A Survey on Choosing the Right IOT Technology Platform

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***Abstract*—This paper addresses the internet of things and various technologies associated with IOT as identification of technology which is best suited for the application is vital to the success and continued usage of IOT enabled devices. The number of estimated devices connected with IOT is enormously increasing the recent advancements in deploying this technology in various fields which has produced excellent results and which further provides scope for innovation are discussed. The challenges encountered during the integration of technologies, network and devices which need to be addressed for proper functioning of the framework are discussed. A review on different types of platforms and the service they provide and specifically the open source platforms available for development of IOT, as choosing an open source platform aids in standardization of technology and indirectly supports the interoperability challenge and the different parameters which assist the developer which have to be considered while choosing the right platform for development of IOT enabled solutions.**

***Keywords*—IOT (Internet of Things), open source platforms, interoperability challenge.**

I. INTRODUCTION

The name Internet of things comprises of 'internet' which is a global network connecting millions of computers, smart phones and tablets which communicate using standard protocols and things could be any device or a physical object that can be identified with a unique IP address and sends or receives data via network. Hence IOT could be defined as a network of physical objects or 'things' which interact to share information between each other and 'things' can be anything like sensors, humans, camera, phones or any possible devices used by human beings.

II. TECHNOLOGIES

A. RFID

The hardware communicates with the middleware using wired or wireless technologies RFID (Radio Frequency Identification) is a wireless sensor technology which captures the information which is stored in tag. These tags are attached to the device to be monitored [14]. The information in the tag is read by the readers when it comes in detectable range using the electromagnetic fields in radio frequency range. EPC global consortium assigns unique identifiers globally called as EPC (Electronic Product Code) encoded into the RFID tags which when associated with an object helps in identifying the object without line of sight contact at distances exceeding 10 meters [8].

B. WSN

In IOT the end devices can also contain sensors which join the internet dynamically generally a Wireless Sensor network comprises of a network of small wireless electronic devices which have different sensors to gather data and forward it through multiple nodes and base stations. The single node in the WSN could directly connect to the internet to form IOT [9].

C. Bluetooth (BLE)

Bluetooth enabled IOT applications are proven to be cost effective for devices which need to exchange data with in short range and for building personal area networks. Advanced version of Bluetooth (Bluetooth Low Energy) BLE helps in swiftly pairing and reconnecting devices along with improved device availability making it ideal for IOT enabled applications.

D. NFC

Near Field Communication enables devices for contact less communication with other devices and transfer data within acceptable range of distance for devices to communicate with each other they should be equipped with an NFC chip. Though there already exists the Bluetooth technology which is on par with the NFC. NFC uses less power, just by a touch or tap of device the NFC lets the devices exchange data which is against the Bluetooth process of device discovery, pass code and pairing of devices hence NFC would play a significant role in IOT [8]. NFC devices work on electromagnetic induction where the devices emit a small magnetic field which connects the physically separated devices. This technology is widely implemented in credit cards, smart phones and smart watches which are embedded with NFC chips to make contact less payments. NFC is not only limited to digitization of wallets but some versions of IOS and android phones allow contact less transfer of photos, links and contacts also.

E. Wi-Fi Direct

This technology allows devices to establish direct wireless connection without the necessity of a wireless router even if the communicating devices belong to different vendors. Wi-Fi direct has been adapted widespread as a standard feature in

smart phones, media players, computer connected peripheral devices like the mouse, printers ,camera and scanners where even without a router a computer can directly make a wireless connection to the printer which is placed remotely within the accessible range to send the documents to print.

III. APPLICATIONS OF IOT

Applications of IOT range from smart connected homes, wearable's, health, agriculture, industry automation to military which are part of every aspect of human lives. IOT has the potential to leverage service in various domains. There are certain domains in which IOT has the potential of exponential growth. Below are few domains with use cases in which IOT plays a major role by enhancing the comfort of humans by simplifying the routine life in the process providing remote access control, accuracy in data collection by reducing the degree of error, easy management and thus increased productivity.

A. Smart Farming

In order to meet the feeding needs of the tremendously growing population in the world, it is essential to implement IOT in agricultural farming techniques. Currently the major hurdles in agriculture include extreme weather conditions and drastic changes in climatic conditions hence incorporating IOT in agriculture leads to smart farming technique and is therefore essential to meet the growing demand for food. In IOT based Smart farming agricultural devices are built with sensors to monitor the environmental like humidity, temperature, PH of soil[4], light, crop health which impact the growth of crops, automation of irrigation system helps farmer in efficient utilization of water. Technology based farming could reduce the use of chemical based products like fertilizers, herbicide thereby promoting organically grown crops with better yield. Some of the specific application of IOT in agriculture is as below:

1) Precision Based Farming: Bulk of the agricultural produce in the world comes from small scale farming where farmers hold small fields and much of the decision taken by these farmers are based on personal experience and speculations rather than proved scientific process. Farmers have to depend on rain for irrigation, soil fertility, temperature [2] and soon as a result this traditional process is not always reliable in predicting these factors. Smart farming technique backed with IOT helps in modernization of agricultural industry where accurate data is extracted through real time data captured by using sensors, drones and automated machineries with less human intervention resulting in improved crop quality, yields and productivity with reduced effort.

2) Livestock tracking and Monitoring: Using the IOT based wireless sensors, cattle's which are spread can be located and monitored remotely for their grazing patterns, well being and health of cattle's. Diseased animals can be identified and separated from the herd there by preventing spread of contiguous diseases. IOT based solution promotes safer outcomes in reproductive livestock where sensors can be deployed for surveillance of heart rate, blood pressure and other vital parameters of the calving livestock thereby preventing cattle death during the process. Some of the existing commercially available solutions include the passive RFID [3] based ear tags which are used for tracking and active collars which are hanged around the neck of livestock for longer tracking. Other products(Monnit) include sensors for tracking the level of drinking liquid for cattle's which can be notified by sending an text , sms or voice message for refilling.(SolChip).

3) Drones for Data Collection: Unmanned Aerial drones and land based drones are increasingly used in large agricultural fields to capture the data under intense weather conditions like hurricanes, tornadoes. This is used for assessing the crop health, yield, water requirements, weed infestation and other parameters like soil and weather conditions. Presence of advanced sensors with digital imaging capabilities assist in imaging, mapping and surveying of agricultural land. PrecisionHawk an organization manufactures agricultural drones which are configured by the farmer with field details like altitude, ground resolution and soon it collects the complex data across several dimensions and returns to the farmer which can be assessed to get better productivity from crops.

4) Green House Management: IOT based solutions for green house automation helps in enhancing the yield of crops grown inside a green house. Green houses act like virtual environment inside which climatic conditions required for crop growth are controlled in a suitable manner by manual intervention which sometimes leads to constant monitoring and less productive thus increased labor costs. The parameters affecting a plant growth inside green house are humidity, temperature, light, soil moisture content hence maintaining these conditions in the desired state is essential by installing IOT based sensors [1] for data acquisition and processing of the current conditions helps in controlling and monitoring the green houses from centralized location remotely.

B. Smart Cities

Innovations based on IOT are bound to play a major role in changing the lifestyles of people living in urban areas across the world. There is a rapid growth in people adapting to urban living hence there is an increasing need to exploit the technologies in order to fulfill and manage the needs of ever growing population. IOT has the potential to be incorporated to automate every aspect of day to day human needs like drinking water supply, waste management, traffic congestion, air and noise quality, vehicles parking, management of street lights and soon. Below are some of the areas in which IOT based

solutions could be effective in applying automation to the existing system.

1) Street Lightning: Illuminating the streets in the city holds a major portion in the demand for energy consumption. Safety of tourists and residents is one of main criteria which attracts for financial investment in the city creating more employment opportunities. NOKIA IMPACT is an innovation in IOT platform which provides smart lighting solution for centralized management of street lamps by integrating into the existing wireless network which is promising in optimizing the electricity usage through real time data collection while automatically detecting non functional lamps. Other services which can be optimized include adjustment of intensity of the lightning based on the existing weather conditions, natural light, and presence of people[6].

2) Smart Parking: As the infrastructure in urban areas is growing with the occupation of people so is the number of vehicles. The space to provide parking for these vehicles is shrinking hence there is an increased necessity to intelligently manage how vehicles are parked. Several parking solutions have been proposed based on wireless sensor networks which include devices like video cameras, microphones and motion detectors[7]. Smart Parking Solutions Inc provides robotic, automated parking solutions with in limited space which are designed to provide highly scalable, faster vehicle retrieval and safe parking space with less initial set up cost. Apart from these factors driver should also be directed to reserve the parking slots along with the best path to reach the destined slot which results in faster time to reach the parking space hence reduced traffic congestion saving fuel consumption and time.

3) Waste Water Management: Apart from the unclean water which is output from the industries the used water from residential areas also required to be treated and recycled which is usually carried out in the isolated areas by setting up sewer water treatment plants. The path leading to the sewer plant consists of several manholes which is the intersection of various channels and are often clogged due to obstruction of bulky objects or during rains due to heavy inflow of water, unblocking the channels becomes essential. Manually cleaning of these sewers leads to causalities as these contain harmful gases which cause asphyxiation leading to the death of cleaning personals although these exists septic cleaning tanks they are not fully automatic and requires manual intervention therefore there is a need for sewer cleaning techniques which can be implemented by using the sensors backed with IOT technology.

C. Smart Electricity Grids

Power grids consists of high voltage transmission lines which are susceptible to drastic weather like heavy rains, wind, snow which leads to damage of transmission power lines resulting in power failure affecting larger areas[5]. With scattered power line across varying geographical boundaries maintenance and monitoring becomes a challenge increasing the demand for remote tracking and maintenance of defective lines. There are several factors like power plant, energy storage, transmission line, energy consumption and storage in power grids which can be optimized with software systems and communication networks backed with IOT.

IV. CHALLENGES

The fact that IOT is increasing used in many day to day applications making life easier there are several barriers which have to be overcome in order to successfully implement the technology and at the same time meet the challenges associated for the proper functioning of IOT system. As in any information based system security and privacy threats pose a biggest challenge where information exchange takes place between many heterogeneous devices it is therefore required to provide different levels of security based on sensitivity of the data. Other factors which have to be considered while designing IOT based system are hardware, software and network constraints. While hardware limitations include battery supply, controlling physical access, interoperability between heterogeneous devices, software challenges like malwares, illegal code injections, protection of user data and privacy. As the number of devices connected to IOT is large and mostly uses the wireless network compatibility with existing architecture, QOS parameters and delays and have to be considered while designing and implementing IOT based system. Challenges also arise due to the integration of legacy systems with new IOT based systems.

A. Security Challenge

Devices implemented in IOT communicate with each other using the internet, these devices mainly embed sensors which collect and process information and further transfer it through the network to cloud based solutions for further storage or processing. Implementing security is one of the main aspects in IOT based system as these systems are heterogeneous and pervasive in nature [13]. Providing security to these systems include preventing the devices from illegal unauthorized access which could be achieved by providing authentication techniques with strong credentials to verify the users. Furthermore IOT devices are more vulnerable to cyber threats like code injection and man in middle attack deploying cryptographic protocols is therefore crucial for proper uninterrupted functioning. In addition to this standardization of heterogeneous technologies, processes, applications, devices and their management represent a major concern.

TABLE I

OPEN SOURCE IOT PLATFORMS

Platform	Best Support	Salient Features
Eclipse Kura	IOT Gateways	• Provides advanced networking and routing capabilities over cellular, Wi-Fi and Ethernet Communication with cloud • API support for remote management of IOT gateways for writing and deploying IOT applications • MQTT based messaging communication between gateways and cloud, additional messaging support with built-in Apache Camel message routing engine • Remote management solution for gateways based on MQTT, ready to use protocols like Modbus, OPC-UA, S7 • Web based visual data flow programming to acquire, process and publish data to cloud
ThingSpeak	Data Collection and Analytics	• Analytics platform to aggregate, visualize and analyze live data streams, send sensor data to cloud privately • Execution of MATLAB code to analyze and process data • API support for storing and retrieving of numeric and alphanumeric data collected throw the sensors • Prototyping and development of IOT systems without setting up of servers and web software • Run analytics based on schedules and events and communication with third party services like Twitter and Twilio
Zetta	Servers	• Provides server which can run on PC's, single board computers and cloud, integration of Raspberry Pi, BeagleBones with cloud • Server communication with microcontrollers like Arduino and Spark using REST API • Optimized architecture for data intensive and real-time application • Visualization tools to monitor and manage devices, streaming of data to machine analysis platforms like Splunk
Ubuntu Core Snappy	Operating Systems,Gateways	• Secure, remotely upgradable, easy integration with desktops, servers and other android OS. • Provides gateways connecting sensors and actuators to cloud along with edge analytics and intelligent decision making to ensure low latency, continuity, reduces the cost of backhaul for low value data. • Multiprotocol support with Modbus, CAN, Zigbee, CoAP, cloud MQTT and AMQP. • Supports diverse hardware, quick prototyping and production with standard reference modules and on Linux platform.
Node-RED	Browser-based flow editor with drag and drop interface	• Provides Light weight,visual programming environment with event driven and non blocking model, javasript support, single threaded event queue. • Fast browser based flow editing built on latest Node.js, supports ReST, MQTT, connection to MongoDB. • Easy to extend and add new packages connection to social media sites. • Suitable for devices using Raspberry Pi, BeagleBone Black, Arduino, Android based devices and clouds environment like Bluemix, AWS, MS-Azure
Contiki	Operating Systems	• Provides powerful low power internet communication with full IP network stack and supports standard protocols like IPv6,IPv4,6lowpan,RPL,CoAP. • Rapid development support with cooja simulator. • Runs on vast range of low power wireless devices with power consumption estimation, memory allocation and management features • Dynamic loading and linking modules during deployment, documentation of source code which assist in writing network program • Cooja simulator to test, debug and emulate large scale networks, regression testing, protothreads, flash file system, optional command-line shell, wireless networking stack • Runs on less memory, runs on different platforms and easy to port, Contiki community support.
Kaa	End to End solution	• Supports lightweight IOT protocols like MQTT and CoAP for device connection to cloud. • Device lifecycle management from initial provisioning, grouping of device, connectivity events, software updates to final provisioning. • Protocol support for device data collection, reliable data delivery, batching of data, store and forward, handling structures and unstructured data. • Processing and conversion of unstructured data into structured time series data convenient for pattern analysis, visualization and charting • Data visualization interactive widgets like gauges, charts, maps, tables interact with devices by sending commands, metadata and configuration changes. • Configuration management for devices data processing
DeviceHive	End to End solutions with quick prototyping and deployment	• Provides deployment options for IOT applications. • Connection of devices using REST API, WebSockets or MQTT, Android and iOS library support. • Easy integration with other devices and cloud. • Customization of platform using javascript. • In built support with Apache Spark and Spark Streaming for batch data analytics and machine learning

B. Privacy Challenge

IOT represents unique challenges with respect to privacy which outreach the existing data privacy problems due to the fact that large number of devices are integrated with IOT and function without conscious knowledge of the user. Many consumer appliances like TV, cars, washing machines are programmed to continuously watch the surrounding activities although being dormant these transmit the captured data to cloud for further storage or processing. The data which is collected from the sensors will be vast ranging from private bank account, health records and also location information where each require different levels of protection to be enforced for example in case of medical field health information should only be revealed to the designated health practitioners while prohibiting access to others protecting the confidentiality. Designing robust cryptographic algorithms is essential to prohibit cyber threats like man in middle attack, eavesdropping, denial of services and other attacks [13] which impact correct functionality of the IOT enabled devices. Another key factor to be considered is the recovery management in event of breach in security and information loss investigating the root cause, identifying and fixing the vulnerability of the system is also measure of its robustness as how quickly the system can be put back to use is essential for continued implementation and functioning of an IOT enabled device [13].

C. Interoperability Challenge

With the advent of internet of things, it becomes quintessential to connect the world with devices and making them to communicate between themselves for continued evolution of the technology. However interoperability between these heterogeneous devices posses a big challenge as each equipment in the device operating on IOT may use different protocol standards and often are not interoperable which hinders interconnection of these devices. First major step to achieve interoperability requires that devices and smart objects communicate and operate using the international standards further more standardization [11] should be achieved at each level be it-devices the protocols, software versions or the network infrastructure connecting the devices. Developing IOT platforms and making them as open source rather than proprietary aids in better adaptation of these technologies in the development of IOT solutions which in the process enhances standardization of the devices.IOT platforms consists of a set of tools and services which are used to develop and run applications. They can be classified broadly based on the support they provide for the development, functionality and maintenance of the IOT applications[11] a fully developed platform should ideally handle everything ranging from the end device to the application which runs on top of that which is actually difficult when handling millions of applications and devices.

There are several platforms which provide specific services like data management to handle data and analytics which are captured from the connected device, device management platform focus on the management of lifecycle of the connected devices, connected device platform which primarily focus on managing the connectivity of the device, cloud platforms for building and managing complex network stacks. TABLE I lists the open source platforms available for development of IOT based solutions and its features. However choosing the right IOT platform is a complex task considering the effectiveness they impact on development of an IOT application several technical criteria have to be evaluated before approving the platform for qualification.

Some of the parameters which have to be assessed for a platform are:

1) Scalability: As the number of connected devices grows the load distribution between the nodes for load balancing has to be supported.

2) Protocol: IOT platform should gracefully evolve with new technologies and upgrade to newer version of protocols.

3) Performance: Average response time taken by a platform when an event occurs increases as the devices get added, IOT platform should provide means to measure the reliability, latency and other QOS parameters.

4) Security: Platform must offer tools for encryption, strong authentication, logging and role based access control mechanism.

5) Bandwidth: Cloud connectivity to devices are limited by bandwidth, upload and download speed should be symmetric.

6) Recovery and disaster management: Data backup, robust infrastructure, fault tolerant and early recovery from failure.

7) Interoperability: Easy integration with existing hardware, workflows and third party tools using API, future readiness with continued support.

V. CONCLUSION

With the advent of internet and internet based technologies there was a drastic change in how information was exchanged, with the incorporation of IOT based devices it has further impacted the fast paced human life bringing in more comfort. First section explained the various technologies and their salient features which the developer can choose while developing an IOT based application based on the domain they can fit in. Various use cases where IOT has been successfully implemented are discussed with classification of IOT platforms based on the service they provide.

As in any technologies the challenges faced in IOT are discussed which have to assessed for continuous functioning and implementation of the IOT system with the focus on interoperability problem and one of the way to address it is by promoting the usage of open source platforms which can bring

about standardization. Finally the parameters which have to be assessed for choosing an IOT platform are listed.

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