
Analysis of BTS Selection for Implementation of Multi Operator Core Network (MOCN): Merger Case Study PT Indosat Ooredoo Tbk With PT Hutchison 3 Indonesia

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Abstract— Multi Operator Core Network (MOCN) is a project that aims to create a network system core for several telecommunication operators in one system, first implemented in Indonesia by Indosat Ooredoo and Hutchison 3. Before the merger Indosat Ooredoo has 29,503 physical BTS and Hutchison 3 Indonesia has 32,489 physical BTS, a total of 61,992 physical BTS that must be maintained and monitored but they are not yet integrated with each other. This makes the focus on customer service larger and unintegrated. With MOCN, BTS networks will be able to be integrated and focus on customer service can be maximized. Indonesia currently uses a tower collocation scheme, where in 1 tower there can be more than 1 operator. Similarly, at Indosat Ooredoo and H3I, there are 22,389 BTS units physically located on the same tower, commonly referred to as 'pair collo'. A decision is needed to determine whether Node B should be activated for MOCN or deactivated during the network consolidation process. Technical analysis by considering BTS capacity, coverage, antenna position, and transmission mode to determine which BTS provides greater benefits to IOH after the network merger. With the network merger, it is hoped that there will be efficiency in network maintenance of 27.6%, as well as maintenance cost efficiency which will be reduced. This research aims to provide strategic and operational solutions for managing the infrastructure, especially related to the selection of operational sites and network optimization. Literature study, case study, and comparative analysis is used in this research. Solution applied includes reconciliation and monitoring post-MOCN performance and ensuring quality the network remains maintained, while maximizing tower rental efficiency.

Keywords – MOCN, Tower Share, Customer Experience, Pair Collo, Network Efficiency.

I. INTRODUCTION

In recent years, Telecommunication industry in Indonesia has undergone a significant transformation, marked by the merger between PT. Indosat Tbk. and PT. Hutchison 3. The merger of these two large companies was carried out as a strategic step to increase competitiveness in the midst of intense industry competition. However, the merger process presents a number of challenges, especially in terms of network technology integration, unification organizational culture, as well as infrastructure and human resources [2]. One crucial aspect in this integration is the consolidation of devices Radio Access Network (RAN) and utilization frequency spectrum owned by each company [3]. There is an ownership spectrum imbalance, such as Hutchison 3 not having access to the 900 MHz frequency band. Encourages the need for network re-configuration to maximize coverage and service

quality, especially in rural areas [4]–[6]. The network merger also raises due to operational issues, where there are many nodes or sites that are close to each other, triggering swelling operational costs due to overlapping Infrastructure [7]. For this reason, the company needs to determine which sites are maintained and the Prophet Muhammad that deactivated based on technical and economic considerations, such as capacity network, rental price, remaining contract, and performance devices. One efficiency solution that is now widely applied is the concept of infrastructure sharing, especially through the application of Multi Operator technology Core Network (MOCN). This technology allows two telecommunication operators to share core infrastructure without compromising the identity of each operator's services and network integration can be carried out optimally and cost-effectively [8]–[10]. Through the MOCN approach, operators can significantly reduce the number of BTS/E-Node B without sacrificing coverage services, as well as

utilizing the spectrum more efficiently. In the context of the Indosat and Hutchison 3 merger, the implementation of MOCN becomes a strategic solution in managing more than 60,000 existing sites spread throughout Indonesia[6]. Therefore, this research is focused on the analysis of BTS/E-Node B selection that is optimal with the MOCN approach, as part of the post-merger network integration strategy. This research is expected to contribute to technical and strategic decision-making to support efficiency operational and improving the quality of telecommunications services in Indonesia.

II. RESEARCH METHOD

A. Multi Operator Core Network (MOCN)

Multi-Operator Core Network (MOCN) is a scheme for sharing Radio Access Network (RAN) among several mobile network operators[11]. In MOCN, valuable radio resources are shared by several core networks dedicated to reduce capital and operational costs[3]. MOCN can be configured to share resources of RF modules and antennas by combining frequencies from two MNOs, while maintaining each MNO's core network[12]. Multi Operator Core Network (MOCN) technology offers various advantages in managing mobile networks, especially in the context of efficiency of costs and resources. One of the main advantages of MOCN is its ability to reduce capital expenditure (CAPEX) and operational expenditure (OPEX) significantly, with potential savings reaching 50% up to 87% through sharing infrastructure between operators[11], [13]. In addition, MOCN enables the utilization of spectrum and infrastructure more efficiently, which impacts on increasing network capacity and performance without requiring additional investment[14]. Technology also supports the allocation and management of resources dynamic power, so it can improve throughput and service quality for users[15].

However, the implementation of MOCN also has several challenges. Complexity in management becomes one of the main drawbacks, because coordination between operators in sharing resources demands careful management to maintain fairness of allocation and service quality. In addition, there is a risk of decreased network performance due to various factors technical, such as efficiency Modulation or

Load Transmission[15]. Another concern that arises is the security and data privacy aspects, because several operators access the same physical infrastructure, potentially creating vulnerabilities to information data leakage [11]. Building a network using the MOCN method requires an understanding of the MOCN network architecture as shown in Figure 1.

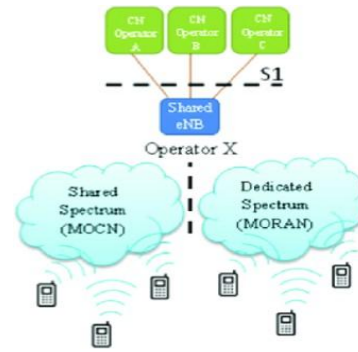


Fig 1. MOCN Architecture.

B. Coverage

Coverage refers to the geographic area that can be reached by the BTS with adequate signal quality sufficient. Coverage is influenced by propagation factors such as the physical conditions of the environment and social factors such as type of area (urban, suburban, rural) [16]. The main goal is to ensure users can connect to the network with a signal that is strong and stable [30]. However, coverage is also influenced by various losses or disturbances in signal propagation as follows [16], [17].

1) Reflection

Electromagnetic waves tend to be reflected by surfaces such as soil and walls when propagating in an environment larger than its wavelength.

2) Diffraction

Loss diffraction occurs when electromagnetic waves are deflected by obstacles sharply, causing signal loss, especially in Non-Line of Sight (NLOS) conditions, and influenced by obstacle height, length wavelength, and transmission path conditions.

3) Scattering

Scattering loss occurs when a signal hits small or dense obstacles, causing signal scattering. This condition is commonly found in the field due to objects such as foliage, light poles, and road signs, especially in urban areas.

4) Multipath Loss

Path loss is influenced by the environment, frequency, and bandwidth. Multipath occurs when signals travel different paths due to reflection, diffraction, or scattering, which can cause selective or flat frequency fading. This effect needs to be considered in network design to maintain signal quality.

C. Capacity

The capacity of BTS/E-Node B determine how many users and data can be served in an area. Factors that influence it include frequency spectrum, bandwidth, and TX/RX configuration TX/RX. This capacity is known as throughput, which is calculated theoretically per sector and per band frequency according to 3GPP standards.

$$\begin{aligned} \text{Throughput} = & (\text{Jumlah PRB} \times \\ & RE_{\text{per PRB per subframe}} \times \text{Bits}_{\text{per RE}} \times \\ & \text{Jumlah}_{\text{layer MIMO}} \times (1 - \text{Overhead}_{\text{persentase}}) \times \\ & 1000 \left(\frac{\text{subframe}}{\text{detik}} \right) : 1,000,000 \left(\frac{\text{bit}}{\text{Mbps}} \right) \end{aligned} \quad (1)$$

D. Link Budget Analysis

Link budget analysis involves various important parameters such as transmit power, SNR, bandwidth, frequency, antenna gain, and environment condition to predict radio coverage and performance [18]. This process is carried out in the early stages of design by network designers to determine main technical parameters, meanwhile constraints such as transmitting power and frequency are obtained from waveform standards and government regulations.

The link budget calculation aims to determine cell area coverage by calculating the Maximum Allowable Path Loss (MAPL), which is the maximum attenuation that still allows the signal to be received with minimum quality (lowest SNR). MAPL is calculated for uplink and downlink to determine coverage limits between transmitter and receiver.

Equation to obtain Maximum Allowable Path Loss (MAPL) for the downlink and uplink can be calculated with the following equation:

1) Downlink

$$\begin{aligned} \text{MAPL} = & EIRP_{DL} - S_{UE} - LNF - IM_{DL} - L_{\text{pen}} - \\ & L_{\text{bodyLoss}} + G_{UE \text{ Antena}} \end{aligned} \quad (2)$$

2) Uplink

$$\begin{aligned} \text{MAPL} = & EIRP_{UL} - S_{eNB} - LNF - IM_{DL} - L_{\text{pen}} - \\ & L_{\text{bodyLoss}} + G_{UE \text{ Antena}} + G_{eNB TMA} \end{aligned} \quad (3)$$

E. Path Loss

Path loss is the decrease in signal strength when propagating from transmitter to receiver, which is caused by distance, physical obstacles, and environment conditions. This term is very important in wireless communication as this directly affects network coverage and signal quality, especially in systems such as LTE and other cellular technology. To predict path loss, some mathematical models can be used. Some models that are commonly used in LTE

networks are Free Space Path Loss (FSPL) and COST-231 Hata Model.

The Hata model is a mathematical version of the Okumura model used to calculate signal path attenuation. This model applies to frequencies 150– 1500 MHz and is suitable for use in urban areas. For suburban areas and open areas, Hata provides additional correction formulas so that the results calculations remain accurate. The COST-231 prediction model Hata for suburban areas is like the equation below.

$$\begin{aligned} PL_{\text{suburban}} = & 69.55 + 26.16 \log(fc) - 13.82 \log h_B - \\ & a(h_R) + [44.9 - \\ & 6.55 \log_{10}(h_B)] \log_{10}(d) - \\ & 6 \log_{10} \left(\frac{fc}{28} \right) - 12 \log_{10} \left(\frac{fc}{1800} \right) \end{aligned} \quad (4)$$

F. Media Transmission

In data process delivery, media transmission will be used as the data carrier. Here are some types of media transmission:

1) Fiber Optic

Fiber optic is a transmission medium based on fiber glass or Fine Plastic that transmits light signals through the principle of total internal reflection. This technology is used widely in modern telecommunications networks as this can send high-speed data in large quantities and long distances, especially for backbone and backhaul networks. Fiber optic is a superior transmission medium in telecommunications because it has various advantages, such as big data capacity up to terabits per second, long distance transmission without the need for signal regeneration, and is resistant to electromagnetic interference. In addition, fiber optics also offer high security high because it is difficult to tap, and very low latency, making it suitable for real-time applications. However, behind its advantages, fiber optic also has several drawbacks, such as the cost of expensive initial installation, complex installation and complicated maintenance because the fibers are easily broken and requires special equipment, and less flexible for use in remote areas or for temporary installations.

2) Microwave

Microwave is a wireless transmission technology that utilizes high-frequency radio waves high (6–38 GHz) to send data line of sight between two points. Generally used to connect BTS to the central network, especially in areas difficult to reach by cable fiber optic. Microwave has a number of advantages, including fast installation without the need for cable digging, lower initial costs compared to fiber optics, as well as high flexibility which is suitable for temporary or emergency networks. In addition, modern microwave technology can support high capacity up to several Gbps. However, this technology also has drawbacks, such as distance limitations and dependence on line of sight (LOS), performance that can be disrupted by weather

conditions, capacity that is still lower compared to fiber optics, and is vulnerable to interference from other devices that use the same spectrum.

G. Tower Sharing

Tower Sharing is a telecommunication tower leasing scheme by mobile operators from tower services providers such as Protelindo, Mitratel, TBG, and others. In this scheme, one tower can be used together by several operators who each place their devices at certain heights according to tower capacity and lease agreement. This scheme is commonly used in MOCN implementation, where devices from two operators such as H3I and IO are on one tower, and it is necessary to choose which device is maintained or dismantled. Tower providers do not necessarily rent out all of their parts because they still have to consider the capacity of the tower structure, the maximum load power supply, as well as the height requirements of each operator's antenna. In practice, some towers are only able to support two operators, especially in areas with low populations that require antennas at optimal heights for maximum coverage. The main advantage of the Tower Sharing scheme is land efficiency and reduce the need for new tower construction. This supports government policy to minimize the impact visual and excessive land use and improves city aesthetics and spatial planning efficiency.

From the operator's perspective, this scheme reduces costs from the operator's perspective, initial investment and operational costs (OPEX). This happened because operators do not have to bear the costs of maintenance, supervision, and tower operations directly. Tower sharing also allows network expansion faster in remote or densely populated areas without having to build their own infrastructure.

III. METHOD

A. Data Collection

Before conducting analysis and testing to select the BTS/Node-B that you want to activate and deactivate. Required some data to support the success of this research.

1. Node-B Location Mapping Data

Node-B site location information PT. Indosat Ooredoo Hutchison mapped in folder to identify which sites are adjacent, have one location, or are not at all adjacent. The following is a mapping of the location of Node-B IOH which is shown in the image below.



Fig 2. Mapping of Node-B IOH locations.

Based on the data shown in Figure 3. 1, the following is an explanation of the mapping categories Node-B on the terms PT. Indosat Ooredoo Hutchison.

a) Not Pair

This category means that there are no Node-Bs located close to each other (within a radius of 30 – 100 m).

b) Pair Collo

In this category it means that the Node-B location is on one site (1 tower).

c) A Couple Nearby

In this category it means that the location Node-B is (30 – 100 m) away and is not located on one location.

2. Data Sites Indosat-IM3 and H3I-3ID Networks

In this study, there are 5 BTS/E-Node Bs from each operator, namely H3I and IO. The area of the site includes Depok, Karawang, and Bekasi. The following is the capacity calculation used in this study.

Where:

B = Bandwidth LTE (Hz)

η = Spectral Efficiency (bit/s/Hz)

N = MIMO Layers

B. Research Analysis Stages

In this study, several stages will be carried out, packaged in the form of a flowchart, as shown in the figure below. The research stage will begin with the formulation of the problem, the data collection stage, site mapping location, coverage considerations, solution determination and finally the preparation of a research report.

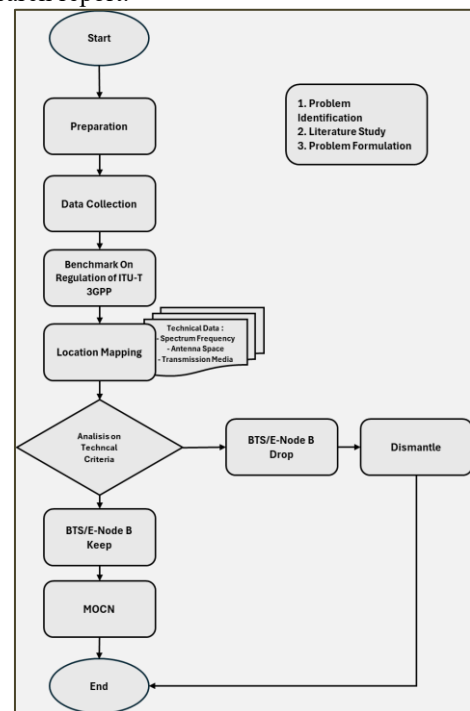


Fig 3. Flowchart of Research Analysis Stages

IV. RESULT

Based on the results of the analysis that has been carried out on the RAN configuration, antenna height, media transmission, and frequency bands at the Depok site, it can be concluded that the Indosat Ooredoo (IO) operator has a more ready network infrastructure compared to H3I. The following is an explanation of each aspect:

A. Analysis Results

1) Depok Site

Table 1. Results of Depok Site Discussion

Operator	H3I	IO	IOH
Configuration	1T2R L1800_(10)	2T2R L900_(10)+4 T4R L1800_(20)+ 4T4R L2100 (15)	2T2R L900_(10)+4 T4R L1800_(20)+ 4T4R L2100 (15)
Capacity (GB/day)	202.11	1520.064	1520.064
Transmission	MW	MW	MW
Cap. Transmission	200 - 600 Mbps	200 - 600 Mbps	200 - 600 Mbps
Frequency Coverage	LTE 1800	LTE 900 + LTE 1800 + LTE 2100	LTE 900 + LTE 1800 + LTE 2100
Bandwidth	10	45	45
Antenna RF Height	26	33.5	33.5
Coverage distance	18.84	24.54	24.54

Based on Table 1. it can be concluded that the RAN configuration of Indosat Ooredoo (IO) has higher capacity (2,318.44 Mbps/day), compared to H3I (202.11 GB/day), because it is supported by bandwidth which is larger and the ability to handle multi-users better. In addition, the IO antenna has a height of 33.5 meters, higher than H3I (26 meters), so the coverage range is wider, namely 24.54 km compared to 18.84 km owned by H3I, based on calculations using the COST-231 Hata model. From the transmission media side, both use microwave which will be maintained in the MOCN scheme. In terms of spectrum, IO has advantages with three frequency bands (900, 1800, and 2100 MHz) compared to H3I which only uses 1800 MHz. More frequencies and bandwidth give IO higher capacity and flexibility in handling traffic violations. From table 4.1 shows that BTS/e-Node B that in terms of configuration, BTS capacity, transmission, frequency, and coverage BTS IO was chosen as a BTS reference for to be a site that is MOCN-ed, and BTS/Node B from IO which will be kept and BTS/e-Node-B from H3I will be dismantled.

2) Site Karawang

Table 2. A Detailed Analysis of the Results

Operator	H3I	IO	IOH
Configuration	1T2R L1800_(10)+ 1T1R L2100_(10)	2T2R L900_(10)+ 4T4R L1800_(20) +4T4R L2100 (15)	2T2R L900_(10) +4T4R L1800_(20) +4T4R L2100 (15)
Capacity (GB/day)	404.21	1520.064	1520.064
Transmission	MW	MW	MW
Cap. Transmission	200 - 600 Mbps	200 - 600 Mbps	200 - 600 Mbps
Frequency Coverage	LTE 1800 + LTE 2100	LTE 900 + LTE 1800 + LTE 2100	LTE 900 + LTE 1800 + LTE 2100
Bandwidth	20	45	45
Antenna RF Height	21	41.5	41.5
Coverage distance	15.24	30.76	30.76

Based on Table 2. the RAN configuration of Indosat Ooredoo (IO) has a higher capacity (2,318.44 Mbps/day) compared to H3I (404.21 GB/day) because it is supported by a larger bandwidth and the ability to handle multi-users. The IO antenna is also higher (41.5 meters vs. 21 meters), resulting in wider network coverage, namely 30.6 km compared to 14.24 km owned by H3I, according to calculations with the COST-231 Hata model in the Karawang area. Both operators use microwaves as transmission media that is still maintained in the MOCN scheme. From the spectrum side, IO operates three frequency bands (900, 1800, and 2100 MHz), while H3I only has two (1800 and 2100 MHz). The advantage of the 900 MHz band gives IO coverage better in difficult areas and allows carrier aggregation the Prophet Muhammad more flexible, so that improves capacity and service quality that is good. The results of this discussion show that BTS/e-Node B that in terms of configuration, capacity BTS, transmission, Frequency, and coverage BTS IO was chosen as the BTS reference to be used as the site to be MOCN-ed, and BTS/Node B from IO that will be kept and BTS/e-Node B from H3I will be dismantled.

3) Bekasi Site 1

Table 3. Results of Discussion Site Bekasi 1

Operator	H3I	IO	IOH
Configuration	1T2R L1800_(10)	2T2R L900_(10)+ 4T4R L1800_(20) +4T4R L2100 (15)	2T2R L900_(10)+ 4T4R L1800_(20) +4T4R L2100 (15)
Capacity (GB/day)	202.11	1520.064	1520.064
Transmission	MW	FO	FO
Cap. Transmission	200 - 600 Mbps	10 - 25 Gbps	10 - 25 Gbps
Frequency Coverage	LTE 1800	LTE 900 + LTE 1800 + LTE 2100	LTE 900 + LTE 1800 + LTE 2100
Bandwidth	10	45	45
Antenna RF Height	31	41.5	41.5
Coverage distance	22.66	30.76	30.76

Based on Table 3. the RAN configuration of Indosat Ooredoo (IO) shows significant advantages compared to H3I, with Capacity 2,318.44 Mbps/day which is able to handle multi-users efficiently, while H3I is only 202.11 GB/day. The IO antenna is also higher (41.5 meters vs. 21 meters), providing a signal range of up to 30.6 km, more wider than H3I which is only 22.66 km, so chosen as the standard in network integration in Bekasi 1 area. From the transmission side, IO uses fiber optics with a capacity of 10–25 Gbps, far exceeding H3I's microwave which is only 200–600 MBps. In addition, IO is also superior in the spectrum frequency, using three bands (900, 1800, and 2100 MHz), while H3I only has one (1800 MHz). This advantage allows IO to carry out carrier aggregation and improve efficiency and quality the network as a whole. from Discussion Site Bekasi I, shows that in terms of configuration, BTS capacity, transmission, frequency, and coverage BTS IO was chosen as the BTS reference to be used as the site that is MOCN-ed, and BTS/Node B from IO that will be kept and BTS/e-Node B from H3I will be dismantled.

4) Bekasi Site 2

Table 4. Results of Discussion Site Bekasi 2

Operator	H3I	IO	IOH
Configuration	1T2R L1800_(10) +1T1R L2100_(10)	2T2R L900_(10)+ 4T4R L1800_(20) +4T4R L2100 (15)	2T2R L900_(10)+ 4T4R L1800_(20) +4T4R L2100 (15)
Capacity (GB/day)	404.21	1520.064	1520.064
Transmission	MW	FO	FO
Cap. Transmission	200 - 600 Mbps	10 - 25 Gbps	10 - 25 Gbps
Frequency Coverage	LTE 1800 + LTE 2100	LTE 900 + LTE 1800 + LTE 2100	LTE 900 + LTE 1800 + LTE 2100

Bandwidth	20	45	45
Antenna RF Height	35	40	40
Coverage distance	25.95	29.51	29.51

Table 4. shows that BTS/e_node B Indosat Ooredoo (IO) has a RAN Configuration with higher capacity and traffic efficiency, allowing multi-user services to be more stable. With a higher antenna height (40 meters vs. 35 meters), providing a signal range of up to 29.52 km compared to H3I which is only 25.59 km, so it is used as the standard for merging networks in Bekasi 2. From the transmission side, IO uses fiber optics with a much larger capacity large (10–25 Gbps), while H3I still uses microwave (200–600 MBps). In addition, IO has three frequency bands (900, 1800, 2100 MHz), while H3I only has two (1800 and 2100 MHz), making IO more superior in network capacity and ability to accommodate customer traffic. With this BTS/e-Node B IO was chosen as the BTS reference for being used as a site that is MOCN-ed, and BTS/Node B from IO that will be kept and BTS/e-Node B from H3I will be dismantled.

5) Bekasi Site 3

Table 5. Discussion Results Bekasi Site 3

Operator	H3I	IO	IOH
Configuration	1T2R L1800_(10)+1T1R L2100_(10)	2T2R L900_(10)+ 4T4R L1800_(20) +4T4R L2100 (15)	2T2R L900_(10)+ 4T4R L1800_(20)+ 4T4R L2100 (15)
Capacity (GB/day)	404.21	1520.064	1520.064
Transmission	MW	MW	MW
Cap. Transmission	200 - 600 Mbps	200 - 600 Mbps	200 - 600 Mbps
Frequency Coverage	LTE 1800 + LTE 2100	LTE 900 + LTE 1800 + LTE 2100	LTE 900 + LTE 1800 + LTE 2100
Bandwidth	20	45	45
Antenna RF Height	33	30.5	33
Coverage distance	24.21	22.21	24.21

Table 5. shows that Indosat's RAN Ooredoo (IO) is superior in handling multi-user, H3I's higher antenna (33 meters vs. 30.5 meters) has a wider signal range (~24.21km vs. ~22.21 km), so it was chosen for network merging in Bekasi 3. Both operators both use microwave as a medium transmission. However, IO has a frequency advantage because it operates three bands (900, 1800, 2100 MHz), while H3I only has two (1800 and 2100 MHz). IO's 900 MHz band provides better coverage and supports carrier aggregation, which impacts the increase in capacity and quality of network services. BTS capacity,

transmission, Frequency, and BTS coverage IO was chosen as a BTS reference to be used as a site that is -MOCN and BTS/Node B from IO that will be kept by using the antenna height of H3I and BTS/e-Node B from H3I will be dismantled.

V. DISCUSSION

Analysis of 5 site samples resulted in several important points in the selection of BTS/e-Node B that will be maintained or discontinued. The discussion not only highlights the technical criteria in the selection but also evaluates BTS performance post MOCN implementation in the Jabotabek area.

1) Discussion Results of Technical Criteria
 From 5 areas in Jabotabek which are used as a reference for analysis of technical criteria such as frequency spectrum, bandwidth, antenna space (height), Transmission Media, and in it the capacity and coverage of each BTS are calculated. The following is a summary of the results of the analysis of the 5 areas above.

Table 5. Results of IO and H3I Component Discussions in 5 site areas.

Area	Operator	Capacity (GB/day)	Cap. Transmission	Frequency	Bandwidth	Antenna Height	Coverage distance	Result
DK	H3I	202.11	200 - 600 Mbps	LTE 1800	10	26	18.84	Drop
	IO	1520.064	200 - 600 Mbps	LTE 900 + LTE 1800 + LTE 2100	45	33.5	24.54	Keep
KRW	H3I	404.21	200 - 600 Mbps	LTE 1800 + LTE 2100	20	21	15.24	Drop
	IO	1520.064	200 - 600 Mbps	LTE 900 + LTE 1800 + LTE 2100	45	41.5	30.76	Keep
BKS1	H3I	202.11	200 - 600 Mbps	LTE 1800	10	31	22.66	Drop
	IO	1520.064	10 - 25 Gbps	LTE 900 + LTE 1800 + LTE 2100	45	41.5	30.76	Keep
BKS2	H3I	404.21	200 - 600 Mbps	LTE 1800 + LTE 2100	20	35	25.95	Drop
	IO	1520.064	10 - 25 Gbps	LTE 900 + LTE 1800 +	45	40	29.51	Keep

BKS3	H3I	404.21	200 - 600 Mbps	LTE 1800 + LTE 2100	20	33	24.21	Drop
	IO	1520.064	200 - 600 Mbps	LTE 900 + LTE 1800 + LTE 2100	45	30.5	22.21	Keep with H3I antenna height

Table 5. shows that Indosat Ooredoo's (IO) BTS/e-Node B is more chosen for MOCN implementation than H3I. This is based on the superior capacity and coverage of the BTS IO which has a greater frequency spectrum and bandwidth, as well as a higher and strategic antenna position. Unused BTS devices belonging to H3I will be dismantled and reused to increase network capacity. Approximately 70% of ex-MOCN devices that are still suitable for use will be reused, providing cost efficiency procurement. In addition, the reduction in the use of antenna space also reduces tower rental costs. Further discussion will be conveyed in the next sub-chapter.

2) Network Efficiency After MOCN
 Based on the analysis of IO and H3I components, there are three technical criteria used to determine which BTS will be retained and which will be discontinued. Of the more than 60,000 BTS owned by Indosat Ooredoo and H3I, the focus of this research is on the selection of BTS in the pair collocation scheme, namely BTS that are located in one tower and used by more than one operator. In the context of mergers, network consolidation is a top priority, especially since around 37% of the total BTS are pair collo. Therefore, the next analysis will discuss the potential efficiency of the number of BTS obtained through the implementation of MOCN.

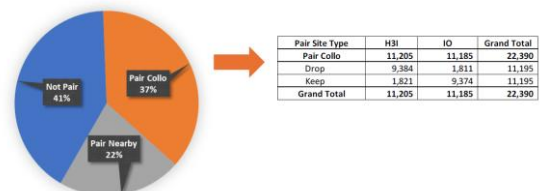


Fig. 4. Chart of Indosat and H3I Pair Site Portion Chart

Figure 4. shows that 37% of the total BTS/e-Node B belonging to H3I and Indosat Ooredoo are pair collocation, which means that there is duplication of infrastructure without service integration between operators. This condition caused operational and maintenance costs to double. With the implementation of MOCN, one BTS can serve two operators at once, so that the number of BTS can be reduced to 27.97% of the total network and 18% of

the BTS pair collo. This reduction has a positive impact on the company's efficiency, both in terms of BTS management, tower rental cost savings, and resource efficiency at the network operational level (L1 to L3). Efficiency simulations due to the 18% reduction of BTS will be discussed next.

3) Post-MOCN Network Performance

After the selection of BTS/e-Node B to be MOCN, the next step is to evaluate how much network efficiency is obtained and its impact on network performance. These checks are important to ensure that the quality of customer service is not compromised. The Jabotabek area was chosen as the evaluation sample because it is the largest area and includes the VVIP area for Indosat Ooredoo Hutchison. Therefore, network performance in Jabotabek is considered to represent the condition of the network nationally.

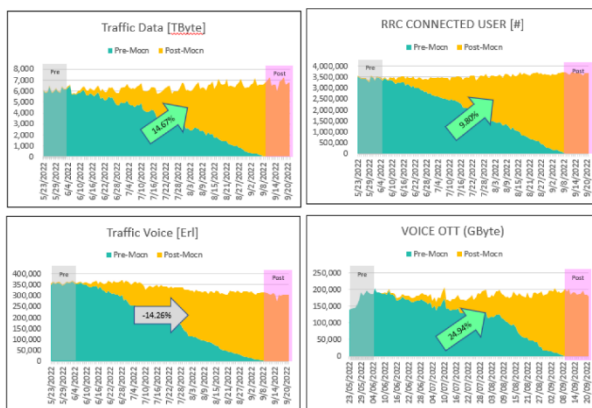


Fig 5. Months Post-MOCN Performance Data.

At Figure 5. There are several parameters monitored by IOH, and will be discussed one by one as follows:

a) Traffic Data

Four months after the implementation of MOCN with progress reaching 50%, there was an increase in data traffic of 14.67% on a weekly basis. Daily data usage increased from an average of 6,000 TB to 7,000 TB, although the number of BTS decreased due to infrastructure sharing for IM3 and Three services. With approximately 4 million customers in the area, this improvement shows that network performance remains optimal even better post-MOCN, proving efficiency without sacrificing service quality.

b) RRC User Connected

Four months after the implementation of MOCN reached 50%, the number of customers (EU) connected to Indosat's network increased by 9.8%, reaching around 4 million users. This increase is in line with the increase in data traffic, which signifies that MOCN is not only infrastructure-efficient, but also able to maintain—and even enhance—the customer experience. This proves that MOCN is an

optimal scheme for network merging without sacrificing quality of service.

c) Traffic Voice & Voice OTT

These two performances are parameters that cannot be separated, since its implementation, Indosat Ooredoo Hutchison fulfilled the request of the Minister of Communication and Information to turn off its 3G and maximize only 2G for voice call purposes, and 4G on LTE. And with this MOCN, Indosat ooredoo Hutchison also activated Voice Over Internet Protocol (VOIP) technology, so it can be seen from the graph that voice traffic in 2G decreased by -14.6% while OTT voice increased by 24.96% in Tbyte data. This shows that MOCN provides customers with the opportunity to enjoy voice services over the internet, so that it will be faster and more reliable.

VI. CONCLUSION

Based on the analysis in chapter IV regarding the method of selecting BTS/e-node B and how much network efficiency and also how the network performance after MOCN is, it can be concluded that:

1. Technical Criteria for BTS/e-Node B Selection

From the 3 existing criteria, namely the frequency spectrum – Bandwidth, antenna height, and also transmission media, BTS will be selected which one provides the largest capacity, farthest range, and also the largest transmission capacity. Of the 60 thousand ++ BTS/e-Node B Indosat pre-MOCN, 44 thousand ++ BTS/e-Node B were selected for MOCN, which is around 72% of the total number of Indosat Ooredoo and H3I BTS. And the remaining 28% is dropped.

2. The Amount of Network Performance Efficiency Post MOCN.

Post MOCN 28% of the network can be efficient, which also results in efficiency in terms of cost. At the end of MOCN, Indosat can save up to approximately 225 billion Rupiah per month in terms of operational costs. With the existence of MOCN, this cost can be more focused on improving customer service.

3. The influence of MOCN in terms of Customer Experience

In terms of performance after MOCN, it is proven that traffic data increased by 14.67%, the number of RRC users connected also increased by 9.8%, and also OTT voice increased by 24.94%. This proves that MOCN is an excellent decision in terms of network integration, in addition to the efficiency of operational costs and the amount of network maintenance, service to customers is maintained.

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