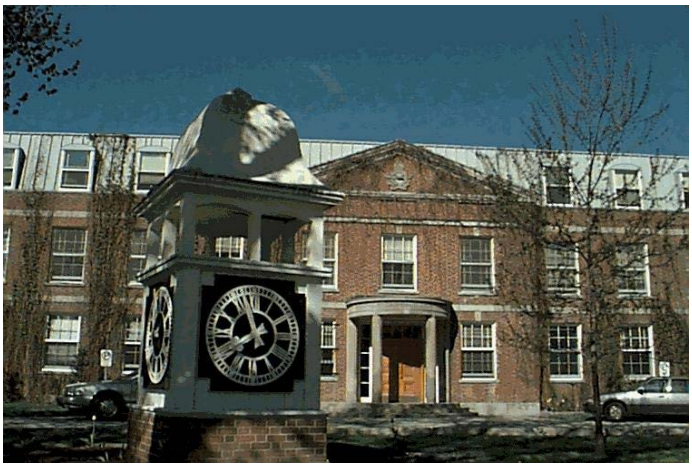
National Defence Défense nationale

Canadian Forces College

Collège des Forces Canadiennes



BLOCKCHAIN: CONTINUING TO EVOLVE THE BUSINESS OF OUR BUSINESS

Lieutenant-Commander Andrew Sargeant

JCSP 45

Service Paper

Disclaimer

Opinions expressed remain those of the author and do not represent Department of National Defence or Canadian Forces policy. This paper may not be used without written permission.

PCEMI 45

Étude militaire

Avertissement

Les opinons exprimées n'engagent que leurs auteurs et ne reflètent aucunement des politiques du Ministère de la Défense nationale ou des Forces canadiennes. Ce papier ne peut être reproduit sans autorisation écrite

Canada

CANADIAN FORCES COLLEGE/COLLÈGE DES FORCES CANADIENNES

JCSP 45/PCEMI 45

15 OCTOBER 2018

DS545 COMPONENT CAPABILITIES

BLOCKCHAIN: CONTINUING TO EVOLVE

THE BUSINESS OF OUR BUSINESS

By Lieutenant Commander ANDREW SARGEANT Royal Canadian Navy
Par le capitaine de corvette ANDREW SARGEANT Marine royale canadienne

Word Count: 2,511

Nombre de mots: 2,511

BLOCKCHAIN: CONTINUING TO EVOLVE
THE BUSINESS OF OUR BUSINESS

AIM

1. Blockchain is a disruptive technology that is changing the way business is conducted in many industries. Originally famous for its role in the rise of cryptocurrencies like Bitcoin, it is now being applied to finance, insurance, contracting, procurement, supply chain management, public records, education, and medicine, among others[1]. This service paper aims to explore how blockchain can be leveraged to improve Royal Canadian Navy (RCN) fleet information infrastructure within the Naval Engineering and Maintenance (NEM) domain. In particular this paper will consider the application of blockchain to supply chain management, material assurance, and material certification. At a minimum it is hoped that this paper will highlight the value proposition offered by blockchain and spark further investment and research in the technology.

INTRODUCTION

2. In 2008 the original paper on Bitcoin was published, which described the mathematical foundation of blockchain[2]. In view of the huge success of cryptocurrencies since the publishing of this paper many industries have dedicated significant resources to applying blockchain technology to their business processes[3]. Despite the presence of blockchain in industry over the past decade, the adoption in defence and security has been slow. Indeed, as a Canadian example, a search on the Defence Wide Area Network (DWAN) for "blockchain" yields only six results – none with any real substance – indicating that this topic is not part of the information technology (IT) discussion within the Department of National Defence (DND). The defence and security sector is understandably conservative in its approach to the adoption of new technologies. This paper argues, however, that blockchain is a rapidly maturing technology in which many industries are investing heavily as a result of the significant benefits it brings in terms of efficiency, automation, digital trust, and transparency.

3. Blockchain is a relatively new technology and is not well known by those outside the information technology (IT) world. Companies like IBM, SAP, Deloitte, and Oracle, however, are all building blockchain into their enterprise resource planning (ERP) platforms and product offerings. The RCN, and indeed DND, need to become smart customers and keep pace as the technology and solutions evolve. This aligns directly with the Commander RCN's priority to

---

[1] Michael Nofer *et al*, "Blockchain," *Business & Information Systems Engineering* 59, no. 3: 183.
[2] Bitcoin, "Bitcoin: A Peer-to-Peer Electronic Cash System," last accessed 9 October 2018, https://bitcoin.org/bitcoin.pdf.
[3] Don Tapscott and Alex Tapscott, "How Blockchain Will Change Organizations," *MIT Sloan Management Review* 58, no. 2 (Winter 2017): 13.

"evolve the business of our business", as stated in the RCN Executive Plan[4]. The primary audience for this paper is the Director General of Maritime Equipment Program Management (DGMEPM), who has authority over the NEM functions being discussed. Secondary audiences are the Assistant Deputy Minister – Information Management (ADM (IM)), who is responsible for DND's IT infrastructure, and the Director of Naval Strategic Management (DNSM), whose office is working to enable enterprise technology for the RCN. Given this varied audience, both NEM and IT concepts are described to a degree of detail that will foster understanding of how blockchain can be leveraged to benefit the RCN. The remainder of this service paper is organized as follows: a foundational understanding of blockchain concepts, how the technology is leveraged by industry, and a discussion on the potential for application within the RCN NEM environment, along with limitations. The paper will then close with conclusions and recommendations for senior management to consider.

DISCUSSION

4. An overview of blockchain is provided here, summarized from a description by Chartered Professional Accountants of Canada[5]. Blockchain is a network-based method of maintaining a distributed digital ledger of transactions that is transparent to and verifiable by all parties in the network. The details of each transaction are encoded into a block that is then linked to the preceding transaction (block) and encrypted using a hash function. The chain of blocks – a digital ledger of all transactions – is distributed and stored on all nodes of the network; thereby avoiding the need for a trusted central registry, yet the entire history of transactions remains verifiable because all nodes have an identical copy of the ledger. A new transaction is permitted when a consensus of participating nodes agree that it is valid. Previous transactions cannot be modified by any participant because their copy of the ledger would no longer be identical to that held by the other nodes.

5. As a digital ledger with trusted, automated transactions, blockchain has specific characteristics that are valuable to many industries[6]:

a. Real-time settlement of transactions with low risk of payment default;

b. A digital ledger distributed to all network nodes, providing a public and verifiable history of transactions;

---

[4] Royal Canadian Navy, *Royal Canadian Navy Strategic Plan: 2017-2022* (Ottawa: Department of National Defence), 13.

[5] Chartered Professional Accountants Canada, "Technological Disruption of Capital Markets and Reporting: An Introduction to Blockchain," last accessed 9 October 2017, https://www.cpacanada.ca/en/business-and-accounting-resources/other-general-business-topics/information-management-and-technology/publications/introduction-to-blockchain-technology.

[6] Chartered Professional Accountants Canada, "Blockchain Technology and its Potential Impact on the Audit and Assurance Profession," last accessed 9 October 2017, https://www.cpacanada.ca/en/business-and-accounting-resources/audit-and-assurance/canadian-auditing-standards-cas/publications/impact-of-blockchain-on-audit.

c. Immutability, in that transaction records cannot be changed once they are in the blockchain and repeat transactions are avoided;

d. Validation through distributed consensus with no requirement for a trusted central registry;

e. No single point of failure, allowing nodes to leave and rejoin the network as it suits them; and

f. Built-in security through public- and private key cryptography.

6. Blockchain has been implemented or is being developed to improve business processes across several industries. Before examining blockchain applications within the RCN NEM context, a review of industry applications will assist in understanding the foundational concepts. The following examples demonstrate practical uses of the technology:

a. Supply chain management. Globalization and technological advancement increase the complexity of supply chains. As materials are produced into products and aggregated into systems, the number of transactions between producers, manufacturers, distributers, sellers, customers, etc. grows rapidly, record keeping becomes problematic, and the potential for errors increases. By creating an immutable digital ledger of products from origin, blockchain increases traceability, reduces transaction errors and fraud, improves certification and compliance, increases automation, and reduces overhead[7]. Recently, Maersk, one of the biggest shipping companies in the world, and IBM partnered on the development of a new blockchain-enabled supply chain ecosystem. This ecosystem will increase stakeholder collaboration through the establishment of a shared common ledger of transactions without compromising details, privacy or confidentiality[8].

b. Smart contracts. Smart contracts are a set of rules delineating how parties agree to interact that is coded into the blockchain and executed if and when pre-defined conditions are met[9]. They allow for the automation, verification, and enforcement of contracts without the requirement for an intermediary, thus reducing transaction time and overhead costs. As an example, the French airline AXA is using smart contracts to enable its flight insurance business. If fights are more than two hours late, purchasers of the insurance are

[7] Kari Korpela, Jukka Hallikas, and Tomi Dahlberg, "Digital Supply Chain Transformation Toward Blockchain Integration," paper presented at the *50th Hawaii International Conference on Systems Sciences, Hawaii, USA, 2017*, pg. 4183, retrieved from http://hdl.handle.net/10125/41666.
[8] Jacob Gronholt-Pedersen, "Maersk, IBM Say 94 Organizations have Joined Blockchain Trade Platform," *Reuters*, 9 August 2018.
[9] Blockchain Hub, "Smart Contracts," accessed 9 October, 2018, https://blockchainhub.net/smart-contracts/.

automatically notified and compensation is automatically deposited into their accounts based on the terms of the smart contract that were agreed to at purchase time[10].

c. Voting. Applications exist in the context of democratic elections but also in other domains such as shareholder voting or corporate board voting. Each voter is issued a vote that they can use only once, and they do so by giving it to a candidate. Anonymity and verification of identification are enabled through encryption and maintained in the digital ledger. Kshetri and Voas[11] document recent examples of blockchain-enabled voting and argue that it increases voter access and decreases voter fraud.

d. Financial audit and assurance. Blockchain is expected to streamline financial reporting and auditing by providing a linked, single source of truth for transactions[12]. Auditors spend significant time compiling evidence to piece the audit trail together, but blockchain-enabled financial processes will do much of this work concurrently as the transactions are executed.

e. Other applications. Blockchain is also being developed and will have a significant effect on medical records, criminal records, intellectual rights, trademarks, patents, property, and real estate[13].

7. Before turning to the application of blockchain within RCN NEM functions, current challenges of RCN supply chain management, material assurance, and material certification will be explored. The supply chain that supports logistics and enables RCN capability is large and complex. Ships and submarines incorporate a dizzying array of technologically advanced systems to allow them to operate effectively for long periods away from home port. These systems are provided for by a long list of defence contractors and suppliers spread out all over the world, and who often have their own network of sub-contractors and materials suppliers. Thus the supply chain from the origins of basic materials to their final destinations on RCN vessels is long, with high risk of error due to numerous intermediaries, modes of transportation, aggregation into broader systems, transactions, documents, and levels of trust along the way. Practically speaking, in terms of executing maintenance and engineering in the Fleet, several challenges exist in the RCN supply chain: parts not arriving on time, unknown location of parts (both physically and in the Defence Resource Management Information System (DRMIS)), unknown lead times and expected delivery dates, incorrect orders, contract reconciliation, unsynchronized automatic restocking, obsolete parts, high shipping costs to meet short fuse

---

[10] Medium, "Five Companies Already using Smart Contracts," accessed 9 October 2018, https://medium.com/polyswarm/5-companies-already-brilliantly-using-smart-contracts-ac49f3d5c431.
[11] Nir Kshetri and Jeffrey Voas, "Blockchain-Enabled E-Voting," *IEEE Software* 35, no. 4: 96.
[12] Chartered Professional Accountants Canada, "Blockchain Technology and its Potential Impact on the Audit and Assurance Profession," accessed 9 October 2017, https://www.cpacanada.ca/en/business-and-accounting-resources/audit-and-assurance/canadian-auditing-standards-cas/publications/impact-of-blockchain-on-audit.
[13] Zilbert, Mark, "Blockchain for Real Estate, Explained," accessed 9 October 2018, https://www.forbes.com/sites/forbesrealestatecouncil/2018/04/23/the-blockchain-for-real-estate-explained/#7d30b6cf781e.

requirements, inability to conduct analytics and performance measurement, and no ability to optimize the enterprise.

8. Naval Material Assurance (NMA) is a rapidly growing area within the NEM functions of the RCN. NMA is a framework for achieving the design intent of a ship – and thus the assurance of a defined RCN capability – by ensuring appropriate technical resources are applied to through-life maintenance[14]. Material certification, related to NMA and with origins in the Royal Canadian Air Force Air-Worthiness program, is a process to ensure the correct materials and technical procedures are used during maintenance through documentation and auditing. Material certification is used within RCN submarine maintenance to ensure systems are repaired according to their design specification and to ensure safety[15], and it is driving change in the surface fleet as well as NMA comes online. At present the exercise of documenting and auditing the vast amount of maintenance tasks for material and procedural correctness takes so much time that it is often the critical path for submarine maintenance periods.

9. Blockchain has the potential to improve on the challenges identified in managing complex supply chains and implementing successful NMA and material certification frameworks in the following ways:

a. Transparency. The digital ledger that is distributed and held by all nodes in the network ensures a one source of truth for transactions and full auditability. Even within DRMIS the receipt and payment for goods is problematic because documentation needs to be sought and attached to provide evidence of order fulfillment, often through email, phone calls, and other means. Furthermore, interfacing and data agreement between DRMIS and contractors' ERP systems requires significant effort to reconcile differences in the records. Blockchain would provide a single, common ledger between all parties, alleviating the requirement to reconcile differences and maintaining an easily auditable record that would assist in resolving disputes and financial reporting to government.

b. Confidentiality. Blockchain uses public- and private-key encryption together to ensure parties share agreed-upon data confidentially. Furthermore, *permissioned*[16] blockchains restrict access to stakeholders within a prescribed group and dictate the operating terms. These would probably be the most useful in the defence and security context, for example as a private network of defence suppliers that join and contribute to the network through terms and conditions of their contracts.

c. Traceability. The digital ledger holds a record of all transactions, so the integrity of materials and parts can be traced from origin. This audit trail directly supports material

[14] Scott Koshman, David Peer, and Russell Green, "Naval Material Assurance - Prelude to Action for the Royal Canadian Navy," *Maritime Engineering Journal* 70 (Fall 2012): 6.
[15] Chris Thatcher, "Submarines Chart a New Course for in-Service Support." *Vanguard*, 16 July 2014, accessed 9 October 2018, https://vanguardcanada.com/2014/07/16/submarines-chart-new-course-service-support/.
[16] As opposed to *permissionless* blockchains that are public and open to any user (like cryptocurrencies).

certification processes and significantly reduces the amount of effort required to validate the integrity of materials and parts. Furthermore, from a supply chain perspective, the location of the right number of the right parts would always be known, facilitating planning and de-risking the procurement process.

d. Configuration management. Critical to NMA and the maintenance of RCN ships to design intent is configuration management, an unwieldy function that currently requires a lot of human effort. The digital ledger can be used to hold a record of all configuration changes to the ship and its systems. The distributed nature of the ledger means that all parties (all ships, maintenance facilities, engineering providers, contractors, etc.) would know the exact configuration at all times.

e. Trust between stakeholders. In-service support arrangements between DND and industry are shifting to a relational contracting model, which is built on trust and solid foundations of good relationships between stakeholders, thereby enabling problem solving and risk sharing for mutual benefit. Blockchain supports this by building trust through transparency and consensus, and reduces conflict by having only one, agreed-upon record of transactions.

f. Automation. The vast number of materials and parts required to support ship maintenance demands significant time and effort in terms of establishing and managing contracts, particularly in light of government procurement policy. Smart contracts have the potential to revolutionize contract management by automating aspects of the procurement process, and thereby increasing the responsiveness of the supply chain. Time spent on contract execution and verification could be significantly reduced, as would frequency and impact of human errors. Furthermore, the audit function in support of NMA and material certification would be almost instantaneous because the records required for verification would be available and up-to-date. This has huge potential for maintenance period planning.

10. Despite the aforementioned positive impacts blockchain offers the RCN, limitations of the technology and areas of caution should be considered[17]:

a. Although the pace of blockchain adoption is quite rapid at present, it is still a relatively new technology that will develop over time. As with most new IT, it is expected that many of the improvements will be a result of learning from failure as it matures.

b. Smart contracts, despite their huge potential, are hard to actually implement, especially with respect to legal mechanisms. It is likely that further development would be required before the defence and security world would be comfortable adopting them.

---

[17] Valentina Gatteschi *et al*, "To Blockchain Or Not to Blockchain: That is the Question," *IT Professional* 20, no. 2 (March/April 2018): 68.

c. Transparency can be at the expense of privacy and confidentiality. Although mechanisms exist to maintain privacy and confidentiality, the right balance would need to be established depending on the application.

d. Distributed digital ledgers imply that all nodes have a copy of the records, which means that vast amounts of memory are used to store all of the copies.

e. Due to the use of public- and private-key cryptography, significant amounts of processing power are required to process the chain.

CONCLUSION

11. Blockchain is an evolving technology that hasn't yet reached a steady state, but industries around the world have recognized its potential and are investing heavily in it. The limitations facing it are similar to any new technology and will likely be mitigated and overcome as more businesses adopt it, develop novel ways of implementing it, increase its efficiency, and learn from mistakes along the way. Blockchain has the potential to positively impact RCN NEM business processes in several specific ways discussed in this paper, and in some cases may totally revolutionize those processes for the better. DND's ERP partner, SAP, has already started integrating blockchain into its product offerings, indicating that the technology is here to stay and will likely become standard within ERP toolsets. In order to become smart customers and continue to evolve the business of our business, blockchain research and development should become a priority for the RCN.

RECOMMENDATION

12. It is recommended that a project be initiated and funded to analyze blockchain in depth as well as its specific application potential in the RCN NEM environment. The project team should consist of representatives from ADM(IM), Defence Research and Development Canada, the division Maritime Equipment Program Management division, and SAP.

BIBLIOGRAPHY

Blockchain Hub. "Smart Contracts." Last accessed 9 October 2018. https://blockchainhub.net/smart-contracts/.

Chartered Professional Accountants Canada. "Blockchain Technology and its Potential Impact on the Audit and Assurance Profession." Last accessed 9 October 2018. https://www.cpacanada.ca/en/business-and-accounting-resources/audit-and-assurance/canadian-auditing-standards-cas/publications/impact-of-blockchain-on-audit.

Chartered Professional Accountants Canada. "Technological Disruption of Capital Markets and Reporting: An Introduction to Blockchain." Last accessed 9 October 2018. https://www.cpacanada.ca/en/business-and-accounting-resources/other-general-business-topics/information-management-and-technology/publications/introduction-to-blockchain-technology.

Gatteschi, Valentina, Fabrizio Lamberti, Claudio Demartini, Chiara Pranteda, and Victor Santamaria. "To Blockchain or Not to Blockchain: That is the Question." *IT Professional* 20, no. 2 (March/April 2018): 62-74.

Glover, Darryl G. and Jan Hermans. "Improving the Traceability of the Clinical Trial Supply Chain." *Applied Clinical Trials* 26, no. 12 (December 2017): 36-38.

Korpela, Kari, Jukka Hallikas, and Tomi Dahlberg. "Digital Supply Chain Transformation Toward Blockchain Integration." Paper presented at the *50th Hawaii International Conference on Systems Sciences, Hawaii, USA, 2017*: 4182-4191. Retrieved from http://hdl.handle.net/10125/41666.

Koshman, Scott, David Peer, and Russell Green. "Naval Material Assurance - Prelude to Action for the Royal Canadian Navy." *Maritime Engineering Journal* 70 (Fall 2012): 6-9.

Kshetri, Nir and Jeffrey Voas. "Blockchain-Enabled E-Voting." *IEEE Software* 35, no. 4: 95-99.

Medium. "Five Companies Already using Smart Contracts." Last accessed 9 October 2018. https://medium.com/polyswarm/5-companies-already-brilliantly-using-smart-contracts-ac49f3d5c431.

Nofer, Michael, Peter Gomber, Oliver Hinz, and Dirk Schiereck. "Blockchain." *Business & Information Systems Engineering* 59, no. 3: 183-187.

Royal Canadian Navy. *Royal Canadian Navy Strategic Plan: 2017-2022*. Ottawa: Department of National Defence.

Shanley, Agnes. "Real-Time Logistics." *Pharmaceutical Technology Europe* 29, no. 10: 46-48.

Tapscott, Don and Alex Tapscott. "How Blockchain Will Change Organizations." *MIT Sloan Management Review* 58, no. 2 (Winter 2017): 10-13.

Thatcher, Chris. "Submarines Chart a New Course for in-Service Support." *Vanguard*, 16 July 2014.

Zilbert, Mark. "Blockchain for Real Estate, Explained." Last accessed 9 October 2018. https://www.forbes.com/sites/forbesrealestatecouncil/2018/04/23/the-blockchain-for-real-estate-explained/#7d30b6cf781e.