
Services And Frameworks of IoT

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Abstract

The rapid growth of the technological industry opens plenty of doors through the use of Internet of Things (IoT) in solving real-world problems. This paper aims at educating an amateur IOT explorer on the importance of Services and Frameworks by showing their various uses in different fields of the industry while comparing their use case with respect to multiple scenarios, advantages, and drawbacks.

Objective

Our goal in this paper is to identify the different services and frameworks of IoT. We propose to provide a detailed description of what they mean and how they contribute to the existing world. Following are a few key points that we plan to assess the topic on -

1. Introduction to the Matter

   To give writing as to what are the different services and frameworks in IoT, what they signify and portray with a brief overview of each and every component. With this introduction, the reader will be able to have a rough idea of what the paper is about and also understand the different terms used throughout the document.

2. Existing Work

   This section is mainly to describe the work that is already done in the field of IoT with its services and framework. Reading this will help us understand the past contributions and developments to enhance the reading of this paper. Only then will the reader be able to perceive the ideas brought out with more clarity and thought.

3. Existing Problems and solutions

   It would be ideal to know the problems that had existed in this field as looking and that with its respective solution might be something meaningful that would help the future enhancements and ideas that are currently being planned out.

4. Future Enhancements

   There are many ideas that are still being discussed and planned but not yet executed and by looking and learning from the existing problems and solutions, this can be something that would help us tackle the problems that are being faced now and that which is preventing the future enhancements from being executed.

5. Conclusion

   On the whole, the last and final section is mainly to wrap up the ideas that are presented in the paper. All the major points and highlights of this paper will be put forth to give an ending of all the services and frameworks of IoT and it's different contributions, setbacks and the like.

Elaborating over the above few points, we hope to put forth a document that would help the reader understand the different services and frameworks that the Internet of Things has to offer.

1. Introduction to the Matter

The world of Internet of Things has exploded over the past couple of years. It has brought about numerous possibilities and functionalities of real-world problems that were never thought of before. Before delving into the topic further, first, let us understand what it means.

An Internet of Things (IOT) device is an electronic entity connected to the internet to perform various functions by communicating with other 'things' or people. It usually contains sensors (used for collecting data from the immediate environment) and actuators (used to act upon the immediate environment) and is connected to a cloud-based server to store or relay information.

Almost immediately, security concerns pop-up in every reader's mind after reading up on the idea and thus, to make this a safer platform, Gateways, Services and Frameworks are provided to keep the user's data safe and protect it from corruption. In the past couple of years, multiple use-cases of IoT devices have been created, such as Home Automation, Smart City Implementation, in the Agriculture Industry, Healthcare Industry and many more. For various scenarios, multiple Services and Frameworks have been used and this paper aims to study the most useful and efficient ones.

1.1 What is a Service?

The traditional definition of service means 'to help someone or something with a task', similarly, in IoT, services usually refer to the platforms used to communicate or transfer data from the 'thing' to the database. They are commonly referred to as protocols.

1.2 Types of Services

IoT devices are broadly distinguished as *resource-rich devices* and *resource-constrained devices.* From [1], resource-rich devices as those that have the hardware and software capabilities to support the TCP (Transmission Control Protocol)/IP (Internet Protocol) protocol suite. Resource-constrained devices are simple devices that do not have the required resources to

[1] "toward better horizontal integration among iot ... - UFMG." http://homepages.dcc.ufmg.br/~mmvieira/cc/papers/Toward%20better%20horizontal%20integration%20among%20IoT%20services.pdf.

support TCP/IP and cannot interoperate easily with resource-rich devices that support the TCP/IP suite.

Some commonly used IOT Protocols (Services) are:

- Constrained Application Protocol (CoAP)
- Representational State Transfer (REST)
- Extensible Messaging and Presence Protocol (XMPP)
- Advanced Message Queuing Protocol (AMQP)
- Message Queue Telemetry Transport (MQTT)
- MQTT for Sensor Networks (MQTT-SN)
- Data Distribution Service (DDS)

1.3 What is a Framework?

Derhamy in [2] defines a Framework as a set of guiding principles, protocols and standards which enable the implementation of Internet of Things applications. It can but does not need to be an active participant of the overall IoT system.

1.4 Types of Frameworks

Frameworks can enhance IoT application development by rapid implementation, interoperability, maintainability, security and technology flexibility. Different kinds of frameworks are constructed for different uses. Following are a few examples:

- *The Arrowhead Framework:*

A light-weight framework, based on Service Oriented Architecture (SOA), whose goal is to enable the Industrial Internet of Things and to improve interoperability between applications. [2]

- *AllJoyn Framework:*

This framework was developed by the AllSeen Alliance and is designed to enable interoperability for home automation and industrial lighting applications.[1]

- *OMA - LWM2M (The Open Mobile Alliance - Light Weight Machine to Machine):*

[2] "A Survey of Commercial Frameworks for the ... - DiVA portal." http://www.diva-portal.org/smash/get/diva2:1009023/FULLTEXT01.pdf.

This framework has been developed for the purpose of monitoring, provisioning and managing connections of networked devices. LWM2M is based on CoAP and defines a layer above CoAP[1]

2. Existing Work

The research paper that we planned to use for our research is titled "*IoT Architectural Framework: Connection and Integration Framework for IoT Systems*". The article was published in February 2018. The paper reveals to us the work that is already in this field such as the Services and Frameworks of IoT. It acts as a reference for our study on this topic.

Frameworks that we learn about in IoT are helpful for performing different case studies and research topics. All of these frameworks only act as catalysts to get tasks done performing interoperability in communities such as academics, research and the like. Some of the things that we should keep in mind before applying a framework in IoT are -

- Scalability
- Ease of testing
- Ease of development
- Fault tolerance
- Lightweight implementation
- Service coordination
- Inter-domain operability

Here are a few frameworks in IoT that would help us succeed in the task of interoperability for integration. Using these frameworks can lead to wonders in executing different projects and case studies for research -

1. Eclipse SmartHome Framework -

   The ESH framework is built on 5 major stacks -

   I. Operating System - This is the support for a basic function of the computer. Eg - Linux, Windows, MacOS etc.

II. RunTime Environment - Written in Java but is managed with a HTTP server.
III. Communication & connectivity - There always needs to be a link between the tools of IoT for home automation. Eg. - Sonos, Philips Hue, Belkin WeMo etc.
IV. Remote Management - This section is designed mainly to have remote monitoring, firmware updates and connectivity of different devices.

2. Calvin Framework

The Calvin Framework divides IoT development into 4 major categories -

a) Describe - Performs an in depth analysis as to what the requirements are and how is it that IoT can meet the different requests that are put forth. Describing would help in understanding and knowing what needs to be achieved. It would also be necessary to prioritise the order in which certain tasks that are put forth in order to achieve the requirements.

b) Connect - A connection is necessary for the different tools in IoT to communicate with each other. Only if the connection is made and secure will the project run as a whole.

c) Deploy - After making a set of requirements and establishing the connection between the different IoT tools, the project has to be excecuted real time for the developer to understand where improvements can be made and what are the different conclusions that can be drawn.

d) Manage - Finally, at the end of all of this, there has to be a means to manage everything - the connection has to be fast and reliable. The data has to be secure and much more. A means of management needs to be set up in order to take full advantage of the project.

3. SOCRADES - A service orientation based integration architecture that helps in the creation and modelling of different processes. It helps us in the connection and integration for an application in an ERP system. The framework is able to ease the controlling and management of devices in their different layers.

4. AllJoyn - This is a framework that targets connections and integration of things irrespective of their modules or their connections. Such a framework is useful for identifying networks between the different devices. Using this framework would help us in creating sessions to create a communication network between the different IoT devices. .

5. ARIoT - Is a framework which uses the concept of augmented reality to build upon the already existing IoT infrastructure. The framework in a gist detects different IoT objects and through the software developed ~ it will be able to identify what the object is, it's identification number, it's attributes and their corresponding values, their respective manufacturers and the like.

6. AVIoT - This is one such framework where the end user can visualise the different communications that happen between the actuators and sensors. The AVIoT framework can be used in an environment where the IoT objects can be managed through the method of users applying their web - based software to manage the different operations on the IoT tools. .

Existing problems/ motivations and challenges

McKinsey Consulting expects the IOT market to worth around 11billion dollars by the end of 2025. If this were to be true then one area that arises as a major need for the growth of the internet of things is interoperability. Interoperability can be defined as the ability of disparate IoT devices; systems or components of systems, to exchange information with each other and make use of the information that has been exchanged. The market of the IoT devices is very fragmented mainly due to the presence of countless brands and the incompatibility between them. In order to overcome this issue, a mutual consensus is needed to find common standards for communication between the countless IoT devices of different types and different profiles.

Current initiatives in IoT are largely focused on devices and applications that address disparate needs. They provide very little room for connection and interoperation. The lack of a shared set of terms for describing services, service constraints, and service strategies not only results in redundant functionality, redundant services, and reduces overall system visibility but also presents problems for change management and limits the scope for reusing the resources and the coordination between them. Connection and interoperability needs to be supported as a building block in IoT solutions in order to provide security and mechanisms which will enable an array of devices and services and devices to be joined up more efficiently in an IoT environment. This will improve the communication between the IoT devices and generate greater efficiencies, capabilities and choices. Interoperability will also improve the ease of use, potentially lower unit cost and lead to economies of scale. There are a number of factors which contribute to poor connection and interoperability. Some of which are given below:

- Lack of Standardized description of services: One the greatest challenges faced in the issue of integration is the lack of standards for naming convention of IoT device services and data information and description. Presently, there are still no standard methods to describe IoT services both at the high and low semantic level. The naming conventions in use are still disparate because of different coding practices, cultural and social backgrounds. This has led to different names being used to represent similar or in many case, same entity. This leads to lesser efficiency and redundancy. Appropriate knowledge acquisition and representation of the IoT domain will help us in the integration of heterogeneous IoT devices.
- Poor Context awareness for services: New approaches need to be utilized while modelling and designing the rule engines for services for a proper context-aware data processing in the IoT domain since the lack of adequate semantics for appropriate service context description is still evident in recent IoT system design.

- Poor device service classification: Cataloguing has long helped in identifying a device or a service at the time of an inquest based on a unique identifier for both the services and the devices the service is catalogued under. However, from a machine to machine point of view, service discovery is still unconvincing. Say a device has failed and is absent from the system, the services under this device will be logged as unavailable services despite the service being available under another device with a different unique identifier. Therefore, a new approach to service classification is required to handle dynamic discovery of services.
- Poor information visualization and analysis: the collection of data could be made more specific i.e. only the data that is required for the analysis could be collected. Tailored data collection and analysis can help in gaining valuable insights into an objects behaviour and the well-being and adequacy of an IoT environment can be analysed more efficiently.

Future Enhancements

In consideration of the existing frameworks and reviewing it with much focus on the adapted SOA paradigm, the paper has analyzed recurring problems in coordinating IoT devices and systems. Architectural style is the distributed systems which is an affirmative approach in building an expansible, robust and error tolerant framework for IoT and hence, the paper is considered to be beneficial from the developer's point of view as it has suggested an architectural framework for IoT.

The paper proposes to employ a microservice architecture for connected devices. A microservice architecture is an architecture that divides one major service into smaller independently maintained services. This type of architecture follows 'share as little as possible' policy, which promotes services to be independent of one another. Services are divided based on functionality, atomity(size) and interaction. Microservice architectures solve the problems faced by monolithic structures and systems by being modular. Each service comprises of its own codebase, database and resources, which makes changes and updates relatively easier and faster to execute. For instance, if a small change is required in a monolithic architecture, the entire codebase has to be updated. On the other hand, microservices can be altered as they are largely decoupled.

Microservices can be broadly classified into two :

- Functional Services: Services that perform the core functions of an IoT system.
- Non-Functional Services: Services that deal with non-operational tasks (such as monitoring, authentication and logging).

The functional and non-functional services are well defined and separated.

IoT has been growing rapidly. Vast number of devices has been spread out in all industries and a lot more are yet to be innovated and reach its full potential. With the help of microservices, new sequences of things and services can be applied into the project easily as the development approach helps commute innovation and create value in a short amount of time.

Microservices need to be upgraded to obtain improved functionality and security. Moreover, one major advantage of microservices is that it allows the failed service to be replaced with a better one. The replacement need not be done from scratch and only the defective service is updated which makes it very flexible and efficient.

Microservices are ideal as they provide the following benefits :

Low cost

While sensors and other hardware components have reduced in price over the years, their usefulness starts to diminish as newer components are introduced. Microservices can fill the gap between the old and new components by gradually upgrading and maintaining the network.

Isolated Risk

Microservices divide each service based on functionality. In a monolithic structure, any error or mistake will affect the whole system. On the other hand, if an error does come up in a microservice system, it will affect only the service it was present in.

Flexibility

A very important benefit of using a microservice architecture is flexibility. A service can be edited, replaced or removed with minimal effect on other services. This allows rapid prototyping and bug fixing during the development phase.

Conclusions

This paper has delved into the different services and frameworks in the realm of connected devices. The term IoT or Internet of Things is referred to a system of interconnected devices, sensors and objects which are connected to the Internet. This enables devices to receive and relay data with other devices in the network. A basic IoT structure consists of three layers;

Physical layer comprises of sensors and other devices that gather real world data.

Gateway Layer facilitates the transfer of data between the Physical Layer and Application Layer.

Application Layer provides an interface for issuing commands and viewing data obtained from the Physical Layer. The adoption of Internet of Things has seen a rapid growth in various domains, ranging from Agriculture to Manufacturing. These IoT systems will be deployed for various scenarios, each with varying levels of complexity. Such challenges have serious implications on how such systems should be developed and deployed. Basic IoT frameworks lack the ability to scale and operate under strenuous conditions and hence, the author insists on employing an efficient, intelligent and capable framework.

Interoperability refers to the concept of systems or devices exchanging information and to utilize it. Current IoT systems focus more on devices and applications to solve a particular problem, rather than interoperability and networking. This eventually results in a constrained and limited network with no support for modifications and additions. IoT is built around the principle of devices interacting with each other to increase efficiency, provide greater functionality and reduce the overall cost associated with it. While such IoT systems get the job done, they lack modularity and extensibility.

For IoT frameworks to be reliable and dependable, the author suggests a few measures that should be satisfied. A few of them are : Scalability, ease of testing, ease of development, and inter domain operability. A few frameworks that satisfy those conditions are listed as follows :

1. Eclipse SmartHome Framework
2. Calvin Framework
3. SOCRADES
4. AllJoyn
5. FRASAD

Each of the above mentioned frameworks utilize different software architectures. Service Oriented Architecture(SOA) is the most prominently used architecture. SOA provides interoperability and contract decoupling, making it very beneficial for IoT frameworks.
In order to meet the demands of a highly scalable, adaptive and fault tolerant framework, a microservice architecture is recommended. A microservice architecture is an architectural style that divides an application into various subparts called services, based on the function. Each service is loosely connected with the other services, providing easy modification, maintenance and deployment. The introduction of such an architectural style resolves various issues faced by conventional IoT frameworks.
The author concludes the paper by promoting the adoption of microservice architecture in the domain of connect devices and smart things. Microservice architectures will greatly enhance the efficiency and reliability of IoT systems. The author presents his view on frameworks to the IoT community in the hopes of achieving a scalable, fault tolerant and lightweight framework.

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