Serverless Functions for IoT Applications – An Analysis

Varun Bhaaskar
Saranathan College of Engineering, Tiruchirappalli
bvarun1999@gmail.com

Tania Simon
SNS College of Technology, Coimbatore
taniasimon28@gmail.com

Shreshta Shajimon
LBS Institute of Technology for Women, Trivandrum
shreshtashajimon@gmail.com

Joms Antony
Amal Jyothi College of Engineering, Kottayam
jomsantony@gmail.com

***Abstract*—Internet of Things (IoT) refers to an ever-expanding network that characterizes an IP address for internet connectivity and inter-communication. It extends network connectivity and computing abilities to sensors and objects which can be used in day to day life. With the increasing growth of IoT, a promising approach to address these IoT devices is serverless computing. Serverless is a cloud-based infrastructure that cherishes upon pay as you use rather than pay as you go. It allows the user to have minimal visibility and control over the server aspects in turn establishing a platform to optimize the infrastructure utilization. This paper analyzes some of the applications and challenges of serverless function for IoT.**

Keywords—Serverless, IoT

I. INTRODUCTION

A report says that by 2020, there will be 30 billion IoT devices worldwide in 2025, the number will exceed 75 billion connected things. This surge has resulted in the production of huge amounts of data with the promise of making the user's life smarter and easier. Cloud computing has seamlessly integrated with IoT for good. It provides a robust way to connect all the devices, process all the data generated by those devices and make available the processed data anywhere in the world at any point in time. Serverless is a type of deployment model of cloud services where the service provider dynamically allocates and manages the servers and are stateless. It allows the user to build and deploy the core logic of the application instead of worrying about all the hardware and software required. Serverless cloud model bills you based on the number of times that particular function is executed instead of billing you for the hardware you hire for a certain amount of time like in Infrastructure as a service or Platform as a service. So, some of the advantages of using serverless are cost efficiency, easy deployment, high scalability and improved latency. But there are some disadvantages as well. Deploying very long-running and complex codes becomes very costly but most of the IoT applications are not so complex. Also, these serverless functions can only be accessed through APIs instead of traditional IP. Testing and debugging becomes more complex and also gives rise to new security concerns. Many vendors provide this serverless functionality to users. One of the biggest vendors is AWS under the name AWS Lambda. In contrast to an Elastic Compute Cloud (EC2) instance, a Lambda function has one dedicated purpose and deliberately only runs for up to a few minutes. Other service providers include IBM Openwhisk, Google cloud functions, Azure functions by Microsoft etc. Many communication protocols are used and one of the most popular one used in IoT is the MQTT (Message Queuing Telemetry Transport) which is a lightweight messaging protocol which doesn't require very high bandwidth to work efficiently. So, this becomes very much suitable for resource-constrained environments such as the case in most IoT applications. The paper is designed as follows. Section I gives an introduction to the contents of the paper. Section II deals with the various applications and III deals with some important characteristics related to IoT applications. Section IV provides a conclusion of the analysis carried out in the paper.

II. APPLICATIONS

A. Human Activity Recognition

The paper [1] talks about a Human Activity Recognition system that proposes to use a modified convolution based deep residual network, IoT node devices and AWS (which provides Function as a Service) to implement it. This deep neural network performs better than the traditional ML models which don't need the feature extraction to take place on the data. Some places which the paper proposes to deploy this is in shopping malls where customer activities can be analyzed to make a better offer and in hospitals to monitor patients who have undergone surgery recently who need proper rest and therapy to recover. This technology can be used to smartly monitor patients so that nurses can provide better care for their patients. This application uses the accelerometer and gyroscope present in smartphones to detect the motion of the user. Smartphones don't have the computing power to run complex algorithms. Thus all the sensor data is sent to the Cloud which facilitates functions of IoT such as periodic automation or an alarm system through MQTT protocol and complex programs can be deployed easily using serverless computing.

B. Disaster Management

The paper [2] presents IoT is based approaches and applications for disaster management. IoT supported protocols for disaster management are also illustrated by

segregating into seven types such as Infrastructure, Discovery. Data, Communication, Semantic, Multi-layer Framework, and Security. The Paper also addresses IoT based cost effective applications for disaster management like BRINCO, BRK, GRILLO, FLOOD BEACON, MYSHAKE etc. The state of the art IoT based Applications for disaster management and ongoing research work is also presented. Different use cases like Flood, Earthquake, Landslide, Forest Fire etc. are addressed.

Early warning, notification, data analytics, knowledge aggregation, remote monitoring, real-time analytics, and victim localization are the important phases in Disaster Management. IoT, Cloud and Serverless technology can be applied to cater disaster management more effectively. In this context, a state of the art disaster management system for Flood is described below.

A flood is a common disastrous event that takes place in different parts of the globe every year. Water level sensors can be placed in critical points based on the ground levels. If the water level is greater than a threshold height in a critical point it can be mapped to nearby regions, alerts are to be generated in the form of SMS, Tweets etc. which will contain the alert level(red, yellow, etc.) and the location. Further, a map can also be generated based on the estimated flood levels. This will be useful to the Disaster Management Force to analyze the priorities and attend to the affected areas without delay.

The occurrence of floods is very infrequent. Data logging, Analysis, Alert generation etc. are to be performed only when the water level crosses a particular threshold. “Deliver on demand, never pay for idle” policy of Serverless computing fits very well for this application Other characteristics of serverless computing which fits well are Automatic Provisioning and utilization, Faster Availability, Fault tolerance, Auto Scaling, Easy Operations and management.

C. Smart home and Workspaces

The paper [3] proposes a smart home control system using a coordinator-based ZigBee networking. A smart energy control system that can optimize the energy consumption of household appliances by controlling the unnecessary energy demands are described. It also illustrates the smart management control system to efficiently control the operating time of the electronic appliances.

It is evident that 70-80% of Living and Working spaces are not enabled with technology to monitor critical events, provide alerts, reduce energy consumption etc. The only solution is to fit in additional micro modules to enable IoT which will bring in some intelligence so that resources are managed efficiently and securely. Some of the issues in homes and workplaces are as follows:

1)AC is to be typically operated in 27-29 Degrees, which is not taken care of in many Places 2) AC’s / Fans/Lights are switched on unnecessarily when no one is occupied 3) Server Rooms/ Computing Facilities which is to be maintained in AC are not taken care of and may lead to huge losses, 4. Remotely Located Overhead Tank filling resulting in water spillage/power wastage, 5. Unattended UPS Battery Water Level Monitoring, 6. Un-attended Water spillage, 7. Un-attended parking of Vehicles, 8) Parking Vehicles in No parking Zones.

D. Intelligent Transportation System (ITS)

The paper [4] proposes an idea to implement a bus route transit planning using IoT and cloud computing. There are a lot of challenges as far as transportation is concerned in developing and developed cities. Having a smart transportation system can bring in significant improvements in areas such as avoiding traffic jams, fuel consumption and air pollution, travel time etc. The paper [4] tries to implement an automatic construction of origin/ destination (O/D) trip matrix using Bluetooth technology. The O/D matrix is fundamental to carry out traffic planning. There are four steps described to automatically generate the O/D matrix and make the information available to the clients. The appropriate and necessary information is collected from the Bluetooth devices constructed using microprocessors such as Raspberry Pi. The collected data is filtered out as the amount of data collected at this step would be quite vast. The collected data is preliminarily stored in a database and to be particular the Firebase database. Then this data is processed and the O/D matrix is generated automatically upon the client’s request using the AWS Lambda services which is the serverless function of the AWS cloud services. The microservice architecture is used to achieve two functionalities: client device management and matrix generation as stated above. The client who is generally administrative authorities can trigger the matrix generation using an HTTP request to the particular AWS server. This paper clearly points out the use of microservices and serverless functions for its advantages such as scalability, cheap cloud services, fault isolation, flexibility etc.

E. Traffic Monitoring system

The paper [5] talks about developing a system to improve the punctuality of transit buses. When a bus arrives at a traffic signal, in-road induction sensors, GPS etc. are used to track the bus number, traffic signal ID and the time of arrival which is sent to the data buffer- AWS Kinesis. Kinesis triggers many lambda functions so as to check the punctuality of the bus with the preset schedule of that bus present in Dynamo DB and accordingly changes the state of the signal. These computations need to occur only when buses reach the traffic signal which indicates that it is event-driven. So serverless is the best fit for this application. This application can be further extended to detect ambulances for clearing out a way for them and to detect personnel who are on the run from law enforcement agencies.

TABLE 1: Summary of Applications

S. No.	Application	Platform	How Serverless?	Characteristics	Sensors Used	Communication Protocols
1	Human Activity Recognition	IBM Openwhisk	Need for a decrease in complexity, lead time, operational costs	The data from the smartphone can be used to determine the kind of activity the user is doing	Accelerometer, gyroscope in smartphones	HTTP, MQTT, COAP
2	Disaster Management	AWS Lambda, IBM open whisk	Sensor values are critical and are to be logged when there are disasters, So resource allocations are infrequent	Data from the sensors can be used to provide early warnings and prioritize the rescue operations	Water level sensors, WSN, Microcontroller, GPS and GSM integration,	HTTP, MQTT, COAP
3	Smart Home/Working Space	AWS Lambda, IBM open whisk	Data logging, Analysis, Voice Detection, Alert generation etc. are to be performed only during critical events	The system can help to monitor the resource utilization in living and workspaces effectively. The resources include electricity, water, space, human resources etc.	Temperature, Water level, Pyroelectric, LDR and Camera Sensors	HTTP, MQTT, COAP
4	Transportation Service	Google Cloud Platform (GCP) punctually Firebase AWS	It is based on pre-execution bases and resources are allocated for each execution.	Origin-destination matrix is generated using which administrative authority generates the planning for BRT.	Pressure, ultrasonic, infrared and image sensors	HTTP
5	Traffic Monitoring	AWS	An event is triggered when the buses arrive at the traffic signal or bus stop	Most transit buses run late	Induction, GPS sensors	MQTT, ZigBee
6	Pest Control	AWS	Update the changes obtained from the several sensors placed in the plant	The changes in plants can be detected from the dataset.	Temperature Sensors	MQTT
7	Smart Vineyard	TelosB Open-source platform	Out of the 3 databases, one resides in the firebase.	Monitoring system to improve the yield and detect diseases.	Temperature, humidity, atmospheric pressure and rainfall, wind speed and direction sensor	MQTT
8	Smart Mirror	AWS and Google Cloud Services	Efficient biometric authentication as well as manage the resources according to the triggers	Data Streaming and several processes.	Camera, microphone	MQTT
9	Waste Management	Azure functions	Only violations need to be stored. So azure functions facilitate storage in a SQL database.	>To ease separation of waste >To monitor violation	Ultrasonic sensor, Camera	MQTT

F. Pest Control

The paper [6] proposes a low cost-effective sensor system for farmers to collect agricultural data efficiently, monitor and detect the pest which helps to take necessary actions by building predictive models based on AWS IoT API. Models can predict outbreaks of diseases in farmland beside the practice of the Amazon ML algorithm in the agriculture domain. We achieved to eliminate the complexity of data bottleneck by putting into service the cloud serverless to manage data and devices successfully. In future, we have to consider the characteristics of each sort of pest and disease to detect, relations between measurements of IoT, pest and disease as well as real-time prediction.

G. Smart Vineyard

The system discussed in the paper [7] called SEnviro for Agriculture is used for designing and developing a system that monitors the farm fields, mostly the vineyards, and improves the quality and also the yield of the production. The major approach used is WSN where the nodes take the images of the field and using image processing techniques any defects or disease in the leaf is detected. It includes a smart embedded system that monitors the temperature and humidity and sends an SMS of the values. Thus the alerts sent can be either data or the state of the node.

H. Smart Mirror

The smart mirror discussed in paper [8] is a voice-assisted interactive IOT device with added Alexa skills and multimedia capabilities that offers unique features to improve system security through biometric authentication. The authentication is implemented with multi-factors, facial and voice which is ensured through serverless computing in AWS. Additionally, the voice assistant and the multimedia display implemented in the mirror make users enjoy the intelligence of the smart home.

I. Waste Management

The paper [9] discusses a serverless IoT framework for smart waste management system where disposal bins can be turned into smart edge IoT devices which is capable of detecting in real-time disposal violations and provides an interface that can be used to monitor the disposal behaviour reducing costs associated with source separation and prevents pollution. Recyle.io takes advantage of edge computing capabilities reducing costs associated with source separation and achieving sustainable consumption or production patterns.

III. IMPORTANT CHARACTERISTICS

A. Security

IoT has penetrated each and every domain possible with the promise of making things better. Lots of personal and vulnerable data like a person's health-related information are being generated in a very short amount of time. The consequences could be fatal if this data falls into the hands of people whose sole purpose is to create harm. Arguably, security must be the most important factor to be considered while designing such systems.

B. Real Time Data Processing

This refers to the processing and execution of data instantaneously. This requires a continuous stream of input data. This kind of processing is very much required in areas like radar systems and traffic signals

C. Scalability

Scale, by definition, refers to "the capability of a system, network, or process to handle a growing amount of work, or its potential to be enlarged in order to accommodate that growth." As we know that IoT is expanding at a rigorous pace and while designing an IoT system, scalability becomes one of the important factors to consider.

D. Data Streaming

Data streaming refers to the continuous and steady transfer of data at high rates. This is usually associated with a good internet connection and high bandwidth.

E. Cost Efficiency

Cost efficiency is a vital factor for a public user or an average private company. They don't have high enough funding to spend lavishly. So, each and every system that they put to use must be very much cost-efficient even if it takes some hit on performance.

TABLE 2: Most important characteristics needed for each application

Application name	Security	Real time Processing	Scalability	Data streaming	Cost effectiveness
Human Activity recognition	✓	✓	X	X	X
Disaster Management	✓	✓	✓	X	X
Smart Home or working space	✓	✓	✓	X	✓
Intelligent Transportation service	X	X	✓	X	✓
Traffic Monitoring System	✓	✓	✓	X	X
Pest Control	✓	X	X	X	✓
Smart Vineyard	X	X	X	X	✓
Smart Mirror	X	✓	X	✓	X
Smart Waste Management	X	X	✓	X	X

IV. CONCLUSION

Thus this paper talked about various advantages and disadvantages of using serverless cloud architecture in IoT. IoT does not need a lot of computational power and serverless architecture steps in perfectly to exploit this characteristic of IoT. Cost efficiency being the best advantage also serves with many more advantages such as reduction in design complexity and scalability.

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