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Research Article

SURVEY OF REFERENCE ARCHITECTURES IN THE INTERNET-OF-THINGS (IOT)

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ABSTRACT

The Internet of Things (IoT) isa epitome in which smart objects actively communicate with diverse physical devices without the need of human interaction that are in a network. IoT environments are described by a grade of miscellaneous including devices with diverse capabilities, Operational and network protocols. To handle such heterogeneity some platforms have proposed to elevate interoperability by eliminating the explicitness of such devices. In this context the referral architecture is used for outlining the inaugural set of building blocks for the IoT environment and provides a solid establishment. This paper targets on reviewing the distinctive reference architectures and provide well integrated and context aware intelligent services for IoT.

INTRODUCTION

The Internet of Things has become the recent trend since it's the smartest way of connecting the physical things or devices to the digital world [Khan, R. *et al*,2012]. As the count of devices and things connected to internet has been increased, by 2020 the count of internet connected things will outnumber humans by 4-to -1[2]. IoT are basically portrayed by a high grade of hardware and software miscelaneousnesss. IoT platform proposed mainly concentrate on absolute integration of miscellaneous devices and accoutre the high level models for developing applications [S.Bandyopadhyay, M. Sengupta, S. Maiti, and S. Dutta., 2011,P. F. Pires,2014]. The lack of standard in the IoT context makes the solution to adapt different programming models that are not congenial with each other and thus arises scalability issues.. To overcome those above mentioned limitations reference architecture is required for outlining the initial set of building blocks for the IoT Environment and provide a solid establishment for the IoT.

In this paper a survey is done on some existing reference architectures for the Internet of things and analysed them for various kind of perspectives such as platform, security, edge computing, authentication and real-time analysis Reference architecture can be said as abstract architecture encompassing knowledge and skills in a accustomed application domain thus making ease and walk through development, standardization, interoperability, and progression of software system in such a domain [E. Y. Nakagawa, F. Oquendo, and J. C. Maldonado ,2014]. Establishing of reference architecture is in need as they depict both integral building elements and design choices for dealing with functional and non-functional essentials in IoT environment. Reference architecture allow the building systems be able to properly satisfy the existing conditions by considering the set of building blocks provided by such architectures. Maintaining interoperability solutions is the main concern in IoT environment. Interoperability is attained by building architectures based upon reference architecture. The IoT architecture portrayed in Figure 1 [Tech beacon, IoT architecture, 5] is a 4 tier architecture (IoT).

The 4 tier architecture is described below.

Stage -1

Sensors/actuators

Sensor is a device that detects and responds to some type of input data from the physical environment. For example temperature sensor sense the temperature and sends the data. Actuators can also interpose to change the physical conditions that generate the data. For example an actuator can shut down a power supply, and adjust an air valve.

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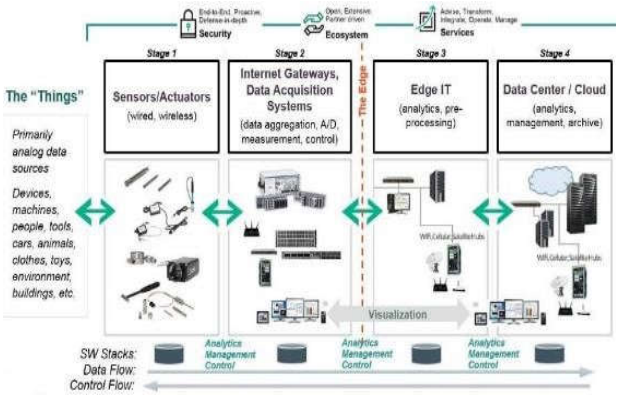

Figure 1 IoT reference Architecture

Stage-2

The Internet Gateway

The raw data (analog) from the sensors is summated and transformed to digital stream for further course of processing. Data summation and conversions are done by data acquisition systems. The digitized and aggregated data is received by the gateway that has to be sent to next stage for further. Gateway often sits in closeness to the sensors and actuators.

Stage-2

Edge IT

The digitized and aggregated data from the 2nd stage is forwarded to 3rd stage for the further processing. This is the stage before the data enters into the data center. Pre-processing and analysing of data is done in this stage. Because to decrease the load on IT core infrastructure and to save the network bandwidth. Machine learning can be used at the edge to scan for abnormalities. That identifies impending maintenance problems that need immediate attention, then by using visualization technology the information can be presented using dash boards, graphs or maps.

Stage-4

The Datacentre and Cloud

Data that needs to be more in depth processed and feedback doesn't have to be immediate, gets forwarded to data centre or cloud based systems. Here high processing IT systems are used for analysing, managing and securely storing the data. Longer time is required for getting the results in 4th stage but more in-depth analysis is done in this stage. In this stage data from sensors can be appended with the data from the other sources to give deeper insights.

Reference Architectures

Aws Iot Refernce Architecture

AWS is an amazon web services platform that collects the Telemetry data from the internet connected things and analyses it and also provides secure bidirectional communication between internet catenated devices and the cloud. Its architecture is displayed in Figure 2[aws.amazon.com/documentation/iot/]. AWS consists of these components 1)Device gateway 2)Message broker 3)Rules engine 4)Security and Identity service 5)Thing shadow 6)Thing Shadows service. It provides SDK for connection of hardware devices or mobile applications and it let the devices to connect, authenticate and exchange messages using the protocols (MQTT, HTTP, WEB Socket). It has a device gateway using which messages can be exchanged using publisher-subscription model. It has device shadows mode which consists of the device latest state and it makes easier to build applications and those interact with devices by providing available REST API's. The rules Engine helps to make IoT applications that collects, process, and analyse and it acts on the data produced by the connected devices at global scale without managing any infrastructure and it is also used for transforming and routing the IoT traffic to a precise location or endpoint such as S3 function or lambda function. AWS is cloud service provider multiple data processing services are already integrated

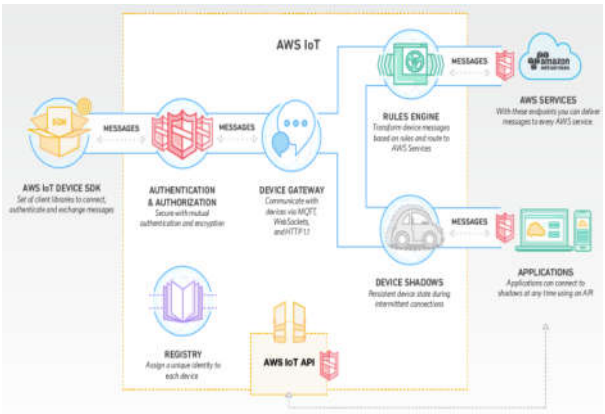

Figure 2 AWS IoT Reference Architecture

Microsoft Azure IoT Reference Architecture

The Azure IoT is built on Microsoft azure platform to connect, store, analyse and operationalize device data to give business insights [Hongyu Pei Breivold,2017]. It is a 3 level architecture which consists of 1) Device connectivity 2) Data processing and Analytics 3) Presentation and business connectivity. IoT hub provides a device registry that maintains a list of devices and provides access to the device specific queue. Its architecture is displayed in figure 3[Azure IoT Reference Architecture, 2016]. The principal point of this reference architecture is to provide software and hardware heterogeneity for different scenarios and provide security [Jasmin Gut, Uwe Breitenb¨ucher, 2016]. Device connectivity provides the different devices to be connected to the IoT cloud using protocols such as AMQP, HTTP and MQTT. Data processing and analytics process the telemetry data that is obtained from devices and analyses it. Presentation and business connectivity gives the end clients to see and break down the information from the Devices. There is additionally great support for IoT checking and diagnostics. Event hub alongside the Azure stream examination is utilized for real-time analysis

Google IoT Reference Architecture

Google cloud Internet of things provides a fully handled service for secure connection and managing of IoT devices. It is three tier architecture [Google Cloud Platform,10] that consists of 1) Devices 2) Standard devices (gateway), 3) Cloud Platform. The telemetry data enters through cloud

Table 1 outlines the analogizing of the referenced architectures.

	parameters	Azure	AWS	google	WSO2
[1] Platform	Protocols	MQTT,AMQP and HTTP	MQTT,HTTP 1.1	Weave,MQTT,HTTP	MQTT,HTTP, AMQP
	SDK	.NET,UWP,Java,C ,NodeJS,Python	C,NodeJS,Java ,Python,IOS	Java,Python,NodeJS,Ruby Go,.NET and PHP	Supported(java)
	Authentication	Per-device with SAS token	x.509 certificate client authentication,IAM service	Google IAM Cloud Resource Manager Google signing	OAuth2 , Mutual SSl
	Communication Patterns	Telemetry, Command	Telemetry, Command	Telemetry, Command	Telemetry command
	Backup	Azure backup	Use 3rd party tools , Aws Datapipe line ,sync to EBS+ snapshot	snapshots	Analytics data backup /restore tool
[2]	Real time analytics	Yes (Event hub along with azure stream analytics)	yes(Kinesis stream)	Yes	Yes
[3]	Edge computing	No (Azure and third party services are providing)	Yes (AWS Greengrass)	No	Yes
[4]	Security	TLS(server authentication only)	TLS(mutual authentication)	End-to-end security using assymetric key authentication over TLS	Mutual SSL
[5]	Device level authentication	Yes	Yes	No	Yes

publisher/subscriber (pub/sub)[Google cloud platform]. Cloud pub/sub supports large scale message ingestion over HTTP (or) gRPC.

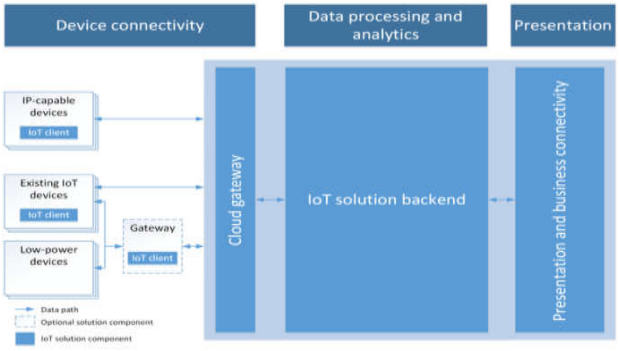

Figure 3 Azure IoT Reference Architecture

Ingested data is maneuvered by the pipeline. Pipeline provides the processing tasks a) Transforming data b) Data aggregation and computing c) Enriching data and d) Moving data. Cloud dataflow renders service for data to be processed in various ways. And it is also devised to assimilate seamlessly with other cloud platforms. Data is stored along Enterprise analytics and logs using big query. Cloud Data lab is a tool for exploring, transforming, analysing and Visualisation of data. State of devices are automatically synchronised with help of NoSQL cloud hosted database. It has built in operational logging and monitoring assistance.

WSO2 is open-source technology that provides the design for the IoT. That aims to support amalgamations between systems and devices [Hongyu Pei Breivold, 2017, WSO_2 architecture]. The architecture is portrayed in Figure 5 [White paper of WSO2, 2015]. The WSO2 architecture has five layers –

1. Devices - Device layer in which every device has a distinctive identity and it is either straightly or indirectly linked to internet.

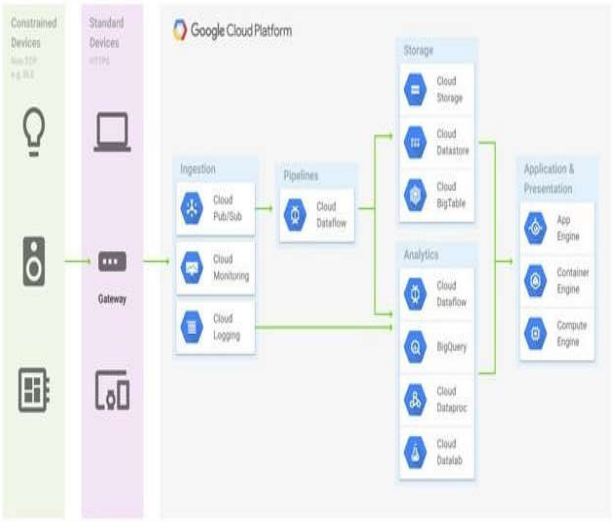

Figure 4 Google IoT Reference Architecture

2. Relevant transports- Communication layer which provides the connectivity of the devices using different protocols.
3. Aggregation /bus layer - Aggregation/bus layer which aggregates communications from multiple devices, brokers communication to a particular device, and transforms between various protocols
4. Event processing & analytics - event processing and analytics layer, which processes and acts upon events from the bus, and perform data storage.
5. Client /external communications - which empower users to communicate and interact with devices and obtain views into analytics and event processing.

Besides the vertical layers it has also two cross cutting layers

- Device manager-Which communicates with remotely manages devices, and maintain the identities of the devices.
- "Identity and access management" -It's for access control.

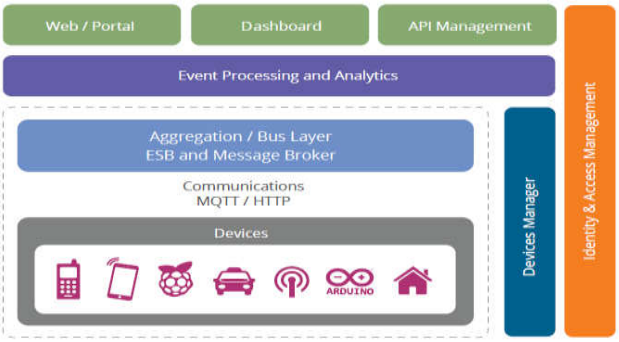

Figure 5 WSO2 Reference Architecture

ANALYSIS AND DISCUSSION

The referral architectures depicted in the above sections has a resemblance in their technical aspects, architectural principles and they differ in their technology approaches and implementation. Therefore we categorized some particular characteristics that have resembling concerns to describe the same or related facets of the reference architecture. The facets in which the reference architectures are compared are –

- Platform – which covers like what are the protocols being used, Authentication, SDK, communication pattern the architecture following and Backup.
- Real time analytics
- Edge computing
- Security
- Device level authentication

CONCLUSION

IoT platforms are growing their influence in daily life as the devices connecting to the internet has been increasing and the integration of heterogeneous hardware to the cloud is also increasing, soa referral architecture has to be developed. In this paper a survey was done on some existing reference architectures of IoT, and comparison has been made on those architectures based on some facets of the architecture. For security WSO2 is not providing TLS level of security compared to others and for the device SDK also it is providing only in java .WSO2 provides extensive support for protocol and authentication. Only AWS and WSO2 are providing edge computing in the architecture while remaining are providing along with the SDK's.

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