

# **DECENTRALIZED FUNCTION AS A SERVICE**

Siyane Koralege Nuwan Uditha Tissera.

209386K

Degree of Master of Science/ Master of Engineering

Department of Computer Science Engineering

University of Moratuwa

Sri Lanka

March 2022

## **DECLARATION**

I declare that this is my own work and this thesis/dissertation<sup>2</sup> does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa, the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date:

The supervisor/s should certify the thesis/dissertation with the following declaration.

The above candidate has carried out research for the Masters under my supervision.

Name of the supervisor:

Signature of the supervisor:

Date :

## ABSTRACT

The objective of this research is to implement an automated, user-oriented, decentralized function as a service provider that replaces the existing centralized, single-authority FaaS providers in a way that can address the weaknesses in the global cloud infrastructure related to the serverless architecture. This refers to applications which heavily depends on third-party services running on the most well-known vendor temporary containers (or FaaS). Existing serverless architecture suffers from deficiencies such as vendor control, multi-tenancy issues, vendor lock-in, security issues, lack of monitoring tools, difficulty managing granular activity, and architectural complexity. The proposed system decentralizes granular functions across a peer-to-peer network to provide decentralized FaaS. A granular function is an atomic function with a single responsibility deployed on the Orb network. "Orb" is a peer-to-peer network of peers (nodes) and super peers (Supernodes/Trackers). Node detection on the network is done using the principles of "Satoshi Client Node Discovery". The user can register to the network as a node or super node by installing the client or server software as required. A node (represents a personal computer) provides the functionality of executing, deploying, and hosting functions. Supernodes keep a record of peers, live Supernodes, host particulate functions, and more. The user can apply an atomic particle function to the network through the server software. For deployment, users are charged in cryptocurrency (Ether). The payment form of "Orb" is based on ether smart contracts that use blockchain technology. The deployed function is sent to the Supernode and distributed across a network of peers across the network to achieve enhancement, reliability, and integrity. The confidentiality of a deployed function (a piece of code) is achieved through technologies such as private-key public-key encryption, proper obfuscation, and containerization. Users can restrict access to the function by keeping it private and opening it to a select group of users. For hosting a function, the user is paid in "ether" depending on the number of requests served and the uptime. When analyzing the response time by calling the function against an active set of peers will provide the real time analytics data about the availability and reliability. In the long run, "Orb" might support decentralized APIs.

## **ACKNOWLEDGEMENT**

I would like to express my heartfelt appreciation and gratitude to Dr. Indika Perera, for mentoring me in the MSc Research Project as it's supervisor and for guiding me throughout the semesters.

I am very grateful for his significant assistance in the research endeavor, His assistants in this research endeavor became a key success factor, which facilitated me with the necessary skills, resources, direction, supervision, and honest feedback. I was able to complete my coursework properly in a timely manner thanks to his expertise and constant guidance. I would like to thank all of my colleagues for their assistance and support in locating relevant study material. I am really grateful for the support of my parents, brothers, sister, nephew, niece, and close friends.

# TABLE OF CONTENTS

DECLARATION	i
ABSTRACT	ii
ACKNOWLEDGEMENT	iii
TABLE OF CONTENTS	iv
LIST OF FIGURES	vii
LIST OF TABLES	viii
LIST OF ABBREVIATIONS	ix
CHAPTER 1	1
INTRODUCTION	1
1.1 Overview	1
1.2 Motivation	2
1.3 Purpose	3
1.4 Conceptual idea	3
1.5 Research problem	4
1.6 Research objectives	6
1.6.1 Decentralized Service Deployment	6
1.6.2 Network Infrastructure	7
1.6.3 Function as a service model	7
1.6.4 Payments model	8
1.6.5 Security	8
CHAPTER 2	11
LITERATURE REVIEW	11
2.1 Overview	11
2.2 Serverless architecture providers	11
2.2.1 AWS Lambda	11
2.2.1.1 AWS Lambda Benefits	12
2.2.1.2 AWS Lambda by examples	12
2.2.1.2.1 File processing	12
2.2.1.2.2 Stream processing	12
2.2.2 Azure Functions	13

2.2.2.1 Overview	13
2.2.2.2 Azure Web Jobs	14
2.2.3 Google Cloud Functions	14
2.2.4 IBM Cloud Functions	17
2.3 Distributed storage	18
2.3.1 IPFS	18
2.3.1.1 IPFS overview	18
2.3.1.2 IPFS Content Addressing	19
2.3.1.2.1 IPFS Objects	19
2.3.2 Storj	19
2.3.2.1 Storj overview	19
2.3.2.2 Storj Decentralized Cloud Storage (DCS)	20
2.3.2.3 Benefits of Storj DCS	21
1. Availability	21
2. Safety	21
3. Durability	22
4. Privacy	22
5. Cost Efficiency	22
6. Developer Friendly	22
7. Open Source Freedom and Flexibility	22
8. Community driven	22
2.4 Decentralized social network	23
2.4.1 Steemit	23
2.4.1.1 Blockchain online social media (BOSM)	23
2.4.1.2 Objectives of Steemit	24
2.4.1.3 Smart media tokens (SMT)	25
2.4.1.4 Price of Steem	25
2.4.1.5 Earn from Steem	26
CHAPTER 3	27
DESIGN & IMPLEMENTATION	27
3.1 Network Design	27

3.1.1 Nodes	29
3.1.2 Supernodes	30
3.1.2.1 DHT	31
3.1.3 Payment manager	31
3.1.3.1 Smart contract	32
3.2 Implementation	33
3.2.1 Client studio	33
3.2.2 Node	41
3.2.3 Supernode	44
3.2.4 Smart contact	46
CHAPTER 4	50
RESULTS & EVALUATION	50
4.1 Overview of the chapter	50
4.2 General functionality	50
4.2.1 Deployment & distribution of functions in the decentralized network	51
4.2.1.1 Function deployment steps	52
4.2.1.1.1 Download & Setup Orb	52
4.2.1.1.2 Implement code on Inline code editor	53
4.2.1.1.3 Code obfuscation	56
4.2.1.1.3 Deploy to the network	59
4.2.1.2 Function distribution/propagation	61
4.2.2 Calling a deployed function	62
4.2.3 Updating and depreciating of a function	63
4.2.4 Handling payments through wallet	63
4.2 Samples scenarios	65
4.2.1 Global temperature warning mechanism using IoT	65
4.2.2 Sharing a reusable function code	66
4.3 Testing	68
4.3.1 Non functional testing	68
4.3.1 Functional testing	69
4.4 Evaluation	70

4.4.1 Cost evaluation	70
4.4.2 Performance evaluation	72
4.5 Research findings	73
CHAPTER 5	76
CONCLUSION & RECOMMENDATION	76
5.1 Overview	76
5.2 Benefits of this research	76
5.3 Revisited objectives	76
5.4 Limitations	77
5.5 Target Market	77
5.6 Marketing Strategy	77
5.7 Contribution	78
5.8 Future work	78
REFERENCES	80

## LIST OF FIGURES

Figure 3.1	Hashing function
Figure 4.1	File processing in AWS Lambda
Figure 4.2	Stream Processing in AWS Lambda
Figure 5.1	“Orb” Architecture
Figure 5.2	Trackers & Nodes
Figure 5.3	Process of function deployment
Figure 5.4	“Orb” Dashboard
Figure 5.5	“Orb” Inline code editor
Figure 5.6	“Orb” Add function in inline code editor
Figure 5.7	“Orb” Obfuscation code
Figure 5.8	Rename Obfuscation
Figure 5.9	String Encryption
Figure 5.10	Control-flow Obfuscation
Figure 5.11	“Orb” Deploy to network
Figure 5.12	“Orb” Confirmation of payment
Figure 5.13	“Orb” Function loading window
Figure 5.14	“Orb” Successful deployment
Figure 5.15	“Orb” List functions
Figure 5.16	“Orb” Add values to parameters
Figure 5.17	“Orb” Executing function



Figure 5.18	“Orb” Wallet dashboard
Figure 5.19	“Orb” Wallet
Figure 5.20	Global temperature warning mechanism using IoT
Figure 5.21	Sharing a reusable function code

## **LIST OF TABLES**

Table 5.1	Simple “Add” function
Table 5.2	Sentimental function

## LIST OF ABBREVIATIONS

Abbreviation	Description
DHT	Distributed Hash Table
FAAS	Function as a Service
DFAAS	Decentralized Function as a Service
AWS	Amazon Web Services
JSON	JavaScript Object Notation
API	Application programming interface
LB	Load balancing/ Load balancer
S3	Amazon Simple Storage Service
EC2	Amazon Elastic Compute Cloud
EFS	Amazon Elastic File System
GCP	Google Cloud Project
DDoS	Denial-of-service attack
AI	Artificial intelligence
SaaS	Software as a service
IPFS	InterPlanetary File System
HTTP	Hypertext Transfer Protocol
SMT	Smart media token
DCS	Decentralized cloud storage
REST	Representational state transfer
URL	Universal resource locator
UI	User interface
MVP	Minimum viable product