Evaluation of Auracast-Enabled Audio Broadcasts for Public Address (PA) Systems

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Abstract—**Auracast [1], a feature of Bluetooth Low Energy (BLE) Audio, enables a single transmitter to broadcast audio streams to multiple receivers, including modern hearing aids, without pairing. This technology can provide assistive listening services in public spaces while reducing the need for costly induction loop installations. This paper evaluates an Auracast-enabled public address system through measurements in a reference outdoor environment and a dynamic indoor environment, with the aim of assessing its performance under realistic conditions and supporting the deployment of the Auracast-based public announcement system at Frankfurt Airport [2]. Signal propagation was analyzed using Received Signal Strength Indicator (RSSI) measurements, and perceived audio quality was assessed via Mean Opinion Score (MOS) [3] values computed by using the Virtual Speech Quality Objective Listener (VISQOL) tool [4]. The impact of transmission distance, transmitter height, broadcast latency, and environmental interference on performance was also investigated. Results indicate that Auracast can deliver high-quality audio under realistic conditions, supporting scalable public announcements and assistive listening services.**

Keywords— Auracast, Bluetooth Low Energy (BLE) Audio, Assistive Listening, RSSI, Mean Opinion Score (MOS), VISQOL, Audio Quality

I. INTRODUCTION

Public address (PA) systems are widely used in airports, train stations, lecture halls, and other public venues to deliver announcements to large audiences. Traditional loudspeaker-based systems, however, suffer from limitations such as poor speech intelligibility in noisy environments, lack of personalization, and accessibility challenges for hearing-impaired individuals. Many facilities deploy assistive listening technologies, such as induction loop systems, to improve accessibility for hearing aid users, but these solutions require dedicated infrastructure, specialized amplifiers, and careful calibration, making installation and maintenance costly and inflexible.

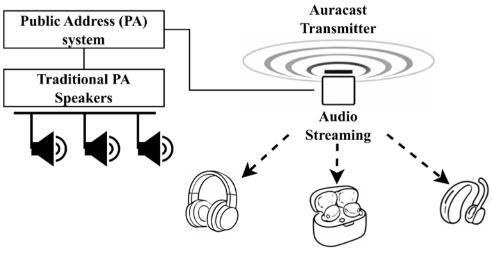

Fig. 1. Auracast broadcast audio integrated into an existing PA system for direct audio transmission to multiple hearing devices.

Recent developments in wireless audio, particularly Bluetooth Low Energy (BLE) [5] with its Auracast broadcast audio feature, offer a scalable alternative. Fig. 1 illustrates the use case of Auracast broadcast audio, integrating into existing PA system. Auracast enables a single transmitter to broadcast audio streams to multiple receivers, including personal hearing devices, without pairing. This approach allows large numbers of users to access the same audio stream simultaneously, potentially improving speech intelligibility and reducing the need for wired assistive infrastructures.

This work focuses on evaluating the feasibility, capabilities, and potential integration of Auracast-enabled broadcast systems in public spaces to improve accessibility and speech comprehension. It presents the first empirical evaluation of an Auracast-enabled broadcast system for PA applications in real-world scenarios. Measurements were conducted in two environments: a reference outdoor setting and a dynamic indoor public space. Performance was assessed using Received Signal Strength Indicator (RSSI) measurements and Mean Opinion Score (MOS) values computed with VISQOL, providing both quantitative communication and perceptual insights. The MOS evaluation is particularly significant, as it reflects the degree to which audio messages can be clearly understood by listeners, which is an essential requirement in dynamic environments where accurate and timely communication is critical, such as airports and train stations. The influence of receiver position, transmitter height, and broadcast latency on system performance was also investigated, yielding practical deployment insights and design guidelines for integrating Auracast into existing PA infrastructures. The evaluation conducted in this work consequently supports the world's first Auracast broadcast system, deployed and assessed at Frankfurt Airport in collaboration with Sittig Technologies [6].

The remainder of the paper is organized as follows. Section II provides background on BLE and Auracast. Section III describes the experimental setup, including the hardware and measurement parameters. Section IV details the test environments and measurement scenarios. Section V presents and discusses the results, and Section VI concludes the paper and outlines directions for future work.

II. BACKGROUND

A. Bluetooth Low Energy

Bluetooth is a wireless communication technology widely used due to its low cost, robustness, and low power consumption. With the introduction of Bluetooth Low Energy (BLE) [7] starting from Bluetooth 4.0, the technology was extended to support power-efficient and scalable communication for emerging Internet of Things (IoT) applications. Typical use cases include wearable devices, health monitoring systems, smart home automation, asset tracking, and industrial sensor networks, which benefit from the low energy consumption and reliable short-range communication provided by BLE.

B. Bluetooth LE Audio

Recent advancements introduced Bluetooth LE Audio [7], which introduces a set of protocol-level enhancements and architectural changes. Bluetooth LE Audio enables high-quality and energy-efficient audio transmission by leveraging the LC3 codec [8]. A key feature of this specification is Auracast broadcast audio, developed by the Bluetooth Special Interest Group (SIG), which allows a single transmitter to broadcast audio streams to multiple receivers simultaneously. This capability enables new applications such as assistive listening systems, personal audio sharing, silent televisions in public venues, and large-scale public announcement systems.

C. Auracast Broadcast Audio

With Auracast broadcast audio, introduced in Bluetooth LE Audio 5.2, different hearing devices, such as earbuds, headsets, or hearing aids, can synchronize to the broadcast audio stream and directly receive audio without requiring pairing. In this broadcast topology, broadcast sources advertise stream availability via BLE advertising channels (37, 38, 39), while other channels carry extended advertising or audio data, though some may be affected by WLAN interference (Fig. 2). Devices supporting Auracast can discover these broadcasts and obtain metadata describing the broadcast stream, such as the broadcast name, language, and audio configuration (e.g., mono or stereo). Broadcast streams can also be encrypted, in which case the receiving device must have the corresponding decryption key to access the audio data. In addition, receivers obtain synchronization information from the advertising data, including timing parameters and channel configuration, which enables them to synchronize with the broadcast transmission and tune to the corresponding data channels carrying the audio packets. The actual audio data is transmitted using Broadcast Isochronous Streams (BIS), which are organized within a Broadcast Isochronous Group (BIG) to provide synchronized and reliable audio delivery to multiple receivers. This broadcast-based communication model enables scalable audio distribution to a potentially large number of listeners while maintaining low power consumption.

As defined by the Bluetooth SIG, Auracast enables a wide range of applications, including assistive listening systems, audio sharing in public venues, silent televisions, and public announcement systems [9]. It supports the transmission of multiple parallel audio streams, which can be received independently by compatible devices. Users can select specific streams based on language, location, or device type, enabling use cases such as multilingual broadcasts and context-specific content delivery. In addition, Auracast can be utilized for important or time-sensitive communications by delivering critical audio messages directly to users' personal devices. This includes scenarios such as airport announcements and real-time travel updates via broadcast audio. Further applications include location-based guided tours, interactive exhibits in museums, and coordinated audio experiences in sports arenas or conference halls. In the context of this work, Auracast is evaluated as a wireless solution for extending the capabilities and improving the accessibility of PA systems, which are responsible for delivering audio announcements in public spaces.

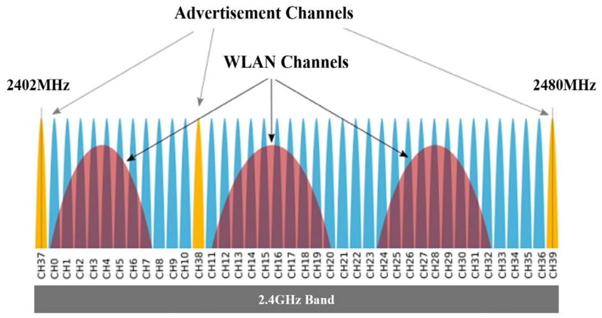

Fig. 2. In the 2.4 GHz band, the BLE advertising channels are positioned to minimize interference with WLAN transmissions [10].

III. MEASUREMENT SETUP

A. Broadcast System Architecture

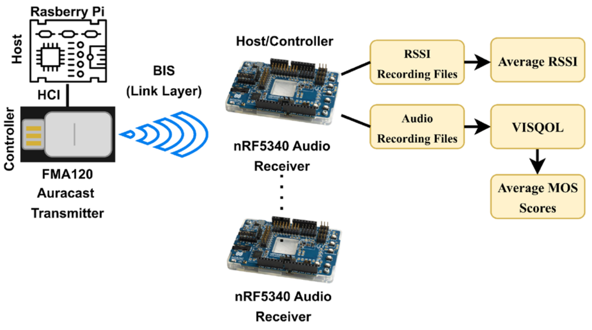

Fig. 3. The measurement architecture implemented for evaluating the Auracast broadcast system.

The measurement setup was designed to evaluate the performance of an Auracast broadcast system. The overall architecture is shown in Fig. 3. The source node comprises a Raspberry Pi acting as the host, interfaced with an FMA120 [11] serving as the controller. The audio data are encoded and transmitted via BIS at the Link Layer (LL). On the receiving side, multiple nRF5340 Audio [12] kits implement both controller and host roles. The controller monitors the physical layer (PHY) to log RSSI values over time, while the host captures the audio payloads. For comprehensive analysis, the average RSSI is computed to assess link reliability, while the recorded audio is analyzed using the VIQOL tool to obtain mean opinion score (MOS) values. This framework enables a quantitative correlation between physical-layer signal strength (RSSI) and application-layer perceptual quality (MOS).

The hardware components used in the measurement setup are summarized in TABLE I. The Auracast transmitter is implemented using a FlooGoo FMA120 USB dongle, while the receivers are based on nRF5340 Audio Development Kits.

TABLE I. THE HARDWARE COMPONENTS USED IN THE MEASUREMENT SETUP

Component	Description	Bluetooth Version	Firmware Version
Auracast Transmitter	FlooGoo FMA120 USB Dongle	5.4	v1.1.4
Auracast Receivers	nRF5340 Audio Kits	5.4	v3.1.0

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B. Parameters

The performance of Auracast transmissions was evaluated through measurements conducted in both indoor and outdoor environments to reflect realistic operational conditions. The nRF5340 Audio DK devices were used as broadcast sinks and placed at predefined measurement points within the test environment. These devices continuously recorded RSSI values and received audio data packets, storing them on internal microSD cards for subsequent analysis. This enabled the assessment of audio reception quality and the investigation of its variation over time under different environmental conditions. To objectively evaluate perceived audio quality, the recorded audio samples were analyzed using VISQOL. This tool computes the Mean Opinion Score (MOS), representing perceived audio quality on a scale from 1 (very poor) to 5 (excellent).

IV. TEST ENVIRONMENT

Measurements were conducted in two distinct environments to evaluate the impact of environmental conditions on the performance of Auracast transmissions. The first environment served as a reference scenario, characterized by minimal interference and near-ideal signal propagation conditions. The second environment was a dynamic public space with a high density of people, numerous wireless devices, and existing wireless infrastructure.

Although this work aims to support the deployment of an Auracast broadcast system at Frankfurt Airport, the Frankfurt University of Applied Sciences (FRA-UAS) Mensa was selected as the second test environment due to security restrictions and limited access to airport infrastructure. Nevertheless, the FRA-UAS Mensa effectively replicates key challenges expected in real-world public deployments, making it comparable to the environmental conditions at Frankfurt Airport.

By comparing results from both environments, the influence of factors such as crowd density, indoor infrastructure, and wireless interference on Auracast broadcast audio performance can be systematically analyzed.

A. Reference Environment

Reference measurements were conducted at the main cemetery in Frankfurt, which features low human activity, few physical obstacles, and nearly no wireless interference (e.g., WLAN access points and Peer-to-peer (P2P) Bluetooth devices). The absence of interference was verified with a spectrum analyzer scanning the 2.4 GHz band. These ideal conditions provide clear line-of-sight propagation and serve as a baseline for evaluating the impact of environmental factors observed in the dynamic public indoor environment.

During the measurements, the Auracast transmitter (FlooGoo FMA120) was positioned at a height of 1 m above ground, reflecting the typical placement inside service desks at the airport. The receiver, implemented with the nRF5340 Audio Kit, was also set at 1 m height, corresponding to the approximate position of hearing devices when users are seated. Measurements were conducted at predefined locations, starting from the transmitter and increasing the distance in 2 m increments. At each measurement point, RSSI values were continuously recorded for 90 s to calculate the average RSSI at that location.

B. Public Indoor Environment

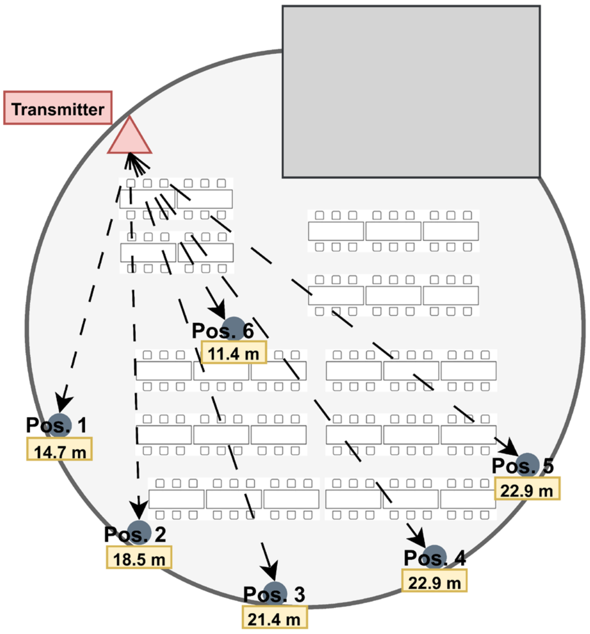

Fig. 4. The positions were selected for the measurements conducted at the Mensa.

Further measurements were conducted to investigate how Auracast transmissions are affected by dynamic and noisy environments typically found in public spaces. These measurements were carried out in the Mensa of the FRA-UAS, which was selected because it provides a realistic and dynamic environment comparable to conditions at Frankfurt Airport. In addition, the location allows for long-term measurements, enabling more in-depth analysis. The Mensa is characterized by a high density of people, continuous activity, and the presence of numerous wireless devices and communication infrastructure, including WLAN access points and P2P Bluetooth devices operating in the same 2.4 GHz frequency band as Bluetooth LE and Auracast.

For this test environment, six receiver positions were selected within the Mensa, as shown in Fig. 4. These locations were chosen based on their distance from the transmitter and areas where signal degradation was expected due to indoor infrastructure, wireless interference, and the presence and movement of people during lunch hours. The Auracast transmitter was tested at two different heights, 1 m and 2 m above the ground, while the receivers, implemented using the nRF5340 Audio Kit, were placed at a height of 1 m, approximating the position of hearing devices when users are seated.

The measurements were conducted over a period of approximately five hours, covering the time before and during the peak lunch period. This allowed investigation of how varying crowd density and operational activities influence the transmission performance. In addition, measurements were performed using different latency configurations (lowest, lower and standard) of the transmitter to analyze their impact on the audio reception performance at the receiver side. In addition, measurements were performed using different transmission latency configurations (lowest, lower, and standard) to analyze their impact on audio reception performance at the receiver side. These latency settings define the buffering and retransmission window of BIS. Higher latency allows more time for an audio packet to be retransmitted, thereby improving reliability at the cost of increased end-to-end delay, whereas lower latency reduces delay but limits retransmission opportunities.

V. EVALUATION

A. Baseline Measurements in Ideal Conditions

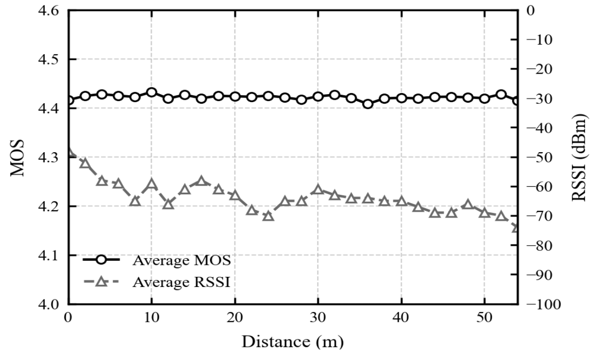

Fig. 5. The variation of average RSSI and MOS with distance in the reference environment

The measured results shown in Fig. 5 represent the tests performed at the cemetery under near-ideal conditions. The average received signal strength at the receiver did not decrease strictly linearly with increasing distance but exhibited minor fluctuations. These variations can be attributed to several factors, including multipath propagation caused by reflections from surrounding objects, small variations in antenna orientation, and the inherent variability of RSSI measurements. Despite these fluctuations, a clear attenuation trend was observed as the distance between the transmitter and the receiver increased. As shown in Fig. 5, the average RSSI decreased from −48 dBm at 0 m to −74 dBm at 54 m. This overall trend confirms the expected signal attenuation with increasing distance in the absence of significant environmental interference.

In contrast to the RSSI behavior, the MOS scores remained stable across the tested distance range, consistently above 4.4. This indicates a very high and stable level of perceived audio quality. Overall, the results show that although RSSI decreases with distance, its impact on perceived audio quality remains negligible within a range of 50 meters under near-ideal conditions.

B. Performance Variation Over Time at the Same Position

For the measurements conducted at the FRA-UAS Mensa, the average RSSI and MOS at each receiver position remain relatively stable, with high MOS values, indicating generally good audio quality. For example, Fig. 6 illustrates the measurement results collected at Pos. 3. A slight decrease in both RSSI and MOS begins around 11:00 a.m., coinciding with increased activity during lunch hours. This degradation can be attributed to higher crowd density and additional wireless activity from personal devices operating in the 2.4 GHz band, which create more challenging signal propagation conditions.

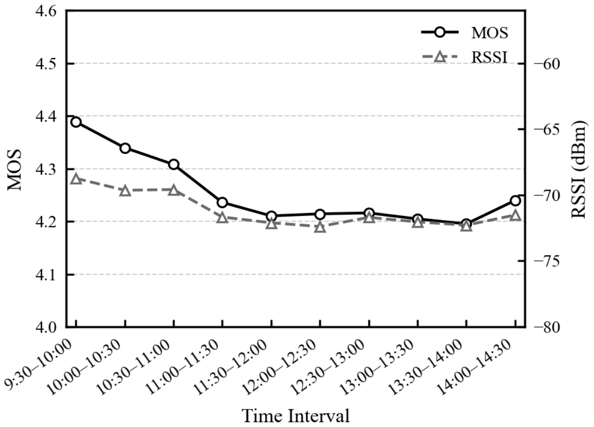

Fig. 6. The average RSSI values and MOS scores measured at the same position over time.

In additions, a clear correlation between RSSI and MOS is observed, indicating that reductions in signal strength due to environmental interferences are reflected in perceived audio quality. Despite degradation over the time, MOS values remain above 4.0, confirming that Auracast provides generally good audio performance under realistic and dynamic environmental conditions. Compared to the reference measurement results, the RSSI and MOS values were closely identical during the first time window, between 9:30 and 10:00 a.m. However, over time, the measured values decreased and became increasingly lower than the corresponding reference values.

C. Performance Comparison Across Receiver Positions

To evaluate performance differences across receiver positions, measurements were conducted at Pos. 1 and Pos. 3 (Fig. 4). The variation in average RSSI over time at these positions is illustrated in Fig. 7, while Fig. 8 depicts the corresponding MOS scores. Initially, the average RSSI values measured at both positions were comparable to the reference values obtained under ideal conditions but decreased slightly over time, confirming a general degradation trend. Pos. 1 exhibits higher RSSI values due to its shorter distance from the transmitter. Since the RSSI values are collected from advertising packets transmitted on the primary advertising channels, which are less affected by WLAN interference, the observed reduction in RSSI at both positions is primarily caused by partial obstruction of the line of sight and absorption by human bodies, indoor furniture, or personal P2P Bluetooth devices, all of which affect signal propagation. Overall, the average MOS scores remain above 4.0 at both positions, indicating consistently good perceived audio quality. Compared with reference measurements under ideal conditions, the MOS scores at Pos. 1 remain consistent and

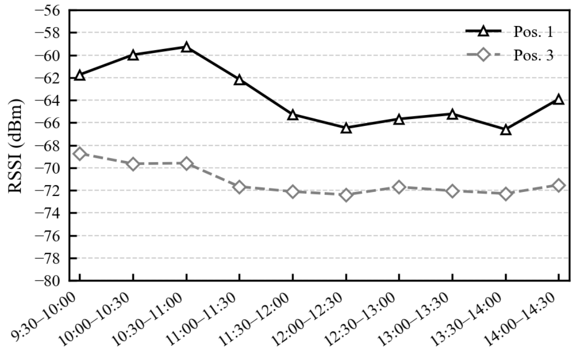

Fig. 7. The average RSSI values measured at two different positions over time.

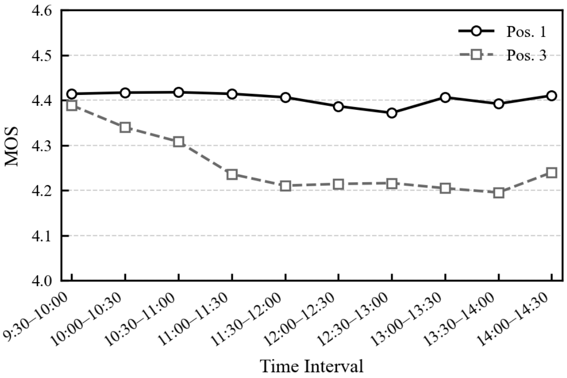

Fig. 8. The average MOS scores measured at two different positions over time.

equivalent, whereas those at Pos. 3 experiences a gradual degradation. Reference measurements indicate that RSSI degradation within the tested range has only a negligible impact on perceived audio quality. However, the transmission of audio data packets, which determines the perceived audio quality at the receiver, is more susceptible to increased wireless activity in the 2.4 GHz band during lunchtime. This leads to transmission collisions and packet loss, resulting in reduced MOS scores at Pos. 3, which was located across a large seating area. Nonetheless, higher received signal strength is required to compensate for propagation loss and poor line of sight, ensuring reliable transmission performance in noisy environments. For this purpose, increasing transmission power or improving transmitter placement would be beneficial.

D. Performance Variation with Transmitter Height

At the same position, measurements were conducted with the transmitter placed at two different heights (1 m and 2 m) to determine whether a higher transmitter position improves link quality. Fig. 9 illustrates the variation in average RSSI over time, while Fig. 10 presents the corresponding MOS values. The results indicate that increasing the transmitter height from 1 m to 2 m has only a minor effect on both RSSI and MOS at Pos. 3. The RSSI differences between the two configurations are small and generally fall within typical measurement variability. Similarly, the MOS values remain nearly identical, indicating that perceived audio quality is not significantly affected by transmitter placement within this height range. A slight improvement in RSSI for the 2 m configuration is occasionally observed during peak hours, likely due to reduced signal obstruction by human bodies. Overall, these findings suggest that environmental factors, such as crowd density and indoor obstacles, have a greater influence on signal performance than transmitter height within the tested range. Positioning the transmitter at a higher elevation, such as on the ceiling, will be more effective.

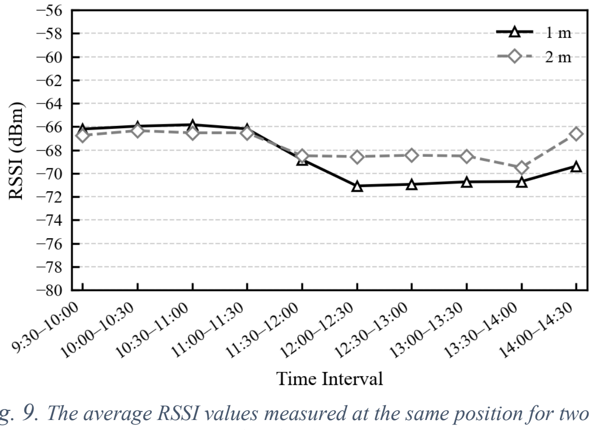

Fig. 9. The average RSSI values measured at the same position for two transmitter heights (1 m and 2 m).

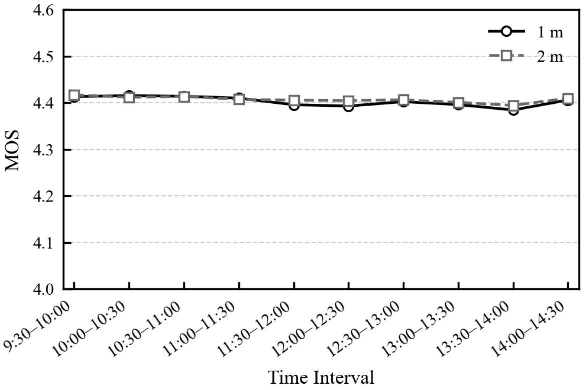

Fig. 10. The average MOS scores measured at the same position for two transmitter heights (1 m and 2 m).

E. Performance Variation with Broadcast Latency

In Auracast broadcast, transmission latency defines the time window for sending a single audio data packet. Higher latency allows more opportunities for packet retransmission, increasing the likelihood that receiving devices obtain the data packet successfully. To investigate the impact of transmission latency on link quality and perceived audio, measurements

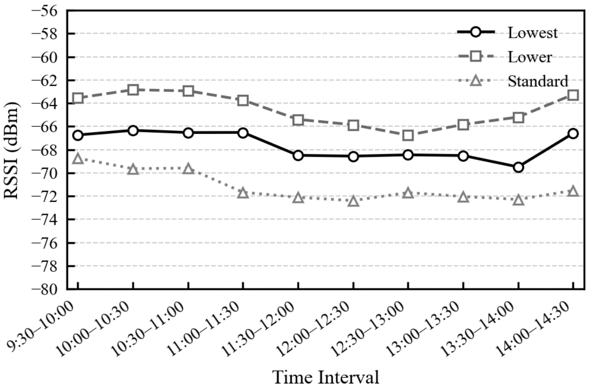

Fig. 11. The average RSSI values measured at the same position for different transmission latency settings.

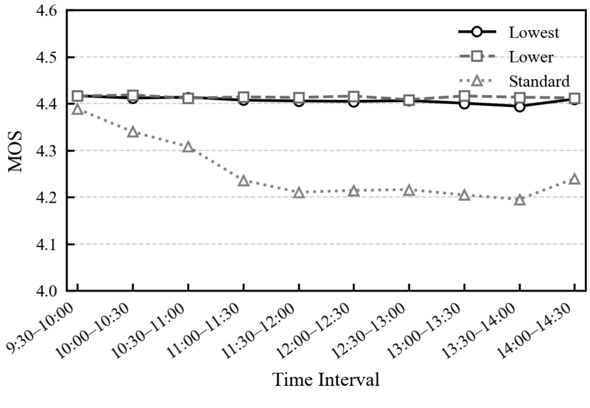

Fig. 12. The average MOS scores measured at the same position for different transmission latency settings.

were performed using different latency settings at the transmitter. Fig. 11 shows the variation in average RSSI over time for the tested configurations (lowest, lower and standard), while Fig. 12 illustrates the corresponding MOS values. The MOS remains consistently high throughout the measurements, ranging from approximately 4.19 to 4.42, indicating good perceived audio quality. Among the evaluated configurations, the standard latency setting generally results in slightly lower MOS compared to the lowest and lower settings, whereas the latter two exhibit nearly identical performance. A slight decrease in MOS is observed during the lunch period, coinciding with increased crowd density and wireless activity. RSSI values show a similar decreasing trend, indicating a correlation between received signal strength and perceived audio quality.

F. *Observed Audio Disruptions Across Receiver Positions*

Long-term measurements were conducted at six different receiver positions within the Mensa. The results indicate that audio disruptions and synchronization issues were observed occasionally at Pos. 4 and Pos. 5. These locations were situated across a large seating area and were relatively farther from the transmitter compared to the other measurement points, which likely resulted in weaker signal reception. In addition, the disruptions occurred primarily during peak hours around lunchtime, when the number of guests and wireless devices operating in the same 2.4 GHz band as BLE and Auracast increased significantly. This suggests that both increased distance and environmental factors such as human body absorption and wireless interference contributed to the observed transmission instability.

VI. CONCLUSIONS

The results demonstrate distinct RSSI–MOS behavior in the two test environments. In the reference environment, RSSI decreased with distance as expected, while MOS remained high and stable, indicating robust audio quality under near-ideal conditions. This confirms that the signal strength and evaluated distance range were effective to ensure reliable transmission performance in this test scenario. In contrast, in the dynamic indoor environment, where measurements were performed at fixed positions, a degradation trend in RSSI over time was observed at the measurement positions. This was primarily due to environmental factors such as crowd density, indoor infrastructure, user mobility, and interference from personal P2P Bluetooth devices. On the other hand, the MOS scores degraded mainly at positions across a large seating area. This was highly due to poor line of sight and increased WLAN activity in the area during lunchtime, which causes transmission collisions and affects the delivery of audio data packets. However, higher received signal strength would be beneficial to mitigate the impact of wireless interference and ensure reliable transmission performance in noisy environment.

Variations in transmitter height between 1 m and 2 m had a negligible impact on both RSSI and MOS. Across latency configurations, the lowest and lower latency settings achieved comparable MOS values, while the standard latency configuration occasionally resulted in slightly reduced perceived audio quality. Disruptions were primarily observed at receiver positions located farther from the transmitter and across large seating areas, particularly during peak lunch hours when crowd density and wireless activity were highest.

Overall, the system demonstrated consistently high audio quality, with MOS values remaining above 4.0 in all measurements, indicating clear and intelligible speech transmission even in challenging environments. These results confirm the feasibility of integrating Auracast broadcast audio into public address systems and demonstrate its maturity for real-world deployment, including large-scale use cases in dynamic public environments such as airports or train stations. Beyond traditional PA applications, Auracast enables advanced capabilities such as multiple parallel audio streams, multilingual broadcasting, and user-selectable content, improving accessibility and user experience in complex environments. Future work will focus on large-scale deployment scenarios, optimized transmitter placement, and further improvements in coverage, scalability, and robustness. In addition, the integration of Auracast into smart infrastructure and next-generation public communication systems will be explored to fully leverage its capabilities.

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REFERENCES

[1] Bluetooth SIG, “Auracast Broadcast Audio.” Accessed: Oct. 22, 2025. [Online]. Available: https://www.bluetooth.com/auracast/.

[2] Jason Marcel, “AuracastTM broadcast audio takes off at Frankfurt Airport.” Accessed: Mar. 19, 2026. [Online]. Available: https://www.bluetooth.com/blog/auracast-broadcast-audio-takes-off-at-frankfurt-airport/.

[3] ITU-T, “P.800.1 : Mean opinion score (MOS) terminology,” 2016. Accessed: Mar. 18, 2026. [Online]. Available: https://www.itu.int/rec/T-REC-P.800.1-201607-I/en

[4] Google, “ViSQOL (Virtual Speech Quality Objective Listener).” Accessed: Mar. 18, 2026. [Online]. Available: https://github.com/google/visqol.

[5] Bluetooth®, “The Bluetooth® Low Energy Primer.” Accessed: Mar. 19, 2026. [Online]. Available: https://www.bluetooth.com/bluetooth-le-primer/.

[6] Sittig Technologies, “Frankfurt Airport Becomes the First Airport Worldwide to Use AuracastTM for Public Announcements.” Accessed: Mar. 18, 2026. [Online]. Available: https://www.sittig-tech.com/post/frankfurt-airport-becomes-the-first-airport-worldwide-to-use-auracast-for-public-announcements

[7] Bluetooth®, “LE Audio.” Accessed: Mar. 19, 2026. [Online]. Available: https://www.bluetooth.com/learn-about-bluetooth/feature-enhancements/le-audio/.

[8] Bluetooth SIG, “LE Audio and LC3 Codec.” Accessed: Oct. 22, 2025. [Online]. Available: https://www.bluetooth.com/learn-about-bluetooth/recent-enhancements/le-audio/.

[9] Bluetooth ®, “An Overview of AuracastTM Broadcast Audio,” 2024. Accessed: Oct. 22, 2025. [Online]. Available: https://www.bluetooth.com/wp-content/uploads/2024/05/2403_Auracast_Overview.pdf

[10] Dorine Gurney, “Bluetooth 5 variations complicate PHY testing.” Accessed: Mar. 20, 2026. [Online]. Available: https://www.edn.com/bluetooth-5-variations-complicate-phy-testing/

[11] Flairmesh, “FlooGoo FMA120.” Accessed: Oct. 22, 2025. [Online]. Available: https://www.flairmesh.com/Dongle/FMA120.html.

[12] Nordic Semiconductor, “nRF5340 DK.” Accessed: Oct. 22, 2025. [Online]. Available: https://www.nordicsemi.com/Products/Development-hardware/nRF5340-DK