Smart Airports: Artificial Intelligence–Enabled Internet of Things Networks Using Blockchain Technology

Edwin Ongola, Independent Scholar, Nairobi, Kenya
edwin.ongola@gmail.com

Abstract This article provides a perspective on how an internet of heterogeneous self-service airport terminal systems can be used for data collection, which is stored on a private or consortium blockchain depending on the ownership or operations of an airport or both. Such a setup would help to increase efficiency, reduce costs, and improve traveler experience at airport terminals. Moreover, it would allow airports to gather data directly from passengers as opposed to waiting to receive the same data from airlines. Subsequently, this data, now on a blockchain system, becomes a data source for other applications such as machine learning. In this way, meaningful insights for immediate and long-term decision-making can be derived. This article can be useful to airport management, blockchain application developers, academics, and researchers who are interested in automating airport terminal systems.

Keywords Smart airports, airport blockchain, Internet of Things - Blockchain infrastructure, airport automation, airport data collection, distributed ledger
INTRODUCTION

According to the World Bank (2015), air transport is an important enabler for achieving economic growth and development. Air transport facilitates integration into the global economy and provides vital connectivity on a national, regional, and international scale. Airports are a key part of the air transport system because it is through them that a modal transfer takes place from air to land and vice versa. Other than serving as starting points, airports can also be intermediate or terminal points for aircraft on the air portion of a trip (Ashford et al., 2013, pp. 19, 25).

Broadly speaking, airport operations can be categorized as centralized or decentralized. The type of operation determines the location of the security screening checkpoint in the passenger terminal. A centralized operation implies fewer staff and fewer fixed equipment. It could also imply longer walking distances for passengers. A decentralized system, on the other hand, implies duplication of staff and equipment. Decentralized screening could cause more boarding delays and has the disadvantage that a challenge to any armed person or group is performed in the vicinity of the aircraft (Ashford et al., 2013, pp. 27, 248).

Airports compete against other airports in terms of service and price in order to attract airlines. Service covers elements such as location, accessibility, and the quality and size of airports’ aeronautical and related facilities. With the exception of location, airport management should be able to influence all the other variables (Forsyth et al., 2010, p. 14). Management’s key concerns include security, passengers, and cargo issues that have an effect on their wage bill.

CHALLENGES

The first challenges for airport management are to employ effective security procedures that are not offensive to passengers and to install cost-effective security equipment such as walk-through metal detectors and explosives detection systems to meet objectives (Hättenschwiler et al., 2018).

The second problem is that passenger traffic varies with time, so it is difficult to know when a bottleneck might occur at a security screening checkpoint. Therefore, scheduling and wage bills for security screening officers who man these checkpoints can be a challenge.

The third issue involves passenger experience. When security screening checkpoints form a bottleneck, they can cause delays for passengers. The possible reasons for the delays include differences in inspection procedures among airports, which confuse passengers; inexperienced staff due to high turnover in the boring job of
inspecting; and inadequate staffing during critical hours such as early in the morning, when people arrive before the inspection stations open (De Neufville & Odoni, 2013, p. 633).

The fourth issue is that security and management may not be able to determine the populations in sterile areas of the terminal.

The fifth problem concerns baggage handling, which is a key element of airport operations. International Air Transport Association (IATA) Resolution 753 on baggage tracking made it mandatory for all airline members to track baggage at four mandatory points throughout the journey, yet the mishandled baggage rate has continued to increase (IATA, n.d.). Frequent complaints from passengers about misplaced or lost baggage are undesirable for any airline or airport.

The sixth and last challenge concerns data. Most details regarding traffic are likely to reside with the airlines, since booking is done through them. So, when any research or audit is done, the data is likely to be sourced from airlines. The problem is that data passed on to the airport authorities from other sources may not be accurate, timely, or both (De Neufville & Odoni, 2013, pp. 702–705).

Suffice it to say that airports require data gathering, self-service systems for security, check-in, and bag drop that are efficient, require less staff, and enhance passenger experience.

PROPOSED SOLUTION

Due to advances in technology, bottlenecks can be reduced because some passengers check in online in advance. For passengers who still check in physically, some airports have common-use self-service kiosks that can be shared among several airlines (Ashford et al., 2013, pp. 148–149).

To further improve customer experience, some airports now have self-service bag drops. In this scenario, bag tags are printed and attached at a check-in kiosk so that when passengers reaches the bag drop, they just place the bag on the receiving conveyor (Ashford et al., 2013, pp. 171, 177).

Once passengers are admitted into the sterile side, an ideal situation would be to have a system that can track passengers at every stage and detect an anomaly such as when passengers have exited the terminal after check-in and gone back to the groundside, leaving their baggage behind. The system should also be able to track hold baggage from the bag drop location to the point where it is placed onto a unit loading device. Once the contents of the last unit loading device have been emptied into the cargo space of an aircraft, the system should be able to detect if the luggage of a passenger who has checked in has not been loaded or if a passenger whose baggage
has been loaded has not boarded the aircraft. Otherwise, the system should alert the passenger, the airline staff, or both for speedy resolution. It should be noted that International Civil Aviation Organization regulations require that unaccompanied bags be unloaded from the aircraft. This would cause aircraft delay (Ashford et al., 2013, pp. 259, 239).

These self-service systems can be connected to form an Internet of Things (IoT) that do not just make go or no-go decisions when processing passengers and baggage but can also store or forward data or both as is necessary. The IoT can be described as a network of physical elements empowered by sensors, identifiers, software, and internet connectivity. The main idea of the IoT is to physically connect anything/everything and processes over the internet for monitoring and control functionality (Rayes & Salam, 2019, pp. 1–3).

The storage of data captured by airport terminal devices can be handled using blockchain technology (BCT), which is a “suite of distributed ledger technologies that can be programmed to record and track anything of value, such as financial transactions, medical records, land titles and so on” (Ahmed, 2020, p. 2). With BCT, a growing list of digital transactions are stored in groups within data structures called blocks, which are chronologically ordered and linked together and also secured via cryptographic mechanism (Kumar et al., 2021, p. 2). A compelling case for the use of BCT at airport terminals is the possibility of employing smart contracts, which are self-executing contracts, that is, pieces of code that is executed upon receipt of electronic data inputs (Corrales et al., 2019, p. 20). This can be used for security checking and for alerting of relevant personnel. For example, if someone is boarding an aircraft but does not exist in the list of those who have undergone security checks, an alert message can be automatically sent to security personnel to investigate. Blockchain networks can be broadly implemented as a public permission-less network or as a private-permissioned network. In the case of airport terminals, BCT implementation would be a private or permissioned network due to the nature of data captured by the airport devices (Ahmed, 2020, pp. 5–6).

So, we now have an IoT-blockchain integration on top of which other applications, specifically data science applications, can be used to derive meaningful insights from the BCT database for immediate security concerns and also long-term decision-making. The IoT network would serve the integration by facilitating the collection of data from heterogeneous devices. BCT, on the other hand, will offer trust-based identity management of the IoT devices and provide fault tolerance due to its distributed nature, smart contracts that can be triggered if an IoT device senses an event of interest, provenance and immutability of data, and the secure deployment of software updates, just to mention a few advantages (Ahmed, 2020, pp. 37–46).
As depicted in Figure 1, an airport IoT network can consist of security systems, self-check-in systems, sensors, and bag drop systems, where each type of system forms a peer-to-peer network with others of its type within and outside of the terminal (indicated by dotted double-edged arrows in Figure 1). For example a self-check-in system forms a peer-to-peer decentralized network with other self-check-in systems such that new data recorded on its copy of the blockchain database is propagated to the others as well. Some data from one type of system may also be propagated to another type through selective replication (e.g., from self-check-in system to bag drop system). A key advantage of this replication is redundancy for the data collected by the self-service devices or sensors. Replication also helps the devices reach a consensus on the correct state of data in the system, making it very difficult to tamper with.

All blockchain databases within an airport are replicated through dew computing to the cloud, where central management, data analysts, and other personnel have controlled access to consolidated data from all terminals at all airports under the national airport authority (Figure 2). This data can aid in detecting anomalies and solving various scheduling problems (e.g., staffing, maintenance).

Figure 3 depicts a high-level flow chart of how passengers and baggage might be processed at an airport. Actual implementations would differ from airport to airport.
depending on the objectives of an organization and the resources available. Note that process boxes with blue backgrounds show potential places where information would be recorded onto a blockchain.

CONCLUSION

This article proposes the use of a combined IoT-blockchain infrastructure that deals with identification of passengers during self–check-in, which then tracks both passengers and baggage up to the time of boarding the aircraft. Both the IoT and BCT are independently budding technologies with few if any completed exceptional projects to learn from in the aviation sector. As proof of how raw the idea of implementing BCT at airports is, in 2021 the Transportation Research Board, a division of the US National Academy of Sciences, Engineering, and Medicine, commissioned a project called “Airport Blockchain Implementation Guidebook” that was scheduled to end in August 2022 (Transportation Research Board, 2021). The IoT, on the other hand, is already being used in different ways in some airports, at least according to Mariani et al. (2019). Examples include traveler information systems, traveler traffic
monitoring, baggage systems tracking, and facilities management. The current use cases are geared toward maintaining throughput with fewer machines, staff, or both.

An IoT-blockchain infrastructure consisting of self-service devices that collect data has the potential to improve security, the tracking of passengers, and baggage handling while at the same time lowering airports’ operating costs. Moreover, decision-making and future research become easier due to readily available and accurate primary data.

Figure 3: High-Level Flow Chart of Passenger and Baggage processing at Airport Terminals
It should be noted, however, that whereas this article covers the processing of airline passengers and their baggage, it is possible to employ an IoT-blockchain infrastructure solution for other airport operations as well.

REFERENCES