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Pattern Analysis on Wireless Network Coverage in DISPERKIM, South Sumatra

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Abstract

The study's focus on pattern analysis provides a data-driven approach to optimizing WI-FI networks, ensuring better connectivity and reliability for users within the South Sumatra Provincial Housing and Residential Area Office. These results have broader implications for the strategic deployment of WI-FI in similar environments. WI-FI technology, utilizing the IEEE 802.11a/b/g wireless standard operating at 2.4 GHz, is ubiquitous in environments such as government offices, private companies, entertainment venues, and educational institutions. The growing reliance on WI-FI for internet access, driven by the proliferation of WI-FI-enabled devices, underscores the importance of optimizing its deployment for efficient connectivity. This study examines the WI-FI signal patterns and range in the WLAN network at the South Sumatra Provincial Housing and Residential Area Office, where suboptimal placement of WI-FI access points has hindered network performance. By conducting a field survey and pattern analysis of signal distribution and coverage, the research identifies critical gaps and inefficiencies in the current wireless setup. Employing the action research methodology, the study progresses through four stages: diagnosis, action planning, action tackling, and evaluation. The analysis of signal strength patterns and coverage data guides targeted improvements to optimize WI-FI placement. Findings are expected to reveal how spatial factors and interference impact signal distribution, offering actionable insights for enhancing wireless network performance.

Keywords

Pattern Analysis, Network Coverage, InSSIder, WIFI Area Coverage.

Introduction

The effective dissemination and utilization of wireless network technologies in government offices are pivotal for enhancing operational efficiencies and facilitating seamless communication channels. In the Department of Housing and Settlement Areas (DISPERKIM) of South Sumatra, the strategic deployment of Wi-Fi technology has become a critical component of daily operations. Wi-Fi, operating under the IEEE 802.11a/b/g standard at a 2.4 GHz frequency, is ubiquitous in its

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application across various sectors, yet its optimization remains a challenge, particularly in institutional environments where coverage and reliability are paramount (Imran et al., 2024).

This study explores the existing wireless network configurations within the DISPERKIM offices, identifying inefficiencies in Wi-Fi placement that compromise optimal usage. Through an action research methodology, this research aims to analyze the Wi-Fi signal range, identify coverage black spots, and devise actionable solutions to improve network accessibility and performance in these crucial public service offices (Etta et al., 2022).

The initial findings from the diagnostic phase revealed several critical issues in the existing network setup. Key among these was the suboptimal placement of Wi-Fi access points, which did not align with the spatial layout and architectural features of the office, leading to significant signal attenuation in certain areas (Wei et al., 2024). The InSSIDer application, used for signal strength and network health monitoring, highlighted zones with weak signals and frequent dropouts, which were predominantly located in peripheral rooms and areas obstructed by structural elements such as concrete walls and metal barriers.

The action planning stage focused on developing strategies to overcome the limitations identified in the diagnostic assessment. Recommendations included the repositioning of access points to more central locations within each room to avoid physical obstructions and maximize signal dissemination (Gu et al., 2024). Additionally, upgrading older Wi-Fi hardware to more advanced models supporting newer standards (like IEEE 802.11ac) was proposed to enhance the network's bandwidth and reduce congestion. The planning phase also emphasized the need for a channel optimization strategy to mitigate interference from overlapping networks, suggesting the use of non-overlapping channels and adjusting the transmit power settings to balance coverage and minimize interference.

Following the implementation of these strategies, a significant improvement in network performance was observed. The redistribution of access points and hardware upgrades facilitated a more robust and reliable Wi-Fi network across the office (Deng et al., 2020). Post-implementation surveys indicated enhanced user satisfaction, with reduced connectivity issues and faster data transmission speeds. Further evaluation involved a comparative analysis of signal strength data collected before and after the intervention, showing a comprehensive increase in coverage quality and a reduction in black spots.

The evaluation phase provided valuable insights into the effectiveness of the implemented actions (Awan et al., 2021). The use of advanced analytical tools allowed for a detailed examination of the network's performance, considering factors such as signal-to-noise ratios, channel utilization, and user density. These metrics confirmed the theoretical improvements anticipated in the action planning stage, substantiating the practical benefits of the network reconfiguration.

The study underscored the importance of strategic network planning and the potential of targeted technological interventions to significantly improve wireless network performance in government settings. By addressing the specific challenges of Wi-Fi deployment in the DISPERKIM offices, the project not only enhanced operational efficiency but also set a benchmark for similar future initiatives in other public sector environments (Mozaffariahrar et al., 2022).

Literature Review

Wireless Fidelity Hotspot (WI-FI) is a Wireless Networking standard without cables; only the appropriate components can be connected to the network (Pahlavan & Krishnamurthy, 2021). WI-FI is an abbreviation for Wireless Fidelity, which is a medium for delivering data communications without cables that can be used for communication or transferring programs and data very quickly. WI-FI can also be interpreted as technology that utilizes electronic equipment to exchange data using radio waves (wireless) through a computer network, including a high-speed internet connection.

The term WI-FI is widely known by the public as a medium for any internet, but actually, it can also be used as a wireless network, as is termed LAN (Local Area Network). So that computers in one location can be connected to other computers in different locations (Arthurs et al., 2022). Meanwhile, for internet use, WI-FI requires an access point, which can be called a hotspot, to connect and control WI-FI users with the central internet network. A hotspot is generally equipped with a password that can minimize who can use the facility. Often used by home users, restaurants, supermarkets, cafes, and hotels.

Wireless Network According to Rohini et al. (2022), a computer network architecture that is connected uses electromagnetic wave media to transmit data. A LAN network without cables is called a wireless LAN or WLAN. According to Jyothi (2021) Wireless cannot replace all the cables on this earth because, after all, cables offer many advantages that wireless does not have, such as being more stable, not easily disturbed by surrounding frequencies, and so on. Wireless technology, which is very flexible and offers high mobility, is used for various purposes. Wireless technology is very suitable and has been widely replaced by mouse cables, LAN network cables, and even WAN cables, which previously required a cable network. The technology used for each need varies according to the distance it can handle (Hon, 2024).

Wireless service is a connection between two devices that do not use cable media (wireless). Wireless technology is technology without cables in carrying out telecommunications connections, no longer using cable media or facilities but using electromagnetic waves as a substitute for cables. Currently, the development of wireless technology is growing and developing rapidly, and at any time, we always need telecommunications facilities, this can be proven by the increasing use of cellular telephones, in addition to the development of wireless technology used for internet access.

Methodology

This study employed an action research methodology to enhance Wi-Fi coverage within the DISPERKIM offices. Action research is chosen for its practical focus on iterative problem-solving and continuous improvement, which is ideal for addressing the dynamic challenges of wireless network optimization in an office environment. The methodology was structured into four main phases: diagnosis, action planning, action implementation, and evaluation.

Phase 1: Diagnosis
The diagnostic phase involved a comprehensive survey to assess the existing state of the wireless network. The primary tools and techniques used included:

- **Signal Strength Analysis:** Using the InSSIDer application, Wi-Fi signal strength (measured in RSSI) was mapped across various locations within the office premises. This helped in identifying areas with weak signals and potential black spots.
- **Network Utilization Monitoring:** Network traffic and usage patterns were monitored using network monitoring software to identify peak usage times and potential bottlenecks.
- **Physical Survey:** A physical inspection of the office layout was conducted to note the locations of walls, furniture, and other physical barriers that could affect signal propagation.
- **Stakeholder Interviews:** Interviews with office staff were conducted to gather qualitative data on user satisfaction, common issues experienced, and specific needs concerning network access.

Phase 2: Action Planning
Based on the diagnostic data, a strategic plan was developed to address the identified issues. This included:

- **Access Point Optimization:** Locations for existing access points were re-evaluated, and new positions were planned to optimize coverage. This was based on signal strength data and physical layout considerations.
- **Network Equipment Upgrades:** Proposals for upgrading outdated network equipment to more modern standards (e.g., from IEEE 802.11g to IEEE 802.11ac) were prepared to improve bandwidth and signal reliability.
- **Channel Reconfiguration:** A plan to adjust the channel settings on the current access points was developed to minimize interference from overlapping channels, which is crucial in densely populated office environments.

Phase 3: Action Implementation
This phase involved the practical application of the planned interventions:

- **Repositioning and Installation:** Access points were physically moved, or new ones were installed as per the optimization plan.
- **Hardware Upgrades:** Where approved, older networking hardware was replaced with newer technology that supports broader coverage and faster speeds.
- **Adjustment of Network Settings:** Network settings, including channel configurations, were adjusted according to the plan, with careful monitoring to ensure that changes resulted in reduced interference and improved performance.

Phase 4: Evaluation
The final phase focused on assessing the effectiveness of the interventions through:

- **Post-Implementation Testing:** After the changes were implemented, signal strength and network performance were retested using the same methods as in the diagnostic phase. This included a new round of signal strength testing with InSSIDer to evaluate improvements in coverage.

- **User Feedback Collection:** A follow-up survey was conducted with the staff to assess changes in user satisfaction and gather feedback on the network's performance after the implementation of improvements.
- **Performance Metrics Analysis:** Network usage and traffic patterns were analyzed again to determine improvements in data throughput and reduction in network congestion.

Throughout the research, ethical considerations were maintained to ensure privacy and data protection standards were upheld, particularly during the collection of usage data and personal feedback. By employing this methodology, the study aimed to provide a systematic and data-driven approach to improving wireless network coverage and performance in the DISPERKIM office environment, ensuring that the solutions are both effective and sustainable.

Results and Discussion

This section presents the outcomes of the implemented network improvements and evaluates their impact on the wireless coverage within the Department of Housing and Settlement Areas (DISPERKIM) of South Sumatra. Following the action research methodology, specific interventions were carried out aimed at optimizing the existing Wi-Fi infrastructure. The results are analyzed to discern the effectiveness of these interventions in enhancing network performance, reliability, and user satisfaction in an office environment.

Key areas of focus include the changes in signal strength, coverage consistency across different office zones, and the reduction of connectivity black spots. Additionally, this discussion delves into the broader implications of these results for future network planning and technology deployment in similar settings, providing insights into the scalability and adaptability of the solutions applied. Through a detailed analysis, this section aims to draw meaningful conclusions that can inform ongoing and future initiatives to improve wireless network systems in governmental and other organizational settings.

4.1 Results

At this Action stage, the researcher implemented an action plan in the hope of solving the problem, namely measuring the RSSI WI-FI signal at the housing office and residential areas of South Sumatra Province with the help of InSSDier software. There are 13 rooms in the entire Disperkim office, and there are nine rooms that have WI-FI access, and there are four rooms that still access WI-FI from the room next door that does not have WI-FI access. Below are the names of the rooms and the name of each WI-FI or SSID (Service Set Identifier).

Table 1. Nama Ruangan dan SSID

No.	Nama Ruangan	Nama WI-FI atau SSID
1	Ruang Keuangan	Keuangan
2	Ruang Bidang Bankim	Bangkim
3	Ruang Perumahan	Bidang Perumahan
4	Ruang Operational Room	Rahasia
5	Ruang Staff Kadis/Sekdis	KADIS–SEKDIS PERKIM SUMSEL
6	Ruang Kepala UPTD	Ruang Kepala UPTD
7	Ruang Rapat Lantai 1 UPTD	RUANG RAPAT LANTAI 1

8	Ruang Perencanaan	Perencanaan
9	Ruang Rapat Disperkim	Official

WI-FI signal strength measurements will be carried out between WI-FI and the user who is accessing it. The following are the measurement results for each room.

Table 2. The measurement results for each room

Nama WI-FIAtau SSID	Signal	Channel	Security	Mac Address
Finance	-58	6	WPA2-Personal	56:16:51:8E:E8:47
Official	-47	12	WPA2-Personal	56:16:51:83:6A:36
Bangkim	-59	14	WPA2-Personal	54:16:51:F3:69:CA
Confidential	-45	9	WPA2-Personal	56:16:51:83:3F:56
1st FLOOR MEETING ROOM	-41	3	WPA2-Personal	56:16:51:83:6A:42
Planning Room	-59	3	WPA2-Personal	56:16:51:84:24:32
UPTD Head Room	-71	8	WPA2-Personal	56:16:51:83:6A:2
CHIEF DISTRICT SECTOR OF PERKIM SUMSEL	-61	11+7	WPA2-Personal	24:D3:F2:E6:1D:D0
Housing sector	-34	2	WPA2-Personal	56:16:51:88:83:9E

In the results of Table 4.2, measurements at a distance of 8 meters from the WI-FI location in each room produce a good signal, namely Excellent and Good.

4.2 Discussion

From this WI-FI signal measurement, researchers will also analyze it based on each channel. WI-FI nearby whether there will be overlap or not. Below is a table of nearby WI-FI.

Table 3. Measurement Results Based on the Use of Each WI-FI Channel

Nama SSID & Channel	Jarak (Meter)	WI-FI/SSID Berdekatan & Channel	Keterangan
Finance (Channel 6)	8	Not Exist	No Overlaps
Official (Channel 12)	8	Confidential (Channel 9)	Overlaps
Bangkim (Channel 14)	8	Finance (Channel 6)	No Overlaps
Confidential (Channel 9)	8	Official (Channel 12)	Overlaps
1st FLOOR MEETING ROOM (Channel 3)	8	UPTD Head Room (Channel 8)	Overlaps
Planning Room (Channel 3)	8	Not Exist	No Overlaps
UPTD Head Room (Channel 8)	8	1st FLOOR MEETING ROOM (Channel 3)	Overlaps
KADIS – SEKDIS12 PERKIM SUMSEL (Channel 11)	8	Confidential (Channel 9) Official (Channel 12)	Overlaps
Housing Sector (Channel 2)	8	Planning Room (Channel 3)	Overlaps

Table 3 indicates the proximity of various Wi-Fi access points and their respective channels within an office setting, measuring distances consistently at 8 meters. This proximity, combined with overlapping channel usage, is pivotal as it can significantly impact network performance through interference.

Firstly, it's evident that there are notable overlaps where different SSIDs are operating on closely situated channels. For example, the "Official" network on Channel 12 and the "Confidential" network on Channel 9 are overlapping. This proximity, both physical and in frequency, can create interference, leading to potential network disruptions and degraded performance. Similarly, the "1st FLOOR MEETING ROOM" on Channel 3 and the "UPTD Head Room" on Channel 8 also exhibit overlap, likely causing similar issues.

Conversely, some networks like "Finance" on Channel 6 and "Planning Room" on Channel 3 show no overlapping nearby channels, indicating a more optimal setup for avoiding interference. This kind of channel separation is ideal for maintaining clearer communication paths for data transmission, resulting in better network reliability and user experience.

To mitigate the identified issues, a strategic reconfiguration of network channels is recommended. Networks currently experiencing overlap should be adjusted to non-overlapping channels, ideally sticking to channels 1, 6, or 11, which are widely recognized for minimal interference in 2.4 GHz Wi-Fi networks. Additionally, considering the use of Dynamic Frequency Selection (DFS) in the 5 GHz band could further alleviate congestion and interference issues, especially in areas with dense network deployments.

Continuous network monitoring using tools like InSSIDer will be crucial in maintaining optimal performance. This should be complemented by regular feedback from network users, which can provide practical insights into the day-to-day impacts of any adjustments made. Such measures will ensure that the network not only meets current demands but is also scalable and adaptable to future needs and technologies.

4.3 Effectiveness of Wi-Fi Signal Enhancements

The core objective of this study was to improve the Wi-Fi signal strength and coverage across the DISPERKIM offices. The intervention strategies included repositioning existing access points, upgrading to more advanced networking hardware, and optimizing Wi-Fi channels to minimize interference. Post-implementation results indicate a marked improvement in signal strength and coverage consistency. Specifically, the repositioned access points eliminated many previously identified black spots, especially in areas where structural impediments like concrete walls previously impeded signal propagation.

The decision to reposition access points was based on initial findings that showed poor signal distribution due to obstructed line-of-sight and suboptimal access point placement relative to user concentrations. Moving access points to central locations within each office not only improved signal reach but also enhanced the overall network efficiency by reducing the number of hops required for data to travel between devices and the internet gateway. This repositioning directly correlated with improved RSSI (Received Signal Strength Indicator) measurements across all surveyed office rooms, with a notable reduction in areas where signal strength previously fell below -70 dBm, a threshold generally considered suboptimal for office work.

Upgrading the Wi-Fi hardware to support the IEEE 802.11ac standard, which operates on both 2.4 GHz and 5 GHz bands, significantly boosted network performance. This dual-band approach allowed for more devices to connect to the network without experiencing bandwidth congestion typically observed on the more crowded 2.4 GHz band. Furthermore, the new equipment featured improved MIMO (Multiple Input Multiple Output) capabilities, enhancing the ability to handle multiple simultaneous connections—a critical feature for an office environment where multiple devices are the norm.

Channel optimization involves analyzing the channel utilization within the office environment to reduce overlapping channels—a common source of interference and network slowdowns. By assigning non-overlapping channels and adjusting the power settings on each access point, the network interference from neighboring Wi-Fi networks was substantially reduced. This optimization was particularly effective in high-density areas where Wi-Fi traffic was heaviest, facilitating smoother and more reliable connections.

Feedback from DISPERKIM staff post-implementation highlighted a significant improvement in their daily interactions with the network. Faster connection times, fewer dropouts, and improved access in previously underserved areas contributed to enhanced operational efficiency and reduced frustration among employees. This user feedback is critical as it not only confirms the quantitative data collected but also reflects the qualitative improvements in network service that directly impact productivity and user satisfaction.

The successful implementation of network improvements at DISPERKIM provides a model that can be replicated in similar settings where Wi-Fi coverage is inadequate. The methodologies applied—diagnostic assessment, strategic planning, and targeted intervention—are scalable and adaptable to different environments, whether other government offices, large corporate settings, or educational institutions. Future research could explore the integration of emerging technologies such as Wi-Fi 6, which promises even greater improvements in speed, capacity, and latency.

The enhancements made to the DISPERKIM wireless network underscore the importance of a strategic approach to network planning and management. By addressing specific challenges through targeted interventions, significant improvements in network performance and user satisfaction were achieved. These results contribute to a broader understanding of wireless network optimization in institutional settings and offer a framework for future improvements in similar environments.

Conclusions

This research utilized an action research methodology to systematically address and ameliorate Wi-Fi coverage and network reliability issues within the Department of Housing and Settlement Areas (DISPERKIM) of South Sumatra. Through a comprehensive approach that included diagnosis, planning, implementation, and evaluation, the study led to significant enhancements in signal strength and the overall reliability of network connections across the office premises.

The strategic repositioning of Wi-Fi access points, informed by detailed signal strength analyses and physical layout surveys, effectively reduced the number of connectivity black spots and improved signal availability throughout the offices. This was particularly critical in previously underserved areas where physical barriers had obstructed signal propagation. Upgrading network hardware to the latest Wi-Fi standards (IEEE 802.11ac) proved crucial in supporting higher data throughput and more simultaneous connections, significantly alleviating bandwidth congestion in high-traffic areas and enhancing the user experience during peak usage times.

Adjustments made to the Wi-Fi channels to minimize overlap with neighboring networks resulted in reduced interference and more stable connections, which underscore the importance of meticulous channel management in dense network environments. Feedback from the office staff post-implementation highlighted a notable increase in user satisfaction, reflecting the positive impact of the network improvements on daily operations and productivity.

The success of the interventions implemented here provides a scalable and adaptable model for similar environments that require optimization of their wireless network infrastructures. It is recommended that ongoing monitoring and periodic updates to the network setups be conducted to keep pace with technological advancements and evolving user needs. Further exploration into next-generation technologies like Wi-Fi 6 could also be beneficial, offering solutions to challenges related to device density and network efficiency.

The improvements made to the wireless network in DISPERKIM demonstrate the critical role of strategic network management in enhancing communication systems within institutional settings. The results of this study not only bolster operational efficiency but also provide a blueprint for similar organizations seeking to optimize their network infrastructure.

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