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An Optimized Wireless Network Architecture for Department of Agriculture

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Abstract. In the emergence of the highly connected Internet of Things (IoT) and the rise of wireless network technologies, organizations are confronting expanded wireless network capability, stability, and reliability. Each organization that aims to manage wireless network services that customers and employees request must be robust, secured, and easy to manage; henceforth, optimized wireless network architecture ought to be a top priority. This study developed the optimized wireless network architecture for the Department of Agriculture, Region 1 to further provide a robust, more secure, and reliable wireless network design using a Prepare, Plan, Design, Implement, Operate and Optimize methodology. The comparative and evaluative research design was used to determine the wireless network status of the current wireless network design of the Department of Agriculture, Region 1 into other agencies' wireless network designs and standards, and the testing and implementation of the optimized wireless network architecture. Wireless network simulation and the wireless network design results are interpreted using the Received Signal Strength Level (RSSL) and service coverage area. The optimized wireless network architecture testing shows that it is reliable, stable, robust, and secured, applicable in the agency.

Keyword: Optimized Wireless Network Architecture, Received Signal Strength, Prepare, Plan, Design, Implement, Operate and Optimize design

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1 Introduction

Tablets, smartphones, and laptops have recently taken over the world. They have successfully replaced wired devices such as desktop computers, land phones, and other devices driven by wired technologies. These technologies have distanced themselves from wired technologies, which has given rise to the term "wireless." Wireless technology covers radio frequencies and signals for data transmission rather than the conventional mode of data transmission via cables and likes. Today's enterprise organizations depend on stable, secure, and reliable wireless networks to keep their day-to-day operations [1]. With cutting-edge wireless technology, high

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availability Wireless Local Area Network (WLAN) is more common than ever. All wireless technology has a reference model that is a conceptual and logical model that states network communication used by the internal system is open to communication and interconnection to another system. It also delineates a logical network system and effectively defines computer packet transfer using different layers and protocols. Layer 1 is all about moving, making, and storing 1's and 0's, called bits. It explains how layer 7 data is turned into 1's and 0's to be transmitted into a medium. The said medium is such as interface specifications and cablings. Layer 2 defines a lower level addressing responsible for converting the logical identifier case of Transmission Control Protocol Internet Protocol (TCP/IP), an Internet Protocol address, to a physical identifier. This is to be used between end systems, and the checksums and lower level framing are spread onto Layer 1 of the OSI Layer. Token Ring, Ethernet, and Frame Relay are examples of Data Link Layer or Layer 2 [2]. Whereas network layer or Layer 3 is concerned with the packets within a communication channel, this includes the delivery of the data packets. The network layer defines the addressing structure of the internetwork, and the data packets should be transmitted to and between end systems [3].

Wireless Local Area Networks (WLANs) are currently being used to complement wired Local Area Network (LANs) in many commercial and educational organizations worldwide. For instance, New Zealand universities set up Wireless Local Area Networks in their library and other study areas where wireless users can connect their laptops and notebooks to access their Intranet and the Internet. With the exponential growth of mobile computers and devices, such as personal digital assistants (PDAs), iPhones, and mobile phones, Wireless Local Area Networks are becoming increasingly essential as a means of data exchange, for example, Wi-Fi Internet services in London, Auckland City, Paris, and the New York, USA metropolitan area, Wi-Fi in android smartphones, Wi-Fi for vehicular ad hoc networks (VANETs), and large and medium-scale Wi-Fi networks deployed in urban areas [4]. Some other wireless network includes sensors. They call it Wireless Sensor Network (WSN), but its characteristics in terms of computing, memory, and energy are limited, so a routing protocol that supports Wireless Sensor Network performance is needed[5].

In Moscow[6], Russia, the wireless network architecture has joined the World's top 3 by the number of free wireless access points. It can be seen that Moscow surpassed some megacities of the world, such as London, New York, and Tokyo. Wireless network architecture connections profited and aided thousands of Russians, tourists, and guests in education, disaster relief, digital literacy, promotion, and tourism. Wireless network architecture is commonly installed in their libraries, streets, parks, student hostels, and cultural centers of Moscow, and there are now more than 18,000 wireless access points that provide free and unlimited Internet. Three thousand (3,000) of these wireless access points have been installed on streets within the Garden Ring and some other locations within the Third Transport Ring, which covers most of the city center, more than 1,200 managed Wi-Fi points in 43 city parks, over 10,500 in college and university hostels including nearly 3,500 in cultural facilities. The government of Moscow said they would continue to develop their Wi-Fi network architecture and continue to increase wireless access points in different 60 libraries, and take the total number of libraries with managed wireless Internet to almost 400. Commonly used wireless specifications include Bartec Wireless X Wi-Fi and Fujikura's cutting-edge 60 Ghzmm Wave wireless communications module.

Wireless technology needs have been rising over the years, so wireless networking seems to preponderate over wired networking design. This has been accomplished because wireless technology is not such complicated as wired technology that considers cabling design, layout, and structure in the implementation [7]. According to the requirements of a company, wireless networks are the best solutions for laptop employees who can roam everywhere in the buildings without cables because it maintains connectivity from almost anywhere, not to mention outdoors if it is desired [8]. Moreover, the scalability of the network gives the entire company the advantage of entering more new employees or guests. It must be stressed that wireless networks could have a lower cost than wired networks, such as additional wiring that will be needed as well as the infrastructure limitations under specific circumstances [9]. Therefore, all modern companies use wireless technology in addition to wired network infrastructure, especially now that all of the security issues of wireless technology have been addressed. The germinal specification used the 2.4GHz ISM radio spectrum through 802.11, 802.11b & 802.11g, which progressed using 5GHz through 802.11a & 802.11ac, not to mention the 802.11n, which communicates on both 2.4 & 5GHz frequency bands.

The wireless network architecture provides flexibility for deployment, which will lessen overall budget cost, planning tools, and time spent organizing a network in the organization. This enables the real-time monitoring of the entire wireless network infrastructure, which will decrease the total cost of unification and ownership of wired and wireless access, a future-proofing investment for upgrades. It can accurately locate and identify each wireless user[9]. Due to the Radio Frequency nature and the development of the wireless controller design, it can easily detect interference rogue devices between nearby Access Points or Wireless Connection and re-configure their channel and power and settings automatically [10]. If wireless access points go down, it can instruct nearby wireless access points to increase their power levels to fill the coverage gap.

The rendition of a wired Local Area Network as a wireless network is known as WLAN "Wireless Local Area Network". Developing an optimized wireless network design could be an in-depth wireless engineering task that has to be performed in order that the wireless network infrastructure required by the organization may be designed and created. Precise planning & designing are essential to achieve a robust, secure, and high-performance optimized wireless network architecture that could lead to easy and secured wireless network management. In the advent of the highly connected Internet of Things (IoT), wireless users populated merely, and the high rise of wireless clients constituted the increase of Access Points/Wi-Fi's in the organizations; this confronts the expanded comprehensive management to their wireless networks. Each organization that aims to deliver the services that customers and employees request must be satisfied and guaranteed full access; henceforth, wireless network design ought to be indispensable.

In Singapore, 9 Megabit per second (Mbps) recorded Singaporeans and even guests and tourists enjoyed an average speed of their wireless network architecture. Cisco and Ruckus products with dual-radio power over Ethernet (Poe) and Aironet have widely used brands and specifications for their Wi-Fi architecture. The wireless access points were commonly deployed and installed in their public places. Singapore's wireless services actually overtook half of the developed countries with free Wi-Fi. They expected to double its hotspots to about 20,000 by the coming years. Singapore is the second country with the fastest Wi-Fi connectivity, and we will find and enjoy government-enabled free Wi-Fi network services at almost all tourist places. Under the protection of Wireless@SG, they aim to equip and deploy all public places with free Wi-Fi through numerous hotspots [10].

In France, a resilient Wi-Fi network infrastructure was established, and tourists can access over 400 Wi-Fi hotspots at about 260 locations around Paris, including parks, museums, and libraries. Other free Wi-Fi cities include Bordeaux, Marseille, and Nice. Wireless connection in France is free and renewable after 30 minutes, fill in a short form, and tourists are entitled to free centralized Wi-Fi. Ruckus dual-band wireless access point was commonly used to deploy their wireless architecture[11].

Today, medium to large-scale organizations require the deployment of robust and secured wireless networks. Cisco Company has developed the concept of the Cisco Unified Wireless Network (CUWN) solution, which helps make it easier to manage large-scale wireless network deployments. Using the Wireless LAN Controller (WLC), this device assumes a central role in the CUWN. Conventional roles of wireless access points, such as association or authentication of wireless clients, were done by the WLC. The Lightweight Access Points (LAPs) in the unified wireless network design automatically register themselves with a WLC and tunnel all the management and data packets to the Wireless LAN Controller, then switch the packets between wireless clients and the wired portion of the network [12].

The Philippine government propelled the installation of 23,100 free Wi-Fi sites to help adapt the country to education and remote work during the ongoing COVID-19 pandemic—this project anchored with advanced wireless network architecture for easy management and updating. Free internet connectivity helped the Filipino community, especially health workers, in their timely submission of situation reports online. It also eases distress and fears among front-liners and patients by allowing them to keep in touch with their families and loved ones through virtual communications[13]. The Department of Information and Communication Technology (DICT) "Free Wi-Fi Internet Access in Public Places" project aims to accelerate the government's efforts in enhancing internet accessibility for Filipinos to help cope up to economic, social, and educational opportunities and in reducing the growing Digital Divide under the overarching e-Filipino Program [14],[15]. The new digital access likely had a muted effect in Manila and some other areas, where most workers have access to the Internet and were already adopting remote working conditions to avoid the city's congestions and heavy traffic. The project made a big difference in the country's regional areas, where many continue to depend on mobile connections for internet access.

In terms of monitoring the performance of Telcos in providing internet access to clients, the Department of Information and Communication Technology (DICT) ties up with Project Bandwidth and Signal Statistics (BASS) according to the mandate of protecting the rights and welfare of consumers and business users in matters relating to Information Communication Technology (ICT), the Department of Information and Communication Technology (DICT), this is to monitor telco companies' performance, in hopes of encouraging them to improve their services [16].[17].

Local government units are currently associated also with a management free public wireless access aims to build a strong foundation for digitalization benefiting the community and our citizens, and that digital is the new normal. Through this project, those who do not have mobile data can now use the online services of the local government public Wi-Fi. At the same time, learners can now keep up with their online classes, and businesses can now improve their services using free public Wi-Fi [17]. The impact of an optimized wireless deployment will be ease of management and stress-free troubleshooting; this comes from self-healing and self-configuring wireless networks [18]. Accurately locating each wireless user and knowing all the possible characteristics of the wireless client and access points such as location, Media Access Control (MAC address), radio type, channel, manufacturer, status on the network, and wireless network name eases management as well.

The Department of Agriculture is an executive department of the Philippine government responsible for the promotion of agricultural and fisheries development and growth. One of the

18 key strategies of the department is technology & innovation, including digital agriculture. This strategy is to improve and make the Information and Communication Technology (ICT) infrastructure become a state of the art technology-driven by a stable, fast, secure, and uninterrupted electronic business transaction for the internal and external clients of the department[1]. The Department of Agriculture, Region 1, is unified with the national government to build a robust, stable, secure, and manageable Information and Communication Technology (ICT) infrastructure [19]. The department has 2 (two) five-story buildings and has more than 500 employees. The majority of the employees have laptops and have mobile devices connected to the network, and the bulk of them was connected via wireless connections. With that number of wireless users, wireless management is always a challenge for the network administrator to provide clients with stable and secured wireless connections. This present situation propelled the researcher to address the exponential number of wireless users to provide and have an advanced, robust, and secure, optimized wireless network architecture that will resolve the unstable wireless connection and frequent wireless disruption due to outdated wireless network devices and autonomously deployed wireless access point. Thus, the current wireless network design lacks network planning and perspective because each wireless access point (AP) operates as a standalone or separate node, this has been autonomously configured, and the network administrator manually checks/troubleshoot physically in the event of wireless failure or disconnections. While these autonomous access point deployments, the system has no mechanism to detect adjacent devices if it is part of the wireless network [20]. The researcher opts to address the following difficulties and have an advanced, robust, and secured wireless architecture. The result of this study is to make all employee in the department that uses wireless connection be connected, satisfied, and have full security for internal and external activities with minimal downtime compared to the current wireless network [1].

In this research study, the researcher conducted a comparative analysis of different agencies to assess and evaluate their wireless design and standards being used. In gathering the data, the researcher used a wireless survey questionnaire [20],[21],[22] . Gathered data were assessed and evaluated based on the felt needs of the department to optimize the current wireless network. The result of the evaluation and assessment with the favorable and applicable result was then applied and integrated into the wireless network architecture. The initial design of the wireless network architecture was based on the results of the comparative analysis [22]. Filled out survey questionnaires were assessed and evaluated based on the given indicators in developing the optimized wireless network architecture.

After identifying the initial design of the wireless network, the researcher used the six phases methodology, which is the Prepare, Plan, Design, Implement, Operate and Optimize (PPDIOO), to develop the optimized wireless network architecture [23]. The PPDIOO network approach defines the continuous lifecycle of services required for a wireless network. The validation and performance test of the optimized wireless network architecture was measured by Received Signal Strength Level (RSSL) and Coverage Service Area. Received Signal Strength Level indicates the received signal level of an antenna or the decibel milliwatts (dBm)[24], [25]. Therefore, the higher the number of RSSLs indicates that the stronger/excellent the signal is obtained. Through mathematical calculations, the receive signal strength level can be calculated using the equation (1).

$$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi}\right)^2 d^{-\alpha} 10^{\frac{X_\varphi}{10}} \prod_{m=1}^{M} |\Gamma_m|^2 \quad (1)$$

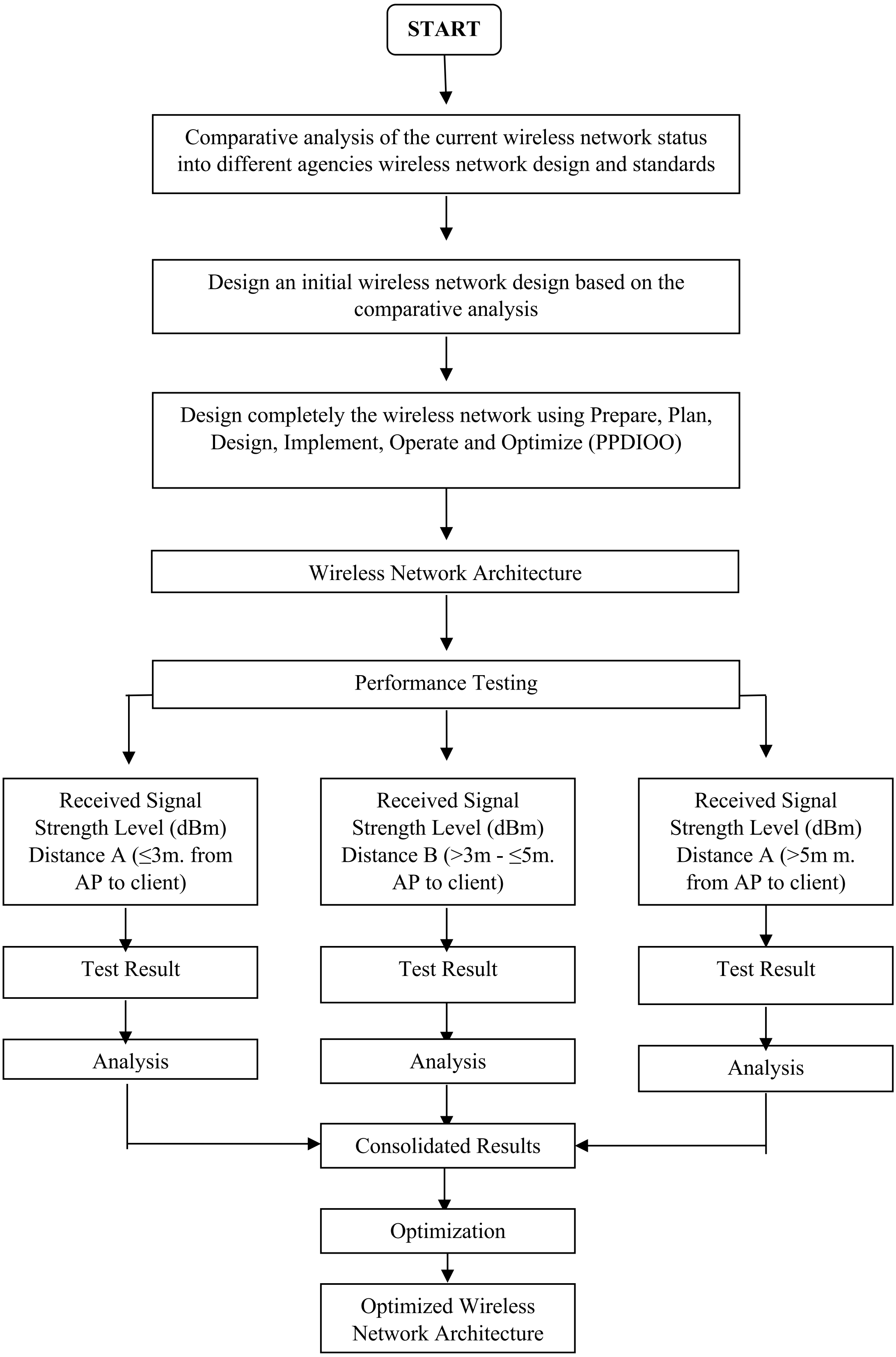
Where P_t is the transmitting power of the AP, G_t is the gain of the transmitting antenna, G_r is the gain of the receiving antenna, d is the AP distance and the user, α is the power of distance, φ is the standard deviation of the normal log shadowing, Γ_m and M respectively denotes the transmission coefficient of the m-th wall is passed by the direct propagation path and the number of walls.

The obtained signal power is in decibel milliwatts (dBm). While through measurement, the received signal power is measured using the WifiAnalyzer tool. The Wi-FiAnalyzer tool was used to analyze the installed wireless network architecture of the Department of Agriculture, Region 1. This application tool can capture wireless signal quality and network saturation information.

Thus the range of the installed access point signals was determined from the service area coverage or the location of wireless clients of access point signals and to enlarge the network for optimal service delivery. Colorized signal strength map was used to map out the service area coverage of Wi-Fi networks of the Department of Agriculture, Region 1. This was utilized to show the range of installed wireless access point networks by adding digital maps. Thus, wireless users easily know where the specific area is not covered with the wireless network. The survey result of colorized signal strength map was indicated by colors with corresponding signal strength values and signal quality categories.

2 Research Methods

Figure 1 shows the wireless network architecture research workflow of the Department of Agriculture, Region 1. In developing the optimized wireless network architecture, the first step is to have a comparative analysis on the current wireless network status of the Department of Agriculture, Region 1, into different agencies' wireless network design and standards. The researcher floated a wireless survey questionnaire to assess and evaluate the different agencies' wireless design and standards. The consolidated results of the comparative analysis, together with the applicable indicators, were the basis in crafting the initial design of the wireless network.



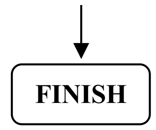


Figure 1. Wireless Network Research Workflow

2.1 Comparative Analysis for Current Wireless Network into Different Agencies' Wireless Network design & standards

Table 1 shows the summary of comparison of the current wireless network of the Department of Agriculture into different agencies' wireless network design and standards. The results of this comparison were the initial design of the wireless network architecture.

After the initial design was crafted, this study used the methodology Prepare, Plan, Design, Implement, Operate and Optimize (PPDIOO) to develop the whole structure of the wireless network architecture. Figure 2 shows the six-phase methodology used for this study. First is the preparation phase, wherein the establishment of the agency technical requirements, developing a wireless network structure & strategy, and proposing an optimized wireless network architecture, identifying technologies that can best support the wireless technology.

Next is the planning phase; the researcher identified the wireless network requirements based on the objectives to optimize the wireless network of the Department of Agriculture, Region 1. The Plan phase also involves the assessment of the site where the installation of wireless network takes place; it also performed a series of analyses to determine if the current infrastructure, operational environment, and sites were compatible with the system. A project plan was established to help manage the responsibilities, tasks, resources, and operational environment required to implement the changes of the network.

In the design phase, the activities were determined the requirements, integrating any additional data gathered during the analysis, the initial requirements were accumulated from the previous phase. In this phase, the researcher produced a comprehensive, detailed design that meets the existing technical requirements; incorporates specifications to support and enhance the reliability, security, scalability, and performance. The detailed design was the basis for the implementation activities.

The implementation and verification begin after the detailed design has been approved. The optimized wireless network architecture and any additional components are built according to the technical requirements and design specifications, with the goal of incorporating wireless equipment and devices without disrupting the current wireless network operations or making points of vulnerability and risks.

Table 1. Summary of Comparative Analysis

	Indicators								
List of Agencies	The maximum wireless client supported	Optimization tools used	Average signal Quality of RSSL	Load balancing capability	Mac address binding	Band width speed	Type of Medium used	Client access control	Redundancy Connections
Current Wireless Network Design of Dept. of Agriculture, Region 1	150	Ping tool	Good	No	No	40 Mbps	Copper cable	No	No
Dept. of Agriculture, Region 2	500	Ruckus Speedflex, ping, traceroute	Excellent	Yes	Yes	1000 mbps	High-Speed Fiber	Yes	No
Dept. of Budget and Management	250	Fortinet, ping, traceroute	Excellent	Yes	No	30mbps	High-Speed Fiber	No	Yes
Dept. of Environment and Natural, Resources, Environmental Management Bureau, Region 1	250	Sophos, ping, traceroute	Excellent	Yes	Yes	48mbps	High-Speed Fiber	Yes	Yes

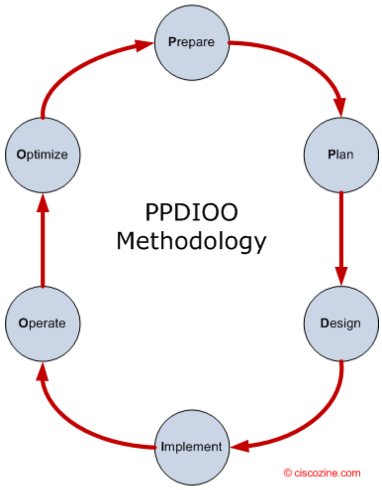


Figure 2. Prepare, Plan, Design, Implement, Operate and Optimize Methodology

This phase was the final test of the design's appropriateness and effectiveness. The operation phase was the maintenance of the network operations, ensuring the high availability and cost reduction during the day-to-day operations. In this phase, the wireless network architecture employed fault detection, performance monitoring, and correction in the event of failure/disruption in daily operations then provided initial data for the wireless network architecture lifecycle.

The last phase is the optimization stage. This was the basis of the optimization of the wireless network architecture wherein proactive management, identifying and resolving issues before the real problems arise, was integrated into the design. Using diagnostic tools to optimize the network were also applied and monitored.

2.2 Wireless Network Architecture for Department of Agriculture Region 1

After the initial design, the final wireless network architecture is shown in Figure 3. Figure 3 shows the final design of optimized wireless network architecture for the Department of Agriculture, Region 1 that addresses the limitation of the current wireless network through the integration of two advanced wireless controllers and 14 (fourteen) patented wireless access points. The two wireless controllers and fifteen wireless access points were connected to the redundant Layer 3 backbone switches. The wireless controllers were used to remotely manage—create access control and policies to all the installed wireless access points and wireless clients. The two wireless controllers will serve as the primary, and the other will be the backup and function as fault tolerance to eliminate and mitigate the risk of disruption and failure. In addition, it can logically access any of the installed access points over the wireless network architecture. The fourteen access points were controlled by a two wireless controller that provides advanced security, radiofrequency, and location management. The wireless controller has a dashboard that allows analyzing wireless traffic trends into specified or whole wireless groups; the result can be presented on the chart as bytes or rate(Mbps). It can capture client trends or the number of wireless clients connected per 1 hour and 24hours. It can also generate a data chart for wireless local area networks (WLANs), total traffic transmitted by all access points, and total usage and operating system (OS)/device type per client. The access point's side tab of the controller displayed the list of wireless groups and access points with their corresponding MAC addresses, device name, model, channel, and virtual local area network and access point IP management. With this tab, the administrator may enable and view the display of general information about the device, edit the existing configuration, display the clients connected, and can show the events or activities of the said access points.

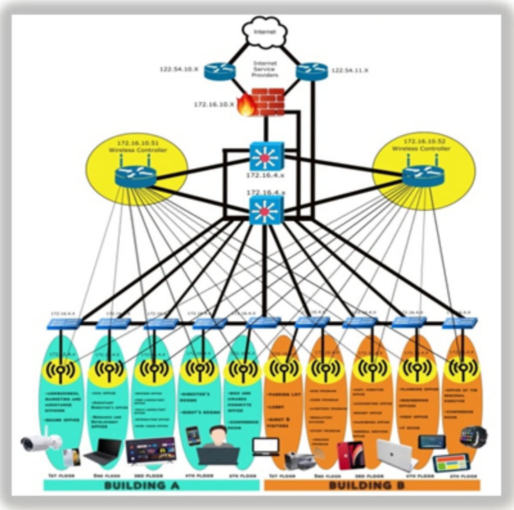


Figure 3. Developed Design of Wireless Network Architecture for Department of Agriculture, Region 1

The fifteen access points were installed to two (2) 5 (five) story buildings and assigned per floor from 1st floor to 5th floor and directly connected to Cisco distribution switches. They were assigned an individual dynamic internet address for easy management. Each wireless access point is logically connected to the two wireless controllers wherein each of the two wireless controllers can manage and remotely modify and control all general settings of each of the wireless access points. The installed wireless access points deliver the ideal combination of performance, coverage, and reliability; it supports data rates up to 1.2 gigabits per second (Gbps). It has the ability to extend coverage because of its patented multiple high-gain polarized antenna elements and patented software algorithms called Beam Flex that utilized 64 multi-directional antenna patterns that increases wireless signals and connect more devices simultaneously by using its two multi-user, multiple-input, multiple-output (MU-MIMO) technology (MU-MIMO) spatial streams, and concurrent dual-band 2.5/5Ghz radios. Also, it has an advanced dynamic channel that automatically uses machine learning technology to find the least congested channels. The access points have a stunning Wi-Fi performance that provides a great user experience no matter how challenging the environment is.

2.3 Service Coverage Area

The service coverage area determines the location and the signal coverage of the fourteen (14) installed wireless access points.

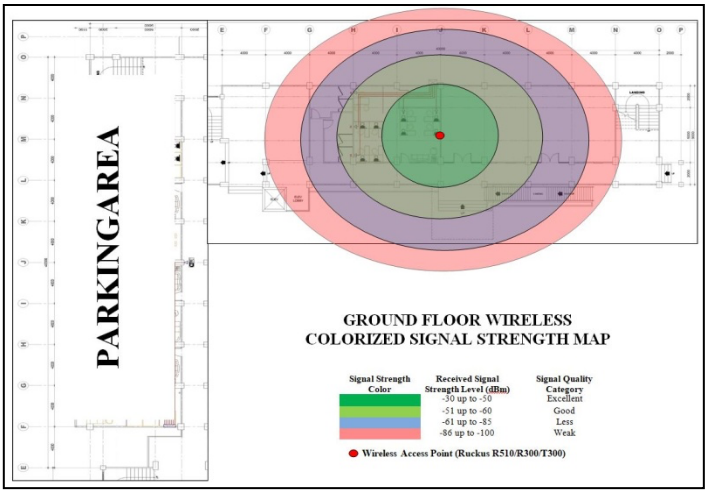


Figure 4. Wireless Signal Strength Map for Access Point installed in Ground Floor

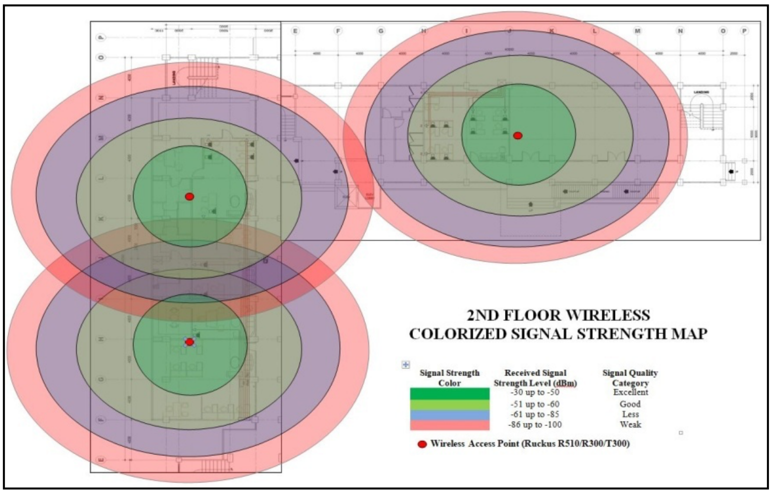


Figure 5. Wireless Signal Strength Map for Access Point installed for 2nd Floor

Figure 6. Wireless Signal Strength Map for Access Point installed for 3rd Floor

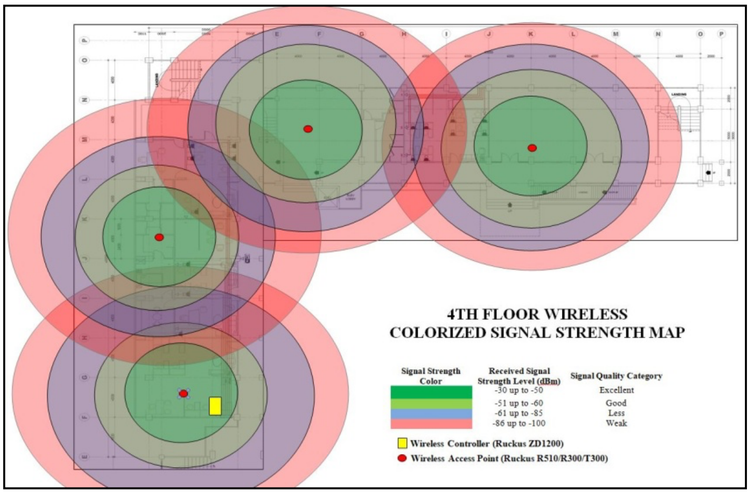


Figure 7. Wireless Signal Strength Map for Access Point installed in 4th Floor

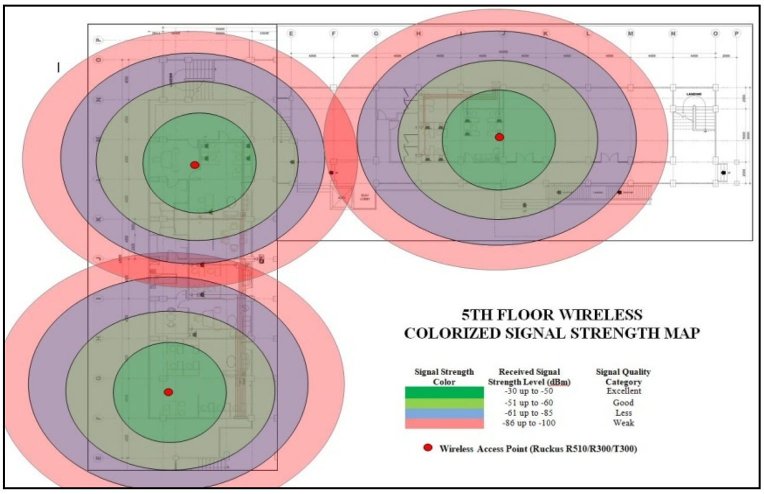


Figure 8. Wireless Signal Strength Map for Access Point installed for 5th Floor

Figures 4, 5, 6, 7 & 8 show the location, wireless signal coverage, and indicators of strength; of the installed wireless access points for the two five-story buildings of the Department of Agriculture Region 1. The researcher used a Wi-FiAnalyzer to validate and measure the received signal strength of every access point installed. The colorized signal strength map indicates the actual service coverage area of all wireless access points installed. Every color in the map has corresponding values depending on the received signal strength level (dBm) and has a signal quality category of Weak to Excellent.

2.4 Performance Testing

After the development of the wireless network, performance testing takes place. The performance testing was conducted using Wi-FiAnalyzer software installed in each wireless client's android devices or laptops and then captured and positioned using the corresponding indicators below.

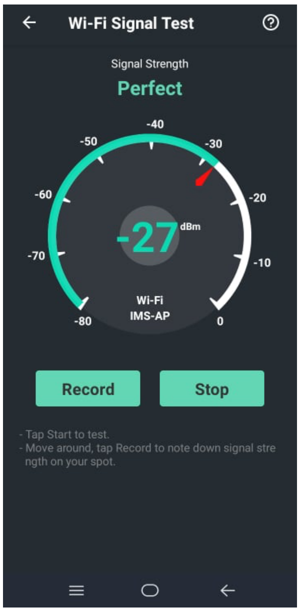


Figure 9. Result of Received Signal Strength of a Wireless Device using Wi-FiAnalyzer

Figure 9 shows the test result of one of the installed wireless access points that received signal strength level using a Wi-Fi Signal Test/Wi-FiAnalyzer installed on the wireless client's android phone. The fourteen (14) installed wireless access points received signal strength levels; were tested and validated with different indicators and different wireless clients [26]. The gathered received signal strength levels were placed in a table for analysis.

Received Signal Strength Level for Installed Wireless Access Point 1-15 in dBm (decibel milliwatts)

INDICATOR	Signal Quality Category			
	< -30 up to -50 dBm	-51 up to - 60 dBm	-61 up to -85 dBm	≥ - 86dBm
1. The received signal strength level from Access Point 1 to wireless client in Distance A (less than or equal to 3 meters)				
2. The received signal strength level from Access Point 1 to wireless client in Distance B (greater than 3 meters to less than or equal to 5 meters)				
3. The received signal strength level from Access Point 1 to wireless client in Distance C (greater than 5 meters)				

Figure 10. Received Signal Strength Level (RSSL) Indicators

Figure 10 shows the indicators for the performance testing. Received Signal Strength Level (RSSL) indicators were analyzed and presented in a table with a rating scale of received signal level, signal quality indicator, and colorized signal strength color[24].

Captured signal strength was categorized using the following signal strength color with corresponding values in dBm, and it is interpreted with Excellent, Good, Less, and Weak as shown in Table 2.

Table 2. Rating Scale for Validity of the Optimized Wireless Network Architecture

Signal Strength Color	Received Signal Strength Level (dBm)	Signal Quality Category
	< -30 up to -50	Excellent
	-51 up to -60	Good
	-61 up to -85	Less
	≥ -86	Weak

Table 2 shows the rating scale for the validity of the optimized wireless network. The received signal strength level (RSSL) dBm was categorized per distance; each distance corresponds with signal strength color and the signal quality category. The <-30 up to -50 dBm RSSL indicates an excellent category and has a signal strength color of green.

The received signal level measurements were performed for the condition of a different barrier/obstruction between the access point and the wireless user clients, where receive signal level was measured according to the distance between the access point and the wireless clients.

Measurements are made using an access point device called Ruckus access point R510/R300/T300 and a laptop device and/or mobile device that acts as a server. The function of the laptop server and or mobile device is to set the Transmission Rate (Tx) rate used. In addition to hardware devices, the researcher installed a Wi-FiAnalyzer application into a mobile device and laptop to use and perform RSSL measurements. With that application, the measurement is done by making sure the wireless access point was connected to any smartphone device and by locking one of the wireless access point signals you want to measure. After locking the connection from the mobile device/laptop to the corresponding access point, the Wi-FiAnalyzer is then run the software so that it will automatically look at the measurement results in the form of Received Signal Strength level.

3 Results & Discussions

In this study, the results were presented in tabular and graphical forms. Each wireless access point received signal strength level (RSSL) captured and validated into three different distances and placed in columns as to the averages and signal quality category and signal strength color.

3.1 Tabular Results of Received Signal Strength Level (RSSL) of Fourteen (14) Installed Wireless Access Points

Table 3 shows the performance testing list and results for the installed wireless access point in the Department of Agriculture, Region 1. The test was performed in the two 5-story buildings of the Department of Agriculture, Region 1, located at Sevilla, San Fernando City, La Union, and accompanied by IT personnel of the department. The received signal strength level was measured for each installed wireless access point; the researcher placed a reference point, which is the access point itself, then set three distances, namely A, B, C, with corresponding distances from the point of reference. The three distances measured in meters, less than or equal to 3 meters for Distance A, more than 3 to less than or equal to 5 meters for Distance B, and more than 5 meters for Distance C. The three-point distances were purposely to test and measure the received signal strength and service coverage area of the installed access point between different distances and diverse environments. Wi-FiAnalyzer tool was installed in the mobile device and laptop to capture and measure the received signal strength level from the wireless client to the access point from different distances and obstructions. The test result for the three Distances A, B, C was indicated in Table 1, together with the average and corresponding signal quality per access point performed. Based on the table, the entire test performed was categorized as Excellent this means the implementation of the optimized wireless network architecture for the Department of Agriculture was significant.

The analysis of the performance of the optimized wireless network architecture for the Department of Agriculture, Region 1 was measured by Receive Signal Strength Level (RSSL) and Coverage Service Area. Received Signal Strength Level is an indication of the received power level of an antenna or the decibel milliwatts (dBm) from installed wireless access point to wireless clients. The lower the RSSL value from the 0 dBm, the stronger the signal is. Thus the range of the installed access point signals was determined from the service area coverage or the location of wireless clients of access point signals and to expand the network for optimal service delivery.

Table 3. Received Signal Strength Level of the Installed Access Points

List of Access Point (AP)	RSSL (dB) Distance A (≤3m. from AP to client)	RSSL (dB) Distance B (>3m - ≤5m. from AP to client)	RSSL (dB) Distance C (>5m. from AP to client)	Average (dBm)	Signal Quality Category	Signal Strength Color
1	-34	-45	-54	-44	Excellent	
2	-37	-46	-55	-46	Excellent	
3	-35	-40	-54	-43	Excellent	
4	-34	-50	-60	-48	Excellent	
5	-38	-50	-62	-50	Excellent	
6	-38	-42	-64	-48	Excellent	
7	-38	-54	-62	-51	Excellent	
8	-37	-58	-58	-51	Excellent	
9	-34	-48	-59	-47	Excellent	
10	-36	-46	-60	-47	Excellent	
11	-37	-47	-58	-47	Excellent	
12	-29	-45	-55	-43	Excellent	

13	-35	-48	-60	-48	Excellent	
14	-38	-45	-55	-44	Excellent	

3.2 Graphical Result of Received Signal Strength Level per Distances

Figure 11 shows the results of Received Signal Strength level of fourteen (14) installed wireless access points with the three distances from less than 3m, more than 3m to less than or equal to 5m, and more than 5m away from the wireless access point. The measurement results for all the access points installed was spread over the two five-story building of the Department of Agriculture, Region 1. Some wireless users in the room were blocked by walls and some other obstructions like window glasses, steel cabinets, doors, and partitions. The results of these measurements are then sorted by the closest distance to furthest distance from the access point position, which is the Distance A to C.

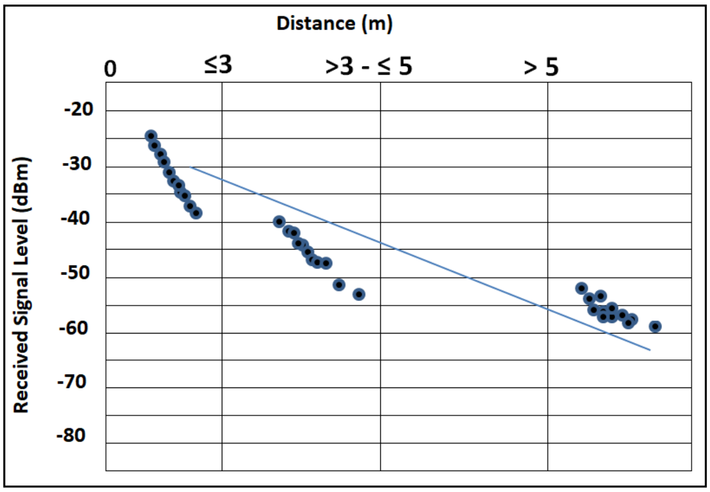


Figure 11. Received Signal Strength Level per Distances

The result shows that the received signal strength level at some measurement point decreased significantly. The maximum RSSL obtained is -25 dBm, and the lowest RSSL reach was -60 dBm. The decrease in RSSL values occurs with increasing wireless user distance and several obstructions to the line of sight of the access point. Based on the above equation, the RSSL value depends on the wall's distance, damping, and shadowing. There are several points with almost the same distance having different RSSL values. The different values but the same distance were affected by several signal disturbances, such as the wireless user being blocked by the wall and other obstructions. However, the majority of the received signal strength level were located in the excellent and good category or less than -30 up to -60 dBm; this means the tested results are significant.

3.3 Optimization of the Wireless Network Architecture

The optimization was based on the consolidated results of the comparative analysis of the different agencies. The researcher optimized the wireless network architecture by integrating and applying the positive results of the indicators stated in the comparative analysis. One of the indicators mentioned in the analysis was using diagnostics tools to optimize the wireless network. Therefore, the researcher applied the identification proactively and resolved wireless issues using diagnostic tools such as event logs and access point logs; this addressed the following stressors such as frequent disconnection, alert on the power spikes and surges, installed access points were lost heartbeats, warnings on rogue devices, etc. prior to network disruptions.

To mitigate the issues identified above, the researcher used reactive fault detection and corrections to predict and mitigate failures/disruption/breakdowns/downtimes. The used fault detection and corrections were access point logs and event logs. The following logs can help the network administrator determine and analyze activities in the entire wireless network.

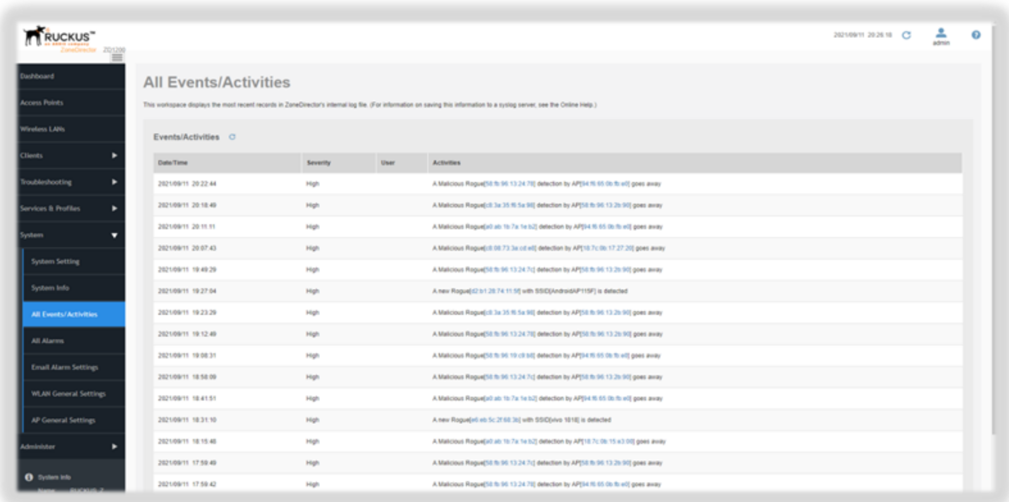


Figure 12. Result of Event logs

Figure 12 shows the captured event logs to detect the event severity and the time of the occurrence, and it displays the workspace of most recent records in the zone director's internal logs.

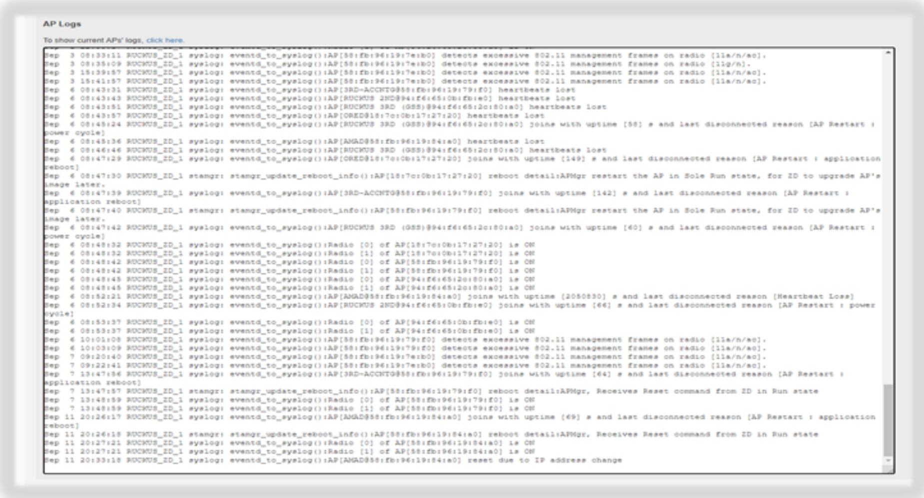


Figure 13. Result of Access Point Logs

Figure 13 shows the access point detailed system logs of all the installed wireless access points; it displays the current condition of the unit reported on the Syslog. It was used in the monitoring and diagnostic tools for all the installed access points.

4 Conclusions

Based on the results, the following conclusions were drawn. The design of the wireless network architecture shows significant results as to the performance testing of the received signal strength level of the fourteen (14) installed wireless access points. The optimization also shows proactive identification and resolving wireless issues using diagnostic tools such as event logs and access point logs; this addressed the following stressors such as frequent disconnection, alert on the power spikes and surges, and installed wireless access points lost heartbeats, warnings on rogue devices, etc. prior to network disruptions. Therefore, the design of the optimized wireless network architecture for the Department of Agriculture, Region 1, is capable of supporting the wireless activities of the department.

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