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Designing of Edge Infrastructure for Establishing Signal Transmission in Palm Oil Field

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ABSTRACT

Edge computing is real-time processing that gathers, analyses, and transports data at the edge of the network using sensor technologies. It has become one of the IoT era's computing solutions because it improves signal transmission while preventing network problems like delay, congestion, or latency. It is advantageous for farm management to be able to monitor farm activities like cropping and fertilization in real-time, which helps increase palm oil production. However, the farm's remote location limits the amount of signal transmission available from its current Internet service providers, which prevents real-time processing. Hence, suitable edge infrastructure must be designed for establishing signal accessibility for data communication. It also required determining the optimal number of edge nodes to be allocated in the palm field due to different terrain and various tree sizes. The number of edge nodes will have an impact on cost utilization because it relates to setup costs and parameters. In response to data communication issues in the palm oil field, our work focuses on developing the edge computing infrastructure to maintain stable signal transmission for real-time processing. A network topology is designed to identify suitable parameters and settings that aligned with topography of the sample palm oil field. Furthermore, by having the right topology and signal frequency settings, the number of edge nodes required in the field can be determined. In our simulated design, the appropriate setting is to add a router with less than 4K million instructions per second (MIPS) compared to connecting through three mobile hot spots. Note that different palm oil fields will have different settings for their edge infrastructure. Optimistically, our study can provide guidance for promoting signal transmission in areas with limited network accessibility.

1. Introduction

Edge computing is a type of computing that operates at the edge of a network. It is commonly used for enhancing real-time processing for various demands. It operates by moving some of the data and resources to a site that is closer to the data source. The closer distance to the data source will also help the data transmission process be done in a short time without facing any network issues

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like delay, congestion, or latency. Besides that, the concept of edge computing can be applied in an area that has limited signal strength, such as a black-spot area. This area refers to areas that have weak network signals and small network coverage. It makes the area unable to have robust signals from available Internet providers. If there is connectivity to the existing Internet, it might have unstable and vague signals [1,2]. Thus, it is hard to achieve real-time processing for data communication. The black-spot area may exist due to two factors, which are interference and distance [2]. Interference occurs when network devices have a low frequency range compared to others, causing the network signal to be lost in that area. For the distance factor, a big delay occurred during the data transmission due to the remoteness of the area from the signal source. Therefore, the edge computing infrastructure solution comes into the picture to be applied in the black-spot area, i.e., the palm oil field, where some of the fields are remote and have weak Internet signals. By applying the edge computing concept, data from the edge nodes can be reached even without the Internet for real-time data processing. In addition, the optimal number of edge nodes can also be determined for better cost utilization [1,3-5]. The choice of edge nodes and setting up their parameters have an impact on strengthening signal data communication among the nodes for real-time processing. In this project, we investigated the edge nodes' performance by determining the type of node and aligning their frequency.

1.1 Related Work

An edge node is a device that has the ability to perceive, measure, understand, and connect to an Internet gateway for the Cloud computing. It often connected to the wide area network (WAN) and offered users a reasonable communication range and low-latency service. The authors, Tandon and Simeone (2016) [6], proposed the Cloud Radio Access Network (C-RAN) architecture and the Fog Radio Access Network (F-RAN) architecture. In their C-RAN architecture, the edge nodes are connected to the Cloud processor. This connection is called "forward-haul links" because they are designed to leverage other performances as well as enhance glitch management capabilities. For the F-RAN architecture, the number of edge nodes is identified based on the number of users that are available. The infrastructure of using different roles in their edge nodes is able to reduce delivery latency during data communication; however, their work focuses on the role of edges in data communication rather than real-time processing. Babou *et al.,* [7] proposed the Home Edge Computing (HEC) architecture, which consists of three levels: home server, edge server, and Cloud central (Figure 1). All these levels have their own roles in this architecture. The home server serves as a gateway for equipment outside the local network because it will be installed and managed by the Internet service provider. At the same time, this level also handles customer requests when they are located inside the box. If the request cannot be handled, the system will transfer it to Edge Server or Cloud Central for continued processing. Their edge infrastructure provided an effective solution for handing off the data between nodes, but their work does not tackle the black-spot areas.

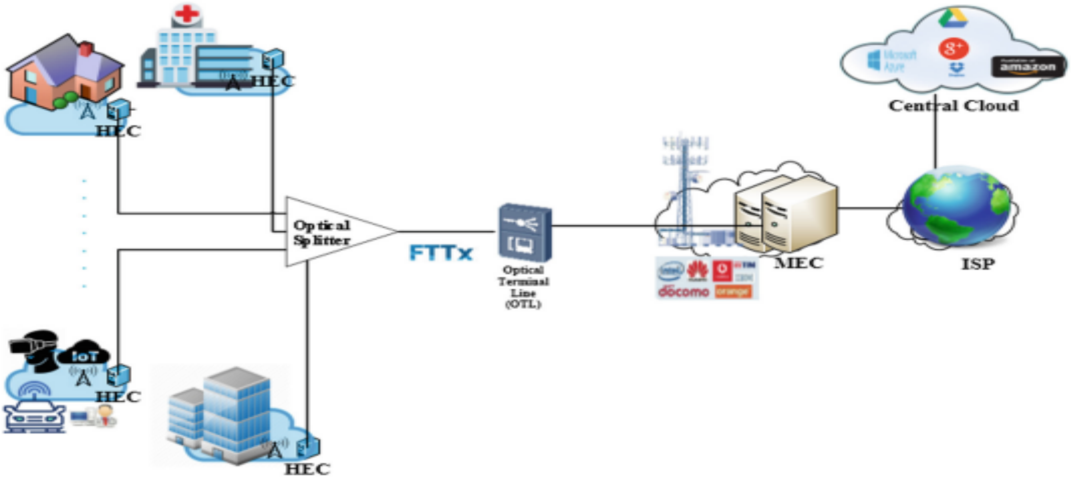

Fig. 1. Home edge computing architecture [7]

The fog computing infrastructure design using the iFogSim simulator was proposed by Hassan *et al.,* [8]. The system's design was produced for remote pain monitoring. Edge nodes come in a variety of forms, including sensor nodes, fog nodes, web servers, proxy servers, and clouds. To establish a stronger link between them, the Rotronic Monitoring System (RMS) is installed in the sensor nodes to record the biopotential signals from the patients. Between fog nodes and the Cloud, there is a proxy server that serves as a gateway. Their design using iFogSim (Figure 2) can improve the security of patient data during transmission. Meanwhile, the authors, Patel and Mohammed (2020) [9], discussed the implementation of the Transportation Management System (TMS) using the iFogSim simulator. Their design consists of various levels. Level 1 includes the Cloud, whereas mobile devices that are connected are included in Level 2. Level 3 then consists of sensors and actuators that are connected via mobile devices. Mobile devices are the targeted nodes because they are connected to the Cloud computing. When sensors and actuators are connected to mobile devices, they are considered the start nodes. In addition, the GPS sensor is used to find the object's location, and the simulation then shows how the transportation process proceeds from source to destination. The TMS design is shown in Figure 3. The simulated edge infrastructure has inspired us to redesign and implement it in a palm oil field with the appropriate settings, even though their work does not concentrate on the black-spot areas.

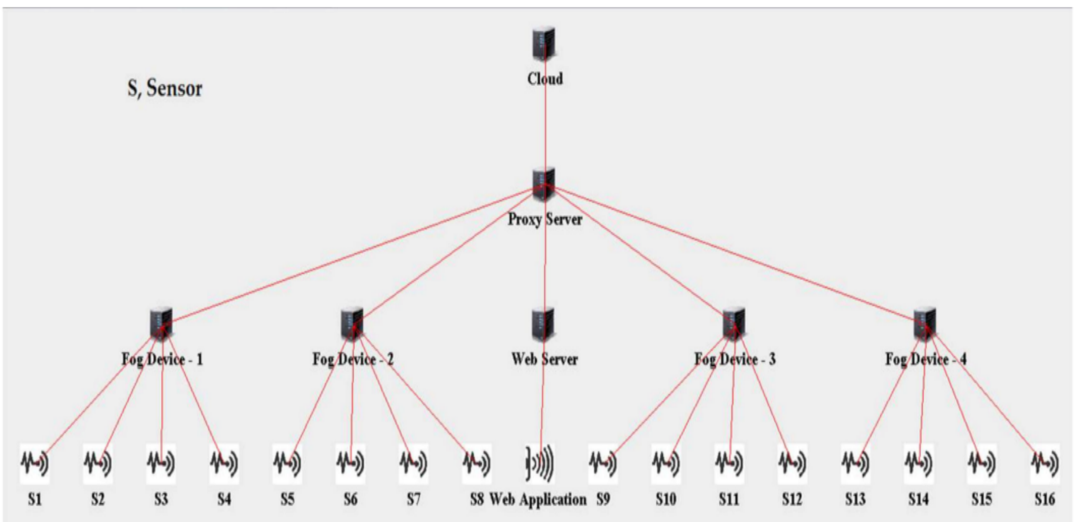

Fig. 2. Remote pain monitoring system [8]

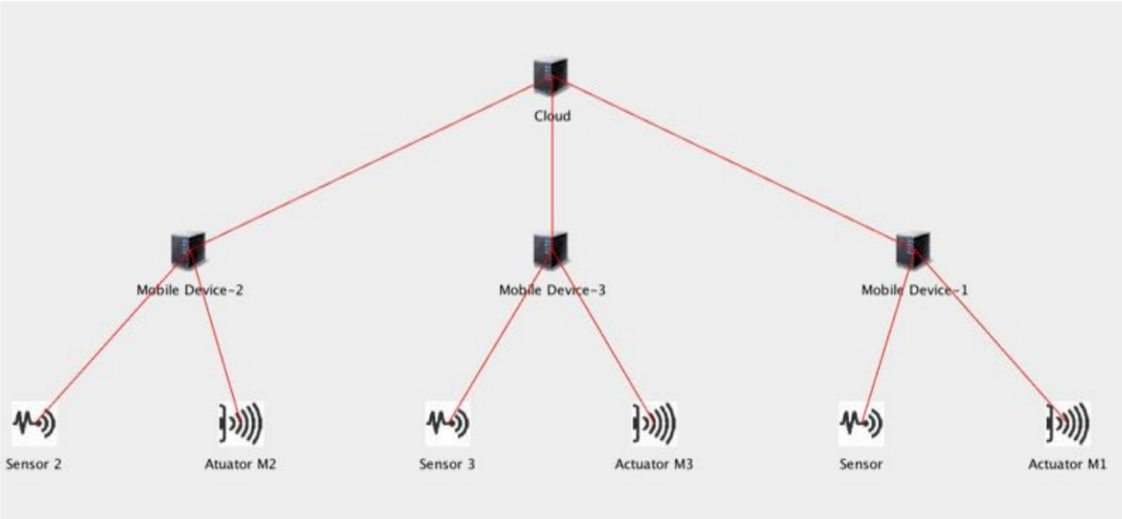

Fig. 3. Design of TMS [9]

The black-spot area is an area where the signal is weak and hard to detect. Simultaneously, there are several locations that have black-spot areas, such as forests, hill stations, islands, and the sea [1,2]. All of those places also have big problems with network issues, which can cause difficulty during data transmission and hinder real-time processing. Therefore, to overcome this problem, LoRa technology is proposed by Kanakaraja *et al.,* (2021) [10]. LoRa is an abbreviation for "long range," which means it has a large communication range with low power consumption. This technology has the ability to create signals and send messages in black-spot areas and remote areas. With this advantage too, it can help the process of data transmission complete its work without facing any network issues. LoRa can be used in edge computing for real-time processing [11,12]. But the choice of cellular communication technology used, such as LoRa and LTE, is not considered in this work. It is because edge computing is fabricated with cellular technology.

The advancement of data communication technology should benefit various domains, including agriculture and remote palm oil fields. The issue of weak signal transmission should be addressed at the design phase before any configuration takes place in the field for effective cost management. In our work, we focus on edge computing infrastructure design by utilising the simulation tool, iFogSim [13-15] to analyse the number and features of edge nodes before they are planted in the field. In the long run, the implementation of edge infrastructure in the palm oil fields (a "black-spot area") means to ensure the existence of signal transmission for real-time data communication.

2. Methodology

2.1 Simulation Tool

We are investigating the design requirements, reasonable assumptions, and expected performance using a simulator. The simulation design provides valuable data and feedback. We can test each created design to gain more experience and understanding before building the real design in the chosen area. The experimentation-based method is compatible with real-world situations. The iFogSim [13-14] is chosen as the simulator for this project. It is an open-source simulator that works in edge environments. It is also able to work in a variety of edge scenarios to create edge node designs. There are a few specifications that were given in setting that up, like bandwidth, latency, Million Instructions Per Second (MIPS) and Random-Access Memory (RAM). The simulator is used to configure edge infrastructures for initial and upgraded designs with the proper setup features. As mentioned by Awaisi *et al.,* [15], this simulator is the most widely used compared to other simulators because of its ability to create different design solutions. We also performed a comparison of the iFogSim with other edge simulators in regard to their platform and programming language, as given in Table 1.

Table 1
Comparison of edge simulator

Edge simulator	Base platform	Programming language
iFogSim	CloudSim	Java
EdgeCloudSim	CloudSim	Java
FogNetSim++	OMNeT++	C++
FogExplorer	Not Applicable (N/A)	JavaScript
YAFS	Simpy	Python

2.2 Project Activities

This section describes the approaches and techniques used to complete the project. There are several steps involved are planning, designing, developing, and testing. The foundation steps are given in Figure 4.

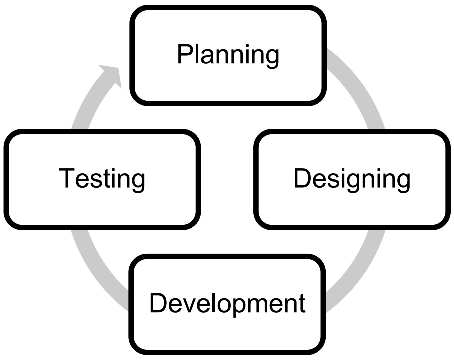

Fig. 4. Agile methodology

2.2.1 Planning phase

This phase required reviewing research papers that are related to our work to get some information. That information can then be used to identify the problem statement and project scope. At the same time, we plan project schedules to meet deadlines with respective outcomes.

2.2.2 Designing phase

We underestimate the edge computing infrastructure that is suitable for the black-spot area. This way is differentiated into two main areas are i) the area with a strong data transmission signal, and ii) the area with no or a weak data transmission signal. All related assumptions and edge computing settings are the main components of this phase. It ensures the design simulates the real setup of edge computing. Our edge infrastructure design scope is initially based on an initial design with areas that can and cannot be connected to the Internet.

2.2.2.1 Initial design

Figure 5 shows the initial design. This design is created as a preliminary test to demonstrate the problem as it relates to the real world. In that too, there are two routers that connect to the Cloud computing, which are router A (r-A) and router B (r-B), and one router that does not connect to the Cloud, which is router C (r-C). For routers A (r-A) and B (r-B), we assumed that they had established data transmission signals to reach the Cloud service. For router C (r-C), we assumed that it resides in a low-signal area, also known as a "black spot area." In this area, it might have a signal, but it is very weak and almost not stable.

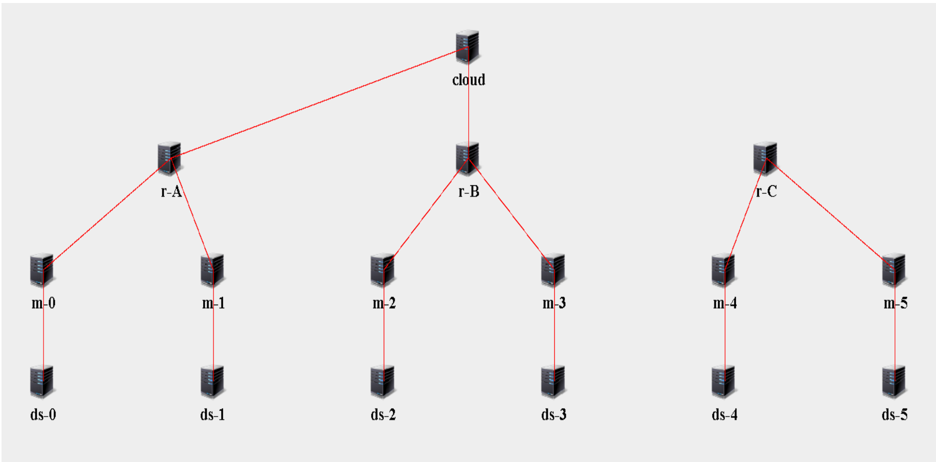

Fig. 5. Initial design

Table 2 shows the properties of links between nodes for the initial design. In the design, the nodes can be categorized as sender nodes and receiver nodes. For network latency, it is typically measured in terms of how far devices or nodes are from servers when making and responding to requests [14]. The data storage nodes 0-5 (ds0–ds5) are considered to have 0 latency as they are integrated within the mobile node, m. For mobile nodes 0 to 5 (m-0 to m-5), we set the latency to 70 ms, which can be categorized as average latency because they become intermediators (repeaters) to another node. For the routers, r-A and r-B, we set their latency to 19 ms because they have a strong signal to Cloud and might have the lowest communication latency. The latency value of 19 ms is considered low and indicates a better connection during data transmission, as also given by the authors, Romano, G. in [16]. Table 3 shows the specifications of each edge node that are set in iFogSim for the initial design. The parameters that we used to set the edge nodes are uplink bandwidth, downlink bandwidth, MIPS, RAM, and RatePerMIPS.

Table 2
Link properties between nodes (Initial design)

Nodes (Send)	Nodes (Receive)	Latency (ms)
ds-0	m-0	0
ds-1	m-1	
ds-2	m-2	
ds-3	m-3	
ds-4	m-4	
ds-5	m-5	
m-0	r-A	70
m-1	r-A	
m-2	r-B	
m-3	r-B	
m-4	r-C	
m-5	r-C	
r-A	Cloud	19
r-B	Cloud	

Table 3
Nodes specifications (Initial design)

Nodes	Bandwidth (MHz)		MIPS	RAM (MB)	RatePerMIPS
	Uplink	Downlink			
ds-0	0	0	1000	0	100
ds-1					
ds-2					
ds-3					
ds-4					
ds-5					
m-0	20	10	1500	4000	300
m-1					
m-2					
m-3					
m-4					
m-5					
r-A			3500	512	500
r-B					
r-C					
Cloud			12000	8000	1000

2.2.2.2 A black-spot area design

Figure 6 depicts a portion of the initial design's black-spot area. There is only one Cloud server, one router (r-C), two 4G mobile phones (m-4 and m-5), and two data sensors (ds-4 and ds-5) in there. At the same time, due to a lack of signal in that area, all of them connected to each other and accessed the Cloud service except router r-C, which does not have or is limited to accessing Cloud service. Each of them is given different specifications based on their own abilities.

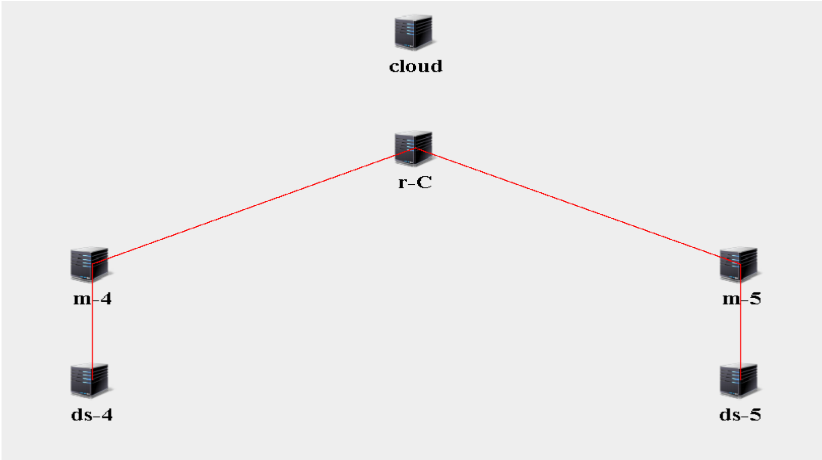

Fig. 6. A black-spot area in initial design

2.2.3 Development Phase

In this phase, we perform the parameter setting for every node by utilizing the simulator, iFogSim. Figure 7 shows the sample output of development when the nodes' parameters are set in the simulator. This output is merely shown when the nodes have an interconnection with each other. It meant that if the node was able to connect to its edge, then the simulator would display details about the connecting nodes. In checking process, the detail information should also be the same as it was setup earlier. Note that every node will produce this output when the interconnection is successful. Otherwise, there is no output displayed. However, we do not provide every output figure in this paper.


```
{"nodes":[{"level":1,"upBw":20,"ratePerMips":500.0,"name":"r-A","type":"FOG_DEVICE","mips":3500,"ram":512,"downBw":10},
{"level":2,"upBw":20,"ratePerMips":500.0,"name":"r-C","type":"FOG_DEVICE","mips":3500,"ram":512,"downBw":10},
{"level":1,"upBw":20,"ratePerMips":500.0,"name":"r-B","type":"FOG_DEVICE","mips":3500,"ram":512,"downBw":10},
{"level":1,"upBw":20,"ratePerMips":550.0,"name":"r-D","type":"FOG_DEVICE","mips":3600,"ram":512,"downBw":10},
{"level":2,"upBw":20,"ratePerMips":300.0,"name":"m-0","type":"FOG_DEVICE","mips":1500,"ram":4000,"downBw":10},
{"level":2,"upBw":20,"ratePerMips":300.0,"name":"m-2","type":"FOG_DEVICE","mips":1500,"ram":4000,"downBw":10},
{"level":0,"upBw":20,"ratePerMips":1000.0,"name":"cloud","type":"FOG_DEVICE","mips":12000,"ram":8000,"downBw":10},
{"level":2,"upBw":20,"ratePerMips":300.0,"name":"m-1","type":"FOG_DEVICE","mips":1500,"ram":4000,"downBw":10},
{"level":3,"upBw":20,"ratePerMips":300.0,"name":"m-4","type":"FOG_DEVICE","mips":1500,"ram":4000,"downBw":10},
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{"level":3,"upBw":0,"ratePerMips":100.0,"name":"ds-0","type":"FOG_DEVICE","mips":1000,"ram":0,"downBw":0}],"links":
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{"latency":0.0,"destination":"m-3","source":"ds-3"},{"latency":0.0,"destination":"m-2","source":"ds-2"},
{"latency":0.0,"destination":"m-1","source":"ds-1"},{"latency":0.0,"destination":"m-0","source":"ds-0"}]}
```


Fig. 7. Output of development

2.2.3.1 Cloud server

Figure 8 shows a Cloud server node. The specification of a Cloud server in the simulator is according to Google Cloud Service (i.e., parameters and values). Such a service setting is chosen due to the regional palm oil office applying the Google service to the Internet. At the same time, we make excellent use of the current service if a palm oil field can receive the signal. We only took into account the field that was designated as a black-spot area for simulation purposes. Next, the Cloud server node will be located at Level 0 (the top rank in hierarchy), with 20 MHz of uplink bandwidth and 10 MHz of downlink bandwidth. The reason the value of uplink bandwidth is greater than downlink bandwidth is because uplink has a higher frequency than downlink. Aside from that, we set MIPS to 12000 based on the number of instructions that this node accumulated from the bottom level to the top level, which is level 0. Next, the standard memory for Cloud servers is setup between 8 GB and 64 GB that recommended by Romano, G. [16]. Hence, for our design, we decided to use 8 GB of RAM, which can be upgraded based on how much data we want to store. RatePerMIPS, also known as the cost rate per MIPS used, will be set based on the value of MIPS that is obtained during the data transmission.

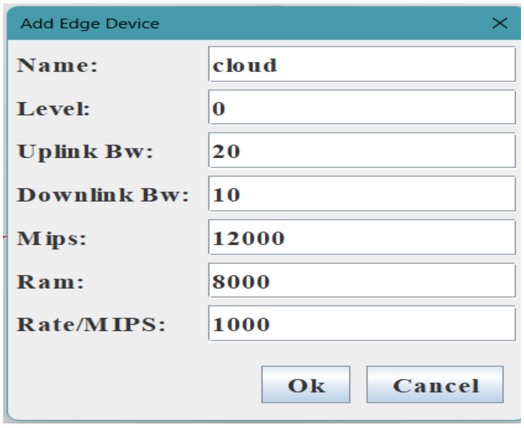

Fig. 8. Specification of a cloud server

2.2.3.2 Router (r-C)

Figure 9 shows a router (r-C) node. It is located at Level 1 (beneath the Cloud server), and we set its uplink bandwidth to 20 MHz in the 2.4 GHz frequency range. We chose 20 MHz as the uplink channel bandwidth because there are a lot of non-overlapping channels there. A large number of non-overlapping channels will ensure the effectiveness of Internet speed and make any network problems during data transmission difficult [17]. For downlink bandwidth, we set it to 10 MHz because its frequency is lower than the uplink frequency. Next, we set MIPS to 3500 based on the number of instructions accumulated by this node from the m4 and m5. For RAM, we set it to 512 MB based on its availability in the market, which also supports 20 MHz and 10 MHz as the bandwidth. For RatePerMIPS, we set it to 500 based on the value of MIPS that was obtained during the data transmission.

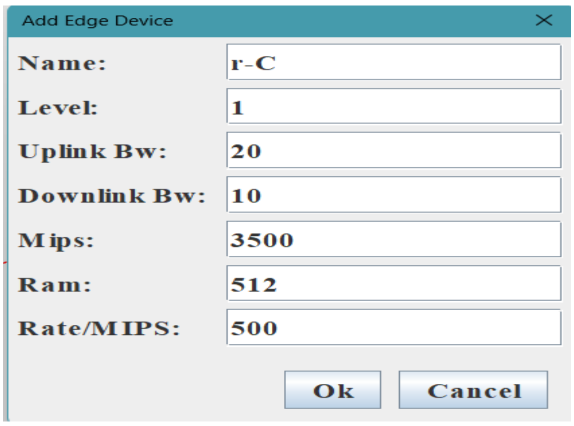

Fig. 9. Specification of a router

2.2.3.3 4G mobile phones (m-4 and m-5)

Figure 10 shows the 4G mobile phones that we used as nodes, which are represented by m-4 and m-5. Both of them are also located at Level 2 (beneath the routers). We choose 4G mobile phones for mobile nodes is because they can support a 20 MHz channel for uplink bandwidth [18]. We also set the downlink bandwidth to 10 MHz. Therefore, with the same bandwidth as the router, it can provide the same frequency connection. At the same time, bandwidth is also directly proportional to the frequency of the signal [19]. With that relationship, it is possible to secure a connection to the Cloud computing. For MIPS, we set it up to 1500 based on the instructions that these nodes get from each of their sensors. Following that, we set the RAM for these nodes to 4 GB because it is less expensive than larger RAM. Lastly, for RatePerMIPS, we set it to 300 to ensure a better rate of cost for MIPS used.

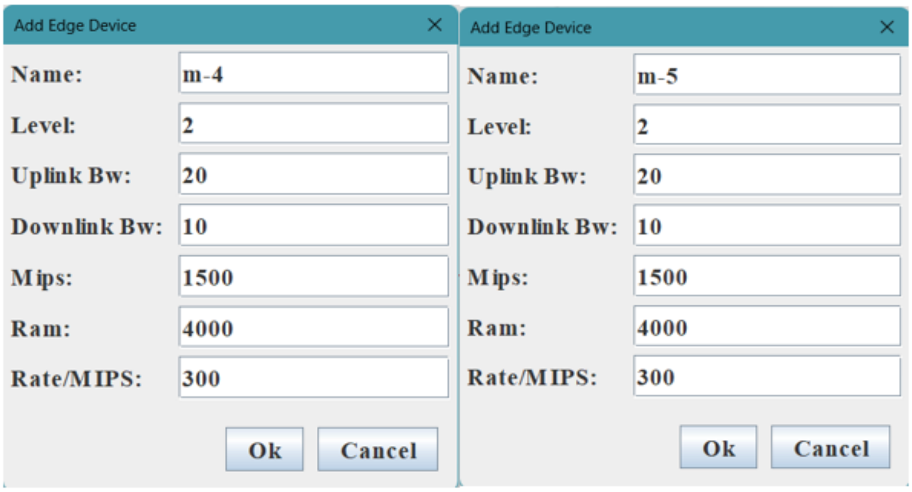

Fig. 10. Specification of the 4G mobile phones

2.2.3.4 Data sensors (ds-4 and ds-5)

Figure 11 shows the data sensors, which are represented by ds-4 and ds-5. Both are also located at Level 3 (after the mobile node hierarchy). At the same time, these nodes also don't have uplink bandwidth, downlink bandwidth, or RAM because they are in each 4G mobile phone. In addition, we also assume that these nodes serve as position sensors that collect data about the location of the device. An example of this sensor is a Global Positioning System (GPS).

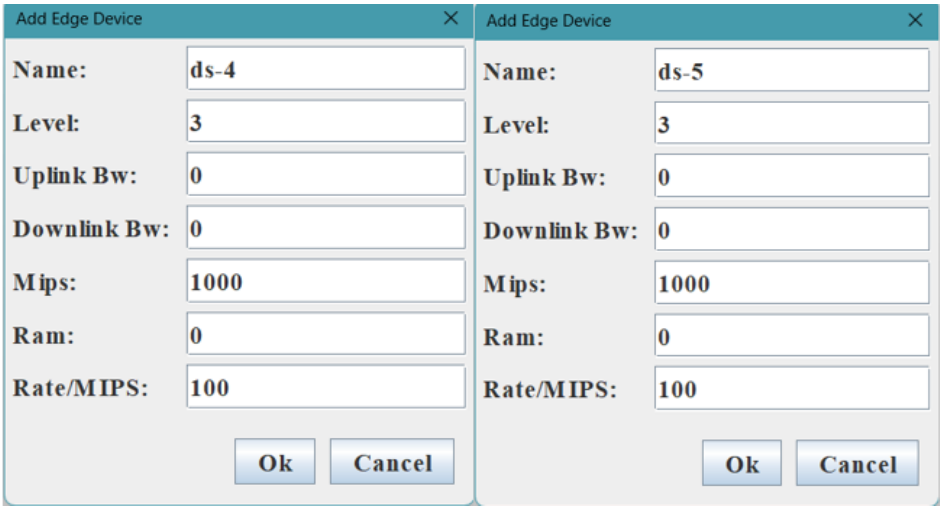

Fig. 11. Specification of the data sensors

2.2.4 Testing Phase

The testing phase aims to check the connection between each node and ensure it can function properly. Some technical issues that were determined, for example, wrong connectivity between identical nodes and imbalance value setting, will be fixed in this phase.

3. Results

In order to improve the signal in a black-spot area, we put the initial design into practice by putting forward two design solutions. Later, a more thorough explanation of the solutions' justifications and results will be provided. At the same time, our edge computing infrastructure design is able to figure out how many edge nodes are needed to strengthen the communication signal in a black-spot area.

3.1 Topology Design: Solution 1

Figure 12 depicts the layout of Solution 1. This design has one additional router, denoted by router D (r-D). We only add one router because placing additional routers in a black-spot area won't always result in signal improvement. Instead, it may cause signal interference, which would slow down the network's speed and reduce its coverage. Therefore, we made the decision to only add one router. Apart from that, it could expand network coverage and aid in the management of network congestion, which would indirectly enhance the signal in a black-spot area. By enabling router C (r-C) to connect to the Cloud, it can also secure the connection.

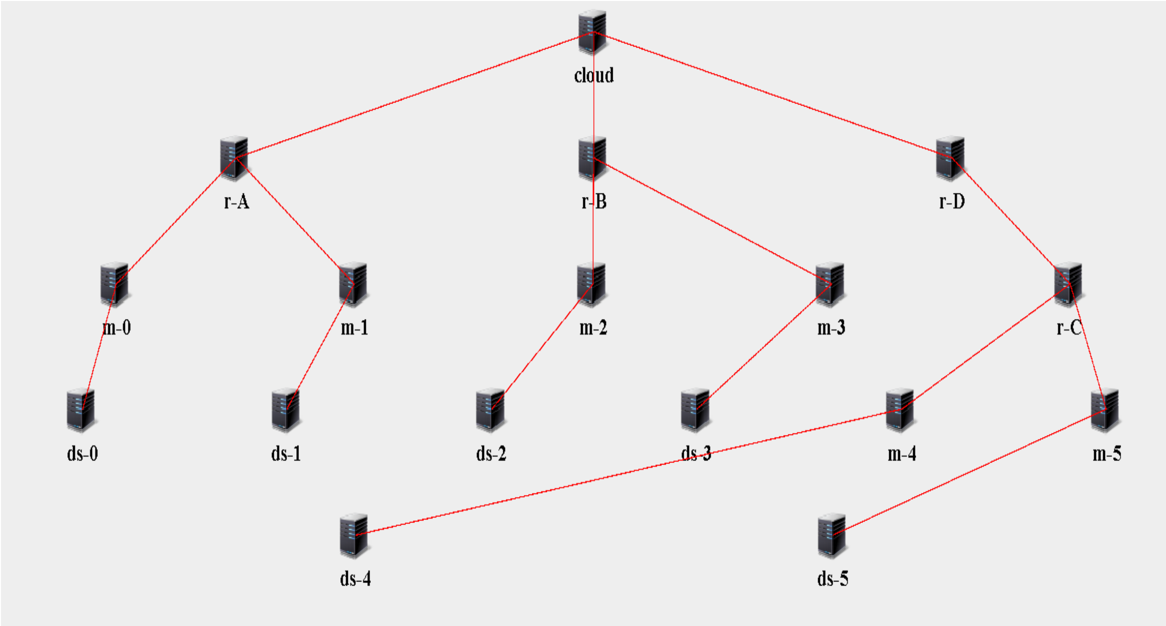

Fig. 12. Design for solution 1

The links between the nodes in the Solution 1 design, which includes all edge nodes classified as sender and receiver nodes, are shown in Table 4. Due to their close proximity to the Cloud server, routers r-A, r-B, and r-D have a network latency setting of 19 ms. Even though it is a little farther away from the Cloud server than the routers, r-C still has a latency of 45 ms, which is still within the low latency range. The initial design of the network latency for m-0 to m-5 and ds-0 to ds-5 remains unchanged. It was previously discussed in the previous section. The specifications for each edge node that were established in the Solution 1 are listed in Table 5. The parameters that we used to set the edge nodes are uplink bandwidth, downlink bandwidth, MIPS, RAM and RatePerMIPS.

Table 4
Link properties between nodes (Solution 1)

Nodes (rend)	Nodes (receive)	Latency (ms)
ds-4	m-4	0
ds-5	m-5	
ds-0	m-0	
ds-1	m-1	
ds-2	m-2	
ds-3	m-3	
m-4	r-C	70
m-5	r-C	
m-0	r-A	
m-1	r-A	
m-2	r-B	
m-3	r-B	
r-C	r-D	45
r-A	Cloud	19
r-B	Cloud	
r-D	Cloud	

Table 5
Nodes specifications (Design 1)

Nodes	Bandwidth (MHz)		MIPS	RAM (MB)	RatePerMIPS
	Uplink	Downlink			
ds-4	0	0	1000	0	100
ds-5					
ds-0					
ds-1					
ds-2					
ds-3					
m-4	20	10	1500	4000	300
m-5					
m-0					
m-1					
m-2					
m-3					
r-C			3500	512	500
r-A					
r-B					
r-D			3600		550
Cloud			12000	8000	1000

3.1.1. Close-up to the black-spot area setup

Figure 13 displays a part of the black-spot area in Solution 1, which contains one Cloud server, two routers (r-D and r-C), two 4G mobile phones (m-4 and m-5), and two data sensors (ds-4 and ds-5) that are interconnected for data transmission. Each of these components will be configured with varying specifications to improve the signal strength in the black-spot area. Figure 14 displays the router node (r-D) located at Level 1, with an uplink bandwidth set to 20 MHz in the 2.4 GHz frequency range. This uplink channel bandwidth was selected due to the availability of numerous non-overlapping channels. The downlink bandwidth is set at 10 MHz, as its frequency is lower than the uplink frequency. The MIPS value is set to 3600, based on the number of instructions processed by the node from r-C and the RAM is set to 512 MB, considering its availability in the market that supports 20 MHz and 10 MHz bandwidth. The RatePerMIPS is set to 550, based on the MIPS value obtained during data transmission. Aside from that, there are slight modifications from the initial design for some edge nodes, including the relocation of r-C to level 2, m-4 to m-5 to level 3, and ds-4 to ds-5 to level 4, due to the addition of an extra router. Other specifications remain unchanged from the initial design, which already discussed in Section 2.2.2.

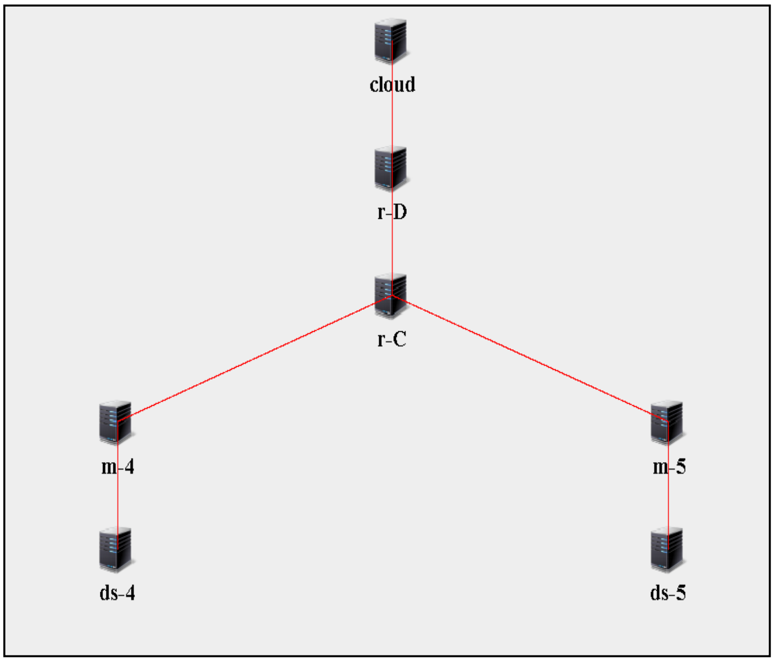

Fig. 13. Improvement of the black-spot area setup for Solution 1

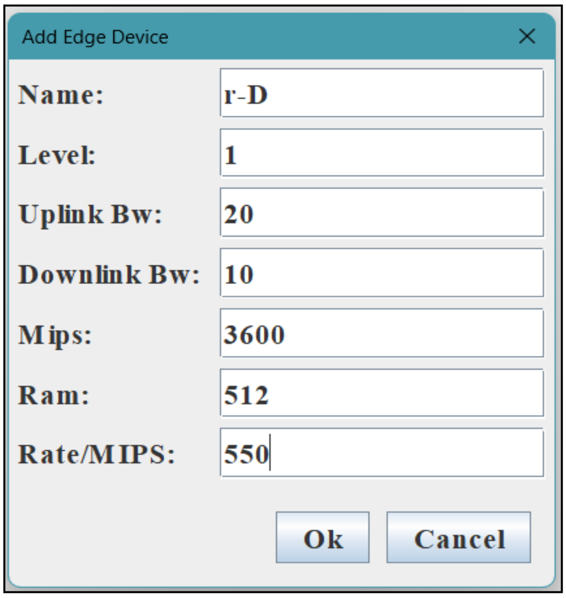

Fig. 14. Specification of the router, r-D

3.2 Topology Design: Solution 2

The design for Solution 2 is shown in Figure 15 and does not involve a router. Instead, three new 5G mobile phones (represented as m-6, m-7, and m-8) are used and connected via a hotspot connection. The use of three mobile phones was chosen over two or one due to research that indicated that having three mobile phones increases network coverage and can provide enough secure connections to the Cloud [20-21]. Next, the choice to use 5G mobile phones over 4G was made due to their ability to reduce network congestion and lower latency rates [19,22]. Additionally, mobile phones m-4 and m-5 are also connected to the three 5G mobile phones. The use of hotspot connections to connect all the devices was claimed to extend network connectivity and increase network coverage between mobile phones [23]. This, in turn, can improve the signal in black-spot areas and provide a secure connection to the Cloud. The network coverage will also be maintained when allowing Wi-Fi and hotspots to work together on each mobile phone (m-4, m-5, m-6, m-7, and m-8).

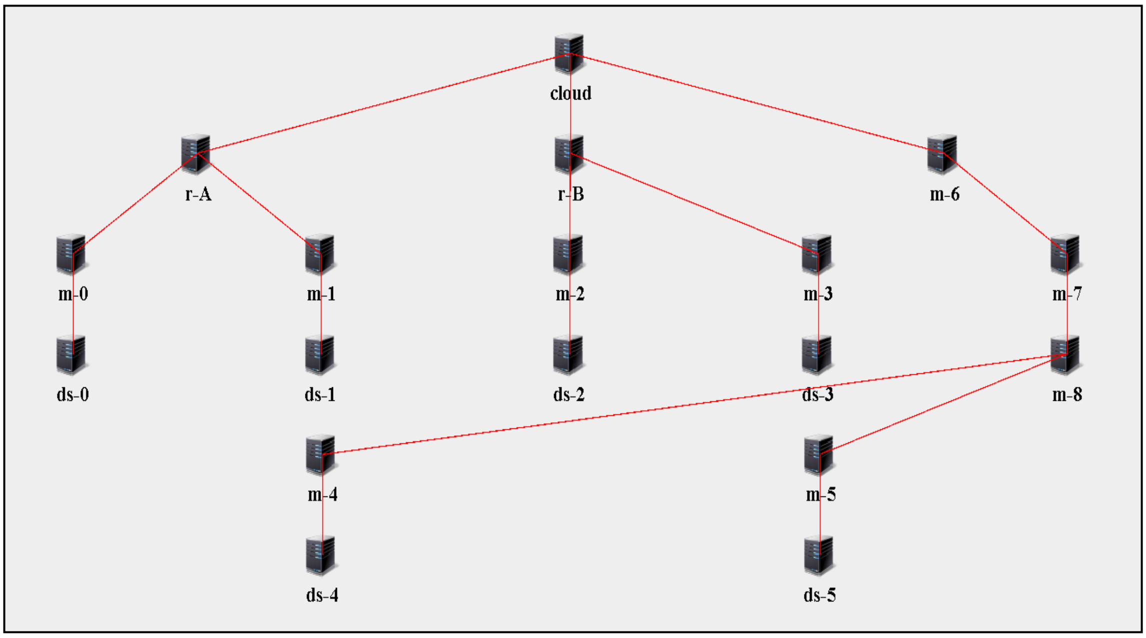

Fig. 15. Design for Solution 2

Table 6 shows the table of links between nodes. Those links existed because the Solution 2 design included all the edge nodes. These nodes can also be categorized as sender nodes and receiver nodes. Next, for network latency, we set it to 19 ms for r-A, r-B and m-6. It is because they are located on the same level, which is level 1 and have a close distance to the Cloud server. For m-7 and m-8, we set their latency to 30 ms and 45 ms, which can still be categorized as a low latency value. The range of low latency also below 50 ms. The network latency for m-0 to m-5 and ds-0 to ds-5 is also the same as with the initial design. Table 7 shows the specifications of each edge node in the iFogSim that were set in the Solution 2.

Table 6
Link properties between nodes (Solution 2)

Nodes (Send)	Nodes (Receive)	Latency (ms)
ds-4	m-4	0
ds-5	m-5	
ds-0	m-0	
ds-1	m-1	
ds-2	m-2	
ds-3	m-3	
m-4	m-8	70
m-5	m-8	
m-0	r-A	
m-1	r-A	
m-2	r-B	
m-3	r-B	
m-8	m-7	45
m-7	m-6	30
m-6	Cloud	19
r-A	Cloud	
r-B	Cloud	

Table 7
Nodes specifications (Design 2)

Nodes	Bandwidth (MHz)		MIPS	RAM (MB)	RatePerMIPS
	Uplink	Downlink			
ds-4	0	0	1000	0	100
ds-5					
m-4	20	10	1500	4000	300
m-5					
ds-0			1000	0	
ds-1	0	0			100
ds-2					
ds-3					
m-8	20	10	3500	4000	500
m-7			3600		550
m-0			1500		300
m-1					
m-2					
m-3					
m-6			3700		600
r-A			3500	512	500
r-B					
Cloud			12000	8000	1000

3.2.1 Close-up to a black-spot area setup

Figure 16 illustrates the black-spot area in Solution 2. This area includes one Cloud server, three 5G mobile phones (m-6, m-7, and m-8), two 4G mobile phones (m-4 and m-5), and two data sensors (ds-4 and ds-5). These components are connected to each other to facilitate data transmission. The specifications of each component will be set differently, based on their capability to enhance the signal in the black-spot area.

Figure 17 displays the 5G mobile phones used as nodes to enhance the signal in a black-spot area. These 5G mobile phones are represented by m-6, m-7, and m-8, which are located on different levels, with m-6 on level 1, m-7 on level 2, and m-8 on level 3. The 5G mobile phones have the potential to increase their bandwidth to 100 MHz [19], but we limited their uplink and downlink bandwidths to 20 MHz and 10 MHz, respectively, to match the bandwidth of the 4G mobile phones (m-4 and m-5) and ensure a secure connection to the Cloud. The RAM for all of these phones was set to 4 GB because it was a cost-effective option. The MIPS and RatePerMIPS for each phone were set differently, with the MIPS value for the m-6 being 3700 and its RatePerMIPS being 600, the MIPS value for the m-7 being 3600 and its RatePerMIPS being 550, and the MIPS value for the m-8 being 3500 and its RatePerMIPS being 500. This allows for seamless data transmission without any network problems. Some changes have been made due to the inclusion of three additional 5G mobile phones, resulting in the location of m-4 to m-5 in level 4 and ds-4 to ds-5 in level 5.

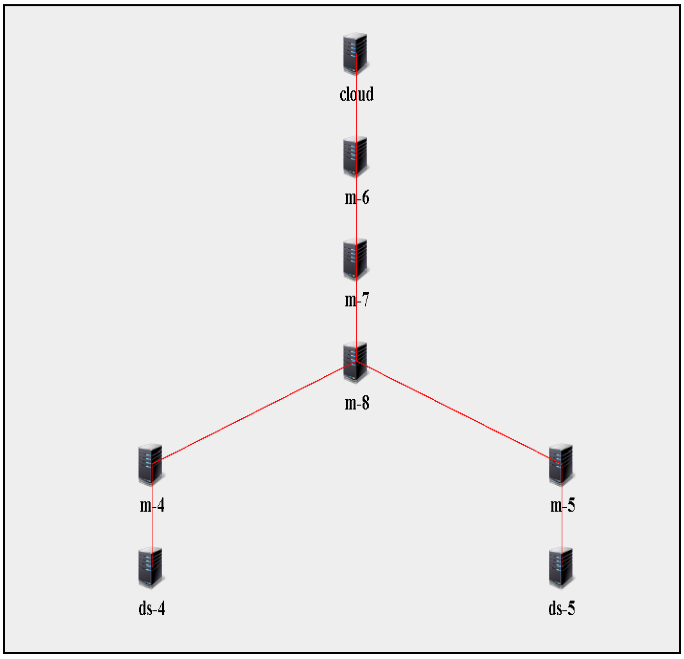

Fig. 16. Improvement of the black-spot area setup for Solution 2

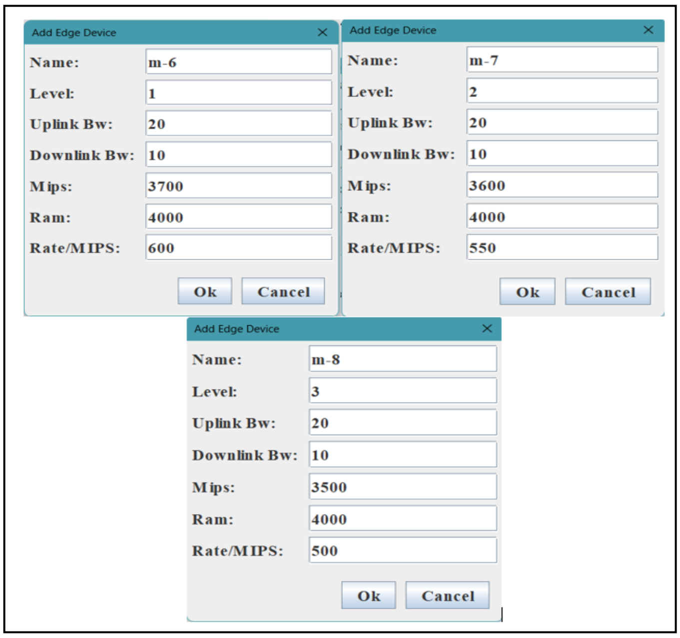

Fig. 17. Specification of the 5G mobile phones *(m-6, m-7, m-8)*

4. Conclusions

Edge computing is a computing concept that brings computing resources closer to the data source and can be applied in areas with weak network signals, like blackspot areas. By improving the network infrastructure, it can switch from black-spot areas to hot-spot areas for signal transmission. The use of an edge simulator, iFogSim, can help analyse design solutions for edge computing infrastructure before it is planted in the palm oil fields. Proper parameter setting is important to ensure connectivity among devices and strengthen the data transmission signal. In our work, we propose two topology designs for edge infrastructure, each utilising a different type of edge node. These topology designs are designed by considering the layout and imbalanced terrain in the palm oil fields. In Solution 1, we brought a router to make the signal exist, and in Solution 2, we employed mobile phones as access points for accessing the Cloud computing and channelling Internet accessibility. Solution 1 is a much preferable design compared to Solution 2 because it merely uses fewer edge devices for successful accessibility, which is expected to lead to better cost management. The edge infrastructure can be configured differently across different palm oil fields. In spite of this, our research aims to offer guidance and support for planning the installation of signal transmission in locations with limited network accessibility.

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