coala

COALITION OF AUTOMATED LEGAL APPLICATIONS

HOW BLOCKCHAINS CAN SUPPORT, COMPLEMENT, OR SUPPLEMENT INTELLECTUAL PROPERTY

WORKING DRAFT

WORKING GROUP ON INTELLECTUAL PROPERTY

BLOCKCHAIN WORKSHOPS

WWW.COALA.GLOBAL

HOW BLOCKCHAINS CAN SUPPORT, COMPLEMENT, OR SUPPLEMENT INTELLECTUAL PROPERTY

This document is a collaborative effort stemming from the contributions of:

- **Primavera De Filippi**, *CNRS / Berkman Center for Internet & Society at Harvard*
- **Greg McMullen**, *ascribe*
- **Trent McConaghy**, *ascribe*
- **Constance Choi**, *Seven Advisory/COALA*
- **Simon de la Rouviere**, *Consensys*
- **Juan Benet**, *IPFS / Protocol Labs*
- **Diana J. Stern**, *Distributive*

1. INTRODUCTION

We live in a knowledge economy: a world where value creation is shifting away from moving atoms around, to moving bits around. The value represented by the bits is in *ideas*, which by nature are intangible. Intellectual property (IP) is a set of legal tools by which creators, connectors, and collectors may manage rights to ideas by claiming those rights, and transferring or assigning rights to access, publish, distribute, use, or build upon the ideas.

INTELLECTUAL PROPERTY LAW

IP law comes in three main flavors: copyright, patent, and trademark, each with its own limits that define what is eligible for protection and the strength of that protection. Copyright is perhaps the best known, and generally refers to original works by an "author". These authored works include not only writing but nearly all other creative works, such as photography, filmmaking, painting, music, software source code, and in some circumstances, even the contents of databases. Patents cover useful inventions. Trademarks protect business branding in names, logos, slogans, and even jingles or sounds. The World Intellectual Property Office (WIPO) provides guidelines for IP through interpretation and management of international treaties, and individual countries implement these guidelines a variety of national laws.

Copyright has been around for centuries, but because of its complexity, it has tended to benefit well-established rightsholders rather than individual creators. It has not been adopted by the general public as it is seen as expensive, slow, and relatively opaque. The centuries-old legal and policy frameworks governing the rights of content creators to share, transfer and license works are based in an analog world of printing presses and the labor-intensive production and distribution of copies, rather than instantaneous access, copy, and transfer of works on the Web in the digital age. Legal precedent cannot be easily analogized to the actual use of content today, leading to inequitable legal results in some court cases, and unenforceability of legal rights in other cases.

There is a fundamental mismatch between current IP law and the Web. The Web makes it extremely easy to copy and share works; it is particularly well-suited to disseminating copyrighted works. The capital costs of producing and distributing works were enormous, from owning a printing press to television broadcasting equipment. The Web cuts this cost to near zero.

These savings come at another cost, however. The Web has cost creators and rightsholders the ability to control how their works are used and their efforts compensated. The Web provides no mechanism by which to claim rights, license works, or get paid. Attribution is far from universal, and is easily

lost when copies are made carelessly or with intent to break attribution. Because copying and transferring works on the Web is free and instantaneous, there is no ability for creators to ascertain how many copies have been made of what in the past would have been unique works. Creators are left feeling they have lost control of their work.

The result of this mismatch between law and technology is that IP does not currently serve the interests of the people using it:

- **Creators and rightsholders** face challenges in claiming rights and monetizing their works, and in many ways lose control of where and how their works are used by others.
- **Connectors** operate under heavy legal scrutiny from creators and rightsholders. Innovative business models face opposition from content providers who are reluctant to adopt new licensing models.
- **Consumers** struggle to access content they want through legal means because it is not available in their region as a result of geoblocking, or not available in a format they can use because of DRM. Consumers often resort to downloading infringing copies of copyrighted works they otherwise would have purchased.
- **The public** loses the benefit of collaborative efforts because individual contributors fear participating in the creation of an infringing derivative work. Working in the public domain or within the framework of user rights or exemptions is risky business due to legal uncertainty as to the rights to the works in question. Public access to existing works and the creation of derivative works are limited by the lack of information about rights to use works, and difficulty in obtaining necessary rights from rightsholders.

INTRODUCTION TO BLOCKCHAINS

This document explores the opportunities to apply blockchain technology and legal thinking to address the mismatch between the Internet and IP law. Blockchains offer opportunities to create new models that better reflect the wants and needs of creators, consumers of content, the connectors who put the two together, and the public as a whole.

WHAT IS A BLOCKCHAIN?

A blockchain is a database with several novel characteristics. Once an entry is added to a blockchain database, it cannot be removed, a feature referred to as *immutability*. A blockchain database is *decentralized*, meaning it is not governed by any single entity and is not subject to manipulation by any group. A blockchain can be publicly accessible, or at the very least accessible to a broad set of interested parties, each of whom can have a complete copy of the database to review. Finally, a blockchain database provides the ability to "tokenize" actions or social and business logic by using a unique digital identifier, or a *token*. This token can be used to allow actions such as copying or transferring, and is written to a blockchain as an immutable entry. Token systems differ from traditional digital rights management (DRM) systems, as will be discussed below.

Blockchains allow the decentralization of the three elements of computing: communication, storage, and processing. The processing element allows *smart contracts*. Smart contracts refer to programmed business or social logic that automatically executes when certain conditions are met. Smart contracts are not necessarily contracts in the legal sense, and are only as smart as what is programmed into them. For example, a smart contract could be designed by a musician to collect payment until a certain threshold is reached, and then automatically unlock a download of the musician's

new album. One can imagine more complicated examples that, for example, automatically track radio plays of a song and issue royalty payments automatically, or even entirely decentralized organizations or art pieces.

Blockchains can add a fourth element: the representation and transfer of value through tokens that can be used directly for payment or to signify value. Bitcoin is the best known example of this kind of value, although there are many variations on the theme of digital currency and other kinds of tokenized value transfer. This paper will not explore the representation and transfer of value through blockchains in depth, but the concept will be referred to and applied where appropriate.

Finally, blockchains enable a trusted, convenient time-stamping architecture. By writing a cryptographic "hash" of a digital file to a blockchain, it can be cryptographically proven that the file existed at a certain state at the time the hash was written. For example, this could be used to demonstrate that a contract was signed or a disclosure contained accurate information.

SMART CONTRACTS ARE NOT DRM

Permissions assigned through smart contracts are not to be confused with traditional DRM. Traditional DRM involves various implementations of the same general idea: encrypting content then allowing it to be decrypted only with a key held by a paying customer. DRM has proven a failure for two key reasons. First, the DRM security model is not adequate, as it requires the end user have a copy of the key to view the content, and the content must be displayed to the consumer in unencrypted form. Second, DRM interferes with consumer expectations about how they can use content: sharing with friends, time- and format-shifting for convenient viewing, backups, or the use of assistive devices by people with disabilities. In addition, DRM challenges notions of ownership by moving copyright into unexpected areas. Keurig coffee makers, John Deere tractors, and Volkswagen emission monitoring systems have all used DRM to restrict what customers can do with purchased products, and in the case of Volkswagen to deceive customers and regulatory bodies.

Smart contracts and blockchain technology could unlock possibilities that traditional DRM could not. Micropayments for use of content is the most obvious example. With existing payment systems such as credit cards or debit cards, payments of anything less than a few U.S. dollars actually costs the recipient money because of the comparatively high cost of clearing those transactions. Payment with blockchain-based tokens like Bitcoin can allow payments of tiny amounts, opening up many possibilities for direct payments to creators. When combined with smart contracts, micropayments can automate complex licensing arrangements to allow creators to more efficiently allocate their resources, and focus more on creating. These advantages will be discussed in greater detail below.

On the other hand, smart contracts could also be used to replicate the worst of DRM. Smart contracts could be written to restrict the use of content rather than encouraging use by limiting the ways content can be reused or shared. For example, a smart contract could require payment every time an ebook page is turned, or charge a micropayment for saving in a videogame. It will be important to discourage these applications and to encourage developers to employ models that respect their customers and do not create unnecessary barriers to accessing content.

ASSUMPTIONS

This document explores specific facets of how blockchain and related technologies may support, complement, or supplement IP. It relies on the trends and assumptions set out here.

We assume rapid growth in processing power, data storage, and networks as a result of the continued application of Moore's Law, a major trend in technology that has and will continue to affect the Internet

and the Web. For the last 50 years, engineers have been able to increase the density of transistors by two every 18 months. This trend is expected to continue for at least another 10 years. Moore's Law has meant that processing, communication, and storage improve by an order of magnitude every few years, while the cost remains the same. It allows small teams to manage vast amounts of data with relatively modest resources, and this effect will get even bigger. Machine learning algorithms that previously could only operate on small data sets can now be operated at Web scale.

We assume that research in quantum computing will not render the cryptographic techniques that enable blockchain technologies obsolete, or that blockchains will adopt quantum encryption as such technology is developed.

Finally, although we address IP as a whole in parts of the paper, much of the paper is focused on copyright. This emphasis should not be read to suggest that blockchains will not have a transformative impact on trademarks or the patent system. Just the opposite. It is our hope this paper will serve as a groundwork for future exploration of blockchains in trademark and patent law.

2. IP REGISTRIES

EXISTING IP REGISTRIES

Ownership registries have been operated by both governments and private entities for centuries, recording ownership of everything from bicycles to land titles. These registries are intended to track the rights specific people enjoy to specific artifacts, places, or ideas. They are essential to resolving disputes over ownership and rights, and in many cases create a legal presumption of ownership by the registered owner that is difficult to rebut.

The benefit of these authorities is that they are trusted by virtue of their size or long history. However, registries are far from perfect: trust is eroded if there is corruption in the creation and maintenance of records. Often the issuing authority has motivations that conflict with the needs of the public, which reduces the benefits of the registry. Finally, registries tend to be nation-specific rather than global, leading to burdensome registration and search processes, and incomplete or inconsistent registries.

In the context of intellectual property, there are both public registries operated by governments, and public registries operated by for-profit corporations.

There are examples of public registries in all areas of IP. These registries often carry powerful statutory incentives to register works. For example, the United States Copyright Office confers additional statutory rights upon registration, even though copyright is automatic on creation of a copyright-eligible work. In trademark, most countries allow businesses to control a mark they use by simply applying a trademark symbol (™), but confer additional protection upon registration of a mark, a status denoted by the registered trademark symbol (®). Most countries have their own patent registries, which in exchange for making the details of an invention public promise a limited monopoly over use of that idea. Private registries, which are primarily concerned with copyright, do not offer any statutory advantages but serve as a trusted authority to attest to the existence and possession of a certain work at a certain time.

THE POTENTIAL OF BLOCKCHAIN REGISTRIES

Blockchain technology can serve as a permanent, time-stamped, decentralized, immutable storer of information. By applying these characteristics, blockchains provide an opportunity to re-think registries and overcome some of the issues existing registries face.

The decentralized nature of blockchains disintermediates central authorities and reduces the amount of trust required among the participants in the registry. The participants' motives are fully aligned with the goals of the registry mechanism, because the participants are both the users and operators of the system. However, disintermediation also means that the original trusted authority is no longer trusted. A new means of legitimizing database entries will be required.

To establish trust, blockchain-based registries can be fully transparent, or as transparent as is desirable to the users of the system. For example, blockchain-based registries can support a federated model in which trust in authorities can be spread between participants in a quasi-decentralized manner, with the system operated by stakeholders. These stakeholders could include whichever actors are appropriate for the registry. The typical governmental and corporate participants could be included, as could proven good actors such as universities, galleries, libraries, archives, and museums (GLAMs), or not-for-profit organizations whose interests also align with those of the registry and its users.

Implementation costs of blockchains are minimal, allowing the registries to be operated at very low cost. Other mechanisms may be able to offset the remaining cost. For example, ascribe's service (discussed in greater detail below) is offered free of charge to individual users, while larger users like galleries or archives may be charged a small fee for access to the application program interface (API) which enables bulk actions.

Finally, the administrative burden of a blockchain registry is vastly reduced in comparison to a traditional registry. The time to make a new entry can be measured in seconds or minutes, rather than months or years.

The greater convenience and reduced cost of a blockchain registry encourages increased use of the registry, from registering more works to recording transactions related to those works. Ultimately, every transaction related to a registered work could be recorded, providing perfect provenance. In theory, sales could be made off-blockchain, but such sales would break the chain of provenance established by the registry and reduce the value of the work significantly as it could no longer be demonstrated to be authentic.

An issue for further consideration is verification of authenticity of works at the point of entry to the blockchain registry. Since this problem is also present with traditional registries, it is not a marked disadvantage from the current system, and the risk appears to be outweighed by the benefits of blockchain outlined above, and demonstrated below.

BLOCKCHAIN REGISTRY CASE STUDY: ASCRIBE

A blockchain registry for IP has already been established: ascribe (*ascribe.io*).

ascribe uses an open source protocol called SPOOL, or the Secure Public Online Ownership Ledger (*github.com/ascribe/spool*). SPOOL was designed specifically for the task of recording IP rights on a blockchain. SPOOL also has an open-source implemention (*github.com/ascribe/pyspool*). ascribe currently uses the Bitcoin blockchain for registrations and other

transactions, but plans to migrate to the public version of its BigchainDB blockchain database (*bigchaindb.com*).

The ascribe Terms of Service (ascribe Terms) (*ascribe.io/terms*) provide a default framework for transferring ownership of editions by requiring that users incorporate specific terms in transfers or licenses to other users. Transfers and licensing through the Terms leverage a combination of existing copyright law and contract law, much in the same way that Creative Commons (CC) (*https://www.creativecommons.org*) does with its licenses. A blockchain entry in itself does not have legal effect. Rather, it is a secure timestamp and a reference to the appropriate license or contract. With this approach, existing legal frameworks can be applied before those frameworks changing to accommodate blockchains.

With ascribe, users can register works, transfer ownership of an edition of the work, license the work, and consign or loan the work. These features are detailed below.

REGISTRATION

The first step in the ascribe model is to register the work on the ascribe registry. To register a work, users upload a digital file representing the work to ascribe, in whatever format they choose. ascribe generates a cryptographic fingerprint unique to that file (a hash), then writes the hash to a blockchain in a way that can be associated with the creator. Metadata about the work is also written to a blockchain, including the creator's name, the date of the work, other information about the work, and the license under which the work is available.

Registration is not required to obtain a copyright in the work—copyright is automatic at the time of creation of a work to which copyright applies. Registration allows the user to secure attribution in the ascribe system and to timestamp their possession of the file and the license applied to it. If there is a dispute over authorship of a work, previous registration with ascribe can help establish possession of a work at a particular point in time. This is a blockchain implementation of "poor man's copyright", the time-honored tradition of date-stamping work by way of the creator sending the work to themselves by registered mail and leaving the package unopened, relying on the postmark if a legal dispute arises.

The ascribe Terms prohibit registration by a party that does not have the right to register a work, but there is currently no technical means by which fraudulent registration can be addressed. There are several possible authentication mechanisms that could be implemented in the future, each with their own advantages and drawbacks. These include user voting and reputation systems, including blockchain-based systems like Backfeed, relying on trusted institutions like GLAMs, and automated systems based on machine learning and probabilistic analysis of fraud.

TRANSFERS

ascribe allows the creation of cryptographically signed limited edition works. Borrowing the European Union's conception of "digital goods", ascribe allows the current owner of a work to transfer it to a new owner with all the rights that come with a physical work, but without assigning copyright in the original work. Each edition is represented by a unique token identifier assigned to the owner's account. When a work is sold, the token is transferred from the current owner to the new owner. The original files are not watermarked or restricted by DRM, instead relying on the authenticity of the token and the connection to the artist to create value.

Consignment from artists to galleries and loans from collectors to museums for public exhibitions are common transactions in the art world. ascribe allows these relationships to be recorded on a blockchain. For certain GLAMs and for Creative Commons (CC) licenses, ascribe associates the appropriate license to a work or edition. The terms of those licenses, or a link to the license, is recorded to a blockchain.

By recording transfers, loans, and consignments to a blockchain in addition to the initial registration, ascribe offers something traditional registries cannot: perfect provenance. This information allows for a detailed and cryptographically provable history of a work.

LICENSING

While ascribe has not yet opened licensing to most users, it has made licenses possible for some GLAMs. Licensing through a blockchain opens interesting opportunities, including smart contracts which can act on the rights that have been licensed, and sub-licensing that can only include the rights licensed and remain visible to the original rightsholder.

Creative Commons France (CC France) and ascribe have been conducting an experiment to see how licenses on a blockchain may operate in practice. CC licenses are non-revocable, so an immutable record like a blockchain is an ideal means for recording CC licensing information. The CC movement also shares a philosophical alignment with the inherent openness of blockchains. If users register their works on a blockchain using a CC license, that license is attached to the work for all time.

From the CC France website, users can choose to "register your work on ascribe", which links to the cc.ascribe.io website. That page allows users to upload their work, enter metadata, and choose one of the CC licenses to apply to their work (see Figure 1 below). A hash of the chosen license is written to a blockchain along with the hash of the file and metadata.

Figure 1: Creative Commons France and ascribe experiment: The cc.ascribe.io CC License Selection.

Blockchain-powered registries of rights and licensing information will gain flexibility going forward. Smart contracts create opportunities for licenses with clear terms and flexible application, especially when combined with "Ricardian contracts"—contracts that clearly define the complex issues that may arise in a manner that is both human and computer readable.

BENEFITS OF REGISTRIES

ORPHANED WORKS

Orphaned works present a problem to which blockchain registries offer a long-term solution. Orphaned works are works with an uncertain copyright status and for which a rightsholder cannot be located or identified. Orphans are common, with an estimated 91 million orphaned works in the U.K. alone.

Orphaned works fall into a cultural black hole and are nearly impossible to republish or use as source material for a derivative work. They exist in a legal limbo, fraught with risk and uncertainty. Even if all signs point to the work being out of copyright, there is no way to confirm this is the case. There is always a possibility that a rightsholder is waiting to swoop in with a lawsuit when an infringing use is detected. For this reason, orphaned works are lost from our cultural heritage.
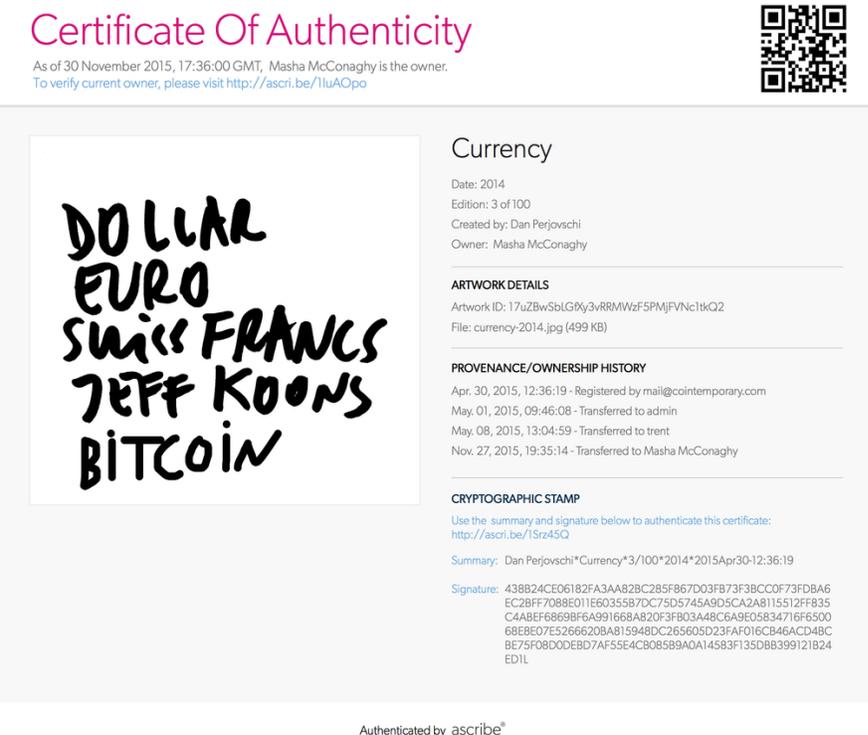
In 2006 and 2008, there were efforts in the U.S. to free up orphaned works by creating a presumption that the work is out of copyright upon due diligence by a potential user. These efforts were defeated by publishers and authors who are concerned the presumption would legitimize infringement.

By registering works on a blockchain, information about copyright status of works cannot be lost, meaning they will not fall into orphaned status to begin with. While inevitably some information will become outdated over the lengthy term of copyright, fewer works will fall victim to this uncertainty, expanding our available cultural heritage.

3. DIGITAL CERTIFICATES

Blockchain technology can be used to issue and verify digital certificates attesting to the rights status of a particular work. Certificates providing information about a work can be registered on a blockchain, and cryptographically signed by an authority— a rightsholder, GLAM institution, or other trusted entity. Unlike paper certificates, certificates written to a blockchain are tamperproof. Multiple certificates can be issued to describe different properties of the work. Certificates could contain bibliographic information, rights information, contractual conditions for use or reuse, and any other important information about the work. Certificates would be cryptographically "signed" by the entity vouching for the validity of the information contained in the certificate, and recorded on a blockchain along with a timestamp.

An example can be found in the Cryptographic Certificate of Authenticity (COA) issued by ascribe is shown below (Figure 2). The COA is generated as soon as a work is registered, or when a work is transferred. The COA provides metadata like artist name, title, owner, year, owners, and cryptographic ID of the edition, the provenance or ownership history of the work, and finally the digital signature that allows the validation of the certificate. ascribe also provides a tool whereby a user can verify the legitimacy of the COA (*ascribe.io/app/coa_verify*) (Figure 3).

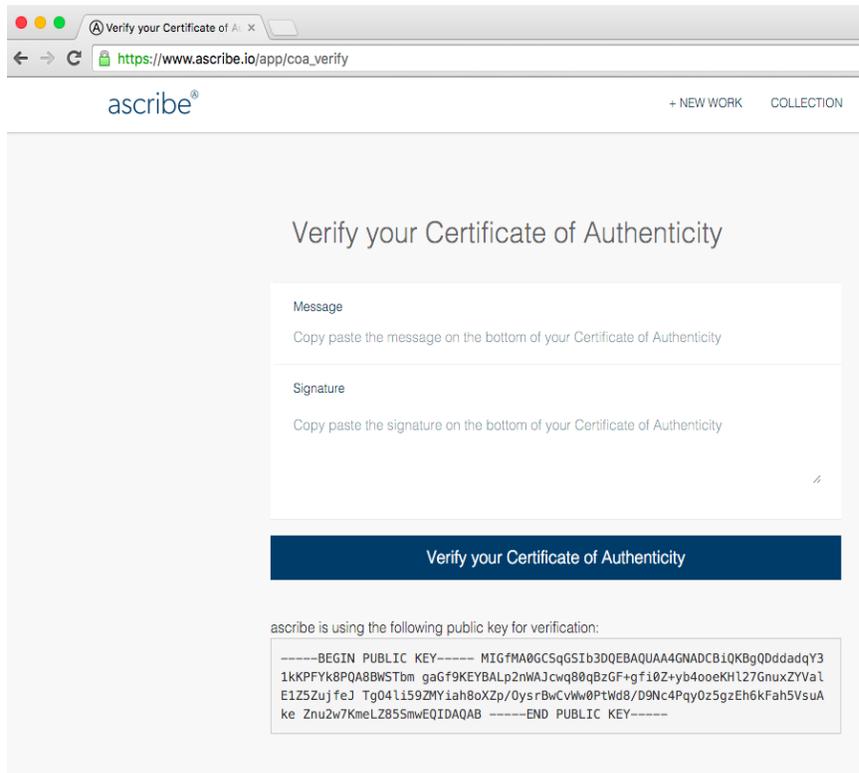*Figure 2: Certificate of Authenticity from ascribe.*

Figure 3: COA verification tool.

Certificates written to a blockchain can be used in a wide variety of circumstances to give confidence to users of a work that the license they are relying on is in fact the license that applies to the work. For example:

- CC licenses can be applied to a specific work, and the signed certificates prove that a work has been released under that specific CC license, providing a reliable statement as to the terms and conditions of use or reuse of the work in question.
- A rightsholder can issue a certificate to a licensee indicating that certain rights have been granted to that licensee, and used by that licensee to prove that she indeed has those rights.
- GLAM institutions can issue certificates under the Rights Statements Initiative of Europeana. These Rights Statements are designed to serve GLAMs that cannot simply state that a CC license or public domain tool applies to a work. A GLAM could issue a certificate confirming, for example, that a particular work is in the public domain in a particular jurisdiction, offering certainty to users.

ADVANTAGES OF CERTIFICATES ON BLOCKCHAINS

There are numerous advantages to using blockchains for the issuance of digital certificates::

- Certificates can be issued, updated, and revoked in a secure and tamper-proof manner;
- Any entity can act as a certification authority, allowing those entities to determine the kinds of certificates that are relevant to their users and the kinds of works they manage.

- Anyone has visibility and choice as to reliance on particular certificate authority. Certificate authorities are incentivised to provide information to gain reputation, and to make sure that information is accurate, because their reputation will be damaged if they do not. Certificate authorities' reputations could even be tracked and maintained through a blockchain-based system like Backfeed (*http://backfeed.cc/*).
- Anyone can verify the authenticity of a certificate without having to contact the certification authority that issued it.
- No one can issue a digital certificate on behalf of a third party without proper authorisation.
- Fraudulent certificates can be identified and invalidated by an authorised party.
- Issued certificates are persistent because information on a blockchain cannot be deleted, even if the certification authority no longer maintains the database, or even if the authority no longer exists.
- Certificates provide a reliable means to seek information about a work, as well as the source of that information, providing transparency and necessary attribution information such as authorship, date of copyright, and probable state of rights attached to a given work, for subsequent publication and derivation. This is particularly important given recent debates over the status of and appropriate approaches to deal with orphaned works, as explored above.
- The information provided in certificates remains available even if the certificate is revoked, providing a historical view of the provenance of works and rights activity around a work.
- Certificates provide a secure source of information about rights that a user can review independently and then make choices as to allowable uses of material. This choice results in a flexibility that is not present in traditional DRM schemes, putting trust in the user to act lawfully and enabling the user rights and exemptions that provide balance in copyright law.

ISSUANCE AND AUTHENTICATION OF CERTIFICATES

This section provides information on the technical aspects of issuing and authenticating certificates.

HASHING

First, the work for which a digital certificate will be issued needs to be hashed. ascribe uses the SHA-256 algorithm used in the Bitcoin protocol, but other options are available. Hashing algorithms can take any arbitrary piece of data as input and produce an alphanumerical string as output. In this case, the work that is the subject of the certificate is the input, and a seemingly randomized string is the output. Despite the random appearance, the string is in fact a unique identifier for the digital file. The original data cannot be retrieved from the hash, but the same hash will always be produced from the original file. Hence, anyone in possession of the same digital file will be able to generate an identical string using the same hashing algorithm, thereby confirming that the file is in fact the file in question.

METADATA

Metadata is information about information. In the context of certificates, metadata refers to information describing the file the certificate refers to, or the certificate itself. Depending on the complexity of the metadata that needs to be attached to the file, two possible approaches can be taken. If the work

needs to be annotated with a small amount of information, such as the author's name and date of creation, the metadata can be recorded directly to a blockchain, along with the hash of the digital file. If more complex information is required, such as specific licensing terms, that information can be incorporated in an external document by writing the hash of that document to a blockchain, or by providing another unique identifier like the name of the license or a link to it.

Since metadata is not inherently linked with the work, it is possible for different certification authorities to provide different information concerning the same file. For example, Europeana might certify that a particular work is in the public domain in Europe, whereas the Digital Public Library of America might issue a different certificate for the same work that applies in the U.S.

TRANSACTIONS

The hash of the work, along with the relevant metadata, is written to a blockchain by incorporating it into a transaction on a blockchain the data will be written to. For example, in the ascribe SPOOL model, the metadata is written to the "OP_RETURN" field of a non-spendable Bitcoin transaction made by the entity issuing a certificate. This transaction serves as a permanent record for the digital certificate issued by the entity.

4. TRACKING USAGE

There is a common perception that when a work is released onto the Internet, it becomes part of the public domain and the creator loses control. This is not true in the legal sense—creators retain copyright in a work no matter how many times they post a work online—but in practice, there is some truth to this belief.

As soon as a work is posted online, creators have no way to know who is using it, what they are using it for, how much it is being copied or shared, who has modified it, or who has made derivative works.

The lack of visibility into the use of a work online is a problem for creators and rightsholders who want to take advantage of opportunities to monetize their work, but also for those who want to release their works for unrestricted use by the public. GLAM institutions frequently make their materials available online for free or under non-restrictive licenses like CC0 or the Europeana Rights Statement, but wish to know how those materials are being used so they can report back to their funding bodies. Under the existing system, gathering reliable information is nearly impossible.

Individual creators often want opportunities to see who has used their work in a new context, or what derivative works have emerged from it. Many want to engage interactively with consumers, changing the paradigm of passive consumption to one of engagement and participation that could be infinitely richer and more collaborative. But again, the information needed to pursue these opportunities is not available to creators.

TRACKING WORKS ON THE INTERNET

Blockchain technology can assist in restoring visibility into usage of works, giving creators increased control over their works online. This can be achieved in two ways:

VISIBILITY BUILT INTO THE SYSTEM A PRIORI

A historical example is Xanadu (*http://www.xanadu.com/*), Ted Nelson's proposal for a hypertext system based on bi-directional links between content so that authors can monitor usage. Under the Xanadu system, creating a link in Document A to Document B updates Document B with a link to Document A. Changes to Document B would be reflected in Document A. Modern examples include

Git (*https://git-scm.com/*), a software version control system, and the Interplanetary File System (IPFS) (*https://ipfs.io*), a distributed file storage system discussed in greater detail below. These models allow attribution but can also tie into how creators get paid, whether by royalties in a historical *droit-de-suite* model, to modern blockchain payments like RoyaltyChain.

VISIBILITY REVERSE-ENGINEERED A POSTERIORI.

A partial solution is traditional reverse image search across the internet. Modern projects combine Internet-scale similarity search with links to registered works. Examples include ascribe's *whereonthe.net*, and Project Octopus.

VISIBILITY: ASCRIBE'S *WHEREONTHE.NET*

The ascribe analytics tool, *whereonthe.net*, is currently a stand-alone service but will be incorporated into ascribe. ascribe searches across many sources of information simultaneously, including the web, CC-licensed sources such as the Museum of Modern Art and the British Library, and industrial partners' sources. A number of visualizations of the results are shown below (see Figures 4-6), ranging from simple statistics to a fine-grained analysis of individual pages the work has appeared on. The website can be used interactively, allowing users to search an image of their choosing and then explore the results.
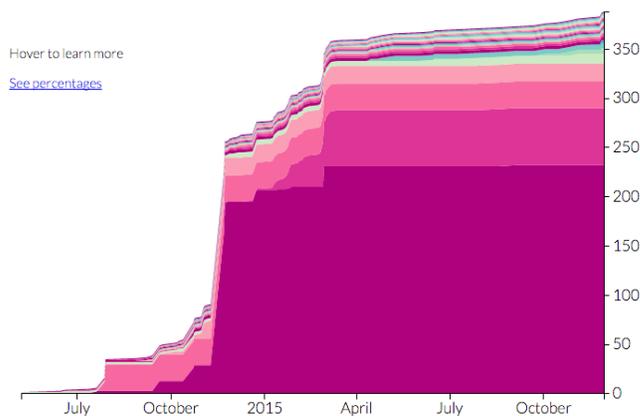

Figure 4: whereonthe.net search results.

Figure 5: whereonthe.net graph showing uses of a searched image over time.

Distribution per website looks a little like this.

Website: reddit.com/r/bitcoin/
Occurrences: 1
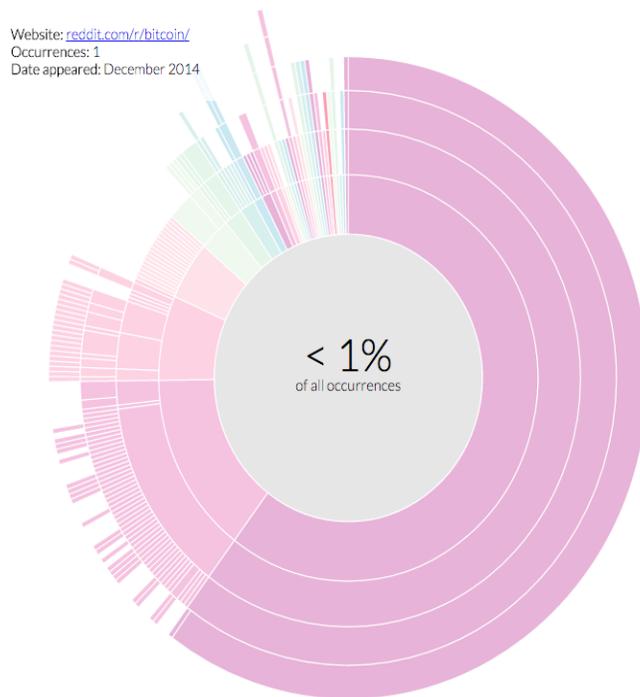Date appeared: December 2014

< 1%
of all occurrences

Figure 6: whereonthe.net chart showing breakdown of uses of the image by webpage.

A *whereonthe.net* search begins with collecting data from multiple sources, indexing the data collected, then performing a context-based query on the entire data set. Many of the data sources are enormous. For example, on the Web, just the links to images take up hundreds of terabytes, with billions of individual works. Indexing and content-based querying are cast as machine learning (ML) problems. ML is a subset of artificial intelligence. It involves computing a content-based, ML-friendly "feature vector", or a mathematical representation of multiple pieces of data that represent a particular work, such as the amount of a particular color in an image or the location of patches of color in the image. The search uses ML-based distance metrics between a reference work and all previously-indexed works, finding works that have metrics similar to the reference work. ascribe has indexed about 15 billion images in its search.

Content-based search can work for any type of content, not just images. ascribe plans to develop search for audio, video, text, and 3d designs. ascribe is already developing content-based search in 3d designs (see Figure 7, below).
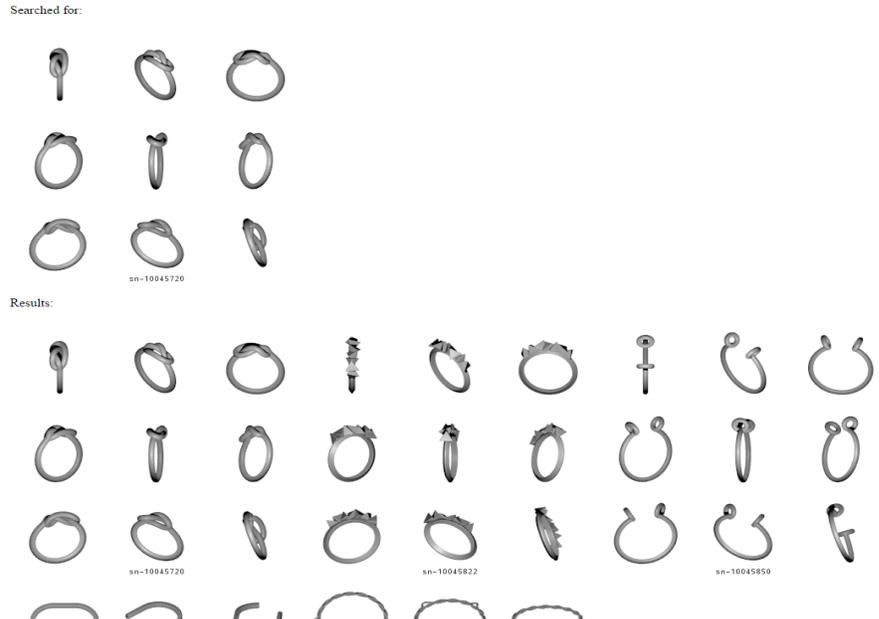
Figure 7: ascribe's 3D content-based search.

BENEFITS OF VISIBILITY

Visibility restores some semblance of control to creators, who so far in the Internet age have had little say in the use of their works and little knowledge as to those uses.

Taking the importance of weighing the impact and influence of a work one step further, in an "attention economy" visibility through sharing online can serve as a proxy for value. Reach is of obvious importance to creators who rely on advertising revenue or who want to spread the word about a product for sale or a crowdfunding campaign. Online view counts or share counts are beginning to take on an importance beyond these direct benefits, however. If an artist's work has been shared millions of times, that may signal that the artist's work has entered the public consciousness and can be sold for more. The Internet has further eroded the wall between fine art and mass culture. Some conceptual artists are embracing this erosion, like Constant Dullaart, who has experimented with

The first step toward creators being able to benefit from use of their work online is knowing where their work has been used.

The most obvious example is identifying infringing use of creators' work and providing an opportunity for them to take measures to stop it. Rightsholders whose works have been infringed should have recourse, and identifying infringement is the first step toward providing such recourse.

This is not a call for aggressive enforcement or copyright trolling as a business model. Copyright trolls have abused the copyright system by developing automated systems to find infringing uses and generate demand letters that skirt the edges of the law. Right now monitoring and enforcement is the domain of "hired guns" incentivized to use takedown notices aggressively.

A system where infringement is identified and stopped is preferable to a system of preemptive control on the user's side. DRM and aggressive takedowns have proven dangerous to user rights, especially rights of access by disabled people and rights to use copyrighted works in certain contexts. Putting those tools in the hands of creators could be the first step toward a more balanced system and a more nuanced approach to balancing user rights with enforcement.

5. DECENTRALIZED ARCHIVES

Information is one of the most valuable assets in modern society. There are many initiatives with the goal of archiving content and information in digital format. GLAMs have been dealing with the issue of digital preservation for years, but a common and interoperable solution has not been developed. Private sector initiatives have emerged in recent years, each coming at the issue in different ways, from centralized commercial services such as Google, Youtube, Netflix, Flickr, Getty, JSTOR, LexisNexis, ProQuest, and so on, to grassroots non-profit initiatives including the Internet Archive, Wikimedia Foundation, and Project Gutenberg.

The costs of storage decrease every year, but the amount of information produced every day is rising at an exponential rate. More and more existing content is being digitized every day, and the creation of new digital content is growing at an unimaginable rate. There is a growing need to collect, store and organise that information in a way that will ensure broad and continued access to it. Yet as the amount of digitized information grows, it becomes increasingly difficult for any single entity to deal with its storage and preservation.

Digital preservation is meant to ensure valuable content remains accessible and usable over time. This means managing the storage and archival needs discussed above, but also ensuring access is possible even after the hardware and software used to create and view the content have become obsolete. This requires storing information in a publicly accessible datastore and in an interoperable format. The preserved content must be an accurate representation of the original to ensure the source and integrity of archived materials. Current efforts involve the use of watermarks and metadata, but these solutions are not tamperproof.

Blockchain technology could provide a solution. Blockchains allow the creation of decentralized archives that do not rely on a single entity to store content or choose which content to archive. Instead, a decentralized archive is maintained through a distributed, decentralized network of peers. There are already initiatives working toward such decentralized archives.

IPFS is one noteworthy example. IPFS is a peer-to-peer distributed file system that seeks to establish a common storage platform, shared amongst all users of the network. By combining blockchain technology with the distributed hash table technology that underpins distributed filesharing like Bittorrent, the IFPS data structure can be used to build versioned file systems, with the goal of achieving a more "permanent web".

A tokenized currency called Filecoin (*filecoin.io*) will serve as the currency of IPFS. Individuals who host files on IPFS are paid in Filecoin, and storage space on the network is purchased using it. Hosts who earn Filecoin can sell it to people who want to use it to buy storage space on the network, providing an incentive for those hosts to continue maintaining the network.

The Alexandria project (*blocktech.com*) is more specifically focused on digital preservation. Alexandria is a distributed online library for sharing and preserving cultural content. Like IPFS, Alexandria relies on distributed hash tables in order to hold large amounts of content while ensuring that data is delivered efficiently when demand is highest. A blockchain provides a permanent distributed public ledger, allowing for trustless payments over the network, and providing a financial incentive for users to contribute to the growth and security of the platform.

6. NEW ECONOMIC MODELS

EXISTING MODELS

Artists, authors, and other creators must strike a delicate balance between maximizing the dissemination of their works to reach the broadest possible audience, while at the same time ensuring they can be properly compensated for their work.

Since the birth of copyright, the copyright regime has been the default solution for rewarding creators. It has come at the cost of a layer of exclusivity that limits the availability of the creator's works to the public. The complexity of copyright licensing and rights management has allowed the establishment and deep entrenchment of powerful intermediaries that control content publishing and distribution.

Market dynamics fundamentally alter the type and quality of content that enters the public sphere. As a result, intermediaries acting on economic interest become the primary curators of content. These curators select works based on the likelihood of profitability according to consumer preferences and a clear path to return on investment.

Under the existing model, mass culture is not truly a reflection of the creators who make it or the public that consumes it, but rather a careful exercise in profit maximization. With this degradation of culture, everyone suffers.

EMERGING MODELS

Blockchains allow for the establishment of new economic models aimed at promoting the maximum dissemination of works, while ensuring compensation for creators, thereby optimizing creativity and unique content production. The models described below can be seen as a complement or supplement to existing copyright law, and are only a few of the innovative models that may be developed as blockchain technology moves into the mainstream.

MICROPAYMENTS

As discussed above, micropayments are made possible by the use of blockchain technology. Before blockchains, there was no way to efficiently send micropayments. The high transaction costs of existing financial networks do not allow for small amounts to be sent. For example, to send a $1.00 payment by Visa or Paypal, intermediaries take about 33% in fees, and while funds appear to be sent and received instantaneously, final settlement takes much longer. Payments can be disputed and charged back for up to sixty days.

By applying micropayments, blockchains could enable a "tip jar" model for works. For example, by assigning a Bitcoin address to a work, anyone who encounters the work can make a micropayment to the address if they so choose, effectively paying a "tip" to the creator, all without transaction fees being paid to intermediary services. With the help of smart contracts, it also becomes possible to set up automated paywalls, whereby anyone willing to access a particular work will first make a micropayment to the author of the work.

CROWDFUNDING

Most current economic models can be optimized to the extent that blockchain technology can reduce transaction costs and create a more direct relationship between audiences and creators.

Crowdfunding is one example of a contemporary service that would benefit from blockchain technology. Crowdfunding already provides creators with a more decentralized funding model than how creation has been funded in the past. Creators propose a project and then source the funds they need to complete that project from their network of fans or the general public, thus reducing or eliminating their reliance on centralized production or publishing firms.

The crowdfunding world is not perfect, however, and it is not completely decentralized. Crowdfunders must trust the central platform to release the funds raised for their projects. Popular platforms like Kickstarter or Indiegogo are highly centralized and enforce strict rules about the kinds of projects that can be funded. The crowdfunding platforms also rely on external payment platforms that have their own set of rules. Unpopular or controversial projects can be blocked by one or both of these gatekeepers. For example, Kickstarter does not allow projects involving genetically modified organisms, and Visa and Mastercard have blocked donations to Wikileaks. And even if the platforms hold up their end of the bargain, the people giving money to a project cannot be certain that the recipients of funds will use the money for the project as proposed.

Creators can be assured that crowdsourced funds will actually reach them, and funders can be assured that the creators must apply the funds in the manner specified in the crowdfunding process.

New crowdfunding platforms are already leveraging blockchain technology: Lighthouse and WeiFund are two examples. Lighthouse (*https://www.vinumeris.com/lighthouse/*) provides a decentralized crowdfunding platform based on smart contracts. A target amount and a deadline is set, with a Bitcoin wallet address set for the project. The wallet has no owner—it operates independently and is governed by smart contracts. If the target amount is reached by the deadline, the funds are released to the project owner. If not, the funds are returned to the funders. WeiFund (*http://weifund.io/*) operates on similar principles, but is based on Ethereum and uses Ether currency rather than Bitcoin.

Blockchain technology allows crowdfunding to operate on a much smaller scale than current platforms, both in terms of the size of the project that can be funded and in terms of the minimum level of contribution. Receiving payments of less than a few dollars has previously been cost-prohibitive due to the cost of processing the transaction, but micropayments can work on a much smaller scale. Even a few cents can be contributed so that even supporters with limited financial resources can participate.

Crowdfunding does not have to stop at the artist or project level. It can go even deeper down into the creative process, to songs or artworks themselves. Through smart contracts, the parameters of a project can be set in code and money collected from funders can be automatically applied according to those parameters.

Plantoid (*http://okhaos.com/plantoid/*), a project by Primavera de Filippi (one of the co-authors of this paper) is an existing example of an artwork that performs its own crowdfunding. *Plantoid* is an Internet-enabled sculpture of a plant that collects Bitcoin donations from viewers of the work, rewarding donors with a display of a song, lights, or a mechanical dance. Upon reaching a target amount, *Plantoid* issues a call for proposals from artists who want to make the next generation of *Plantoid*. Donors vote on submissions, and *Plantoid* hires the artist whose submission was most popular to create an offspring.

BLOCKCHAIN COLLABORATION

Blockchains can enable new forms of incentivized collaboration that would not be possible without the technology.

Only a few decentralized, non-hierarchical initiatives based on large-scale collaboration have been successful. Most of these successes are concentrated in the realm of free/open source software.

With blockchains, it becomes possible to introduce new economic incentives for collaboration, and without those incentives being monetary. These incentives can be designed to encourage people to contribute at any level of a project, including the production, curation, archiving, distribution, preservation, or restoration of creative works.

An early example is an experimental band called "The Cypherfunks" (*http://thecypherfunks.com/*), which aims to create a global band powered through cryptocurrency. Production and ownership of the music was shared amongst members. The technology has matured since the birth of The Cypherpunks, allowing for much deeper collaboration. New tools allow a group to come together using a smart contracts governance tool like Boardroom (*http://boardroom.to/*) to crowdfund an album and automatically distribute a portion of royalties earned to the fans that funded it. Remixes or other derivative works based on the music could be authorized by the group, with the proceeds of sales or licenses of those remixes automatically distributed to the remixer and original group through smart contracts. Proven stakeholders like fans or remixers could help in the governance of the project, voting on new ideas and tracks for a future album, or choosing tour destinations and merchandise.

ROYALTY PAYMENTS AND COLLECTING SOCIETIES

The contemporary music industry is built on top of a complicated legal and financial infrastructure for the collection, handling, and payment of royalties to artists. This infrastructure is expensive to maintain and largely opaque to artists, who often have no sense of their royalty entitlement until the cheque arrives.

Ujo Music (*http://ujomusic.com/*) (Ujo) is a project that attempts to address this situation by applying smart contracts to disintermediate the music business. Built on the Ethereum platform, Ujo stores the creative work on the Ethereum blockchain and automatically distributes royalties to entitled parties upon the sale of a song. In this model, a blockchain serves as both the content registry and settlement layer. Complex rules can be written that allow creators to see their works used in many ways: a normal download, a codified Creative Commons agreement, remixable stems, and more. Only one song is currently available through Ujo—Imogen Heap's "Tiny Human"—but royalties for the song are automatically paid directly to the artists entitled to those royalties when a user purchases the song.

The widespread adoption of micropayments for access to works, or tipping for enjoyment of the works, could have a dramatic effect on traditional collecting societies. These organizations are tasked with collecting royalties and negotiating the royalty rates as a part of compulsory licensing regimes on behalf of their member rightsholders. There are collecting societies for authors, songwriters and composers, and so on, in almost every country and for almost every creative field. Under the current system, part of the licensing fees paid by users finances the collecting society infrastructure.

Creators are entitled to royalties based on how often their works are used, but precise tracking has been cost prohibitive in the past. Rather than tracking every use by every licensee, collecting societies have established sampling formulas that estimate total usage by tracking some usage. This results in a bias toward well-known creators whose works appear across the samples, at the expense of lesser-known creators whose works may be missed by the sampling formulas.

Smart contracts and new delivery mechanisms could help solve both the problems of the costly infrastructure of collecting societies and the imprecise sampling formulas. Internet delivery of content allows more precise tracking of use of works, and smart contracts could automate royalty payments to artists. The result could be both increased rewards to creators and decreased costs to users.

DROIT DE SUITE

Droit de suite, directly translated as "right to follow", refers to a statutory entitlement of a creator to a share of the proceeds of future sales of the creator's work. The *droit de suite* is meant to remedy an imbalance in the art world, where galleries and collectors often benefit most when an artist's work increases in value.

Droit de suite does not exist everywhere in the world, however, and it is not applied with any regularity or consistency even in the jurisdictions where it is in force. This legal uncertainty is compounded by the fact that artists have no reliable way to know if their works have been sold, to whom, or for how much.

Blockchain registration and transfer of works could help with these problems. At the very least, it could provide artists with visibility into sales of their work, showing when and to whom the work was sold. Blockchain transfers could also provide information on where sales were made and for how much, allowing for automatic payment of the *droite de suite* via cryptocurrency.

AUTOMATED LICENSING

An enormous barrier to user-generated content is the complexity of licensing existing works. A typical YouTube user would have no idea how to license a song for use in a fan-made video. It should not be so hard to use content legitimately.

If a public registry for content existed, these fans could easily learn how to get the rights to a work and pay for their use. As demonstrated by the success of subscription streaming services for audio and video, users are willing to pay if they are given an easy way to do the right thing. This will unlock new revenue streams for creators and, more importantly, new ways for creators to access works to build upon.

PREDICTION MARKETS FOR CREATION

A prediction market could aid creatives by providing incentive for traders to bet on the success of their work. For example, Ujo has a public log of how many copies of Imogen Heap's "Tiny Human" have been sold. This information could be used to resolve bets on future sales of the song, leveraging the "wisdom of the crowd" to help decide what songs to release as singles or to remix.

For future projects, creators can release samples or snippets of new songs. Fans and traders can start predicting what songs will be a big success, making it easier for creators to pick a lead single to promote, or songs to play live.

In the context of crowdfunding, creators could set a financial goal in advance or leverage information from the crowd to predict how much will be raised, thus giving creators data to make more informed decisions about cashflow management.

DIGITAL GOODS AND ARTIFICIAL SCARCITY

A variety of new economic models could be devised around the concept of artificial scarcity. The current copyright regime creates scarcity at the content level—you can buy access to the content of a book or an album as a digital or physical copy, but you do not own the underlying work.

Digital goods have found success in platforms such as video games and online marketplaces. Virtual swords or armour in games like *Dota 2* (*http://blog.dota2.com/*) or spaceships in *EVE Online* (*http://www.eveonline.com/*) have sold for hundreds or thousands of dollars—one *EVE Online* player lost a ship valued at $11,000 in a 2013 virtual battle. Blizzard has perhaps been the most successful at selling virtual goods through its *Hearthstone* (*battle.net/hearthstone/*) card game and *Heroes of the Storm* (*battle.net/heroes/*) brawler. Neonmob (*https://www.neonmob.com/*) sells limited edition artwork that

users can collect and trade. The problem with all of these examples is that the goods are only valuable within the centralized worlds of these games or platforms. Goods cannot be bought or sold outside the confines of the game world, and buyers are subject to the whims of the centralized systems operating the platform.

General purpose ownership of digital goods has always been problematic because of how easily those goods can be copied and shared. An album in the MP3 file format does not have the same feeling of authenticity as a vinyl record of the same album, even though the sounds are nearly the same and the musical composition is identical.

Blockchains make it possible to create general purpose digital goods, artificially scarce crypto-tokens that represent 'status', like Document Coin, or general purpose ownership of unique editions like those offered through ascribe. These virtual goods on a blockchain rely on cryptography to create value, not on a centralized platform. Even if the platform disappears, the digital asset can maintain its value.

BEYOND MONETARY INCENTIVES

Ironically, although blockchains have been brought into being by the Bitcoin currency, they open possibilities to move creative works beyond the opposing binaries of "free" and "expensive". The current Internet is characterized by a binary opposition between nearly free, which in the context of intellectual property means universal piracy, and expensive, which means slick corporate websites and DRM. We can do better.

Ted Nelson's Xanadu project was about bringing life to a "transpublishing zone" intended to be mutually beneficial to copyright holders and those who wish to use their copyrighted works. Bitcoin and other blockchain technologies can be applied to build a generalized system of micropayments for creators that would both operate in the background and serve as the basis for customized, flexible payment applications programmed by second and third parties.

Blockchains allow us to consider the reality of economies based solely on reputation, where participation and contribution are incentivized and rewarded even if there is no monetary value created. The innovations of Bitcoin and other virtual currencies allow an Internet of Creators to design and implement mechanisms for the conversion back and forth between symbolic or reputational wealth and monetary wealth.

7. DEMOCRATIZING IP FOR PUBLIC USE

Blockchain technology can help creators who wish to donate their efforts to the public domain. This can be true for both copyrightable and patentable works.

COPYRIGHT AND THE PUBLIC DOMAIN

Copyright automatically arises upon creation of a work. This is in many ways beneficial to creators, but it creates obstacles for creators who wish to see their work benefit the public as a whole as a part of the public domain.

Until very recently, it was not possible for creators to put their work into the public domain in a way that let people use it safely and reliably. From the user's perspective, unless the work was definitively in the public domain because copyright has expired, or a specific license was issued to them for the use of the work, there was always a risk that a rightsholder could claim rights to the work and allege infringement on the part of the user.

Creative Commons addressed this problem with the development of the CC0 license (*https://creativecommons.org/publicdomain/zero/1.0/*), which is designed to dedicate the work to the

public domain. A CC0 license is irrevocable. Once a work has been made available under the CC0 license, it can be used under that license for all time, but the issue of proof remains a concern to users. Blockchain registries could add another layer of protection, as discussed above in the section on orphaned works.

CHANGING THE FUTURE

Blockchain registration could also be used to state a creator's intention to dedicate the work to the public domain or release the work under a CC license at some later date. For example, a photojournalist could register her works on a blockchain together with a smart contract that would attach a CC0 license to the work at a future date, months or years in the future. She would still be able to exploit her work commercially in the "all rights reserved" copyright model for her chosen timeframe, but she can also be certain the public will see the benefit of her work long before the copyright formally expires. In a morbid example, it would be possible for a creator to create a smart contract that attaches a CC license to the work immediately upon news of her death, eliminating the concern that the creator's estate will have a different vision of the conditions under which her work should be made available.

PATENTABLE INVENTIONS

Blockchains hold a growing pool of technologies that anyone may legally use and reuse, without seeking permission. The existence of such public libraries accelerate collaborative innovation, generating and accruing public benefits. Inventors can register their ideas on a blockchain in the form of designs, mockups, code, blueprints, and so on. Then they assign a public license, signalling to the world that their invention may be used freely.

Through smart contracts, a blockchain could be set up to operate as an autonomous legal entity, capable of holding patents and defending itself against threats from patent trolls or other attackers.

Using a blockchain to safeguard technologies for public use generates several benefits:

a. contributors can receive feedback and suggested improvements on their unfinished work;
b. contributors themselves can (re)use ideas from a growing pool of permissionless technologies;
c. new technologies become collaborative efforts, rather than closed-silo approaches.

One potential example is a shared effort to solve a pre-determined problem. Using a blockchain-based organization, different entities attempting to solve the same problem may contribute their incremental steps toward a solution. Each piece of progress is registered on a blockchain. Rather than each working at the same problem alone, trying to "win the lottery", finding the solution becomes a shared effort. This collaboration reduces total effort and shortens the time to find a solution. Once a viable solution is found, each party could benefit from the result. The benefits could be distributed according to a predetermined scheme—perhaps each contributing member shares equally by being able to use the resulting invention, or perhaps future licensing fees are divided according to each party's proportional contribution. The different parties do not even need to know or trust each other.

8. CONCLUSIONS

The promise of the Internet is nothing less than an upgraded version of Jorge Luis Borges' imagined Library of Babel—a fantastic repository of all human knowledge, available anywhere, at any time, to anyone.

That dream has remained just out of reach. The same technologies that allow us to build the Library could mean its shelves lay bare, with users taking content without paying, and creators unable to support themselves in performing the creative efforts we all value. Despite endemic piracy, the amount of new information being created increases exponentially, posing technical challenges to our ability to reliably archive, index, and retrieve the content that is generated.

Blockchain technology moves us toward a solution to both of these problems. It allows:

1. Secure content registries tying creators and works;
2. Reliable decentralized content repositories that cannot lose information and are not vulnerable to censorship by authorities of any kind;
3. Micropayments to creators for every use of their works;
4. Automated smart contracts for sales, licensing, and novel uses of works; and
5. Entirely new forms of collaboration and creation that allow people who do not know or trust each other to work together.

Of course, blockchains are not without their drawbacks:

1. The immutable, perfect provenance offered by blockchain registries threatens user privacy.
2. The decentralized, censorship resistant nature of blockchain storage means that harmful or illegal content such as child pornography cannot be removed.
3. Smart contracts and micropayments could be used to limit access to those with the ability to pay for content rather than to encourage creation.
4. If information about a work is invalid at the point of entry to the blockchain, it may be difficult to correct.

With careful planning and a focus on ethics, blockchains can be developed and applied in a way that achieves the benefits while mitigating the risks. We look forward to building the real world Library of Babel.

BL■CKCHAIN
W■RKSH■PS

WORKING GROUP CONTRIBUTORS

This document is a collaborative effort stemming from the contributions of:

- **Primavera De Filippi**, *CNRS / Berkman Center for Internet & Society at Harvard*
- **Greg McMullen**, *ascribe*
- **Trent McConaghy**, *ascribe*
- **Constance Choi**, *Seven Advisory/COALA*
- **Simon de la Rouviere**, *Consensys*
- **Juan Benet**, *IPFS / Protocol Labs*
- **Diana J. Stern**, *Distributive*

THE BLOCKCHAIN WORKSHOPS ARE SUPPORTED BY OUR ACADEMIC PARTNERS