CHAPTER I
INTRODUCTION

1.1 Background

Internet of Things (IoT) is a new paradigm that has changed the traditional way of living into a high-tech life style. It surrounds us everywhere we go: smart cities, smart homes, pollution control, energy saving, smart transportation, smart industries are such transformations due to IoT (Kumar, Tiwari & Zymbler 2019, 1). These are all enabled through interweaving sensors, actuators, and data analytics platforms.

The term Internet of Things, was first coined in 1999, when Kevin Ashton of Procter & Gamble wanted to attract his senior management's attention to a new exciting technology called the RFID (Radio-Frequency Identification). He called his presentation "Internet of Things", since the Internet was, at that time, the hottest new trend (IOT Analytics 2021). However, it wasn't until around 10 years later, that IoT really got the spotlight it needed.

It has been proven that around 2,5 exabytes of new data is constantly generated every passing day since the year 2012 (McAfee et al. 2012, 62). During those early years of IoT development, CISCO already estimated that there would be around 50 billion interconnected devices by 2020 (Evans 2011, 3) and according to a recent Cisco Annual Internet Report, M2M (Machine-To-Machine) connections, which is also referred to as IoT according to CISCO, will see make half of the global connected devices and connections by 2023. To be precise, the share of M2M connections will grow from 33 percent in 2018 to 50 percent by

2023. There will be 14.7 billion M2M connections by 2023 (CISCO, 2021). With IoT experiencing this sort of rapid growth, sending data toward a centralized Cloud server for processing and storage, would be inefficient due to potential network congestion, large power consumption and high latency (Pallewatta, Kostakos and Buyya 2019, 71).

This was where CISCO introduced the term Fog Computing around the year 2012. In essence, Fog Computing is a decentralized computing structure that extends cloud-based services to the edge of the network by using devices that reside between IoT devices and the Cloud (Redowan, Kotagiri & Buyya 2017, 1) with the goal to support real-time data processing and latency sensitive applications. The idea in this context is that Fog Devices such as gateways, switches, routers, can store application modules before they are being sent over to the Cloud (Silva et al. 2019, 1).

So, in short, rather than having the collected data from insurmountable amounts of IoT devices around the world sent through a single network channel that links straight to the cloud, the data can be distributed to fog devices that reside closer to the source of information, resulting in lower latency and more real-time control.

The sheer importance of Fog Computing can be realized with concrete scenarios that we probably overlook, ironically because of the advancements of Fog Computing technology itself. For example, in a case scenario where a patient would need to wear a heartrate sensor every time of the day, in which his/her irregular heartbeat could cause serious complications if not treated fast enough. The wonders of Fog Computing would enable more real-time control for the patient's doctor to react based on the information received on his end.

Another concrete scenario that this paper will cover is Smart Mining. Smart Mining is an industry, that performs the processes of using information, autonomy, and technology to obtain enhanced safety, reduce operational costs, and gain better productivity for a mine site (Phoke and Khandelwal 2021). The global smart mining market size is expected to reach $23,465.8 million in 2027, from $9,265.7 million in 2019, growing at a Compound Annual Growth Rate (CAGR) of 16.3% from 2020 to 2027 which is very good growth rate for such a large-capital market. According to a research done by IBM (IBM 2021), every individual requires approximately 3.11 million pounds of fuel, minerals, and metals in his/her life.

Just based on the information above, we can deduce that Smart Mining requires loads of data analysis, and would pose a lot of risk too. During mineral and coal mining for example, chemical reactions, hazardous gas emission, suffocation and rock sliding are among the many probable risks that could happen to the lives of the mining personnel. Therefore, it is of utmost importance, that IoT devices relevant to the scope of mining are deployed in order to gain better productivity, reduce operational costs but gain enhanced safety. Not only will the IoT devices be able to pick up the gases, chemicals and surroundings to inform personnel of possible dangerous situations, the sensors can collect important data before the actual digging process as well. These would result in better predictions in finding coal and minerals thus reducing cost and energy consumption as a whole (Awaisi et al. 2020, 17), a win-win situation.

Modelling the real-world interconnected infrastructure of IoT devices to their Fog devices to a central Cloud, would be extremely time-consuming, expensive, and too complex (Mahmud & Buyya 2019, 435). An alternative for this is made possible by the advent of Fog Computing simulators. This paper will use the iFogSim Fog Simulator toolkit to model the fog environment along with custom resource configurations.

There have been numerous examples of fog simulation using various types of fog simulation toolkits (Kunde & Adam Mann 2020, 1-2), like YAFS, EdgeCloudSim and MyiFogSim but this paper will focus only on using iFogSim as it has been not just the oldest, but one of the simulators out there that's most widely implemented due to its very "complete" nature, and of course, using the Java language – unlike YAFS, done in Python. A practical comparison was done to compare fog simulation toolkits, and found that the comparison between iFogSim, MyiFogSim, YAFS toward EdgeCloudSim wouldn't be fair as EdgeCloudSim only has a very limited, default implementation of a network model, coupled with the lack of sensor and actuator availability.

The problem is, there is a lack of guided, and comprehensive works within the fog simulation community. They are usually either partial or incomplete in their explanation, or too overwhelming for the average learner. As a workaround, this paper will provide a user-friendly tool, using a multiconfiguration GUI, enabling the user to configure certain elements within the GUI, producing a direct result that would exhibit all essential information like latency, energy consumption and throughput all via their respective charts, thus paving the way for a proper introduction into fog computing. As a result, a business owner who does the business side of things up-front with the aim of being more tech-integrated, would make up a considerable edge by understanding the essentials of modeling a fog computing environment. To be precise, by knowing how different the network congestion, cost of energy consumption, and latency in cloud computing and fog computing can be, business owners might prioritize better budget allocation in order to maximize the utilization of fog computing peripherals for a higher purpose that directly relates to their business vision.

Many other works have done simulations toward different case scenarios, but only very few have proposed easy multiconfiguration-able solutions to visualize latency, throughput and energy consumption metrics for easy interpretation and learning by business owners and planners. Specifically, on the topic of smart mining, only a vague, incomplete solution has been found to model these metrics (Awaisi et al. 2020, 17-23) that produce raw and hard-to-understand outputs. With JavaFX working in tandem with iFogSim, this predicament can be solved thoroughly, providing comprehensible graphical outputs in a charted format, and varying input configurations to make understanding and visualizing easier for anyone from business owners to even new aspiring learners.

1.2 Problem Formulation

The formulation of the problems that will be discussed are as follows:

1) How to fix and refine the previous related Smart Mining code so that it runs and produces an output.
2) How to model a presentable and adequate simulated Smart Mining environment with the application of Fog Architecture through the use of the iFogSim toolkit.
3) How to produce multi-configurable user inputs in the GUI to visualize graphical outputs of network bandwidth consumption, energy consumption, application loop delay times (latency), and tuple execution times in the Smart Mining environment simulation.
4) How to save the outputs of user-configured inputs into a text file for future reference.
5) How to represent the saved outputs into narrow-scale charts for easier compare-and-contrast interpretation/viewing.

1.3 Scope Limitation

The simulation has limitations as follows:

1) The simulation will not specify precise models and types of fog devices, rather their computational and connectivity-related resources along with simple labels for reference.
2) The scope of the simulation is not large-scale and all-compassing. It is designed adequately enough to accommodate a rough idea of a Smart Mining ecosystem.

3) The simulation will only use the iFogSim toolkit to model the simulation, and JavaFX to visualize the output in a graphical format.
4) The multiconfiguration inputs will still have a limited scope, designed just enough to portray notable differences in the output metrics.
5) The fog devices that will be used in this simulation are limited to just a proxy server, a router, along with master modules and the corresponding sensors and actuators (integrated into a microcontroller).
6) iFogSim does not deal with the low-level network issues such as interference management between densely co-located devices.

1.4 Purposes

The purpose of this research are as follows:

1) To prove if modification of the relevant classes in the iFogSim toolkit to suit the needs of the developer is possible, based on the goal of the simulation environment; which in this case is a Smart Mining environment.
2) To add the necessary classes and integrate it together with the iFogSim toolkit to actualize the goal of creating a Smart Mining fog simulation environment.
3) To produce a multiconfiguration GUI that is both user friendly and concise in visualizing the Smart Mining fog simulation output values.
4) To add an extra feature within the multiconfiguration GUI that saves the simulation outputs of the current configurations into corresponding text files, for further compare-and-contrast scenarios.

5) To add an extra feature within the iFogSim toolkit that visualizes each performance measurement metric in Line Charts based on the previously saved configurations.
6) To highlight the importance of a fog simulation, through the comparison of the performance measurement metric values of Cloud and Fog Computing implementations, by doing a configuration comparison test.

1.5 Methodology

In conducting this research, there are several stages of the research method that must be passed in which are as follows:

1) Conduct deep-research and studying of Fog Computing and its important concepts.
2) Conduct deep-studying on the iFogSim toolkit.
3) Conduct adequate research to model a presentable Smart Mining ecosystem.
4) Refine and fix the previous related Smart Mining code to produce an output.
5) Improve the Smart Mining environment with the essential, required fog device hierarchy and specifications within the iFogSim toolkit, written in the Java Language.
6) Conduct further improvements on the written Smart Mining fog computing environment, with the aim and purpose to be as encompassing and "close-to-real-life-situations" as possible.
7) Create a GUI for an easy input-output interface, with multi-configurable inputs that result in scatter-charted outputs.

8) Conduct exemplary data sampling of multi-configured simulation environments.
9) Model the data samples in a compare-and-contrast, charted manner, with respect to their individual performance metrics.
10) Conduct critical analysis of data samples and highlight the differences between the configurations.
11) Conclude the findings.

1.6 Writing Systematic

This thesis will be arranged with the format as follows:

CHAPTER I INTRODUCTION

This chapter will begin with an explanation on the background of the research entitled "GRAPHICAL MULTICONFIGURATION USER INTERFACE OF A SMART MINING FOG SIMULATION USING THE IFOGSIM TOOLKIT". It will be continued by the problem formulation and limitation scopes, along with an explanation for the purpose and methodologies used in this research. This chapter will be closed with a brief explanation of the writing systematics that will be used.

CHAPTER II THEORETICAL FOUNDATION

This chapter contains the theories that are used as a reference in planning and developing the thesis which includes the theory on JDKs, IDEs, Cloud Computing, Fog Computing, Smart Mining and the iFogSim toolkit itself.

CHAPTER III METHODOLOGY AND DEVELOPMENT

This chapter will discuss the planning of the Smart Mining fog simulation application modelling itself, from the modelling of the main execution class, to the planning of the GUI design and more.

CHAPTER IV RESULTS AND ANALYSIS

Chapter four will showcase the results from the aforementioned planned systems. This chapter will cover everything from how the Smart Mining environment is being set up, the errors and bugs encountered along the way, how they were resolved, how the main Smart Mining GUI is being designed, together with the design of other LineChart GUIs for comparison purposes.

CHAPTER V CONCLUSIONS AND SUGGESTIONS

This chapter will be the last chapter. It will discuss the conclusion obtained and the suggestions that will be used for future developments.