

Blockchain in a Maintenance Database

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Abstract. Nowadays data management is part of the maintenance management. Organizations are now gathering a diverse range of data, including information from sensors and operator logs, among others. To structure a database may be a challenge when organizing data collected from sensors on a ship, and the difficulty increase when maintenance managers apply algorithms trying to give early results from data that will support decision making. A Blockchain structure is not unbreakable but is safer than others known structures. It will be exposed how a blockchain structure applied to data collected from equipment's may enhance the database integrity and security. A state of art on blockchain and maintenance are made to expose its advantages in the maintenance management, and then it will be proposed a data structure for a maintenance ship system and present some directions for further studies. Also, the Portuguese Navy maintenance organization for surface ships and the advantages and disadvantages of blockchain in it are presented.

Keywords: Blockchain, Database, Maintenance, Security.

1 Introduction

1.1 Database as part of organizations management

Nowadays data storage and management are part of organizations data management. The strategies developed for database proper functioning can be various. Organizations along the years have adapted to the type of collected information but also to the risk of database hack or misuse.

The type of collected data can vary from data from sensors, captured video and images, manual registration, and others. To structure a database with all this information is complex, difficult and a challenge. When it is allied the collected data with an im-

planted planned maintenance system the complexity increases. If the maintenance system is based in data, and that data is treated with mathematical algorithm the complexity is even higher.

There are various types of database structure, but in this study, we focused on Blockchain structure.

Blockchain is a system originally developed for financial purposes that is now being adapted for integration into other information systems existing within a network. Access to blockchain information is granted through a variety of user certifications. While the structure is not impervious, it is more secure than other known architectures.

The Blockchain concept has been gaining “terrain” in the databases type. This is an important concept that in our opinion can be revealed by the quantity and quality articles we can found in 68uukt6kutquick research in google scholar, Fig 1 and legend at Tab. 1.

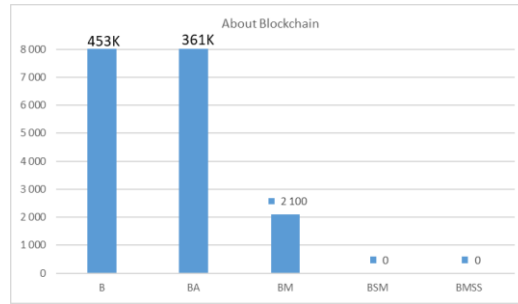


Fig. 1. Research about blockchain

Table 1. Research abbreviation

Abbreviation	Name
B	Blockchain
BA	Blockchain applications
BM	Blockchain “in Maintenance”
BSM	Blockchain “in Ships Maintenance”
BMSS	Blockchain “in Military Ships Maintenance”

In google scholar research, in the military area, we couldn’t find, yet, any articles, or maintenance in military ships, but there are publication in others relevant types of network publication.

One characteristic that made blockchain attractive and secure to apply to databases is the fact of the distributed cloud storage [1].

There are three types of blockchain: “the public blockchain is decentralized, consortium blockchain is partially centralized and private blockchain is fully centralized as it is controlled by a single group.” is it is centralized [2][3].

In the present study, we conducted a concise overview of the state of the art in blockchain technology, followed by an exploration of some of its applications. Next, we introduced the maintenance database used for surface ships in the Portuguese Navy, and subsequently, we presented a proposal for restructuring the existing database using blockchain technology. Finally, we will conclude the study and discuss potential avenues for further research and development.

2. What About Blockchain?

2.1 Blockchain Applications

A blockchain is a cryptographic technology that functions like a database comprising various interconnected entries referred to as blocks. These blocks can store data in a decentralized organizational structure. [4] (Green, et al., 2020)(Green et al, 2020).

The blockchain applied to financial matters uses multiple stages of validation on the network, these stages are represented by nodes Fig. 2. [5]. Although malfunction occurred in the network usual, the system maintains its operability [5].

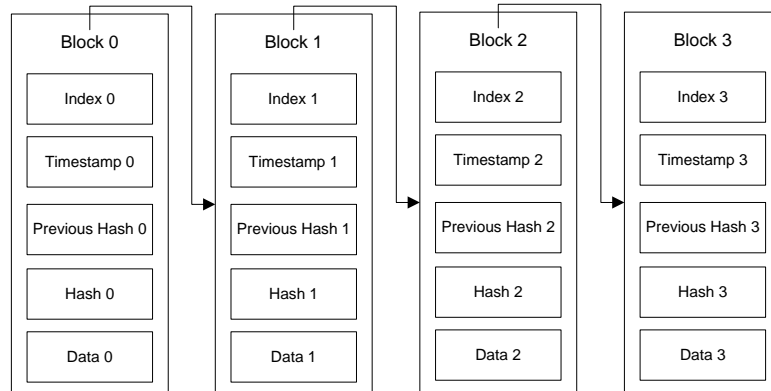


Fig. 2. Blockchain structure

Source: Adapted from [5]

To enhance data security and flexibilization many companies are decentralising the information along a common network instead of a centralized information way [4]. In the network, the responsibility is shared by the various users and not from a centralized authority. [4].

Blockchain technology (BT) by Petkovic et al (2019) was proposed to guaranty secure network information change and data “data storage exchange between Marine Autonomous Surface Ships and shore control system.”

A blockchain concept in data from ships allow a secure network with connections between users from the ship, the ship itself, and shore control centre, for that the users interaction with the database require certified access granted by those responsible from database [6]. Who access the network must continuously certified their access. This procedure decreases the cyber treats to the systems, Fig. 3 [6] (Petkovic et al, 2019) (Petkovic, et al., 2019).

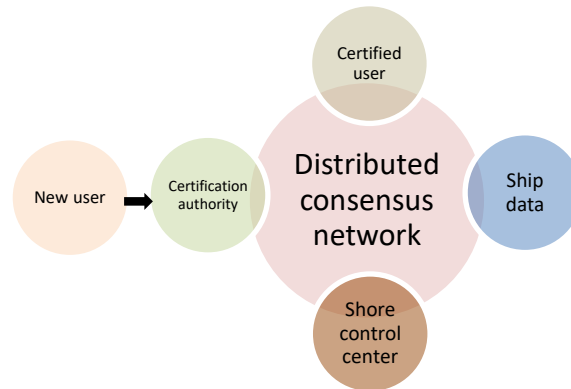


Fig. 3. Example of application of blockchain in maritime area
Adapted from Petkovic et al, 2019.

In the past, blockchain was considered an unbreakable security system, but now, in public blockchain networks, it has already been compromised. [7][8].

The blockchain structure is now being applied in new concept, with “benefit of ensuring that war fighters maintain high confidence in the authenticity and security of the data they get from DOD¹ networks.”[9]

“Chinese military publications have consistently proclaimed that blockchain technology will provide people’s Liberal Army (PLA) with an edge in intelligence, weapons lifecycle, personnel management, and information warfare” contributing for military supply chains [10].

Ahmad et al (2020) considered that blockchain concept because of its trustworthy might be implemented in various areas in the Aerospace and Defense, such as “operations management”, “Logistics and supply chain management, and others [11].

The critical factors in determining when blockchain technology might apply to military or not may be if the process involves collaboration or not and what type of correlation (ex.: interrelated or sequential), or there is climate of distrust between involved ones, and if decentralization is aligned with applicable command directions and normative [12].

“Blockchain technology presents a new chapter of capabilities for cyber, operations, and even acquisitions.” [13].

For United States of America (USA), China and Russia militaries it is determinant for blockchain implementation is the network security and military logistics [14].

¹ DOD – Department of Defense

A private blockchain applicable in a maintenance system, with accreditation levels, with nodes corresponding to identify users may be a decentralized system with the same structure of original blockchains [15]. In a military context, where data is typically confidential, blockchain technology appears highly suitable, as it continues to be a more secure system compared to other concepts [15].

Usually, the Military Command has centralized information, so in case of a hack event, in wartime or in peacetime, confidential information may be vulnerable being available or even loss of information [16]. If a blockchain database is implemented some risks, like access and uncertified information share, may be mitigated, by having data layers or network layers that will enhance data reliability and credibility [16].

2.2 Blockchain Advantages and Disadvantages

In financial applications the data collection and arrangement in database is fluid as the transactions are made, because of the certification steps to carry out the transactions [17].

Blockchain structure data has now been applied in other concepts, which do not finance.

Blockchain main advantages are:

- Decentralized System;
- Multiply clearance Chain to carry out an objective, which enhance security in the actions [18];
- People trust more in database's structured like blockchain then others, may be used in faster ...“bank payment transactions”, decentralized systems which conducted to maintain the original data [17];
- Hierarchical responsibility [19];
- Immutable information [19];
- Transparency - All participants can view the operations made [19];
- Cyber - attacks are possible, but most of it are not possible to intervene in blockchain operation.

Blockchain main disadvantages are [19]:

- Energy consumption to maintain real-time information and access;
- If a node fail, and redundancy does not exist, may mean blockchain system failure;
- The balance between nodes and the costs for the users.

If Blockchain is applied in the maintenance management, it will either probably enhance the database security and the maintenance interventions and action.

3. Maintenance Database in Portuguese Navy

3.1 Current Database in Portuguese Navy Maintenance Management

Maintenance in the Portuguese Navy has three levels. The first level is carried out by the ship's crew, the second level is carried out by a shore based technical support workshop and the third level, is under the responsibility of the Navy Technical Management (NTMC), that define where 3rd level work is carried out by the Navy main support shipyard (AA – Arsenal do Alfeite) or provide by outsourcing.

The maintenance data management system implemented on surface ships is called Data Collection and Treatment System (in Portuguese: “*Sistema de Recolha e Tratamento de Dados*” (SRTD)) [20].

The SRTD it is a subsystem of the Portuguese Navy Maintenance Management System (SGM - Sistema de Gestão da Manutenção). The other subsystem it is the Planned Maintenance System (SMP – Sistema de Manutenção Planeada) which will not be explored in the present study [20]. The SGM in turn is part of the Portuguese Navy logistic system [20].

The today software for SRTD is called SICALN (an ORACLE language software, which represents the Navy Logistic Integrated System software for surface ships) and support the maintenance information from SMP, and some technical manuals about the equipment's from surface ships. And it works has a maintenance registration and maintenance intervention requests from ships.

When maintenance need occurs, the ship reports the maintenance if it is a 1st stage one or makes a request for maintenance at SICALN to the administrative command (AC) of the ships is responsible for processing the request and forwarding it to the 2nd stage workshop or sending it to the 3rd stage, that is to NTMC to define the work and send it to the shipyard.

The servers from SICALN are not physical in NTMC, this system feed the Integrated Logistic System (ILS). The SICALN has network connection between NTMC, the organism also responsible for software management, between Ships and the AC. These organisms have online actualized maintenance information if it are connected to the network. But if not, they use another channel for maintenance occurrences and request.

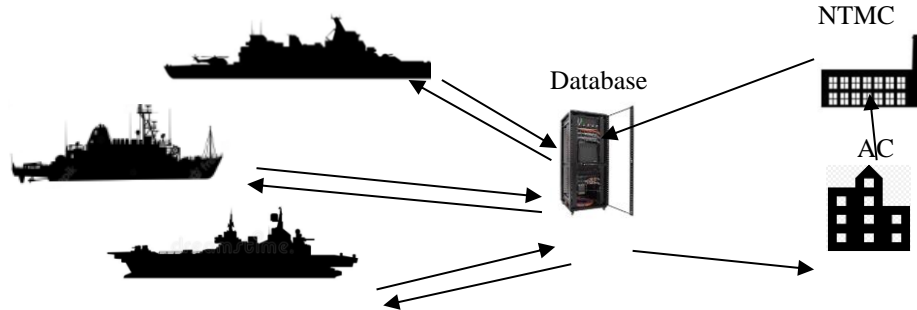


Fig. 4. Adapted SRTD model [20].

The Fig. 4 is an adaptation of SRTD [20]. The connections between ships and database mean ships sending processed information or requests in three type of registering data models. For example, the DSM58 is where ships report or request maintenance support, in the DSM59 is where ship report the monthly the equipment's hours of functioning, oil and marine gasoil consumption, and the DSM60 is where the technical services or departments on board request (internally the ship) or report consumption of spare parts for a maintenance action [20]. From the Database the next procedure in the database is responsibility of AC, and if the work is considered to be on the 3rd level the NTMC take action.

The SICALN database should be reconfigured and full integrated, to make data available in a dynamic way showing, for example, multilayers pages of equipment's state graphs, anomaly tendency, available spare parts, available ships, and its performance to all interested Navy organization.

Although an integrated logistic system enhances the decision-making process, it brings other cyber security preoccupations, but with proper cyber safety or with blockchain implementation an eventual network attack can be minimized or mitigated.

Has we saw the SRTD in a certain type of maintenance works in a decentralized way, although the Technical Management can always check the maintenance interventions from the ships.

4. How May a Blockchain Database Be Implemented in Ship Maintenance?

The main advantage of blockchain in maintenance may be to introduce faster decision maintenance procedures in high complex and technologic machines [21].

The implementation of a blockchain database in the Navy maintenance system may represent some challenges and risks, mostly because it means that data from more than 20 years, from the still operational ships must be imported, and some procedures should be adapted along the various and related to maintenance organizations in the Navy.

But a structure like blockchain may also represent an enhancement in the maintenance database integrity and security.

The implementation of a blockchain database in the Navy's maintenance system may pose certain challenges and risks. This is primarily due to the necessity of importing data spanning over 20 years from ships that are still in operation, as well as the need to adapt various procedures across the maintenance organizations within the Navy. However, a blockchain-based structure can also bring about improvements in the integrity and security of the maintenance database.

In Fig. 5 it is proposed a data flux structured for a maintenance of few systems from a ship (not specifying them) that should be collected in an autonomous way, but with installed control of malware system between the various steps of data processing. All the equipment and systems of a ship made part of it maintenance plan. So, the various sensors from various equipment collect the data to an AI system to distribute data for a compilation of each equipment, and then the data is treated accordingly the specifications and the respective applied algorithm considering Clusters for a previous analysis, modified control charts and neural networks, and may others have introduced in the system and applicable. Then a fuzzification of the data is made and then the decision. The data analysis may be considered the ship responsible, but also the AC and NTMC should evaluate the data and carried studies between similar ships and equipment.

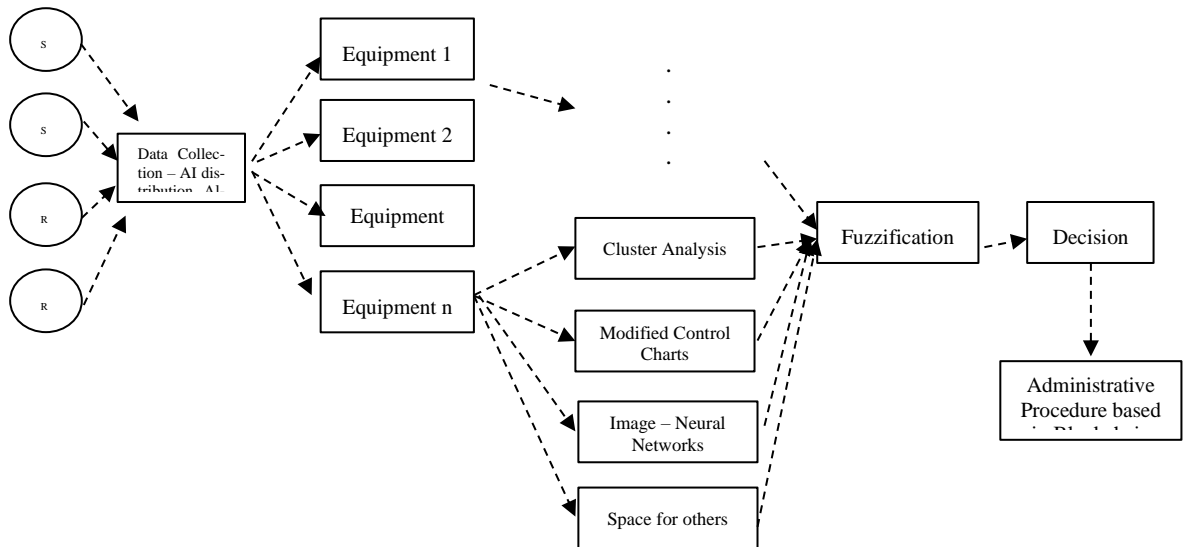


Fig. 5. Data Flux

In an intervention of the third level four main organization participate, the ship, the administrative command, the Navy Technical Management Center, and the shipyard or workshop. Between this organizations and in the own organizations, specifically validation access exists, Fig. 6.

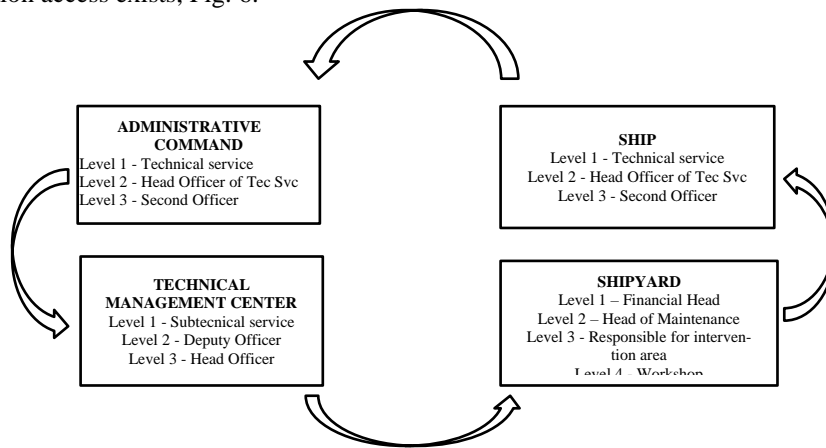


Fig. 6. Organizations involved in maintenance administrative procedure.

The advantages of Blockchain in the Portuguese Navy may be the decentralized information. The SICALN is a private database and secured by military firewalls so probably it's more unbreakable than others, by introducing the blockchain concept safety may be enhanced. However, if data centers and computers are not actualized it may affect the system performance, because the data is increased every day, and many users may be trying to access the blockchain platform at the same time.

When analyzing the main disadvantages of Blockchain in relation to the maintenance database for the Portuguese Navy, we can identify a few key aspects. Initially, there may be challenges in striking the right balance between nodes and addressing user costs. However, given that we are observing a finite organizational universe, these costs are unlikely to significantly escalate over time.

Energy consumption will persist, but it will also remain limited due to the finite number of users. In the event of a node failure, there is no cause for concern, as the Navy has alternative communication processes (or redundancy) in place and can initiate a maintenance action accordingly.

5. Conclusions

Blockchain is a database structure that initially was only applied in the financial areas. But by the state of art, it was possible to conclude that blockchain is now being applied in others areas in various organizations, and may have the potential to be applied in various areas, such has in defense and maritime areas.

It was present the actual maintenance organization on the Portuguese Navy, describing the three level of maintenance, the involved organizations on the maintenance process and present the SRTD that is used in the surface ships for maintenance administrative procedures between the respective responsible in the process.

It was present the data flux in the blockchain database with its diverse steps.

Finally, it was exposed some advantages and disadvantages by implementing the blockchain in the Portuguese Navy.

It was concluded that blockchain structure may be applied in a restructuration of the actual maintenance database in Portuguese Navy.

For future studies, it is proposed to experiment automatically data arrangement in the blockchain maintenance database and explore the algorithms that may be applied to data in blockchain maintenance database to support decision making on maintenance interventions.

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