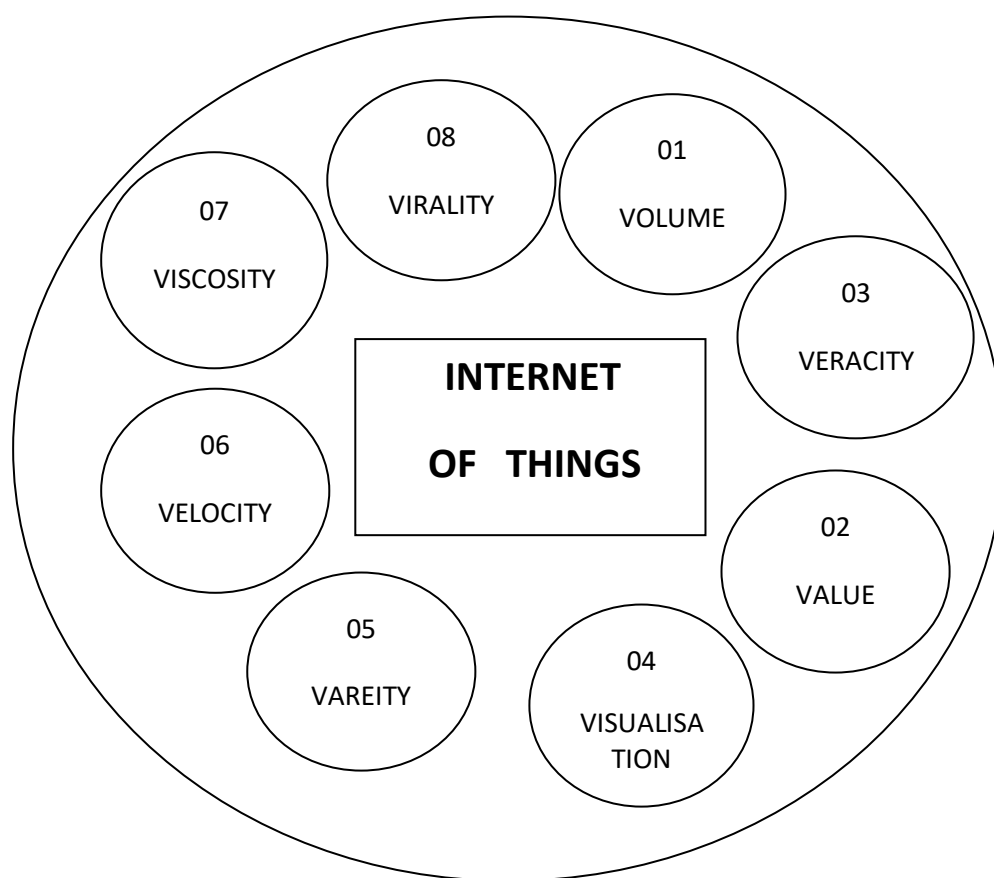
LIBRARY PERSPECTIVE

Library is a complex organization which has embedded constituents linked together and a large number of interactions take place to be it with man to man or man to machine, machine to man and with IoT objects . In libraries , technically the IoT is working at three levels for its three basic functionalities **.** From this point of view , from the use of IoT in libraries by the internet computers , we can knew the everything to anything and using data and also we can collect the things without any help . Apart from this , we would be able to track and count more things and greatly reduced waste , loss and cost .

APPLICATION OF IoT IN LIBRARIES

The IoT is not only capable to performing of the tasks which were previously impossible to do earlier because it also have the more potential to do it more efficiently with securely any mundane task. This Internet of Things is based on intelligent protocol in Libraries and general approaches . The IoT is present a valuable impact on libraries and general uses which present some also valuable plan for use in libraries with managerial perspective and those especially focused on library service , innovation and general purpose . **Therefore its basic structure consist on five (5) component : 1. The information base 2. The protocol base 3. The IoT sensors 4. The information systems and 5. The intelligent information evacuation protocol system .** According to **J. Gubbi and M. Palaniswami** to this **" IoT system architecture for IoT solution designed into four logical level which including the physical level , communication level , System level and End-user level . (11).** This IoT architecture where the user is at the center and can develop or enable the data of the IoT solution using proposed architecture **.** This IoT is help librarians to manage better their facilities, equipment and appliances. Library facilities such as multimedia rooms, discussion and study sections, seminar or conference rooms , computer and printing labs can be transformed into IoT enabled devices to quickly and easily determine the status . Similarly, library computers, electronic imaging equipment and multimedia equipment connected with IoT devices may produce an important usage report which is needed by the librarians for the improving of library services . Also this IoT is refers to activities aimed to improve the user's knowledge , skills and information seeking behavior and information literacy with professional developments. These days libraries are facing many types of problems in his management and services . For the solvent of this problems and it should find the opportunities for development in regard to the emergent technology such as the IoT necessary . Using Internet of Things and new technologies can improve libraries information and user services . The inter communication between the objects and the IoT technologies can make easier decision making and management process in libraries . Libraries equipped by IoT devices will be enable libraries to minimize loss and introduce safely techniques . Libraries will be able to add more value addition to their services .

APPLICATION AND PERSPECTIVES OF BIG DATA OF IoT

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                    08              01
                  VIRALITY       VOLUME

        07                                    03
     VISCOSITY                             VERACITY

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IMPACT ON LIBRARIES OF IoT

Libraries are essential part of the education system to improve our knowledge. Because of the rapid development in information and communication technologies , it has an impact on libraries . Internet of Things (IoT) is one of the most interesting concepts of recent years. The IoT is the excellent working in the library sector and which create the new system and opening to new path for research and feasible solution by interconnecting multiple devices to improve operational efficiency , real-time visibility and users learning experiences . Even though IoT is still in its infancy but it has a huge potential for libraries because libraries will be able to add more value addition to their services and offer rich library experience for patrons . IoT is all about connecting objects each other online as they are uniquely identifiable . Librarians are already familiar with this in libraries owing to the use of RFID . Which does the similar thing of interacting of machines, tags and updates library management system with entries of reading contents issued to any user . Libraries have books , journals, CDs / DVDs thesis and many more

physical objects and It can help in strengthening the ties between the books and readers which is formulates the **Dr. S.R. Ranganathan's 2nd basic law of library science theory – " Every Reader his or her Book . "** Since most of the user in present days have a smart devices and using the mobile app . Libraries can enable them to access and use of library resources through virtual library card .

Some of the potential areas for implementation of IoT in libraries include the following :

✍ **Access to Library and its Rresources :**

Libraries using of IoT, may provide a virtual library of his users which could be enable to gain access to libraries and use those resources. When a user accesses the library catalogue to locate the require resources the library app stored on his device will provide a map of the library guiding user to the location of resources and it can also provide additional information about a resources by connecting to a site . So that user has detailed information about any resource .

✍ **Collection Management :**

From the using of IoT in libraries are able to locate their each and every items and their identification with virtual representation by Internet Computers (byRFID Tags) during material collection management . Because this IoT is may help in better and easy inventory management with may be able to promote the content based material on past records and search history on the Internet .

✍ **Information Literacy :**

Information literacy or orientation is offered to new patterns to educate them about a library, its resources and services . IoT may help libraries in providing self guided virtual tour of the library. Libraries having setup beacons like wireless devices at various sections of the libraries. When users visit the particular section by their devices . It may even able to provide enriched experience of special collections such as manuscripts .

✍ **Recommendation Services :**

IoT can available data suggest tailored recommendations with using real time data which based on the history of their records . When a researcher searching any database for resources on topic of his or her research , it can direct them to his resources and also as well indicate to like same other resources, which would be like a interest to them . Apart from this , IoT could be able to inform the user about new arrivals in his or her area of work or about availability of material .

✍ **Location based Services :**

IoT could help libraries in providing location based services. If a user having created his favorite list in library catalogue using from home or office with IoT enabled mobile device, would be able to get directions for receive , where favorite contents available on shelves in the libraries and also would be able to know her interest .

✍ **Appliances Management :** IoT may help libraries and their users in better management of available appliances thus saving the energy costs . Because it may extend the ability of use to technology not only to library staff but also to users
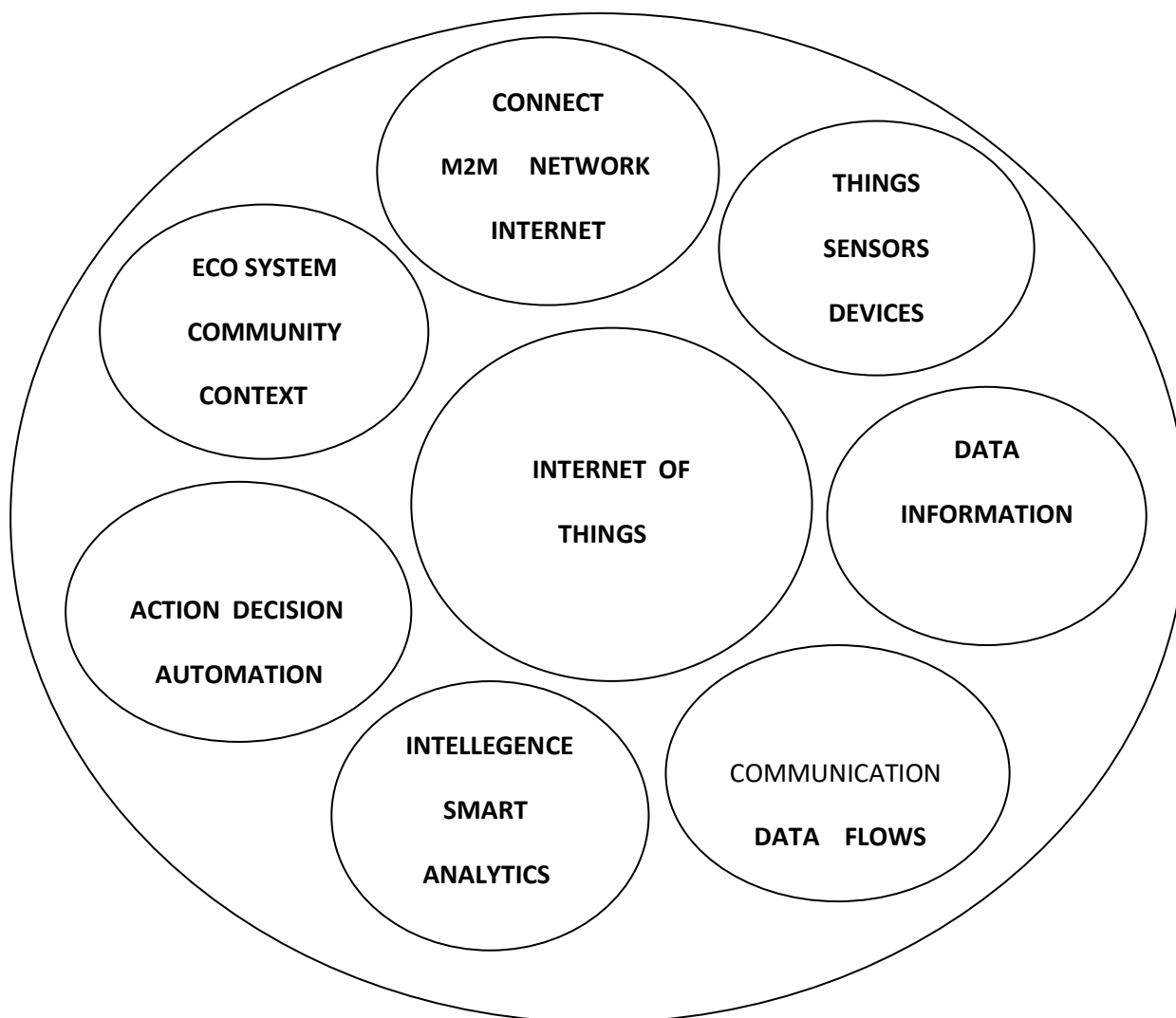
RFID IN LIBRARIES

In the early 2000s, during the advent of the IoT , radio frequency identification (RFID) technology was developed for logistic and inventory management applications . It was also utilized to trace the locations of products being delivered using location-based information systems. Gradually RFID technology continuously evolved and advancing into machine-to-machine (M2M) applications, which is doing enable to control of direct communications, monitoring and controls between devices . It transmits data between humans and things and between things and other things . In fact , this Radio Frequency Identification(RFID) is a technology that helps IoT to identify and track the data of objects . Since its introduction in the 1948 , libraries have been using RFID as a replacement for EM (electro-mechanical) Security Strip and Barcodes . Actually, RFID technology, utilizes tiny radio frequency transmitters or 'tags' that can be placed on book that send out a radio signal containing data on its where about, checkouts structure and any other programmed in to the tags . RFID readers devices that can be placed at the exists and around the library to decipher these signals and collect tangible data in real time implementing RFID technology on books and other form of media in a library would greatly reduce the amount of theft as well as make operational process more efficient and less labor intensive . Now a days , each item in the library is equipped with an RFID tags containing bibliographic information , transaction logs and virtual representations . In fact, RFID is a combination of radio-frequency based technology and microchip technology . In which information contained on microchips in the tags affixed to library materials is read using radio frequency technology regardless of item orientation and

alignment. From the use of RFID in libraries , library can be reduces the amount of time which required to perform their operation and services . The most significant fact that those information can be read from RFID much faster than barcodes and which save the time .

SENSORS IN LIBRARIES

Recent technological advances in low power integrated circuits and wireless communications have made available efficient, low cost , low power miniature devices for use in remote sensing applications . Virtually sensor is a device which detects or measures a physical property and records , indicates or otherwise responds to it . In fact the sensor is a type of device, module , machine or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics for computer processor . In fact , the uses of sensors to be acquire information by detecting the physical , chemical or biological property facts and quantities and convert them into readable signal . These sensors offer to real time monitoring including detection and reporting as needed by a process . A sensor is always used to with other electronics . These days combinations of these factors has improved the viability of utilizing a sensor network consisting of a large number of intelligent sensors , enabling the collection , processing, analysis and dissemination of valuable information . Virtually IoT uses a identification sensors for collecting data from various things or objects . This collected data can be simple or sophisticated and complex . Through the networking software , sensors to be able to communicate and transfer these data's to a cloud infrastructure . This transfer to allow the system the process to existing data and then a user interface to be able to help to communicate and interact with other devices . Smart sensors are built as a IoT components that convert the real-world that they are presenting a digital data stream for a advancement of digital world.

 In the libraries , Sensor technologies are now being developed for long-term vision that includes intelligent systems that are self-monitoring, self-correcting and repairing and self-modifying which the ability for a system to see (photonic technology) , feel (physical measurements) , smell (electronic noses), heart (ultrasonic's) , think / communicate (smart electronics and wireless) and move (sensors integrated with actuators) is progressing rapidly and suggests an exciting future for sensors . In fact, in libraries, sensors can improve and fulfill the promise of ubiquitous sensor systems providing situational awareness at low cost.. For example, new nano wire-based materials that have unique sensing properties can provide higher sensitivity, greater selectivity and possibly improved stability at a lower cost . Such improved stability at a lower cost and such improvements are necessary to the sensor future in libraries.

IOT IN LIBRARIES - CHALLENGES AND SOLUTIONS

Internet of Things has great potential for libraries and it is an emerging area were several possible services may become available as a result of an increasing inter-connected smart devices and networked environment . If the proposed IoT solution is implemented in the desired scope, it can capture desired results and make a valuable addition to library services shows that IoT technology has broad development scope in libraries. In libraries, evolvement of new technology many new avenues open which help us in various tasks. But , despite of , positive IoT contributions to the innovations and transformation of library resources and services , the implementation and application of the technologies cannot be achieved without several challenges , difficulties and obstacles . Because technology brings also new challenges and issues. These issues could be what it is , how to use , what are the drawbacks , how to improve upon etc. Some of the probable challenges and issues that may arise with adoption of IoT for libraries could be:

Privacy and Security challenges : Privacy and Security is a major concerned in IoT implementation in libraries . IoT functionality requires connectivity , communication and data transfer among objects for users . For availing of the IoT , the users may have to keep the mobile data always enabled . This enabling may have track its location and can theft/hacked of his various contents / objects as sensitive information or photographs or documents from users device . Hence the privacy of individuals may get compromised and could be unauthorized use .

Accuracy in Understanding : It is very essential that the IoT is highly accurate and system understands the semantics clearly . Its need a clear understanding of the requirement of the user without any ambiguity otherwise the whole system can fail . Also any ICT device including IoT systems are vulnerable at times to the issue of inaccuracy in functioning due to technical problems or human errors .

Administrative and Financial / Expenditure Challenges : In libraries, IoT implementation requires lot of financial commitment to acquire all the necessary equipment needed for the implementation of this new technology .Therefore , it is preferred to prepare a financial plan for the implementation before any action . Usually , librarians do not have problems to prepare this kind of plan or to propose innovative and creative ideas .
  Apart from this , In libraries , IoT involves tagging the items of the inventory of the library , so this may involve added expenditure on the library budget . Other expenditures involved are : sensors , actuators, communication devices, Internet connectivity, etc. These may huge investment . Also maintenance of the involved technology has to be all time requirement . This issue could be another challenge for the IoT .

Nascent stage of System Development : The development and use of IoT applications for libraries is at a very sophisticated stage . The libraries have to clear understand and identify that where and how IoT can be used . Because different applications will require different inputs from the different sources and it is difficult for librarians and other staff .

User Training : Though not much of the information literacy and not sufficient training process which may be required for smooth running of the IoT in libraries . Because of this reason , library staff and user may not be comfortable to use of the application .

Existence of physical Library : Libraries are already facing problems like less footfall , come as another problem which may generate fear in the librarian to adopt it .
Apart from this , In addition , face recognition is a challenging problems in the area of image processing and computer vision when utilized as a security parameter. Also in libraries , sensing and collecting data from physical world are not an easy task . Because the challenge in data collection multiples in a complex environment , where there are more of unwanted data that may be generated .

Problem Description : It is worth mentioning here that , although IoT is a new technology and the new technology is bringing a new opportunities , but also risks privacy and security of data , managing of which is going to be a challenge . However , the supporters of IoT argue that , when technology evolves , it brings also the threats and solutions . Actually , IoT is that technology , which might provide solutions to protect personal data by individual themselves as IoT is different from web and concentrates more on individual behavior and action and it kept the quick solution for the library which make the libraries to the fastest , most efficient way to track and locate their library services .

FUTURE OF IOT IN LIBRARIES

As discussed earlier , the potential of IoT is huge and it has already drastically changed the face of many fields with its ability to monitor continuously . In the future, IoT is capable of getting incorporated into many more fields . Research has already started in most of the fields on how to incorporate and take advantage of the new technology . The future directions of IoT are expected to take IoT into cloud and to incorporate efficient big data analytics . The trio (library and librarians , reading materials and users) of IoT , cloud , big data analytics is set to change the technology world . In fact , The future of IoT in libraries seems to be robust looking in to the developments in this sector . IoT once fully evolved , may bring in see change in a way how libraries function and provide services to their users . It may turn library views and users can interact with various things in the library and get virtually all kinds of information using devices having communication capabilities. Over the years, apart from the possible areas of implementation mentioned above , IoT may enter deeper into various areas of libraries and may be able to give statistics on usage of library resources , map indicating areas of library most used , satisfaction level of users . Libraries need to take into consideration various issues before jumping into the bandwagon of IoT . For this , by libraries , taking their users into confidence , informing them about privacy and security of data and providing the required training and infrastructure which that would be able to implementation of IoT to enrich their services and users library experiences . In fact , in the future , more objects and things are believed to be IoT enabled devices , therefore , librarians and users should be ready to welcome to IoT .
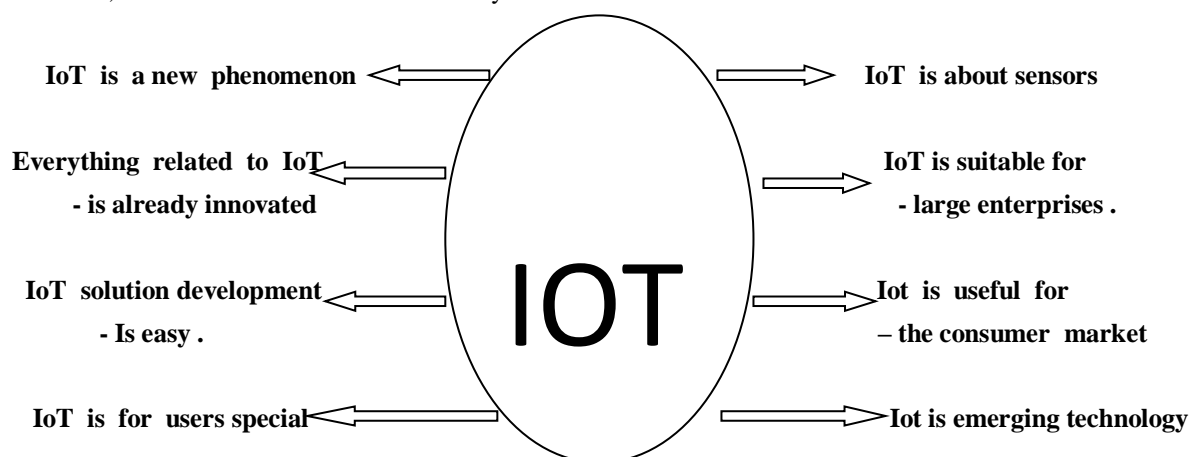
CONCLUSION

Although it has been in existence for nearly twenty years now , IoT is still one of the most important emerging and budding library technology which is rapidly growing and changing the knowledge and information landscape in many areas . The main vision behind IoT of is to connect everything and anything at any time and this is vision has brought in lots of research interests from the world . In libraries , this IoT application is bringing in a better understanding and helping the research community and their users to bring in more advancements and contributions to the area of IoT . In fact , 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 a plethora of changes in the libraries area . Particularly this changing of way for the libraries connects and communicates with its users . It is certain that , despite of existence of multiple challenges , the use of IoT in libraries , contributes positively and effectively to collection management ; management of library facilities , equipment and appliances , access to library resources and services and user education . As a result , it helps librarians to make effective and efficient decisions to increase productivities and performances of library and to have effective interaction with the users and to improve user's satisfaction .

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