David S. Bloch [*]

NON-FUNGIBLE TOKENS: A SOLUTION TO THE CHALLENGES OF USING BLOCKCHAIN BILLS OF LADING IN THE INTERNATIONAL SALES OF GOODS

ABSTRACT

The non-fungible token (NFT) has emerged as a way of authenticating unique digital assets. Thus artists have started selling digital artwork authenticated by NFTs, gaming companies can sell unique in-game products, and athletic leagues have started selling digital "cards" depicting key moments in sporting events.

Like cryptocurrencies, NFTs are applications of blockchain technology. A blockchain is a series of cryptographically linked records. The blockchain itself is "public" in the sense that every transaction is visible to all participants. But an encrypted block cannot be changed without altering all prior blocks – and alerting all other users in the blockchain.

Cryptocurrencies and NFTs differ in a critical respect. A unit of cryptocurrency is a fungible token, meaning it is identical to any other unit of cryptocurrency. In the same way that one Euro is equal to any other Euro, one Bitcoin has the same value and same characteristics as any other Bitcoin. An NFT, by contrast, is uniquely identified in the blockchain. So while one NFT may have the same market value as another NFT, no two NFTs are the same. This means NFTs are not useful as currency, but are valuable as incorruptible identifiers.

NFTs have other useful attributes. For example, they inherently include ownership information. This means that the NFT itself indicates who owns it—when it was created and by whom, who controls it now, and every transaction leading from the original to the current owner—at all times. Also, they are "extensible." This means that NFTs can be added together or merged in order to create a new NFT in a traceable way.

There are, of course, other digital representations of physical assets. Goods already are stamped with bar or QR codes, expensive products typically have serial numbers or other unique identifiers, and software often is accompanied by one-time-only passwords. But none of these are cryptographically secure in the way NFTs are, and none of them combine proof of authenticity and proof of ownership in a single instrument.

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[*] Shareholder, Greenberg Traurig LLP, San Francisco, California, USA. Admitted to practice in California and the District of Columbia. B.A. (FBK), Reed College; M.P.H., J.D. with honors, The George Washington University; 1997 Fellow in International Trade Law, Instituto Universitario di Studi Europei

The bill of lading is a venerable institution in international trade. Evolving over centuries and well developed by the time of the medieval lex mercatoria, the bill of lading is a paper form specifically contemplated and described in the key treaties enabling modern cross-border sales of goods—the Vienna Convention, the Hague-Visby Rules, and the U.S. Carriage of Goods by Sea Act. It indicates ownership of goods in transit, evidences the terms of the contract of carriage, and shows where, when, and to whom the goods were conveyed at every step between origin and ultimate destination. As a paper document, however, the bill of lading (often in multiple counterparts) is a critical bottleneck and source of risk.

Proposals to update paper bills of lading with an electronic equivalent have circulated for many years. And with the development of blockchain technology a decade ago, more recent proposals have discussed putting bills of lading on a blockchain. But these proposals are incomplete, because the blockchain is merely a ledger.

An NFT on a blockchain, however, is the ideal replacement for bills of lading and other documents reflecting passage of title. Each change of ownership of an NFT is publicly documented in the NFT's blockchain ledger. Done right, the NFT itself, in each block, contains both an incorruptible copy of the bill of lading and a complete chain of custody. And the fact that NFTs are extensible means a business can verify both components and finished goods.

This paper will discuss using NFTs as a substitute for traditional bills of lading.

SUMMARY

1 Introduction

The non-fungible token (NFT) has emerged as a 21st-century way of authenticating unique digital assets by way of blockchain technology.

Bills of lading are as old as NFTs are new.[1] The key treaties and domestic trade laws—the Vienna Convention,[2] the Hague-Visby Rules,[3] and the U.S. Carriage of Goods by Sea Act,[4] among many others—expressly contemplate the exchange of bills of lading to

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[1] G. Marcus Cole, 'The Long Convergence: "Smart Contracts" and the "Customisation" of Commercial Law' [2019] Southern California Law Review 851, 862-869 (tracing the history of contract law); David A. Bury, 'Comment: Electronic Bills of Lading: A Never-Ending Story?' [2016] Tulane Maritime Law Journal 197 at 200 ("The bill of lading owes its universal recognition, under both the common law and the civil law, to the lex mercatoria, the body of commercial law shaped by merchant practice and custom during the medieval period").

[2] United Nations Commission on International Trade Law (UNCITRAL), 'Convention on the International Sale of Goods' (Vienna 1980) 1489 United Nations Treaty Series 25, 567.

[3] UNCITRAL, 'International Convention for the Unification of Certain Rules of Law relating to Bills of Lading (The Hague Rules)' (Hague 1924, Visby 1968) 120 League of Nations Treaty Series 2764 and 1412 United Nations Treaty Series 23, 643.

[4] 46 United States Code §§ 30701 *et seq*.

effectuate the international transhipment of goods. Yet bill of lading remains a paper instrument. "A negotiable or order bill of lading is a fundamental and vital pillar of international trade and commerce, indispensable to the conduct and financing of business involving the sale and transportation of goods between parties located at a distance from one another."[5] But as a paper instrument that passes from hand to hand accompanying identified goods, it is inefficient and highly susceptible to mistake—to say nothing of outright fraud.[6]

Various commentators have proposed to use blockchain-based ledgers to replace bills of lading, but this solves only half the problem: a blockchain consists of a transparent and tamper-proof record of transactions but does not uniquely identify the goods being transacted. The development of non-fungible tokens, however, unlocks the other half: a blockchain tracing ownership of NFT-associated goods is transparent, tamper-proof, and allows sellers, shippers, and buyers, to precisely track and pass title to identified goods without sending laminated bits of paper back and forth across the ocean. Using the UNCITRAL model law on electronic transferrable records, open-source blockchain, and NFTs, shippers can finally adapt their historic practices to 21st-century technology.

2 Blockchains and tokens

2.1 Blockchain[7]

A *blockchain* is a *distributed-ledger*[8] (a ledger that all participants jointly record and maintain[9]) that lists cryptographically linked records. Each record (or "block") contains a unique identifier of a particular transaction, a timestamp showing when it was created, and a cryptographic "hash" (a mathematical transformation of the prior block's

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[5] United States Court of Appeals for the Second Circuit, *Berisford Metals Corp. v. S/S Salvador*, 779 F.2d 841, 845 (2d Cir. 1985).

[6] Naomi Chetrit, Mayrav Danor, Angelic Shavit, Boaz Yona & Dov Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [Fall 2018] 22 Virginia Journal of Law & Technology 56 at 69-74.

[7] See generally Jean Bacon, Johan David Michels, Christopher Millard & Jatinder Singh, 'Blockchain Demystified: A Technical and Legal Introduction to Distributed and Centralised Ledgers' [2018] Richmond Journal of Law & Technology 1; Lawrence J. Trautman & Mason J. Molesky, 'A Primer for Blockchain' [2019] University of Missouri-Kansas City Law Review 239.

[8] A "ledger is a shared system of record among participants on a business network; each member of the network has access rights and consensus is required from all network members; and all validated transactions are permanently recorded." Joyce G. Mazero & Leonard MacPhee, 'Setting the Stage for a Best-in-Class Supply Chain: Part 2' [2021] Franchise Law Journal 403 at 404-05.

[9] Jung-Ho Yang, 'Applicability of Blockchain based Bill of Lading under the Rotterdam Rules and UNCITRAL Model Law on Electronic Transferrable Records' [2019] Journal of Korea Trade 113 at 117 ("the blockchain can be defined as a distributed-ledger system in which all participants jointly record and manage transaction information by distributing the ledger that records transaction information over a peer-to-peer network rather than a central server of a particular agency").

unique identifier) that identifies the record it was created from (its "parent").[10] Because each block contains a cryptographically distinct hash value that identifies the previous block, one can trace the blockchain back to its original ("genesis") block. The below graphic, Figure 1, shows an extremely simplified blockchain:
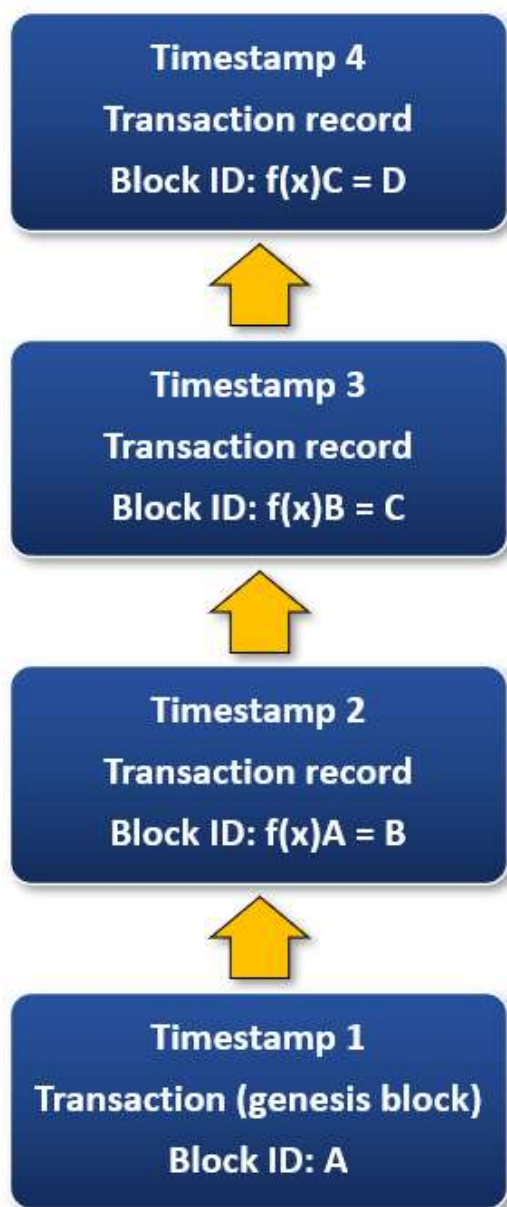
Timestamp 4
Transaction record
Block ID: $f(x)C = D$

Timestamp 3
Transaction record
Block ID: $f(x)B = C$

Timestamp 2
Transaction record
Block ID: $f(x)A = B$

Timestamp 1
Transaction (genesis block)
Block ID: A

Figure 1: Simplified blockchain schematic

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[10] J Bacon, JD Michels, C Millard and J Singh, 'Blockchain Demystified: A Technical and Legal Introduction to Distributed and Centralised Ledgers' [2018] Rich. J. L. & Tech. ¶¶ 4-8.

In Figure 1, a particular item or a digital representation of one (a token, a coin, etc.) is created at Time 1 in Block A. The token or coin in Block A is then transacted in some way (sold, exchanged for goods, etc.) at Time 2 using two-factor (public key/private key) encryption,[11] and a record of that transaction appears in Block B. The Block B ID is a mathematical transformation (designated here as *f(x)*) of the ID in Block A. So anyone on the blockchain can verify that Block B did indeed come from Block A. But only the owner of Block B (who holds the private key) can transact (and hence unlock) it. In Figure 1, the same item (coin, token, etc.) is then transacted to Block C and thence to Block D.

Identical copies of the blockchain are stored by all participating computers, so that every transaction is visible and verifiable by every other computer participating in the ledger.[12] To add an additional block to the blockchain, all of the computers in the peer-to-peer network must agree that the new transaction is valid. Any effort to change a block after the fact would require changing the blockchain at every node of the network—a daunting task. This can be done in various ways, but most commonly is achieved by way of a consensus algorithm.[13] That is to say, each participant in a particular blockchain keeps a copy of the blockchain in a peer-to-peer network.[14] So the blockchain is relatively impervious to fraud.

Changing the ledger requires cooperation between the consignor and consignee of a particular block:

Verification of each party's intent to change the state of the ledger is done through digital signatures attached to transactions. This is done through public key cryptography, a cryptographic technique whereby two sets of 'keys' … are generated. One of these keys, the private key, is kept secret by the user, as, together with the information in the transaction message, it constitutes an element in the function to generate the digital signature. This digital signature allows users to approve changes in the state of the address to which they have access by virtue of the secret key. A second function using the public key is used to verify the validity of the digital signature.[15]

In this fashion, the payload of a particular block can be transacted in a way that is verifiable by all even though only the owner can decrypt and use the block.

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[11] Ibid.

[12] JH Yang, 'Applicability of Blockchain based Bill of Lading under the Rotterdam Rules and UNCITRAL Model Law on Electronic Transferrable Records' [2019] J. Korea Tr. at 118 ("blockchain operating on a distributed network is designed to be managed jointly by members with identical transaction records copied to their computers in the system without independent servers").

[13] Ibid. 118 ("The consensus algorithm is an algorithm that ensures the integrity of the system by cross verifying the mathematically calculated result values subject to a specifically defined procedure by nodes that are not mutually reliable in the distributed network. Computers on the network must reach an agreement on the validity of the transaction before new data blocks are added to the end of the blockchain").

[14] Ibid. 117.

[15] Niels-Philip Adbellatif, 'An Ethereum bill of lading under the UNCITRAL MLETR' [2020] Maastricht Journal of European & Comparative Law 250 at 257.

2.2 Tokens

In blockchains, a *token* is a digital representation of anything of interest or value.

Physical coins and paper money are "tokens" in the sense that they have no (or very little) inherent value but can be exchanged for valuable goods or services because both buyer and seller agree on the equivalency between the currency and the goods being purchased. Before the era of floating currencies, the value of coins and scrips were backed by a store of value (the British Pound Sterling could be converted to silver till 1717 and gold till 1931; gold backed the U.S. dollar till 1971). Now, such currencies are not pegged to precious metals but instead are "floating" and backed only by consumer confidence and the full faith and credit of the issuing central bank. Economists have been proposing forms of electronic fiat currency since the early 2000s.[16]

Moving to the digital space, tokenisation predates and is logically separate from both electronic currency and blockchain technology. Digital tokens in computing environments are used as a mechanism for managing access or use rights – hence, a click-through license or software download code work because a *token* (representing an authorisation right) is placed on a user's computer in exchange for money or simply the agreement to be bound. Web sites place "cookies" (tokens) on user devices for purposes of tracking (navigation, targeted advertising) or authorisation (age verification). A mobile phone-based electronic ticket for an airplane flight or a concert likewise uses a *token* to represent the requested access right (entering the airport, getting into the show). All of these tokens are issued by the provider of the goods or services the user seeks to access (the airline, the concert promoter), and in theory the provider is able to validate whether the token is authentic or counterfeit.[17]

A blockchain token likewise can represent a physical asset (a kitchen table, a tree), a digital asset (a license to use an app, a "skin" in a videogame, a downloadable music track), a security interest (a share in a company; fractional ownership of a sports franchise), or a permission of some kind (a ticket to a museum or a concert; access to a nightclub or airplane). The key difference is that there is no unique issuer, central authority, or guarantor. Rather, a blockchain token is governed by a smart contract and ownership of that token is confirmed by consensus on the blockchain itself. Thanks to public key-private key encryption, only the holder of an encrypted token's private key can unlock—and hence transact—the block on the blockchain containing that particular token.[18]

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[16] E.g., Robert J. Shiller, *The New Financial Order* (Princeton University Press 2003) 202-221.
[17] Shermin Voshmgir, *Token Economy* (2nd edn, Token Kitchen 2020) 39, 152-168.
[18] Ibid. 38-50, 68-80.

3 Existing use cases for blockchain technology

There are at least a half-dozen primary use cases for blockchain technology today.

3.1 Cryptocurrency

The most common use case for blockchain technology—indeed, the use case for which blockchain was developed—is cryptocurrency. A cryptocurrency is a fiat currency that is not backed by a government. The genesis block of a cryptocurrency is consists of a highly complex equation, puzzle, or challenge with a finite number of increasingly difficult solutions.[19] These solutions require significant computer processing power to find, and thus cryptocurrency "miners" attempt to acquire additional units of cryptocurrency by devoting computer processing power to uncovering additional solutions to the equation. Each new solution is added to the blockchain ledger, and the registered owner of that solution can then engage in economic transactions using his "mined" cryptocoin.

Importantly, while the blockchain keeps an indisputable record of transactions involving cryptocoins, the coins themselves are *fungible* tokens. This means that any particular unit of cryptocurrency is identical to any other unit of cryptocurrency. In the same way that one Euro is equal to any other Euro, one Bitcoin has the same value and same characteristics as any other Bitcoin. From the perspective of the underlying mathematical function, there is no difference between the first solution and the hundredth solution—each solution is equally correct and each yields a token with the same transactional value. They are uniquely *identified*, in much the same way that each U.S. dollar bill has a unique serial number, but cryptocoins are not meaningfully different from one another.

The blockchain also enables decentralised exchanges, which allow currency trading without the need for a clearing house.[20]

3.2 Identity Verification

Because blockchain operates via public-key/private-key encryption, a user can verify his identity or personal information by presenting proof of a verified attestation rather

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[19] For example, "[t]o mine a valid new Bitcoin block, the hash value of that block must achieve a particular pattern, namely it must start with a certain number of zeros. To create a valid block, a miner must add a random number, known as a *nonce*, to the header of the block such that the resulting hash value fits the pattern. Miners solve this puzzle by trial-and-error, iterating through different nonces until the hash value has the required number of leading zeros. The higher the number of zeros required, the harder the puzzle." J Bacon, JD Michels, C Millard and J Singh, 'Blockchain Demystified: A Technical and Legal Introduction to Distributed and Centralised Ledgers' [2018] Rich. J. L. & Tech. ¶ 40 (emphasis original).

[20] S Voshmgir, *Token Economy* at 224.

than revealing the information itself.[21] "For example, when an identity owner presents a proof of their date-of-birth, rather than actually checking the truth of the date of birth itself, the verifying party will validate the government's signature who issued and attested to this credential to then decide whether he trusts the government's assessment about the accuracy of the data."[22] This the basis of products such as Tykn's Self-Sovereign Identity single-sign-on solution.[23]

3.3 Cross-Border Money Transfers

Blockchain also has the potential to revolutionize remittances, cross-border payments, and wire transfers. Today, most international transactions between banks use the SWIFT system, which functions as a secure central messaging service that financial institutions use to facilitate interbank transactions.[24] SWIFT is in effect a hub-and-spoke system, with all transactions routing through the central SWIFT node. If the same SWIFT transactions were instead performed on a blockchain, each financial institution would be connected directly to the others, speeding up the process of moving money between banks by removing SWIFT's intermediation. This decentralised peer-to-peer financial exchange system is at the heart of Ethereum.[25] But others also offer similar services. Abra, for example, operates by transferring money from the sender to a "teller" registered on Abra's network, who then transfers the money to a teller in the recipient's home location, with the second teller sending the money to the recipient—all validated on a blockchain accessible to all four participants (and many others).[26]

3.4 Accounting and Auditing

Public and private companies need to be able to reliably track their transactions—both for internal accounting purposes and (particularly for public companies) for external audits. Maintaining a register of transactions on a blockchain would significantly streamline the accounting and bookkeeping process. Major international

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[21] Ibid. 84-86.

[22] <https://tykn.tech/identity-management-blockchain/> accessed 15 February 2022.

[23] See <https://tykn.tech/> accessed 15 February 2022.

[24] The Society for Worldwide Interbank Financial Telecommunications. See <https://www.swift.com/about-us> accessed 15 February 2022, and <https://www.swift.com/about-us/history> accessed 15 February 2022.

[25] <https://ethereum.org/en/what-is-ethereum/> accessed 16 February 2022.

[26] David Hamilton, 'Blockchain Remittance: The Future of International Money' (20 August 2018) Coin Central, <https://coincentral.com/blockchain-remittance/> accessed 16 February 2022.

accounting firms such as Deloitte,[27] KPMG,[28] and Ernst & Young[29] offer specific guidance on (and products for) using blockchains to track and audit transactions.

3.5 Validation of Uniqueness

Most tokens on most blockchains are fungible, which is to say that they are interchangeable even if they are uniquely identified on the blockchain. Thus, in the case of a cryptocoin, each unit of currency is worth the same as any other, even though it is possible to trace the blockchain back and determine specifically when each new coin was mined. Likewise, a fractional ownership[30] in a work of art or a sports team is fungible (every fraction is equal to every other fraction) even when the item owned (The Last Supper, Juventus) is unique. Tokenised concert tickets may be fungible (for a general-admission show) or nonfungible (for a show where particular seats are at a premium).[31]

That is, indeed, the key difference between a cryptocoin and a *nonfungible* token or *NFT*. A nonfungible token is uniquely identified in the blockchain.[32] A unit of cryptocurrency is not. Cryptocurrencies and NFTs differ in that critical respect. Each unit of cryptocurrency is identical and hence *fungible*, in the same way that one Euro is equal to any other Euro. Not so for NFTs. While a particular NFT may have the same *market value* as another NFT (for example, two NFTs of Stephen Curry three-point shots may be valued at the same price), the NFTs themselves are not the same. This means NFTs are not useful as currency (except by way of barter), but are valuable as incorruptible identifiers.

Blockchains that support non-fungible tokens can be used to authenticate unique digital assets. Thus artists have started selling digital artwork authenticated by NFTs (*e.g.*, the digital artist Beeple sold a group of NFTs for over $69 million[33]), gaming

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[27]   Deloitte, 'An internal auditor's guide to auditing blockchain' (2019) <https://www2.deloitte.com/us/en/pages/risk/articles/internal-auditing-guide-to-blockchain.html> accessed 16 February 2022; Sandro Psalia, 'Blockchain: A game changer for audit processes' (22 September 2017), <https://www2.deloitte.com/mt/en/pages/audit/articles/mt-blockchain-a-game-changer-for-audit.html> accessed 16 February 2022.

[28]   KPMG, 'Auditing blockchain solutions' (October 2018), <https://assets.kpmg/content/dam/kpmg/in/pdf/2018/10/Auditing_Blockchain_Solutions.pdf> accessed 16 February 2022.

[29]   EY Americas, 'How blockchain will revolutionize finance and auditing' (29 April 2019), <https://www.ey.com/en_us/digital/blockchain-why-finance-and-auditing-will-never-be-the-same> accessed 16 February 2022.

[30]   S Voshmgir, *Token Economy* at 253-261.

[31]   Ibid. 169 (discussing asset tokens, credential tokens, and access tokens).

[32]   Ibid. 168-170.

[33]   Jacqui Palumbo, 'First NFT artwork at auction sells for staggering $69 million' (21 March 2021) CNN, <https://www.cnn.com/style/article/beeple-first-nft-artwork-at-auction-sale-result/index.html> accessed 28 November 2021.

companies can sell unique in-game products (from skins[34] to crypto-kitties[35]), and athletic leagues have started selling digital "cards" depicting players or key moments in sporting events (*e.g.*, the U.S. National Basketball Association's NBA Top Shots, digital renderings of particular "moments" in basketball history[36]; SoRare sells NFTs of professional soccer players for fantasy gaming[37]).

NFTs have two other attributes relevant to our discussion here. *First*, they inherently include ownership information. This means that the NFT itself indicates when it was created and by whom, who owns it now, and every transaction leading from the original to the current owner. *Second*, they are "extensible." This means that NFTs can be added together or merged in order to create a new NFT in a traceable way.

Thus, the NFT has the function, already, of representing ownership. But it is distinct from copyright. A copyright confers the right to copy, reproduce, translate, prepare derivative works, display, and perform a particular work.[38] Not so for NFTs. Owning an NFT does not confer the copyright in a particular digital work, meaning that the NFT-holder cannot (for example) copy or make derivative works of it. Owning the NFT associated with a particular digital performance does not prevent others from copying and redistributing that performance—it merely gives the NFT-holder the ability to say that he is the "true" owner of the "original" performance. Ownership of an original artwork has value in the real world—even the best reproduction is nowhere near as valuable as an original da Vinci, and it is of course possible for copyright owners to convey their rights to particular works of art—but digital copies of digitally recorded audio-visual performances are *exact*, meaning that the value of an NFT associated with a particular digital asset is mostly psychic, unless the copyright holder also has agreed to prevent the creation of additional copies—and is willing to police the market to prevent bootlegs.

3.6 Supply Chain Management

Manufacturers have started using NFTs to monitor supply chains and track components. Thus, Alfa Romeo plans to use NFTs to identify the sources of component parts (which will help with respect to possible recalls and manufacturing problems), track the car's performance and repair history, and even authenticate that—should the

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[34] Hafsa Lodi, 'NFT clothing and designer avatar skins: how fashion is being digitised' (25 September 2021) The National News, <https://www.thenationalnews.com/lifestyle/luxury/2021/09/25/nft-clothing-and-designer-avatar-skins-how-fashion-is-being-digitised/> accessed 28 November 2021.

[35] Available at <https://www.cryptokitties.co/> accessed 28 November 2021.

[36] Available at <https://nbatopshot.com/> accessed 28 November 2021.

[37] Available at <https://sorare.com/> accessed 28 November 2021.

[38] See 17 United States Code § 106.

car be resold—it is authentic and contains authorised parts.[39] This approach could easily be applied to other complex products containing multiple parts from different vendors.

3.7 Data-as-an-Asset

It has been proposed that NFTs can be used to "containerize" personal or corporate data (in the form, for example, of a "basic attention token"[40]), allowing to be used only with pre-set permissions and securely tracking those uses without inadvertently sharing more than is allowed. Because NFTs are digitally signed and time-stamped, data owners possess "a secure and verifiable audit trail" of the data the NFT represents.[41] Voshmgir discusses the alternative vehicle of "privacy tokens," which can facilitate compliance with know-your-customer laws without compromising personal privacy.[42]

4 A new use case: NFTs for bills of landing

4.1 Problems with Paper Bills of Lading

Bills of lading are critical instruments in international trade. A bill of lading describes the goods being ships, identifies the points of origin and destination, and generally contains all of the necessary information for shippers and carriers to properly transmit goods across national boundaries. Because it is critical to establishing the chain of custody and passing the risk of loss, the bill of lading is physically signed serially by the shipper, the carrier, and the receiver to confirm all points at which the shipped goods change hands. No matter what goods are being shipped or how they are shipped, the bill of lading itself has always been a paper document. The necessity of a bill of lading is called for in the core treaties and laws supporting international trade. Possession of a bill of lading conveys title to the described goods.

The bill of lading has three distinct functions. *First*, it is an indicator of ownership. To hold a bill of lading is to hold title to the identified goods. *Second*, it evidences the terms (payment, insurance, and so on) of the contract of carriage between the seller, the shipper, and the buyer (and others along the chain of custody). *Third*, it functions as a receipt, showing where, when, and to whom the goods were conveyed at every step

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[39] George Downs, 'This Car Comes With an NFT (And No, It Isn't a Bored Ape Picture)' (17 February 2022) *The Wall Street Journal* (New York, 17 February 2022).

[40] S Voshmgir (2020) 'Token Economy' at 298-302.

[41] Praphul Chandra & Arushi Goel, 'If data is the new oil, then enterprise NFTs are the tankers. Here's why' (29 September 2021) World Economic Forum, <https://www.weforum.org/agenda/2021/09/if-data-is-the-new-oil-then-enterprise-nfts-are-the-tankers/> accessed 16 February 2022.

[42] S Voshmgir, *Token Economy* at 202-203.

between origin and ultimate destination. This helps fix the risk of loss and allows interested parties to track the progress of a particular shipment.

Possession of a bill of lading conveys title to the goods the bill of lading describes.[43] Thus, there is often controversy when the description contained in the bill of lading does not exactly conform to the goods received by the consignee.[44]

Being paper documents, bills of lading are also susceptible to fraud.[45] Reported cases describe situations in which a Korean seller of ladders bribed a carrier's local agent to issue bills of lading for 44 containers of folding ladders when in fact only 9 containers were shipped,[46] goods were misdescribed in order to reduce freight rates,[47] and dates were fraudulently backdated to avoid breach of contract[48] or shift the risk of loss.[49] Indeed, in light of collusion and fraud, "a paper bill of lading may be subject to suspicion by all members of the supply chain."[50]

And to be sure, the authenticity of the goods described in a bill of lading can have real-world consequences. Counterfeiting remains a substantial problem worldwide. When high-technology goods are counterfeited, the risks are not borne just by buyers and sellers, but also by broader segments of the population (as, for example, if a counterfeit router causes a hospital's computer systems to crash[51]). In part for this reason, the international shipping community has developed detailed chain-of-custody processes to ensure that authentic goods are taken from the point of manufacture, to the point of shipment, to the point of receipt—and likewise insurance and related instruments to protect against the risk of counterfeits. The bill-of-lading system does not cure *all*

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[43] Marek Dubovec, 'The Problems and Possibilities for Using Electronic Bills of Lading as Collateral' [2006] Arizona Journal of International & Comparative Law 437 at 442; NP Adbellatif, 'An Ethereum bill of lading under UNCITRAL MLETR' [2020] Maastricht J. Euro. & Comp. L. at 250.

[44] NP Abbellatif, 'An Ethereum bill of lading under UNCITRAL MLETR' [2020] Maastricht J. Euro. & Comp. L. at 252-253.

[45] N Chetrit, M Danor, A Shavit, B Yona and D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [2018] Va. J. L. & Tech. at 69 ("The most prominent shortcoming of the traditional bill of lading is its physical nature").

[46] Supreme Court of the Netherlands, *Damco Maritime International BV v. Meister Werkzeuge Werkzeugfabrik GmbH*, 4 April 2003, NJ 2003, Nr. 122.

[47] United States Court of Appeals for the Second Circuit, *La Fortune v. S.S. Irish Larch*, 503 F.2d 952 (2d Cir. 1974).

[48] Queen's Bench Division of the High Court of the United Kingdom, *Kwei Tek Chao v. British Traders* (1954) 2 QB 459.

[49] United Kingdom Court of Appeal, *Motis Exports Ltd. v Dampskibsselskabet AF 1912 Aktieselskab and Aktieselskabet Dampskipsselskabet Svendborg* (2000) 1 Lloyd's Rep 211.

[50] Christian Albrecht, 'Blockchain Bills of Lading: The End of History? Overcoming Paper-Based Transport Documents in Sea Carriage Through New Technologies' [2019] Tulane Maritime Law Journal 252 at 258.

[51] See, *e.g.*, U.S. Department of Justice, 'Departments of Justice and Homeland Security Announce 30 Convictions, More Than $143 Million in Seizures from Initiative Targeting Traffickers in Counterfeit Network Hardware' (6 May 2010), <https://www.justice.gov/opa/pr/departments-justice-and-homeland-security-announce-30-convictions-more-143-million-seizures> accessed 3 December 2021 ("'These cases involve greedy businessmen hocking counterfeit and substandard hardware to any buyer—whether it could affect the health and safety of others in a hospital setting or the security of our troops on the battlefield,' said John Morton, Assistant Secretary of Homeland Security for ICE.").

risks—misdescription of goods can be catastrophic[52]—but they system has certainly stood the test of time.

It is, however, an anachronism. "Whatever benefits the current paper-based system still provides, it also results in a number of costly problems including delayed arrival, insufficient or inaccurate information, high cost of transport and fraudulent issuance of the bill of lading."[53] In short, "[t]he paper bill of lading system is not a failsafe means of protecting its holder's right to possess cargo."[54] So it is not surprising that theorists have for many years reached for alternatives to modernize bills of lading.

4.2 Blockchain-Based Bills of Lading

There have long been digital representations of physical assets. Goods already are stamped with unique bar or QR codes, expensive products typically have specific identifiers (*e.g.*, vehicle identification codes), and software often is accompanied by one-time-only password-protected authorisation codes. And earlier systems such as BOLERO (the Bill Of Lading Electronic Registry Organisation),[55] SeaDocs (the Seaborne Trade Documentation System),[56] CMI,[57] essDOCS,[58] and TradeCard[59] attempted to create electronic bills of lading without relying on blockchain. But none have been widely adopted.

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[52] For a discussion of multiple shipping disasters resulting from misdescribed goods, see Kyle Brennan, 'Up in Flames: The Explosive Risks of Misdeclared Hazardous Cargo in Shipping Containers Following the *Maersk Honam* Fire' [2019] Loyola Maritime Law Journal 259.

[53] N Chetrit, M Danor, A Shavit, B Yona and D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [2018] Va. J. L. & Tech. at 69.

[54] DA Bury, 'Comment: Electronic Bills of Lading: A Never-Ending Story?' [2016] Tulane Mar. L. J. at 210.

[55] For a discussion of why BOLERO has not been more widely adopted, see Paul Todd, 'Electronic bills of lading, block-chains and smart contracts' [2019] International Journal of Law & Information Technology 339; N Chetrit, M Danor, A Shavit, B Yona & D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [2018] Va. J. L. & Tech. at 77-78; and DA Bury, 'Comment: Electronic Bills of Lading: A Never-Ending Story?' [2016] Tulane Mar. L. J. at 218-223 ("Bolero's largest obstacle is that no corporation or financing bank would ever make use of a system that precludes insurance").

[56] For a discussion of why SeaDocs has not been more widely adopted, see N Chetrit, M Danor, A Shavit, B Yona and D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [2018] Va. J. L. & Tech. at 76-77; and DA Bury, 'Comment: Electronic Bills of Lading: A Never-Ending Story?' [2016] Tulane Mar. L. J. at 213-215 ("The SEADOCS project collapsed after less than a year for myriad reasons").

[57] See DA Bury, 'Comment: Electronic Bills of Lading: A Never-Ending Story?' [2016] Tulane Mar. L. J. at 215-218 ("While the CMI model rules demonstrate one of the best efforts of "soft laws" meant to dematerialize the negotiable bill of lading, major flaws impeded its success").

[58] Ibid. 228-230 ("For a viable electronic bill of lading system to succeed, international conventions or national laws must recognize the legal effect of electronic negotiation. The essDOCS website is unable to cite to either in support of its claim to be a 'legal equivalent' to paper bills of lading").

[59] See N Chetrit, M Danor, A Shavit, B Yona and D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [2018] Va. J. L. & Tech. at 78 ("Unfortunately, Trade-Card was also prone to fraud from malicious users").

Characteristics of blockchain make it particularly promising for supporting electronic bills of lading. And so several academics have proposed adapting blockchain technology to bills of lading in international transactions.

There are barriers, of course. Professor Mark Shope concludes that a blockchain bill of lading is not supported by the combination of the UNCITRAL Model Law of Electronic Commerce,[60] the UNCITRAL Model Law on Electronic Signatures,[61] and the UN Convention on the Use of Electronic Communications in International Contracts,[62] because the UN Convention that seems to embody those UNCITRAL model laws expressly excludes bills of lading.[63] While the United States Federal Bills of Lading Act[64] does not plainly say that a bill of lading must be a physical document, various provisions (for example, the requirements surrounding delivery where a bill of lading has been lost, stolen, or destroyed[65]) make little sense in the context of electronic transactions. Similarly, the U.S. Electronic Signatures in Global and National Commerce Act,[66] like the UN Convention, approves electronic signatures on any "contract or other record created, generated, sent, communicated, received, or stored by electronic means,"[67] but does not speak to bills of lading.

But both Professor Shope and Professor Jung-Ho Yang propose using blockchain within the context of the UN Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea (the "Rotterdam Rules")[68] and the 2017 UNCITRAL Model Law on Electronic Transferrable Records[69] to replace paper bills of lading with a blockchain bill of lading.[70] Shope says that the Rotterdam Rules are structured to support a bill of lading in the form of a "negotiable electronic transport record"[71] and that "blockchain bills of lading (correctly configured) would be compatible with the Rotterdam Rules, but there is still work to be done to fully realize blockchain bills of lading within this legal framework."[72] In particular, he focuses on the problem of moving between electronic and paper bills of lading as part of the same transaction—something

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[60] UNCITRAL, 'Model Law on Electronic Commerce' (1999) U.N. Sales No. E.99.V.4.

[61] UNCITRAL, 'Model Law on Electronic Signatures' (2002) U.N. Sales No. E.02.V.8.

[62] UNCITRAL, Convention on the Use of Electronic Communications in International Contracts (2007) U.N. Sales No. E.07.V.2, 2898 United Nations Treaty Series 50,525.

[63] Mark L. Shope, 'The Bill of Lading on the Blockchain: An Analysis of its Compatibility with International Rules on Commercial Transactions' [2021] Minnesota Journal of Law, Science & Technology 163 at 173.

[64] 49 United States Code §§ 80101-80116 (the Pomerene Bills of Lading Act).

[65] 49 United States Code. § 80114.

[66] 15 United States Code §§ 7001-7006.

[67] 15 United States Code § 7006 (4)

[68] U.N. General Assembly, 'United Nations Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea' (2 February 2009) G.A. Res. U.N. Doc. A/Res/63/122.

[69] UNCITRAL 'Model Law on Electronic Transferable Records' (2017) U.S. Sales No. E.1.V.5, A/CN.9/834.

[70] JH Yang, 'Applicability of Blockchain based Bill of Lading under the Rotterdam Rules and UNCITRAL Model Law on Electronic Transferrable Records' [2019] J. Korea Tr. at 130.

[71] ML Shope, 'The Bill of Lading on the Blockchain: An Analysis of its Compatibility with International Rules on Commercial Transactions' [2021] Minn. J. Law, Science & Tech at 174.

[72] Ibid. 188.

the Rotterdam Rules would seem to require but that would undermine the singularity and uniqueness inherent in transactions recorded by way of a blockchain system. Yang proposes that "the transfer of token between trading participants on a blockchain network can be performed in parallel with the movement of physical assets, and a clear chain of asset proof can be established, establishing a clear chain of asset provenance."[73] He goes on to demonstrate that a blockchain transaction can satisfy Article 9 of the Rotterdam Rules, which sets forth the minimum requirements for an electronic document to replace a paper one, as well as the UNCITRAL "functional equivalence" rule.[74] Professor Shope likewise concludes that the UNCITRAL Model Law on Electronic Transferrable Records would support blockchain bills of lading as "electronic records," depending on whether more jurisdictions adopt the model law.[75]

Professor Niels-Philip Abdellatif agrees, writing that the Model Law "would remain an exercise in futility (or, at the very least, of far decreased worth) where [bills of lading] are concerned were it not for the fact that an exciting new technology, blockchain, is capable of succeeding in the digitisation of [bills of lading] where others have failed."[76] Others have reached the same conclusion.[77] The newest iteration of the U.S. Uniform Commercial Code likewise embraces electronic documents of title,[78] and at least arguably would support a blockchain bill of lading.[79]

The virtues of blockchain are reasonably clear. "Blockchain is unique in that it does not require any central server or authority, which makes it extremely secure from hacking and allows for instantaneous transfer and usage of information. … The transparency introduced by [b]lockchain would make it much easier for parties in the container supply chain to verify the accuracy of information, vet their customers, and detect shell companies and companies with deficient compliance histories."[80]

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[73] JH Yang, 'Applicability of Blockchain based Bill of Lading under the Rotterdam Rules and UNCITRAL Model Law on Electronic Transferrable Records' [2019] J. Korea Tr. at 120.

[74] Ibid. 122.

[75] ML Shope, 'The Bill of Lading on the Blockchain: An Analysis of its Compatibility with International Rules on Commercial Transactions' [2021] Minn. J. Law, Science & Tech at 199-200.

[76] NP Abdellatif, 'An Ethereum bill of lading under UNCITRAL MLETR' [2020] Maastricht J. Euro. & Comp. L. at 255.

[77] *E.g.*, Koji Takahashi, 'Blockchain Technology & Electronic Bills of Lading' [2016] Journal of International Maritime Law 202; C Albrecht, 'Blockchain Bills of Lading: The End of History? Overcoming Paper-Based Transport Documents in Sea Carriage Through New Technologies' [2019] Tulane Mar. L. J. at 272-74; N Chetrit, M Danor, A Shavit, B Yona & D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [2018] Va. J. L. & Tech. at 92-97 (arguing that the Wave system is consistent with the Rotterdam Rules).

[78] Allison Skopec, 'PIN Chagrin: The Glencore Heist and EDI Through the Lens of Delivery Orders' [2017] Tulane Maritime Law Journal 221 at 228-229 and 238.

[79] Christopher M. McDermott, Jeffrey Nagle, Martin Horowitz and Stephen M. Johnson, 'Will Blockchain Render the Bill of Lading a Relic?' (21 August 2017) <https://www.cadwalader.com/resources/clients-friends-memos/will-blockchain-render-the-bill-of-lading-a-relic> accessed 6 December 2021.

[80] K Brennan, 'Up in Flames: The Explosive Risks of Misdeclared Hazardous Cargo in Shipping Containers Following the *Maersk Honam* Fire' [2019] Loyola Mar. L. J. at 283-84; see also N Chetrit, M Danor, A Shavit, B Yona and D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with

Blockchain is a fundamental building block of all cryptocurrencies, and is widely used by "banks, insurance companies, and those in the diamond trade who need to establish chains of custody."[81]

Moreover, blockchain bills of lading would enhance shipping safety, because information on shipments could easily and cheaply be "provided all the way down the chain via the cargo's electronic bill of lading to the actual crew of the ship carrying that cargo, with no bulky paperwork to manage and no possibility of the shipper being able to alter this data once it was introduced in the chain."[82] So "from a technical perspective, blockchain is fit for the purpose of issuing a unique bill of lading record."[83] Some technologies, such as Wave, already seek to use blockchain to "connect[] all members of the international trade supply chain via a P2P network" that "allows a confidential direct exchange of official trade documents," including bills of lading.[84]

But blockchain itself is not enough. Yang also identifies a key problem: the "[g]uarantee of uniqueness is [an] essential requirement for electronic bill of lading to be recognised as paper bill of lading in that it is necessary to prevent multiple claims from being made on the same obligation."[85] But, he says, "it is difficult to guarantee uniqueness technically."[86] This problem also has plagued prior efforts to replace paper bills of lading with electronic bills of lading.[87] If somehow the same electronic bill of lading is placed in two blockchains, there is no easy technical way to distinguish which is the right one – and thus which possessor is entitled to the underlying goods.

Bills of Lading' [2018] Va. J. L. & Tech. at 81 ("An important characteristic of blockchain is that it is practically and effectively immutable, which means that one cannot change a record placed on blockchain. As such, it is secure, transparent, relatively fast, and potentially scalable"); JG Mazero & L MacPhee, 'Setting the Stage for a Best-in-Class Supply Chain: Part 2' [2021] Franchise L. J. at 412 ("Incorporating blockchain into the shipping process will make available a record of the bill of lading and the shipment's transport and transport history available [*sic*].").

[81] N Chetrit, M Danor, A Shavit, B Yona and D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [2018] Va. J. L. & Tech. at 82.

[82] K Brennan, 'Up in Flames: The Explosive Risks of Misdeclared Hazardous Cargo in Shipping Containers Following the *Maersk Honam* Fire' [2019] Loyola Mar. L. J. at 285.

[83] C Albrecht, 'Blockchain Bills of Lading: The End of History? Overcoming Paper-Based Transport Documents in Sea Carriage Through New Technologies' [2019] Tulane Mar. L. J. at 263.

[84] N Chetrit, M Danor, A Shavit, B Yona and D Greenbaum, 'Not Just for Illicit Trade in Contraband Anymore: Using Blockchain to solve a millennial-long problem with Bills of Lading' [2018] Va. J. L. & Tech. at 82, 92-94 (discussing Wave); DA Bury, 'Comment: Electronic Bills of Lading: A Never-Ending Story?' [2016] Tulane Mar. L. J. at 236-237 (discussing Wave); Dakota A. Larson, 'Comment: Mitigating Risky Business: Modernising Letters of Credit with Blockchain, Smart Contracts, and the Internet of Things' [2018] Michigan State Law Review 929 at 961 ("More recently, blockchain has also been used to generate documents like bills of lading in letter-of-credit transactions. Because international transactions involve many documents—potentially with multiple phases of correspondence--blockchain is an easy way to store, organize, and verify documents").

[85] JH Yang, 'Applicability of Blockchain based Bill of Lading under the Rotterdam Rules and UNCITRAL Model Law on Electronic Transferrable Records' [2019] J. Korea Tr. at 123.

[86] Ibid. 124.

[87] M Dubovec, 'The Problems and Possibilities for Using Electronic Bills of Lading as Collateral' [2006] Ariz. J. Int'l & Comp. L. at 437.

It is not hard to imagine a situation where a blockchain supporting a bill of lading splits[88] or where two actors both claim the same bill of lading using different blockchains. And advances in quantum computing threaten to penetrate both hash functions and public/private key cryptography, rendering a blockchain more vulnerable to manipulation.[89] Even without quantum computers, though, "hacking of blockchain platforms has occurred, leading to cyber-security concerns over the possibility of fraudulent blockchain transactions."[90]

To fight fraud, Yang proposes that blockchain can single out the earliest transaction and void later transfers "using timestamping and cryptographic techniques."[91] But while this is a good way to detect and unwind fraud, it is an imperfect solution to the need for a truly unique bill of lading that cannot be copied or altered. An NFT bill of lading solves the problem, elegantly. Unlike blockchain tokens, NFTs are *by definition* unique.

4.3   Use of NFTs as Bills of Lading

As noted above, there have been many prior experiments with electronic waybills and even blockchain-based bills of lading. But none of these are cryptographically secure in the way NFTs are, and none of them combine proof of authenticity and proof of ownership in a single vehicle. Mere digital records do not resolve "the common concern related to digitisation, namely the loss of electronic data in the event of hardware or software failure."[92] This risk is particularly acute if the electronic registry or ledger is centralised.[93]

Professor Abdellatif proposes to tokenize bills of lading using a "Satoshi," the smallest Bitcoin denomination.[94] This has the virtue of leveraging an existing tokenisation platform, but Bitcoins have independent (consensus) value—if the value of the Satoshi exceeds the value of the underlying bill of lading, a holder may prefer to use the currency *as currency* rather than acquiesce in its function as a bill of lading, in much the same way the silver in old American quarters is worth more than the coin's nominal value of $0.25.[95] He proposes to address this problem by converting the bill of lading into

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[88] A blockchain splits where there is no consensus in the network about which of two competing and incompatible transactions is valid. See generally AKM Najmul Islam, Matti Mantiymaki & Marja Turunen, 'Why do blockchains split? An actor-network perspective on Bitcoin splits' [2019] Technological Forecasting and Social Change 148.
[89] LJ Trautman & MJ Molesky, 'A Primer for Blockchain' [2019] U. Missouri-Kansas City L. R. at 249-252.
[90] DA Bury, 'Comment: Electronic Bills of Lading: A Never-Ending Story?' [2016] Tulane Mar. L. J. at 237.
[91] JH Yang, 'Applicability of Blockchain based Bill of Lading under the Rotterdam Rules and UNCITRAL Model Law on Electronic Transferrable Records' [2019] J. Korea Tr. at 125.
[92] NP Abdellatif, 'An Ethereum bill of lading under UNCITRAL MLETR' [2020] Maastricht J. Euro. & Comp. L. at 254.
[93] Ibid. ("taking for granted that said administrator is competent and can be trusted not to act with malicious intent, this system introduces a clearly discernible centralised entity embodying a single point of failure").
[94] Ibid. 259-260.
[95] Quarter coins minted before 1964 are worth approximately $4 and fluctuate with the value of silver. 'Quarter Values Rising' (22 November 2021) <https://www.coinstudy.com/quarter-values.html> accessed 28 November 2021.

a smart contract on the Ethereum platform.[96] And he notes in passing that Ethereum standard ERC-721[97] enables NFTs, which "are useful in representing documents, such as deeds," and hence represents "the natural choice for a [bill of lading] token."[98] Leaving aside whether Ethereum is the preferred blockchain platform,[99] this is exactly right: blockchain-based NFTs are an ideal replacement for bills of lading and other documents reflecting passage of title.

Each change of ownership of an NFT is publicly documented in the NFT's blockchain ledger, but only the owner of any given block can use a private key to unlock or decrypt the NFT. Thus, the NFT itself embodies and includes a complete chain of custody, with ownership and access controlled inherently by the blockchain system.[100] The blockchain is distributed, so there is no risk that the data will be lost. And because the NFT is traceable back to its source, it also helps validate the provenance of goods that derive value from particular sources—whether Champagne from a DOC, coffee beans sourced from organic farms, or a particular shipment of microchips earmarked for a specific customer.

In order to achieve all of this, the bill of lading can be embedded as the blockchain's payload, such that an encrypted copy of the bill of lading itself is carried in the block and can be decrypted,[101] or the bill of lading can be "tokenised" (that is, replaced by a random and unique sequence of characters), such that "the transfer of token[s] between trading participants on the blockchain network can be performed in parallel with the movement of physical assets."[102] If the bill of lading is converted to an NFT—a non-fungible token—then it can be tracked uniquely across the chain of title, from shipper to freight forwarder to Customs to the recipient.

Shown very simply, the sequence would look something like the flowchart in Figure 2:

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[96] NP Abdellatif, 'An Ethereum bill of lading under UNCITRAL MLETR' [2020] Maastricht J. Euro. & Comp. L. at 260-265.

[97] The standard is described at <http://erc721.org/> accessed 3 December 2021.

[98] NP Abdellatif, 'An Ethereum bill of lading under UNCITRAL MLETR' [2020] Maastricht J. Euro. & Comp. L. at 264.

[99] In 2021, the Ethereum blockchain split in two as a consequence of outmoded software. Luke Conway, 'Ethereum's Blockchain Just Split in Two' (27 August 2021) <https://www.thestreet.com/crypto/ethereum/ethereums-blockchain-just-split-in-two> accessed 9 December 2021 ("Ethereum's blockchain has split in two from a bug in a previous version of the chain's main node software. ... This means that around 50% of Ethereum nodes are running a split-off chain with out-of-date and bugged software that could allow double-spends").

[100] For example, Britain's WiV Technology already is offering a blockchain-based way of investing in fine wines while tracking transactions in real time. See 'EY helps WiV Technology accelerate fine wine investing with blockchain' (August 2019) <https://www.ey.com/en_gl/news/2019/08/ey-helps-wiv-technology-accelerate-fine-wine-investing-with-blockchain> accessed 26 November 2021.

[101] ML Shope, 'The Bill of Lading on the Blockchain: An Analysis of its Compatibility with International Rules on Commercial Transactions' [2021] Minn. J. Law, Science & Tech at 168 ("The block body could contain any string of text, including the entire contents of a bill of lading").

[102] JH Yang, 'Applicability of Blockchain based Bill of Lading under the Rotterdam Rules and UNCITRAL Model Law on Electronic Transferrable Records' [2019] J. Korea Tr. at 120.

Timestamp 4
Bill of Lading
Customs conveys to buyer
Block ID: f(x)C = D

Timestamp 3
Bill of Lading
Shipper conveys to Customs
Block ID: f(x)B = C

Timestamp 2
Bill of Lading
Original owner conveys to shipper
Block ID: f(x)A = B

Timestamp 1
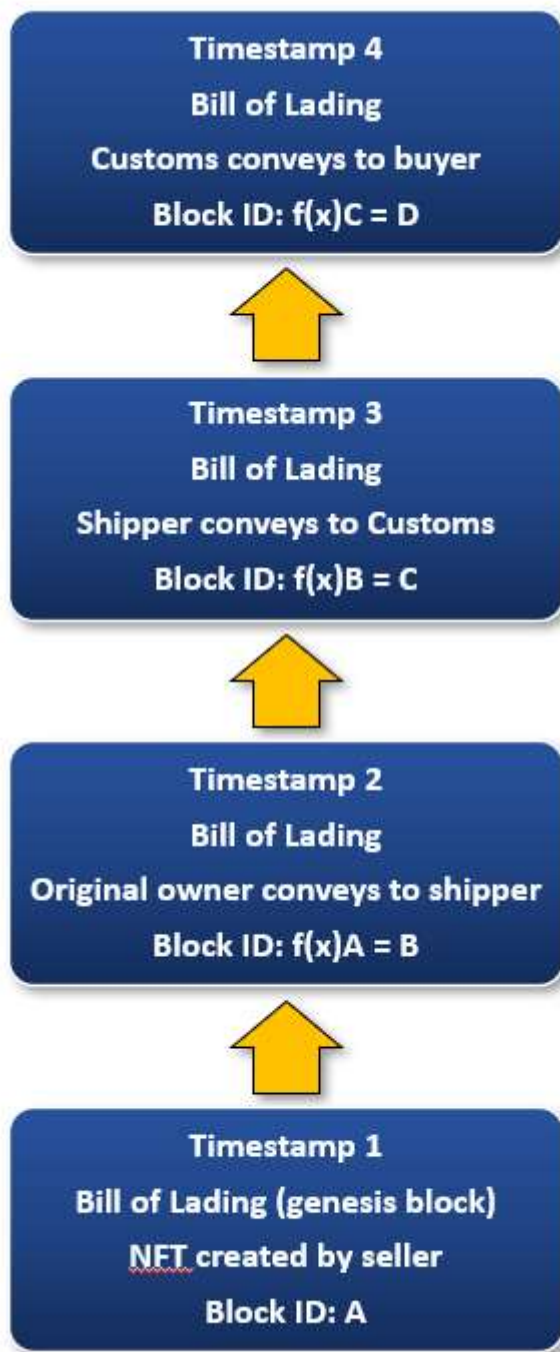Bill of Lading (genesis block)
NFT created by seller
Block ID: A

Figure 2: Simplified blockchain schematic for NFT-enabled bill of lading

Figure 2 is basically the same as Figure 1, except that the hypothetical transaction is now identified specifically as an NFT transacted via a blockchain. It shows how an NFT-enabled blockchain can function as a bill of lading. At Time 1, the seller creates an

electronic bill of lading (containing all of the information normally contained in a bill of lading) and encrypts it as a non-fungible token with Block ID A. At Time 2, the seller delivers the identified goods to the shipper and the NFT bill of lading is conveyed to the shipper in Block ID B (a mathematical transformation of Block ID A using a function we are calling *f(x)*). The buyer can see that the bill of lading has been passed by the seller to the shipper, but no one except the shipper is able to access or modify it. At Time 3 (Block ID C), goods and the NFT bill of lading are securely conveyed to Customs. At this point all of the participants—seller, shipper, and buyer—can see that Customs has the bill of lading and associated goods, but only Customs can access the bill of lading itself. Customs then releases the goods and the NFT bill of lading to the buyer at Time 4, Block ID D. At this point the seller takes possession of the goods and is able to access and modify the bill of lading.

In this way, the bill of lading is rendered essentially fraud-proof. It cannot be backdated, each transaction is transparent to all participants in the blockchain, and the payload (the bill of lading itself, including the description of goods) cannot be altered by a non-owner without detection.

Moreover, the fact that NFTs are extensible means a business can verify both components and finished goods. The NFTs accompanying particular chips shipped from Taiwan can be combined with NFTs accompanying circuit boards and other components in order to create an NFT validating a particular phone made in South Korea and shipped to Germany. Anyone with basic knowledge of the blockchain ledger could confirm the phone's true owner and the chain of title of every NFT-tagged component, as depicted (again, in a *very* simplified form) in Figure 3:
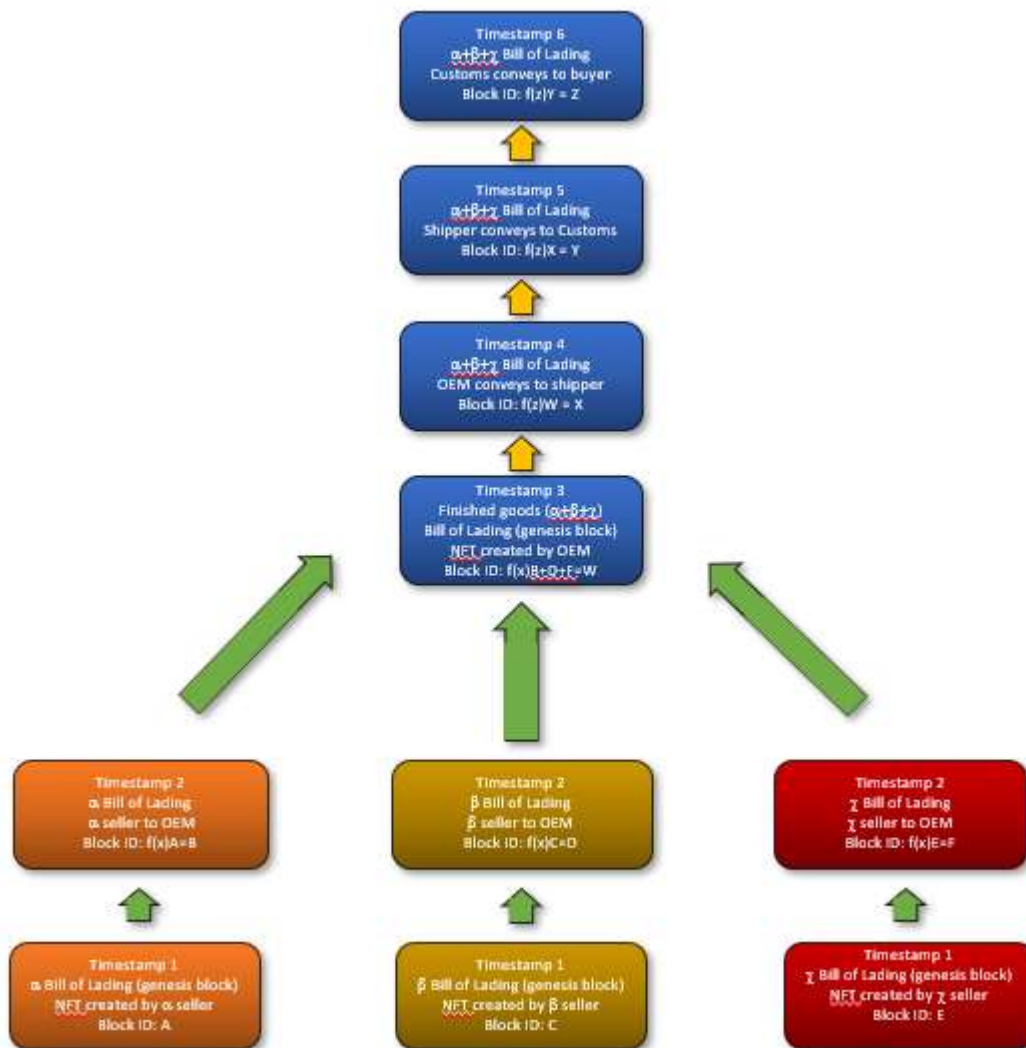
Figure 3: Simplified blockchain schematic for a good comprising three components, each using NFT-enabled bills of lading

In the simplified sequence depicted in Figure 3, three component makers (components α, β, and χ) each create NFT bills of lading at Time 1, using the same cryptographic system (designated as *f(x)*) and ship them to the original equipment manufacturer (OEM) at Time 2. The OEM folds all three NFT bills of lading into a single, combined bill of lading (using the extensible property of NFTs and the same *f(x)* transformation) at Time 3, and then ships the combined product $\alpha + \beta + \chi$, with an intact chain of title for each of the three components, via the same simplified shipping route depicted in Figure 2 to the buyer at Time 6.

Of course, a real bill of lading can go through dozens—even hundreds—of hands, especially when traced back to particular components of a finished good. But in the digital environment, that is no impediment at all. Indeed, the ability to pass secure documents through multiple hands without fraud or mistake is one way that the NFT-enabled blockchained bill of lading is superior to a fungible form of bill of lading on a blockchain. The NFT's extensibility means that NFTs can be combined with other NFTs in ways that can be easily and transparently traced. If the shipper at Time 5 wants to see the bill of lading for component β, it is right there in the blockchain and can be traced forward and backward in time.

5 Conclusion

Despite pandemics and conflicts, international trade has brought the world ever closer together. Business supply chains extend beyond national boundaries and hence businesses (and the societies they serve) are ever more interdependent. But the key document of title and transport that lubricates this system has remained largely unchanged for centuries. The need to replace this obsolete and expensive system for tracking goods across borders has never been more acute. Yet the quest to replace paper bills of lading has been, in the words of one scholar, "never-ending."[103]

Blockchain could finally break that logjam. The distributed, encrypted ledger enhances predictability and traceability, and is much harder to scam than traditional paper ledgers, or even centralised electronic ledgers. And so it is no surprise that multiple players in the shipping industry are already experimenting with blockchain-based electronic documents.[104]

But blockchain alone is not enough. The blockchain is merely a ledger of transactions—it traces but does not necessarily secure the payload, and encrypts blocks without necessarily capturing the uniqueness of what has been transacted. This is where non-fungible tokens come in. When the bill of lading is an NFT, the objections to blockchain-based bills of lading disappear.

Enhancing a blockchain-based bill of lading by use of NFTs is simple, elegant, tamper- and fraud-resistant, and satisfies all of the requirements for a functional bill of lading under the Rotterdam Rules, the UNCITRAL Model Law on Electronic Transferrable Records, and the Uniform Commercial Code. Of course, those are merely model statutes and treaties that have not yet come into effect. Saying that NFT-enabled

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[103] DA Bury, 'Comment: Electronic Bills of Lading: A Never-Ending Story?' [2016] Tulane Mar. L. J. 197.

[104] A Skopec, 'PIN Chagrin: The Glencore Heist and EDI Through the Lens of Delivery Orders [2017] Tulane Mar. L. J. at 242-246 (discussing IBM-Maersk blockchain project partnership and the Port of Rotterdam Blockchain Project); see also Jesse Marks, 'Distributed-ledger Technologies and Corruption: The Killer App?' [2018] Columbia Science & Technology Law Journal 42 at 78 (discussing IBM-Maersk project).

blockchain bills of lading are consistent with these statutes is no guarantee that those statutes will ever come into effect. The more salient point is that, excluding only the requirement of *paper*, an NFT-enabled bill of lading on a blockchain *already* satisfies all of the requirements of *existing* international trade laws, *e.g.*, the Vienna Convention, the Hague-Visby Rules, and the U.S. Carriage of Goods by Sea Act.

There is, in reality, no issue of practical reliability or legal impediment that should block the widespread adoption of NFT-enabled blockchain as an electronic bill of lading. It is only a question of will.