
Blockchain technology and electronic bills of lading

Koji Takahashi

*Professor, Doshisha University Law School, Japan**

Blockchain technology has the potential to herald a long-awaited breakthrough in the digitisation of bills of lading, since it could provide the guarantee of uniqueness, an essential function of bills of lading, without the requirement of membership subscription. A blockchain-based bill of lading would not, however, take off unless it is given sufficient support from the legal infrastructure. Of particular relevance are the Rotterdam Rules and the draft UNCITRAL Model Law on Electronic Transferable Records. It should be possible to interpret the former and finalise the latter in a way compatible with blockchain technology.

I Introduction

A blockchain-based bill of lading is not yet a reality. But its potential merits incubation studies to build supporting legal infrastructure. This article will begin with a brief explanation of what the blockchain is. It will then observe that the blockchain technology is capable of guaranteeing the uniqueness of tokens on a blockchain ledger and will suggest on that reasoning that transferable documents, such as bills of lading, are a most promising use case of the technology. It will also consider the advantages which the blockchain offers for the dematerialisation of bills of lading, noting that it works on an open, decentralised platform unlike the existing models of electronic bills of lading which are invariably based on a closed system with a central registry.

A blockchain-based bill of lading, as with any electronic bill of lading, would not flourish unless there is sufficient support from the applicable legal systems. Accordingly, the remaining part of this article will examine two international works of particular relevance: the Rotterdam Rules (UN Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea) and the draft UNCITRAL Model Law on Electronic Transferable Records. Blockchain technology was born after the adoption of the Rotterdam Rules and it was not widely known when work on the Model Law was started. This article will consider the principle of functional equivalence, which underpins these works, to see whether a blockchain-based bill of lading can be equated with a paper bill of lading.

2 Blockchain

The word 'blockchain' has recently become a new buzzword. Originally, a blockchain was invented to create the Bitcoin crypto-currency in 2009. It is an online ledger which is for append-only use, in the sense that the existing data cannot be deleted or otherwise amended. It consists of a chain of blocks, with each block recording a set of transactions of coins that have been confirmed on a

* Professor at the Doshisha University Law School in Japan. This article is based on the author's presentation at the seminar 'Electronisation of transferable documents or instruments used in international trade' organised jointly by UNCITRAL, the Attorney-General's Chambers of Singapore and the Association of Banks in Singapore on 10 March 2016 in Singapore.

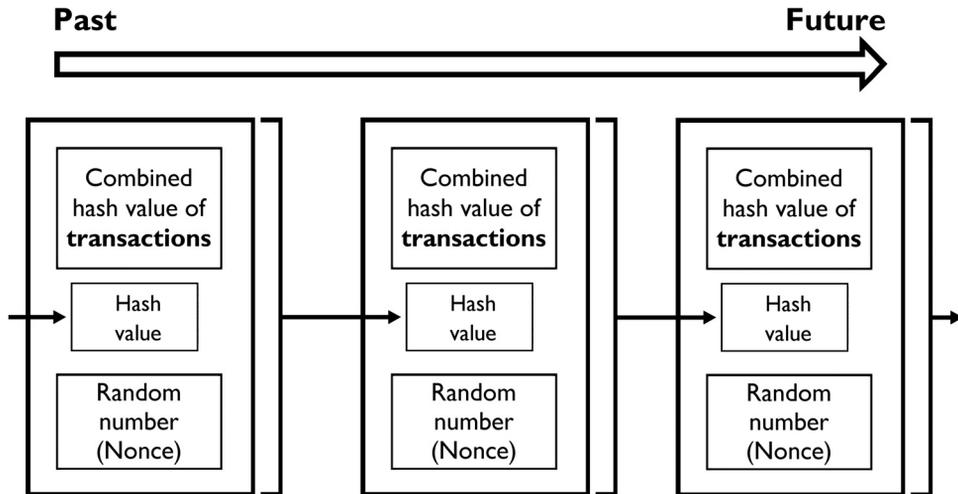


Figure 1

block-by-block basis (see Figure 1, in which the largest rectangular boxes represent blocks). Although this figure only illustrates a chain of blocks, each transaction also forms part of the chain in the sense that the output of one transaction becomes the input of the next transaction.

Each transaction is secured by a digital signature to make it tamper-resistant: the identity of the transferor¹ is authenticated and the immutability of the transaction is ensured.² The digital signature is nothing new. It is a technique that has been used widely prior to the invention of the Bitcoin. The blocks, on the other hand, are formed into a chain by a new technology known as 'the blockchain technology' to avoid double-spending of the same coin.

3 Avoidance of double-spending

To avoid double-spending, it is necessary to decide on the priority of the transactions by which the same coin has been used multiple times. In a closed system based on a central registry (as illustrated on the left in Figure 2, in which the circular cone represents a ledger), that task can be entrusted to the third party who administers the registry.

In an open, decentralised system (as illustrated on the right in Figure 2), it had been thought until recently that it was impossible to synchronise the ledgers held by all the participants since it had

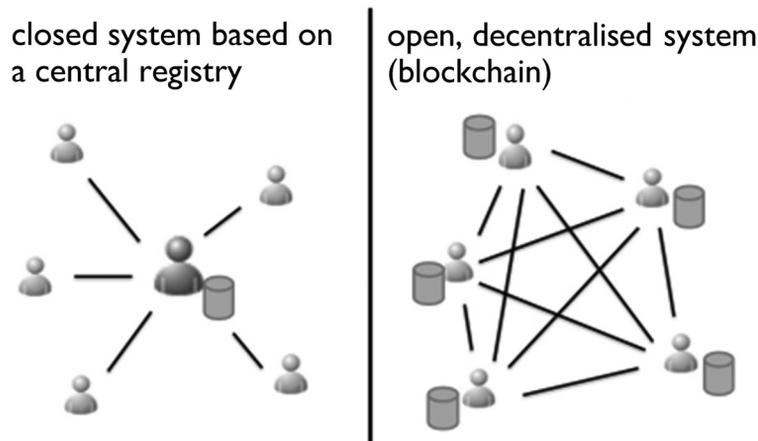


Figure 2

¹ The transferors are pseudonymous on a blockchain ledger; see section 11 below.

² See also n 27 below.

been believed that a consensus could not be reached among unspecified participants on the priority of the transactions. Blockchain technology, an innovation of the Bitcoin, has made that possible by way of confirming a set of transactions on a block-by-block basis, with each block added through solving a computationally difficult puzzle. For the purposes of this article, it is not necessary to understand the details of this mechanism;³ it is sufficient to appreciate that blockchain technology has, for the first time in history, made it possible to reach a consensus on an open, decentralised platform.

Still more recently, there have been initiatives to develop closed blockchain platforms. In common with open blockchain platforms, they create and maintain append-only online ledgers. However, unlike open platforms they are member-only systems, which require would-be members to identify themselves and obtain permission to join the transaction network. Unlike open systems, closed systems allow predetermined persons to do the block validation, building accountability into the system. This makes it easier for financial institutions in particular to operate the system within the existing regulatory framework. The closed blockchain platforms do not, however, offer the advantage of an open system as described in section 6 below. For that reason, this article will focus on open blockchain platforms.

4 Tokens other than coins representing monetary value

Bitcoins are in truth simply unspent transaction outputs. However, it is possible to give them individual identities by stamping additional information (meta data) onto them, using the Bitcoin's in-built scripting capability. Thus, one satoshi (the minimum possible transaction value in Bitcoin) might be, to use a metaphor, 'dyed' (or 'coloured') to represent something other than monetary value. It is also possible to create wholly new blockchains to circulate non-monetary tokens. These possibilities have led to a number of proposals and trials on the application of blockchain technology in the past few years. Thus, for example, tokens indicating proprietary interests (such as ownership and security interests) in tangible or intangible assets (such as stocks, debentures and copyrights) could be issued and transacted on a blockchain.

Another possible use of blockchain technology is to circulate a token that functions like a transferable document, i.e. a document which entitles the rightful holder to claim the performance of the obligation indicated in the document. Thus, a carrier of goods may issue an electronic bill of lading in the form of a token on a blockchain which represents the right to demand the carrier to deliver the goods. The token may then be transferred to the seller and thereafter to the subsequent buyers on the blockchain.

5 Guarantee of uniqueness

A transferable document, by its nature, must be a unique document throughout its life cycle. It is a feature known as the 'guarantee of uniqueness' or 'guarantee of singularity', which is essential to ensure that only the holder of the document can exercise the right to claim the performance of the obligation. This feature is difficult to replicate in an electronic environment because an electronic record can be copied to create an indistinguishable duplicate. Until recently it had been thought that, in an electronic environment, the guarantee of uniqueness was possible only by means of a central registry administered by a trusted entity.

It has, however, been pointed out by an insightful author that: '[a]t least in theory, the same result could also be achieved if computer technology were able to create a "unique" electronic record that could be exclusively held by a holder and transferred to another without replication at some point down the negotiating chain'.⁴ Later in the same article, the author also states that: '[o]ne conceivable model ... might rely on a technical device that would assure the uniqueness of an electronic record

³ For details see the foundation paper of Bitcoin: Satoshi Nakamoto 'Bitcoin: a peer-to-peer electronic cash system' (2008) <https://bitcoin.org/bitcoin.pdf>, in particular the explanation of the concept 'proof of work' at 3.

⁴ José Angelo Estrella Faria 'Uniform law and functional equivalence: diverting paths or stops along the same road? Thoughts on a new international regime for transport documents' (2011) 2 *Elon Law Review* 1.

to allow the record itself to be “passed” down a negotiation chain’. To this sentence, the author attaches a footnote stating that: ‘[s]o far, however, computer technology has not yet been able to create such a “unique” electronic record, which means that electronic negotiability systems continue to rely essentially on electronic registries’.

The blockchain technology that was invented to avoid double-spending can now provide the guarantee of uniqueness.⁵ The author could hardly be blamed for not mentioning it since this article was published in 2011, some years before the blockchain technology came to be widely known outside the circles of information technology specialists.

6 Advantages of blockchain-based bills of lading

The guarantee of uniqueness, an essential feature of transferable documents, makes the latter an attractive use case of blockchain technology. Besides, a blockchain-based bill of lading would have advantages over existing and previous electronic bills of lading.

Bills of lading have been the subject of a number of attempts at digitisation since 1986. They are invariably closed, member-only systems based on a central registry, which is administered by a trusted intermediary. To make transactions on a closed platform, all parties who wish to be involved in these transactions must be registered members. When a non-member is involved, an electronic bill of lading needs to be replaced by a paper bill of lading.⁶ This requirement of membership has been known to be a major obstacle to the use of electronic bills of lading. Thus, according to a survey conducted by the United Nations Conference on Trade and Development (UNCTAD), the lack of readiness of trading partners was among the biggest obstacles (see the table below).

<i>Obstacles to the use of electronic alternative responses (more than one answer possible)</i>	<i>(% of respondents)</i>
Infrastructure/market/trading partners not yet ready	51
Legal framework is not clear enough or is not adequate	44
Electronic equivalents are not sufficiently secure	25
Technology and/or switch to electronic environment is too costly	12
Confidentiality concerns	10
Other reasons	2

Table reproduced from the report of the survey.⁷

Citing this survey, one author observes that: ‘even once membership is obtained, the user may be trading with non-members, which would prevent the user from benefiting from the investment’.⁸ None of the existing platforms for electronic bills of lading seem to have succeeded in reaching a critical mass in their membership, with paper bills of lading still prevalent in world trade.

Unlike the existing systems based on the central registry model, blockchain technology has made the guarantee of uniqueness possible in a decentralised system. Transactions take place peer-to-peer on an open platform where no prior subscription to membership is required. This will be a significant advantage as trading often involves a wide range of persons – both large and small enterprises –

⁵ To be precise, blockchain technology does not create a unique transactional record but avoids the continued circulation of duplicate records by enabling a consensus to be reached on priority among the competing transactions.

⁶ See Rule 10 (Option to receive a paper document) of the CMI Rules for Electronic Bills of Lading (1990).

⁷ UNCTAD ‘The use of transport documents in international trade’ (2003) (UNCTAD/SDTE/TLB/2003/3) para 79. It is interesting to note that the costs of switching to an electronic environment and any accompanying confidentiality concerns were not perceived as major obstacles.

⁸ Miriam Goldby *Electronic Documents in Maritime Trade: Law and Practice* (Oxford University Press 2013) 11.06. See also Miriam Goldby ‘Electronic bills of lading and central registries: what is holding back progress?’ (2008) 17(2) *Information & Communications Technology Law* 125, 132.

derived from a diverse sector of industry such as trading, banking and transport. This openness also ensures worldwide reach of the participants.

Decentralisation comes with further advantages. It eliminates human errors that might otherwise be made by the registry administrator. It renders the system less vulnerable to accidents or hacking attacks since there are no single points of failure. It also reduces concerns about censorship by the registry administrator or governments. Launching a blockchain-based bill of lading would, however, have to contend with some significant challenges. Thus, technical details will have to be worked out and viable business models explored.⁹ There are also legal problems, which will be addressed in the remainder of this article.

7 Need for supporting legal infrastructure

For any electronic bill of lading to be successful, it is essential for it to be given sufficient support from the legal infrastructure. It is no different from acknowledging that a paper-based bill of lading would only be a piece of paper in the absence of empowering legislation.

By way of example, suppose that the parties to a sale contract have agreed on the use of an electronic bill of lading and the seller has concluded a carriage contract under which the carrier has agreed to issue such a bill of lading. Their arrangements will work amongst themselves. If any of them fails to honour their arrangements, normal remedies for breach of contract will be available. However, their agreements have no effect on third parties in the absence of support from the applicable legal systems. Thus, such agreements may not be sufficient to enable the buyer to assert his title against third parties such as a creditor of the seller seizing the goods, the trustee of the seller's bankruptcy estate, or another buyer who has bought the same goods from the same seller.

The past and present projects of electronic bills of lading have been dogged by the lack of sufficient support from the legal infrastructure, resulting in the reluctance of banks to accept electronic bills of lading as adequate collateral.¹⁰ By the same token, a blockchain-based bill of lading would not take off unless it is given sufficient support from the applicable legal systems.

8 Rotterdam Rules and UNCITRAL's Model Law project

One notable initiative for embracing electronic bills of lading is found in the Rotterdam Rules, where these bills are called 'negotiable electronic transport records'. The Rotterdam Rules were adopted in 2008, prior to the birth of the blockchain technology.¹¹ Although not yet in force, if the Rotterdam Rules become part of the legal infrastructure, the question will arise whether a blockchain-based bill of lading constitutes a 'negotiable electronic transport record'. This question will be addressed further below.

Since 2011, UNCITRAL has been working to create the Model Law on Electronic Transferable Records. It is expected that the drafting of the text will be completed towards the end of 2016 with a guide to enactment to follow. As currently drafted, an 'electronic transferable record' is defined as an electronic record which contains all of the information that would make a paper-based transferable document effective, the latter being described as a document that 'entitles the holder to

⁹ While it may be difficult to envisage what profit-making opportunities exist when an open blockchain ledger is used, we can expect that the business acumen of entrepreneurs will spot them. Creating a business model where none hitherto exists is often a key to success in the commercialisation of a new technology. Indeed, at the dawn of the World Wide Web, few would have thought that providing a search engine could generate so much revenue from advertising.

¹⁰ See Faria (n 4) fn 134. It is clearly in the interests of the banking industry to promote paperless trading, as exemplified by its support for BOLERO (Bill of Lading Electronic Registry Organisation) through SWIFT (Society for Worldwide Interbank Financial Telecommunication), as well as its initiative in developing the Bank Payment Obligation (BPO), a new trade finance product. At the level of individual transactions, however, banks cannot feel secure in accepting an electronic bill of lading as adequate collateral unless the applicable law enables them to treat it as such.

¹¹ Michael Sturley, Tomotaka Fujita and G van der Ziel *The Rotterdam Rules: The UN Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea* (Sweet & Maxwell London 2010) para 3.039 states that: 'it appears that the technology needed for a reliable token system is still not available in the market place'.

claim the performance of the obligation indicated in the document'.¹² The main targets are bills of lading and promissory notes.¹³ An important aim of the Model Law is to promote the equal treatment of electronic records with the corresponding transferable documents. It is submitted that the Model Law should be made compatible with blockchain technology so as to facilitate its implementation to replace transferable documents.

9 Two guiding principles

One of the principles guiding UNCITRAL in its work on the Rotterdam Rules and the Model Law is the principle of technology neutrality, which means that the law should neither require nor assume the adoption of a particular technology.¹⁴ It follows that no technology is excluded *a priori*. Thus, blockchain technology has never been excluded, although nowhere in the official documents on the Model Law project was there any reference to it until as recently as November 2015.¹⁵ The principle of technology neutrality does not, however, mean that all aspects of the Model Law are compatible with any technology. Nor does it mean that any technology can create a 'negotiable electronic transport record' within the meaning of the Rotterdam Rules.

Only an electronic record that fulfils the essential functions of a paper document can replace the latter. This is known as the principle of functional equivalence, another guiding principle of UNCITRAL.¹⁶ It is manifested in Article 9 of the Rotterdam Rules, according to which the use of a 'negotiable electronic transport record' is subject to the procedure referred to in the contract of carriage, which must provide for:

- (a) the method for the issuance and the transfer of the record to an intended holder
- (b) an assurance that the record retains its integrity
- (c) the manner in which the holder is able to demonstrate that it is the holder and
- (d) the manner of providing confirmation that delivery to the holder has been effected or that the record has ceased to have any effect or validity.

The requirement mentioned in (d) would be satisfied if the system is configured in a way that causes a blockchain-based bill of lading to be transmitted to the carrier upon the delivery of the goods, in much the same way that a paper bill of lading would be physically surrendered. The requirements mentioned in (a)–(c) will be examined in the discussion below to see whether they, too, are satisfied by a blockchain-based bill of lading.

10 Exclusive control = possession

The possession of transferable documents entails various legal consequences. Thus, under German law, the passage of property in goods requires not only an agreement between the transferor and the transferee but also handing over of the goods or the delivery, with indorsement where necessary, of the bill of lading representing the goods.¹⁷ This was also the position reflected in the wording of the repealed English Bills of Lading Act 1855,¹⁸ although current English law makes the transfer of

¹² Draft Article 2 set out in Secretariat 'Draft Model Law on Electronic Transferable Records: Note by the Secretariat' A/CN.9/WG.IV/WP.137 (2016).

¹³ According to the definition of an 'electronic transferable record' as currently drafted, the Model Law is not applicable to crypto-currencies which, unlike the traditional forms of electronic money, do not entitle the holder to bring a claim against anyone for the performance of any obligation. Nor is it applicable to an electronic record, which only indicates proprietary interests.

¹⁴ Secretariat 'Legal issues relating to the use of electronic transferable records' A/CN.9/WG.IV/WP.115 (2011) para 35.

¹⁵ Secretariat 'Report of Working Group IV (Electronic Commerce) on the work of its fifty-second session (9–13 November 2015)' A/CN.9/863 paras 24, 49. The Model Law project began in 2011.

¹⁶ *ibid* para 30.

¹⁷ Tobias Eckardt *The Bolero Bill of Lading under German and English Law* (Munich Sellier European Law Publishers 2004) 103.

¹⁸ In its recital, the Act stated that: 'by the Custom of Merchants a Bill of Lading of Goods being transferable by Endorsement the Property in the Goods may thereby pass to the Endorsee'. The opening words of s 1 of the Act also stated that: '[e]very Consignee of Goods named in a Bill of Lading, and every Endorsee of a Bill of Lading to whom the Property in the Goods therein mentioned shall pass, upon or by reason of such Consignment or Endorsement'.

property dependent solely upon the intention of the parties.¹⁹ Under other legal systems, the transfer of a bill of lading may perfect the passing of property in goods by conferring on the transferee an *erga omnes* title, a title which can be asserted against all persons.²⁰

The Rotterdam Rules and the draft Model Law treat the exclusive control of an electronic record as functionally equivalent to the possession of a transferable document, on the reasoning that they both fulfil the function of guaranteeing uniqueness. Thus, the definitions of the two concepts ‘issuance’ and ‘transfer’ referred to in Article 9(a) of the Rotterdam Rules are laid down in its Article 1, which provides in the relevant part (emphasis added):

For the purposes of this Convention:

...

21. The ‘issuance’ of a negotiable electronic transport record means the issuance of the record in accordance with procedures that ensure that the record is subject to *exclusive control* from its creation until it ceases to have any effect or validity.
22. The ‘transfer’ of a negotiable electronic transport record means the transfer of *exclusive control* over the record.

In the current draft text of the Model Law,²¹ Article 17(1) provides in the relevant part that (emphasis added):

Where the law requires the *possession* of a transferable document or instrument, that requirement is met with respect to an electronic transferable record if a reliable method is used:

- (a) to establish *exclusive control* of that electronic transferable record by a person; and
- (b) to [identify] [establish] that person as the person in control.

The question which then arises is whether a token on a blockchain is subject to the exclusive control of a person. The answer is yes. A blockchain-based token is under the control of the holder of the private key corresponding to the address where the token is kept (see Figure 3). The control is exclusive since blockchain technology provides the guarantee of uniqueness and, accordingly, no two persons could claim to hold the same token. It follows that the holder of the private key corresponding to the address at which an electronic bill of lading is kept will be deemed to have possession of it.

The UNCITRAL Secretariat notes that: ‘reference to the person in control of the electronic transferable record does not imply that that person is also the rightful person in control of that record as this is for substantive law to determine’.²² Put in the context of blockchain technology, this would mean that the holder of the private key corresponding to the address at which an electronic bill of

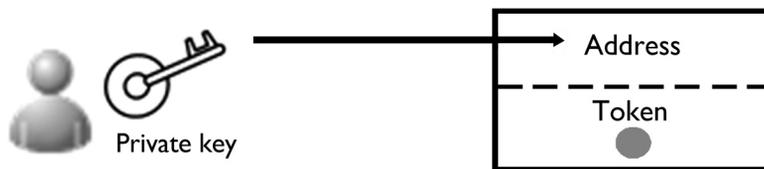


Figure 3

¹⁹ See s 17 of the Sale of Goods Act 1979, which provides in para 1 that: ‘[w]here there is a contract for the sale of specific or ascertained goods the property in them is transferred to the buyer at such time as the parties to the contract intend it to be transferred’.

²⁰ This is the position where the applicable law is, for example, Japanese law by virtue of the combined effect of art 178 of the Civil Code and art 575 of the Commercial Code. The former provides that a transfer of title in movable goods may not be asserted against third parties unless the goods have been delivered to the transferee. The latter provides that the delivery of a bill of lading to its lawful holder has the same legal effect as the delivery of the goods represented by it.

²¹ As set out in Secretariat ‘Draft Model Law on electronic transferable records: note by the Secretariat’ A/CN.9/WG.IV/WP.137/Add.1 (2016). The working group in its latest session decided to retain the word ‘identify’ outside the square bracket: Secretariat, ‘Report of Working Group IV (Electronic Commerce) on the work of its fifty-third session (9–13 May 2016)’ A/CN.9/869 para 108. For the meaning of the word ‘identify’, see the discussion in section 12 below.

²² *ibid* para 21.

lading is kept is not necessarily the rightful person entitled to claim delivery of the goods, since the rightfulness is a substantive question which is to be determined by the applicable law as specified by the choice of law rules of the relevant forum. If, for example, a blockchain-based bill of lading has been transferred by a person who has stolen the private key, a subsequent transferee is not necessarily a rightful person simply because he holds the private key corresponding to the address at which the electronic bill of lading is presently kept.

11 Approaches to establishing the identity of the holder

In an official document published in 2011²³ which marked the start of the Model Law project, the Secretariat envisaged two approaches to establishing the identity of the holder of an electronic transferable record, namely the token model and the registry model. The 2011 document described the former as a model which identifies the person in the record itself, whereas the latter is a model which identifies the person in a separate registry.²⁴ Whilst the registry model actually existed, the token model was imaginary, there being little awareness of blockchain technology, let alone its potential for creating non-monetary tokens at that time. The description of the token model in that document is ill-suited to a blockchain-based token since the latter does not identify the holder in the record (token) itself.

A blockchain ledger displays the addresses at which tokens are kept. The addresses are cryptographic identities of the holders of the tokens. The holders are therefore pseudonymous: they are not displayed by their real-life identities (names). The private keys corresponding to the addresses are secret. Whilst a private key creates the corresponding public key and the public key creates an address, the reverse process cannot be performed (see Figure 4).

12 Functional equivalence to a bearer bill of lading

In a more recent official document for the Model Law project, the Secretariat suggests that the holder of an electronic record may be identified otherwise than by name. It says that: ‘... identification should not be understood as implying an obligation to name the person in control, as the draft Model Law allows for the issuance of electronic transferable records to bearer, which implies anonymity’.²⁵ This understanding of the concept of ‘identification’ is welcome as it will ease the way for accommodating blockchain technology. This understanding should be spelt out in the Model Law or at least in the explanatory note or the guide to enactment for the Model Law. It seems to be consistent also with the Rotterdam Rules, in that Article 9(c) of the Rules requires the contract of carriage to refer to a procedure which must provide for ‘the manner in which the holder [of

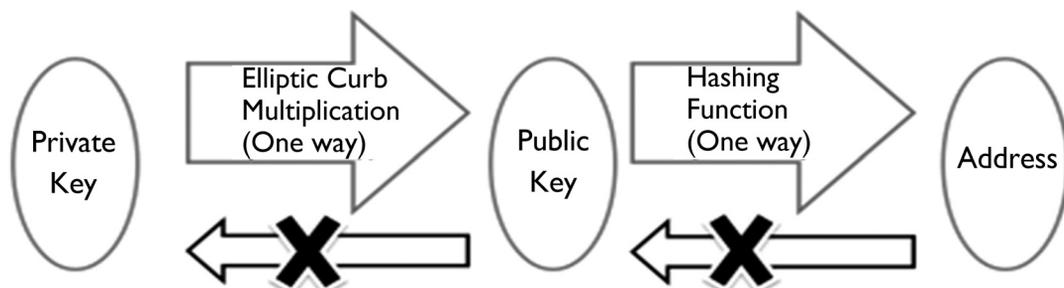


Figure 4

²³ See Secretariat (n 14).

²⁴ *ibid* para 48.

²⁵ Secretariat ‘Draft Model Law on electronic transferable records: note by the Secretariat’ A/CN.9/WG.IV/WP.135/Add.1 (2015)) para 22. This understanding was confirmed in the latest working group session: see Secretariat ‘Report of Working Group IV (Electronic Commerce) on the work of its fifty-third session’ (n 21) para 106.

negotiable electronic transport record] is able to demonstrate that it is the holder'. The method of demonstration is not prescribed and accordingly not limited to identification by name.

Logistically, it seems possible to build a system whereby the holder of a blockchain-based token can obtain the delivery of goods without revealing its name by enabling the token to activate the real-life key to the floating warehouse (or container). The analysis above leads to the conclusion that a blockchain-based bill of lading may be seen as functionally equivalent to a bearer bill of lading.

13 Resistance to tampering

The Rotterdam Rules do not make a distinction between order bills of lading and bearer bills of lading when defining the functions of bills of lading which must be fulfilled by a 'negotiable electronic transport record' (see Article 9 set out above). This approach makes sense since the use of an electronic bill of lading depends on the parties' agreement to use one²⁶ and the parties will not usually specify which particular type of bill of lading they will seek to replace with an electronic record.

For a blockchain-based bill of lading to constitute a 'negotiable electronic transport record' within the meaning of the Rotterdam Rules, it must also be able to provide for 'an assurance that the record retains its integrity' (Article 9(b)). There are two grounds for saying that a blockchain-based bill of lading would be more tamper-resistant than an order bill of lading. First, while the identity of transferors is authenticated with respect to an order bill of lading by the handwritten signatures attached to endorsements, with respect to a blockchain-based token, the identity of transferors, albeit pseudonymous, is authenticated by the digital signatures. The digital signature is more secure than any handwritten signature. Secondly, the digital signature also ensures the immutability of transactions,²⁷ a function which a handwritten signature cannot perform. It may therefore be said that a blockchain-based bill of lading would be able, better than a paper bill of lading, to provide for 'an assurance that the record retains its integrity'. It follows from the foregoing analysis that a blockchain-based bill of lading may, as a species of 'negotiable electronic transport record', be viewed as functionally equivalent to a paper bill of lading under the Rotterdam Rules.

14 Conclusion

A bill of lading, by its nature, must be a unique document throughout its life cycle. Until recently, it had been thought that in an electronic environment, the guarantee of uniqueness was possible only by means of a central registry administered by a trusted entity. Now, the blockchain technology, which was invented to avoid double spending, could provide the guarantee of uniqueness.

A blockchain-based bill of lading would have advantages over the existing models of electronic bills of lading. Thus, an open blockchain platform requires no prior subscription to membership unlike the existing models. This will be a significant advantage since the membership requirement has been known to be a major obstacle to the spread of electronic bills of lading. There are also other advantages which stem from the decentralisation enabled by blockchain technology.

A blockchain-based bill of lading would not take off unless it is sufficiently supported by the applicable legal systems, and we have seen the particular importance of the Rotterdam Rules and the draft UNCITRAL Model Law on Electronic Transferable Records. Under the principle of functional equivalence which underpins both projects, the exclusive control of an electronic record is deemed to be functionally equivalent to the possession of a paper bill of lading. In this regard, a blockchain-based electronic bill of lading would be subject to the exclusive control of the holder of the private key corresponding to the address where the bill of lading is kept. While the holder of a

²⁶ See art 8(a) of the Rotterdam Rules. See also draft Article 13 of the Model Law (which the working group in its latest session decided to merge with draft Article 6: Secretariat 'Report of Working Group IV (Electronic Commerce) on the work of its fifty-third session (9–13 May 2016)' (n 21) para 94).

²⁷ See the text accompanying note 2.

blockchain-based bill of lading is pseudonymous, it should not prevent the holder from being able to demonstrate that he/she is the holder. Being also tamper-resistant, a blockchain-based bill of lading should qualify as a 'negotiable electronic transport record' within the meaning of the Rotterdam Rules. The UNCITRAL Model Law, on the other hand, will be influential in shaping the law of individual countries. Finalising the Model Law in a way compatible with blockchain technology will facilitate the implementation of the technology and encourage its replacement of paper bills of lading and other transferable documents.