Dynamic Mobile Satellite Channel Analysis in MEO Orbit Using Overlap and Overlay Approaches

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***Abstract*—Medium Earth Orbit (MEO) satellites represent a high-speed satellite technology poised to supplant geostationary satellites in telecommunication roles. However, the utilization of MEO satellites for this purpose encounters a significant hurdle in the form of limited frequency spectrum resources. This scarcity necessitates a delicate balance between network efficiency and quality. To address this challenge, applying tele traffic theory becomes imperative for optimizing the performance of MEO satellite communication systems. The proposed solution involves the implementation of an overlap algorithm within satellite beams and a concurrent overlay algorithm across available channels. The overlap algorithm extends the call connection duration by introducing increased waiting time without prematurely terminating connections. In tandem, the overlay algorithm dynamically allocates channels through the dynamic channel allocation method, enhancing channel utilization. A notable channel efficiency of 43% is achieved through the synergy of these algorithms. Optimal performance materializes when configuring five channels within microcells and 11 channels within macrocells, delineating the best utilization strategy for maximizing system performance while ensuring efficient channel allocation.**

***Keywords*—Medium Earth Orbit (MEO) satellites, traffic, dynamic channel allocation, overlap, overlay**

I. INTRODUCTION

Technology development evolves according to customer needs, encompassing various functionalities such as making calls, accessing the internet, television, and data storage. Several technologies utilized to fulfill customer needs include cellular, fiber optic, and satellite technologies. Cellular technology serves customers with high mobility but limited coverage. Fiber optic technology ensures stable access within a specific area but confines customer mobility. Recognizing the existing limitations in these two technologies, a new technology emerges—satellite technology. Compared to cellular and fiber optic technologies, satellites offer the advantage of covering remote areas, reaching both land and sea with limited accessibility. This superiority facilitates customer mobility within extensive coverage, making satellites a more convenient option for users [1].

The complexity of satellite communication arises from the satellite's swifter motion than users' movement on Earth, resulting in fluctuating available and occupied channels. To address this issue, it is essential to determine the channel allocation frequency. channel allocation frequency is a technique used to distribute channels according to the number of users, ensuring each user receives one channel. channel allocation frequency has two types: dynamic channel allocation and static channel allocation. The most effective approach in channel allocation to prevent channels from becoming excessively full or empty is through dynamic channel allocation, where channel allocation occurs within a single channel. dynamic Channel allocation is employed in both microcells and macrocells. In channel overload in microcells, channels are allocated to macrocells, ensuring coverage for users requiring larger channels [2].

The microcell and macrocell will be configured using overlay and overlap structures. Through the overlapping, sufficient time is allocated for calls by identifying the average call parameter, allowing for the identification of additional time required to queue before obtaining a channel cell for connection. The advantage of utilizing macrocell within the overlapping cell structure lies in the capacity augmentation independent of radio frequency. The low customer mobility simplifies signal processing, while the moderately high transmission power permits savings and reductions in Base Station and Mobile Station costs within the radio frequency system. The overlay cell structure combines dynamic channel allocation and power control. This system does not necessitate dynamic channel allocation or power control methods, thereby eliminating the need for borrowing neighboring channels, often referred to as channel borrowing, which reduces traffic

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congestion in hotspots but can lead to significant blocking when neighboring channels are full [3].

II. Literature Review

The research titled "Architecture Design, Frequency Planning, and Performance Analysis for a Microcell/ Macrocell Overlaying System" by Li-Chun Wang and Chin-Tau Lea explores an innovative hierarchical microcell/ macrocell architecture employing the concept of cluster planning and sectoral antenna arrangement. The proposed design aims to create efficient microcells that can reuse the same frequencies as overlaying macrocells without compromising the latter. This approach doesn't just gradually utilize frequencies; it extensively deploys them to provide comprehensive coverage, thereby enhancing the capacity across the telecommunication system services, ultimately evolving into a hierarchical microcell/ macrocell architecture [4].

The research by Prajawati titled "Traffic Analysis of Mobile Cellular Communication Systems via GEO Satellites with Overlap and Overlay Cell Structures" delves into the dynamic channel allocation for mobile cellular, aiming to conserve frequency by providing longer wait times for calls, allowing them to queue before obtaining a channel cell for connection. The combination of overlay and overlap structures offers greater traffic and channels compared to setups without these features. The study utilizes Matlab to calculate call rates or data. Conclusions drawn from this research showcase optimal system performance observed through values of blocking probability and dropping probability, achieved when the macrocell has 35 channels and the microcell has five channels. Regarding system performance based on maximum traffic intensity per cell, it is reached with 9 channels in the microcell and 7 in the macrocell, ensuring a higher traffic intensity of 40% [5].

The research by Lee and Choi titled "Performance Evaluation of High-Frequency Mobile Satellite Communications" discusses the evaluation of system performance is conducted in conditions involving high-frequency bands and users moving at high speeds. This analysis focuses specifically on two key metrics: outage probability and channel capacity. Three distinct channel models are utilized for this assessment—namely, the conventional Land Mobile Satellite (LMS) channel models developed by Lutz and Loo, along with the Nakagami fading model. The study encompasses a range of user speeds, and the system's effectiveness is examined under different propagation delays within the LMS channel models and Line-Of-Sight (LOS) components within the Nakagami fading model. Furthermore, a comparative analysis is carried out among the conventional models, considering variations in altitudes for Geostationary Orbit (GEO), Medium Earth Orbit (MEO), and low earth orbit (LEO) satellites, as well as High-Altitude Platforms (HAP) [1].

In the research conducted by Néstor J. Hernández Marcano, Luis Diez, Ramón Agüero Calvo, and Rune Hylsberg Jacobsen titled "On the Queuing Delay of Time-Varying Channels in Low Earth Orbit Satellite Constellations", the influence of ground-to-satellite/ satellite-to-ground links and background traffic significantly outweighs that of unobstructed inter-satellite connections in outer space, particularly in terms of both mean and variance of end-to-end delay. This effect remains pronounced even when moderate queues are present. This phenomenon is observed along an established path between two ground stations and throughout the constellation. Such considerations could pose challenges to the practical usability of these networks, especially for services with stringent time requirements [6].

III. Research Method

In this research, channel design is conducted using a dynamic channel allocation system employing the overlap and overlay cell structure approach. The overlap approach extends call waiting times without call terminations, optimizing channel usage. On the other hand, the overlay cell structure approach eliminates the need for power control and involves channel distribution in both macrocells and microcells to prevent call terminations. The calls are redirected to macrocells if microcell channels reach total capacity [3]. Parameters utilized include call rate, channels, traffic, blocking probability, holding time, period, and satellite velocity, as illustrated in Fig. 1.

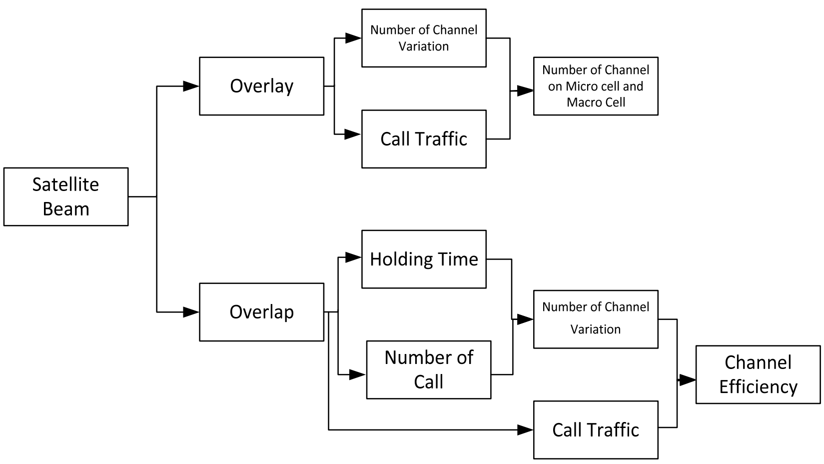

Fig. 1. Flowchart of research.

A. MEO Satellite Parameters

In this study, a MEO satellite or high-velocity satellite is employed, which in the future will be utilized as a telecommunications satellite, replacing geostationary satellites. The parameters used for this research can be observed in Table I [7]:

TABLE I. PARAMETER OF MEO SATELLITE SIMULATION

No	Parameters	Value
1	Orbit's height (km)	10355
2	Elevation degree (deg)	40
3	Maximum velocity (km/hour)	5132.63
4	Spot-beam diameter (km)	668.37
5	Offset between PRACH in beams (Slots)	0
6	Frame duration (ms)	20
7	Number of slot in frame	13
8	Number of bit in TCH burst (uncoded 4800 bps)	96
9	Number of burst in RLC block	4

This research employs the Ku-Band service frequency within the frequency range of 8-12 GHz for the uplink, while the downlink operates within the frequency range of 10.7 GHz to 12.75 GHz for mobile satellite broadband services.

B. Calculation of Call in Microcell

1) Incoming call rate

The interval of new incoming calls, data, and handoff calls are calculated using exponential distribution with consecutive averages λ_n^{-1} and λ_h^{-1}. The relationship between these average arrival values is based on the following Eq. (1) [8]:

$$\lambda_h = \lambda_n(1-p_N)p_{hn} + \lambda_h(p_0 - p_h)p_{hh} \tag{1}$$

where:

λ_n = Probability of uninterrupted and successful handoff calls.
λ_h = call rate of handoff call
p_{hn} = Probability of a connected call entering the overlap area
p_{hh} = The probability that a handoff call was connected to the previous or near cell.
p_N = The probability of a new call or data being rejected in the microcell.
p_0 = Probability of uninterrupted and successful handoff calls.

2) Probability of a connected call entering the overlap area

The p_{hn} probability represents the probability of a call connecting upon entering the overlap area of the macrocell before any disconnection occurs [9]:

$$p_{hn} = \int_0^{Ts} \frac{1}{T} \int_{t_2}^{\infty} \frac{1}{T} e^{\frac{-t1}{td}} dt_1 dt_2 = \frac{T_d}{T_s}\left(1 - e^{\frac{-Ts}{Td}}\right) \tag{2}$$

where,

p_{hn} = Probability of a connected call entering the overlap area
T_s = Length of period required (ms)
T_d = Total channel occupation time to the macrocell (ms)
T = Number of observation periods

3) The probability that a handoff call was connected to the previous or near cell

Notation p_{hh} is denoted as the probability of allowing additional time for connection during handoff calls [9]:

$$p_{hh} = (1-p_N)\int_{Ts}^{\infty} \frac{1}{T_d} e^{\frac{-t}{Td}} dt + p_N \int_{(1-\alpha)Ts}^{Ts} \frac{1}{\alpha T_s} \int_{t2}^{\infty} \frac{1}{T_d} e^{\frac{-t1}{td}} dt_1 dt_2 \tag{3}$$

where:

p_{hh} = The probability that a handoff call was connected to the previous or near cell.
p_N = The probability of a new call or data being rejected in the microcell.
T_s = Length of period required (ms)
T_d = Total channel occupation time to the macrocell (ms)
t = Time required for the handoff process (ms)
α = Overlap structure Call Rate

4) Probability of uninterrupted and successful handoff calls

A handoff call that is not interrupted in the handoff area and successfully carries out the handoff can be written using Eq. (4), [5]:

$$p_0 = (1-p_N) + p_N \int_0^{\alpha T_s} \frac{1}{T_d} e^{\frac{-t_2}{Td}} \int_0^{t_2} \frac{1}{\alpha T_s} dt_1 dt_2 + p_N \int_{\alpha T_s}^{\infty} \frac{1}{T_d} e^{\frac{-t_1}{td}} dt_1 \tag{4}$$

p_0 = Probability of uninterrupted and successful handoff calls.
p_N = The probability of a new call or data being rejected in the microcell.
T_s = Length of period required (ms)
T_d = Total channel occupation time to the macrocell (ms)
t = Time required for the handoff process (ms)
α = Overlap structure Call Rate

5) Channel holding time

The average value of channel holding time for a call or new data in one cell can be written using Eq. (5), [5]:

$$T_{cn} = T_d(1-p_{on}) \tag{5}$$

T_{cn} = Channel Holding Time on new call
T_d = Total channel occupation time to the macrocell (ms)
p_{on} = Probability of successful call on new call

6) Channel holding time of handoff call

The average channel holding time value of a handoff call can be written using Eq. (6), [10]:

$$T_{ch} = T_d(1-p_{oh}) \tag{6}$$

T_{ch} = Channel Holding Time of Handoff Call
T_d = Total channel occupation time to the macrocell (ms)
p_{oh} = Probability of successful call on handoff

7) Evacuation probability

Because evacuation of a new call occurs when the call enters the next overlap area or redirects to a macrocell before disconnection, the evacuation probability can be seen in Eq. (7), [10]:

$$p_{on} = p_{hn}p_0 \quad or \quad p_{oh} = p_{hh}p_0 \tag{7}$$

p_{on} = Probability of a successful call (newcall) entering the macro cell
p_{hn} = The probability of a new call entering the overlap
p_0 = Probability of uninterrupted and successful handoff calls.

8) Utilization of channel holding time for new calls and handoffs

Using channel holding time for new calls and also handoffs, the average value of channel holding time for all calls in a cell can be written according to Eq. (8), [5]:

$$T_c = \frac{\lambda_n(1-p_N)T_{cn}+\lambda_h(1-p_H)T_{ch}}{\lambda_n(1-p_N)+\lambda_h(1-p_H)} \tag{8}$$

where:
T_c = Average of channel holding time for all call in cell (ms)
λ_n = Probability of uninterrupted and successful handoff calls.
λ_h = call rate of handoff call
p_N = The probability of a new call or data being rejected in the microcell.
p_H = Probability of handoff switching
T_{cn} = Channel holding time on new call
T_{ch} = Channel holding time of handoff call

9) Call handoff diversion calculation

This call diversion calculation focuses on the call process in a channel [5]:

$$\mu_i = \frac{1}{T_c} \tag{9}$$

μ_i = Handoff call diversion
T_c = Average of channel holding time for all call in cell (ms)

The calculation above is focused on the process of a call's progression within a cell, and for further discussion, attention will be directed towards the process of a handoff call in a First in First Out queue waiting for an available channel in the next cell for handoff. We assume that a handoff call is unable to find an available channel in the next cell during the handoff call; the call may be dropped while waiting in the queue or diverted to a macrocell. The channel holding time during handoff redirection in the overlap area is shorter than the excess duration of idle call time and the interval during the connection to the cell and during evacuation of the cell due to a call to the macrocell. Thus, the number of terminations in handoff calls due to disconnection or redirection from handoff calls can be expressed according to Eq. (10), [5]:

$$\mu_i = \frac{1}{T_d}(1 - p_{00}) \tag{10}$$

μ_0 = Number of diversions from handoff calls
T_d = Total channel occupation time to the macrocell (ms)
p_{oo} = It is possible that before being disconnected from the service, the handoff call was then evacuated and transferred to microcell:

$$p_{00} = \int_{\alpha Ts}^{\infty} \frac{1}{T_d} e^{\frac{-1}{T_d}} dt = e^{\frac{-\alpha Ts}{T_d}} \tag{11}$$

α = Overlap structure Call Rate
T_s = Length of period required (ms)

C. Number of Calls in Microcell

The waiting calls are served by the previous microcell and the maximum total number of calls is 2Si so that the call distribution at equilibrium can be determined by the following Eq. (12), [11]:

$$\pi(n) = \begin{bmatrix} \frac{1}{n!}\left(\frac{\lambda_n+\lambda_h}{\mu_i}\right)^n & \pi(0), (0 \le n \le s_i) \\ \frac{1}{s_i!}\left(\frac{\lambda_n+\lambda_h}{\mu_i}\right)^{s_i}\left\{\prod_{k=0}^{n-s_i}\left(1+k\frac{\mu_0}{s_i\mu_i}\right)\right\}^{-1}\left(\frac{\lambda_h}{s_i\mu_i}\right)^{n-s_i} & \pi(0), (s_i \le n \le 2s_i) \end{bmatrix} \tag{12}$$

$$\pi(0)^{-1} = \sum_{n=0}^{s_i-1}\frac{1}{n!}\left(\frac{\lambda_n+\lambda_h}{\mu_i}\right)^n + \sum_{n=s_i}^{2s_i}\frac{1}{s_i!}\left(\frac{\lambda_n+\lambda_h}{\mu_i}\right)^{s_i}\left\{\prod_{k=0}^{n-s_i}\left(1+k\frac{\mu_0}{s_i\mu_i}\right)\right\}^{-1}\left(\frac{\lambda_h}{s_i\mu_i}\right)^{n-s_i} \tag{13}$$

n = Number of traffic
λ_n = rate of new call
λ_h = rate of handoff call
s_i = Number of channels in microcell
μ_i = Number of diversions from handoff calls of microcells
μ_0 = Number of diversions from handoff calls of macrocells
k = Number of channels used

P_N is the probability of a new call being rejected in a microcell or in other words the probability when the number of calls n has no available channels in the microcell S_i [7]:

$$P_N = \frac{1}{S_i!}\left(\frac{\lambda_n+\lambda_h}{\mu_i}\right)^{s_i}\left\{\prod_{k=0}^{n-s_i}\left(1+k\frac{\mu_0}{s_i\mu_i}\right)\right\}^{-1}\left(\frac{\lambda_h}{s_i\mu_i}\right)^{n-s_i}\pi(0) \tag{14}$$

The probability of handoff transfer can be formulated based on the average probability $P_{H|n}$, so it can be written [11]:

$$P_H = \sum_{n=si}^{2si} \pi(n) P_{H|n} \tag{15}$$

p_H = Probability of handoff switching
s_i = Number of channels in microcell
n = Number of traffic
$P_{H|n}$ = Handoff diversion probability on newcall

Macrocell is a loss system where traffic input is redirected from the microcell. Macrocell serves both new calls and handoff calls. It is assumed that the arrival intervals of both types of calls from N microcells to macrocell follow an exponential distribution. Hence, it can be written according to the following Eq. (16), [5]:

$$\lambda_a^{-1} = \{(\lambda_h \lambda_n + \lambda_h P_H)N\}^{-1} \quad (16)$$

λ_a^{-1} = The arrival interval between two calls
N = Number of call

The number of calls within the macrocell can be managed using channel planning methods [5]:

$$\prod n = \frac{1}{n!}\left(\frac{\lambda_a}{\mu_a}\right)^n \prod(0) \quad (17)$$

n = Number of traffic
λ_a = Macrocell wavelength
μ_a = Average of channel holding time on macrocell

$$P_b = P_N \prod(S_a) \quad (18)$$

P_b = Probability of diverted calls (handoff and newcall)
S_a = Number of channels in microcell
P_N = The probability of a newcall being rejected in a microcell

IV. Result and Discussion

A. Traffic Analysis

Traffic refers to data or call transmission measured in Erlangs, where each Erlang equals one hour. For ease of traffic calculation, this research employs Erlang B calculations. The objective of traffic calculations is to determine the call or data traffic intensity within a specific timeframe, enabling the assessment of required channels to minimize call blocking. Consequently, higher traffic necessitates more channels. Traffic assessment derives from calculating call arrival rates, service times, and observation durations. In Fig. 2, the measurement results of traffic intensity for the overlap and overlay cell structures are presented. It showcases a graphical representation of traffic intensity by comparing channel quantity with blocking probability.

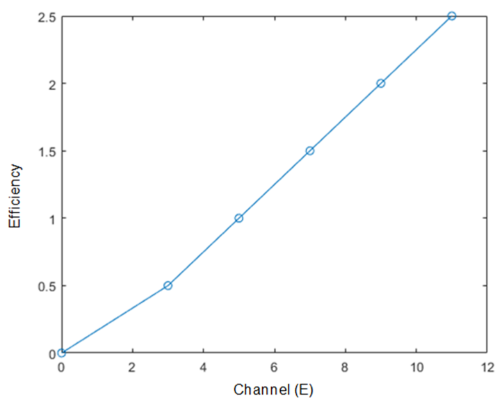

Fig. 2. Traffic intensity.

The disparity in these traffic intensity results is due to the varying traffic load on each channel with a blocking probability of less than 0.01, indicating only 1 failed call per 100 calls. Based on the traffic intensity generated in this study, as the channel size increases, the resulting traffic intensity value also escalates. To ascertain the occupied calls when the traffic intensity ranges from 0.5 E to 2.5 E, it is determined by finding the calls per single channel, calculated by multiplying 1 Erlang and dividing it by the specified holding time, where 1 Erlang equals a 60-second holding time, and the used holding time is 1 second. Hence, the minimum accommodated traffic amounts to 30 calls.

B. Analysis of Channel Usage Efficiency

Channels are a limited resource, and the more users making calls or using data, the greater the demand for channels. To anticipate channel congestion, channel and beam overlap on satellites are implemented. Hence, channel efficiency analysis is required to assess how well the employed algorithms can conserve channels. Calculating efficiency necessitates several channel variations with varying traffic within a specific observation period. Table II illustrates channel efficiency in percentage, while Fig. 3 showcases the graphical outcomes of calculations using the overlay cell structure.

TABLE II. Channel Efficiency Using Overlay Cell Structure

No	Si (Microcell)	Sa (Macrocell)	Efficiency (%)
1	9	8	3%
2	8	9	10%
3	7	10	16%
4	5	11	23%
5	3	12	26%
6	2	13	30%

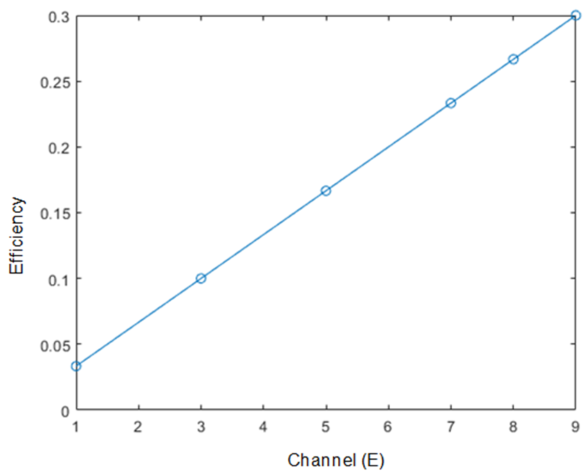

Fig. 3. Overlay structure efficiency.

Based on the results obtained from Table II, the Number of Channels (Sa) significantly influences channel efficiency. When 100 traffic loads are allocated per channel, the efficiency is merely 3%. Conversely, with multiple channels, the efficiency increases to 30%. In this study, the highest or optimal value is chosen, which corresponds to 2 channels in the microcell and 9 channels in the macrocell, yielding an efficiency of 30%. This signifies the capacity to accommodate the existing traffic plus an additional 30%. Fig. 4 depicts a linear graph as each channel is occupied by the same total traffic of 30 E.

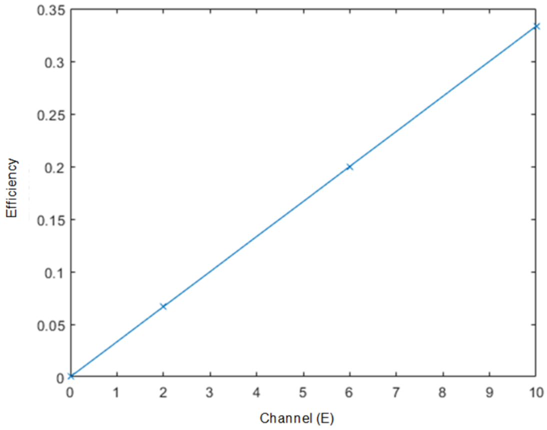

Fig. 4. Overlap structure efficiency.

Based on the results obtained in Table III, the efficiency value of traffic when burdened with the same traffic load, totaling 30 E in average calls per unit time, yields the best alpha value of 0.5, resulting in an efficiency of 33%. This implies a saving of up to 33% of the existing traffic channels. The overlap cell structure exhibits a better efficiency of 3% compared to the overlay cell structure. Providing a longer waiting time without call disconnection or blocking becomes more efficient because there is no certainty of cell vacancy in neighboring cells.

TABLE III. CHANNEL EFFICIENCY USING OVERLAP CELL STRUCTURE

No	N	Alpha	Efficiency (%)
1	30	10^{-5}	6.6×10^{-4} %
2		0.1	6 %
3		0.3	20 %
4		0.5	33 %

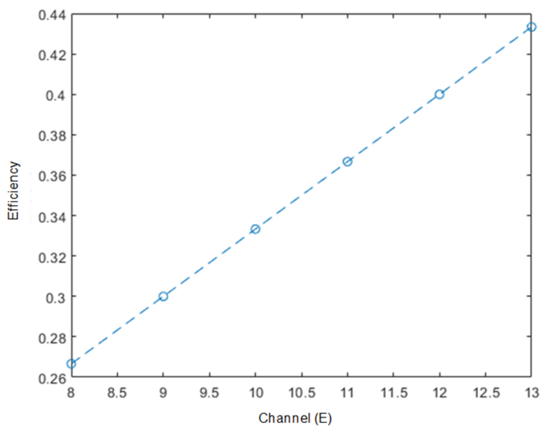

Fig. 5. Overlay and overlap structure efficiency.

Based on the results obtained in Table IV, the channel efficiency achieved through the combination of the overlap and overlay cell structures reaches a maximum value of 43%. The graphical results of calculations with the overlay and overlap cell structure are displayed in Fig. 5. This can be influenced by the number of channels in the macrocell and microcell, as well as the call rates used in this study. If we compare it with reference [5] which uses a GEO satellite which produces an efficiency of up to 40%, the application of the MEO satellite has a better efficiency value of up to 43%.

TABLE IV. CHANNEL EFFICIENCY USING OVERLAP AND OVERLAY CELL STRUCTURES

No	Si (Microcell)	Sa (Macrocell)	Alpha	Efficiency (%)
1	7	10	10^{-5}	33 %
2	5	11	0.1	36 %
3	3	12	0.3	41 %
4	2	13	0.4	43 %

Traffic refers to the movement of information from one location to another, and nearly all telecommunication network facilities are used simultaneously for several subscribers, resulting in rejected calls or waiting times in telecommunications connections. To satisfy customers, the rejection or queue of customers should not exceed the agreed-upon value. Therefore, a compromise between network efficiency and network quality is crucial. To address this, the theory of tele traffic is essential. Tele traffic theory is closely related to probabilities that can resolve issues regarding the planning and evaluation of telecommunication system performance.

C. *Blocking Probability Analysis*

Probability of Blocking refers to the blocking that occurs when more than *n* customers make telephone calls simultaneously. For unsuccessful probability of blocking, a specific target value acceptable to customers is determined. The smaller the probability value, the more capacity can be built into the telecommunication network. Probability of Blocking itself is the likelihood of total channels in the system being busy; if the channels are full, incoming calls will be rejected. At first glance, Grade of Service (GOS) and Probability of Blocking are similar but different. The fundamental difference between GOS and Pb lies in GOS being referred to as call congestion, measured from the customer's point of view, observing how many calls are rejected, whereas Probability of Blocking (Pb) is referred to as time congestion, measured from the network or switching point. This study uses a target value of less than 0.01%, which means there is only 1 failed call out of every 100 calls. In Fig. 6, the measurement results of the probability of blocking in the overlay structure can be seen, while in Fig. 7, the measurement results of the probability of blocking in the overlap cell structure are presented.

In Fig. 6, the comparison results between the number of channels and traffic demonstrate the Probability of Blocking. In this study, one channel is calculated for each traffic value, resulting in various probabilities of blocking. Automatically, these are selected according to the requirement, which is less than 0.01%. The overlay graph also exhibits similar outcomes in the combined structure, i.e., the overlap and overlay structures. Since the same channels are used, both the graph and the resulting values are identical. Overall, the best Probability of Blocking values are found with 5 channels in the microcell and 8 channels in the macrocell, as depicted in Table V.

TABLE V. DIVISION OF CHANNELS INTO MICROCELLS AND MACROCELLS BASED ON PB_{MIN}

Si (Micro cell)	Sa (Macro cell)	Pb_{min}
31	6	0.0012636
32	6	0.0011664
33	6	0.0010692
34	6	0.000972
35	6	0.0008748
36	6	0.0008748

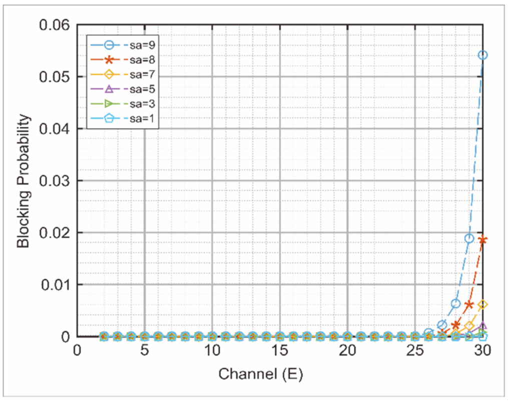

Fig. 6. Overlay structure blocking probability.

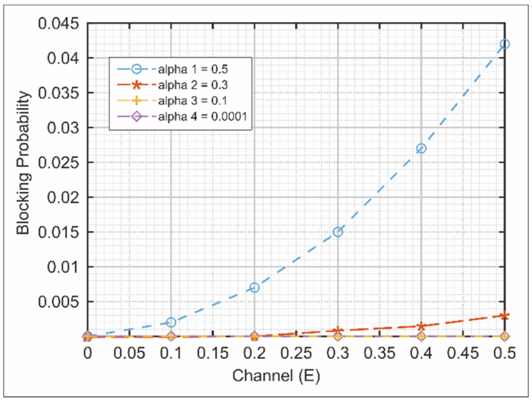

Fig. 7. Overlap structure blocking probability.

The values in Table V are heavily influenced by the arrival rate (lambda), holding time, traffic volume, and traffic intensity. In this study, an arrival rate of 0.1 is used, derived from the average arrival rate by comparing the number of calls and the time required per unit time. A decrease in the arrival rate results in a smaller probability of blocking. The holding time represents the idle time, typically ranging from 1 to 12 seconds in telecommunications standards. Traffic volume (the occupancy time of the number of calls) is obtained by multiplying the number of calls by the existing holding time. All notations are interrelated, culminating in the determination of traffic intensity. Setting the traffic intensity at 100 calls is an initial assumption based on standard blocking probability. Once all values are obtained, the subsequent step involves determining the probability of new calls, where the initial channels are used in the microcell. Following this, the Pb formula is applied, where Pn (probability of new calls) is multiplied by the channels in the macrocell. In this study, each microcell is multiplied by a number of macrocells, aiming to find the optimal probability value when the microcell channels are paired with macrocell channels.

In Fig. 7, the calculation results of the Probability of Blocking (PB) in relation to channels can be observed, where each channel is tested with different traffic intensities. The distinction between overlay and overlap lies in the average calls; hence, for the overlap method, the number of channels needs to be determined beforehand using alpha and holding time. The channel value significantly impacts the incoming traffic. This can be observed where a small alpha value influences the Probability of Blocking parameter. Following the performance test criteria for Probability of Blocking, an alpha value of 0.00001 is deemed unsuitable, while those meeting the requirements are 0.1, 0.3, and 0.5. However, the optimal value is achieved when alpha is at 0.3.

V. CONCLUSION

Based on the discussion regarding the analysis of dynamic mobile satellite channels in MEO orbits using the overlap and overlay cell beam approaches. Employing the overlay cell structure resulted in a 30% channel saving, while using the overlap cell structure achieved a 33% efficiency. Combining both overlap and overlay structures yielded an efficiency of 43%. The parameter of probability blocking (time congestion) is measured from the network or switching points. In this study, a target value of less than 0.01% was used, signifying only 1 failed call among 100 calls. The optimal numbers determined for microcells and macrocells in the performance of MEO satellites are 5 microcells per macrocell and 8 macrocells per spot beam of the MEO satellite. Evaluating the satellite communication system's performance based on the obtained traffic intensity reveals the ideal channels or slots lying within 5 microcells and 11 macrocells, translating to 2.5 E or accommodating approximately 100 to 150 simultaneous calls.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Anggun Fitrian Isnawati coordinated the research including conceptualization, resources, methodology, writing-review, validation, analysis and supervision; Agita Purwandani doing the administration and editing; Ade Wahyudin focused to the software/ programming and visualization; all authors had approved the final version.

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