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The Utilization of Blockchain Technology in The Airport Industry: A Review

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***Abstract*— Blockchain is a digital ledger technology in which transactions are stored in a continuously growing list of blocks that cannot be changed and distributed without a centralized server. In recent years, the airport industry has become one of the industries that have implemented blockchain into its business processes. For this reason, we would like to review existing research on the implementation of blockchain in the airport industry to provide an overview of how far blockchain has developed in the industry and also to identify which business processes in the airport industry can be optimized by implementing Blockchain. The review results show that there are three business processes that take place in airports, namely baggage handling systems, cargo handling, and passenger management for aircraft. Blockchain Technology can also be combined with other supporting technology, such as IoT, Artificial Intelligence (AI) / Machine Learning (ML), Big Data, etc. From the research literature that we analyzed, the combined use of blockchain technology with IoT and AI/ML can increase security in the process of data transactions in the system.**

***Keywords*— Blockchain, Airport, Aviation, IoT, Big Data, Artificial Intelligence.**

I. INTRODUCTION

Blockchain is a digital ledger technology in which transactions are stored in a continuously growing list of blocks that cannot be changed and distributed without a centralized server [1-2]. Blockchain was first widely known in 2008 through Nakamoto's research [3] which introduced Bitcoin as a digital money with a peer-to-peer system with secure transactions without third party involvement. Blockchain is not only used for digital money transactions but can also be used for development in other fields such as smart contracts [4], security services [5], and the Internet of Things (IoT) [6].

Traditional aviation systems mostly rely on direct negotiation or centralized mediation services for mediation to resolve business disputes. Blockchain technology, however, can use smart contracts to automate business rules and resolve disputes in a highly reliable and trustworthy manner [29]. In recent years, the airport industry has emerged as one of the industries that have implemented blockchain in their business processes. A report by Accenture confirms that 86% of airline industry partners intend to integrate blockchain technology into their business by 2021. [29]. For this reason, we would like to review existing research on blockchain implementation in the airport industry to provide an overview of the extent to which blockchain has been implemented in the airport industry.

This study is the progress result of our ongoing research in the Blockchain Technology Research Group at the National Research and Innovation Agency, Indonesia, regarding the use of blockchain technology in the airport industry. This article is organized as follows: section 2 described the research methodology, section 3 presents the literature review, section 4 explained the business process in airports, section 5 elucidated the opportunities of blockchain application in airport industry, and finally, in section 5 the conclusion is discussed.

II. METHODOLOGY

A. Research Questions

In order to formulate guidelines for the selection and collection of literature, research questions have been formulated. The research questions are listed in Table 1.

TABLE I
RESEARCH QUESTION

No	Research Question	Motivation
1.	What business processes utilize blockchain technology?	To identify business processes where blockchain technology could be utilized
2.	What are the benefits of implementing Blockchain technology in business processes at the airport?	To discover the benefits of using Blockchain technology at the Airport
3.	Can other supporting technologies be used in Blockchain implementation?	To identify the combination of other supporting technologies with Blockchain technology in business processes at the Airport

B. Searching Process

The searching process is the process of finding articles that will later be used as Systematic Literature Review (SLR) reference sources. The search engine we use in the search process is google scholar. The reason for choosing google scholar is tttt google scholar already includes all major publisher venues, e.g., IEEE publications, Elsevier, and Springer. The keywords

we used in the search process were: "blockchain" AND ("airline" OR "aviation" OR "airport" OR "aircraft").

C. Inclusion and Exclusion Criteria

After the search process was done, the next thing we did was to filter the articles with inclusion and exclusion criteria. There are two inclusion criteria that we choose, namely papers with publication years after 2017 and has been written in English. Meanwhile, the criteria for papers that we do not use as references are duplicated papers and papers that are from thesis or dissertations.

D. Information Extraction

After the selection is made, the selected literature will be extracted to retrieve the necessary information. The information to be extracted includes titles, years of publication, keywords, and sources of literature acquisition. The results of information extraction can be seen in Table 2.

TABLE II
INFORMATION EXTRACTED FROM LITERATURE

No	Ref	Year	Keyword	Benefits	Supporting Technologies	Source
1	[7]	2020	Blockchain, Technology Acceptance Model, Adoption Behavior, Air Transport, Aviation	The intentions to utilize blockchain are influenced positively by efficiency enhancements and technological advancements as well as by digitized management, regulatory governance, industry standards, and air traffic management. The Technology Acceptance Model (TAM) is applied to portray the flight business' plan to utilize blockchain innovation for expected applications and future enhancements.	Adoption TAM	Science Direct
2	[8]	2021	Blockchain, Edge Storage, RFID, IPFS, Baggage Tracking, Attribute-Based Access Control	1. Reduced data breach risk and enhanced data security 2. Facilitate airports' simultaneous processing of multiple types of data and business requirements. 3. Reduce labor costs and guarantee the safety of data transfer 4. Improve system scalability 5. In a testbed, both software and hardware were used to measure how quickly and efficiently the proposed system processed transactions. 6. CSPBFT is simplified to reduce communication traffic between nodes Implemented integrity protocol. 7. Enhancing the system's long-term operational effectiveness	IoT	IEEE Xplore
3	[9]	2021	Blockchain, Air Cargo	The IATA Cargo Account Settlement System and the use of the blockchain technology will significantly speed up the process of completing financial transactions between air cargo participants.	IoT	Google Scholar
4	[10]	2020	Blockchain Technology, Supply Chain Management, Operations Management, Airport Industry	Contributions to make it easier for practitioners to come up with management solutions for managing A-CDM applications and to avoid and get around potential limitations.	Adoption of the A-CDM system	Science Direct
5	[11]	2022	Blockchain, UHF-RFID, Smart Contract, Smart Cargo Management	Gives a quicker, more proficient and more secure option in contrast to customary freight the executives framework.	IoT	Science Direct
6	[12]	2022	Blockchain, Air Traffic Management	Define the ATM's blockchain-based CPS security architecture and its schema in detail from three perspectives: the security information sharing algorithm, scheme framework, and background	IoT	Google Scholar
7	[13]	2020	Airline Baggage Tracking, Blockchain	1. Reduce costs by reducing bags that have been mishandled, lost, or damaged. 2. Improved operational efficiency 3. Improved performance with self-service check-in and baggage drop. 4. Utilizing exception handling and baggage tagging to reduce departure delays. 5. Minimize check-in time by making this process more digital. 6. When something goes wrong, an informed passenger always knows what to do. 7. The reduction in the number of checkpoints will allow for faster and more comfortable passenger journeys throughout	IoT	Google Scholar

No	Ref	Year	Keyword	Benefits	Supporting Technologies	Source
8	[14]	2021	Consensus Algorithm, A-CDM, RAFT, Blockchain	In a RAFT-based Airport Collaborative Decision Making (A-CDM) network, an optimization strategy employing outlier detection algorithms to examine the behaviour of each node ensures that the leader node that dominates the consensus phase is a trusted node. An outlier detection algorithm is used for optimization in the A-CDM. Finding anomalies that deviate from normal behaviour, such as Credit Card Fraud or Network Intrusion Detection, is its primary responsibility. In order to enhance the security performance of RAFT algorithms, combine detection algorithms and RAFT rules.	RAFT algorithm	IEEE Xplore
9	[15]	2017	Blockchain, Ethereum, Logistics, Smart-Contracts	1. Create an effective framework with three layers: contract layer, network layer, and application layer. 2. Create modules for risk detection, threat traceability, monitoring, and traceability simplification to implement AGSS. 3. Evaluating AGSS's performance through experiments under various conditions	Design the system model of AGSS	Google Scholar
10	[16]	2021	Airline, Blockchain, Hyperledger Fabric	Logistics procedures can be improved by providing a mechanism that is verifiable and fosters trust among stakeholders.	Big Data	IEEE Xplore
11	[17]	2022	Blockchain, Smart Contract, Decentralized Application, Record and Data Integrity, Aircraft Maintenance	1. AirChain, a blockchain-based aircraft maintenance record system supported by China Airlines, is being developed and implemented. ~~B.~~ Arrangement of CLB, TLB and their sub strategies. 2. Explore our system's initial performance by simulating an experimental setup.	Big Data	IEEE Xplore
12	[18]	2021	Blockchain Technology, SQL, Airline's Reservation, Java,	Collaboration blockchain and java programming that produces transactional flight reservation data. Java was chosen to be integrated with it to support better backend capabilities because java backend has been tested for large data loads for scalability.	Big Data	IEEE Xplore
13	[19]	2021	Aviation Security Management, Blockchain Technology, Big Data Application	Information transmission, potential safety hazard rectification, security audit, risk management, and emergency response are all included in the implementation blockchain's security management functions.	Big Data	IEEE Xplore
14	[20]	2019	Blockchain, Air Traffic Flow Management, Decentralized Optimization, Multi-Agent Systems	Developing a brand-new coordination platform for distributed multi-agent systems based on the Hyperledger Fabric ecosystem and its smart contract/chain code paradigm, two of the most recent blockchain technologies. This platform gives this ATFM (Air Traffic Flow Management) system in the region the decentralized control capabilities it needs.	Framework architecture	IEEE Xplore
15	[21]	2018	Blockchain Technology, Distributed Ledger Technology, Gateless Entry, Immigration	1. Biometric identification airport for controlling immigration and passenger 2. This recording system avoids misuse of stamp/record information which can make someone an illegal participant in some countries that rely on stamps in passports to validate arrivals 3. Securing the personal data of every passenger with blockchain technology distributed data	AI	Springer
16	[22]	2022	Blockchain, flight delay insurance,claim platform, frameworks design	By incorporating blockchain into the flight delay protections system trade preparation, which disentangles various structures such as specialized information and flight delay protections claim stages, it can increase the effectiveness of protection usage and make strides in the encounter of claim clients.	Framework architecture	IEEE Xplore
17	[23]	2021	blockchain; industry 4.0; Internet of Things (IoT); big data; service supply chain; performance evaluation	Di-ANFIS (Adaptive Network-based Fuzzy Inference Systems) architecture by integrating blockchain technology, IoT, and smart contracts to achieve a secure, trustable, and intelligent performance evaluation system. The proposed Di-ANFIS architecture contains six layers: the data layer, connection layer, blockchain layer, smart layer, ANFIS layer, and application layer. This architecture can track and transfer information and collected data in a secure and tamper-proof environment across the supply chain.	Framework architecture	Google Scholar

No	Ref	Year	Keyword	Benefits	Supporting Technologies	Source
18	[24]	2020	Blockchain, smart contract, aviation, exchange, trust	In this design there will be an information utilization collaboration composed of a few aircraft, activity control offices, air terminals, and so on, in which each data hub includes a nearby information server and client, the client is naturally worked by commerce or gets to benefit staff information, each data hub builds a nearby private chain, and various private chains shape a collusion chain.	Framework architecture and Big Data	IEEE Xplore
19	[25]	2020	Blockchain, civil aviation, AI, safety supervision, IATA, SITA	Blockchain innovation will closely coordinate with advances such as IoT, massive information, cloud computing, AI, and 5G in the future in the aviation industry. Various nations have investigate blockchain direction approaches, the implies and profound coordination of blockchain development and data innovation to aviation industry 4.0	IoT, massive information, cloud computing	IEEE Xplore
20	[26]	2021	Privacy preservation, Encryption, Dual public key, Consortium Blockchain, Aviation business	Includes the recipient's open key based on Dan Boneh's identity-based encryption scheme. The double open key encryption component is imaginatively coordinated into the consortium blockchain framework. The plot is built on a consortium chain settlement framework and cleverly coordinates a slew of open key encryption components. On the one hand, it guarantees the security of utilization information and accomplishes the conservation of security for both travelers and corporate clients.	Framework architecture	IEEE Xplore
21	[27]	2022	Blockchain, Artificial intelligence, Transportation systems	The blockchain might improve the AI applications in terms of dependability, decentralized computing, effectiveness, straightforwardness, and lower passage showcase barriers. In the interim, the AI applications may progress the blockchain from a few perspectives, counting vitality utilization, adaptability, security, protection, efficiency, equipment, and information doors.	AI	Science Direct
22	[28]	2022	Consortium Blockchain, Flight Data, Data Sharing	The proposed system for sharing flight information is safe from quantum assaults based on consortium blockchains utilizing lattice-based multi signature conspiracies. It dispenses with information spillage amid information sharing, squandering of flight assets, and data spillage. The demonstrator can also achieve high capacity and productivity at work.	lattice-based multi signature scheme	Google Scholar
23	[29]	2021	Information exchange, Smart contracts, Blockchain, Maintenance engineering	Identification of the role of blockchain in aspects of the aviation industry such as Secure Customer Loyalty Program, Realtime tracking of baggage and cargo, Digital Crew Certification Format, Safe Maintenance, Repair and Overhaul (MRO) operations, Air Management and Secure Identity Tickets, Automation of Airport Collaboration Decisions Industry (ACDM) and case studies of some of the parties that have taken on roles with actions such as start-up companies, open-source technologies and distributed support systems.	Big Data	IEEE Xplore
24	[30]	2022	Blockchain, Air Cargo, Supply chain financing, Consensus protocols, Credit risk	A decentralized system is proposed to fathom the issue's straightforwardness and credibility. A blockchain-based monetary exchange stage called ACFB is built to encourage money-related exchange between different supply chain stakeholders.	Framework architecture ACFB	Science Direct

E. Analysis Process

The analysis process is carried out with the aim of looking at relationships or trends between literatures. The analysis is based on the publication year distribution and the acquisition source distribution. The release year graph is used to see the trends in interest and interest among researchers investigating the application of blockchain to airport business processes. The graph of the distribution of literature years is shown in Figure 1. It can be seen in Figure 1 that the distribution of publication started from 2017 to 2022. From 2019 to 2021 the number of literatures published has significantly increased, indicating that there is a growth in research interest on the application of blockchain to airport business processes.

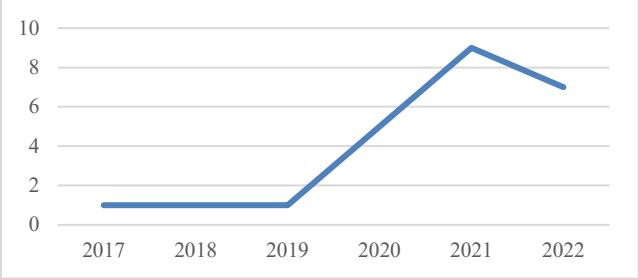

Fig 1. Graph of the year of publication of literature

The distribution graph of acquisition sources is used to see where researchers are more active in publishing and can be used to assist researchers in finding references regarding the application of blockchain to airport business processes. The graph of the distribution of literature acquisition sources can be seen in Figure 2.

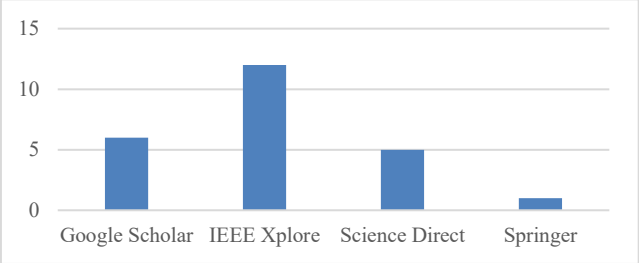

Fig 2. Graph of the year of publication of literature

It can be seen in Figure 2 that the highest source of acquisition is IEEE Xplore, this indicates that some researchers have published more work at IEEE but this result does not mean that the source is better than other sources.

III. Literature Review

Based on the literature reviews result in Table 2, it is obtained that the utilization of Blockchain technology in airport business processes promotes airport business process optimization. In addition, the advantage of the application of Blockchain technology also comes in the form of cost efficiency [8, 13].

According to the review result in Table 2, we also got information that Blockchain Technology can be combined with other supporting technology, such as IoT, Artificial Intelligence (AI), Big Data, etc. The relation between Blockchain Technology implementation on airport business processes are visualized in Figure 3.

Fig 3. Blockchain integration graph in Airport

Blockchain is basically about implementing security. Blockchain can be integrated with various methods to produce a more secure system in terms of data storage. From the research literature that we analysed, the combined use of blockchain technology with IoT and AI can increase security in the process of data transactions in the system. In addition, by focusing on the implementation of blockchain technology at airports, information is obtained that blockchain technology plays an important role in terms of tracking, digital management, and air traffic management. This enables the establishment of a system in which an effective and safe airport will be an important point of excellence. This advantage can be offered to passengers who expect better service in the future so that it can be an advantage for the airport and other related parties.

Current technological developments also support improving the quality of existing business processes if implemented properly. An example of technology that is widely used today is Artificial Intelligence. Another technology that is often used together with Blockchain technology is IoT. IoT is used as system input. For example, IoT is used in baggage handling and tracking processes to mark goods managed at airports [5, 6, 7]. Using blockchain to secure the data received from IoT sensors is one of the solutions to secure the data transaction process. Much research has been done, including using IPFS [32] and others, to support enhanced security of incoming data transactions in IoT.

IV. Airport Business Process

According to the literature study, there are three categories for the business processes that take place at airports: baggage handling systems, cargo handling, and airline passenger management. These three categories will be explained in the following paragraphs, along with the potential applications of blockchain in it.

A. Baggage Handling System

Baggage Handling is an activity to handle passenger luggage from the departure station to the destination station. A ground handler performs this task, and the steps are as follows: (1) the baggage is inspected by security personnel; (2) the baggage is weighed; (3) the baggage is labelled; (4) the baggage is tagged for the baggage claim; (5) charges are paid if the baggage weighs is more than the allowed amount; (6) the baggage is carried and loaded onto the aircraft; and (7) it is unloaded by an officer and brought to the baggage claim area.

B. Cargo Handling

Cargo is goods sent by sea, or air which is usually carried out between regions/cities, within the country or between countries which is commonly referred to as export - import. Cargo Handling is a series of work processes from the time the cargo is received until they are loaded onto the plane to be transported from one city to another. There are three main parties related to the delivery of cargo or expedition services, including Shippers, Carriers and Consignee.

C. *Flight Crew Licensing*

The aviation industry is a professional industry in which airline crew must pass the necessary training and competency tests to obtain proficient certification from certification agencies and internal aviation companies. Inside the certificate, there must be guarantee that the certificate is genuine, verifiable, valid, or has expired. Things like this will be used by unscrupulous fraudsters to change information without official permission from other related parties. Centralized technology still has problems with traceability to confirm the proven track record of pilot and crew skills, as aircraft flight logs can easily be misused to obtain fake certificates. Blockchain innovation can create opportunities for the aviation industry to digitize flight crew certificates to solve this problem. Moreover, blockchain can leverage traceability to increase trust among stakeholders.

V. BLOCKCHAIN APPLICATION OPPORTUNITIES

Based on the results of our study above, several alternatives of blockchain applications can be used to optimize business processes at airports, for example:

A. *RFID and Blockchain for baggage tracking*

RFID and Blockchain as baggage tracking solution [13] were initiated because baggage mishandling is one of the major problems in the airline industry. A large number of lost baggage occurs during connecting flights. Passengers are not aware of what happens to their baggage once it's put into the baggage area. In addition, there is no system to track passengers' baggage throughout their journey and this causes airlines to face tremendous losses.

The RFID sensor network, local gateway, blockchain network, and IoT application layer are the system's four primary parts. The local gateway stores the RFID sensor network's luggage information. The information is subsequently kept on a distributed blockchain network that can be accessed by users through the web3.js protocol. The application layer then shows the baggage's location and other information, as well as reporting any errors with the baggage handling processes.

B. *Machine Learning, Sensors, and Blockchain to maximize flight and cargo routes*

Machine learning and deep learning, IoT sensors, and blockchain technology were all used in the research to maximize flight and cargo routes [18]. Judging from the experiences encountered, such as changes in regional weather, aircraft readiness or maintenance, loading and unloading, and airports situations, these can be aspects that affect the efficiency of flight routes that have an impact on airline companies' profits and losses.

Data such as flight delay data predictions, identifying trajectory patterns and traffic flow patterns from aircraft movements, lightning storm predictions with data obtained from satellite products, aircraft maintenance predictions based on aircraft type, age, and activity, predictions of the risk level of abnormal flight events, which indicate high performance in measuring the risk of hazardous events. All of these datasets will be processed to produce predictions that companies can use to maximize flight efficiency.

In terms of data security, blockchain is a solution because the data is distributed into a network of nodes so the data is more secure in the event of a hacking attack or makes it easier to track data from transaction history. Blockchain can only add data, so all history is tracked by blockchain in case of changes.

C. *Blockchain for Data Management in Immigration*

In order to prevent people and goods from entering a country illegally, borders between nations are strictly controlled. Every day, a sizable number of people travel across international borders. The main problem associated with current entry/exit methods is the centralized nature of data, making it an easy target for attacks and manipulation attempts that can lead to complete or partial data loss. The next point of failure may be distrust of every stakeholder regarding passenger information. Lastly, log-in/out logs are always vulnerable to modification either by malicious third parties or due to internal political pressure and so on.

With the key distinction that the immigration officer now marks his immigration choices that are recorded to the blockchain [21], the proposed process is quite similar to the current workflow. Passengers are permitted to move through after all the information has been recorded. The system automatically locates the pertinent foreign national arrival records for the country in the case of a departure procedure and validates these departures. When an arrival occurs, the system automatically locates the relevant citizen's departure record and verifies the entry.

Because it offers a quick, scalable system with capabilities that complement the unique requirements and blockchain deployments allowed, Hyperledger is the ideal option for this use case. Instead of relying on mining, Hyperledger makes use of Support for Order Services. Using their current public key infrastructure, developers can register peers using the Hyperledger Certificate Authority (CA).

VI. CONCLUSION

The purpose of this research is to identify the benefits of implementing blockchain technology in airport business processes and discover the use of other supporting technologies to optimize these business processes. We obtained and analyzed 24 relevant publications from various sources.

The implementation of blockchain technology in several business processes at airports provides benefits to optimize the existing business processes. Three examples of business processes that occur at airports are obtained based on the literature study that was done, namely baggage handling systems, cargo handling, and passenger management for aircraft.

Also, combining Blockchain technology with other supporting technology, such as AI / ML, Big Data, and IoT, are possible to be done in order to give more benefits to the existing business processes. For example, on the IoT aspect, to identify, track and ensure passenger baggage handling with RFID integration, on the Big Data aspect, it could be used to purchase passenger tickets where the confidentiality of ticket data containing ID is

individual privacy, on the AI / ML aspect, there could be an integration that cuts through administrative processes and data security, e.g., it is possible for the passenger verification process to integrate biometric and blockchain technology.

As future work, our plan is to extend this work by doing more in-depth research about Blockchain implementation in Digital Identity and applying it in Airport Industry.

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