FACULTAD DE INGENIERÍA Y CIENCIAS APLICADAS
UNIVERSIDAD CENTRAL DEL ECUADOR

INGENIO
2025, VOL 9(1), JULIO - DICIEMBRE, PP. 062-069

REVISTA INGENIO

FPGA-Based Simulation of Open Wi-Fi Service Using the Analog Devices SDR Platform

Simulación basada en FPGA de un servicio Wi-Fi abierto utilizando la plataforma SDR de dispositivos analógicos

Holger Santillán | Salesian Polytechnic University, UPS Telecommunications Systems Research Group - GISTEL (Ecuador)
Arleth Rodríguez | Salesian Polytechnic University, UPS Telecommunications Systems Research Group - GISTEL (Ecuador)
Erick García | Salesian Polytechnic University, UPS Telecommunications Systems Research Group - GISTEL (Ecuador)

Recibido: 20/10/2025
Recibido tras revisión: 31/10/2025
Aceptado: 4/11/2025
Publicado: 28/1/2026

KEY WORDS
FPGA, Software Defined Radio (SDR), Open Wi-Fi, Wireless Communication, Signal Processing.

ABSTRACT
The paper presents a simulation of open Wi-Fi service using the Analog Devices ADRV9364-Z7020 card, which integrates an FPGA-based architecture. The proposal seeks to analyze the behavior of wireless communication within a telecommunications system implemented using software-defined radio (SDR).

During development, the installation, configuration, and verification stages of the logic blocks associated with the routing protocol were carried out, in addition to parameter optimization and testing with specialized simulation tools. Subsequently, the system's performance was evaluated under different operating conditions, considering the 2.4 GHz and 5 GHz bands.

The results obtained show that the equipment used offers stable and adaptable performance, with an adequate level of sensitivity for monitoring environments, intrusion detection, and commercial applications, highlighting its potential for real implementations of experimental wireless networks.

PALABRAS CLAVE
FPGA, SDR, Wi-Fi, Comunicación inalámbrica, Procesamiento de señal.

RESUMEN
El trabajo presenta una simulación del servicio de Wi-Fi abierto empleando la tarjeta Analog Devices ADRV9364-Z7020, que integra una arquitectura basada en FPGA. La propuesta busca analizar el comportamiento de la comunicación inalámbrica dentro de un sistema de telecomunicaciones implementado mediante radio definida por software (SDR).

Durante el desarrollo se realizaron las etapas de instalación, configuración y verificación de los bloques lógicos asociados al protocolo de enrutamiento, además de la optimización de parámetros y pruebas con herramientas de simulación especializadas. Posteriormente, se evaluó el rendimiento del sistema bajo distintas condiciones de operación, considerando las bandas de 2.4 GHz y 5 GHz.

Los resultados obtenidos evidencian que el equipo empleado ofrece un desempeño estable y adaptable, con un nivel de sensibilidad adecuado para entornos de monitoreo, detección de intrusiones y aplicaciones comerciales, destacando su potencial para implementaciones reales de redes inalámbricas experimentales.

1. INTRODUCTION

This work was developed internally at the institution with the aim of strengthening competencies in the field of wireless communication networks and promoting future lines of collaborative research. It also seeks to promote the generation and dissemination of applied knowledge, contributing both to the academic environment and to the technological development of the community.

The project is based on the implementation of a software-defined radio (SDR) system based on the Xilinx Zynq XC7Z020-1CLG400I processor, whose architecture allows flexible updating using high-level programming languages such as C/C++, Java, and Python [1]. The IEEE 802.11 standard is adopted as a technical reference, especially its most recent versions, which have significantly improved the performance of wireless networks,

https://doi.org/10.29166/ingenio.v9i1.8936

pISSN 2588-0829
eISSN 2697-3243
fing.revista.ingenio@uce.edu.ec

bringing them closer to the behavior of conventional Ethernet networks [2].

Several studies complement this research. In [3], for example, the performance of an OpenWRT-based router on Raspberry Pi 4 and Cisco 1905 platforms was analyzed, obtaining average reception (RX) speeds of 964 Mbps and 963 Mbps, and transmission (TX) speeds of 947 Mbps and 963 Mbps. In [4], the multipoint CSI localization technique was applied in OpenWiFi environments, comparing the results with emulation models. For its part [5] proposed a system for predicting quality of service parameters using OpenWRT and NoDogSplash, modifying the router's firmware to generate a captive portal [6].

These works demonstrate the versatility of OpenWRT and its value in the evaluation of routers, location techniques, and quality of service analysis, providing innovative solutions in different wireless communication contexts [3].

Finally, the experiments carried out in this study allowed us to observe the behavior of the equipment, the quality of the link, and the influence of the antenna position. Initial results indicate that the device performs better in short-range links, making it particularly suitable for indoor applications. These findings provide a useful basis for assessing its potential implementation in practical network scenarios.

2. RELATED WORK AND METHOD

2.1. RELATED WORK

2.1.1. Evolution of wireless networks and IEEE 802.11 standards

Wireless networks have transformed the interconnection between devices, reducing dependence on cables and facilitating more agile and flexible installations. This advance has enabled immediate transmission of information, with notable improvements in performance and quality of service [7]. Wireless communications are now central to digital transformation, driven by continuous investment in technological infrastructure [8].

Wi-Fi technology, based on the IEEE 802.11 standard, has established itself as an essential tool in modern computing [9]. The progressive adoption of variants of the standard has made it possible to achieve transfer rates comparable to traditional Ethernet networks, thanks to optimizations in the physical layer and the MAC layer [10]. The most recent versions integrate MIMO (Multiple Input Multiple Output) schemes that allow speeds greater than 100 Mbps in the 2.4 GHz and 5 GHz bands [11].

2.1.2. Software-Defined Radio (SDR) and the OpenWiFi Project

In the context of wireless network research, software-defined radio (SDR) has gained relevance as a versatile and low-cost solution. Its architecture allows functions traditionally implemented in hardware to be transferred to programmable environments, offering flexibility, portability, and cost reduction compared to dedicated solutions [12].

One of the most representative projects in this field is OpenWiFi, an open-source initiative developed by engineers at Ghent University (Belgium). This project addresses the implementation of the IEEE 802.11 standard on SDR platforms, facilitating experimentation in wireless network research and development [13]. OpenWiFi can run on various devices and has demonstrated its potential in multi-access configurations and 4G/5G research environments [14].

The OpenWiFi embedded system is based on the Linux mac80211 framework, complying with the specifications of the IEEE 802.11 standard. Its structure consists of two parts: the Processing System, responsible for the upper layers and data link, and the Programmable Logic (FPGA) [15], which executes the real-time functions of the physical layer [13]. This separation allows for a modular and reconfigurable design, ideal for highly flexible experimental platforms [16].

2.1.3. OpenWRT applications and wireless location systems

The OpenWRT system, widely used in routers and gateways, has proven its usefulness in various network evaluation and location technique projects. In [3], the performance of an OpenWRT-based router using Raspberry Pi 4 and Cisco 1905 was analyzed, achieving average reception (RX) speeds of 964 Mbps and transmission (TX) speeds of 947 Mbps. Meanwhile, in [4], a multipoint Channel State Information (CSI) location system was implemented, achieving superior results compared to simulated environments.

In another study, [5] proposed a predictive model of service quality using OpenWRT and NoDogSplash, modifying the router's firmware to include a captive portal. These works demonstrate the potential of open systems to develop reproducible and adaptable test environments in the field of wireless communications.

2.1.4. Principles of signal transmission and propagation

Orthogonal Frequency Division Multiplexing (OFDM) modulation forms the basis of most modern wireless communication standards [17]. Its principle is based on the insertion of a cyclic prefix (CP), which replicates the final part of the OFDM symbol to compensate for channel dispersion and avoid intersymbol interference [18].

Compared to single carrier (SC) or spread spectrum (DSSS) schemes, OFDM has higher synchronization requirements and greater sensitivity to phase noise [19], although it significantly improves spectral efficiency.

To complement the characterization of propagation, the Fresnel zone describes the ellipsoidal volume between the transmitter and receiver within which obstacles must be kept clear to avoid diffraction losses [20].

To determine the radius of the nth Fresnel zone, the following is used:

$$R_n = \sqrt{\frac{n\lambda d_1 d_2}{d}} \quad (1)$$

Replacing the wavelength with the frequency of the signal relative to the speed of light in a vacuum, we obtain the following:

$$R_n = 548\sqrt{\frac{d_1 d_2}{d \cdot f}} \quad (2)$$

d_1 : the distance from the transmitter to the re ection point (in kilometers).
d_2 : the distance from the receiver to the re ection point (in kilometers).
D : the total distance between the transmitter and receiver, d1+d2 (in kilometers).
R_n : radius of the nth Fresnel zone (m).
n : zone number (normally the rst zone is used, n = 1).
f : signal frequency (GHz).
λ : Wavelength (m)

ese zones determine the di erent contributions to the total eld of the receiver, the most important being the rst Fresnel zone, which contains 50% of the wave's pow

2.1.5. SDR hardware platforms and development modules

The AD9364 family from Analog Devices includes high-performance radio frequency transceivers designed for 3 and 4G applications. In particular, the ADRV9364-Z702(card, based on the Xilinx Zynq-7000 processor, o ers a operating range between 70 MHz and 6.0 GHz, making an ideal tool for prototyping SDR systems [21].

Analog Devices' SDR carrier module allows for 1x and 2x2 con gurations, with access to Ethernet, USB JTAG, and serial interfaces, as well as 100-pin connect that facilitate system expansion [22].

e development board generates power rails and provides adjustable voltages for the FPGA's logic inputs and outputs, integrating measurement points for power consumption and voltage control [23].

is architecture combines performance and flexibility, providing a solid foundation for research and development projects in recon gurable wireless communication systems.

2.1.6. Wi-Fi network analysis and diagnostic tools

The Inssider software, developed by Metageek, allows the quality of Wi-Fi connections to be analyzed and optimized by identifying interference and channel con icts. Although it is only available for Windows, the LinSSID alternative in Linux environments o ers similar functionality [24].

ese tools are useful in evaluating channel quality and detecting dead zones or tra c overload, which are fundamental aspects when designing and adjusting OpenWiFi and SDR-based networks.

2.2. METHOD

2.2.1. Test bench design

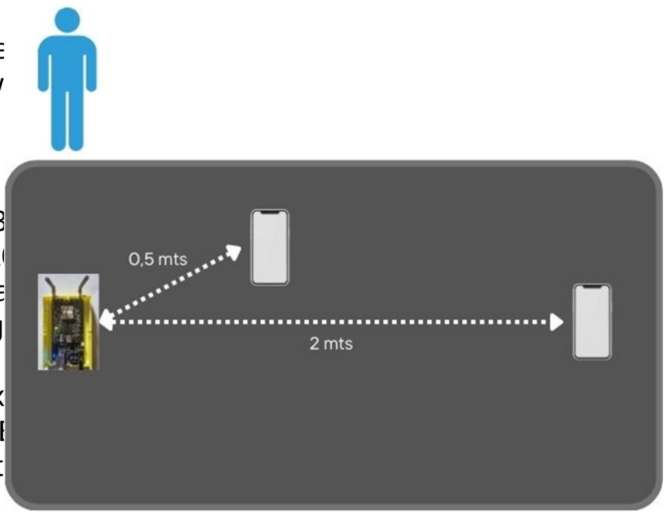
The test bench was developed at the Optical Communications Laboratory, where various experimental scenarios were de ned to evaluate the system's performance under di erent operating conditions.

Each scenario considered transmission and reception rate measurements (Mbps), varying the distance between devices and the presence of obstacles in the line of sight. is approach allowed us to obtain representative data on the performance of the equipment in real, uncontrolled environments.

Fig. 1 illustrates the general layout of the tests, in which the host devices are located at di erent distances from the access point to analyze power loss, delay, and link stability. In this way, we seek to establish a comparative behavior between ideal conditions and partially obstructed environments.

Fig 1.

Assessment area



2.2.2. System configuration and evaluation network

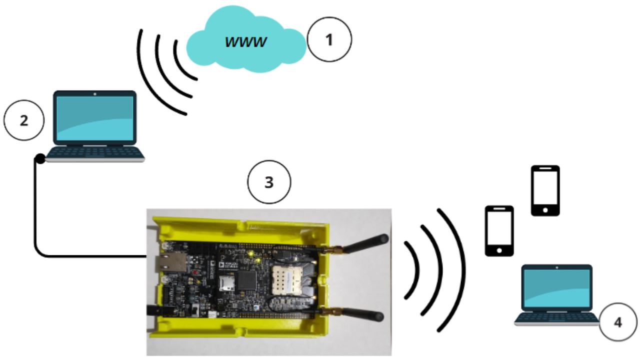
The experimental network, shown in Fig. 2, was designed using the Analog Devices ADRV9364-Z7020 card, installed on the ADRV1CRR-BOB breakout board.

e OpenWiFi service was implemented on this platform to analyze wireless communication in terms of data rate, response time, and signal quality, establishing connections with a cellular device and a computer.

e system diagram consists of the following elements:

1-Internet connection: Provides access to the main network and connectivity to the Admin Computer, through which data from devices connected to the access point is routed.

Fig 2.
Wireless Communication Network Diagram



2-Admin Computer: Acts as the main node of the system, responsible for the installation, con guration, and control of the network. It also acts as a route and rewall once the OpenWiFi service is active.
3-FPGA cards: ese act as wireless transceivers, managing both the transmission and reception of data t the Admin Computer.
4-Host devices: ese represent the client devices-connected to the network generated by the FPGA: ese devices are used to validate the connectivity, speed, and stability of the link.

2.2.3. Configuration and connection procedure

During configuration, on-board mode was used for direct command execution on the FPGA board. On the main PC, a static IP address of 192.168.10.1 with a mask of 255.255.255.0 was set, corresponding to the OpenWiFi network segment.

Subsequently, the system was accessed using the command: ssh root@192.168.10.122 with the default password "openwi , which allowed logging into the-system interface.

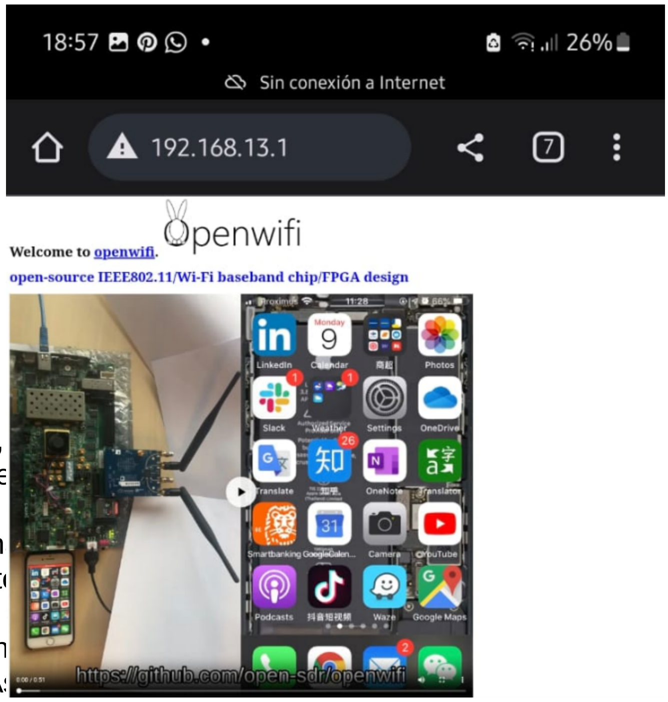
Before activating Access Point mode, speci c functional settings were executed through the SSH console (detailed in the appendices). Once this con guration was complete, the SSID "openwi " became visible to nearby devices, allowing connection using the password "openwi ." e connected devices received IP addresses within the range 192.168.13.x, ensuring correct DHCP assignment.

2.2.4. Link verification and gateway access

Fig. 3 shows the gateway verification process, a fundamental step in con rming system connectivity.

A er establishing the connection, the address 192.168.13.1, corresponding to the web interface hosted locally on the FPGA board, was entered into the-device's browser. Successful access to this page con rmed the operation of the access point and bidirectional communication with the hosts.

Fig 3.
View of the gateway from the browser of a computer connected to the network



Finally, routing/NAT was con gured on the Admin Computer to allow Internet access from devices connected to OpenWiFi. e commands used for this stage are detailed in the technical annexes, along with the additional network con gurations necessary for the system to function properly.

2.2.5. Experimental validation

With the operating system and configurations in place, connectivity tests and performance measurements were performed using network diagnostic tools.

e parameters evaluated included transmission rate (TX), reception rate (RX), packet loss, average latency, and link stability. e results of these measurements were then used to compare the behavior of the system in di erent scenarios of distance and physical obstruction.

3. RESULTS AND DISCUSSION

3.1. RESULTS

3.1.1. General performance evaluation

The results obtained come from the analysis of several experimental scenarios designed to evaluate the performance of the OpenWiFi system implemented on the ADRV9364-Z7020 card.

e measurements were performed using Inssider so ware, complemented by quality of service (QoS) tests and link drop detection using terminal commands.

These evaluations allowed us to observe the behavior of the network as a function of distance, the presence of obstacles, and variations in signal strength.

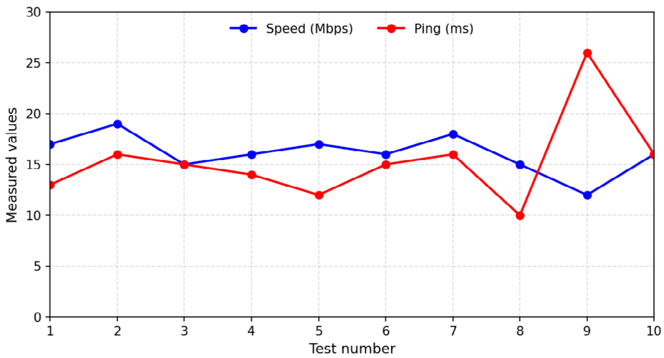
3.1.2. Tests without obstacles

The first test bench consisted of measuring the performance of the wireless link with a direct line of sight between the host devices and the access point.

Fig. 4 shows the variation in the connection speed of the devices at a distance of 1 meter, represented by the blue line. e same graph shows the evolution of the ping overtime, which allows us to identify the stability of the link and its responsiveness under ideal conditions.

Fig 4.

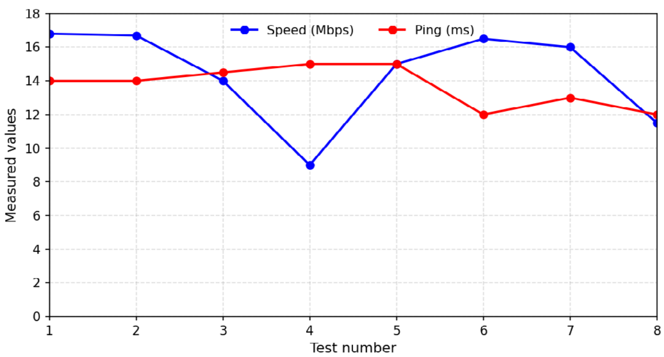
Performance Evaluation of Speed and Ping at a 1m Distance



Subsequently, the distance was increased to 1.5 meters while maintaining line of sight. Fig. 5 shows the evolution of average speed and latency, where a slight decrease in the transfer rate can be seen, associated with the natural dispersion of the electromagnetic eld and the attenuation of the received power level.

Fig 5.

Performance Evaluation of Speed and Ping at a 1.5m Distance



3.1.3. Tests with obstacles

In the second set of tests, physical obstructions were introduced in the line of sight between the host devices and the access point, maintaining the same distance as before.

Fig. 6 in annex, shows the results at 1 meter with obstacles, showing a noticeable reduction in average transfer speed and an increase in ping variability, indicating greater uctuation in link quality.

Similarly, Fig. 7 shows the behavior of the system at 1.5 meters with obstacles, where an increase in response times and a partial loss of connection stability can be observed.

3.1.4. Signal strength and link stability

The Inssider software allowed the Wi-Fi signal strength to be recorded in both scenarios.

Fig. 8 shows the record obtained during the test with obstruction, in which intervals of disturbance and momentary signal drop are identi ed. ese uctuations correspond to temporary variations in channel attenuation and propagation delay.

In contrast, Fig. 9 shows the behavior of the signal strength without obstruction, where the trace remains stable over time, evidencing a continuous link with low variability.

Overall, the results re ect the sensitivity of the system to physical interference and con rm the correct operation of the OpenWiFi service at short distances under controlled conditions.

3.1.5. Comparative analysis

Comparing both scenarios, it was observed that the average transmission and reception speed decreases progressively as the distance increases or obstacles are introduced.

At 1 meter without obstacles, the link maintained stable communication with minimal latency and negligible packet loss. In contrast, at 1.5 meters with obstacles, there was an increase in delay and a moderate drop in throughput, although without total loss of the link.

 ese observations con rm that the ADRV9364-Z7020 platform with OpenWiFi service is optimal for short-range links, making it ideal for indoor environments or experimental laboratory applications where line of sight can be guaranteed.

3.2. DISCUSSION

3.2.1. System performance analysis

During the experiment, notable variations were identified in the transmission and reception speeds of the OpenWiFi system implemented on the ADRV9364-Z7020 card.

Fig. 10 shows the relationship between both variables throughout the day, revealing uctuations linked to the network load in the laboratory.

Around 12:00 p.m., a signi cant decrease in average speed was recorded due to the activity of a user who accessed high-de nition content, which increased bandwidth consumption.

Subsequently, around 1:00 p.m., the speed reached a maximum of close to 900 Mbps, stabilizing as interference from surrounding networks decreased.

Complementarily, Fig. 11 shows the results obtained after disconnecting the other active networks in the environment.

In this case, the system reached transmission peaks of up to 1.0 Gbps, demonstrating that electromagnetic interference and channel competition directly influence the overall performance of the wireless link.

This behavior highlights the sensitivity of the system to environmental conditions and the importance of spectrum planning in shared environments.

3.2.2. Comparison with previous studies

The results obtained are consistent with those described by the research team in [5], who conducted tests under similar conditions using FPGA platforms and the OpenWRT operating system.

In both cases, the measurements confirm that environmental variability and the number of simultaneous networks have a direct impact on quality of service (QoS) and effective transfer rate.

However, the commercial routers analyzed in [5] showed greater sustained transmission capacity due to their optimized architecture and mature firmware.

In contrast, the experimental configuration of this study based on OpenWiFi shows greater flexibility for system customization, making it a viable alternative for research, simulation, and teaching scenarios for programmable wireless networks.

3.2.3. Applicability of the ADRV9364-Z7020 + OpenWiFi system

The ADRV9364-Z7020 platform proved to be suitable for experimentation in SDR networks thanks to its adaptability and reconfigurability via software [10].

The OpenWiFi environment enabled the execution of advanced functions such as intrusion detection, IQ frame capture, channel state information (CSI) analysis, and radar emulation or network fuzzer [11].

These features make the system a versatile tool for research projects in security, spectrum modeling, and wireless performance evaluation under controlled conditions.

3.2.4. Implications and final observations

The comparative analysis suggests that OpenWRT remains a preferred choice for commercial applications and router evaluations, thanks to its extensive package library and support community.

However, OpenWiFi represents an open environment that favors direct understanding and manipulation of the physical and MAC layers, something that is not readily accessible on closed platforms. Consequently, the system proposed in this work is ideal for academic laboratories, protocol testing environments, interference simulations, and short-range spectral performance studies [18].

4. CONCLUSIONS

During testing, it was verified that the ADRV9364-Z7020 equipment has an automatic shutdown feature after approximately four hours of continuous operation, which represents a practical limitation for prolonged unsupervised testing. It was also observed that wireless link performance is affected by the movement of host equipment and the presence of obstacles in the line of sight between the transmitter and receiver, causing variations of up to 15% in effective transmission speed. Quality of service (QoS) was found to be closely related to antenna gain and spatial orientation, factors that determined the level of directivity and channel stability. On average, the system maintained a link efficiency of 92%, with losses of less than 8% under controlled conditions and latency ranging from 18 to 35 ms depending on the level of interference present. These results confirm that the equipment is more suitable for short-range links, particularly in indoor environments where propagation and antenna position can be precisely controlled.

The findings allow for a clearer assessment of the device's viability in different contexts of use, from academic experimentation to the design of specific communication systems. The information obtained provides a solid basis for deciding on its implementation according to the needs of coverage, stability, and system efficiency. For those working with this type of platform, it is recommended to use Linux-based operating systems, given their flexibility for programming, automation, and driver debugging, as well as their ease of integration with scientific development libraries. It is also advisable to perform a preliminary review of the physical and functional status of the hardware before each test to detect possible failures or incompatibilities that could compromise the performance or security of the system.

Finally, it is suggested to take advantage of the tools and resources provided by Analog Devices, particularly the OpenWiFi environment, for the development of educational and research projects aimed at evaluating SDR networks, experimenting with channel parameters, and simulating interference conditions. These results confirm that the ADRV9364-Z7020 device is a valuable platform for teaching and analyzing programmable wireless communications, and that its correct configuration can offer competitive performance compared to higher-cost commercial solutions, if it is kept within controlled distance and power ranges.

REFERENCES

[1] Y. Liu, H. Liu, M. Zhang, P. Chen, and F. Yang, "Software Defined Radio Implementation of an

enhanced LTE-WiFi Aggregation System," presented at the 2018 IEEE/CIC International Conference on Communications in China (ICCC), Beijing, China, Aug. 2018, pp. 604–608. doi: 10.1109/ICCChina.2018.8641258.

[2] F. Tramarin, A. K. Mok, and S. Han, "Real-Time and Reliable Industrial Control Over Wireless LANs: Algorithms, Protocols, and Future Directions," *Proceedings of the IEEE*, vol. 107, no. 6, pp. 1027–1052, Jun. 2019, doi: 10.1109/JPROC.2019.2913450.

[3] J. Damasceno, J. Dantas, and J. Araujo, "Network Edge Router Performance Evaluation: An OpenWrt-Based Approach," presented at the 2022 17th Iberian Conference on Information Systems and Technologies (CISTI), Madrid, Spain, Jun. 2022, pp. 1–6. doi: 10.23919/CISTI54924.2022.9820027.

[4] L. Ghiro, M. Cominelli, F. Gringoli, and R. L. Cigno, "On the Implementation of Location Obfuscation in openwi and Its Performance," presented at the 2022 20th Mediterranean Communication and Computer Networking Conference (MedComNet), Pafos, Cyprus, Jun. 2022, pp. 64–73. doi: 10.1109/MedComNet55087.2022.9810411.

[5] M. Ateeq, M. K. Afzal, S. Anjum, and B.-S. Kim, "Cognitive quality of service predictions in multi-node wireless sensor networks," *Computer Communications*, vol. 193, pp. 155–167, Sep. 2022, https://doi.org/10.1016/j.comcom.2022.06.042.

[6] L. Ye, B. Chen, C. Sun, S. Wang, P. Zhang, and S. Zhang, "A Study of Semi-Fungible Token based Wi-Fi Access Control," presented at the 2024 IEEE 24th International Conference on Communication Technology (ICCT), Chengdu, China, Oct. 2024, pp. 722–727. doi: 10.1109/ICCT62411.2024.10946664.

[7] S. Chakrabarty and D. W. Engels, "Secure Smart Cities Framework Using IoT and AI," presented at the 2020 IEEE Global Conference on Arti cial Intelligence and Internet of ings (GCAIoT), Dubai, United Arab, Dec. 2020, pp. 1–6. doi: 10.1109/GCAIoT51063.2020.9345912.

[8] B. Li, Z. Fei, C. Zhou, and Y. Zhang, "Physical-Layer Security in Space Information Networks: A Survey," *IEEE Internet of Things Journal*, vol. 7, no. 1, pp. 33–52, Jan. 2020, doi: 10.1109/JIOT.2019.2943900.

[9] C. Chen, H. Song, Q. Li, F. Meneghello, F. Restuccia, and C. Cordeiro, "Wi-Fi Sensing Based on IEEE 802.11bf," *IEEE Communications Magazine*, vol. 61, no. 1, pp. 121–127, Jan. 2023, doi: 10.1109/MCOM.007.2200347.

[10] D. M. Molla, H. Badis, L. George, and M. Berbineau, "So ware De ned Radio Platforms for Wireless Technologies," *IEEE Access*, vol. 10, pp. 26203–26229, 2022, doi: 10.1109/ACCESS.2022.3154364.

[11] X. Jiao, W. Liu, M. Mehari, M. Aslam, and I. Moerman, "openwi : a free and open-source IEEE802.11 SDR implementation on SoC," presented at the 2020 IEEE 91st Vehicular Technology Conference (VTC2020-Spring), Antwerp, Belgium, May 2020, pp. 1–2. doi: 10.1109/VTC2020-Spring48590.2020.9128614.

[12] S. Bräuer, A. Zubow, and F. Dressler, "Towards So ware-Centric Listen-Before-Talk on So ware-De ned Radios," presented at the 2021 IEEE Wireless Communications and Networking Conference (WCNC), Nanjing, China, Mar. 2021, pp. 1–7. doi: 10.1109/WCNC49053.2021.9417395.

[13] Z. Yun, P. Wu, S. Zhou, A. K. Mok, M. Nixon, and S. Han, "RT-WiFi on So ware-De ned Radio: Design and Implementation," presented at the 2022 IEEE 28th Real-Time and Embedded Technology and Applications Symposium (RTAS), Milano, Italy, May 2022, pp. 254–266. doi: 10.1109/RTAS54340.2022.00028.

[14] J. Navarro-Ortiz *et al.*, "Combining 5G New Radio, Wi-Fi, and LiFi for Industry 4.0: Performance Evaluation," *Sensors*, vol. 24, no. 18, p. 6022, Sep. 2024, https://doi.org/10.3390/s24186022.

[15] Z. Lei, X. Qiu, Z. Lei, and Z. Lei, "Research on So ware Radio Signal Processing Technology Based on FPGA for OpenWi ," presented at the 2024 3rd International Conference on Electronics and Information Technology (EIT), Chengdu, China, Sep. 2024, pp. 61–66. doi: 10.1109/EIT63098.2024.10762444.

[16] H. J. Santillán Carranza, J. D. Ochoa Ayala, J. A. Ordoñez Guzmán, and P. M. A. Wong Wong, "Implementation of a Weather Station Using FPGA with Real Time Data Access and Analysis," *INGENIO*, vol. 8, no. 2, pp. 53–66, Jul. 2025, https://doi.org/10.29166/ingenio.v8i2.7449.

[17] J. Li, S. Dang, Y. Huang, P. Chen, X. Qi, and M. Wen, "Composite Multiple-Mode Orthogonal Frequency Division Multiplexing With Index Modulation," *IEEE Transactions on Wireless Communications*, vol. 22, no. 6, pp. 3748–3761, Jun. 2023, doi: 10.1109/TWC.2022.3220752.

[18] R. Estrada, I. Valeriano, X. Aizaga, L. Vargas, N. Vera, and D. Zambrano, "WiFi Indoor Positioning System Based on OpenWRT," presented at the IEEE EUROCON 2023 - 20th International Conference on Smart Technologies, Torino, Italy, Jul. 2023, pp. 728–733. doi: 10.1109/EUROCON56442.2023.10199056.

[19] I. Khan, M. Che ena, and M. M. Hasan, "Data Aided Channel Estimation for MIMO-OFDM Wireless Systems Using Reliable Carriers," *IEEE Access*, vol. 11, pp. 47836–47847, Apr. 2023, doi: 10.1109/ACCESS.2023.3269659.

[20] W. Hao *et al.*, "Robust Design for Intelligent Reflecting Surface-Assisted MIMO-OFDMA Terahertz IoT Networks," *IEEE Internet of Things Journal*, vol. 8, no. 16, pp. 13052–13064, Aug. 2021, doi: 10.1109/JIOT.2021.3064069.

[21] V. Grigoriev, A. Komissarov, K. Ryutin, and G. Fokin, "So ware-De ned Radio Wireless Communication

Technology Design. LibreSDR Board Validation," presented at the 2024 Systems of Signals Generating and Processing in the Field of on Board Communications, Moscow, Russian Federation, Mar. 2024, pp. 1–6. d 10.1109/IEEECONF60226.2024.10496728.
[22] D. D. Langer *et al.*, "Robust and Reconfigurable On-Board Processing for a Hyperspectral Imagin Small Satellite," *Remote Sensing*, vol. 15, no. 15, p. 3756, Jul. 2023, https://doi.org/10.3390/rs1515375
[23] M. Majoral, J. Arribas, and C. Fernández-Prade "Implementation of a GNSS Rebroadcaster in a All-Programmable System-On-Chip Platform," presented at the 2022 10th Workshop on Satelli Navigation Technology (NAVITEC), Noordwijk, Netherlands, Apr. 2022, pp. 1–9. doi: 10.1109 NAVITEC53682.2022.9847537.
[24] X. Cui, J. Yang, and C. Wu, "Improved Genetic Algorithm to Optimize the Wi-Fi Indoor Positioning Based on Arti cial Neural Network," *IEEE Access*, vol. 8, pp. 74914–74921, 2020, doi: 10.110 ACCESS.2020.2988322.

ANNEXES

Fig 6.

Speed and Ping Performance at 1m with Obstacle

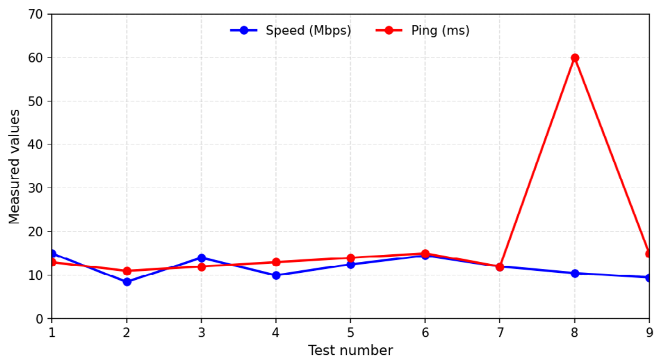


Fig 7.

Speed and Ping Performance at 1.5m with Obstacle

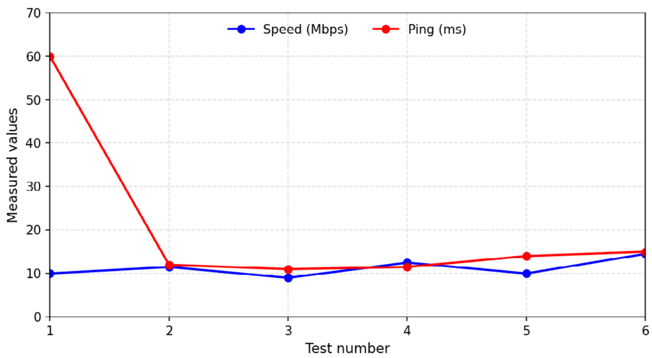


Fig 8.

Signal strength test with link intrusion

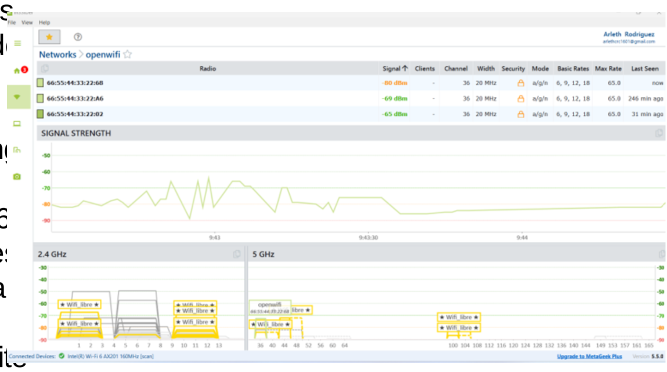


Fig 9.

Signal strength measurement under non-intrusive link conditions

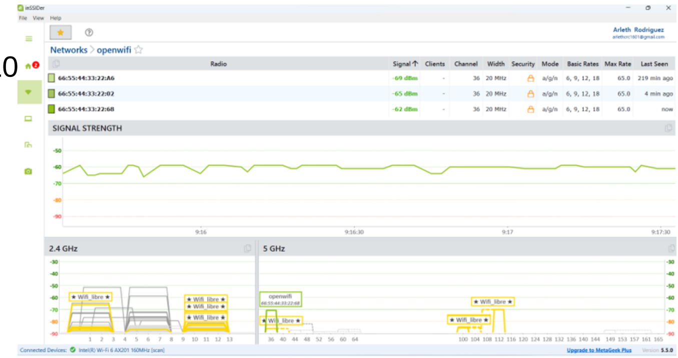


Fig 10.

Relationship between transmission and reception speed of the devices

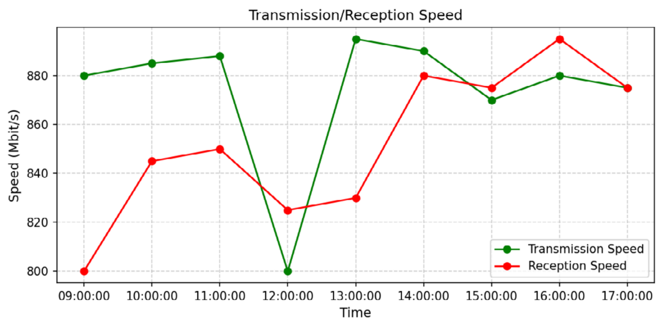


Fig 11.

Data transmission peak after disabling other active networks.