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A Review on Different Internet of Things Platforms

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ABSTRACT: *The Internet of things (IoT) examines the interconnection of devices within the existing Internet infrastructure. IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications (M2M) and looks at a variety of protocols, domains, and applications. Rapid growth in IoT adoption and collaborations between involved cutting edge systems for delivering its business applications are fuelling demand for Platform as a Service (Paas), to the large extent it is aiding implementation of IoT. IoT Analytics Market is expected to exhibit an ever-growing 16.2% CAGR by 2017-2025. In this paper, we will first start with the introduction of IoT platforms as well as IoT middleware and then will discuss different wellknown IoT platforms, and will end up with the conclusion.*

Keywords: *Internet of Things, IOT platform, middleware, cloud platform.*

I.INTRODUCTION

The Internet-of-Things is, perhaps, one of the fastest growing industries today. We see connected devices in our homes, cars and offices, and they are getting even smarter and more effective. Moreover, the IoT technology is creating interesting integrations with other advanced areas, such as artificial intelligence or blockchain. Gartner predicts that by 2020, 95% of all new products will use Internet-of-Things technology, so we may expect some truly amazing and sometimes unusual implementations[3]. There seems to be a consensus in the industry that the Internet of Things will be the “next big thing”. Cisco predicts 50 Billion internet-connected devices by 2020 . ABI Research speaks of 10 Bn wireless connected devices today, and more than 30 Bn in 2020 . Already now, there are more connected devices than humans. But has the Internet of Things changed our lives or radically changed how business works?[1]. Another key requirement for the IoT is a platform that facilitates the virtualisation of real world objects. Existing research works have focused on sensor (and actuator) middleware frameworks that offer sensor descriptions , sensor site data and measurement data services on the Web and/or at the application level. More generic approaches include those that provision flash interfaces for instantiating semantic profiles of connected objects . To extend this to heterogeneous real world objects, the data from the physical world needs to be interlinked to domain knowledge and existing data sources on the Web. This can facilitate automated annotation and reasoning on the physical world data and lead to provisioning of intelligent applications.[4]. Section I gives the introduction of

IOT. In Section II, IoT platform is described. In Section III, IoT middleware is elaborated. In section-IV, various popular IoT platforms are discussed and then at last the paper is concluded in section-V.

II. INTERNET OF THINGS PLATFORMS

IoT platforms are the support software that connects everything in an IoT system.

So what is an IoT Platform exactly?

To understand what an IoT platform is, you first need to understand what goes into a complete IoT system. It is summarized as follows[2]:

1. A complete IoT system needs hardware, such as sensors or devices. These sensors and devices collect data from the environment (e.g. a moisture sensor) or perform actions in the environment (e.g. watering crops).
2. A complete IoT system needs connectivity. The hardware needs a way to transmit all that data to the cloud (e.g. sending moisture data) or needs a way to receive commands from the cloud (e.g. water the crops now). For some IoT systems, there can be an intermediate step between hardware and connecting to the cloud, such as a gateway or router.
3. A complete IoT system needs software. This software is hosted in the cloud (what's the cloud?) and is responsible for analyzing the data it's collecting from the sensors and making decisions (e.g knowing from moisture data that it just rained and then telling the irrigation system not to turn on today).
4. Finally, a complete IoT system needs a user interface. To make all of this useful, there needs to be a way for users to interact with the IoT system (e.g a web-based app with a dashboard that shows moisture trends and allows users to manually turn irrigation systems on or off).

IoT platforms help:

- Connect hardware, such as sensors and devices
- Handle different hardware and software communication protocols
- Provide security and authentication for devices and users
- Collect, visualize, and analyze data the sensors and devices gather
- Integrate all of the above with other web services.

The Internet of Things is at the centre of overlapping Internet-oriented (middleware), things-oriented (sensors) and semantic-oriented visions. The Internet-oriented vision emphasises the networking paradigm and exploits the established IP-based networking infrastructure, in order to attain efficient connections between devices. It also focuses on developing lightweight protocols to meet IoT specifications. Being things-oriented focuses on physical objects, and on finding the means to identify and integrate them with the virtual world. The semantic-oriented vision aims to utilise semantic technologies, making sense of objects and their data to represent, store, interconnect and manage enormous amounts of information provided by the increasing number of IoT objects. [6]

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III. IOT-MIDDLEWARE

Internet of Things middleware is software that serves as an interface between components of the IoT, making communication possible among elements that would not otherwise be capable. More comprehensive IoT platforms include middleware along with sensors and networking components. Middleware connects different, often complex and already existing programs that were not originally designed to be connected. The essence of the Internet of Things is making it possible for just about anything to be connected and to communicate data over a network. Middleware is part of the architecture enabling connectivity for huge numbers of diverse Things by providing a connectivity layer for sensors and also for the application layers that provide services that ensure effective communications among software[20]. Mulesoft, Oracle, RedHat and WSO2 are among the companies that offer IoT middleware. These products provide API management as well as basic messaging, routing and message transformation. More comprehensive IoT platforms include middleware along with sensors and networking components. IoT middleware aims to hide the heterogeneity of different hardware and software and enables the use of common platform so that the system is easy to use and manage. Thus, IoT middleware is a mediator suite which hides heterogeneity among devices, components and technology of an IoT system[5]. IoT middleware deals with the structure, format and encoding of the information that is being exchanged between different layers, devices and sensors. "It will act as a common standard amongst the diversity of devices, sensors, OS and applications that will make up the IoT ecosystem architecture. Also, middleware has a role to play in security. IoT solutions should incorporate access control and data authentication while maintaining the privacy of users and devices[21].

Internet of Things platform Vs. Internet of Things middleware**:** IoT platform is a complete suite of services that facilitates services like development, deployment, maintenance, analytics as well as intelligent decision making capabilities to an IoT application. Whereas IoT middleware is a service suite which is mainly intended to overcome the heterogeneity problem of the entire IoT system by enabling smooth communication among devices and components of different vendors and different technology[5].

III. DIFFERENT INTERNTET OF THING PLATFORMS

Here are few really Popular supervised and unsupervised machine learning algorithms, such as:

1. Amazon web service
2. Google cloud IOT
3. Microsoft Azure IOT
4. SAP
5. Salesforce IOT
6. Oracle IOT

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7. Cisco IOT Cloud connect
8. Bosch IOT Suite
9. IBM Watson
10. ThingsWorx

Various IoT platforms are now a day available that can be used for developing an IoT solution but in this section we have covered ten popular platforms that are widely used for IoT solution building.

1.Amazon Web Services

Amazon Web Services (AWS) allows Internet of Things on a global scale by facilitating security, services and support. It facilitates immediate access to desired computing power by means of Amazon Elastic Cloud Compute (EC2). Helps to performs big data analytics and supports high volume data. Amazon Kinesis helps to ingest data from thousands of sensors[5]. AWS IoT is a managed cloud platform for the IoT, pursuing the concept of Things instead of devices. Since AWS uses Things synonymous to devices with integrated sensors and actuators, the Things component is covered by our Device, Sensor, and Actuator components. Furthermore, a Gateway component is not represented within the architecture, but it is located between the Things and Message Broker components. The Message Broker, Thing Shadows, Thing Registry, Rules Engine, and the Security & Identity components provide the main functionality of the platform. Hence, they represent the IoT Integration Middleware component of our IoT reference architecture. Our Application component encapsulates the already integrated data processing services, such as AWS Lambda or Amazon Kinesis, and, additionally, the IoT Applications component, which enables the connection of further applications[7]. As shown in Figure 1, Amazon Kinesis can collect high throughput data from devices and gateways, and then it can analyze and store it over cloud so that applications can consume it and can generate quick decision. It can support data up to any scale[5].

Fig.1:Data streaming from Gateway to cloud by Amazon Kinesis [8]

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2.Google Cloud Platform

Google Cloud IoT is a complete set of tools to connect, process, store, and analyze data both at the edge and in the cloud. The platform consists of scalable, fully-managed cloud services; an integrated software stack for edge/on-premises computing with machine learning capabilities for all your IoT needs. Gain real-time business insights from globally dispersed devices, at the edge or in the cloud, with comprehensive services from Google Cloud IoT. Device data captured by Cloud IoT Core gets published to Cloud Pub/Sub for downstream analytics. Easily do ad hoc analysis using Google BigQuery or run advanced analytics and apply machine learning with Cloud Machine Learning Engine. Plus, you can visualize results with rich reports and dashboards in Google Data Studio. Extend AI capabilities to gateways and edge devices with Cloud IoT Edge and Edge TPU , Google's purpose-built hardware accelerator chip. With Google Cloud IoT platform, you can run IoT solutions with machine learning capabilities both locally and in the cloud. The result is edge and gateway devices that deliver deep insights faster from locally generated data[11]. The platform supports a wide variety of embedded operating systems, works seamlessly with Debian Linux OS, and provides out-of-the-box support for devices from leading manufacturers like Intel and Microchip. Plus, trigger automatic changes based on real-time events using Cloud Functions workflows.

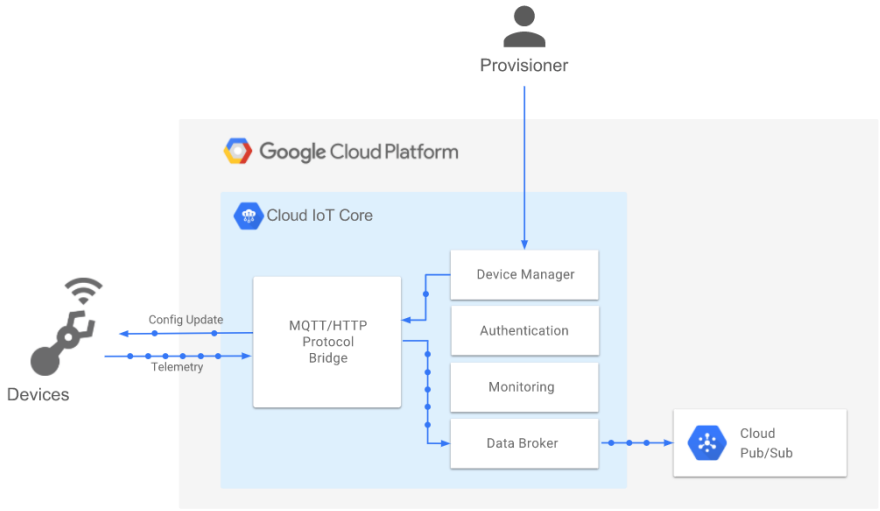

Fig.2:Google Cloud Platform[12]

3.Microsoft Azure Cloud

Microsoft provides Microsoft Azure Intelligent System Service which forms an integrated platform and services that builds Internet of Things systems and applications by gathering, storing and processing data. Intelligent systems services build upon Microsoft Azure helps organizations to securely connect, manage, capture and transform machine generated data into valuable information. Power BI, Office 365 and HD insight are powerful Microsoft

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assets that can be used to produce meaningful insights. Intelligent Systems Service provides agents and open-source agent software which help to support heterogeneous operating systems and protocols for Internet of Things System. With the help of Microsoft Cloud Compute facility, scalable data collection, processing and analysis can be done for your business processes. Cloud provides solution for data storage, data processing, data consumption and data analysis on real time or latent data [5] . Figure 3 shows the Azure IoT product portfolio. It is an overview of the available PaaS/SaaS technologies and solutions. It presents the two paths that are available for building your own solution[10].Platform as a Service (PaaS): build your application using any of the following services. Azure IoT solution accelerators, which are a collection of enterprise-grade preconfigured solutions that enable you to accelerate the development of custom IoT solutions, or Azure Digital Twins service, which allows you to model the physical environment to create contextually-aware IoT solutions using a spatial intelligence graph and domain-specifc object models. Software as a Service (SaaS): get started fast with Azure IoT Central, the new SaaS solution to develop IoT applications without being exposed to the complexity of IoT solution. If your organization lacks the resources to build your own IoT solution, Azure IoT Central is a codeless IoT solution that can create device models, dashboards, and rules in minutes[10].

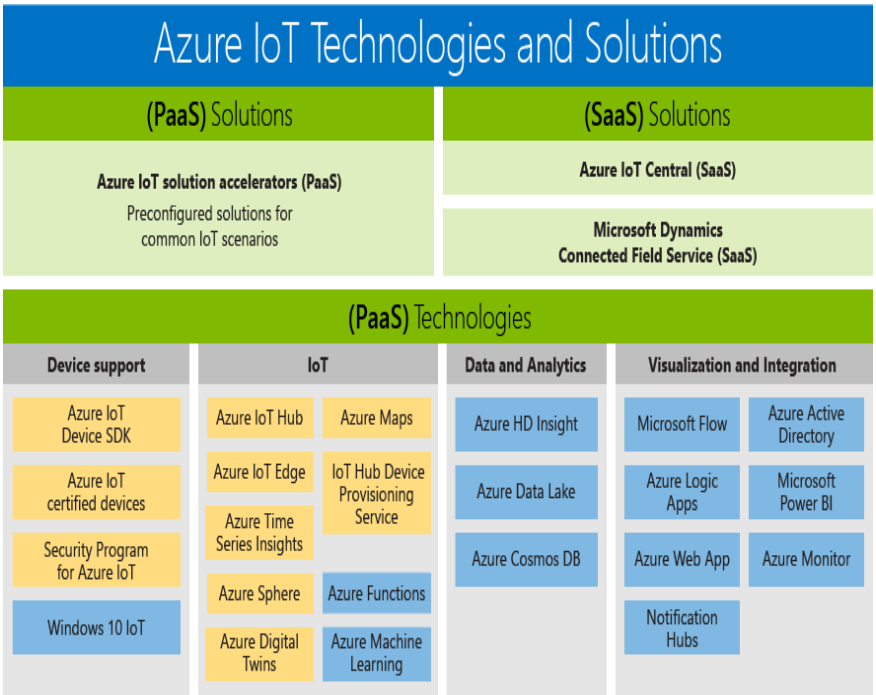

Fig. 3: Microsoft Azure IoT Technolgies and Solution [9]

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4. SAP

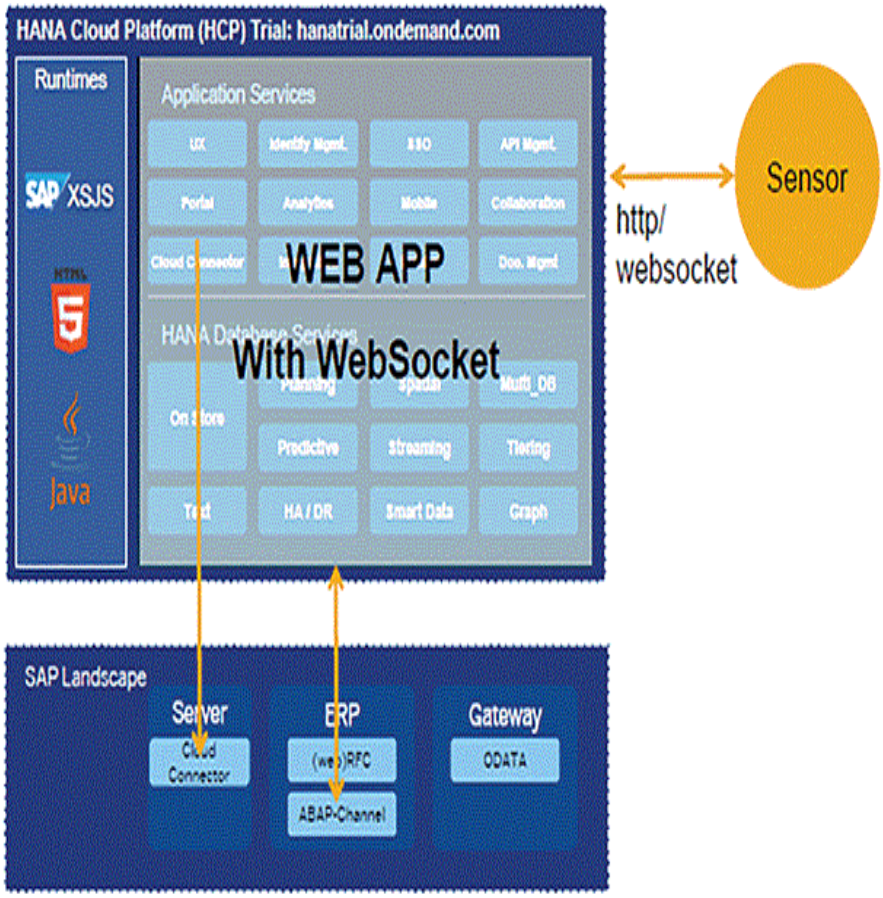

Fig.4: SAP HANA IOT Platform[16]

SAP HANA Cloud Platform is a platform for extending, integrating, and building new applications. It provides design templates and prebuilt applications that have responsive user interfaces that help to expedite the development process for developers. SAP HANA Cloud Platform provides many services, with one of them being the IoT. SAP HANA Cloud Platform for the IoT helps you to build real-time applications from sensor feeds and perform real-time predictive analysis. As shown in fig.4, The sensor sends the data to SAP HANA Cloud Platform using IoT services with either HTTP or the WebSocket Protocol. The received data in SAP HANA Cloud Platform is saved to the SAP HANA database to be used for analytics. SAP HANA Cloud Platform can interact with SAP on-premise systems either using Open Data Protocol (OData) or the SAP HANA Cloud Connector for various reasons such as the creation of a notification [16].

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5. Salesforce IOT: Salesforce.com is a San Francisco-based customer relationship management (CRM) and social enterprise software-as-a-service (SaaS) provider. The company launched IoT Cloud in the fall of 2015.

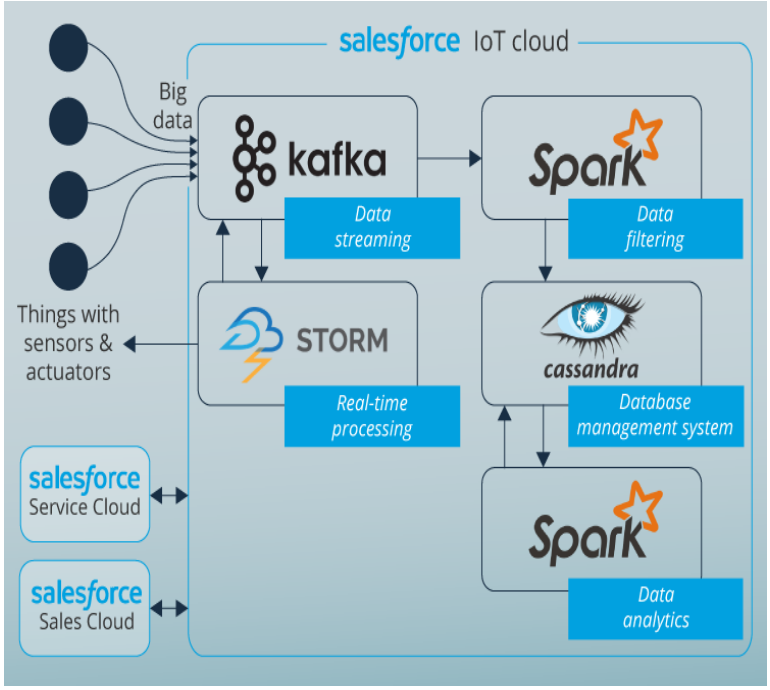

Fig.5: Salesforce IOT cloud Platform[18]

IoT Cloud is a platform from Salesforce.com that is designed to store and process Internet of Things (IoT) data. The IoT Cloud is powered by Thunder, which Salesforce.com describes as a "massively scalable real-time event processing engine." The platform is built to take in the massive volumes of data generated by devices, sensors, websites, applications, customers and partners and initate actions for real-time responses. For example, wind turbines could adjust their behavior based on current weather data; airline passengers whose connecting flights are delayed or cancelled could be rebooked before the planes they are on have landed[17]. To store and process such big data, Salesforce provides the platform called Salesforce IoT Cloud. It is powered by Thunder which is an event-processing engine designed to capture, filter and respond to events in real time[18].

6. Oracle IOT

Oracle's Internet of Things platform provides an end-to-end solution for a comprehensive, scalable, and cost-effective IoT architecture, enabling organizations to: Develop and Deploy applications faster, shrinking development costs and time to market. Manage and Analyze large volumes of device data throughout the lifecycle,

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from collection to analysis Integrate and Automate, using data from connected devices to make decisions closer to the network edge.

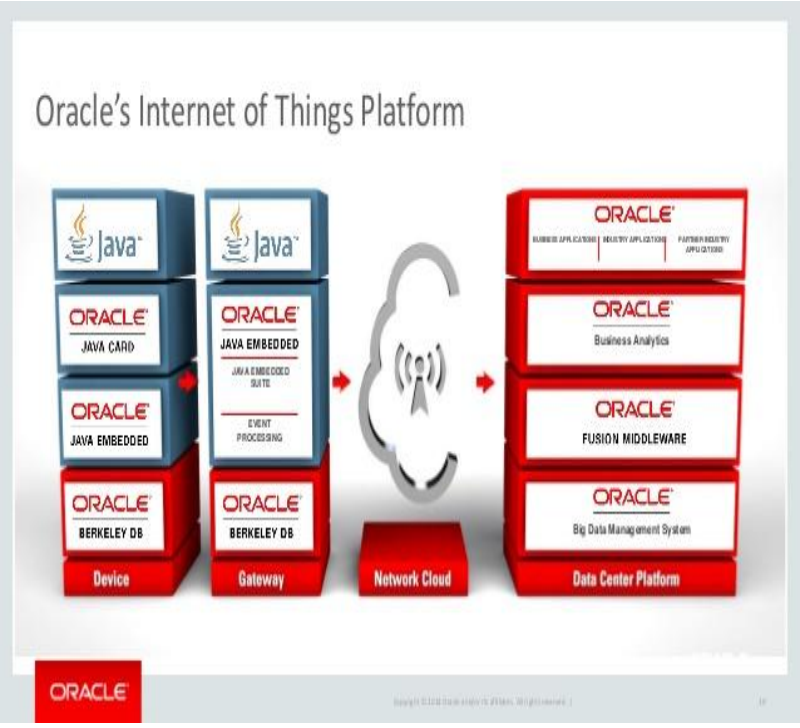

Fig.6: Oracle IOT Platfom[13]

It Protect and Comply with security and regulatory requirements with robust, end-to-end data protection. Optimize and Innovate, integrating with Oracle business and industry applications to reduce costs and accelerate new service delivery[13]. Key Benefits are – Accelerate time to market for innovative applications – Plan for future growth with unmatched flexibility and seamless scalability – Reduce total cost of ownership with simplified management across the IoT architecture – Simplify storage and analysis of diverse data from connected devices – Ensure tight integration between IoT applications and operational systems – Protect valuable data throughout the extended IoT value chain – Keep pace with rapid changes by adapting with ease to new sensor technologies [13].

7. Cisco IOT cloud connect:

The Cisco IoT Operations Platform includes tools to mange connections at scale via the company's technologies and industry partners. Fog computing is another feature that will be included into the platform along with data collection tools from edge systems. Cisco also outlined threat detection technologies to bolster security.

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Fig. 7: Cisco IOT Platform[14]

Features of Cisco IOT Platform:

IoT networking: Deploy Cisco industrial networking solutions for robust, automated, and highly secure connectivity for the extended enterprise**. IoT data management**: Get maximum value from your IoT data by engaging the Cisco Kinetic IoT platform to extract, compute, and move your data. **IoT management**: Keep IoT operations running smoothly. Use familiar tools, such as Cisco DNA Center and Field Network Director, to integrate IT and OT infrastructure. **Built-in security**: Protect your IoT deployment against threats with a secure IoT solution architecture enhanced with IoT security services[14]. The Cisco Kinetic platform includes three modules that work together to help you securely connect devices, and then extract, compute, and move your IoT data. **Gateway Management Module (GMM):** Provision IoT gateways at scale with a highly secure, low-touch workflow. View and control your gateways from a cloud-based dashboard. **Edge and Fog Processing Module (EFM):**Compute data in distributed nodes. Make critical decisions near the point of action, and make the most efficient use of network resources. **Data Control Module (DCM):** Move the right data from diverse connected devices to the right cloud-based applications, at the right time, according to policy set by the data owner[15].

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8. Bosch IOT suite

Fig. 8: Bosch IOT Suite[3]

With the Bosch IoT Suite, they provide their customers and partners a comprehensive software platform for the Internet of Things (IoT). It consists of various cloud services and software packages all aiming to help IoT developers create, implement, and maintain IoT applications in a fast, easy, and secure way. The Bosch IoT Suite is a comprehensive toolbox for IoT developers and offered as a Platform-as-a-Service (PaaS). It provides key middleware capabilities needed to build sophisticated IoT applications from top to bottom. Thereby our IoT platform serves as the technical foundation on which Bosch and our customers realize a broad range of solutions and projects. The Bosch IoT Suite is a flexible IoT platform based on open source technology and industry standards, which enables a wide range of IoT use cases. It also supports seamless integration of other platforms and services as well as hosting in various cloud and on-premises environments[19].

9. IBM Watson

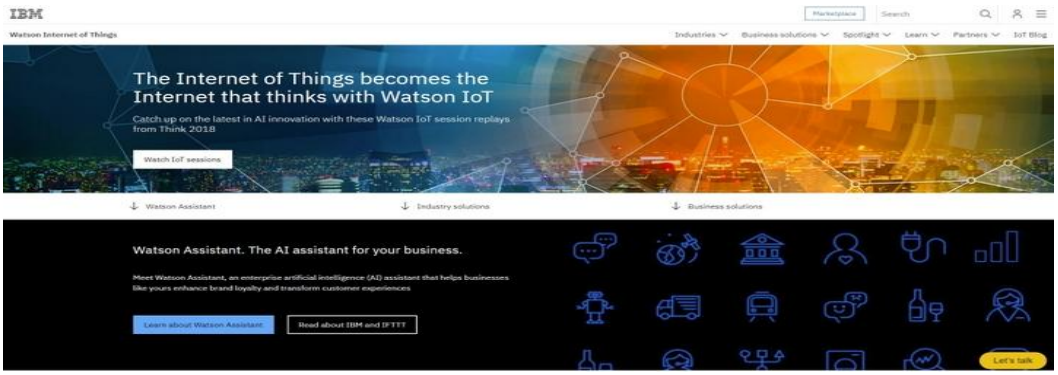

Fig.9: IBM Watson IOT Platform[3]

According to their own description, with IBM Watson "the Internet of Things becomes the Internet that thinks".

This bold statement means that IBM experiments with integration IoT with artificial intelligence creating unique experiences and solutions. The IBM Watson IoT platform supports effective remote device control, secure data transmission and storage in cloud, real-time data exchange, as well as machine learning options and it's integration

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with AI technology. The development platform offered by IBM includes a number of convenient tools and services, making IoT software creation easier and more efficient[3].

10. ThingWorx

ThingWorx is the first software platform designed to build and run the connected world applications. ThingWorx focuses on reducing the time, cost, and risk required to build innovative Machine-to-Machine (M2M) and Internet of Things (IoT) applications. Thingworx focuses on the integration, transformation and presentation of the created data. It does not provide a solution to the question "how is data collected?" but it addresses the problem of "What happens to the data after it has been collected?"[1]. In 2011, Thingworx defined four building blocks for its platform: Search, Mashability, Composability and Crowdsourcing. These building blocks are realized by the different key features of Thingworx. SQUEAL allows the search of distributed data and devices. The Codeless Mashup Builder allows the creation of applications by "drag and drop". The Composer integrates different visualizations, data storages and business logics. Finally, social networks are used to allow the collaboration of users and developers. The most important capability of Thingworx is the integration of different channels. Devices can be connected by a variety of protocols like REST, MQTT, or traditional sockets. It offers an interface to business systems like SAP, Oracle and Salesforce.com. It also embeds cloud services like Twitter and Amazon Payments. In conclusion, It reduces complexity for non-technical users by providing mashup technologies[1]. As shown in Figure10 ThingWorx IoT platform provides device cloud to connect millions of devices with IoT application. It provides always on communication using REST, MQTT and sockets. Above the layer of communication there are system service integration, 3D storage engine and business logic. System service integration interact with business systems like ERP, CRM etc. 3D storage engine enables big data analytics. Above it there is a layer for REST APIs that helps to implement and use social services and cloud services. Then the data is presented via various visualization techniques[5].

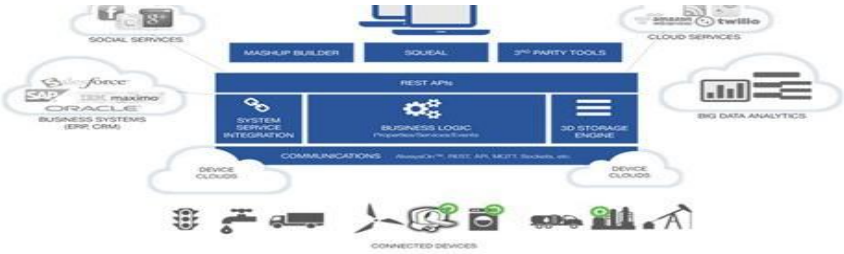

Fig.10: ThingsWorks IOT Platform[5]

V. CONCLUSION

This paper presents the basic concept of IOT platform and different types of well known IOT platforms. ThingWorx and Microsoft Azure are the most popular platforms for IoT solution as compared to the others. The IoT is slowly turning from vision into reality: IoT platforms play very important role within this evolution by providing significant building blocks. A lack of standardization and development has led to a heterogeneous platform . As a result of this heterogeneity, comparing and selecting one of these platforms is a difficult task. To help with these problems, we introduced here different IoT platforms with its basic features. Future work could present a technical definition of the reference architecture of IOT platforms. Furthermore, this work will build the basis for a decision for selection of IOT platform based on user-given preferences. This will help a user to determine a suitable IoT solution for his use case.

REFERENCES

[1] Marcus Köhler, Dominic Wörner, Felix Wortmann, "Platforms for the Internet of Things – An Analysis of Existing Solutions".

[2] https://www.iotforall.com/what-is-an-iot-platform/

[3] https://da-14.com/blog/10-best-iot-platforms-iot-technology-forecast

[4] Suparna de, Tarek Elsaleh, Payam barnaghi, Stefan Meissner , "AN INTERNET OF THINGS PLATFORM FOR REAL-WORLD AND DIGITAL OBJECTS", Scalable Computing: Volume 13, Number 1, pp. 45–57. ISSN 1895-1767 , 2012

[5] Bhumi Nakhuva and Prof. Tushar Champaneria, "STUDY OF VARIOUS INTERNET OF THINGS PLATFORMS", International Journal of Computer Science & Engineering Survey (IJCSES) Vol.6, December 2015

[6] https://opensourceforu.com/2018/10/the-top-open-source-iot-platforms-for-developers/

[7] Jasmin Guth, Uwe Breitenbücher, Michael Falkenthal, Paul Fremantle, Oliver Kopp, Frank Leymann, Lukas Reinfurt, "A Detailed Analysis of IoT Platform Architectures: Concepts, Similarities, and Differences", © 2018 Springer-Verlag., The original publication is available at http://dx.doi.org/10.1007/978-981-10-5861-5_4
See also LNCS-Homepage: http://www.springeronline.com/lncs

[8] A. Kinesis, E. User, and A. Kinesis, "Scaling Internet of Things Data Movement with Amazon * Kinesis *," no. November2014.

[9]https://www.google.com/search?rlz=1C1ASUC_enIN653IN653&q=Microsoft+Azure+IOT+platform+images&tbm=isch&source=univ&sa=X&ved=2ahUKEwjP2se3l7PhAhUP63MBHVnCByMQ7Al6BAgJEA0&biw=1366&bih=657#imgrc=GNEF2wCW-zHnrM:

[10] https://docs.microsoft.com/en-us/azure/iot-fundamentals/iot-services-and-technologies

[11]https://cloud.google.com/solutions/iot/

[12] https://cloud.google.com/iot/docs/concepts/overview

ISBN : 978-93-87793-82-8

[13]http://www.oracle.com/us/solutions/machine-to-machine/m2m-brochure-1951397.pdf

[14]https://www.cisco.com/c/en_in/solutions/internet-of-things/overview.html

[15] https://www.cisco.com/c/en/us/solutions/internet-of-things/iot-kinetic.html#~stickynav=2

[16]https://sapinsider.wispubs.com/Assets/Articles/2018/June/SPJ-How-to-Design-the-Architecture-and-Develop-an-IoT-Application-on-SAP-HANA-Cloud-Platform

[17] https://searchcustomerexperience.techtarget.com/definition/IoT-Cloud-Salesforce-IoT-Cloud

[18] https://www.scnsoft.com/blog/salesforce-iot-cloud-benefits-and-limitations

[19] https://www.bosch-iot-suite.com/

[20] https://internetofthingsagenda.techtarget.com/definition/IoT-middleware-Internet-of-Things-middleware

[21] https://www.computerworld.in/feature/how-middleware-plays-crucial-role-iot