**IOT Platform and Architecture**

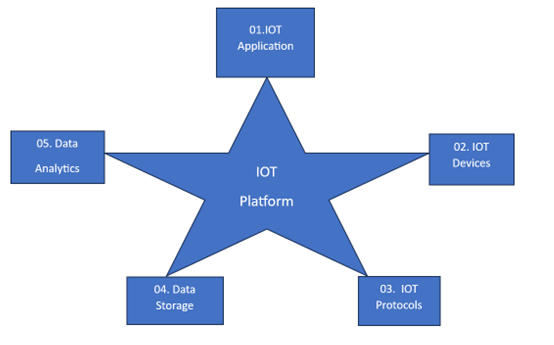
Dr. Anemone Koul Chaku

Applied Sciences, Niet College of Engineering

Greater Noida, India

**1.Introduction**

With the rise in internet accessibility the people around the globe are trying to exploit its usage for various applications. One such field where internet is finding its place is IOT (internet of things). IOT refers to connecting different devices to each other through the internet. It is revolutionizing the digital world enmasse. The IOT is a multiple-layer platform that carries out direct management, automating and catering of devices within the Internet’s domain. IoT platform relates to a set-up of IoT elements which includes gateways, sensors, actuators, communication protocol, cloud server setup, and end-user application interface. With the speedy evolution in the industry, there are many different ways to device an IoT platform. It is a convenient platform for apprentices and designers for instant use, which runs at an incredible speed. It is a remote device allowing users to manage the linking between hardware and application devices. Having unique features like cloud and various gateways, it has a good scope for the business development. Various stages of IOT Platform are shown in Figure 1.



**Figure 1: IOT Platform**

**1.1 IOT Platform and Architecture**

“An IoT Platform is a fusion of cloud-based services and applications used to monitor, manage and interact with smart, connected devices.”

We need to have various sets of methodologies and tools for actual deployment of IOT. The various techniques and tools used in the explicit domain for the specific IoT solution, is referred to as an integrated IoT platform. Platform allows to deploy and run application. It is a combo of hardware plus software upon which other applications can run. Platform could comprise hardware above which operating system can reside.[1] This operating system allows applications to work above it by providing essential execution environment. IoT platforms provide a complete set of generic claims, independent functionalities to build IoT applications. [2] Only a specific service can be set, when there is only one communication link between devices of one type with another device. A need of some common standard application platform is a must for devices of multiple types to hide the heterogeneity of various devices, by paving a common working environment to them. [3] An IOT application platform is a real solution as it resides over cloud. Due to cloud connectivity, IOT platform translates devices data into useful information. It offers means to implement business use cases and permits prophetic maintenance, analytics, pay-per-use and also real time data management. IOT application platforms offer a whole set for application development to its distribution and maintenance. IoT platform is generally built within the intricate bionetwork of machines, software and the people, dealing with diverse relevant issues, straddling from M2M connectivity, to data analysis and visualization. The utmost features of the different domains are immense scaling and security.

Stankovic [4] emphasized the following directions for IoT application platform based on research work:

1. massive scaling (which involves to address, discover, architectural models supporting the anticipated heterogeneity),
2. architecture and dependencies (involving IoT apps, execution, determining interfering problem in using the utility device for diverse apps by some kind of multiplexing, requirements across applications especially for safety critical apps),
3. generating knowledge and big data (knowledge formation, real-time data interpretation, innovative inference techniques, confidence levels for trusting data, consistent data associations),
4. robustness and openness,
5. security (finding and diagnosis of attack and deployment of other means without fail),
6. privacy (assess requests against policies, resolution of the different policies)
7. humans in the loop (displaying human behaviours, human use and controlling).

The technologies and standards for the purpose of IoT device manufacturing and communication are still in the early phase of development, so the IoT platforms should hold a role of IoT experimentation facilities. Gluhak [5] recognized the necessities for a coming generation of experimental research facilities for the IoT:

1. scale - “supporting thousands of nodes: minimized human intervention, maximized plug-and-play configuration, automatic fault management”.

2. heterogeneity - “management of devices, easy programmability of heterogeneous devices”

3. repeatability – “across different test beds: agreements on standards”.

4. federation – “with other test beds, or other experiments: common framework for authentication, interoperability”.

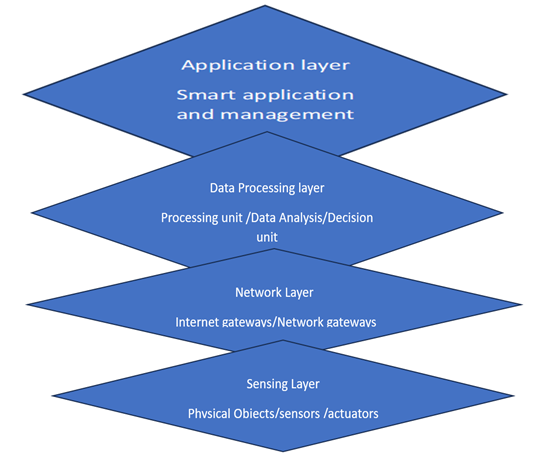
5. concurrency- “virtualization of devices, multiple experiments for one device”.

6. experimental environment – “robustness towards the environmental conditions”.

7. mobility- “handling system dynamics, movement of devices”

8. user involvement and impact- “multi-modal mechanisms for user feedback, automated detection of situations where user behavior influences the data validity”.

As there are different application areas of Internet of Things, it is designed and developed accordingly. Though there is not a well-defined architecture followed universally. The architecture of IoT mainly is based on the functionality and implementation in different sectors. However, there is a basic process flow based on which IoT is built. Figure 2 shows the various IOT architecture.



**Figure 2: Stages of IOT architecture**

**Various layers/stages of IOT architecture are listed below:[6]**

1. **Sensing Layer –**    
   The first layer of the IoT architecture is sensing layer which is responsible for collecting data from various sources. This layer comprises of sensors and actuators that are positioned in the environment to gather information about the temperature, humidity, light, sound, and various other physical parameters. These devices are linked to the network layer through wired or wireless communication protocols.
2. **Network Layer –**    
   The network layer of an IoT architecture offers communication as well as connectivity between devices in the IoT system. This layer includes protocols and technologies that allow devices to link and communicate with each other and also to the wider internet. Various examples of network technologies commonly used in IoT include Bluetooth, WIFI, Zigbee and 4G, 5G networks. This network layer also includes gateways and routers that act as mediators between devices and the wider internet, and also have potential to offer security features like encryption and authentication to guard against unauthorized access.
3. **Data processing Layer –**    
   The data processing layer is the third layer of IoT architecture which involves both the software and hardware which are accountable for collecting, analysing and interpreting data from the IoT devices. This layer is also responsible for receiving the raw data from the devices, processing it and then making it available for further investigation and then action. The data processing layer includes a variety of technologies and tools like the data management systems, analytics platforms and also machine learning algorithms. These tools are used to extract the meaningful insights from the data and make decisions accordingly on that data. One of the examples of a technology used in the data processing layer is a data lake, which is a centralized storehouse for storing raw data from the IoT devices.
4. **Application Layer –**    
   The application layer of the IoT architecture is the topmost layer which interacts directly with the end-user. It is highly responsible for providing user-friendly interfaces and functionalities that enable the users to access and control IoT devices. The application layer includes various software and applications such as mobile apps, web portals, and other user interfaces that are intended to interact with the underlying IoT infrastructure. Also, middleware services are included in this layer that allow different IoT devices and systems to communicate and share data uninterruptedly. The application layer also comprises analytics and processing capabilities that allow data to be analysed and transformed into meaningful insights. This includes machine learning algorithms, data visualization tools and other advanced analytics capabilities.

In nutshell components of Iot architecture can be placed as :

(1) Sensors/ Devices

(2) Gateways and Networks

(3) Cloud based management service layer

(4) Application layer

**1.2 Various IOT Platform**

IOT support platforms are listed below.[7]

**Arrayent:**

The IoT platform composed of four components. Link/connect Agent is a firmware, a lightweight agent deployed in devices (bulk firmware updates enabled). This agent exchanges data with the Connect Cloud by using 128-bit AES encryption which is highly sensitive. Each of the device has its private digital copy in Connect Cloud which hosts the virtual devices to which mobile apps can connect with. Mobile Framework being used for expansion of apps which manage connected devices. It also uses engine for dealing and sending generated alerts that could also then activate response actions in the product that generated the alert. Lastly the Insights provide secure access to data through dashboards, data streaming, batch exports and data connectors.

**Axeda :**

Connectivity middleware ease connecting machines and devices to the cloud. Application enablement platform abridges development of IoT apps, with skills such as data management, scripting engine, integration framework, Software development kits and web services for retrieving data and apps in the cloud. Connected machine management applications enable remote monitoring, management, service and control of remote devices. Competences also include software (client, firmware) distribution and configuration management.

**Bugswarm:**

It is a lightweight platform that can gain data from and control devices using JavaScript or plain HTTP. It states a “swarm” – system of resources for communicating to other resources within the system, according to the well-defined access policy. A resource is anything that can communicate through HTTP, not confined to devices only but also web or mobile applications. Device-specific, client-side applications, device connectives are available for use, to connect prevailing device as a resource to a swarm. As the specific device is connected sending the private message to all swarm members, with the list of its skills or services that the device can provide(feed). Other resources concerned about these services could send a feed request to a device, which then reply with a feed response i.e sensed data.

**Carriots:**

This platform acts like an aggregator; enabling connectivity between any type of device with web connectivity which can send a stream of data, by using MQTT (protocol), cURL (software), Poster, to Carriots REST API. For each of the protocols, a client installation is desired for the device. Later a Listener or Trigger component is developed and deployed on platform to perform operations on data. Device control and maintenance are enabled i.e checking status, managing configurations, updating firmware. Development is carried by using Java Carriots Software development Kits (SWKs), by putting a code to the specific fields in Carriots Control Panel web application. Free use is enabled but with limited functionality for up to 10 devices.

**Evrythng :**

The natively digital identity management platform, also referred as “Product Relationship Management” (PRM) platform. Semantic data store is used to modify dynamic data profiles – digital identities of the products, such that they can exchange data with sanctioned applications.

**Exosite :**

The cloud-based IoT platform which offers M2M connectivity and data visualization tools and services. Open application programming interface (API) is accessible for advanced data processing and integration with enterprise applications. Groove Streams is data analytics cloud platform, allowing data collection from multiple platforms which includes IoT devices. Open API is used to send data streams at a fixed or random interval or as a point stream of a fixed values. Data analytics tools are accessible with near real-time performance. Data can also be redistributed as Derived Streams, or can be visualized with customizable charts and graphs. This platform is open access. Top features are available, related to number of organizations, users and increased/scalable data.

**Ifttt (If This Then That):**

Ifttt is not a native IoT platform; it is an interoperability-as-a-service platform which permits users to generate chains of simple conditional statements, called “recipes”, which are implemented upon the particular events recorded from the different services. It is the platform enabling users to create their own recipes, which can also include actions from the different devices. Some of the current examples of IoT related recipes are: “delay watering your garden if it’s going to rain tomorrow”, “receive and emergency call if smoke is detected”, and others. Some alternatives to this service are Zapier and Yubnub.

**Kaaproject:**

It is an open-source IoT middleware platform which enables management and maintenance of device inventory and also near real-time communication between the devices. It promotes use of structured data. It offers software development kits (SDKs) that can be embedded into devices. Comprehensive solutions already exist for Android, IoS, Raspberry Pi and other platforms as well. It is pre-integrated with present data processing solutions, such as mongoDB, Hadoop, Oracle and others.

**LinkSmart:**

It is open-source middleware platform/ framework and a service infrastructure for construction of IoT applications, formerly developed by Hydra EU project. The project is introduced by Fraunhofer FIT(Fraunhofer Institute for Applied Information Technology). It contains Device Connector for integrating devices with different implementations for specific devices, Resource Catalogue for managing devices and also resources they expose, Service Catalogue (services used to access devices and resources) and Global Connect tunnelling service that permits access to devices outside the boundaries of a private network.   
**Mbed:**

It aims at even tighter integration, by treating all its connected devices as embedded devices. All having in-house mbed open-source Operating System, event-driven single-threaded architecture which is scaled down to the simplest, lowest cost, lowest power consumption devices. Mbed supports devices based on Advanced RISC Machine (ARM), Cortex-M microcontroller. Key principles are security, connectivity and manageability which uses OMA Lightweight M2M, a popular protocol for monitoring and managing embedded devices.

**Nimbits:**

It is data logging service and rule engine platform for M2M connectivity. It offers nimbits.io open-source Java library for evolving Java, web and Android solutions that use Nimbits Server as a backend platform. Backend platform assembles geo and time-stamped data and executes rules on that data, such as calculations, email alerts, xmpp messages, push notifications and others. Also Free and Enterprise editions of the server are available. Particle.io offers hardware development kits for building the firmware for the devices, by using web-based IDE and deploying this firmware over the air. Then, ParticleJS and Mobile SDK libraries can be used to build web and mobile apps, based on the collected data.

**Autodesk SeeControl:**

It is IoT cloud service used to virtualize machines, link them with reporting devices and use analytics to unlock their data. No-coding, drag -and-drop method is implemented. This Platform is focused to the requirements of the manufacturing industries, in specific to making product performance data, predicting a product failure, performing maintenance and optimizing supply chain and material replenishment costs. It also provides a large library of prevailing protocol and vendor device adapters. Service also includes light Enterprise Resource planning (ERP) modules and business management tools.

**SensorCloud:**

It is a cloud IoT platform used for acquisition, visualization and analysis of data. This platform natively supports connectivity with LORD MicroStrain’s wireless and wired sensors. Visualization tools are readily available. It is likely to setup simple alerts, triggered by the data threshold values. MathEngine analysis tools are provided, with a simple interface which facilitates common operations such as FFTs, smoothing, filtering and interpolation.

**PTC ThingWorx:**

In the IOT platform, each device is represented by so-called Thing Template. Template defines properties (for example, mass), services (for example, posting to Instagram) and events (for example, malfunction). Devices use the agents to connect to IoT platform; different agents are used for the different types of devices. Composer application (web based application) is used to model the things, business logics, visualizations, data storage, collaboration and security required for generating IoT application. The Mashup can be assembled by means of different thing templates, namely, UI widgets which are pre-wired to the thing templates. The mashups are then used for interactive IoT applications, real-time dashboards, collaborative workspaces and mobile interfaces. BPM component is involved to enable definition and execution of the processes, starting with an alert or event from a remote connected device. Device asset management tool is also involved to facilitate remote diagnostics, control and scheduled software update of things. The Free use is possible but only with limited functionality.

**ThingSpeak:**

It is an IoT platform, with features very similar to SensorCloud. It provides open channels to available data from different devices, published by the users. This Platform enables actuation, namely talking back to the device, which is done over the Hypertext Transfer Protocol (HTTP).

**Google Cloud Platform:**

Inventors can code, test and install their applications with vastly scalable and dependable infrastructure that is provided by Google and Google itself uses it. Developers need to just pay attention to the code and Google handles issues regarding infrastructure, computing power and data storage facility.[8] Google is one of the most popular IoT platform as it provides: Fast global network, Google's BigData tool, Pay as you use strategy, Supports various available services of cloud like RiptideIO, BigQuery, Firebase, PubSub, Telit Wireless Solutions, Connecting Arduino and Firebase and Cassandra on Google Cloud Platform and many more.

Some Key features:

Depends on Google's infrastructure

Scalability

Computing

Storage/ services

Higher performance

Guarantee of Google Grade security

**IBM Blue mix:**

The IBM Cloud platform fuses platform as a service/ PaaS with the infrastructure as a service/ IaaS to deliver an integrated experience. The platform is developed to scale and also support both small development teams and organizations as well as the large enterprise businesses. Its data centres are Globally deployed around the world, moreover the solution one builds on IBM Cloud spins around fast and has high reliability.

IBM Cloud provides the most open and secure public cloud for business with a next-generation hybrid cloud platform with advanced data and AI competence. Solutions are accessible depending on ones needs for working in the public cloud, on-premises, or the combination of both.

IoT foundation combined with IBM BlueMix platform offers powerful application access to IoT data and devices. IBM BlueMix supports speedy development of analytics applications, visualization dashboard, and mobile IoT applications. One can create IoT application with IBM Bluemix and then IBM provide REST and secure API to connect device data with the application. IBM IoT foundation is the where one can set up and manage ones connected devices. IBM IoT foundation uses Message Queuing Telemetry Transport (MQTT) protocol to securely transfer device data to cloud. [9] Some Key features:

Authoritative web dashboard

Device Registering

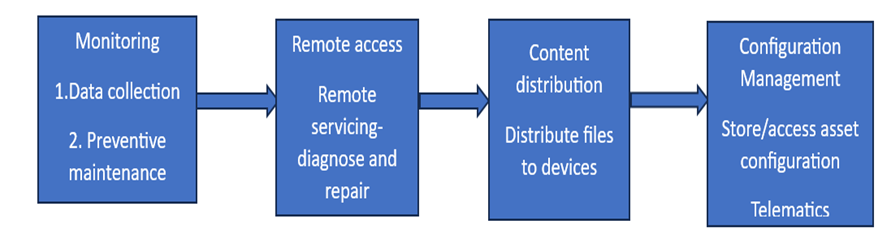
Scalable connectivity

Security

Proper storage of data

**Microsoft Azure cloud:**

Internet of Things for the business starts with the things that are involved in the business and affect it the most, according to Microsoft. Starting from the substructure of the business by adding devices and services into it with technological expansion, will lead one to get insight of the information related to that and to make powerful and informative business decision. Thus, IoT is essentially Internet of Your things. The portion of data about the customers, sales, business procedures or other inventory data is valued asset to one’s organisation and it can help one to power the business. Microsoft offers Microsoft Azure Intelligent System Service which forms an integrated platform and services that shapes Internet of Things systems and applications by assembling, storing and processing data. Cloud offers solution for data storage, data processing, data consumption and data analysis on real time/ latent data. IOT application provides monitoring, remote access, content distribution and configuration management facilities for connected devices.



**Figure 3: Various steps involved in Microsoft Azure Cloud**

Microsoft Azure cloud connects of millions of devices and sensors with IoT application, thus providing big data analysis, social as well as business integration and dash boarding tools for IoT application to shape an IoT solution.

Some Key features:

Figures out on what is already established

Does small changes with big reflections

Trusted support

Skilled in development to deployment

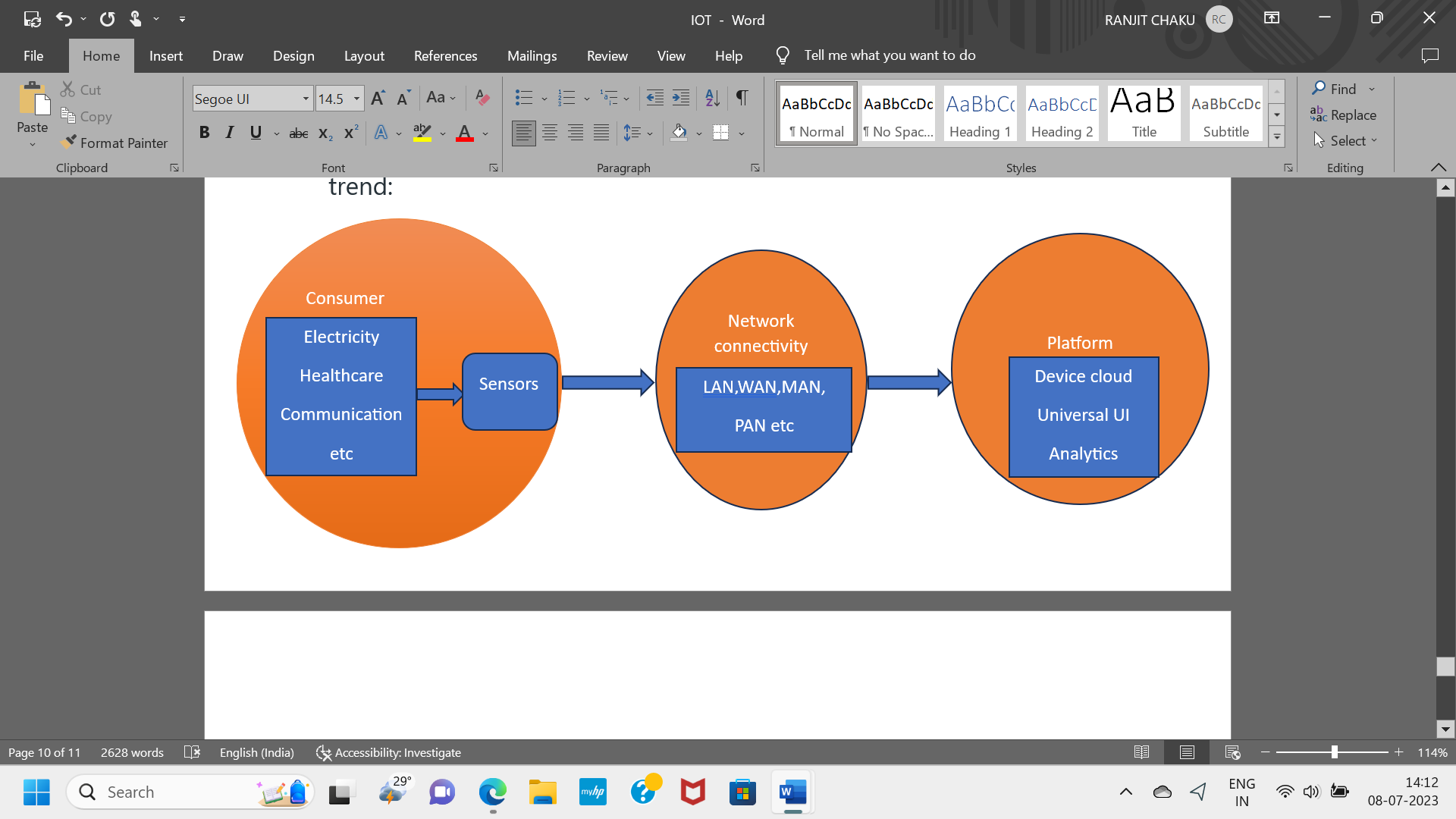
Connectivity to any device

Trained partners and commanding innovation

Scalability

Easy way to transform business

**Digital Service Cloud:**

Digital service cloud (DSC) is an open IoT platform. This platform permits IoT innovators to own their customers the way customers own their products. It supports product launches, start-ups, global technological brands and product innovators. This platform paves way for the process of a new innovation. One can build customised IoT solutions by connecting devices and using plug and play dashboard by using the readymade infrastructure provided by Digital Service Cloud. Then, only one has to monitor and manage the product over lifetime. It helps to connect the product with a network of millions of devices. DSC foundation involves the following sequence:

**Figure 4: Digital Service Cloud Platform**

The consumer devices equipped with various sensors can connect to IoT application available on cloud and can communicate with application. Numerous networking/connectivity techniques are existing that can connect the devices over cloud. Cloud delivers device management and application development.

**Zetta:**

Zetta is an open-source platform, developed in Node.js for creating IoT servers that run across geo-distributed servers and cloud. Zetta merge REST API, reactive programming and web sockets. This merger is apt for assembling many devices into data intensive and real time applications. Zetta can run everywhere in the cloud, on PCs and also on single board computers. Raspberry Pis, BwangleBones and PCs together are linked with cloud platform like Heroku with the help of Zetta so that it can help to create geo-distributed networks. Zetta has the capacity to turn any device into an API. By collaborating with microcontrollers like Arduino and Spark Core, Zetta can provide every device a REST API as locally and also in the cloud.

Zeta provides support for assembling distributed system of devices that communicate and react via APIs. Zetta is a very developer friendly. It gives direct access of underlying protocols and conventions to developers so that they can easily and efficiently transform sensors, actuators and controllers into innovative IoT applications and systems. Architecture of Zetta is optimized for data intensive and real-time applications. Zetta allows monitoring of device and system behaviour in code and using visualization tools to get actionable insights. Also provides streaming of data into machine analytics platforms like Splunk. IoT projects consist of multiple devices across multiple locations running multiple applications developed by various companies. So, Zetta allows you to assemble smartphone apps, device apps and cloud apps together into large and complex systems. Example of such complex and large-scale systems is home automation, smart transportation and wearable computing. [10]

**Yaler:**

Yaler is a pay-as-you use platform which offers an infrastructure, securing access to embedded systems and also works with any device with a Transmission control protocol (TCP) socket. Yaler is one of the cost effective solution suitable for enterprise applications, offering a hosted service on dedicated relay instances. A fixed -yearly- fee per relay instance helps one to reach to the number of devices connected to a dedicated instance. The Yaler relay service also holds SSL/TLS encryption. The integration of theYaler.net (a cloud-based connectivity service), enables a secure ad hoc connection for data streaming.[11] Mainly designed for providing a stable, secure, and high-performance execution environment for the applications running on Amazon EC2.[12] **1.3 Benefits of IOT**

IoT provides a number of benefits to organizations, permitting them to:

1. Monitor their overall business developments
2. Expand the customer experience
3. Saving time and money
4. Boost employee productivity
5. Integrating and adapting business models
6. Making better business decisions
7. Generating more revenue.

**1.4 Discussion**

The Typical features of IoT platforms are: Connectivity, monitoring and maintenance of devices which includes firmware updates, data visualizations, data analytics, basic applications logic through the alerts and triggers. Connectivity as a service is attained by enabling the unrestricted access to devices for the clients, even if they are located behind the firewall, a Network address translation (NAT) or mobile network router. The service should work with any device that provides a Transmission control protocol (TCP) socket. [7] **The following categories of existing IoT platforms have been identified**:

**1.** **Domain-specific platforms** / IoT platforms facilitating specific domain scenarios. These platforms are often built on the top of the generic M2M connectivity providers. Various examples of such platforms are rachio (smart irrigation), nest (home automation), getcleverpet etc.

**2.** **Technology-specific IOT platforms** are the platforms which are accountable for specific set of devices. These platforms are every so often closed, in the sense that they are based on the devices with proprietary (having owners) technology. Examples are Mbed, supporting devices based on Advanced RISC Machine (ARM) Cortex-M microcontroller, Zatar, Nest etc.

**3.** **M2M** connectivity benefactors offer connectivity as a core service, with only few other features, mostly related to the data analytics. The primary objective is data acquisition and analysis.

**4.** **Full scale generic IoT middlewares** like ThingWorx provide full range of connectivity services and also facilitate the application development which is based on data collected by the devices and transformed by the analytical tools. Such expansion is possible by making use of the integrated development environments (IDE), API’s or even the language interpreters.

**5.** Some platforms which offer supporting services are considered as important but they do not offer M2M connectivity services, so they are not considered as IoT platforms. But they do offer functionality which is useful for IoT scenarios. Examples are Groove Streams which is a data analytics cloud platform, and ifttt, interoperability-as-a service platform.

With the rise of IoT platforms, cross-platform interoperability and reuse is starting to emerge. There are cases where the domain-specific IoT platforms are made by using M2M connectivity providers. For example, getcleverpet, groovelabs.io and fishbit are implemented by using particle.io. Similarly, first cases of collaboration between platforms appear, with interoperability solutions. For example, ThingSpeak platform is connected to realtime.io. Further collaboration may be facilitated by increasing number of stable open-source solutions. In fact, they already exist on market like Kaaproject, LinkSmart offering significant opportunities for the development of complex systems over existing core communication management and communication platform. Finally, IoT ecosystem will certainly benefit from the further development of supporting services (interoperability-as-aservice, storage-as-a-service, data analytics and visualization, etc.). Hypertext Transfer Protocol (HTTP) and Representational State Transfer (REST) will probably be the way to communicate with devices as well as between platforms. It has been found that RESTful Web Services are more suitable for programming access to IoT devices, than WS- service architecture. However, it is emphasized that the latter are better choice when complex requirements related to advanced security and QoS are considered. IoT at scale is a crucial technical requirement for further development, scalable performance, storage and connectivity being the most important topics. Scaling at a client side is considered with least priority; devices are still the most sensitive and weakest components of IoT architecture in terms of reliability and power consumption. A. Issues and challenges of current cloud IoT platforms Centralized approach to managing IoT ecosystem may pose challenges to the devices, reusability in multiple contexts/applications, due to potential conflicts between clients. It may also affect the future of IoT ecosystem architecture and pose an approach characterized by exclusive ownership over a device, where services and data of this device would be offered through a central platform that controls that device, forming a network of networks. This may lead to application silos, with potential risk of interoperability issues. The communication between devices is worth considering as an alternative. Energy consumption issue makes the case for centralized approach. Though convenient, turnkey solutions, such as the group of full scale generic IoT platforms may affect the development of IoT market. Namely, when considering current cloud computing applications, the only feature that distinguishes IoT platforms from the other cloud services platforms is M2M connectivity as a service. All the other services, such as analytics, visualization and application development are value-added, non-IoT core services and they may be provided by the third-parties. However, the use of non-core services by the M2M connectivity providers is not at the significant rate. Finally, the third major issue is lack of support to complex data structures and business logics that is beyond the level of simple triggers or rules, to be used for the development of applications, based on collected and/or transformed data.  **Conclusions**

Internet of Things (called IoT), associated with the concept of "future internet" is a vision where each object will become a part of the Internet. Here objects can be any living entity like humans or animals and any non-living entities on earth. IoT is like a vision in which every object which is on network can uniquely be identified, its status and position can be known, it is accessible to the network and also services and intelligences are added to this network. So, it fuses real world with virtual world of digital technology and impacts our social, personal as well as professional life. IoT will change the information world and technology world drastically to make a more comfortable world full of technology for us. Various prototyping hardware boards, on chip systems, sensors, RFID and ubiquitous networking capabilities are supporting candidates for IoT evolution.[13]

Although Gartner’s analysis of the emerging technologies positions IoT platforms at the very early phase of development, experiences from this survey show that cloud-based M2M connectivity services offer is well established. Some characteristic market niches are already recognizable, namely, M2M connectivity, data storage and analysis, data visualization, Interoperability-as-a-Service and others. What is clearly missing at this point is IoT ecosystem application building environment. While the objective of this paper was to identify the gap in the current state of art of IoT platforms, comparing to the theoretical foundations and vision of IoT, its motivation was to setup the novel design of IoT platform which core feature will be exactly application development. Based on the survey, following main principles for the development of formal model-driven IoT software execution platform (InoTEP) are defined: - InoTEP is web application for devices in IoT which enables composition and realization of IoT scenarios, by using peer-to-peer approach (multiple InoTEP instances installed on multiple devices, communicating over REST). - InoTEP provides Application-as-a-Service service which will interpret any formal model (RDF/RDFS/OWL ontology) in a runtime and deliver CRUD (create/read/update/delete data) application. - InoTEP enables formal definition of the device’s capability to sense and/or actuate, by using Capabilities ontology. - InoTEP uses RDF as a transport protocol for communication between devices (over REST). - InoTEP tries to match any data received through its own REST interface (external data), with domain and capabilities ontologies. The above listed principles are further used in selection of the enablers of the key components of InoTEP. Application-as-a-Service component will be implemented by using OntoApp system ; W3C Sensor ontology [7] is being extended to develop a Capabilities Ontology; Active Semantic Model approach will be used for a matching engine.

**References**

[1] B. Nakhuva, T. Champaneria,” Study of various internet of things platforms,” International Journal of Computer Science & Engineering Survey (IJCSES) Vol.6, No.6, December 2015.

[2] **“**Platforms for the Internet of Things an Analysis of Existing Solutions."- A university paper.

[3] http://www.zatar.com/blog/what-is-an-iot-application-platform

[4] J.A.Stankovic, Research Directions for the Internet of Things. Internet of Things Journal, 1(1)3-9, 2014

[5] A. Gluhak, S. Krco, M. Nati, D. Pfisterer, N. Mitton, “ A Survey on Facilities for Experimental Internet of Things Research”. IEEE Communications Magazine, Institute of Electrical and Electronics Engineers, 49 (11), pp.58-6 ,2011

[6] <https://www.geeksforgeeks.org/architecture-of-internet-of-things-iot>

[7] M. Zdravković, M. Trajanović, J. Sarraipa, R. Jardim-Gonçalves, M. Lezoche, A. Aubry, H. Panetto, “Survey of Internet-of-Things platforms” ICIST , 216-220,2016

[8] <https://cloud.google.com/solutions/iot/>

[9] <https://internetofthings.ibmcloud.com>

[10] <http://www.zettajs.org>

[11] <http://blog.yaler.net>

[12] https://yaler.net/

[13] L. Coetzee and J. Eksteen, “The Internet of Things Promise for the Future an Introduction," IST Africa Conference Proceedings, pp. 1- 9, 2011.