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Design of a 5G Fixed Wireless Access (FWA) Network at 3.5 GHz Frequency in Urban Areas: A Case Study of Kambang Iwak Park, Palembang

Perancangan Jaringan 5G Fixed Wireless Access (FWA) pada Frekuensi 3.5 GHz di Area Urban: Studi Kasus Taman Kambang Iwak Palembang

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Abstrak

Penyediaan infrastruktur *fiber optic* di kawasan urban padat seperti Taman Kambang Iwak, Palembang, seringkali menghadapi kendala perizinan galian dan potensi kerusakan estetika tata kota. Teknologi *Fixed Wireless Access* (FWA) berbasis 5G hadir sebagai solusi alternatif strategis untuk menyediakan akses *broadband* berkecepatan tinggi tanpa memerlukan instalasi kabel fisik ke sisi pengguna. Penelitian ini bertujuan merancang jaringan 5G FWA menggunakan frekuensi 3500 MHz (Band n78) dengan *bandwidth* 100 MHz. Perancangan dilakukan melalui simulasi menggunakan perangkat lunak RadioPlanner 3.0 dengan model propagasi Okumura-Hatta yang disesuaikan untuk karakteristik lingkungan urban. Parameter yang dianalisis meliputi cakupan sinyal (*coverage*) berdasarkan *Reference Signal Received Power* (RSRP), *Reference Signal Received Quality* (RSRQ) dan kapasitas data (*throughput*). Hasil simulasi menunjukkan bahwa skenario perancangan dengan tiga antena sektoral mampu memberikan cakupan sinyal kategori "Baik" di area target. Secara performansi data, sistem mampu menghasilkan *throughput downlink* maksimum hingga 750 Mbps dan *uplink* berkisar antara 500 Mbps hingga 750 Mbps. Berdasarkan hasil tersebut, implementasi 5G FWA pada frekuensi 3.5 GHz terbukti layak diterapkan dan memenuhi standar kebutuhan layanan data kecepatan tinggi di kawasan Taman Kambang Iwak.

Kata Kunci: 5G, *Fixed Wireless Access* (FWA), RadioPlanner, 5G Frekuensi, Okumura-Hatta.

Abstract

The provision of fiber optic infrastructure in dense urban areas like Taman Kambang Iwak, Palembang, often faces constraints related to excavation permits and potential damage to city aesthetics. 5G-based Fixed Wireless Access (FWA) technology serves as a strategic alternative solution to deliver high-speed broadband access without requiring physical cable installation to the user's premises. This study aims to design a 5G FWA network utilizing the 3500 MHz frequency (Band n78) with a 100 MHz bandwidth. The design was conducted through simulation using RadioPlanner 3.0 software with the Okumura-Hatta propagation model tailored for urban environmental characteristics. Analyzed parameters included signal coverage based on Reference Signal Received Power (RSRP), Reference Signal Received Quality (*RSRQ*) *and data capacity (throughput). Simulation results indicate that the design scenario using three sectoral antennas is capable of providing "Good" category signal coverage in the target area. In terms of data performance, the system achieves a maximum downlink throughput of up to 750 Mbps and uplink ranging from 500 Mbps to 750 Mbps.* ***(Discussion)*** *Based on these results, the implementation of 5G FWA at the 3.5 GHz frequency is proven feasible and meets the standards for high-speed data service requirements in the Taman Kambang Iwak area..*

Keyword: Fixed Wireless Access (FWA), *RadioPlanner, 5G Frequency, Okumura-Hatta.*

1. Introduction

The design of 5G Fixed Wireless Access (FWA) networks operating at the 3.5 GHz frequency band in urban environments requires a comprehensive approach to meet the challenges and increasing demand for high-capacity connectivity. FWA technology is expected to deliver high-speed internet services with low latency and wide coverage, particularly in areas where fiber-optic infrastructure is difficult to deploy [4], [2]. This is further supported by techno-economic studies showing that FWA at 3.5 GHz represents a feasible solution for densely populated urban regions such as Tangerang [8].

One of the key aspects of network design is the selection of an appropriate propagation model. Farré *et al*. demonstrated that the use of 3GPP and Ray-Tracing propagation models in network simulations provides more accurate path-loss estimations in urban environments [4]. Studies on 5G path loss at the 3.5 GHz mid-band also indicate that the choice of propagation model such as SUI and CI significantly affects coverage predictions and signal quality [7]. The complex characteristics of urban areas, including high-rise buildings, dense user concentration, and physical obstructions, greatly influence overall network performance [4].

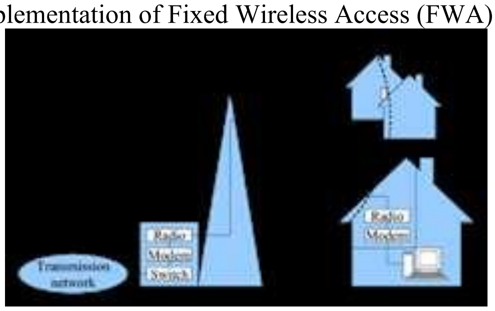
The 3.5 GHz band serves as one of the primary spectrums for 5G deployment due to its balanced trade-off between coverage and capacity, making it suitable for both mobile broadband and FWA applications. Field measurements on 3.5 GHz standalone deployment demonstrate that throughput performance remains satisfactory even in highly congested environments such as stadiums [3]. Another study on simulated 5G deployment in central Jakarta also confirms that the 3.5 GHz band delivers stable performance under dense-urban scenarios [9].

In urban contexts, efficient spectrum utilization is essential to mitigate inter-system interference. Solutions capable of delivering fiber-like broadband speeds have become increasingly important for urban communities, and FWA is considered a viable alternative to meet this demand [2]. Moreover, the integration of 4G and 5G through spectrum re-allocation highlights that precise frequency planning plays a critical role in ensuring service quality [5]. A comparative analysis of 5G NR coverage at 3.5 GHz and 26 GHz in industrial zones further shows that the mid-band offers superior wide-area coverage, reinforcing the suitability of 3.5 GHz for FWA networks [10].

As the demand for 5G continues to grow, efficient antenna design also becomes an essential consideration. The implementation of Yagi-Uda antenna arrays for mid-band frequencies can enhance transmission power and signal reception quality in dense urban areas [6]. Additionally, studies addressing design challenges and solutions in MIMO systems provide valuable insights for developing antennas capable of improving the capacity and reliability of 5G FWA deployments [1].

Overall, this study provides a solid foundation for further development of FWA systems operating at 3.5 GHz, particularly in urban areas where accurate propagation modeling, efficient spectrum utilization, and optimal antenna design are critical for achieving reliable and high-performance 5G connectivity.

The Kambang Iwak Area in Palembang City represents an urban zone with high levels of community activity. This region encompasses public parks, residential areas, hotels, office buildings, and entertainment centers. The demand for fast and stable internet access is essential in this area. However, deploying fiber-optic networks presents challenges: excessive overhead fiber cables can disrupt the aesthetic quality of the Kambang Iwak city park, while underground fiber infrastructure development also faces limitations. Therefore, a more efficient, rapid-deployment, and fiber-comparable connectivity solution is needed. One potential approach to address this challenge is the implementation of Fixed Wireless Access (FWA).

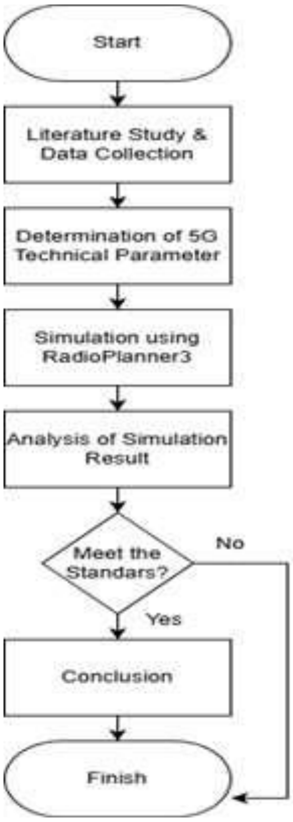


Gambar 1. 1 Cara kerja *Fixed Wireless Access*

Fixed Wireless Access (FWA) is a broadband access technology that utilizes wireless connectivity to link customer premises to the wider internet. FWA employs wireless devices that operate similarly to small cellular base stations to deliver high-speed internet services to homes and businesses [2]. To function effectively, an FWA system transmits signals from a base station to Customer Premises Equipment (CPE) installed at the user's residence or office. In several newer-generation FWA implementations, dedicated broadband modems are used, enabling operation independent of conventional telephone networks. This configuration supports significantly higher data rates compared to traditional wired connections. By utilizing radio-wave transmission, FWA can offer substantial bandwidth capacity without relying on physical cable infrastructure [3].

This study aims to design and analyze the performance of a 5G FWA network in the Kambang Iwak Park area. The network design is carried out using RadioPlanner 3 software with the Okumura–Hatta propagation model, adapted for urban environments. The performance parameters evaluated include signal coverage through Reference Signal Received Power (RSRP), signal quality using Reference Signal Received Quality (RSRQ), and estimated data throughput for both downlink and uplink directions. The findings of this study are expected to provide technical recommendations for the implementation of a reliable wireless broadband network in densely populated areas without compromising environmental aesthetics.

2. Materials and Method



Gambar 2. 1 Flowchart Penelitian

2.1 Research Area and Simulation Tools

Gambar 2. 2 Research Area

The Kambang Iwak Besak area is located in Palembang City, South Sumatra Province. This area represents an urban environment with a relatively high population density. It consists of a city park, schools, residential zones, hotels, and various public facilities. According to data from the Central Bureau of Statistics (BPS) of Palembang City in 2021, the Bukit Kecil District has a population of 38,439 inhabitants, with the research area covering approximately 459,607 m². The average elevation of Palembang City is around 8 meters above sea level, with a generally flat topography. These characteristics make the implementation of Fixed Wireless Access (FWA) technology highly suitable, given the dense population and environmental structure that supports optimal signal propagation.

Gambar 2. 3 BTS Location

The location of the BTS used in this study is situated at –2.9922178691014314 latitude and 104.74729678857251 longitude. This BTS site corresponds to an existing tower that is physically present at the specified location.

The simulation tool used in this study is RadioPlanner 3. RadioPlanner3 is a radio network planning software designed to model, analyze, and visualize signal coverage for wireless communication systems. The software is commonly utilized for LTE/4G and 5G network planning, IoT systems (such as LoRa and NB-IoT), and professional radio systems including VHF/UHF, microwave links, and public safety communication networks. Its advanced propagation modeling and visualization capabilities make it an appropriate tool for evaluating signal coverage and network performance in urban environments.

2.2 Parameter Design

The system is designed using 5G New Radio (5G NR) technology operating at a frequency of 3500 MHz with a 100 MHz bandwidth, installed on an existing site owned by the company. The Kambang Iwak area will be covered using three sectoral antennas, each separated by an azimuth difference of 120°. The complete set of baseline design parameters is presented in the following table.

Tabel 2. 1 Parameter Design

Parameter	**Nilai**
Frequency	3500 MHz
Bandwidth	100 MHz
Radiated Power	40 dBm
Antenna Gain	17 dBi
Antenna height	40 M
Downtilt	Mechanical tilt 5°
Feeder Loss	2.5 dB
Gain Pattern	Omnidirectional

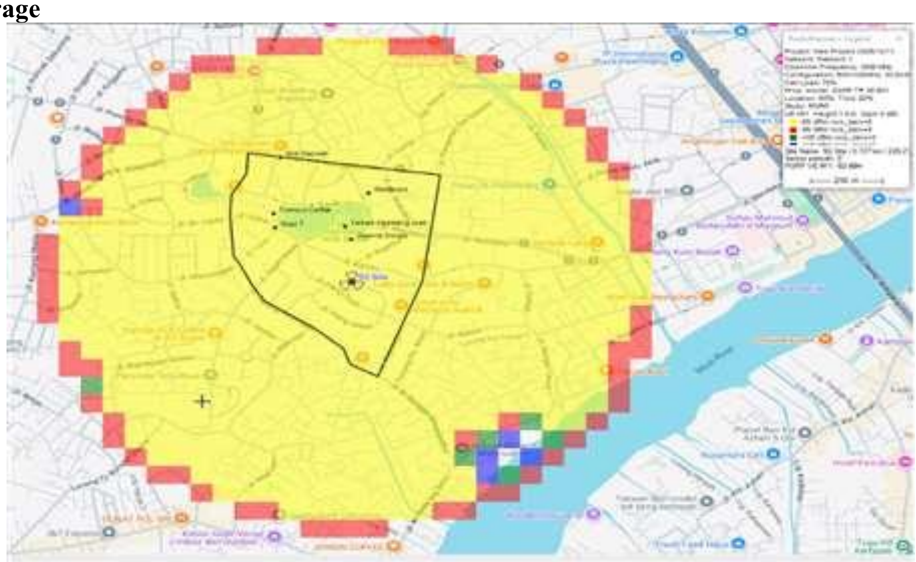
Beamwidth	360° (horizontal)
MIMO	8×8
EIRP Total	55 dBm
Modulation	16QAM
Load factor	75%
Propagation Model	3GPP TR 38.901 UMa
Environment	Urban Padat

2.3 Propagation Model

3GPP TR 38.901 defines a set of standard channel models to support the evaluation and simulation of 5G New Radio communication systems. One of the propagation scenarios defined in the document is Urban Macro (UMa), which represents an urban macrocell environment with complex geometric characteristics and environmental structures. According to Zhu *et al*, the UMa scenario describes conditions where the base station is placed at a height of approximately 25 meters above ground level—typically on a rooftop—while the user device is located at a height of between 1.5 and 22.5 meters. This environment is dominated by high-rise buildings that produce multipath propagation phenomena such as reflection, scattering, and diffraction, significantly affecting channel parameters. TR 38.901 provides a Line-of-Sight (LOS) probability model, a path loss model, and fading parameters specifically designed to reflect propagation conditions in macro-scale urban areas. Thus, the UMa scenario serves as a formal and standardized representation of radio channels in dense urban areas, and serves as a primary reference in link-level and system-level performance analysis for 5G NR technology [6] .

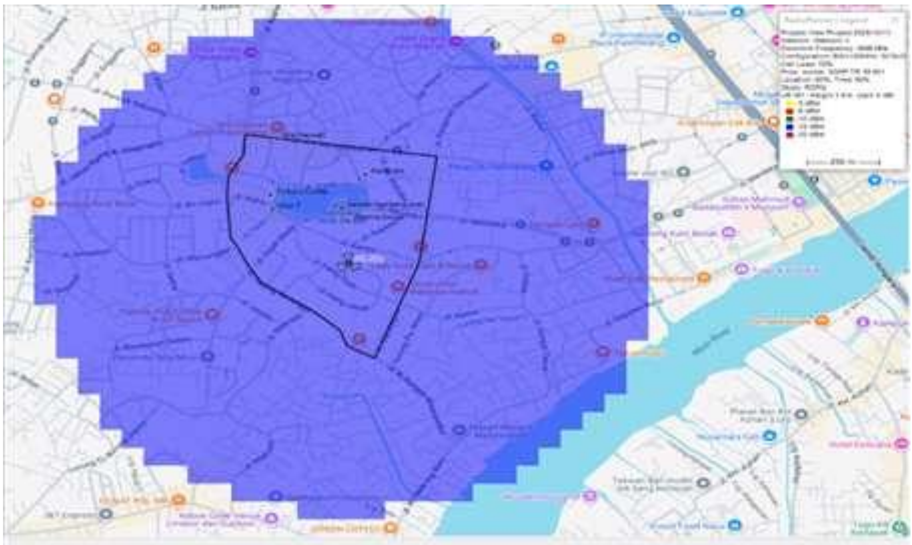
3. Results and Discussion

3.1 Coverage



Gambar 3. 1 RSRP Simulation

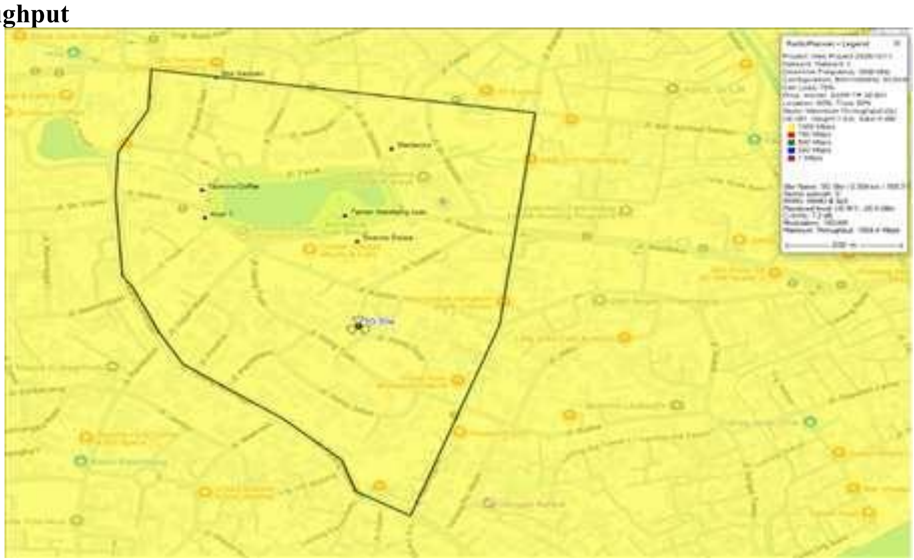
Based on the simulation results, the received signal strength in research area is classified as Excellent, indicated by the yellow region with values ≤ -85 dBm. While the outermost area of BTS coverage has an RSRP ranging from -95 dBm to -105 dBm, there are specific areas—particularly those located along the river—that display RSRP values ≥ –105 dBm.



Gambar 3. 2 RSRQ Simulation

Based on the RSRQ simulation results for the 5G FWA network in the Kambang Iwak area, the signal quality distribution appears relatively uniform across the entire coverage region. The simulation map indicates that most areas fall within the –15 dB to –10 dB range, which corresponds to Fair to Good signal quality levels according to standard RSRQ classifications. This consistency in RSRQ values is primarily due to the system configuration, which utilizes a single type of User Equipment (UE) with fixed parameters in the RadioPlanner software, resulting in minimal variation in measured signal quality between different locations. Additionally, high user density and potential inter-cell interference within the urban environment may contribute to the moderate RSRQ levels observed in the simulation. Overall, the results indicate that the 5G signal quality in the study area remains within an acceptable range for Fixed Wireless Access services, although further optimization—particularly in interference management and uplink quality improvement—may enhance network performance.

3.2 Throughput



Gambar 3. 3 Throughput Downlink

Based on the simulation data, the entire study area achieves a uniform throughput performance of more than 1000 Mbps. This result was obtained from experiments conducted using user equipment positioned at a height of 1.5 meters and operating with 16QAM modulation. The maximum throughput observed in the simulation reaches 1069.6 Mbps.

Gambar 3. 4 Throughput Uplink

Similarly, the maximum uplink throughput within the study area also exceeds 1000 Mbps, with the highest uplink throughput recorded at 1292 Mbps. These simulation results are consistent with the 3GPP theory, where the standard spectral efficiency for a 5G network is more than 7.5 bit/s/Hz, which can be calculated using the following formula:

$$R = \eta_{eff} \times BW$$

- R = *Throughput* (Mbps)
- η_{eff} = *Spectral Efficiency* (bit/s/Hz) = ≥7.5 bit/s/Hz
- BW = *Bandwidth* (MHz) = 100MHz.

Then:

$$R = 7.5 \times (100 \times 10^6)$$
$$R = 750Mbps$$

The higher-than-expected throughput obtained in the simulation can be attributed to the use of a 100-MHz bandwidth with a 60-kHz subcarrier spacing, combined with idealized PHY-layer assumptions such as high MCS levels, minimal interference, and negligible control-channel overhead, all of which collectively result in peak throughput values that exceed those typically reported in the literature.

3.3 Customer Premises Equipment (CPE) Validation

CPE Name	Radio Equipment
Hotel Swama Dwipa	FastMile 5G Gatew...
Kopi 7	FastMile 5G Gatew...
Tomoro	FastMile 5G Gatew...
Starbucks	FastMile 5G Gatew...
Mie Gacoan	FastMile 5G Gatew...
Taman Kambang Iwak	FastMile 5G Gatew...

Gambar 3. 5 CPE Locations

In this study, several locations were selected as CPE installation points. These locations were chosen due to their relatively high population density and the correspondingly high demand for internet services.

Gambar 3. 6 RSRP Customer Premises Equipment

Based on the simulation results, the RSRP values of all CPEs located within the research area fall within the Excellent category, with RSRP levels better than –85 dBm, as indicated by the six yellow-marked CPE points.

Gambar 3. 7 RSRQ Customer Premises Equipment

The simulation results for all six CPEs show similar RSRQ values, falling within the Fair to Poor category, ranging from –15 dB to –35 dB. This degradation in signal quality can be attributed to several factors, including high inter-cell interference and a high network load, as the base station load was configured at 90% during the simulation.

Gambar 3. 8 Maximum Throughput Downlink Customer Premises Equipment

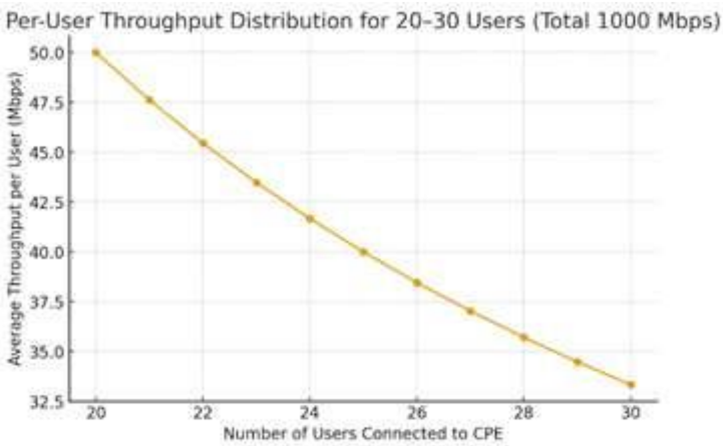
The simulation results show that all CPE locations achieve similar downlink throughput values despite being situated at different points within the coverage area. The downlink throughput for all six CPEs is more than 1000 Mbps, indicating that the system is capable of delivering high-performance broadband consistently across the deployment area.

Gambar 3. 9 Maximum Throughput Uplink Customer Premises Equipment

For the uplink throughput, all six CPEs also exhibit similar performance levels, with uplink speeds more than 1000 Mbps. Achieving optimal throughput requires the received RSRP to be within a favorable range, specifically better than –95 dBm.

Assuming that each CPE serves approximately 20–30 connected users, the estimated per-user throughput is as follows:

1. Downlink Estimated User Throughput: 50–33 Mbps
2. Uplink Estimated User Throughput: 50–33 Mbps



Gambar 3. 10 User Distribution

These values indicate that the network is capable of supporting high-speed broadband applications even under multi-user load conditions.

4. Conclusion

Based on the results of the design and simulation of the Fixed Wireless Access (FWA) network using 5G NR technology operating at 3500 MHz with a 100 MHz bandwidth in the Kambang Iwak area of Palembang City, several conclusions can be drawn as follows:

1. The 3GPP TR 38.901 propagation model used in the simulation produced Excellent RSRP values for urban environments such as the Taman Kambang Iwak area.
2. The RSRQ values exhibit minimal variation across the entire study area. This behavior is likely due to the limitations of the RadioPlanner software, which allows the simulation to be sampled using only a single type of User Equipment (UE), resulting in uniform quality measurements.
3. The maximum achievable throughput, both downlink and uplink, reaches optimal theoretical values. The estimated per-user throughput ranges from 50–33 Mbps (downlink) and 50–33 Mbps (uplink), assuming that each CPE serves 20 to 30 users.

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