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Identifying the Design Principles and Standard Considerations for IoT Systems

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Abstract

Evolution of technology has always inspired the way of living. And IoT and its associated technologies are growing at an exponential rate. With growth of any technology there come numerous challenges. This paper is thus an attempt to identify the design principles and standard considerations while making IoT architecture. Various features of IoT systems are identified in this paper. The characteristics of a robust, reliable and secure IoT architecture are projected in this work. IoT problems, solutions and capabilities are explored in this paper.

Keywords: *IoT, Sensors, Design Principles, Standard Considerations*

1. Introduction

IoT is a framework that aims to automate sensing, collection and exchange of data among various connected devices and components [1]. At present more than 9 billon things are connected to each other and it is expected that by 2025 nearly 20 billion things will be connected under the IoT environment [2]. An example of IoT system could be the connection of various features present in our mobile phone. Like the brightness of the phone could be set as per the environment parameters obtained from the GPS of the mobile phone.

The word thing in IoT is designated to anything to everything that is connected with the internet. Things that could be connected to each other may include wearable technology [3] connected to smart phone. A smart phone further connected to the GPS of the car. A car whose GPS location is tracked by the lighting of the house. A further enhancement could be making online shopping after voice recognition or command. From paying the bills automatically to getting services on the airplane IoT will be found everywhere in the coming future.

IoT automation is linked to Artificial Intelligence (AI), Machine Learning [4], Big Data, Clod Computing, Internet Security, Data Science, Hardware, Software and many more. You think of the thing connected to the internet and it will be a part of IoT evolution. With IoT system there is greater transparency, control and better performance that can be obtained.

Any technological advancement flourishes if the core is right. The core of IoT is the cloud platform or the server at which all the processing is done. It is through the cloud that the common platform [5] is created. Every time an IoT event has to happen then the core responsibility of activation will lie with the cloud. All the central functions will be operation form the cloud.

Every IoT system is different depending upon the requirement of industry, business or the need of the organization. But a few aspects remain common which include Things, Gateways, Cloud Infrastructure and Network Infrastructure [6], [7]. These four act as strong pillars on which any IoT system can be designed to meet the specific needs.

2. Features of IoT

Various features that are associated with IoT systems include connection, analyzing, integrating, AI, sensing, active engagement and end point management. A high speed end to end connectivity is essential for real time data transfer between the IoT devices. Concerns related to reliability, security and time delay must be considered for an efficient IoT environment.

A well-integrated IoT system is a desired feature of the IoT system. An example for the same could be matching a Mi-smart watch [8-10] with the Mi-smart phone. The same brand products could be integrated well. Use of AI with IoT enhances the quality of life. A suitable example could be like a coffee vending machine, identifying that the coffee beans are about to end. The machine could automatically place the order to the vendor of the choice of beans that are preferred by the owner of the machine.

Sensing devices identify and measure any gross level changes that is happening in the environment and in the system [11], [12]. Shifting from passive networks to active networks would be a step forward in this direction [13]. There must be active involvement of the devices in the IoT sytem like automatically switching on the Air Conditioner when the car location is 5 minutes away from the home.

End point management is a must feature for the success of any IoT system. For example in the coffee vending machine example if the owner of the machine is not available for receiving the coffee beans then the whole system would fail. The desired output in this case is not achieved, so the whole process becomes questionable.

3. Building IoT Architecture

IoT architecture is the framework over which an IoT system is built [14]. Various stages included in this architecture are:

Stage 1: Sensing and using Actuators

Stage 2: Data Acquisition

Stage 3: Pre-processing and Edge Analytics

Stage 4: Cloud Analytics

Sensing device intents to sense and capture data related to temperature, pressure, humidity, vibration, fluid flow in a value and other gross parameters as per the system requirement. A sensor converts a physical attribute to an electrical signal. Various kinds of sensors can be installed like temperature sensor, vibration sensor, security sensor, pressure sensor, humidity sensor and gas sensor etc. [15-17].

An actuator is the movable part that takes an action on the type of signal that is received. Actuators can of various types like manual actuator, pneumatic actuator, hydraulic actuator, electric actuator, and spring actuator. The direction of actuator is opposite to that of the sensor as it converts the electrical signal into the physical attribute. Both the sensors work in numerous industrial applications and one often directs the other one.

In the second stage data acquisition is done where data is aggregated and sometimes converted into a format that id needed for further processing [18]. Hundreds and thousands of sensors might be generating enormous amounts of data. So, further filtration and compression of data is done for optimum transmission through the network gateways.

Before the actual analysis, edge analysis can be used [19]. In this stage intermediate switching elements like routers, switches etc. can be used where initial pre-processing can be done. Machine learning with feedback facility can be quite beneficial at this stage to improve the processes that are already being executed in the system.

In depth analysis is performed at the cloud in the fourth stage [20], [21]. Highly advanced information technology systems can be put for analysis, management and security of the data. Companies use the analysis to identify the key trends that is prevalent in the market. Similar patterns can be identified using cloud analysis. Anomalies and processing errors can also be identified in this stage. Business rules are then applied in the form of suitable action by careful analysis of data. Data so generated is futher kept for record keeping purpose and for future analysis.

Efficient resource utilization must be the target while designing the IoT architecture. Not only the human efforts will be reduced but a lot of time will be saved.

4. IoT Design Principles

Identification of problem is the first design principles while thinking of any IoT system. It is only after the true identification of the problem that a solution could be proposed. The proposed system should be executed only after laying the objectives as to how the problem could be solved. Barriers related to the design principles should also be considered in this phase.

IoT involves integration of several devices and processes from multiple vendors. So, a holistic view must be taken into consideration where all the systems work in harmony with each other. Interfaces must be designed carefully for a smooth transfer of data and signals. The role of each device must be identified carefully along with the specifications.

Since the interaction of IoT is not only digital but involves real world, so safety should be the first priority. Organizations must build trust in product, processes and services. Error situations must be prevented at the first stage. If the error still persists then proper guidance must be given to the customers related to solving of the error. Quality checks must be done in the real environment for a certain period of time before the product launch. Social context should also be considered as per the location where the product is to be used.

Building a brand does not happen in a single day. It requires a lot of effort to make it happen. A strong connection must be made with the customers so that stand your side even at the point of a fault. Brand values should also be reflected in the logo, color and the literature related to the product.

Lifespan of hardware and software must be aligned with each other. If hardware lasts for 5 years and software for 20 years, then the product is of no use after 5 years only. So such alignment should be done at an early stage only. A prototype should be build first before making the final design. Continuous refinements must be done in the prototype so that the final product is error free.

Data is huge and to handle this data sophisticated data science techniques must be used. Cleaning of data should be done so that faulty, error and missing data is filtered out. There is no need to hoard the data but important points must be identified. It is only through these points that useful conclusion can be designed.

5. IoT Standard Considerations

Security risks and challenges are a matter of great concern. Security of sensors, actuators, operating system, server or cloud, and communications is to be considered. From information stealing to physical tampering and then to encryption of communication, each subpart has an important role to play and concerns security issues. The denial of sleep attach should be avoided to prevent the decay of network performance.

The second set of considerations include understanding the behavior patterns of the customers, delivering up to date services, improving the product and identification of the business moments. Central and non-central analytics can be done for data interpretation. All important things within the IoT system require proper management and monitoring. Any fault can lead to a failure that is non-reversible in the real world environment.

Low power short range IoT networks must solve the contradictory requirements that concern range, battery life, product cost and operational cost. Fixed or wireless networking communication must be chosen for the IoT product. Cellular networks can be of great benefit for suct low power, short range IoT networks. Similarly low power wide area networks must also be specified. In this a long battery life with worldwide connectivity is a major concern.

IoT processors and architectures must be powerful to handle vast amount of data. Sophisticated operating system and robust firmware are the core requirements of IoT

systems. Complex trade-offs is to be understood between features that involves hardware cost, software cost, and software upgradability, so as to provide the best IoT solution. Operating systems like Windows and iOS are of no use for the IoT platform as the power and memory requirements are quite high.

Wireless transmission and automatic measurement plays a key role while identifying the standard considerations. Distributed stream computing platforms and parallel architecture can be used for processing of high data transfer rate.

From low level data control operations to high level data analysis and decision making, each step needs concern for making a risk free IoT system. Application programming interfaces(API's) can be used to interoperate and communicate.

6. Conclusion

In the coming future the markets will be flooded with the IoT products, but only the solutions that are robust, consistent, reliable and risk free will survive this race. It is in this concern that the paper has been written that specifies the features of IoT. Further elaborations are done as to how to build an efficient IoT architecture. The design principles and standard considerations of IoT are discussed in the paper.

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