

Configuration Manual

MSc Research Project
Cloud Computing

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Project Submission Sheet
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Configuration Manual

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1 Introduction

This configuration manual gives a complete guide for setting up and implementing the research project "Optimisation of Load Balancing in Fog Computing Using Bacterial Colony Optimization Algorithm." It includes step-by-step instructions for installation of dependencies, libraries, and packages required for project implementation. The purpose of this manual is to help researchers and practitioners in understanding the research design and conducting performance analysis.

2 Software and Hardware Requirements

2.1 Software Requirements

- Eclipse Integrated Development Environment (IDE): Eclipse, a popular integrated development environment that includes a wide range of Java development tools has been used for implementation in this research project.
- iFogSim Simulation Tool: iFogSim is a toolkit that extends the CloudSim framework, specifically designed for modelling and simulating fog computing systems. In this project, iFogSim2 (the new version) is used.
- Java Development Kit (JDK): JDK is required to compile and run Java programs, including simulation code and other project components. In this research, JDK version 17.0.7 has been used.
- Other Dependencies: CloudSim is the core of iFogSim and provides the simulation framework for cloud and fog computing scenarios. It is a prerequisite for executing iFogSim-based simulations.

2.2 Hardware Specifications

- Operating System: For this research, MacOS has been used but it is compatible with multiple operating systems, including Windows and Linux.
- Processor: 1.8 GHz Dual-Core Intel Core i5
- Memory (RAM): 8 GB

3 Software Installation

3.1 Eclipse IDE Installation

- Step 1: Install eclipse as shown in Figure 1 (Eclipse IDE for Java Developers) Eclipse Foundation (2023)
- Step 2: After succesful installation, select a directory as workspace and launch as shown in Figure 2

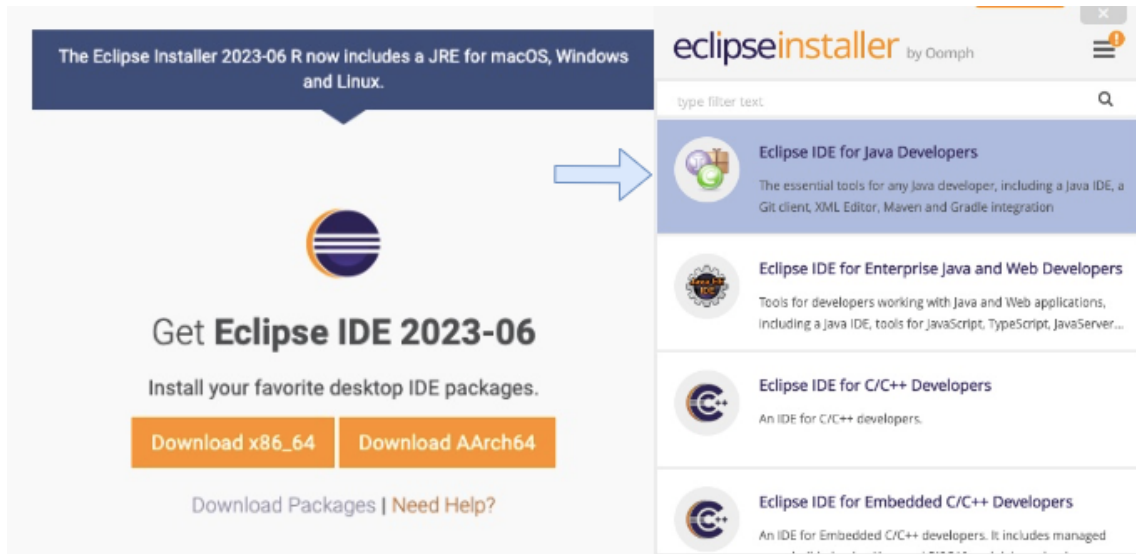


Figure 1: Step 1: Eclipse Download Eclipse Foundation (2023)

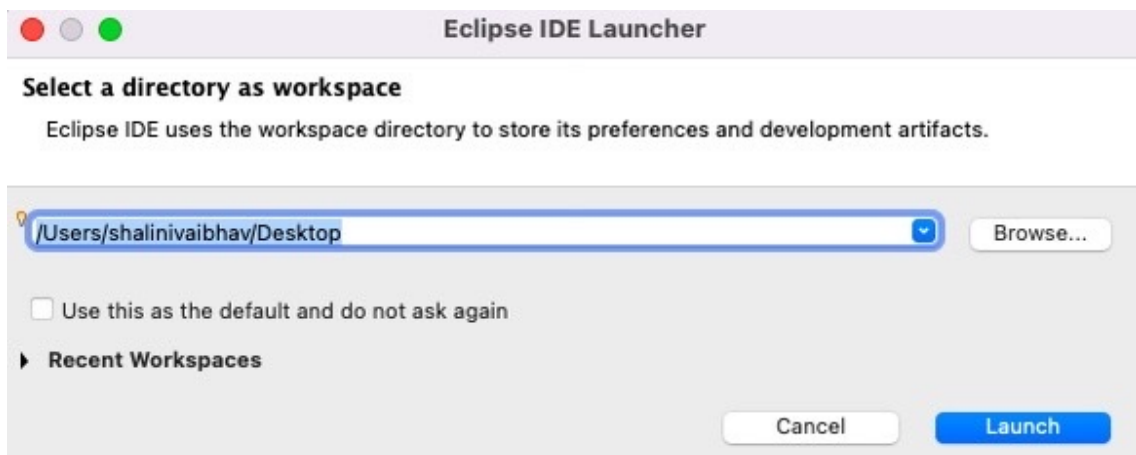


Figure 2: Step 2: Eclipse Workspace Launch

3.2 iFogSim2 (The new version)

- Step 1: Download *iFogSim GitHub Repository (2023)* and unzip the ifogsim2 folder in the system.
- Step 2: Launch the Eclipse IDE and click on new Java project and give the project a name as shown in Figure 3.
- Step 3: Uncheck the option "Use default location" and select "Browse" to the unzipped folder in the system as shown in Figure 4.
- Step 4: Click the "Next" button.
- Step 5: Under the "Libraries" tab, make sure that Cloudsim3.0 is present.
- Step 6: Click the "Finish" button.

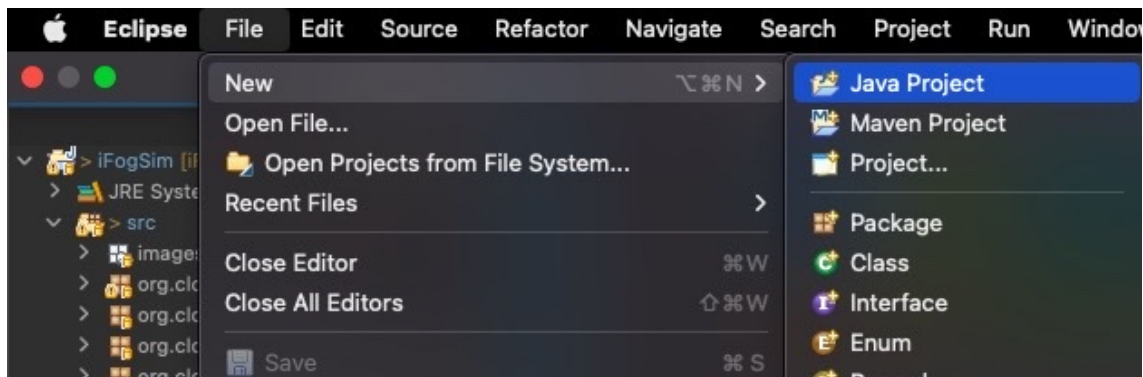


Figure 3: iFogSim project creation

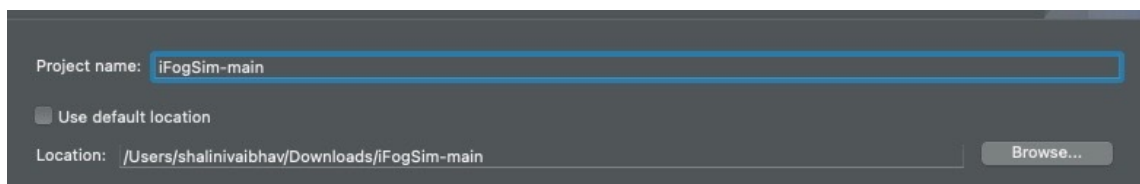


Figure 4: iFogSim unzipped folder import to eclipse IDE

3.3 Java Development Kit

- Step 1: Download the JDK version *Oracle JDK 17 Archive Downloads (2023)*, based on the operating system as shown in Figure 5.
- Step 2: Install it into the system as shown in Figure 6.

ORACLE		
Products	Industries	Resources
Customers	Partners	Developers
Company		
Linux x64 Compressed Archive	173.30 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_linux-x64_bin.tar.gz (sha256)
Linux x64 Debian Package	148.86 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_linux-x64_bin.deb (sha256)
Linux x64 RPM Package	173.04 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_linux-x64_bin.rpm (sha256)
macOS Arm 64 Compressed Archive	167.78 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_macos-aarch64_bin.tar.gz (sha256)
macOS Arm 64 DMG Installer	167.19 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_macos-aarch64_bin.dmg (sha256)
macOS x64 Compressed Archive	170.21 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_macos-x64_bin.tar.gz (sha256)
macOS x64 DMG Installer	169.63 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_macos-x64_bin.dmg (sha256)
Windows x64 Compressed Archive	172.19 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_windows-x64_bin.zip (sha256)
Windows x64 Installer	153.28 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_windows-x64_bin.exe (sha256)
Windows x64 MSI Installer	152.07 MB	https://download.oracle.com/java/17/archive/jdk-17.0.7_windows-x64_bin.msi (sha256)

Figure 5: JDK Download *Oracle JDK 17 Archive Downloads* (2023)

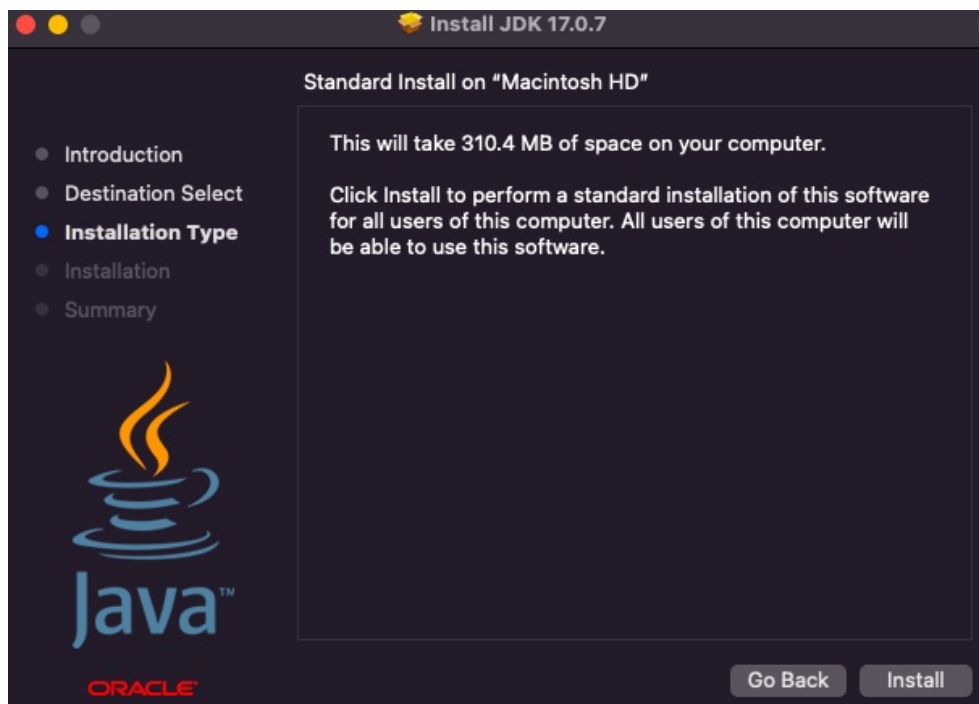


Figure 6: JDK Installation

4 Algorithm Implementation: Bacterial Colony Optimization (BCO)

4.1 Data Collection

For using load balancing algorithms in fog computing, the Cloud-Fog computing dataset available on Kaggle *Vehicular Fog Computing Dataset* (n.d.) is useful . It is publicly

available as shown in Figure 7 with its source paper Nguyen et al. (2019) having licenced under the Creative Commons Attribution 4.0 International (CC BY 4.0) protocol, which regulates its use and permits sharing and customization of datasets for any purpose with appropriate citation as shown in Figure 8. There are 13 nodes in the collection, 10 of which are called fog nodes and 3 cloud nodes. It has 7 files, each with a different task count ranging from 40 to 280 tasks, going up in increments of 40 tasks.

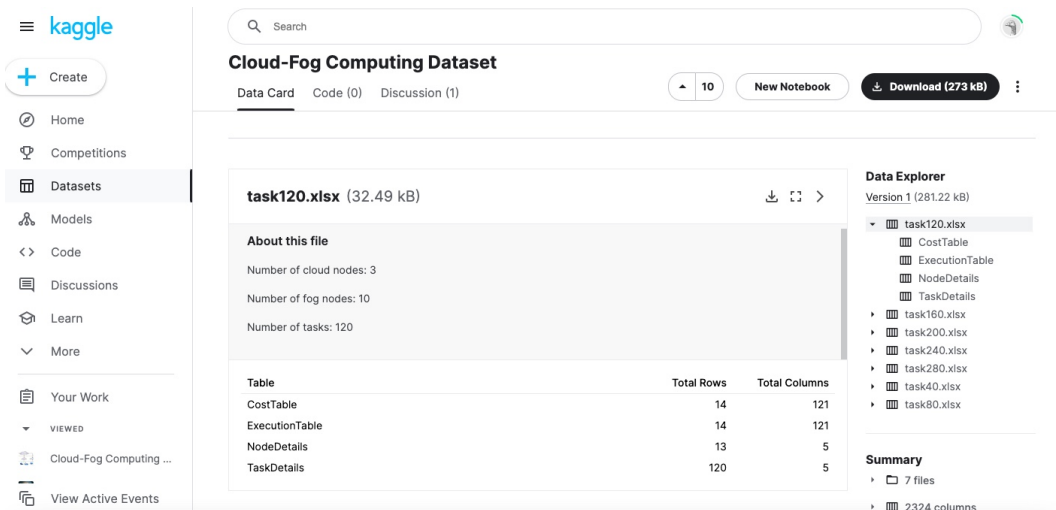


Figure 7: The Cloud-Fog computing dataset

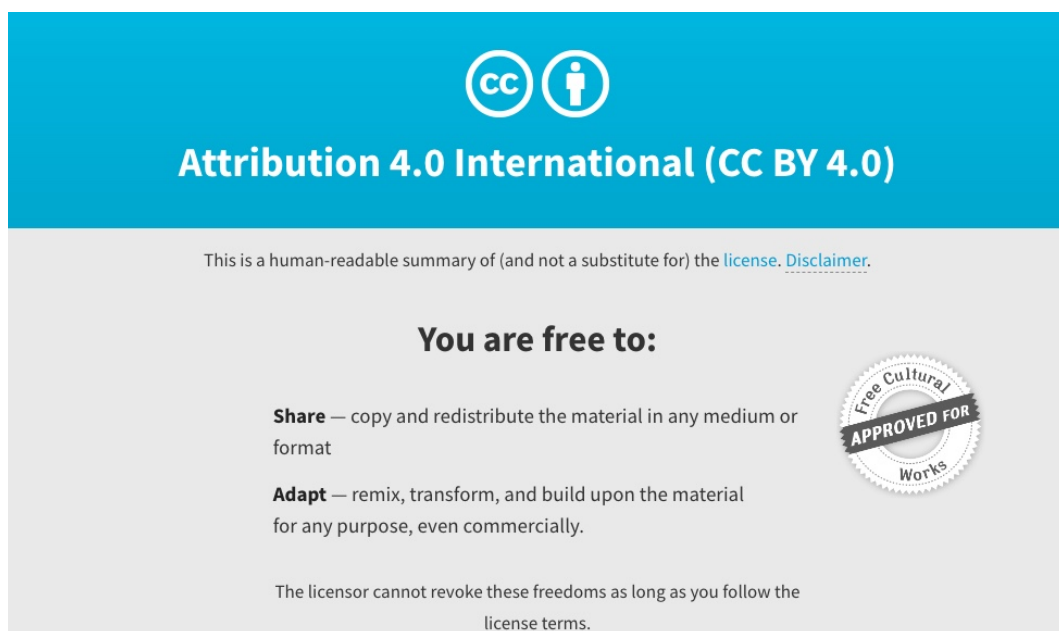


Figure 8: The Creative Commons Attribution 4.0 International (CC BY 4.0) license

4.2 BCO Algorithm Code Development and Implementation

- Create the file (LAlgorithm.java) and code the BCO algorithm logic for the fog computing setup as shown in Figure 9.

```

121
122 public static void BCOAlgorithm(List<FogDevice> fogDevices, List<? extends Cloudlet> c
123 // BCO Parameters
124 int bacteriaSize = 100;
125 int maxBCOIterations = 100;
126 double movementStepSize = 0.1;
127 double replicationRate = 0.1;
128 // Access numFogDevices directly from the fogDevices list
129 int numFogDevices = fogDevices.size() - 1;
130 int numCloudlets = cloudletList.size();
131
132 // Initialize the population of bacteria
133 List<String> population = initializePopulation(cloudletList.size(), numFogDevices,
134 // The rest of the method remains the same
135
136 // Create BCO object and set up parameters
137 Random rand = new Random();
138
139
140
141 double minTime = Double.MAX_VALUE;
142 double minCost = Double.MAX_VALUE;
143

```

Figure 9: The code development for BCO algorithm

- Create another file (FogLoadBalancing.java) for calling the BCO algorithm to implement it as shown in Figure 10. Please include the dataset file for nodes and tasks configuration.

```

65 application = createApplication(appId, broker.getId());
66 application.setUserid(broker.getId());
67
68 // Initiating the fog-cloud devices list
69 fogDevices = createFogDevices(broker.getId(), appId);
70 broker.setFogDevices(fogDevices);
71
72 // Initiating the tasks list
73 listCloudlet = createCloudlet(filename_cloudlet);
74 broker.setCloudletList(listCloudlet);
75
76 // Setting up the scheduling algorithm to run
77 broker.myAssignCloudlet(LBAlgorithm.BCO);
78
79 } catch (Exception e) {
80 e.printStackTrace();
81 Log.println("Unwanted errors happen");
82 }
83
84 // Creates the fog devices in the physical topology of the simulation.
85
86
87 private static List<FogDevice> createFogDevices(int userId, String appId) {

```

Figure 10: The code for load balancing algorithm implementation

- Update the file to include the other two load balancing algorithms for comparison with BCO algorithms. Here we are comparing the BCO algorithm with Round-Robin (RR) as shown in Figure 11 and Throttle Load Balancing (TLB) algorithm as shown in Figure 12.

```

421 // Add the energy consumption of the current fog device to the total e
422 totalEnergyConsumption += fogDeviceEnergyConsumption;
423 }
424 }
425 return totalEnergyConsumption;
426 }
427
428 // Round Robin Algorithm
429 public static void RoundRobinAlgorithm(List<FogDevice> fogDevices, List<?
430 int numFogDevices = fogDevices.size() - 1;
431 int numCloudlets = cloudletList.size();
432
433 // Create an array to store the assignment of each cloudlet to a fog d
434 int[] assignment = new int[numCloudlets];
435
436 // Round Robin assignment
437 int currentDeviceIndex = 0;
438 for (int i = 0; i < numCloudlets; i++) {
439 assignment[i] = currentDeviceIndex;
440 currentDeviceIndex = (currentDeviceIndex + 1) % numFogDevices;
441 }
442
443 // Calculate and print the makespan, cost, latency, and energy consum

```

Figure 11: The code for Round-Robin algorithm


```

542 // Add the energy consumption of the current fog device to the total energy consu
543 totalEnergyConsumption += fogDeviceEnergyConsumption;
544 }
545
546 return totalEnergyConsumption;
547 }
548
549
550 public static void ThrottleLoadBalancingAlgorithm(List<FogDevice> fogDevices, List<?
551 int numFogDevices = fogDevices.size() - 1;
552 int numCloudlets = cloudletList.size();
553
554 // Create an array to store the assignment of each cloudlet to a fog device
555 int[] assignment = new int[numCloudlets];
556
557 // Initialize the assignment with Round Robin assignment
558 int currentDeviceIndex = 0;
559 for (int i = 0; i < numCloudlets; i++) {
560 assignment[i] = currentDeviceIndex;
561 currentDeviceIndex = (currentDeviceIndex + 1) % numFogDevices;
562 }
563
564 // Perform Throttle Load Balancing iterations
565 for (int iteration = 0; iteration < THROTTLE_ITERATIONS; iteration++) {

```

Figure 12: The code for Throttle Load Balancing algorithm

- Run the simulation : Run the FogLoadBalancing.java file to implement the BCO, RR and TLB algorithms and obtain the simulation results according to the configurations setup. The output console gives the performance metrics value in terms of latency, energy consumption, makespan and cost as shown in Figure 13.

```

254 return list;
255 }
256
257
258 @SuppressWarnings({ })
259 private static Application createApplication(String appId, int userId) {
260
261 Application application = Application.createApplication(appId, userId);
262 return application;
263 }
264 }
265

```

```

<terminated> FogLoadBalancing [Java Application] [Users/shalinvaibhav/p2/pool/plugins/org.eclipse.justi.openjdk.hotspot.jre.full.macosx.x86_64_17.0.7.20230425-1502/jre/bin/java
> org.fog.application
> org.fog.application.selectivity
> org.fog.entities
> org.fog.gui.core
> org.fog.gui.dialog
> org.fog.gui.example
> org.fog.mobilitydata
> org.fog.placement
> org.fog.policy
> org.fog.scheduler
> org.fog.test
> org.fog.test.perfeval
> org.fog.utils
> org.fog.utils.distribution

```

```

Cloudlet 31 assigned to device: 8
Cloudlet 32 assigned to device: 7
Cloudlet 33 assigned to device: 7
Cloudlet 34 assigned to device: 1
Cloudlet 35 assigned to device: 7
Cloudlet 36 assigned to device: 4
Cloudlet 37 assigned to device: 5
Cloudlet 38 assigned to device: 5
Cloudlet 39 assigned to device: 2
Best Makespan: 93.0
Best Cost: 27.02
Best Latency: 92.0
Best Energy Consumption: 155500.0

```

Figure 13: Simulation Output

5 Presentation and Demo Video

Please refer this link for presentation and demo video.

References

Eclipse Foundation (2023). Eclipse downloads, <https://www.eclipse.org/downloads/>.

iFogSim GitHub Repository (2023). <https://github.com/Cloudslab/iFogSim/archive/refs/heads/main.zip>.

Nguyen, B. M., Thi Thanh Binh, H., The Anh, T. and Bao Son, D. (2019). Evolutionary algorithms to optimize task scheduling problem for the iot based bag-of-tasks applica-

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