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Strategic Deployment of Ducklink Wireless Devices for Disaster Mitigation and Management in Nueva Ecija University of Science and Technology Sumacab Campus

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Abstract:- A significant challenge during disasters is the breakdown of traditional communication systems, impeding rescue operations and information dissemination. To tackle this issue, researchers conducted a study on strategically deploying DuckLink wireless devices within a small community, particularly at NEUST Sumacab Campus. Utilizing tools like Google Maps, Google Earth, and WiFi Heat Map, optimal locations for device placement were identified. Analyzing signal range and performance characteristics, the study endeavored to enhance disaster management capabilities on campus. Findings revealed DuckLink devices operate with omnidirectional polarity, ensuring reliable communication, with a clear correlation between distance and message transmission time emphasizing strategic device placement for efficient campus-wide connectivity. Recommending the installation of 112 devices across 79 buildings, with key locations designated for Papaduck receivers and Mamaduck transmitters, this research offers crucial insights into disaster management strategies, optimizing wireless communication infrastructure in educational environments, thus contributing to safer and more resilient communities.

Keywords:- *Ducklink Wireless Devices, Disasters, Disaster Management, Communication Systems, Strategical Deploymen.*

I. INTRODUCTION

In recent years, the global community has witnessed an alarming increase in the frequency and intensity of natural disasters, ranging from earthquakes and typhoons to floods and wildfires. The Philippines, located in the Pacific Ring of Fire, is particularly susceptible to such calamities, experiencing an array of geophysical and meteorological events. These disasters not only pose immediate threats to human lives and infrastructure but also disrupt vital communication networks, exacerbating the challenges faced during emergency response efforts (UNDRR, 2019).

The susceptibility of regions like Nueva Ecija, particularly in need of efficient communication for coordinating disaster relief and resource management, becomes evident in the wake of devastating events. In 2013, Super Typhoon Haiyan (Yolanda) struck, marking the strongest typhoon globally and revealing critical flaws in rescue coordination, resulting in over 30,000 lives lost due to inadequate communication among rescuers (Philstar, 2015). Furthermore, the impending earthquake on the West Valley Fault, known as "The Big One," is anticipated to cause substantial human casualties and economic losses, emphasizing the importance of robust communication systems (Aguila, 2019).

A significant challenge faced during disasters in the Philippines is the breakdown of traditional communication systems, hindering the dissemination of crucial information to affected communities and impeding rescue operations. As technology advances, innovative solutions become pivotal in addressing these challenges. Effective communication plays a crucial role in disaster management and response efforts, requiring fast and direct communication channels for first-hand responders, especially considering the unpredictable nature of disasters.

In the summer of 2018, OWL emerged from the collaboration of five coding enthusiasts who answered IBM's Call for Code, spurred by the aftermath of Hurricanes Harvey and Maria in 2017. Their innovation, the DuckLink, embodies a compact Internet-of-Things (IoT) device designed to establish connectivity for consumer electronics via WiFi or Bluetooth, while also enabling communication with other DuckLinks through 915Mhz LoRa technology. This combination of wireless capabilities within a single device offers a resilient networking solution, capable of operating off-grid and independent of traditional telecommunication infrastructure during times of crisis (OWL Integrations, 2024)

The DuckLink Wireless Device, with its wireless technologies consolidated into one unit, offers a comprehensive off-grid, off-telecoms networking solution. This becomes particularly critical when traditional infrastructure is offline or compromised during disasters, ensuring continuous and reliable communication capabilities. The DuckLink Wireless device's ability to function independently of conventional telecommunication networks positions it as a strategic asset in disaster-prone regions, like Nueva Ecija, where disruptions are common, and immediate communication is paramount for effective disaster response.

The utilization of Arduino modules for communication purposes, exemplified in various applications, showcases the versatility and adaptability of this platform in addressing diverse communication needs. Advancements in network placement optimization by Wzorek (2019) and Gaikwad (2017) contribute to the discourse by addressing router node placement problems and wireless network antenna placement, respectively, enhancing communication capabilities in emergency situations.

The imperative of establishing fast and reliable communication infrastructure for crisis management is emphasized by Dilmaghani and Rao (2007), who stress the importance of reliability, quick reconfiguration, and interoperability in designing communication systems for disaster scenarios. These features are essential for ensuring seamless information dissemination and coordination of relief efforts, thereby mitigating the impact of disasters on affected communities (Dilmaghani & Rao, 2007). Similarly, Shibata et al. (2009) propose a ballooned wireless mesh network system tailored for disaster use, aiming to provide prompt communication services in disaster-affected regions.

This research study focuses on the Strategic Deployment of the DuckLink Wireless Devices at Nueva Ecija University of Science and Technology, Sumacab Campus. By exploring the nexus between disasters, communication challenges, technology utilization, and the role of civil engineers in device preparation and placement, this research aims to contribute valuable insights into the development of resilient communication infrastructures for disaster-prone regions. Civil engineers play a pivotal role in this context, not only in the preparation and placement of these devices but also in designing infrastructure that can withstand disasters and support effective communication during critical times. Their expertise is essential for ensuring the resilience and sustainability of communication systems in disaster-prone areas.

➢ *Objectives*

- *General Objective*

This study focuses on strategic deployment by determining the signal range or distance that the DuckLink wireless device can effectively reach, thereby enabling effective communication and coordination among various stakeholders involved in disaster management within the Nueva Ecija University of Science and Technology.

- *Specific Objectives*

- Determine the operational polarity of the Sender DuckLink wireless device.
- Determine the effective range or distance and time speed of the DuckLink wireless device within civil engineering infrastructures.
- Identify optimal placements across the Nueva Ecija University of Science and Technology to strategically deploy DuckLink wireless devices.

II. METHODOLOGY

A. Research Design

This study employed an experimental research design to evaluate the optimal placement of the DuckLink wireless device for enhancing communication infrastructure within the university campus. Experimental research design is the process of carrying out research in an objective and controlled fashion so that precision is maximized, and specific conclusions can be drawn regarding a hypothesis statement (Zubair,2023).

Using various software tools like Google Maps, Google Earth, and WiFi Heat Map this study aims to pinpoint appropriate locations for deploying the DuckLink device. By strategically deploying these devices across the campus and analyzing key performance metrics such as signal strength and data transfer rates, researchers can create insights into the effectiveness of the DuckLink solution in improving wireless connectivity.

Furthermore, the research design incorporated control groups to compare the performance of DuckLink devices with existing communication infrastructure or alternative solutions. By controlling variables and isolating the effects of DuckLink placement on communication enhancement, researchers can get valuable insights into the efficacy of the solution. Furthermore, this experimental approach facilitates a systematic evaluation of the DuckLink wireless device's impact on communication infrastructure within the university campus, offering critical insights for optimizing wireless connectivity and addressing communication challenges comprehensively.

B. Research Setting

This study primarily focused on the Nueva Ecija University of Science and Technology - Sumacab Campus, Cabanatuan City.

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Fig 1: NEUST Sumacab Este, Cabanatuan City, Nueva Ecija (Google Map)

C. Research Instrument

This study utilized basic civil engineering principles with the aid of software such as Google Maps, Google Earth, and Wi-Fi Heat Map to determine directivity, signal range assessment, data transmission effectiveness, and deployment strategy for the DuckLink Wireless device in NEUST Sumacab Campus. The researchers used different parameters in assessing the device's capability such as wall penetration, rain hindrance, and the effect of other signals and frequencies.

D. Data Gathering

The researchers utilized data analysis and information from previous research studies to gather prior data on the capabilities of ESP32 and LoRa technologies before conducting a comprehensive range analysis of the DuckLink wireless device within the NEUST premises.

To acquire the necessary materials, the researchers procured the ESP32 module and other components from various online platforms such as Lazada, DEECO, and Shopee. Additionally, the device was coded and debugged using the Cluster Duck Protocol created by the Project OWL, while the battery was connected through a JST pin 1.25mm female type.

The researchers employed a combination of data analysis, insights from previous research studies, and online resources such as Google Map, Google Earth, and Wifi Heat Map to determine various parameters. These parameters include in determining the polarity of the device, range or distance, time effectiveness in transmitting and receiving data considering the interference and strategizing the optimal deployment of the DuckLink Wireless device.

Furthermore, the researchers sought guidance from Unified Command Center (UCC) of Cabanatuan City to gain insights and expertise from professionals in the field and enhanced their understanding of effective range assessment techniques and strategies. The UCC aims the safety and security of the community, also it enables not just the awareness of situations and detection of uncertainties but also mitigation of threats and immediate response to crises or emergencies from natural calamities—utilizing state-of-the-art technologies for more efficient disaster risk reduction and management.

E. Data Analysis and Technique

➢ *Polarity and Directionality Assessment of Sender DuckLink Wireless Device*

This approach offers a streamlined technique for assessing the DuckLink Wireless device's polarity and directionality, facilitating effective deployment for signal propagation. Polarity and directionality assessment using Google Map and Google Earth involves using its geographic visualization capabilities. This tool was used to examine different angles, identifying prominent landmarks for reference. Analyzing these angles enables researchers to ascertain whether the device is horizontally, vertically, or omnidirectionally oriented. Findings are then documented for deployment planning and further analysis.

➢ *Required Range for Signal Coverage*

Distance measurement methods such as Distance Between 2 Points Formula in 3D are used to estimate the device's required range for signal coverage. By such, the researchers can determine the quantity of the device needed for the devices' deployment.

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The distance between two points P (x1, y1, z1) and Q (x2, y2, z2) expressed as:

$$PQ = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2]} \quad \text{------------} \quad \text{Eq. 1}$$

(Source: https://byjus.com/maths/distance-between-two-points-3d/)

➢ *Transmission and Reception Analysis*

This method determined the time speed of data transmission and reception in both open areas and environments with interference, utilizing Wi-Fi Heat Map application and Signal speeds, propagation times and distance formula expressed as,

$$Speed = \frac{Distance}{Time\ propagation} \quad \text{-----------------} \quad \text{Eq. 2}$$

(Source: https://www.open.edu/openlearn/science-maths-technology/it-information/content-section-5.3)

➢ *Mapping Signal Coverage Representation to Develop Deployment Strategy for Disaster Mitigation and Management*

This method is employed to develop a deployment strategy for disaster mitigation and management, ensuring reliable communication and effective response during emergencies. This representation aids in determining the effectiveness of the current deployment and determining where additional devices or infrastructure may be needed to improve coverage and resilience.

- *Preparation of DuckLink Wireless Device*

The following are the steps in preparing the ESP32 LoRa WiFi Module:

- *Coding the DuckLink Wireless Device*

✓ Install and Open Arduino IDE.
✓ Download and install LoRa, ESP32, Ug8b2, and Heltec Libraries.
✓ Go to GitHub and download the software from IBM and OWL.
✓ Comment (adding //) and Uncomment (//) the lines and modify Line 25.
✓ Set Code "PD" for Papa Duck, and "MD" for Mama Duck
✓ Modify the SSID, GPS, and HTML.ino files.
✓ Click Upload.

For additional insights and comprehensive information, consider exploring the OWL Integrations website via the provided link: https://www.owlintegrations.com/ducklink

- *Assembling the DuckLink Wireless Device*

✓ After coding, connect the ESP32 module to the computer through a USB cable.
✓ Open Arduino IDE.
✓ Set board as ESP32 in Tools > Boards > Heltec ESP32
✓ Set tools as USB_PORT in Tools > Ports > USB_PORT
✓ Click Upload.
✓ Disconnect USB cable.
✓ Solder Battery holder cables to the included JST 1.25 pin.
✓ Insert 18650 batteries in the battery holder.
✓ Attach JST 1.25 pin at the back of module.
✓ Attach the included antenna.
✓ Place the device in the plastic enclosure.

- *Conceptual Design of DuckLink Wireless Device*

Fig 2: Rendered View of DuckLink Wireless Device

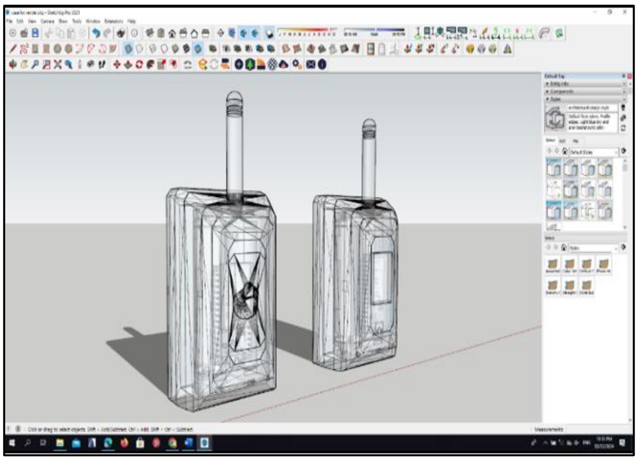

Fig 3: Designing the Enclosure for Device with SketchUp4

- *Technical Specifications of parts of the DuckLink Wireless device*

The LoRa ESP32 with OLED Development Board (SX1276) Heltec – 868Mhz is an all-in-one WiFi plus LoRa Development board that allows you to create LoRa and Wi-Fi projects for internet connected projects like IoT applications. This board is based on ESP32 core chip and a LoRa chip tuned at 868Mhz (SX1276). Additionally, 3.7V 2x 18650 Battery and Battery Holder Connector Storage Case Box with ON/OFF Switch with Cable. This battery box holder with pin connector, fit for 18650 batteries with weld leg design, with a cap and on/off switch button.

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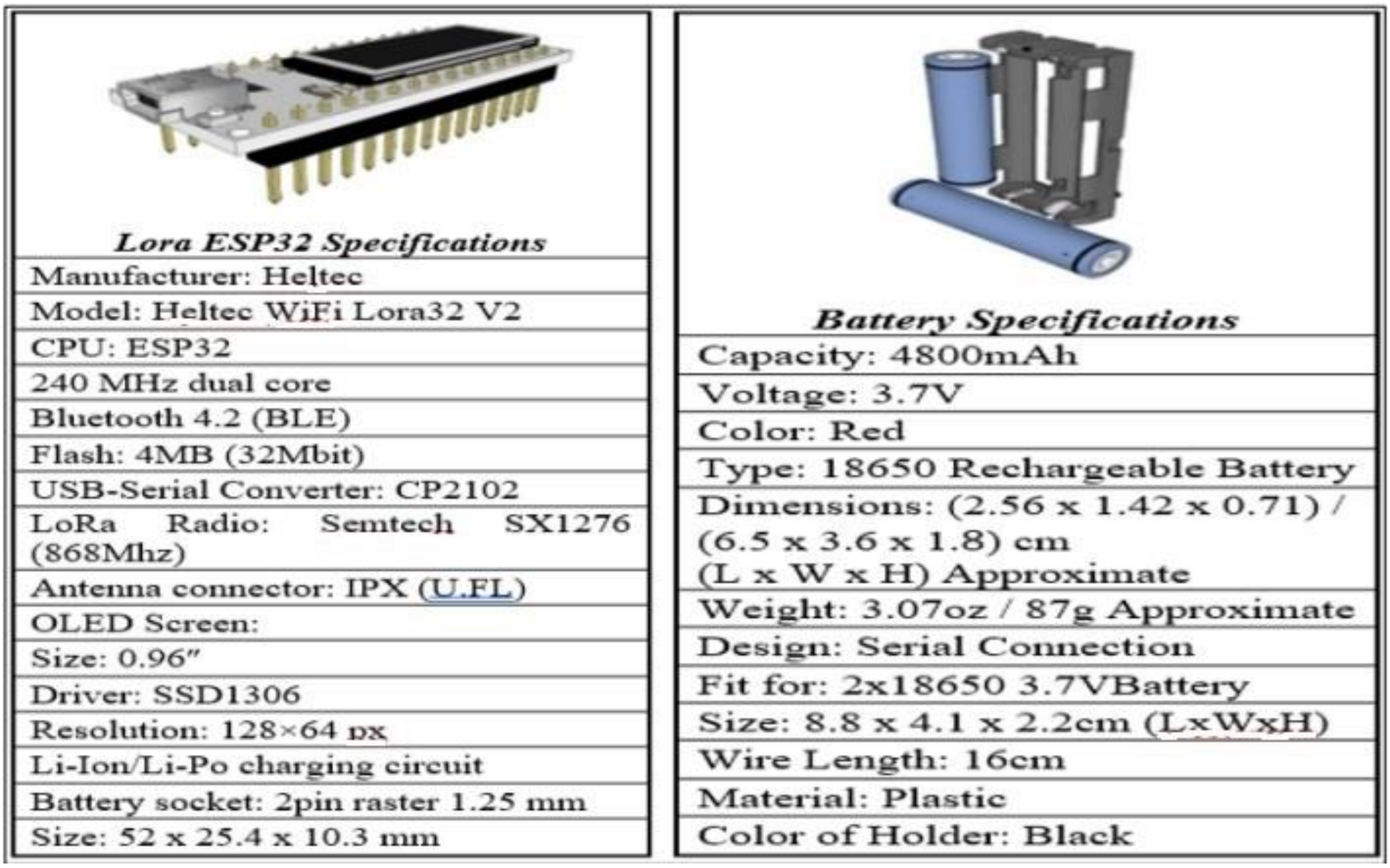

Lora ESP32 Specifications
Manufacturer: Heltec
Model: Heltec WiFi Lora32 V2
CPU: ESP32
240 MHz dual core
Bluetooth 4.2 (BLE)
Flash: 4MB (32Mbit)
USB-Serial Converter: CP2102
LoRa Radio: Semtech SX1276 (868Mhz)
Antenna connector: IPX (U.FL)
OLED Screen:
Size: 0.96″
Driver: SSD1306
Resolution: 128×64 px
Li-Ion/Li-Po charging circuit
Battery socket: 2pin raster 1.25 mm
Size: 52 x 25.4 x 10.3 mm

Battery Specifications
Capacity: 4800mAh
Voltage: 3.7V
Color: Red
Type: 18650 Rechargeable Battery
Dimensions: (2.56 x 1.42 x 0.71) / (6.5 x 3.6 x 1.8) cm (L x W x H) Approximate
Weight: 3.07oz / 87g Approximate
Design: Serial Connection
Fit for: 2x18650 3.7VBattery
Size: 8.8 x 4.1 x 2.2cm (LxWxH)
Wire Length: 16cm
Material: Plastic
Color of Holder: Black

Fig 4: Battery with Holder and ESP 32 LoRa Module

III. RESULTS

➢ *Analysis pf Data*

- *Polarity and Directionality*

Based on the findings of the researchers, the operational polarity of the DuckLink wireless device was determined by placing the device on the middle floors of the College Engineering Building A and analyzing its signal from various angles. By placing around the device and testing on both the upper and lower floors of the building, the researchers were able to determine that it has supplied a signal horizontally and vertically. This implies that the device's transmission capabilities were not limited to a single polarization axis but rather encompassed a broader range, allowing for transmission and reception of signals in multiple directions.

The ability of the DuckLink wireless device to operate effectively in both horizontal and vertical polarizations indicate a characteristic of omnidirectional functionality. According to Sanny Telecom (2024), omnidirectional antennas emit and receive signals in all directions, providing a 360-degree coverage pattern. This capability is particularly advantageous in scenarios where communication needs to be established with multiple devices located in various directions without the need for precise alignment or orientation.

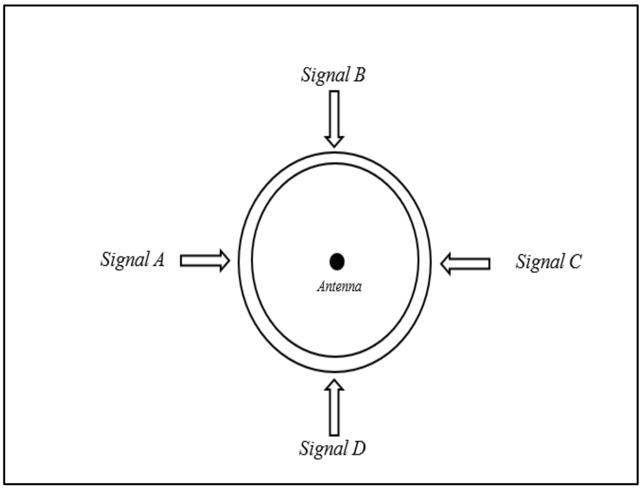

Fig 5: Omnidirectional Orientation

In practical terms, the omnidirectional nature of the DuckLink wireless device enhances its versatility and usability in diverse environments. Whether deployed in open spaces, urban settings, or indoor facilities, the device can effectively transmit and receive signals without being restricted by directional constraints. This feature is especially beneficial in applications such as campus-wide communication networks, where seamless connectivity across multiple buildings and areas is essential.

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- *Transmission and Reception Evaluation with Interference*

Table 1: Speed Transmission and Reception of Messages

LOCATION	DISTANCE (m)	TIME PROPAGATION (s)	SPEED (m/s)
A	100	0.7	142.86
B	150	1.1	136.36
C	200	1.6	125.00
D	300	2.7	111.11
E	380	3.7	102.70

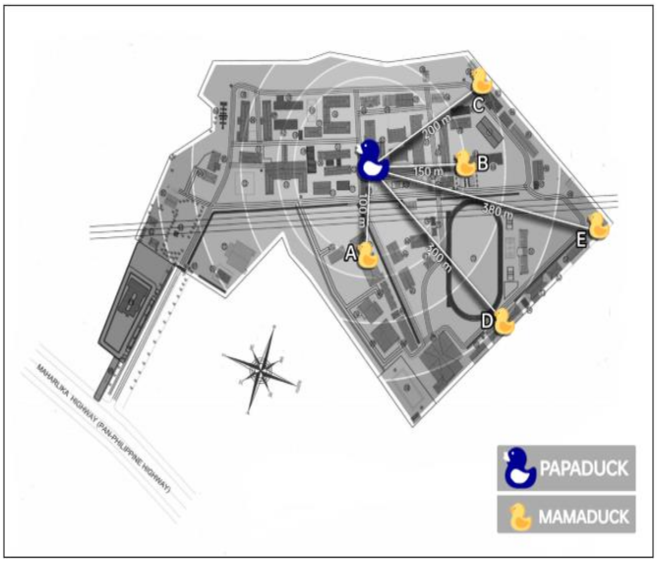

Fig 6: Ducklink Wireless Network Diagram (Top View)

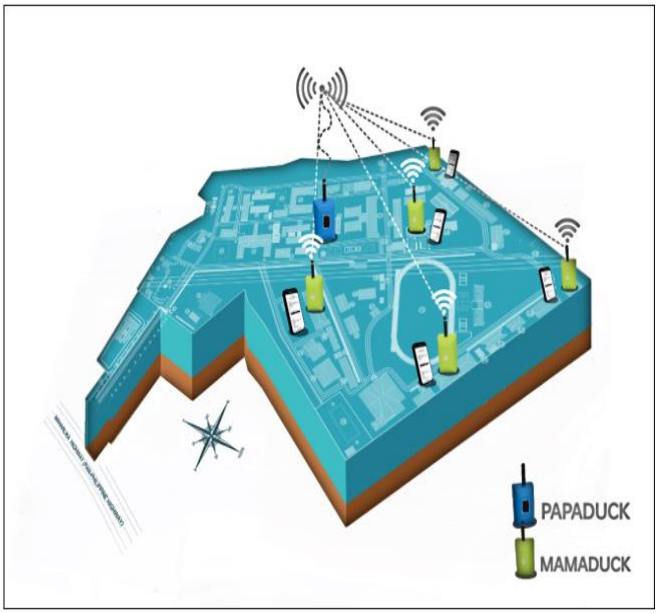

Fig 7: Ducklink Wireless Network Diagram (Isometric View)

Table 1, Figure 6, and Figure 7 provided a detailed analysis of the transmission speed of messages over different distances, as well as the connectivity of DuckLink wireless devices. Evaluating the performance of these devices was crucial as it laid the foundation for strategically deploying them across the NEUST Sumacab Campus.

The data in the table distinctly demonstrated that as the distance between the sender and receiver increased, so did the time require for message transmission. For instance, from Point A (COE Building 1) to the receiver at the Infirmary Building (100 meters away), it took approximately 0.7 second for the message to transmit, resulting in a transmission speed of 142.86 meters per second. Similarly, at Point B (Nieto Hall), located 150 meters away, the transmission time was 1.1 seconds, achieving a speed of 136.36 meters per second. This pattern persisted with longer distances, such as 1.6 seconds for Point C (Material Recovery Facility Building) at 200 meters, resulting in a speed of 125 meters per second. At Point D (CICT Building), 300 meters away, the transmission time was 2.7 seconds, yielding a transmission speed of 111.11 meters per second, and at Point E (Ortiz Hall), 380 meters away, it took 3.7 seconds for the message to transmit, achieving a speed of 102.70 meters per second.

Furthermore, the researchers performed tests to know the device's maximum range of interconnectivity, assessing both horizontal and vertical distances. Horizontally, they found the range to be approximately 600 meters, extending from Ortiz Hall to the Guest House, with a transmission time of around 4 seconds. Vertically, the researchers based their test on the tallest building in the NEUST Sumacab campus, the College of Communication and Technology Building, determining a maximum vertical distance with a transmission time of around 2 seconds. It's worth noting that during these tests, the researchers considered for various interferences such as physical obstacles, overcrowding, environmental factors and frequency interference that could potentially affect the transmission performance of the DuckLink wireless devices.

In simpler terms, the research findings indicated that the farther the distance, the longer it took for messages to be transmitted. This information played a crucial role in identifying optimal locations for DuckLink wireless devices across the NEUST Sumacab Campus. Furthermore, it provided valuable insights for designing reliable and efficient communication systems capable of operating effectively across varying distances.

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- *Mapping Signal Coverage Representation*

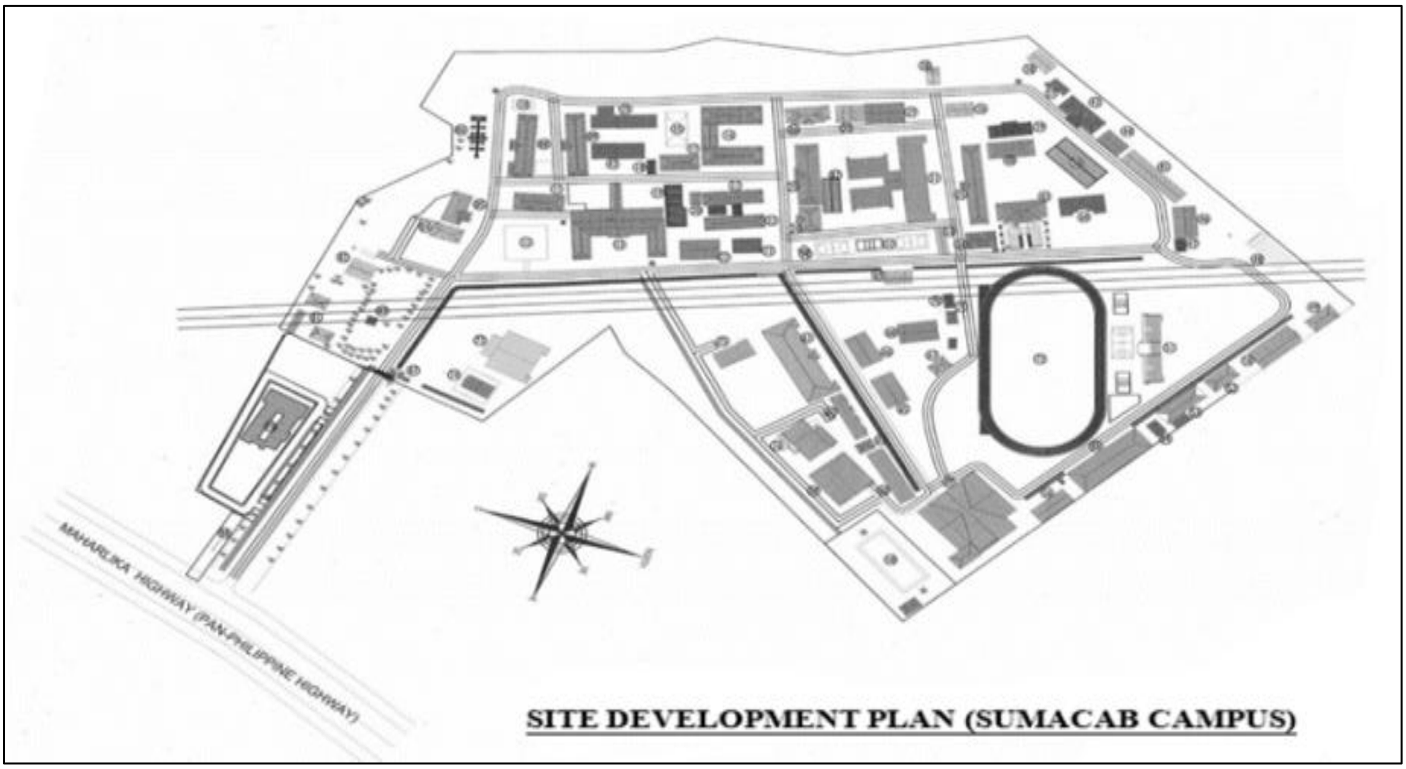

Fig 8: Site Development Plan (Sumacab Campus, Source: IDO)

Table 2: Speed Transmission and Reception of Messages

NO.	DESCRIPTION	BUILDING		RANGE			COMPUTED RANGE (m)	FLO ORS	DEVICES (pcs)
		DISTANCE X (m)	DISTANC E Y (m)	X (m)	Y (m)	Z (m)			
1	GUEST HOUSE	34	22	17	11	3.35	20.52	-	1
2	GENERAL SERVICES	36	26	18	13	3.35	22.45	1	1
3	ENERGY PARK								-
4	ALUMNI BUILDING	18	11	9	5.5	3.35	11.07	1	1
5	NSTP BUILDING	29	14	14.5	7	3.35	16.45	1	1
6	ROCK GARDEN	35	11	17.5	5.5	3.35	18.65	-	1
7	GUARD HOUSE (MAIN GATE)	10	6	5	3	3.35	6.72	1	1
8	UNIVERSITY HOSTEL	55	13	23	6.5	3.35	24.13	2	2
9	(ATHLETE'S QUARTER) HOSTEL 2	57	14	23	7	3.35	24.27	2	2
10	GREEN HOUSE	13	4	6.5	2	3.35	7.58	1	1
11	UNIVERSITY MUSEUM	37	14	18.5	7	3.35	20.06	2	2
12	HEROES PARK							-	-
13	ADMINISTRATION BUILDING	67	64	23	32	3.35	39.55	2	2
14	PUBLIC ADMINISTRATION AND PASTER MANAGEMENT BUILDING	49	12	23	6	3.35	24.00	2	2
15	CMBT OPEN GYMNASIUM	32	20	16	10	3.35	19.16	1	1
16	COLLEGE OF MANAGEMENT AND BUSINESS TECHNOLOGY BUILDING	44	43	22	21. 5	3.35	30.94	2	2
17	CMBT ENTRE BUILDING	29	14	14.5	7	3.35	16.45	2	2
18	CMBT ENTRE CULTIVATION ROOM	11	8	5.5	4	3.35	7.58	1	1

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19	COLLEGE OF ARCHITECTURE EXTENSION BUILDING	29	12	14.5	6	3.35	16.05	2	2
20	COLLEGE OF ARCHITECTURE STUDENTS CENTER	10	7	5	3.5	3.35	6.96	1	1
21	COLLEGE OF ARCHITECTURE BUILDING A	44	12	22	6	3.35	23.05	2	2
22	COLLEGE OF ARCHITECTURE BUILDING B	48	12	24	6	3.35	24.96	2	2
23	TECHNO HUB	29	20	14.5	10	3.35	17.93	3	3
24	INFIRMARY BUILDING	**22**	**15**	**11**	**7.5**	**3.35**	13.73	**2**	**1**
25	UNIVERSITY LIBRARY BUILDING	54	16	23	8	3.35	24.58	2	2
26	QUALITY ASSURANCE BUILDING	31	15	15.5	7.5	3.35	17.54	1	1
27	MOTOR POOL	19	14	14.5	7	3.35	16.45	1	1
28	CANTEEN (VLADZ)	11	10	5.5	5	3.35	8.15	1	1
29	FOOD COURT 1	27	17	13.5	8.5	3.35	16.30	1	1
30	TOURISM BUILDING	40	16	20	8	3.35	21.80	2	2
31	COLLEGE OF EDUCATION BUILDING	76	57	23	28.5	3.35	36.78	2	2
32	COLLEGE OF EDUCATION QUADRANGLE							-	-
33	COLLEGE OF EDUCATION STUDENT CENTER	17	7	8.5	3.5	3.35	9.78	1	1
34	HOSPITALITY MANAGEMENT STUDENT CENTER	12	9	6	4.5	3.35	8.21	1	1
35	HOSPITALITY MANAGEMENT BUILDING A	71	14	23	7	3.35	24.27	2	2
36	GAD AND CHILD MINDING BUILDING	18	15	9	7.5	3.35	12.18	1	1
37	MATERIAL RECOVERY FACILITY BUILDING	17	9	8.5	4.5	3.35	10.18	1	1
38	SUPPLY STORAGE	20	13	10	6.5	3.35	12.39	1	1
39	UNIVERSITY STUDENT GOVERNMENT DORMITORY	31	11	15.5	5.5	3.35	16.78	1	1
40	HOSPITALITY MANAGEMENT BUILDING B	34	15	17	7.5	3.35	18.88	2	2
41	TRAINING CENTER (NIETO HALL)	42	18	21	9	3.35	23.09	1	1
42	UNIVERSITY DORMITORY WITH HEALTH AND WELLNESS CENTER	36	12	18	6	3.35	19.27	2	2
43	SCIENCE AND TECHNOLOGY BUILDING	33	12	16.5	6	3.35	17.87	2	2
44	CRIMINOLOGY LABORATORY BUILDING	19	13	9.5	6.5	3.35	11.99	2	2
45	COLLEGE OF CRIMINOLOGY BUILDING A	52	12	23	6	3.35	24.00	2	2
46	COLLEGE OF CRIMINOLOGY BUILDING B	26	14	13	7	3.35	15.14	2	2
47	COLLEGE OF CRIMINOLOGY BUILDING STUDENT CENTER	12	8	6	4	3.35	7.95	1	1
48	UNIVERSITY FIRING RANGE	16	5	8	2.5	3.35	9.03	1	1
49	RESEARCH AND EXTENSION BUILDING	22	12	11	6	3.35	12.97	2	2
50	AMPITHEATER	45	17	22.5	8.5	3.35	24.28	1	1
51	GRANDSTAND	62	14	23	7	3.35	24.27	1	1
52	CULTURAL BUILDING	22	12	11	6	3.35	12.97	2	2
53	ATHLETES' CENTER	38	10	19	5	3.35	19.93	1	1
54	CICT STUDENT CENTER	12	8	6	4	3.35	7.95	1	1
55	COLLEGE OF INFORMATION AND COMMUNICATION TECHNOLOGY BUILDING (CICT)	63	21	23	11	3.35	25.50	4	4
56	PHYSICAL FITNESS BUILDING	28	12	14	6	3.35	15.60	1	1
57	UNIVERSITY CLOSED GYMNASIUM	54	56	23	23	3.35	32.70	1	1
58	UNIVERSITY SWIMMING POOL COMPOUND							-	-
59	UNIVERSITY OPEN GYMNASIUM	31	35	15.5	17.5	3.35	23.62	2	2
60	COLLEGE OF ENGINEERING BUILDING B	50	12	23	6	3.35	24.00	3	3
61	COLLEGE OF ENGINEERING STUDENT CENTER	16	16	8	8	3.35	11.80	1	1
62	COLLEGE OF ENGINEERING LABORATORY	42	9	21	4.5	3.35	21.74	1	1
63	COLLEGE OF ENGINEERING BUILDING A	70	22	23	11	3.35	25.71	3	3
64	GRADUATE SCHOOL BUILDING	42	18	21	9	3.35	23.09	1	1
65	METAL CASTING CENTER	42	12	21	6	3.35	22.10	2	2
66	METAL INNOVATION BUILDING	42	12	21	6	3.35	22.10	2	2
67	ON-THE-JOB TRAINING BUILDING	14	10	7	5	3.35	9.23	2	2
68	FOOD COURT II	26	20	13	10	3.35	16.74	1	1
69	UNIVERSITY MARKETING	24	7	12	3.5	3.35	12.94	1	1
70	USG STUDENT CENTER	12	8	6	4	3.35	7.95	1	1
71	UNIVERSITY STUDENT GOVERNMENT BUILDING	10	6	5	3	3.35	6.72	1	1
72	UNIVERSITY TRACK OVAL WITH PLAYING FIELD							-	-

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73	UNIVERSITY MINI-CONVENTION CENTER	30	32	15	16	3.35	22.19	2	2
74	UNIVERSITY ECUMENICAL CHAPEL	28	22	14	11	3.35	18.12	1	1
75	OFFICE OF THE ADMISSION AND REGISTRATION (OAR)	26	14	13	7	3.35	15.14	2	2
76	SUPPLY AND PROPERTY MANAGEMENT BUILDING	32	18	16	9	3.35	18.66	2	2
77	UNIVERSITY ROBOTICS AND DATA CENTER BUILDING	20	14	10	7	3.35	12.66	2	2
78	INFORMATION TOWER 1							1	1
79	PROPOSED CENTER FOR INTERNATIONAL EDUCATION BUILDING							-	-
								Total	112

Figure 8 depicted the Site Development Plan of NEUST Sumacab Campus, while Table 2 provided detailed data on distances, required range for signal coverage, floor quantities per building, and the number of devices needed per building. After thorough analysis, researchers identified a total of 79 buildings on campus. Their examination of the recorded data highlighted the need for 112 DuckLink devices across the campus infrastructure. These devices played essential roles in communication, with one serving as the Papaduck for message reception and the remaining 111 as Mamaducks for message transmission.

In planning the strategic deployment of these devices, it was crucial to position the Papaduck device strategically to enhance safety and security measures. The Infirmary building emerged as a key location due to its vital role in providing medical care during emergencies. Placing a Papaduck device there ensured efficient communication and effective coordination of response efforts during uncertain situations.

Moreover, the distribution of the remaining 111 Mamaduck devices was evenly spread, with one allocated to each building as outlined in Table 2. This systematic approach guaranteed comprehensive coverage across the campus, facilitating efficient communication and response capabilities in various scenarios.

To further enhance communication efficiency, one device was placed on each floor of the buildings. This approach contributed to rapid message transmission and timely coordination of responses. By strategically situating DuckLink Wireless Devices, the campus achieved seamless integration, enabling fast message transmission crucial for ensuring prompt responses to emergencies and bolstering overall safety measures.

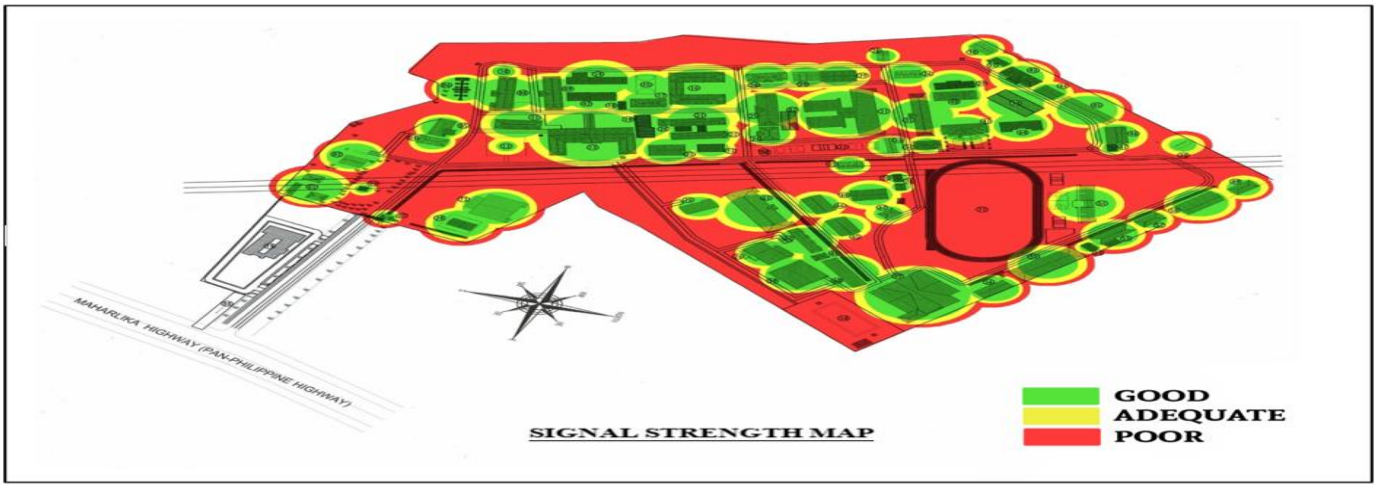

Fig 9: Signal Strength Coverage of Sender Ducklink Wireless Devices

Figure 9 illustrates the signal strength coverage generated by the Ducklink wireless devices, delineating areas of connectivity. Green areas depict regions with strong signal reception, yellow signifies moderate signal strength, and red indicates areas with weak signal reception.

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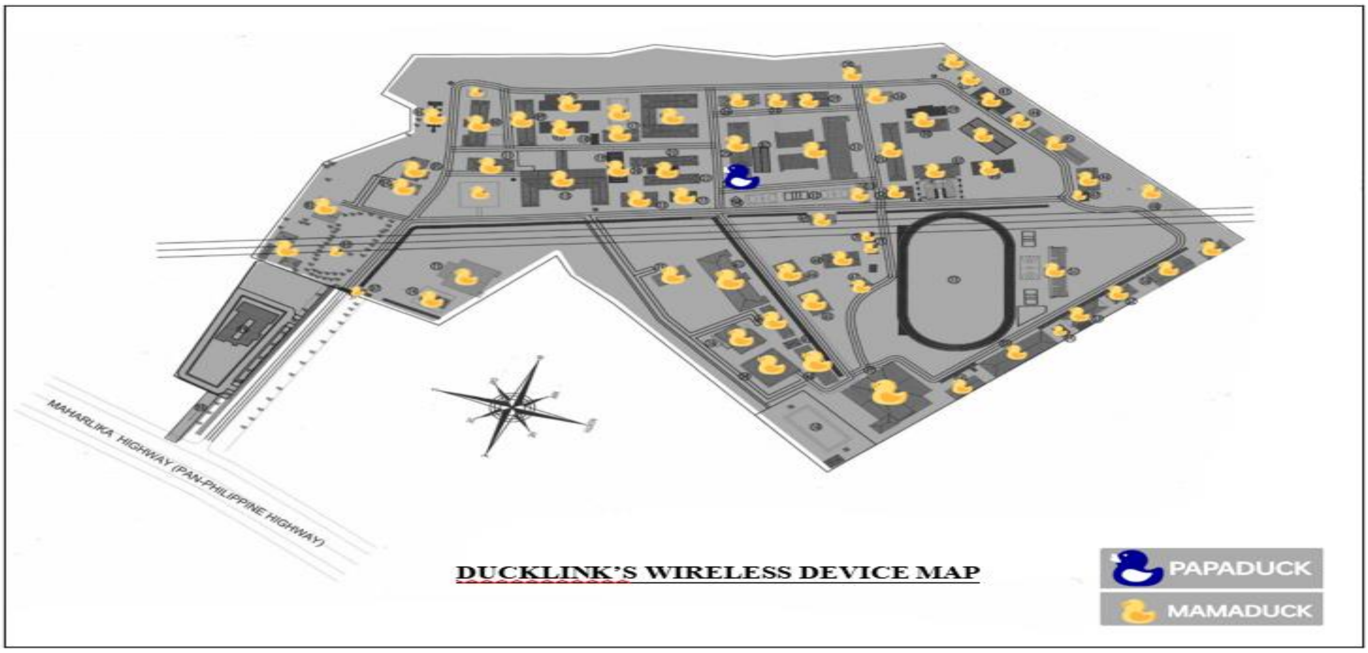

Fig 10: Deployment of Ducklink's Wireless Device

Figure 10 illustrates the arrangement and distribution of Ducklink Wireless devices throughout the premises of Nueva Ecija University of Science and Technology. This deployment map provides a comprehensive overview of how these devices are strategically positioned across the university campus to ensure optimal coverage and connectivity for users.

IV. CONCLUSION

Through an intensive study utilizing various methods, the researchers have arrived at several pivotal findings and conclusions:

A. DuckLink Wireless Device Polarity

The DuckLink wireless devices was tested by the researchers by placing it on the middle floors of the College of Engineering Building A and analyzing its signal from various angles. By going around the device and testing on both the upper and lower floors of the building, the researchers were able to determine that it has supplied a signal horizontally and vertically. Considering that the gadget responds, they also concluded that its polarity is omnidirectional. These findings underscore the device's adaptability and effectiveness in facilitating reliable communication without being limited by directional constraints, thus contributing significantly to emergency response and communication infrastructure.

B. Transmissibility and Receptivity of Messages

The research findings reveal a clear correlation between distance and message transmission time for DuckLink wireless devices. As distances between sender and receiver increase, transmission times also increase, indicating a decrease in transmission speed. This trend is evident across various points tested, with transmission speeds ranging from approximately 100 m/s to 140.74 m/s for distances ranging from 100 to 380 meters. Furthermore, the testing of the device's maximum interconnectivity range of approximately 600 meters supports these findings, with a transmission time of around 4 seconds observed. These results underscore the importance of understanding transmission characteristics for optimizing the placement of DuckLink devices across NEUST Sumacab Campus. Additionally, this data informs the development of robust communication systems capable of maintaining reliable and efficient connectivity across varying distances, essential for effective emergency response and communication infrastructure within the campus environment.

C. Location and Quantity

The researchers determined the need for 112 devices across the campus's 79 buildings. These devices, consisting of one Papaduck for message reception and 111 Mamaducks for transmission, formed integral components of the communication infrastructure.

In planning the strategic deployment, researchers recognized the importance of placing the Papaduck device at key locations, such as the Infirmary building, to facilitate efficient communication during emergencies. Additionally, each building was equipped with at least one Mamaduck device, ensuring comprehensive coverage and enabling seamless integration of communication systems.

Moreover, in further enhancing communication efficiency, one device was placed on each floor of the buildings, contributing to rapid message transmission and timely response coordination. This strategic placement of DuckLink Wireless Devices contributed significantly to the campus's overall safety and security measures, ensuring fast responses to emergencies and promoting a safer environment for the campus community.

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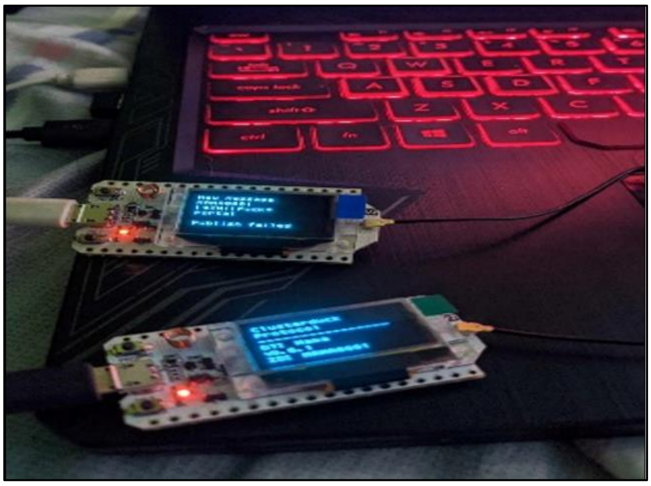
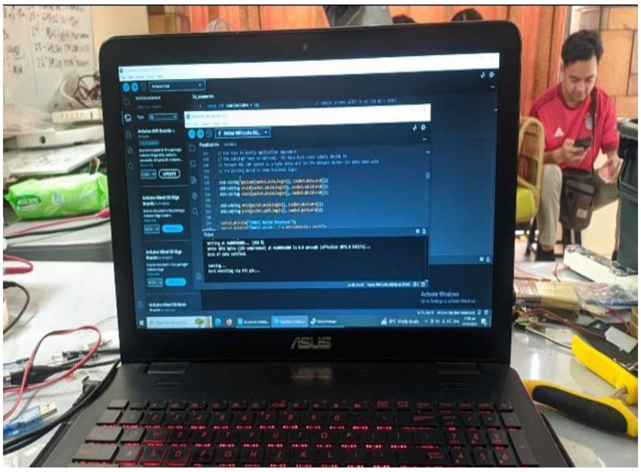
DOCUMENTATION

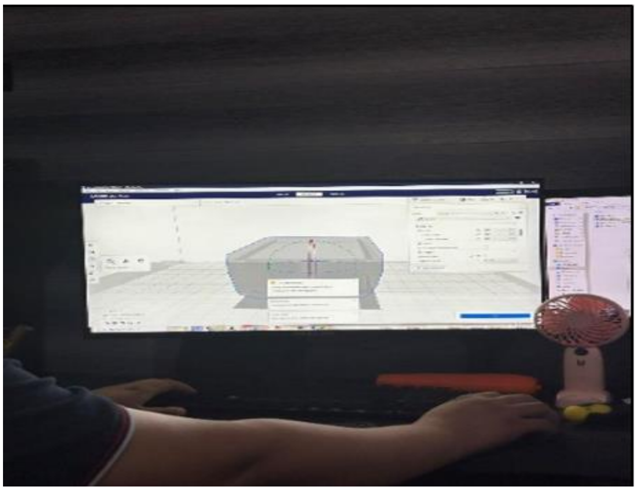
Picture 1, 2, and 3: Materials need for the Construction of DuckLink Wireless Devices



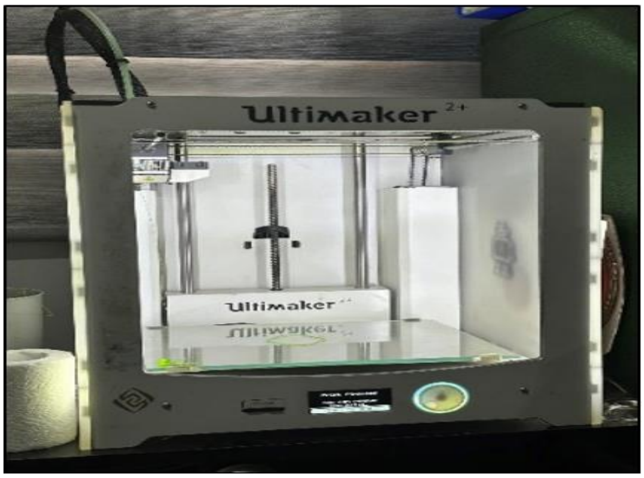
Picture 4: Configuration and Setup of Sender and Receiver



Picture 5: Programming, Coding and Debugging Phase of Arduino Module



Picture 6: Preparation of Case for 3D Printing



Picture 7: Utilization of the 3D Printer for Devices' Cases

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Picture 8 and 9: The Actual Ducklinkwireless Devices

Picture 10 and 11: Initial Device Testing Phase

Picture 12, 13, 14, 15, 16, 17 and 18: Final Testing