APPLICATIONS AND ARCHITECTURE FOR UWB LOCALIZATION IN AIRCRAFT CABINS AND AVIATION

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Abstract

Obtaining data from real-time location systems (RTLS) is critical in aviation for enhancing operational workflows, reliability, and passenger services. For example, applications such as wheelchair tracking, baggage management, seat-specific service delivery, and equipment monitoring require accurate and continuous positioning information within both aircraft cabins and airport terminals. Ultra-Wideband (UWB) technology, characterized by high accuracy for indoor localization, low latency and robustness against interference, can be employed to address these needs. This paper presents a platform architecture utilizing UWB localization that can be integrated into the cabin and can be certified in accordance with aviation regulations to support various applications on ground and in-flight. The architecture comprises modular edge cloud systems deployed across aircraft and ground environment, interconnected to enable efficient data exchange and hosting of location-based services. The onboard system integrates the ARINC 853 Cabin Secure Media-Independent Messaging (CSMIM) standard to ensure secure and standardized communication of localization data across the cabin network. The overall UWB RTLS is based on Kubernetes edge cloud platforms enabling the deployment and management of various location-based applications. Secure communication between aircraft and ground edge clouds is maintained through a virtual private network (VPN). Exemplary use cases include wheelchair tracking across airport and cabin environment and passenger-tailored onboard services such as meal ordering and serving tied to seat localization. The presented system and architecture support improvements in process efficiency and the delivery of personalized services, contributing to a unified, data-driven and smart aviation ecosystem.

Keywords

real-time location system, RTLS, ultra-wideband, UWB, aircraft cabin, cabin secure media-independent messaging, CSMIM, ARINC 853, edge cloud

1. INTRODUCTION

The aviation industry continuously seeks innovations to improve process efficiency and passenger experience, driven by competitive pressures and increasing cost constraints. Continuous tracking and tracing of assets, e.g., a wheelchair, at the airport on ground and in the aircraft in-flight, can be achieved with Ultra-Wideband (UWB) technology. This technology is characterized by using low-energy radio frequency (RF) signals with a large bandwidth, resulting in characteristics such as accurate ranging, robustness to propagation fading, improved obstacle penetration, covert operation, resistance to jamming, interference rejection, and coexistence with narrowband (NB) technologies, such as Bluetooth and WiFi, which are also used in the aircraft cabin. Thus, UWB technology finds application in areas including short-range communications with high data rates (up to 500 Mbit/s), sensor networks combining low data rates with precise ranging, high-precision geolocation, and UWB-based radar. UWB systems can achieve improved localization accuracy in environments with multipath propagation, noise, and interference. The capacity to resolve multipath components and provide detailed spatial resolution contributes to its suitability for environments where traditional localization methods, such as global positioning system (GPS), may not work. This means that UWB technology can be used in airport interiors and even in radio-technically complex environments such as the reflective and shielding aircraft cabin [1].

UWB-based real-time location systems (RTLS) rely on a network of fixed reference points known as anchors, which measure the exchange of short UWB pulses between anchors and mobile tags or UWB-enabled smartphones. Please note that real-time in the context of this paper refers to what is meant with non-deterministic near real-time, i.e., tracking almost close to wall clock time. Such measurements enable an accurate calculation of distances between anchors, tags, and/or smartphones. The technology is currently spreading due to standardization and integration of UWB in commercial smartphones and other consumer devices, as well as the availability of UWB tags. UWB chipsets such as the NXP Trimension® modules [2] found in devices like the Samsung Galaxy S21+ 5G® [3] enable native and highly accurate ranging capabilities [4]. This advancement facilitates not only the tracking of objects with tags but also of passengers and cabin crew via their personal mobile devices.

UWB technology has already been investigated in industrial aviation projects related to the aircraft cabin [5], [6]. The comprehensive use of UWB technology in the aircraft cabin and airport primarily improves services where detection, tracking and tracing offers an advantage. To orchestrate the exchange of localization data in such heterogeneous environment and across information silos, this paper presents a

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platform architecture that integrates UWB localization infrastructure with standardized aircraft communication protocols, hosted on interconnected edge cloud systems. This platform relies on the ARINC 853 Cabin Secure Media-Independent Messaging (CSMIM) standard, which defines a secure and interoperable communication framework for cabin systems [7]. CSMIM specifies data models and access control mechanisms designed to enable consistent information exchange among diverse cabin devices, facilitating their integration and management within a broader aircraft and aviation network infrastructure. The following sections of this article are structured as follows. Section 2 summarizes UWB technology fundamentals and shows applicability to localization tasks. Section 3 presents application scenarios involving the use of UWB, covering both the cabin and the airport environment. Section 4 describes the proposed platform architecture that can support the proposed application scenarios. Section 5 discusses an example implementation of the platform architecture for the wheelchair tracking use case. Section 6 summarizes the results and identifies future work towards implementation.

2. ULTRA-WIDEBAND TECHNOLOGY

2.1. Fundamentals and physical layers

The fundamentals of UWB have been previously described in the literature. To understand all details and particulars, please refer to [8], [9], for example. According to literature UWB is a wireless communication protocol that transmits information using pulses in an impulse radio signaling scheme. Because these pulses are extremely short in duration, UWB signals spread their energy over a broad spectrum of frequencies at the same time. UWB physical layer supports three independent bands of operation: the sub-gigahertz band, consisting of a single channel spanning 249.6 MHz to 749.6 MHz; the low band, consisting of four channels spanning 3.1 GHz to 4.8 GHz; and the high band, consisting of eleven channels spanning 6.0 GHz to 10.6 GHz [8]. IEEE 802.15.4z-2020 standard defines two distinct UWB physical layers, namely Low Rate Pulse (LRP) and High Rate Pulse (HRP), each tailored to support precise location and ranging applications under varying operational conditions. The LRP physical layer is characterized by a relatively low pulse repetition frequency (PRF) typically in the order of 1 to 2 MHz, which confers enhanced robustness to multipath propagation and increased effecttive range. Furthermore, the LRP physical layer supports an Enhanced Payload Capacity (EPC) mode using advanced modulation techniques, which facilitates higher data throughput while maintaining stringent timing accuracy requirements essential for high-precision localization. In contrast, the HRP physical layer employs significantly higher PRFs, enabling greater temporal resolution and faster data transmission rates suitable for short-range positioning scenarios where rapid updates are prioritized. However, these higher PRFs render HRP more susceptible to multipath interference and limit its effective range compared to LRP [9].

2.2. Time-based ranging and 2D & 3D multilateration

In UWB technology there exist different time-based positioning techniques that leverage the precise timing capabilities of UWB physical layers to enable accurate ranging and localization. The fundamental principle underlying these techniques is the measurement of Time-of-Flight (ToF) of UWB signals exchanged between ranging-capable devices. ToF refers to the propagation time of signal packets traveling between an anchor (locator) and a tag (object to be located) [8]. By using the ToF along with the constant value of the speed of light *c*, the distance between the anchor and the tag can be obtained, since distance is calculated as the product of ToF and *c* [8].

$$Distance = ToF \cdot c \quad (1)$$

The three primary time-based ranging methods supported are: Single-sided two-way ranging (SS-TWR), double-sided two-way ranging (DS-TWR), and one-way ranging (OWR) used in time difference of arrival (TDoA). In SS-TWR, the initiator device sends a ranging signal to a responder, which replies after some delay. The initiator measures the round-trip time and estimates the ToF, but this approach is sensitive to relative clock offsets between devices, which may induce ranging errors [9].

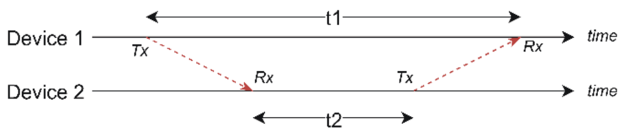

FIG 1. SS-TWR and ToF calculations, based on [9].

$$\mathrm{ToF} = \frac{1}{2}(\mathrm{t}_1 - \mathrm{t}_2) \quad (2)$$

To mitigate such errors, DS-TWR employs two consecutive round-trip measurements initiated reciprocally by each device, and combines the results to compensate for clock offsets, thereby enhancing ranging accuracy and reliability.

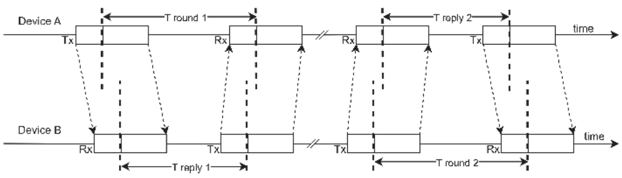

FIG 2. DS-TWR, based on [9]**.**

$$Tprop = \frac{(Tround1 \times Tround2 - Treply1 \times Treply2)}{(Tround1 + Tround2 + Treply1 + Treply2)} \quad (3)$$

Alternatively, TDoA-based localization uses OWR where a mobile device's transmitted signals are received by multiple synchronized fixed nodes. The relative differences in arrival times at these nodes are used to compute the device's position by solving hyperbolic equations. This method is particularly suitable for passive or low-power tags that only transmit and do not engage in two-way exchanges. Focusing on ToF, positioning a tag is achieved by determining its spatial location relative to anchor points with precisely known coordinates. Distances obtained from each anchor are represented as ranges around each anchor, as shown in Figure 3.

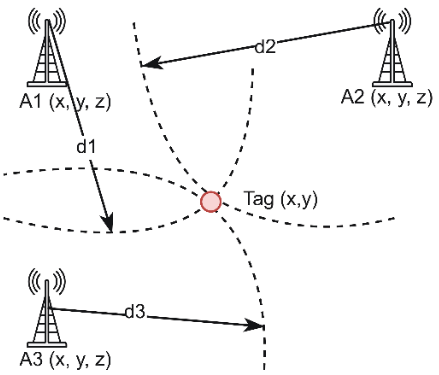

FIG 3. 2D localization using multilateration method.

Each anchor's range forms a circle in the two-dimensional (2D) space, with a radius equal to the measured distance to the tag. Using multilateration, the tag's position is estimated by finding the intersection of these three circles, as illustrated in Figure 3. Multilateration is a localization technique that determines an object's position by minimizing the difference between the measured distances from multiple anchors and the calculated distances from the estimated position to these anchors [9]. In an ideal scenario without measurement errors, the tag's position corresponds exactly to the intersection point of these geometric shapes. However, in practical applications, measurement errors and uncertainties in both the distance estimates and anchor positions usually prevent the circles from intersecting at a single point. Consequently, multilateration is commonly formulated as a nonlinear least squares optimization problem, which seeks the position estimate minimizing the sum of squared differences between the measured and calculated distances. This optimization yields a minimum error solution that effectively accounts for inherent ranging inaccuracies, thereby enhancing the robustness and reliability of the localization [10].

Nevertheless, this approach is inherently limited to two-dimensional localization, which may be sufficient for some applications. For 2D localization three distance measurements can unambiguously define a point within a plane. To achieve localization in three-dimensional (3D) space, at least four anchors are required [11]. With four anchors, the distance measurements define spheres, and the unique intersection of these four spheres determines the tag's 3D position, as illustrated in Figure 4.

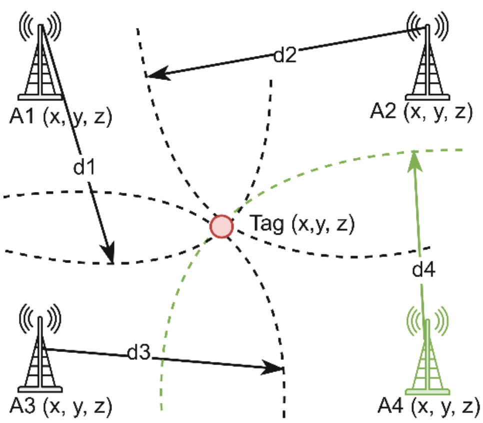

FIG 4. 3D localization using multilateration method.

The introduction of the fourth anchor (cf. lower right in Figure 4) resolves the ambiguity inherent in 2D multilateration, enabling an accurate and unique 3D position estimate for the tag. While four anchors represent the minimum necessary for unique 3D localization, deploying additional anchors further improves system accuracy and robustness. The extra anchors provide redundant measurements, which help mitigate the effects of measurement errors and environmental factors such as multipath interference, thereby enhancing overall localization performance.

2.3. Usability of UWB in aviation

In Europe, the use of UWB technology onboard aircraft is authorized within a harmonized frequency range of 6 GHz to 8.5 GHz. This authorization is granted under specific technical and operational conditions established by the European Conference of Postal and Telecommunications Administrations (CEPT) through ECC Decision (12)03 and associated regulations [12]. These regulations impose stringent limits on power emissions and spectrum usage, alongside mandatory interference mitigation measures designed to protect essential aeronautical services and other sensitive radio frequency users operating in adjacent or overlapping frequency bands. The framework ensures the integrity and reliability of safety-critical airborne communication and navigation systems while facilitating the integration of UWB applications onboard aircraft. Summarized in other words, thanks to its frequency allocation and low RF power level, UWB technology can be used as a locating system at airports and even in aircraft and their cabins without the risk of interfering with other aviation systems relevant to flight operations.

3. USE OF UWB IN AVIATION

Numerous research efforts have explored the integration of UWB devices for localization in aviation. For example, a system tested aboard an Airbus A321 achieved an average localization error of approximately 16 cm with a seat assignment accuracy of 97% [5]. UWB technology has also been applied to track passengers and equipment within aircraft cabins, aiding in the optimization of boarding procedures and improving operational efficiency [13]. Beyond these cabin applications, UWB has been used extensively for baggage management at airports. By providing precise real-time location data, such systems help reduce mishandling rates and improve tracking and retrieval processes of passenger baggage [14]. Moreover, real-time tracking of construction workers and equipment at airport construction sites supports situational awareness and enhances safety by preventing runway incursions [15]. UWB is also employed for the navigation of Automated Guided Vehicles (AGVs) in baggage handling centers, where Time Difference of Arrival (TDoA) methods enable accurate real-time positioning to optimize path planning and avoid collisions [16].

As can be seen from these examples, UWB localization technology has a wide range of applications within the aviation sector, spanning multiple environments and user groups. To categorize these applications, a grouping according to their operating environment is proposed, with a primary distinction being made between applications in the aircraft and cabin and those used at the airport, and then further classified according to the primary user groups they serve, such as passengers, crew, or ground staff.

Table 1 depicts such classification along with representative example applications and user groups.

TAB 1. UWB application environment, user group and examples of use in aviation.

Environment	*User Group*	*Examples of use*
Cabin	Passenger	Seat-specific services (e.g., meal ordering, location-based content delivery), personal device localization for enhanced experience.
	Crew	Occupied seat detection, equipment and tool tracking, real-time passenger assistance.
	Maintenance	Tracking of high multiplicity equipment (e.g., life vests) in cabin, automatic configuration of equipment.
Airport	Ground Staff	Wheelchair and mobility aid tracking, baggage and luggage location management, inventory control of trolleys and carts, monitoring of construction workers and equipment.

3.1. Cabin environment

The integration of UWB into technically complex RF-environments such as aircraft cabins poses a challenge due to cabin equipment and people, such as large monuments, aircraft seats, passengers, and their luggage, as these can lead to non-line-of-sight (NLOS) conditions and impair accuracy. One method addresses this challenge by combining multilateration with Artificial Neural Networks (ANN) to analyze raw Channel Impulse Response (CIR) data, reducing localization errors by up to 70% and achieving an average accuracy of 12.3 cm in an Airbus A330 cabin mock-up, even under NLOS conditions [6]. Another study focused on strategic anchor placement within an Airbus A321 cabin, installing anchors inside luggage compartments near the aircraft hull to maximize coverage while minimizing visual impact. This approach used single-sided two-way ranging and machine learning algorithms to reduce interference and increase positioning reliability [5]. Simulation results also indicate that placing anchors above the seats improves line-of-sight conditions and reduces positioning errors compared to below-seat placements, highlighting the importance of optimal anchor positioning [13]. To improve positioning under dynamic conditions, deep learning models have been used to classify signals as line-of-sight (LoS) or NLOS by analyzing CIR and distance measurements. This classification informs an adaptive Kalman filter that adjusts measurement weighting to reduce errors. Combined with trilateration algorithms, this method enables reliable tracking of UWB devices in challenging environments [17].

These examples show that localization in the aircraft cabin remains a challenge. However, UWB systems currently appear to offer the most suitable solution for use in the cabin, as other technologies, such as Radio Frequency Identification (RFID) tags, have failed mainly due to challenges with multipath propagation of radio waves in this complex cabin environment. UWB technology currently offers the best possible option for localization to improve both passenger comfort and crew efficiency. For passengers, UWB can facilitate seat-specific services, such as personalized meal ordering and serving directly linked to their seat location. Additionally, by localizing passengers' personal devices, airlines can offer tailored content and notifications during the flight. For crew members, UWB enables real-time monitoring of seat occupancy as well as the localization and navigation to essential tools or medical equipment, which increases safety and operational reliability. Moreover, rapid location awareness of crew and passengers' aids in passenger assistance scenarios, for example, prioritizing support in case of emergencies or specific needs.

3.2. Airport environment

Since UWB technology was originally developed for high-precision indoor positioning and navigation using low-energy radio waves, UWB systems are also ideal for use in airports. UWB-based localization supports ground staff and operational workflows that significantly impact turnaround times and passenger processing. For example, wheelchair tracking ensures that mobility aids are efficiently managed and distributed to passengers who need them, minimizing wait times. Similarly, baggage tracking using UWB tags affords improved accuracy in luggage handling, reducing mishandling or loss, which in turn improves passenger satisfaction. Inventory management of ground equipment such as trolleys and carts also benefit from UWB tracking by enabling real-time visibility and streamlining logistics operations in both aircraft service areas and ground support zones, ultimately reducing losses and improving operational efficiency. Airport zones undergoing construction or maintenance, UWB localization enhances safety by monitoring the positions of workers and heavy equipment, ensuring compliance with safety protocols and avoiding accidents.

3.3. Integration across environments

The integration of UWB localization across both aircraft and airport environments offers new possibilities for continuous tracking and seamless service delivery. For instance, wheelchairs equipped with UWB tags can be tracked throughout their complete journey, from the airport terminal to the aircraft cabin, enabling optimized allocation and usage. Likewise, passenger mobile devices can be localized for personalized services extending from check-in through boarding to the in-flight phase, creating a more connected and customer-centric aviation ecosystem.

4. ARCHITECTURAL DESIGN

The system functional needs derived from the exemplary use cases in Table 1 (cf. Table 1 in Chapter 3) provide the basis for the architectural design presented in this chapter. The integration of UWB-based localization in aviation requires a robust and scalable system architecture that is capable of accommodating the wide range of use cases. In order to efficiently support these various use cases and enable bridging of existing information silos in the ecosystem, the architecture must be interoperable across heterogeneous systems and environments. Moreover, it must enable secure communication between aircraft and ground systems, and remain scalable to handle multiple simultaneous localization sessions. Last but not least, it must deliver real-time location information to allow for dynamic tracking, while adhering to published standards, e.g., the MQTT-based ARINC 853 cabin secure media-independent messaging protocol [7].

4.1. Platform overview

The high-level architecture of the proposed platform is illustrated in Figure 5. It consists of two main areas: The edge cloud onboard aircraft (Edge Cloud 1) and the edge cloud at the airport (Edge Cloud 2). Both edge clouds 1 and 2 each host a localization engine, a message broker, and applications required for the respective use cases onboard or on ground. For example, the onboard edge cloud hosts applications such as meal ordering or crew support tools, whereas the ground edge cloud hosts applications like monitoring of airport equipment. The architecture also integrates UWB anchors and UWB-enabled devices within the cabin and airport zones. The onboard edge cloud uniquely interfaces with the cabin network and employs the CSMIM protocol to ensure standardized message exchange. Aircraft and ground are interconnected via a site-to-site VPN, which guarantees secure data exchange and synchronized state between both environments, aircraft and ground. This connection enables cross-environment services, e.g., asset tracking at the airport and in the cabin onboard the aircraft.

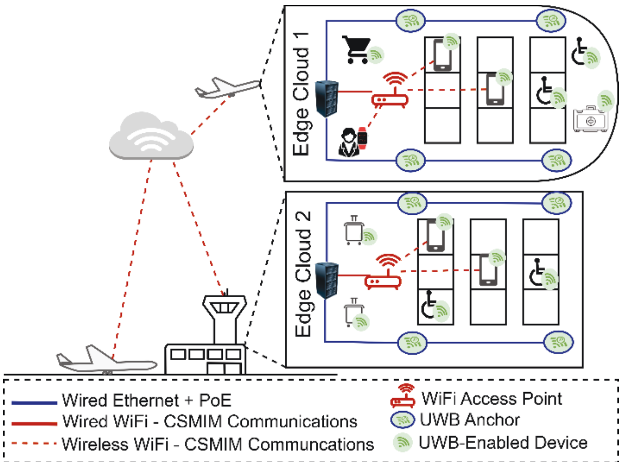

FIG 5. High-level architecture of the UWB location and communication system.

UWB anchors provide ranging data to the localization engine, which is doing multilateration by computing raw coordinates based on the UWB coordinate system and subsequently maps these results to locations such as seat numbers or galley identifiers. The location results are published via CSMIM. Figure 5 highlights the interaction between UWB infrastructure, WiFi-based CSMIM communication, and edge cloud services, demonstrating how multiple applications such as wheelchair tracking and personalized passenger services are supported within a unified platform.

4.2. Core components and functions

The internal structure of the aircraft environment is shown in Figure 6, which details the low-level architecture. Edge Cloud 1, deployed onboard the aircraft, includes a Kubernetes-based hosting environment (k3s) [18], the localization engine, and application components such as backend and frontend services. A dedicated VPN component ensures secure connectivity to Edge Cloud 2 on the ground, which hosts the ground services as well as the complementary components for cross-environmental services. This bridges the existing information silos on the ground and onboard the aircraft.

The proposed platform employs Kubernetes as its container orchestration layer. This choice reflects the current state of the art in software engineering practices, where container orchestration has become a key enabler of scalable, reliable, and portable application deployments. Similar strategies are observable in the aviation domain. For instance, Lufthansa Technik's AVIATAR platform [19] leverages container-based technologies to accelerate development cycles and ensure operational consistency across hybrid and edge cloud infrastructures. In addition, aerospace suppliers such as Thales have explicitly explored Kubernetes-native architectures in the context of application security and orchestration for avionics-related environments [20] further underlining the relevance of Kubernetes in this domain [21].

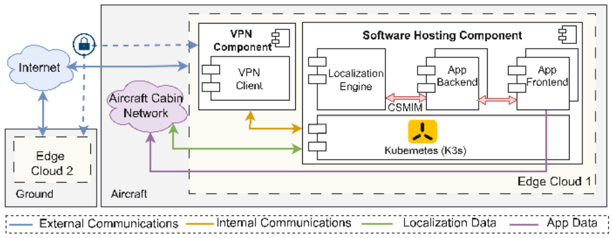

FIG 6. Low-level architecture for hosting aircraft localization applications.

The lightweight Kubernetes distribution k3s is particularly relevant for aviation edge computing deployments, as evidenced by its built-in use in scenarios requiring minimal dependencies and remote operation [19]. Studies comparing Kubernetes distributions in edge computing environments have found that k3s delivers superior performance in resource-constrained deployments relative to alternatives [19] demonstrating lower overhead and satisfactory throughput even under stringent hardware constraints.

Another core function of the proposed platform is observability. Since the applications corresponding to the exemplary use cases in Table 1 (cf. Table 1 in Chapter 3) are deployed as containerized workloads on k3s, they generate logs that can be collected and managed in a standardized manner. In practice, these logs are typically persisted within the backend component of the respective application, as shown in Figure 6. Service personnel can access them to monitor application behavior, perform troubleshooting, and support maintenance activities. In this way, observability is seamlessly integrated into the overall platform design and contributes to reliable operation across both aircraft and ground environments.

4.3. Communication and data flow

Communication within the aircraft environment is logically segmented. UWB anchors provide ranging data to the localization engine via an internal communication protocol, which does not require standardization since it remains confined to the subsystem. The localization engine processes these measurements to compute precise locations of an object or device (cf. 2D & 3D multilateration methods in Subsection 2.2.). The resulting location data is then distributed in a standardized manner by publishing it via CSMIM into the cabin network. Applications can then subscribe to this data for realizing services such as real-time wheelchair tracking and seat-specific meal ordering and serving.

The interconnection between aircraft and ground environment is realized with broker federation creating message routes with RabbitMQ® brokers [22]. Within the onboard Edge Cloud, CSMIM-compliant services publish localization data via MQTT. Federation is established by configuring the onboard broker as an upstream of the ground broker, thereby enabling message flows across the VPN-secured air-to-ground link. Messages published in the aircraft for which subscribers exist on the ground are transparently forwarded in a downstream to the RabbitMQ® broker on ground and made available to the respective services [23]. In this way, the federation supports ground-related scenarios such as boarding, catering, maintenance, or equipment tracking, where synchronized information exchange between aircraft and airport systems is required.

5. EXAMPLE IMPLEMENTATION

This chapter presents an example implementation designed to validate the architecture which was introduced in the previous Chapter 4. It focuses primarily on two practical applications: wheelchair tracking and first aid kit localization within the aircraft cabin. Still, the implemented localization platform consists of both, aircraft environment and ground environment. With demonstrating these two characteristics it is validated that the platform fulfils the needs for use case examples as given in chapter 3.

5.1. Aircraft environment

In the aircraft environment, a LattePanda Sigma® single-board computer [24] emulates Edge Cloud 1, primarily hosting the localization engine and the RabbitMQ® message broker. To simulate onboard connectivity, it is equipped with a Quectel® LTE module [25], which provides internet access and enables connectivity between the air and ground environments. The LattePanda Sigma® computer runs two virtual machines (VMs), as described in Table 2.

TAB 2. Virtual machines (VMs) content and functions.

VM No.	*Services*
#1	VPN client providing secure connectivity to the ground environment.
#2	Location engine software and RabbitMQ broker federated bidirectionally with ground environment broker to enable message exchange. The location engine computes tag positions via multilateration using ranging data from anchors.

The localization engine continuously processes ranging measurements obtained from the four UWB anchors to determine precise positions of tracked tags. Each UWB anchor combines an NXP SR150® module [2] (IEEE 802.15.4z HRP PHY compliant) and an ESP32-POE® microcontroller [26] communicating with the localization engine. Anchors connect to the LattePanda Sigma® via a PoE-enabled Ethernet switch. Tags, composed solely of the NXP SR150® module, are mounted to a wheelchair and an aircraft cabin first aid kit. Unique MAC addresses assigned to anchors and tags ensure unambiguous identification and tracking within the system.

5.2. Ground environment

The ground environment, emulated by a Raspberry Pi 4® [27] (cf. Edge Cloud 2), runs a RabbitMQ® broker federated with the broker onboard the aircraft (cf. Edge Cloud 1) to enable exchange of localization data. It also hosts a VPN client to build a shared network with the aircraft environment. Ground applications subscribe to the federated RabbitMQ® broker to receive localization data from the aircraft.

In this example implementation, the ground environment does not yet include a UWB localization setup. However, it can be expanded to incorporate UWB anchors and localization capabilities in the same way as demonstrated in the aircraft environment. Such extension enables consistent and integrated localization services across both air and ground environments.

5.3. Network and communication

Within the aircraft environment, the localization engine computes the positions of the tags using multilateration and publishes location updates via MQTT messages on the RabbitMQ® broker. Through the broker federation, these updates are synchronized via the VPN tunnel with the RabbitMQ® broker in Edge Cloud 2 on the ground environment. This setup enables continuous, end-to-end tracking of, for example, a wheelchair moving through the airport and into the aircraft at the gate. The platform defined in Chapter 4 provides MQTT localization messages that comply with the CSMIM standard. This ensures that the data is standardized and interoperable, supports integration with other localization-based applications, and guarantees data integrity.

The further implementation of this important feature for data communication is the subject of current work and includes the definition of CSMIM object types (location.tag.position, location.anchor.status, location.session.metadata, for instance) to support more comprehensive semantic integration and standardized data exchange across cabin systems.

Internal traffic in both environments on ground and in the aircraft is managed by a combination of software and hardware switches. A hardware switch connects anchors to the computing device of the aircraft environment. Software switches and routers link the external anchors, virtual machines, the LTE uplink, and the VPN interface.

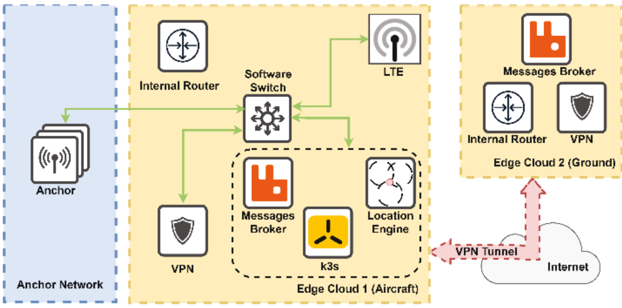

FIG 7. Network diagram.

6. CONCLUSION AND OUTLOOK

This document presents a comprehensive platform architecture for Ultra-Wideband (UWB) localization that is specifically tailored to aviation environments. Due to the frequency allocation and low power of the radio waves, this technology is even suitable for use in aircraft and can be certified in accordance with aviation regulations. Based on time-of-flight (ToF) measurements of radio waves, this technology is currently one of the most suitable methods in the cabin for locating objects and people with their mobile devices.

The platform's communication architecture is based on the Cabin Secure Media-Independent Messaging (CSMIM) ARINC 853 standard, which is implemented in the platform via a so-called broker federation. This enables data and information exchange within a complex ecosystem and bridges existing information silos, e.g., at the airport and onboard the aircraft. The platform's communication and localization principles are demonstrated using example use cases such as wheelchair tracking and first aid kit localization.

Due to the suitability of UWB localization technology and its integration into standardized aircraft communication protocols such as CSMIM ARINC 853, the proposed framework enables secure, interoperable, and continuous position data exchange in heterogeneous and regulated aviation environments. This platform approach provides a solid foundation for future work, including scalability testing, deployment, and refinement of localization accuracy, etc., under various constraints.

ACKNOWLEDGEMENTS

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