BITMARK

Defining Property in the Digital Environment

By Casey Alt, Sean Moss-Pultz, Amy Whitaker, & Timothy Chen

ABSTRACT

While physical goods are protected by a long history of private property rights, digital assets are, to date, essentially unownable. This paper examines and proposes solutions to the current problems of digital ownership by retracing the history of property in the West. We argue that, in accordance with the Coase Theorem, the establishment of property rights for real property and intellectual property has decreased negative externalities and fueled the major socioeconomic revolutions of the modern world. Similarly, the digital environment's most pressing negative externalities — from current epidemics of security breaches to rampant online piracy to the privacy intrusions inherent in mass surveillance — can be ameliorated by the introduction of digital property rights. What is needed is a trustworthy, secure, and enduring property system that is flexible enough to incorporate digital properties into any community's broader property rights traditions. As a solution, we propose Bitmark, a blockchain-based property system for the digital environment that expands and strengthens the Internet's essentially decentralized, open, and transparent ethos. The ability to establish ownership claims to digital assets — of well-understood forms of intellectual property such as music, movies and books but also for emergent and increasingly critical ones such as computer code, digital art, user-generated data and metadata — will transform many of the 21st century's largest negative externalities into a new asset class capable of powering the next economic revolution.

1. INTRODUCTION

> "It was a bright cold day in April, and the clocks were striking thirteen."—George Orwell, 1984

On July 17, 2009, Amazon Kindle owners awoke to discover that their *1984* ebooks, which they had paid for and thought they owned, had mysteriously disappeared. Amazon had remotely deleted the book overnight and credited customers' accounts for the purchase price. We have been led to believe that digital goods are like physical goods, only better. Yet this case proved

otherwise. If Amazon had sneaked into its customers homes in the middle of the night, taken some books off their nightstands, and left a little cash behind, they would have been accused of breaking and entering, trespass, and theft. How could a company headquartered in a country that champions individual property rights even consider such an Orwellian scheme, let alone get away with it?

The reason is simple: ownership of digital goods is nothing like ownership of physical goods. The underlying causes of this difference are complex, and unwinding the mess requires a return to the history of property and its first principles so that we may gain a clearer view of the specific problems plaguing the digital environment. We will use the general term *digital environment* to describe the multitude of interconnected computer software spaces, whether localized to personal devices or spread across the wider Internet and Internet-of-Things, through which digital assets circulate in all their various forms. From this vantage point, we will discuss the kind of property system that is needed — not only to remedy the current problems — but to provide a sustainable foundation upon which the larger economy can continue to move forward and thrive into future generations.

2. A BRIEF HISTORY OF PROPERTY

2.1. The Rise of Property

Figure 1. The evolution of property.

Historically, Western economic progress has been pushed forward by two all-encompassing legal frameworks that followed parallel trajectories at different times: private property and intellectual property. Before there was any modern notion of private property,

all property was owned either by the Crown or the Church. In England, *property* did not actually have a legal definition until the 17th century when the term entered popular parlance in reference to land ownership. Monarchs awarded selected individuals by granting them a title (e.g., "Duke," Earl," "Lord") which carried with it ownership rights to a specific parcel of land. These properties were made productive by the commoners who inhabited them as subsistence farmers. The commoners collectively worked the "commons" for the ultimate benefit of their landlords.

Starting in the 12th century, certain commoners undertook the radical enterprise of enclosing portions of land from the larger commons. Such acts were gradually recognized as a commoner's assertion of an exclusionary right to ownership of the land as well as to the fruits of their labor produced from the land. This movement accelerated in the 16th and 17th centuries despite strong objections from various factions of the nobility, and legislation was proposed to counteract the process. But Parliament faced a major dilemma. Enclosed land improved agricultural productivity to such a degree that significantly fewer farmers were needed. In fact, the migration of these displaced commoners to cities provided much of the labor force fueling the Industrial Revolution that was making England so powerful at the time. After weighing the various political pressures, Parliament sanctioned large-scale land reform in 1801, thereby ushering in the British Agricultural Revolution and unleashing a powerful new catalyst in the form of individual private property rights for land ownership.

The evolution of intellectual property followed a similar trajectory. As with land, early Europeans tended to view knowledge as a kind of commons. All human understanding was ultimately an expression of God's divine ingenuity and therefore was collectively held by everyone. However, in the same way that monarchs had awarded gifts of land titles to friends of the Crown, patents and copyrights emerged in the form of royally sanctioned monopolies. Patents conferred exclusive monopolies over specific markets or commodities, such as starch and salt. Copyrights conveyed the exclusive right of publishers to print and censor literary works. The Crown was so bold in its issuance of patent grants that commoners eventually revolted in 1624 and forced Parliament (again) to intervene and restrict patent awards to "projects of new invention" whose protections were only enforceable for a limited number of years. Shortly after, Parliament stepped in again to transform copyright protections from private legal privilege into a public law grant that was vested in individual authors rather than in publishers.

This synergy of private and intellectual property rights catapulted Western societies out of the darkness of feudalism and into an era of unprecedented economic progress and prosperity. Private property rights for land ownership enabled any commoner to become the king of his own castle and protected the freedom to improve one's "lot in life" through hard work and resourcefulness. Intellectual property empowered anyone to amass tremendous wealth through individual ingenuity and invention as a reward for creating something valuable to society. Both types of property secured a new form of sovereignty for individuals and together provided the necessary climate for the full flourishing of the Industrial Revolution, in which new mechanical inventions eased the burden on all humanity and increased the individual level of wealth and wellbeing across all classes.

2.2. The Need for Digital Property Rights

The enabling factor for this seismic social shift was the nascent realization that resources held in common are susceptible to inefficient use as well as to an inequitable depletion. This degradation of shared resources is caused by parties wishing to maximize individual gains at the expense of the collective, a condition often referred to as *the tragedy of the commons*. Present-day economists understand tragedies of the commons as the result of *negative externalities*, which are costs involuntarily incurred by parties external to an economic transaction. For example, air pollution from a factory is a negative externality if a factory does not pay to pollute the shared resource of clean air so that the larger society must bear the costs of the resulting damage to human health and the environment.

The economic solution to the problem of externalities is to "internalize" them by assigning property rights, such as carbon emission credits for the right to pollute the air. This understanding of the ability to internalize externalities via property rights was demonstrated in 1960 by the economist Ronald Coase, who was later awarded the Nobel Prize for work in which he showed that, in markets where there are externalities, assigning property rights allows the markets to value the externalities via private bargaining, assuming bargaining costs are low and property rights are clearly defined. Containerizing externalities via property rights transforms a complex social problem into a relatively straightforward business decision: the cost of the right to create an externality versus the cost of changing the business to avoid creating the externality in the first place. When properly implemented, property rights enable societies to convert tragedies of the commons into thriving new markets.

Our inability to clearly assign property rights in the digital environment has resulted in a catastrophic mess of externalities — a 12-trillion-gigabyte primordial soup of digital data as wide and as deep as the Internet itself and doubling in size every two years. In tandem, the repeated epidemics of centralized data breaches, mass surveillance, and state-sponsored incursions on privacy attest to the increasing negative externalities and prevalence of abuse. As with previous property revolutions, the most effective way to safeguard and develop undervalued resources is to establish property rights for them. What is needed is a property system for the digital environment that brings real property rights to digital assets, thereby transforming them from a growing social liability into an unparalleled new property class capable of fueling the larger global economy.

3. THE FIRST PRINCIPLES OF DIGITAL PROPERTY

3.1. What is Property?

At its simplest level, *a property is an asset plus a property title*. While most people probably consider property to be the stuff that they own, property is technically defined as the rules governing access to and control of assets, whether those assets are land, means of production, inventions, or other creative works. Within every society, laws known as *property rights* regulate which entities can assert ownership claims to which assets and what rights come with such property claims:

Figure 2. Property rights.

A valid ownership claim functions as a "bundle of rights" for a specific property and can include such rights as:

- the right to exclusive possession
- the right to exclusive use and enclosure
- the right to transfer ownership (conveyance)

- the right to use as collateral to secure a debt (hypothecation)
- the right to subdivide (partition)

Property rights are neither absolute nor static; they can vary widely across different societies and can change over time. In Medieval Europe, common law considered all water resources as being statically tied to the land rights in which they were located, such that landholders owned parts of rivers with full accompanying rights. Over time, property rights for water resources have generally changed from being land-based to use-based, thereby allowing non-landowners to hold enforceable property rights. Also consider how different national flavors of political and economic ideologies, such as capitalism, socialism, and communism, have differently dictated who can own which properties, e.g., communism mandating that all means of production can only be owned by the state.

Within most property rights regimes, a property title is the legal instrument by which an entity claims ownership of an asset. Property titles are often embodied in a formal legal document, such as a real estate deed or a motor vehicle title, which serve as physical evidence of the possessor's claim to property rights. One function of the property title is to uniquely identify the asset being claimed, most commonly by recording distinctive feature sets, such as geographic coordinates or geological features for land, or serial numbers, such as vehicle identification numbers (VIN) for motor vehicles. The moment that properties lose this unique identification, they become fungible commodities that behave more like money than like property. In order for money to circulate seamlessly and easily within a community, it must be completely fungible: It needs to be mutually interchangeable, functionally indistinguishable, and completely impersonal.[1] The moment someone values one dollar bill more than another is the moment the dollar bill ceases to be money and starts to be property. However, the opposite is true for property. To establish an enduring record of a property's authenticity, an asset's unique identifier must be recorded in the property title as a permanent and immutable pointer to the asset, such that the asset can always be identified from its corresponding property title.

A second function of a property title is to make the bundle of property rights portable by acting as a container that allows its rights to be transferred from one owner to another. For assets that require a property title, transfers of ownership must be publicly recorded via a centralized government entity, such as a county land registrar or a state department of motor vehicles, in order for the transfer of property rights to be legally recognized. This history of ownership, or *provenance*, is most often tracked via a formal

property system, which records the complete provenance of every registered property:

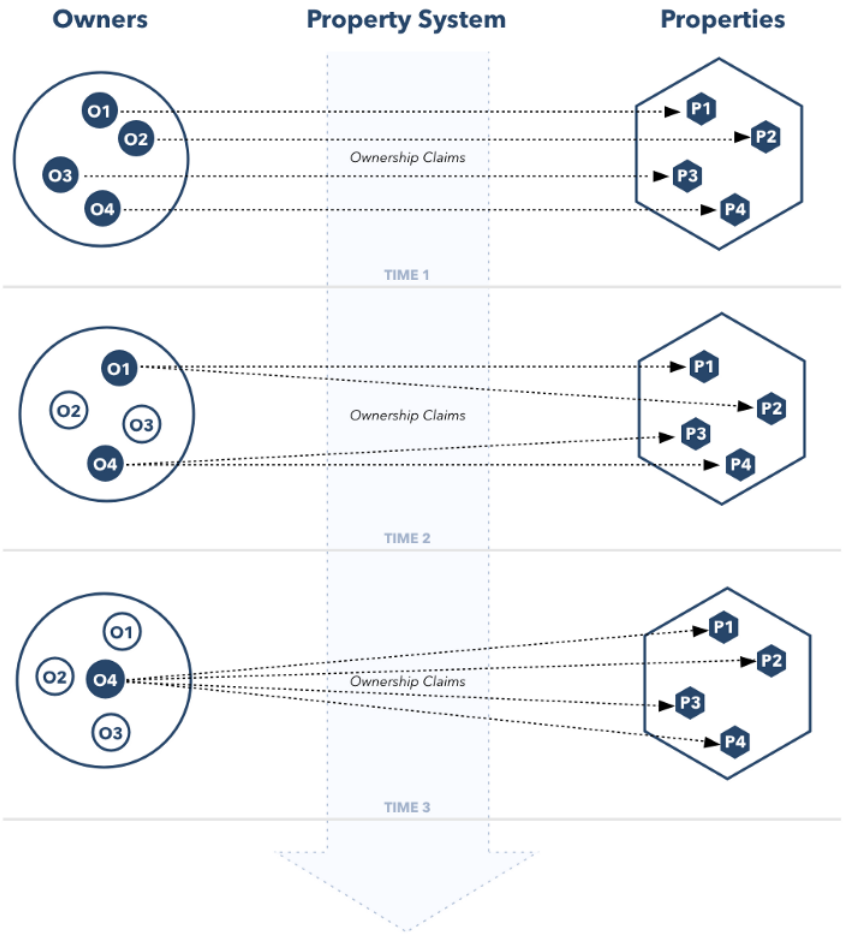

Figure 3. Property systems.

3.2. Piracy & Property Rights

In an ideal world, every property would have a property title. Property titles are the clearest legal means for defining private property rights. At the simplest level, *property is provenance*. The ability to demonstrate clean title is what protects one's investment in a property by guaranteeing strong provenance. However, current property systems suffer from high transaction costs, which is why property titles traditionally have been reserved for physical properties whose valuations are high enough to justify the property title costs, such as real estate, vehicles, or works of art. However, if these transaction costs could be reduced to near zero, property titles could be issued for any asset, thereby clarifying property rights and further reducing negative externalities resulting from ambiguous ownership claims.

The Peruvian economist Hernando de Soto Polar has gone so far as to argue that, particularly in developing regions, the lack of access to robust property rights systems is the primary underlying cause of many nations' most urgent negative externalities. According to De Soto, this inability to demonstrate legal ownership of assets compels many citizens, particularly small entrepreneurs, to seek extralegal remedies for their business problems since traditional means of judicial redress are only available to legal property owners. This massive exclusion from property rights systems results in the emergence of two parallel economies with disparate rules and risks: the official legal economy and a makeshift extralegal economy. It is the flourishing of extralegal shadow economies that generates many of the widespread negative externalities for their larger societies. De Soto coined the term "dead capital" to describe assets locked into such extralegal economies since their lack of property rights explicitly excludes them from becoming wealth-generating property within the larger global economy.[2]

Within the digital environment, there exists a similar extralegal shadow economy in the form of online piracy of copyrighted works. While it is tempting to depict the rise of piracy as an unfortunate side effect of contemporary digital technologies, copyright infringement is as old as copyright itself.[3] However, the recent prevalence of online piracy begs the question: What is it about the current state of digital assets that impels people, who in any other context would never commit crimes of piracy or theft, to engage in acts of piracy? While there are undoubtedly cases of piracy that are a simple matter of people wanting to get something without paying for it, De Soto's research suggests that, more often than not, such recourse to extralegal solutions stems from too few property rights rather than too many. In the absence of readily available property rights for desired digital assets, otherwise law-abiding citizens resort to piracy to get what they want. Consider that a large portion of piracy occurs in countries that lack international licensing agreements to access high-demand digital assets. A more inclusive and universally accessible property system with low transaction costs that establishes clear property rights for digital assets could radically reshape the current piracy landscape by transforming disenfranchised pirates into invested property owners.

3.3. Privacy in the Digital Environment

Finally, it is important to recognize that, in the case of digital assets, there is a significant convergence of private property rights and rights to personal privacy. These seemingly unrelated sets of rights were once intrinsically linked. Historically, the ability to

circumscribe an area of land as one's own created an adequate level of protection of personal privacy through defense against unsolicited trespass.[4] Thus, the fundamental right to private property also served as protection to personal privacy by clearly defining exclusive access rights to properties.

As new technologies have developed, courts have continuously needed to reinterpret the relationship between private property and privacy rights beyond the boundaries of physical properties by extending privacy protections to "people, not places."[5] These protections have included rights to privacy for posted correspondence, phone conversations, and any form of personal communication in which the content is presumed to be private. Unfortunately, however, these core personal privacy protections have not been as reliably applied to the Internet and personal data. A primary reason for these shortcomings is that most privacy laws are focused solely on protecting the *content* of digital communication while totally disregarding privacy protections for user *metadata*, which is often more revealing than the actual content itself. As an example, consider the fact that a mobile device's detailed log of user location data is usually not protected, despite the fact that the ability to surveil someone's daily movement patterns is, in most cases, a much more threatening privacy intrusion than monitoring any authored content transmitted from the device.

Online data privacy faces an additional complication with the continued popularization of social media applications and a growing trend towards centralized, third-party cloud computing platforms, both of which customarily require users to voluntarily store personal data on their remote servers. Under many legal systems, the act of voluntarily giving private information to third parties is considered an explicit forfeiture of any expectation to privacy rights over that information. The result of this voluntary surrender of privacy is that government authorities have been permitted to bypass traditional protections against search and seizure without first demonstrating probable cause and obtaining judicial search warrants. Within the context of digital data assets, this doctrine has been interpreted such that any third-party Internet service that stores user data — including everything from Internet service providers, cellular data providers, social media websites, and cloud storage services — must comply with government requests to access to that data, thereby significantly weakening privacy protections across nearly every category of contemporary digital communication practices.
The ability to convert digital assets into properties offers a way out of this privacy dilemma by realigning rights to private property and rights to personal privacy — that is, essentially creating the digital

equivalent of a fence that affords digital property the same bundle of private property and privacy rights historically attached to land. It is in this potential to protect digital property that we most clearly recognize that private property and privacy are two sides of the same coin.

A property system for digital properties must therefore offer both legal and technical affordances for protecting property rights and privacy rights. At the legal level, the property system must integrate into existing property rights frameworks to such an extent as to guarantee exclusionary access to the data in the same way that exclusionary access is afforded to physical properties. At the technical level, the property system must provide a minimum capacity for heightened security and privacy through strong encryption practices and other barriers to unauthorized access in the same way that security fences or monitoring systems provide an added measure of privacy for physical properties.

4. BITMARK: THE PROPERTY SYSTEM FOR THE DIGITAL ENVIRONMENT

4.1. Bitmarks as Digital Property Titles

As a solution, we propose Bitmark, the first property system for the digital environment. The Bitmark system achieves extremely low transaction costs by supplanting conventional centrally controlled property systems with a shared, distributed ledger for recording digital property titles, or *bitmarks*, for any digital asset. A bitmark consists of four basic elements:

- *an asset fingerprint*
- *asset metadata*
- *an owner account*
- *a digital signature*

A bitmark's *asset fingerprint* is created by applying a cryptographic hash function to a digital asset. The resulting fingerprint is an alphanumeric value that uniquely and permanently identifies the digital asset. The *asset metadata* consists of the property's name and relevant attributes, as defined by the bitmark's original issuer. The *owner account* identifies the current owner's Bitmark account number, which is a cryptographic public key. The owner may choose to publicly link his or her identity with this account number, depending on the desired level of privacy. A *digital signature* is a secure mark of authenticity that is appended to the bitmark when first issued or whenever it is transferred to a new owner. One way to think of a bitmark is as an unforgeable chain of digital signatures that form the property's provenance.

4.2. The Bitmark Blockchain

To enable this recording of property titles across the full depth and breadth of the Internet, Bitmark supplements existing methods for tracking provenance with a globally accessible property ledger known as the *Bitmark blockchain*. Blockchain technology is the key innovation of the Bitcoin currency and refers to a digital ledger that is publicly yet anonymously shared to all members of a peer-to-peer network. The Bitmark blockchain contains every single property title and ownership transfer ever recorded in the Bitmark system. This Internet-native ownership registry allows the Bitmark system to satisfy all the functional requirements of conventional property systems in a single public data resource:

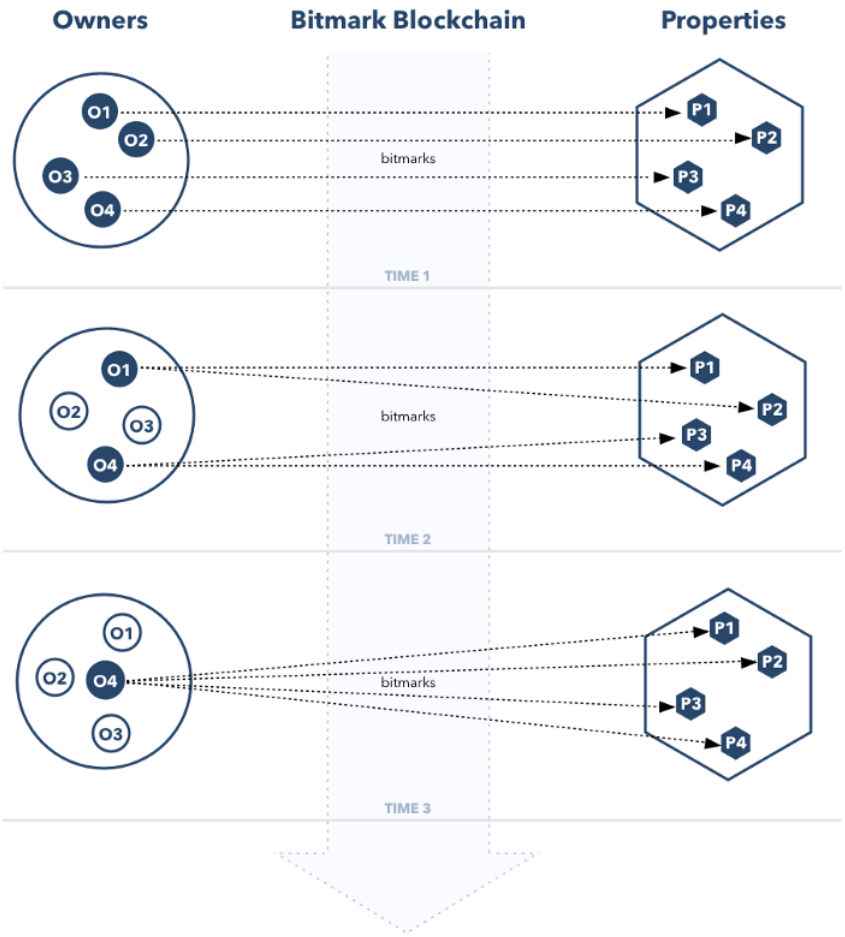

Figure 4. The Bitmark blockchain.

At a more granular level, each bitmark consists of a chain of transfer records that weaves in and out of different blocks of transactions to create its provenance. The authenticity of each property's provenance is maintained by continuously verifying this chain of owner signatures.

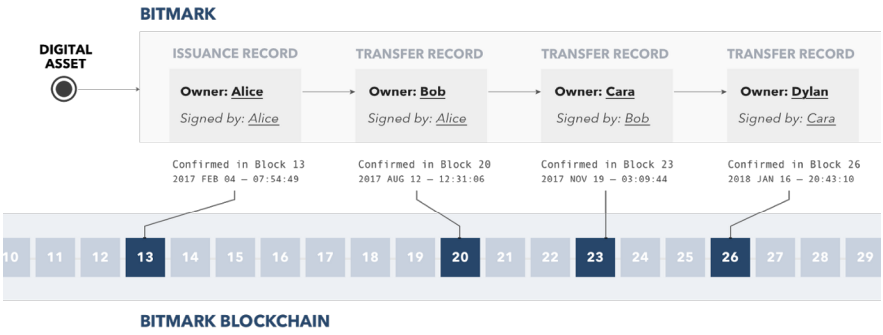

Figure 5. A bitmark's chain of signatures.

As an example, consider figure 5 above, in which a Bitmark user named Alice issues a bitmark for a specific digital asset. Her Bitmark app first uses a cryptographic hashing function to generate a unique fingerprint for the digital asset along with an issuance record for the bitmark which lists Alice as the owner. Alice's app also digitally signs the issuance record with her private key. Once it has been verified by the Bitmark network, this issuance record is aggregated into latest block of the Bitmark blockchain (let's say block 13). When Alice later wishes to transfer ownership of the property to Bob, Alice directs her Bitmark app to create a transfer record that contains a link back to her previous issuance record, designates Bob as the new owner, and digitally signs the transfer record with her private key. Once this transfer record has been verified by the network to contain an authentic signature from the current owner (Alice), the transfer record is recorded in block 20 of the blockchain, at which point ownership passes to Bob. This method of requiring the current owner to digitally sign ownership transfers creates an unforgeable provenance for a property. The Bitmark system has been architected to support multiple digital signing methods, including digital signatures that guard against the possibility of future attacks from post-quantum computers.

4.3. Strength through Decentralization

Unlike conventional property systems that rely on a handful of trusted government officials to act as centralized gatekeepers, the Bitmark blockchain is an open and transparent property system that is strengthened through the active participation of anyone on the Internet. The integrity of Bitmark's open-source blockchain is ensured by a peer-to-peer network of voluntary participants running the Bitmark node software called *bitmarkd*. These software nodes are incentivized to participate in verifying Bitmark property transactions through the possibility of winning monetary and property rewards.

Every Bitmark property transfer requires a nominal transaction fee. One reason for this fee is to discourage vandals from spamming the blockchain. A second reason is to motivate the participating nodes to independently compete against one another to be the first node to verify the current block of transactions and "win" that block. A node wins a block by solving a difficult computational problem called a *proof-of-work*, which functions like a lottery to randomly select a winner.

Whenever a node announces itself to the network as the winner of a block, it presents its result so that the entire peer network can instantly check the proof-of-work and validate the block's transactions. After confirming the block's validity, non-winning nodes "vote" for the winner by adding the block as the next block in their local blockchains. The block winner is then awarded all the aggregated transaction fees for that block. As an added incentive, the Bitmark system treats the blocks that comprise its blockchain as digital properties in and of themselves, and the block winner is also issued a bitmark for that block. Block owners are entitled to collect royalties on all future property transfers for properties whose issuance records are recorded in their blocks. The ability for nodes to win ownership of blocks not only creates a further incentive for node participation but also reduces transaction costs for adding digital properties to the Bitmark system to near zero.[6]

This strategy of rewarding an open network of peers for competitively verifying the results of one another's work creates an impregnable security model that is an emergent property of the individual peer interactions themselves. Unlike centralized property systems, which suffer from increased negative externalities as larger populations exploit the shared resource, Bitmark's decentralized blockchain grows more resilient and valuable as the network grows. As a method for encouraging the widest possible participant base, the Bitmark blockchain has been designed to resist centralized monopolization of network node resources. Unlike preceding blockchains, many of which have become vulnerable to the outsized influence of a few well-financed mining pools, the Bitmark blockchain has implemented a proof-of-work algorithm that has proven itself largely impervious to the high-end custom mining hardware that has led to the inequitable concentration of Bitcoin mining power, thereby diversifying node participation and fostering cost-competitiveness among independent participant nodes.[7] Wherever possible, Bitmark has endeavored to build upon the lessons of pioneering blockchain systems to broaden network participation because a more diverse and decentralized participant community means a more robust property system for everyone.

4.4. Data Privacy through Digital Property

Bitmark affirms individual privacy rights within the digital environment by, first, allowing anyone to create private property from any type of digital asset and, second, by implementing strong encryption measures for the digital assets themselves. The ability to convert any type of digital assets—whether content or metadata—into private property makes any unauthorized data access a violation of one's property rights, thereby providing an added measure of legal defense against unwarranted search and seizure of digital properties. Asserting explicit private property claims are particularly advantageous in incipient domains where digital property rights remain murky, such as device location data, Internet-of-Things traffic, or collaboratively authored social media content. As more of our daily activities are inconspicuously scattered across different third-party cloud servers, Bitmark offers a mechanism for asserting clear ownership claims to personal data, even in cases where individuals have voluntarily consented to provide their data to third-party services.

There will undoubtedly be cases where governments or other entities succeed in circumventing Bitmark's legal and technical privacy protections and obtain access to owners' properties, whether through legitimate due process, abuses of power, or radical political upheaval. History is replete with examples of asset forfeiture, eminent domain, expropriation, and nationalization, in which the powers that be have forcefully seized selected populations' properties and subsequently reallocated their property rights. One of the glaring liabilities of government-administered property systems is their inherent susceptibility to the vagaries of political climates. By providing a shared global property ledger independent from any single institution, regime, or hegemony, the Bitmark blockchain serves as a permanent and politically agnostic record of ownership claims. While the blockchain can never prevent the possibility of government confiscation of one's assets, it does provide an enduring record of ownership claims that can serve as grounds for future contestation of property rights should political conditions change.

In addition to providing increased legal defensibility of digital properties, Bitmark employs strong technical measures for protecting digital assets during transfer and storage. By default, Bitmark encrypts all digital assets so that only verified property owners can access their properties. Whenever a property's bitmark is transferred to a new owner, the corresponding asset is encrypted then transferred so that only the new owner can access it. This method of end-to-end encryption affords asset protection for local or remote storage in addition to safe asset transfer over the

Internet or across peer-to-peer file-sharing networks.

Finally, the Bitmark system protects owners' identities by default. Even though every bitmark issuance and transfer record is freely accessible in the public Bitmark blockchain, these records only contain references to owners' cryptographic public keys, which function as pseudonymous identifiers devoid of any personal information. In cases where owners wish to have their accounts tied to their personal identities, they can opt to publicly link their Bitmark public key to other verifiable means of identification, including web domains, Twitter accounts, and GitHub accounts. This combination of asserting private property rights over digital assets as a legal safeguard for data privacy in conjunction with leveraging strong encryption protocols for protecting the privacy and integrity of the digital assets achieves a level of privacy protection commensurate with long-standing protections for physical properties.

4.5. Towards a Healthy Digital Environment

The Internet's earliest pioneers and homesteaders demonstrated little regard for something as prosaic and establishmentarian as property rights. To them, the early Internet held the promise of a vast, utopian frontier where humans could transcend the age-old restrictions of physical existence and come together in an unfettered society of the mind.[8] For these early explorers, the Internet's lack of property rights was not a bug, but a feature. Yet for all the romantic allure of frontiers, the Internet has turned out to be a pretty rough place, precisely because it lacks the rule of law that has developed to protect individual rights within modern societies. In frontiers, more often than not, might makes right, and one person's new-found liberation is another's negative externality.

The Internet has democratized communication to such a degree that today anyone with a networked device can instantly connect to hundreds of millions of people. A teenager with a smartphone and a Facebook account can become an Internet sensation overnight. But for most of its existence, the Internet has not possessed a similarly democratized means for valuing what happens in its spaces. E-commerce exists, of course, but primarily only as high-friction articulation points between the Internet and conventional financial systems. It is ironic that credit cards, whose security model hinges on absolute privacy of account numbers, have become the default payment method for the Internet. When limited to the physical point-of-sale payments for which credit cards were originally designed, their fraud risk was manageable. Credit card designers never anticipated that people would voluntarily give their credit card numbers to anonymous entities

on the Internet. Retrofitting the ill-suited credit card system to underpin e-commerce has required a monumental centralization of technical and commercial infrastructure, which has largely come at the expense of increased fees for merchants and greater incursions on individual customer privacy than are necessary for the lion's share of online transactions.

If one considers the level of decentralization and privacy afforded by simple physical cash, e-commerce gateways represent a large leap away from the decentralized spirit of the Internet rather than a step toward it. Only with the advent of Bitcoin in 2008 did the Internet have its own truly endogenous currency—a unit of exchange as decentralized as the Internet itself. Suddenly, anyone with a networked device could freely engage in the kinds of financial transactions that had previously been the exclusive domain of sovereign states and their monetary trustees. Suddenly, the frontier had a native means for anyone in the world to exchange money as safely and privately as one might exchange a text message or selfie.

Just as e-commerce sites offered an intermediate remedy to the problem of payments on the Internet, "digital rights management" (DRM) has served as a stopgap for the lack of an Internet-native property system. However, DRM concentrates too much power in the hands of a few centralized gatekeepers at the expense of individual property rights for everyone else. Although DRM platforms position themselves as altruistically doing the heavy lifting required to make the digital economy work, the reality is that DRM platforms only serve their own interests by further locking both creators and consumers into their platforms. While DRM offers the semblance of digital property rights, in actuality DRM functions more as an extralegal police force that—as cases like Amazon's 1984 incident have made clear—is solely concerned with hamfisted enforcement of its own platform policies, even at the expense of trampling over long-established individual property rights.

Conversely, property rights offer an elegant solution that *has already evolved to be decentralized* in the same way that physical currency is already decentralized. Centuries of legal precedents have already balanced property rights to protect both creators and owners. What is needed, therefore, is not the engineering of a new kind of police force for the digital environment but rather an Internet-native property system that brings already established property rights to digital assets. What is needed is a system that allows anyone to safely and easily claim and transfer property rights in the digital environment as safely and easily as they can transfer physical properties.

Bitmark has built this property system for the digital environment. Particularly with the emergence of the Internet-of-Things, we are realizing that the Internet is not some idealized, disembodied, virtual realm that is discontinuous with our physical realities. Rather, the Internet is deeply embedded in our physical world and increasingly orders and controls its relations. This convergence between physical and digital environments makes establishing clarity around digital property rights all the more urgent. The Internet can no longer be governed by a frontier code. The resultant negative externalities—from widespread privacy intrusions to rampant online piracy to entire asset classes mired in dead capital—are just too numerous and too acute to remain unaddressed. We have reached a tipping point at which we must pose the same question of the digital environment that we have previously asked of our physical environment: Are we creating the kind of world that we want future generations to inherit?

Bitmark both strengthens and expands the Internet's essentially decentralized, open, and transparent ethos. The Bitmark blockchain supplants the byzantine jumble of archaic, expensive, and incompatible state-controlled property systems with a single cryptographically secure, extremely low-cost, and globally accessible system for tracking properties and provenance. By bringing both market forces and the rule of law to the digital environment, Bitmark allows creators to exert clear ownership claims to digital properties so that they can be fairly recognized and compensated for their efforts. Similarly, Bitmark extends real property rights to consumers by granting them full control over the disposition of their properties. As an all-inclusive property system that respects and accommodates jurisdictional differences, Bitmark broadens the types of commerce that can occur, thereby reducing the expediency of solutions that result in negative externalities. This ability to extend economic participation to every corner of the Internet creates value for the larger global economy by transforming the digital environment's deepening morass of negative externalities into a new property boom capable of powering the next major economic revolution.

Notes:

1 A fascinating early legal precedent establishing this fundamental distinction between money and property is the 1749 Scottish court case Crawford v. The Royal Bank, as discussed in Reid, Kenneth, “Banknotes and Their Vindication in Eighteenth-Century Scotland” (May 1, 2013). David Fox and Wolfgang Ernst (eds), Money in the Western Legal Tradition (Oxford University Press, 2014, Forthcoming); Edinburgh School of Law Research Paper №2013/19. Available at SSRN: http://ssrn.com/abstract=2260952.

2 Hernando De Soto Polar, The Mystery of Capital (UK: Black Swan, 2000).

3 Prior to the Statute of Anne in 1710 which established modern copyright protections in England, anyone violating the Stationers’ Company of London’s royally granted monopoly on printing was labeled a “pirate” and laws were created to punish such offenses.

4 In the U.S., the Fourth Amendment provides the explicit legal “right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures,” except in cases when probable cause merits a government search warrant.

5 From the U.S. Supreme Court case Katz v. United States, long-considered a key ruling for privacy rights in which the Court broadened privacy protections from physical property and effects to any area or communication medium in which a person has a “reasonable expectation of privacy.”

6 As a deterrent to prevent bad actors from spamming the Bitmark blockchain, bitmark issuance still requires a small fee, payable either as a proof-of-work result or a nominal bitcoin fee.

7 For a discussion of this problem, see Phillip Rogaway, “The moral character of cryptographic work,” Cryptology ePrint Archive, Report 2015/1162. 2015. http://web.cs.ucdavis.edu/~rogaway/papers/moral-fn.pdf.

See, for example, John Perry Barlow, “A Declaration of the Independence of Cyberspace,” February 8, 1996. https://www.eff.org/cyberspace-independence.

About the authors:

Casey Alt (Head of Design, Bitmark Inc.) is an artist whose research explores how computational technologies have transformed various forms of cultural production. He frequently writes about media practices as diverse as bioinformatics to architecture and 3D modeling programs to video games. Alt holds a BA in Human Biology and an MA in History & Philosophy of Science both from Stanford University and an MFA in Design | Media Arts from UCLA. Previously he has held professorships at Duke University and Columbia University and has worked with Sean Moss-Pultz on a number of projects, such as the social reading platform Intelligencia.

Sean Moss-Pultz (CEO, Bitmark Inc.) is an expert in developing technology for consumer electronics and Internet services, especially blockchain-related projects. Prior to

Bitmark Inc., he was a senior executive for EMQ Limited, a financial technology startup. Recognized as a pioneer of open-source hardware, Moss-Pultz launched and was CEO of Openmoko Inc., the first open-source phone and a precursor to iPhone and Android smartphones. He has led his dedicated team of specialists across a number of successful projects who have now joined him at Bitmark Inc. Moss-Pultz holds both a BS degree in physics and a BA degree in mathematics from UC San Diego.

Amy Whitaker (Advisory Board Member, Bitmark Inc.) is an assistant professor of Visual Arts Management at the Steinhardt School of Culture, Education, and Human Development at New York University. She is the author of Art Thinking (Harper Business, 2016) about how creativity and commerce come together. Whitaker holds both an MBA from Yale and an MFA in painting from the Slade School of Fine Art and researches ownership rights around creative work. She is an entrepreneur-in-residence at the New Museum Incubator in New York.

Timothy Chen (Board Member, Bitmark Inc.) is CEO of VIA Technologies, Inc., China, a leading worldwide innovator of PC silicon and platform technologies. Chen also holds board and advisory positions at a number of technology companies and is involved in social ventures, social media, premium content providers, hardware companies at the semiconductor and system level, and an angel investor. Chen holds a BE in Engineering from UC Berkeley and is listed as a World Economic Forum Young Global Leader.