# Visibility and digital art: blockchain as an ownership layer on the internet

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**Title**: Visibility and digital art: blockchain as an ownership layer on the internet

**Short Title**: Visibility and digital art

**One sentence Summary**: Visibility of digital art and its ownership can be achieved using blockchain technology as part of a broader solution for identification, attribution and payment for digital work.

- This paper examines how technology can provide greater visibility into ownership rights of digital property on the internet.
- A case study is provided of a firm using the Bitcoin blockchain as part of an integrated solution to identify and authenticate ownership of digital property.
- An integrated ownership ledger allows for secure attribution, transfer, and provenance of digital property.
- Blockchain technology enables limited edition digital property, while Internet-scale web crawl and machine learning shows where and how works are being used on the Internet.

**J.E.L. classification codes**: D83 (Search; Learning; Information and Knowledge; Communication; Belief);M21 (Business economics); Z10 Cultural Economics; Economic Sociology; Economic Anthropology: General; B41 (Economic Methodology)

## Short, single-paragraph biography

**Masha McConaghy** is Founder and CMO at BigchainDB GmbH and ascribe.io. A Professional Curator and Researcher with a PhD in Arts from Paris I University, Panthéon-Sorbonne and Museology Degree from Louvre School, Paris, France. Masha has extensive experience in exhibition organization as an independent curator and as an assistant to curators of the renowned museums in Paris and is an expert in the international art scene.

**Greg McMullen** is Co-Founder and Executive Director of the Interplanetary Database Foundation, as well as Chief Policy Officer at BigchainDB GmbH. Greg is a lawyer who works in the areas of privacy, intellectual property, governance, decentralization, and security. He was formerly a plaintiff-side class actions litigator with one of Canada's top class action law firms.

**Glenn Parry** is Professor of Strategy & Operations Management at Bristol Business School, UWE. Glenn is interested in what 'Good' means for an organisation, where value is measure of goodness, but has many meanings. He works with organisations, both for-profit and charities, to help develop understanding of value through business model development.

**Trent McConaghy** is Founder & CTO of BigchainDB, IPDB, and ascribe.io. Trent received his PhD in EE from KU Leuven, Belgium. He is a serial entrepreneur; his first startup (ADA), explored creative AI, his second startup (Solido) leveraged AI to help accelerate chip design and Solido SW is used for most modern chip designs. He then co-founded ascribe to help compensate creators in the digital era (via IP on the blockchain). That work evolved into IPDB, BigchainDB, and Coala IP.

**David Holtzman** is a former security analyst and military code-breaker, a futurist, activist, security expert, technologist, technology executive, and writer. During the Dot Com Boom of the late 1990s, Holtzman ran the domain name system. As Chief Technology Officer of Network Solutions and the manager of the Internet's master root server, Holtzman oversaw the growth of the commercial Internet from five hundred thousand to over twenty million domain names. An experienced businessman and entrepreneur, David is currently president of Globalpov, a business-services company analyzing critical ways technology and society interact.

# Visibility and digital art: blockchain as an ownership layer on the internet

Numerous debates in legal, business and political domains have arisen over copyright protection on the internet (Parry et al., 2014). Illegal copying is a significant issue, but in this work we begin with the premise that many people would pay for their use of digital property if a simple process was available. When a digital file is available on the internet, metadata is usually absent regarding who owns the content, if it is possible to use the work, any limitations and a mechanism for payment due. In parallel the creators and rights holders cannot see how, where, and how much their work is being used. There is a need to establish clear ownership of digital content and use rights, and facilitate payment processes where required.

This paper examines how blockchain technology has used as part of a broader solution for identification, attribution and payment for digital work. The study presented in this paper focusses upon digital art as digital artists face challenges when their work appears on the internet as their work may be shared widely, but often they receive no payment and their work is frequently not properly attributed. A single case study has been created through a process of co-operative writing with members of a company, BigchainDB GmbH (https://bigchaindb.com/). BigchainDB has developed a solution called ascribe which uses a distributed ledger as a register of ownership and record providing provenance of work as part of a broader solution that includes identification of work in use on the internet.

The paper proceeds as follows. First, an overview is given of theory relating to visibility and how distributed ledger technology may be used to facilitated visibility, particularly of ownership and copyright. Second, an examination of intellectual property is presented. Third, an examination of the context of the research, the art market and digital art in particular. The research methodology is then followed with the case example which describes the ascribe solution. The work ends with discussion, conclusions and future work.

## The need for better Visibility

Innovations in information technology play a key role in changing how providers and customers interact and how providers gain competitive advantage in markets (Gattorna, 1998). Flows of goods in commercial supply chains are reliant on flows of information. Historically, forward flows of information give details of the product or service being exchanged and reverse flows are used to track asset transfers and synchronise production and demand (Alshawi, 2001).

As the key driver of decision making, data is critical to the survival of supply chains (Attaran, 2007). The linking of useful information to assets and the flowing of that information to those who need it within a network gives individuals and organisations *visibility*. Building on the classifications for visibility from the literature (Caridi et al., 2010; Caridi et al., 2013; Klueber and O'Keefe 2013) three definitions are given (Parry et al., 2016): (1) visibility relates to access and use of information in supply chains and focuses on information sharing; (2) visibility relates to the properties of the information exchanged which is determined by the extent to which information is accurate, trusted, timely, useful and usable; (3) visibility is the availability and capability of information to inform and initiate action.

Taking the latter definition we can see that information availability helps both initiate and inform action, thus impacting upon an individual's decision making process. In the current digital domain, there is limited data and often information asymmetry occurs where one party has information and another does not. The internet, and especially the world wide web, have been built with uni-directional links. As opposed to a continued dialogue, data flows in one direction at a time and the flow can end whenever a party disengages; in the case of an image file on the web, information flows from the end user who requests content to the server it ishosted on, and from the server to the end user who downloads it. The consumer may not have complete information about the rights pertaining to a work, and once the creator has put the work online they do not have complete information about who is using their work, where, when and how.

In a contractual situation, if both parties do not have the same data then information asymmetry can be problematic. There is a great deal of literature relating to the issue of buyer-supplier information asymmetry and how asymmetry often results in deception

due to a conflict of interests (Clots-Figueras et al., 2015). Google allows users to search and view any image, and does not block the ability to copy that image. The conflict of interest between buyer and supplier seen in the case of digital music can readily lead to copyright infringement. An individual who wants to listen to a music track can choose to pay for it as a download, stream it from an authorized source like Spotify, or access it free by downloading it illegally. The conflict of interest is in paying for content as the user gives away metadata about themselves to the provider, whereas in engaging in illegal activity not only does the user gain content for free, they also are usually anonymous. Websites such as YouTube, SoundCloud allow users to upload music for others to share and in certain circumstances, the site pays a royalty to the creators. There is a lack of transparency as to the contractual processes of a website. Consumers may not be aware that an action is legal or illegal due to unfamiliarity with digital distribution formats and a lack of visibility over who owns the work and how it may be used which could better inform or influence their actions (Parry et al., 2012). The creator of a work also lacks visibility of the use of their materials unless they are contacted by a site with regards potential royalty payment, or spend time searching to see if their materials are being used.

It is with regards the provision of visibility to creators and consumers of content that the Bitcoin blockchain provides a part of a potential solution. The Bitcoin blockchain is the distributed ledger technology underpinning the eponymous cryptocurrency, Bitcoin (Nakamoto, 2008). The Bitcoin blockchain consists of a cryptographically secure ledger of all transactions made using the currency. Bitcoin as a currency may not succeed in the longer term, but the authors of this paper share the belief that it is the blockchain technology behind the Bitcoin currency that will have the greater impact on the world (Kiviat, 2016).

Blockchain technology provides a decentralized network in which the participants in the network, known as “nodes”, record transactions on a public ledger. As a set of transactions accumulates, those transactions are written to the list together as a “block”, which is added to the previous block of transactions, forming a chain. To create a block, participants in the network must perform a complicated mathematical “puzzle” requiring massive computing power, and the solution is included in the block. While

difficult to solve, it is easy to verify the solution, allowing anyone to confirm that the block is valid. Users are encouraged to devote computing power to the task of securing the network by the network offering Bitcoin currency as a reward for solving the puzzle, a process known as “mining”. The more computing power is dedicated to the problem, the harder the problem gets, so blocks are created on a fixed schedule (Kraft, 2016). Approximately six blocks are created each hour. Every block has its own unique cryptographically generated code—a hash—which is added to the next block of transactions, effectively locking the blocks together in a linear time sequence and ensuring individual transaction records are not duplicated. The hashes can demonstrate cryptography that the transactions are valid and that no blocks have been changed.

Blockchain technology solves a networking problem where individuals wish to undertaken value exchanges over a computer network that can be monitored, verified, and enforced, all without the need for a centralised governance institution. The blockchain forms a distributed ledger of transactions that is duplicated across many computers and can be read and verified by anyone, creating visibility of transactions.

While the Bitcoin currency was the first application of blockchain technology, there are many other areas where the technology can be applied. It is possible to add data other than Bitcoin transactions to the blockchain, such as information about valuable asset transfers, to provide a ‘trust-less’ record of those transactions (Swanson, 2014).

## Intellectual Property and the Law

Creative works such as art, literature, music, and film are protected by copyright law. This is true for digital works as well as traditional works, but the effectiveness of these laws in the digital world has been limited.

The World Intellectual Property Office (WIPO) is a body of the United Nations tasked with overseeing international copyright treaties and creating guidelines for intellectual property. The WIPO guidelines serve as a baseline, and each country decides how to implement the guidelines in their domestic law. Implementations can vary significantly from country to country, but are rarely consumer-centric. Examples of the legislation introduced to protect intellectual property rights in the digital domain include the UK

Digital Economy Act (DEA, 2010), France's Haute Autorité pour la Diffusion des Œuvres et la Protection des droits d'auteur sur Internet (HADOPI), introduced in 2009, and the USA's Digital Millennium Copyright Act (DMCA) of 1998.

There is debate about the nature of intellectual property law and how principles that are used to govern ownership and protection of tangible physical property could or should also apply to the intangible digital space (Menell, 2011). In the UK, Cammaerts et al., (2013) argue that the UK DEA risks "stifling innovation as individuals cannot edit content to create something new". The arguments are countered by Parry et al. (2014), who questioned why rights to dispose of the property of an artist should be different for artists in the physical realm than those working in digital media. HADOPI faced significant opposition from groups who felt it infringed upon their rights through heavy-handed measures like suspension of internet service to alleged repeat infringers (Giblin, 2014), and the legislation was subsequently tempered, though the work of Danaher et al. (2013) who empirically demonstrated that the implementation of the law reduced online copyright infringement and increased revenues by up to 25% for music sold on the iTunes platform. The US DMCA is also more restrictive than the WIPO guidelines require, which stifles and damages innovation and limits consumer choice (Stout, 2015). Despite these criticisms, it would appear the laws in place to protect digital art are already very strong which suggests new legal restrictions are not required.

Whilst some individuals may believe that "property is theft" (Proudhon, 1840) and 'piracy' is their right (Bustinza et al, 2016), for others the situation surrounding the copying and use of digital property is less clear. The act of taking digital property can be considered from many different perspectives: moral, ethical, legal, and economic (Al-Rafee, Cronan, 2006; Yoon, 2011; Houle, 1991; Ku, 2002). The key question is why those who would reject 'theft' in the physical domain do not bring this framework to their understanding of copyright infringement in the digital domain (Coyle et al., 2009, p. 12). Rightsholders want to call copyright infringement "theft" but it isn't theft in law – it's infringement of an artificial monopoly on copying. The belief in the existence of copyright infringement may not cross the boundary from the socio-cultural epistemic domain represented by the wider (physical) world to the epistemic domain governing an individual's beliefs and hence action in the digital domain (Davis et al.,

2015). An epistemic belief is based upon knowledge and understanding, which can only be formed in domains where the individual has visibility. In the physical store the products are clearly in the ownership of the store holder and the method and processes of transactions to purchase and transfer ownership are well understood as part of general beliefs in the socio-cultural context: taking a physical good from the store holder is clearly and immediately to their detriment. By contrast, the ease of digital copying and the fact that the rightsholder does not have less after the copy is made creates a different context in the digital realm. There is a complex argument regarding copyright infringement and business models, though the current online behaviour would suggest change is needed to protect property rights whilst allowing creative use of content by communities (Parry et al., 2014; Doctrow, 2014).

In the digital domain the visibility of who owns what and who is using what is obscure. We find a situation where limited visibility and poor understanding of the law in a relatively new domain where cultural norms have yet to be established. The internet makes it easy to copy and distribute digital work, making copyright law ineffective in practice. Visibility of ownership, use, and clear, simple processes to transfer ownership are required to enable consumers to pay for digital assets. A failure to provide such process technologies will mean consumers in the digital domain will continue to act in abeyance, incongruous with their behaviour in other domains (Davis et al., 2015).

## The challenge of digital Art

The global art market is $64B (TEFAF, 2015), which is comparable to video games ($91.4B) (Newzoo, 2015), film, or online advertising. The market for art is moving online, however, as buyers are increasingly familiar with online shopping and are comfortable making payments online. The 2014 online art market was $1.57B and is expected to be $3.7B by 2018 (Hiscox, 2014). However, much of the online art trade relates to the exchange of physical pieces of work and not art that is digital in origin. According to Hiscox (2014) the digital art market is in its infancy and is estimated to make up just 11% ($173M) of the online art market and 50% of purchases are less than £100. The market seems small when compared to the well-established market for photography, which makes up 46% ($720M) of the online art market. The digital art

market remains relatively small for a number of reasons; norms and standards for collecting digital art have not yet been established, meaning people are not sure what it means to own a digital work and attribution, authenticity and provenance have yet to be resolved satisfactorily.

Collecting physical art seems straightforward: an artist makes a work and consigns it to a gallery or dealer; the work is put up for sale; a collector sees the work in the gallery or is contacted by the dealer, likes the work, pays for it and takes it away; an agreed amount of money is retained by the dealer or gallery owner and the balance is paid to the artist; the collector is said to 'own' the purchased work.

In the art world, "provenance" is a work's history—its biographic details, proof of authenticity, and attribution. Ideally, there will be a complete dataset from the moment of creation through to the present, including each transfer of ownership and information on the work's location, dates, and reasons or means of transference (i.e. inheritance, private sale or auction) (IFAR, 2016). Provenance is important for proving the authenticity of an art work as it establishes a chain of ownership and drives the value of a work. One example is the *Mona Lisa*, possibly the most famous picture in the world. It has a detailed provenance[1], even though it is over 500 years old. There are few questions pertaining to its ownership or history. The Mona Lisa was assessed at $100 million USD on December 14, 1962. Taking inflation into account, the 1962 value would be around $782 million USD in 2016, making it the most expensive painting in the world. While it is impossible to speculate as to its value if it did not have such a clear provenance, it would certainly not be as valuable without detail of its colourful history.

[1] The provenance dates back to manuscript reports during the initial creation of the work in 1503-04, its purchase by King Francois I from Leonardo da Vinci when the artist moved to France and was in the Royal Court. Following the French Revolution of 1789-1799, ownership transferred to the French State and the painting was relocated with the Royal Art Collection to the Louvre museum in 1797. After the French Revolution, it was moved to the Louvre, but spent a brief period in the bedroom of Napoleon in the Tuileries Palace. During the Franco-Prussian War (1870–71) it was moved from the Louvre to the Brest Arsenal. During World War II, the painting was again removed from the Louvre and taken safely, first to Château d'Amboise, then to the Loc-Dieu Abbey and Château de Chambord, then finally to the Ingres Museum in Montauban.

Many art works have poor provenance, which negatively affects their value (Danchev, 2006). To assist in proving the authenticity of works by famous artists, a *catalogue raisonné* may be created, which is a ledger that providing descriptive detail of all the works they have produced. The market for physical art is well established and beliefs and actions therefore conform to larger socio-cultural and domain specific contexts (Muis et al., 2006; Davis et al., 2015). However, despite processes to capture provenance in the physical art world, experts from the Fine Arts Expert Institute (FAEI) of Geneva suggest that more than 50% of works circulating on the market are not authentic (Larson, 2014). It is even easier to commit fraud or misattribute art when the work is digital.

Digital art is a new domain. Existing norms do not apply and new behaviours are not yet established or shared within the wider socio-cultural context. Behaviour in this digital world is incongruent with behaviour in the physical world. There is no physical artefact, so what is being exchanged is digital information. Free and easy sharing of digital work in its many forms has been normalised on social networks. Over 1 billion users access YouTube every day (YouTube, 2016), and in 2014 over 1.9 billion images were reported to be shared online daily (Meeker, 2014). Copyright infringement has also been normalized. Research in the music industry has shown that at least 28% of the population participate in illegal file sharing (Bustinza et al., 2013). Whether it is obtained legally or illegally, much of this content will be consumed on the screens of laptops or smartphones, never taking physical form.

There are additional challenges with regards establishing the provenance of digital art: How does a collector collect digital art in a way that allows resale? How does one establish provenance of a digital file, if a perfect copy of the file can be made at will? The problem of digital art ownership has been called “the elephant in the room” of the art world (Osberg, 2013).

Reproduction of work is common in the art world, and has a rich history in areas such as traditional wood block printing, sculpture, engravings and ‘wet’ film photography. In these media, artworks are often reproduced in limited editions by the artist themselves to generate revenue. In these cases, an original or source work was retained by the artist, and copies sold to collectors. Industrial-era bronze statues had moulds from which

multiple bronze “prints” were made. For example, there are many copies of Rodin’s “The Thinker”, and Rodin himself produced different versions, making moulds and casting in bronze and plaster and from which over 20 ‘copies’ have been made (De Roos et al., 2004). In photography, the negative was a source from which unlimited copies of a work could be made, but the negative and intellectual property (IP) rights remained with the photographer. The photographer chooses a fixed number of editions in advance and could destroy the negative in order to create scarcity.

The nature of digital works changes this relationship with an original source. Unlike with prints, sculpture, or photographs, anyone with a copy of a digital artwork can make many perfect copies indistinguishable from the original, and then share those copies globally at close to zero effort or expense. To counter this ease of reproduction, digital artists have tried to introduce physicality to their work in an effort to engender to the norms of the physical art market. Examples of this adoption of physicality have included: (1) Saving the work in physical format and trading that as the object, whilst encouraging the owner not to digitally copy and share it. This is a variation on the model that had been used for physical music or home movie sales (e.g. vinyl, CD, DVD, or tape). In the context of digital art, the object may be any of those, or USB stick or DVDs. Further physical artefacts or bonuses may be included, such as signing the physical format or creating an ad-hoc Certificate of Authenticity; (2) Embedding the work into an object which then becomes part of the work. For example, a television linked to a VCR or DVD player with the tape or disc literally glued inside, or a number of televisions placed one on top of the other; and (3) Making the digital idea into a physical object or representation by some means, such as printing an image, 3D printing a sculpture, and so on. Though these methods have been tried, none of are wholly satisfactory precisely because the physicality aspect is being artificially created for art that is naturally digital, unless the choice of embedding the file into a physical object is part of the artistic concept.

Domain names have emerged as a partial solution to owning digital art. If a domain and website make up a work of art, then a contract with the artist can state that the owner of the domain is the owner of the art. It’s a simple idea but a powerful concept made possible because domain names have scarcity. Only one entity can own a domain name.

The technology enabling the scarcity is the Domain Name System (DNS), which at its core is a ledger recording a list of connections between a domain name (e.g. amazon.com) and a network address (e.g. 54.239.26.128). People trust the DNS not just because of its widespread use, but because the body in charge of it, the Internet Corporation for Assigned Names and Numbers, is independent of government or corporate control (Kalinauskas and Barčys, 2013; Escudero, 2012). The result is that internet domains offer scarcity in the digital world because they are catalogued in a public ledger that is trusted by users. The system is "trust minimizing" as contractual parties do not need to know or trust each other significantly.

Websites for art are not a complete solution, however, as many digital artefacts are not naturally websites—they are images, videos, or other code executing on a platform. To force such media into a website format is as contrived as creating a physical object. The website approach also introduces new fees and requirements, as the owner is forced to pay annual domain name registration fees. If the fee is not paid, the domain and associated art may get removed or deleted. The possibility of expiration reveals another problem: the DNS record itself is relatively safe but there is no direct link between the domain and the art except that the art appears on the domain. Furthermore, websites were never intended to support editions: there can be only one 'collector' per website domain—the registered owner of that domain—so a website would need to be duplicated with different domain names given to each collector to represent their own edition. Finally, it is not obvious where to store metadata such as the provenance of the work, although third party historical domain name information provides a partial solution to this problem.

Despite rapid innovation, art is still significantly bound to the physical, as it is in the physical format that established processes exist for the creator to sell and ensure that property rights are not violated. Innovation is needed to change behaviour and support artists working in digital art. We need to be able to 'see' who owns what and who is using it.

## Method

The purpose of the research was to examine the use of blockchains outside of cryptocurrency, in the realm of intellectual property. The approach was from the perspective of a critical realist, reflecting the complexity of the research subject that links the empirical world of computer code and software that are mechanisms creating phenomena, and the individuals who view the world through their own framework (Bhaskar, 2008). There are unobservable events which influence what can be observed, and understanding of socio-cultural actions can only be achieved by seeking understanding of the structures that drive events.

A case study approach has been adopted as blockchain technology is a contemporary phenomenon and boundaries between the phenomenon and its context are not clear (Yin, 2003). In this paper case study is useful for examining "why?" and "how?" phenomena occur in complicated contexts (Stuart et al., 2002). The single case example selected allows researchers to understand phenomena in depth and provides information to support explanation and theory building (Eisenhardt 1989; Dyer and Wilkins, 1991).

The choice of case as a unit of analysis was BigchainDB GmbH (bigchaindb.com), who with their ascribe service (ascribe.io) use the Bitcoin blockchain to create a transparent ledger of transactions. ascribe provides a web-based solution that facilitates attribution, ownership, provenance, and trade in the digital art market. While the product can be applied to many kinds of digital goods, ascribe was developed to meet the specific needs of the digital art market, and that market is the focus of the work here.

The work was undertaken through a process of co-operative writing, with academic researchers and BigchainDB personnel, including founders, programmers, and managers, acting as co-researchers in the production of the case study materials. In creating this paper the joint researchers reflected ideas and concepts back and forth to ensure that practical and experiential knowledge were correctly captured and contextualised within the extant literature.

## The ascribe case study

The ascribe service has been open to the public since April 2014, and as of  used by 4,500+ users who have registered nearly 38,000 editions of digital property in the form of images, videos, 3D designs, screensavers, software, and other medium.

ascribe approaches the challenges of the digital art market by conceptualising a two factor problem captured by the phrase: “Where’s my stuff?” The first factor in this problem is the issue of “my stuff”, which identifies ownership claims and requires a system for registry of ownership along with a means of transfer of ownership or the ability to grant usage rights. The second factor is visibility, which asks “where?” on the internet an artist’s work is in use, how, and by who.

To address the “my stuff” part of the equation, ascribe allows users to record claims about rights to a work on the Bitcoin blockchain (Nakamoto, 2008). The Bitcoin blockchain can be treated as a database in which anyone can add information by performing a transaction, but no one can delete information once it has been added, and no one owns the information it contains or the protocol it runs on. The Bitcoin protocol was designed to provide a means of transferring value and enabling payment, but in this application the payment aspect is not important. Instead, ascribe uses the Bitcoin blockchain to store information about works and ownership transactions.

There are other protocols that are designed to transfer non-financial assets represented by “tokens” on a blockchain, such as OpenAssets (Theron, 2013) and Counterparty (www.counterparty.io). However, these protocols do not support ascribe’s needs for ownership processing in two key areas: the feature set and the legal requirements. The feature set is different as art needs to distinguish between unique editions, such as edition 1/10 of a photograph from edition 2/10. Other protocols consider these simply as quantities or units of value but without unique identities. Protocols for art also need to support a number of different ownership actions beyond a simple yes or no for ownership, such as consigning, un-consigning, loaning, renting, and more. The other protocols do not support those needs.

The ascribe Terms of Service (TOS) seek to make the legal processes simple for both creators and consumers. It incorporates actions such as claiming rights by a creator

registering a work, creating editions, transferring editions, or consigning a work for sale by a third party. ascribe has worked with its users and lawyers in several countries to ensure that its basic terms meet the needs of most users, while customers with special use cases can use custom contracts. Users can also choose to register a work under a Creative Commons license, as part of an ongoing experiment with Creative Commons France. Similarly, ascribe's legal solution enables electronic transfer of digital property between individuals, allowing digital property flows across the internet and potentially into the long tail, though it is noted that ascribe does not deal in the transfer of funds (Anderson, 2005)

Existing blockchain protocols were not sufficient to meet the identified needs. ascribe developed a new protocol called Secure Public Online Ownership Ledger, or SPOOL, which it has made available to the public under a Creative Commons license (https://github.com/ascribe/spool). SPOOL is built with intellectual property on the Bitcoin blockchain in mind, and allows secure registration with a timestamp. This is a modern version of the "poor man's copyright", the practice of artists mailing their own work to themselves and keeping it in a sealed envelope in case of a dispute over authorship, allowing the artist to demonstrate they had the work at the time of the date stamp. SPOOL also allows information about transfers or consignments to be recorded to the blockchain, creating provenance on the blockchain.

Because ascribe uses the blockchain to record ownership and transfers, rights holders and collectors do not have to rely on ascribe to maintain ownership records for them. The blockchain is stored on the thousands of computers making up the Bitcoin blockchain, meaning that each of those computers has a record of every transaction written to SPOOL. Even if ascribe ceased operations, the transactions recorded by its users would still be recorded on the Bitcoin blockchain.

The two main ownership transactions are registering a piece of work, and ownership of an edition. Figure 1 illustrates both. The transactions have special choices for inputs and outputs. On the left figure 1 shows a *registration* transaction, when the work has three editions (1/3, 2/3, 3/3). The input address is a public ascribe address, in the role akin to a certificate authority. There are six outputs. The first output is a hash of information defining the work: the file containing the work, the artist name, the title, and the year.

The second, third, and fourth outputs are the addresses "owning" edition 1/3, 2/3, and 3/3 respectively. By definition of the TOS, whoever has the private key to one of those addresses is the owner of that work. The fifth output is the verb of the transaction; ascribe use the bitcoin OP_RETURN to embed the word "register". The final output is change. It is a quirk of the Bitcoin blockchain protocol: you have to send all your money from the ascribe address and then get most of it back. Change is therefore the refund for the amount unspent in the transaction, so if the amount to be transferred is 0.1 BTC and you paid 1 BTC, the change would be 0.99 BTC.

In the event of a legal dispute involving work registered on ascribe, it is hoped the blockchain registration would provide evidence as to authorship or ownership of a work. While blockchain evidence is in its early days, blockchain evidence was admitted in the Ross Ulbricht "Silk Road" criminal trial (Brandom, 2016).

SPOOL alone does not create a contract for a sale or assignment of copyright. It must be used with a contract the participants have agreed to. On ascribe, the default contract is defined in the TOS and participants agree to use it in their transfers[2]. The SPOOL protocol helps support an internet-based marketplace flows across borders, but it draws its power from its combination with national copyright laws.

##### INSERT FIGURE 1 AROUND HERE ########

Figure 1 shows an *ownership transfer* transaction; for example transferring ownership of edition 2/3 of a work. The first time any bitcoin leaves the existing owner's wallet, and then ownership is transferred to the output wallet. This also includes an OP_RETURN to embed the verb "transfer". The final output is change.

[2] A separate Ricardian Contract approach was considered (Grigg, 2004), but implementation postponed. A Ricardian contract is readable by both computers and humans, is legally binding and could be part of a protocol, such that the contract is embedded with every transaction. The potential benefit is that it allows for a decentralized store of the contract itself. However, a fully decentralized approach can reduce usability and adds complexity. In addition, once the contract is released it cannot be changed easily, although there are ways to update the contract while maintaining decentralization which will be reviewed for future implementation.

##### INSERT FIGURE 2 AROUND HERE ########

In the digital art world, as with physical art, values of works are linked to provenance. If there are gaps in the ownership history of an art work then the value of the work is diminished. Before ascribe, there was no way to automate provenance of a digital edition of a piece of art. SPOOL enables automated provenance, as Figure 2 illustrates. Knowing any of the owning addresses allows a party to use a blockchain explorer to identify all the other addresses that have owned the address, all the way back to the original registration by the creator. In this way SPOOL enables automated digital provenance.

SPOOL makes it possible for each unique edition to have its own identifying address, which can be thought of as a serial number, as illustrated in Figure 3. On the left, we see that SPOOL defines the ID of a piece as simply the bitcoin address associated with the piece at registration; when the ownership of the piece changes, the piece ID remains the same. Figure 3 right emphasizes how a work's hash and an edition are bound; they are both defined in the same Bitcoin transaction (registration), and the protocol makes their relationship clear.

##### INSERT FIGURE 3 AROUND HERE ########

SPOOL facilitates searching as one can take a work's hash and find it on the blockchain, and from that find all the addresses that own each edition. Or, by starting with any piece ID it is possible to find the whole ownership history, which provides perfect provenance of a work. Starting with any owning addresses of any edition it is

possible to see the whole history of each edition[3]. The transactions are public, but they are also pseudonymous. Without additional information, the owners' identities are private by default on the blockchain. The ascribe web app and API are also private by default, and are not browsable. However, if the user wishes to make their identity or their collection public, they can share the Bitcoin address they own or an internet address pointing to the edition details on ascribe.io.

To address the question of "where's my work?", ascribe conducts an automated web crawl, indexing visible content on the internet and incorporating public web crawl records called Common Crawl (commoncrawl.org), totalling 220 terabytes of text. Through a website called WhereOnThe.Net (https://whereonthe.net), users provide an image and ascribe will search for occurrences of that image in the crawl. The results display how many copies of the subject image can be found, the websites it can be found on, and when the image first appeared there. The search is based on BigchainDB's artificial intelligence "image match" software (https://github.com/ascribe/image-match), which finds not only exact copies of the image but also similar images, so if for example the image were modified, it would still be found by the crawl. For now, ascribe's search is limited to images, but will extend to other data formats in the future, including 3d models and video.

ascribe only displays WhereOnThe.Net search results when specifically requested. However, it would be possible to use the data from the web crawl and similarity search to automatically create bi-directional links between creator and consumer through the content, without the complexity of changing existing web protocols and without involving third parties, only the second party signatories to the ascribe service.

There are several use cases that emerge specifically for ownership, all which address the visibility question. The data resulting from similarity search allows for tracking use of a work, giving information to rightsholders such that they know who is using an artist's work and where. The rightsholder can then make a decision on what to do. Options for the rights holder include ignoring the use, asking for licensing fees or an honorarium for

[3] Ascribe considered putting the hash inside the OP_RETURNs in order to facilitate blockchain maintenance. However, this would have prevented the ability to search based on a piece's hash, and searchability was the priority.

use, or issuing a takedown request. The information could provide data for a screening process that can be employed when someone tries to register ownership of work. If the goal is broad distribution or attention, the data can be used as an indicator of influence or the potential value of a work. An artist trying to sell work may be able to charge more if they can show evidence that their work is popular and has been viewed or shared often. However, this could be a double-edged sword as collectors accustomed to measuring value in terms of scarcity may be reluctant to pay for a work if it is known to have been widely circulated.

## Summary and conclusion

In this paper we have described how digital art has so far failed to achieve its potential, in part because of uncertainties in the culture around digital art and how it should be collected. Digital images are frequently shared via the internet which creates uncertainty for creators and collectors alike. Visibility is the availability and capability of information to inform and initiate action (Caridi et al., 2010; Caridi et al., 2013; Klueber and O'Keefe 2013; Parry et al., 2016). The challenge is to provide information and process sufficient to identify an image, establish ownership and usage rights, and provide information to the consumer and the rights holder.

A solution to the challenge of creating visibility of who owns a piece of digital artwork and how the legal transfer of ownership or usage rights may be undertaken has been offered by the case firm BigchainDB. The ascribe solution starts with registration of a work, which records a cryptographic hash of the work to the Bitcoin blockchain. Once a work is registered, a creator can create a certain number of "editions" of a work, each of which can be dealt with individually. Works can be transferred, consigned, or shared, and any transfers of the work are recorded to the Bitcoin blockchain, providing perfect provenance of works transferred through the service. Editions are transferred according to a simple default contract the parties must agree to, or by customized contracts set by the users. Finally, web crawl and "machine learning" artificial intelligence technology finds similar images online, even if the image has been slightly modified from the original. BigchainDB developed a service called WhereOnThe.Net

(https://www.whereonthe.net) to allow users to search the internet for a particular image.

The case example gives details of how digital art may be afforded increased visibility through both use and digital provenance through a public distributed ledger, which may be critical for the sustainability of this market (Attaran, 2007). Visibility is in the form of data and processes which allow the ownership of digital artwork to be made clear to consumers and the use of their work made visible to the artist. The underpinning register of ownership and any IP transfer is recorded to a blockchain, thus the distributed ledger creates global visibility of this record of ownership. The online image search provides information that can initiate action; allowing the owner to prompt the user to acknowledge, pay or desist from using work. Legal precedent has been set for the use of the Bitcoin blockchain as evidence (Brandom, 2016) that provides a foundation that action is enforceable by law. In providing visibility of use to an artist the artist can contact the user for the required acknowledgement or payment, which also provides an opportunity to build personal relationship. Widespread adoption of this or similar solutions that provide visibility of use, ownership, methods for transfer, provenance and simple ways to pay for digital assets could challenge consumer behaviours and establish epistemic belief that digital art should be paid for (Davis et al., 2015). We assume the best in people; individuals will pay for content they use if they are provided with visibility of a real person behind a piece of work.

The case provides an example of how the bitcoin blockchain providers an asset ownership layer on the internet. In seeking to create a cryptocurrency, the technology has led to the creation of a distributed ledger that acts as a trust-less asset management system (Swanson, 2014). Going forward, ascribe is moving away from Bitcoin blockchain to use IPDB, a not-for-profit public instance of its own BigchainDB, which will be launching later in 2016 (https://ipdb.foundation). BigchainDB is also collaborating on a replacement for SPOOL tentatively named COALA IP Protocol, which allows a wider variety of rights claims and licensing agreements to be registered and implemented on IPDB and other platforms. The authors believe that blockchains will evolve as distributed computing platforms, rather than solely as cryptocurrency,

and these platforms will have the greatest potential to transform business (McConaghy et al., 2016).

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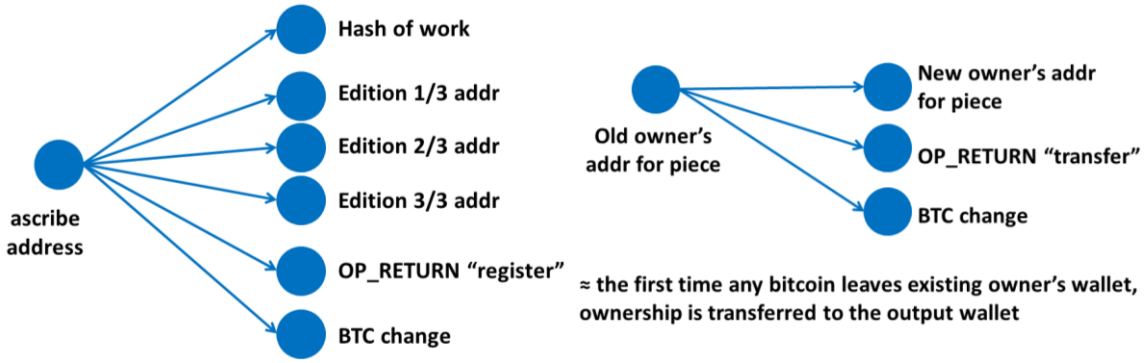


*Figure 1: SPOOL transactions. Left: register transaction on 3 editions. Right: ownership transfer transaction*

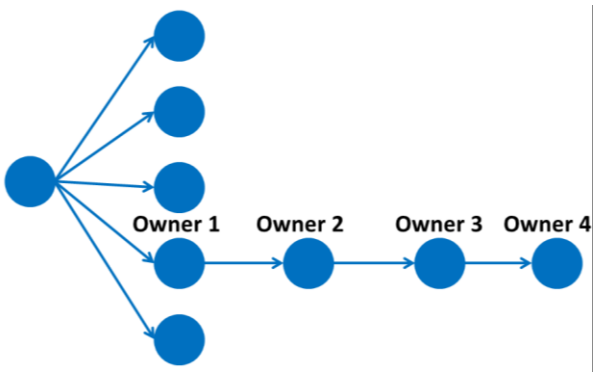


*Figure 2: In SPOOL, provenance emerges naturally*


*Figure 3: About piece IDs in SPOOL. Left: each edition of work gets a unique ID. Right: the register transaction binds the work hash to all piece IDs*