

Blockchain: Digitally Rebuilding the Real Estate Industry

by

Avi Spielman

B.A., Philosophy, 2008

Vanderbilt University

**Submitted to the Program in Real Estate Development in Conjunction with the Center for Real Estate in
Partial Fulfillment of the Requirements for the Degree of Master of Science in Real Estate Development**

at the

Massachusetts Institute of Technology

September, 2016

**©2016 Avi Spielman
All rights reserved**

The author hereby grants to MIT permission to reproduce and to distribute publicly paper and electronic copies of this thesis document in whole or in part in any medium now known or hereafter created.

Signature of Author _____ **Signature redacted**

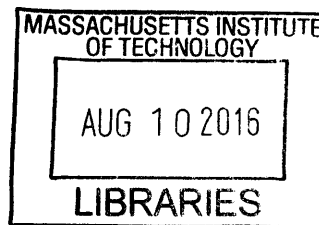
~~Center for Real Estate
July 29, 2016~~

Certified by _____ **Signature redacted**

~~John F. Kennedy
Lecturer, Center for Real Estate
Thesis Supervisor~~

Accepted by _____ **Signature redacted**

~~Professor Albert Saiz
Daniel Rose Associate Professor of Urban Economics and Real
Estate, Department of Urban Studies and Center for Real Estate~~



ARCHIVES

Blockchain: Digitally Rebuilding the Real Estate Industry

by

Avi Spielman

Submitted to the Program in Real Estate Development in Conjunction with the Center for Real Estate on July 29, 2016 in Partial Fulfillment of the Requirements for the Degree of Master of Science in Real Estate Development

ABSTRACT

There are tremendous potential applications for blockchain technology, an innovative distributed ledger database system, within the real estate industry. This paper will explore one aspect- recording property titles- by comparing the benefits and limitations of a blockchain with those of the current record keeping system.

This paper will begin with a brief overview of the current state of the title recording system in the U.S. followed by a deeper look into the procedures of one rapidly growing American city, Nashville (Davidson County), Tennessee. The goal is to understand current real estate title systems and technologies in order to identify their benefits and limitations.

Next, this paper will introduce the concept of blockchain technology, starting with a high level technical overview of how the technology works, as well as its benefits and limitations. It will also examine Bitcoin, which operates on the largest blockchain, as a potential model, whose practical applications may be adapted in creating a more efficient and safer title registry system. Recommendations will then be made for possible methods of implementing a blockchain-based registry and how its use might change the way real estate title transactions are handled in Davidson County, TN in order to determine if the collective benefits outweigh the costs.

The research to date leads to the following conclusions: A blockchain title recording system *is* the future of title record keeping and would provide immediate benefits over the current title recording system, with additional benefits accruing in the future as blockchain technology grows in acceptance. However, at the moment, these benefits do not yet outweigh the costs and challenges associated with implementing a prototype blockchain title registry system in Davidson County, or elsewhere in the country. That being said, steps can, and should be taken now to lay the foundation for a blockchain system.

Thesis Supervisor: John F. Kennedy
Title: Lecturer, Center for Real Estate

Table of Contents

I.	Recorder of Deeds.....	5
II.	Davidson County, Tennessee: Introduction.....	6
	A. Davidson County: Deeds.....	7
	B. Davidson County: Register of Deeds Workflow Analysis	8
	C. Davidson County: Register of Deeds Technology Overview	11
	D. Davidson County: Tax Assessor Workflow Analysis	12
	E. Davidson County: Tax Assessor Technology Overview.....	13
III.	Title Insurance: Introduction.....	15
	A. Title Insurance: Current System.....	17
	B. Title Insurance: Pain Points.....	19
	C. Title Insurance: One Local Firm’s Experience.....	21
	D. Title Insurance: An Underwriter’s Perspective.....	23
	E. Title Insurance: Old Republic’s Workflow & Technology	25
	F. Title Insurance: Summary.....	27
IV.	Blockchain: Introduction.....	30
	A. Blockchain: How It Works.....	31
	B. Blockchain: Public or Private?.....	34
	C. Blockchain: Limitations.....	35
V.	Bitcoin: Introduction.....	38
	A. Bitcoin: Benefits.....	40
	B. Bitcoin: Limitations.....	41
VI.	Blockchain: Title Registry Applicability.....	42
	A. Blockchain: Title Registry & Colored Coins.....	43
	B. Blockchain: Title Registry & Applying Colored Coins to Davidson County.....	45
	C. Blockchain: A Hybrid Model for Title Registry.....	46
	D. Blockchain: Limitations to Applicability in Title Registry.....	47
VII.	Blockchain: Title Insurance.....	49
VIII.	Conclusion.....	52
	Works Cited.....	61
	Appendix A – Real Estate Terminology.....	64
	Appendix B – Blockchain Terminology.....	67
	Appendix C – Warranty Deed.....	69
	Appendix D – Special Warranty Deed.....	70
	Appendix E – Quitclaim Deed.....	71
	Appendix F – Register of Deeds Correction Form	72
	Appendix G– Handwritten Deed from John Donelson to Andrew Jackson (1793).....	73
	Appendix H – Example of Blockchain “Block”.....	74
	Appendix I – Example of Blockchain “Hash”.....	75
	Appendix J – Possible Statutory Language for Blockchain Recognition.....	76

Acknowledgements

In memory of my grandfathers: Rabbi Leon Spielman and Zev Vishnia, of blessed memories.

In honor of my parents: Yael and Eli Spielman and Karen and Fred Yazdian.

With gratitude to my siblings: David Spielman, Dani and Josh Spielman, Tal and Seth Yazdian.

Thank you Michael Casey and Brian Forde of the MIT Digital Currency Initiative and Simon Johnson of the MIT Sloan School of Management for introducing me to blockchain through their courses and activities.

Thank you John F. Kennedy for being a great thesis advisor and mentor.

Thank you Professors Tod McGrath, David Geltner, Walt Torous, and Dennis Frenchman for guiding me through the Masters of Science in Real Estate Development program.

Special thanks to the “Cap Rate Kids” and my “FaMiTy” for being the ultimate peers, friends, and teachers.

With love and admiration to my wife, Rachel Yazdian Spielman, without whom none of this would have been possible.

For my son, Jonah Lavie Spielman, the greatest gift Boston bestowed upon me.

I. Recorder of Deeds

Most of the industrialized world uses land registration systems for the transfer of land titles or interests in them.¹ The Torrens title system is the basis for land registration systems in several common law countries, such as Great Britain. Under these systems, the government determines title ownership and encumbrances using land registration, as opposed to deeds. The objective of this system is to simplify land transactions, since a person wishing to take part in a purchase or sale of property can rely on the information on the register as accurate and absolute. A few jurisdictions in the United States (U.S.), such as Minnesota and Massachusetts, have adopted a form of this system. In fact, at one time or another, at least 20 U.S. states have experimented with various other title registration systems, including Torrens, but eventually return to the land recording system.

The majority of U.S. states have opted for a land recording system. With land recording, there are no governmental officials to make absolute determination of who owns title to a property or whether the instruments transferring the title are valid. As opposed to a *registration* system, in a *recording* system, the person wishing to partake in the transfer of title must look beyond the information recorded at the Register of Deeds and establish a concrete chain of title in order to transact safely. As such, a recording system provides a framework for determining whom the law will protect with relation to those titles and interests when a dispute arises.

The recorder of deeds (for whom different jurisdictions have different titles) provides a single site at which records of real property rights are recorded and may be researched by interested parties. The recorder of deeds maintains regularly recorded documents such as:

¹ Arrunada, Benito. "A Transaction Cost View of Title Insurance and Its Role in Different Legal Systems." *Geneva Papers Geneva Papers on Risk and Insurance - Issues and Practice* 27.4 (2002): 582-601. Web.

deeds, mortgages, mechanic's liens, releases and plats, etc. Several indices are maintained that provide access to deeds historically recorded including grantor-grantee indices, tract indices, and plat maps. Various storage methods may include paper, microform, and computer databases.²

II. Davidson County, Tennessee: Introduction

According to the United States Census Bureau, as of 2013, there a total of 3,143 counties (and county-equivalents) in the country,³ 95 of which are located in the state of Tennessee.⁴ Research and analysis for this paper were conducted in Davidson County (i.e. greater Nashville).

Property titles in Davidson County are recorded at the Register of Deeds (ROD), an office established under Tennessee state law as the custodian of such real property legal documents. These include warranty deeds, deeds of trust, releases, powers of attorney, liens, plats, amendments, and other miscellaneous pertinent documents.⁵ Register of Deeds Bill Garrett is the current elected official overseeing the office and practices of ROD.

Standard local practice is to have title "checked" at the office of the Davidson County Tax Assessor (TA). Here, individual Property Record Cards are created and maintained for every parcel of property in the county (approximately 236,000). These record cards belong to a database in the Computer-Assisted Mass Appraisal (CAMA) system. Information included on these cards list, among other items, the street address of the property, the name(s) and address(es) of the owner(s), the parcel identification number, and the subdivision name.

² "Recorder of Deeds." *Wikipedia*. Wikimedia Foundation, 19 May 2016. Web. 1 June 2016.

³ "County Totals Datasets: Population, Population Change and Estimated Components of Population Change: April 1, 2010 to July 1, 2012". *2012 Population Estimates*. United States Census Bureau, Population Division. March 2013.

⁴ "Chief Deputy of Operations Kimberly LeGate, Register of Deeds." Personal interview. 7 June 2016.

⁵ "Davidson County Register of Deeds." *Nashville Register of Deeds*. N.p., n.d. Web. 1 June 2016.

The TA's office also maintains a set of some 2,000 maps for all properties in the jurisdiction in order to maintain size, location, and boundary information. These maps are constantly updated through the use of data contained in transfer deeds, registered surveys, and recorded plats of subdivisions. Currently, the TA is overseen by an elected official, County Assessor George L. Rocker Jr.

II.A. Davidson County: Deeds

Five primary deeds⁶ can be submitted for recording at the Davidson County ROD: master deed; warranty deed; quitclaim deed; installment deed; and deed of trust

- *Master Deed* -- Created by a developer and used to obtain approval from the planning commission. It covers the subdivision of a property as well as rules and regulations. Note: A master deed does not convey property.
- *Warranty Deed* – This is a general sale of property. It reveals that a person has a good right and title to sell the property (Appendix C & Appendix D).
- *Quitclaim Deed* – The most popular type of deed in Davidson County, this is often the deed of choice when the seller and buyer know each other. Since a quitclaim deed strictly conveys interest in a property (as opposed to a purchase of interest), it is often used to indicate additions or divisions in ownership (e.g. marriages or divorces). [Interestingly, the Davidson County Registrar finds this method of conveying title problematic: With a warranty deed, for example, the state requires a conveyance tax to be paid at \$3.70 / \$1,000 of sale. In the “oaths of consideration” provision of the warranty deed, the seller declares the value of the transaction, which is the greater value of the property or sales

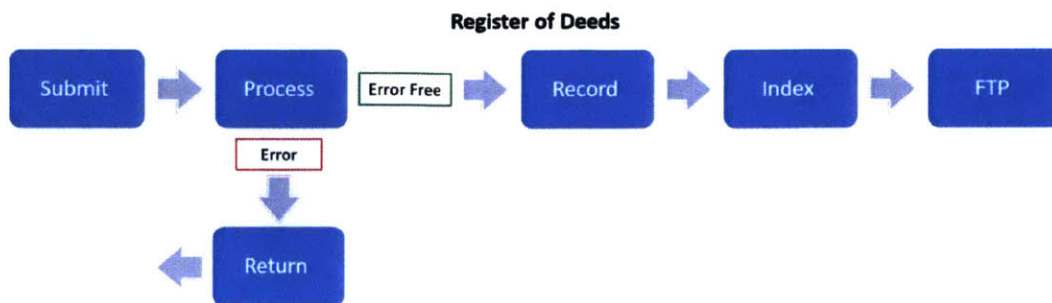
⁶ See formal legal definitions in the “Real Estate Terminology” section in Appendix A.

price. In a quitclaim deed, however, one can avoid paying the conveyance tax by claiming the value to be “\$0”] (Appendix E).

- *Installment Deed* – This is the least commonly used deed in Davidson County. An installment deed is similar to seller financing. The buyer agrees to pay a monthly installment, usually for a set period of time, with a balloon payment at the end. If the buyer is unable to make an installment payment or the balloon payment, the seller may cancel the contract and keep the land as well as the money paid to date. While similar in concept to a mortgage, the cancelation of an installment deed is much easier than mortgage foreclosure proceedings. Moreover, an installment deed acts as a one-stop-shop, handling all the deeds within one document.
- *Deed of Trust* – This is similar to a mortgage. It shows that a person borrowed money to purchase a property. Commonly, the deed of trust is drawn up by a title company and the note is held by a bank.

II.B. Davidson County: Register of Deeds Workflow Analysis

There are currently 27 employees at the Davidson County Register of Deeds who are responsible for the acceptance and recording of title information. This information flows through a process of recording, as shown in the following diagram:



The first part of the recording process is submitting documents. According to Tim Hill, Team Leader of Information & Research, there are four methods by which documents and forms are delivered to the ROD: In-person (walk-in), standard mail, express mail (overnight delivery), and eRecording (online).⁷

Walk-in, standard mail, and express mail submissions are passed along to processing. Deputy Register Tami Frazer and her team enter the relevant submitted information (such as the grantor and the grantee) into the database system, and process any accompanying materials and payments.⁸ The system then generates a barcode, which is printed and added to the document (now referred to as an instrument). During the scanning process, the ROD software reads the barcode and adds the instrument (and any associated documents) to the case file.

It is important to note that every document that comes through the office, whether it be correct or returned to the sender for correction, is scanned and processed by Frazer and her department. Any documents that are accepted for recording are processed and passed along to various senior staffers who double check the information as a second pair of eyes. Any documents that are not accepted for recording are returned-to-sender with a form (Appendix F) indicating what needs to be corrected. This might include a missing date of execution, illegible information, a missing a legal description, or submission to the wrong county.

Furthermore, documents that are sent back to the submitter for correction are logged by Frazer into a spreadsheet, where notes and comments are inputted for future reference. In 2015, 3,657 documents were sent back for correction. As of June 7, 2016, 1,585 mistakes of one type or another were logged to-date for calendar 2016. Overall, the Davidson County ROD handles an

⁷ "Tim Hill, Team Leader of Information & Research, Register of Deeds." Personal interview. 7 June 2016.

⁸ "Tami Frazer, Deputy Register, Register of Deeds." Personal interview. 7 June 2016.

average of 500 documents per day (exclusive of eRecordings) most of which are submitted by mail.

According to the ROD website, “The remote filing service is an Internet-based program that allows the user to create a transaction containing as many or few documents as desired and post them to the Register of Deeds office for recording.” This makes the process almost instantaneous. The site continues, “The program is very user-friendly and easily mastered. Either an Escrow account or ACH transfer may be used for payment to use the system.”⁹ Currently, the ROD has relationships with four different third-party eRecording services: Simplifile, Corporation Service Company, eRecordings Partner Network, and Indecomm Global Services.¹⁰

Remote filing is not a new option in Davidson County. In fact, it has been available for a few years already. Initially, the adoption rate was about 20 percent and remained steady at 20 percent for years, according to Kim LeGate, chief deputy of operations.¹¹ However, on November 2013, the Consumer Financial Protection Bureau (CFPB) issued a final rule amending Regulation Z (Truth in Lending Act) and Regulation X (Real Estate Settlement Procedures Act) to integrate several mortgage loan disclosures. On July 21, 2015, the CFPB issued another final rule establishing October 3, 2015 as the new effective date for implementation of these new forms and the associated rules. The TILA-RESPA Integrated Disclosure Rule, commonly known as the TRID rule,¹² put a time limit on how long title companies have to make sure the funding amount is correct. This pushed a lot of people to eRecording because it’s faster, more accurate, and

⁹ "Davidson County Register of Deeds Remote Filing Service." *Nashville Register of Deeds Remote Filing*. N.p., n.d. Web. 2 June 2016.

¹⁰ "Table 4.18. Communications Data for Key Partners and Partners Countries." (n.d.): n. pag. Davidson County Register of Deeds. Web. 2 June 2016.

¹¹ "Chief Deputy of Operations Kim LeGate, Register of Deeds." Personal interview. 7 June 2016.

¹² Gormley, Joe. "ICBA Summary of the TILARESPEA Integrated Disclosure (TRID) Rule." *ICBA Summary of the TILA- RESPEA Integrated Disclosure (TRID) Rule* (n.d.): n. pag. Independent Community Bankers of America, Oct. 2015. Web. 9 June 2016.

errors are processed more quickly. When TRID came into effect on October 3, 2015, the number of eRecording users jumped to 40 percent and continues to grow.

After the initial recording comes “indexing.” This is where additional pertinent information that may not have been originally needed is added to the case file for search purposes. Such information may include additionally listed instrument numbers, other grantees, and so forth.

Once everything is indexed, the information is uploaded to an FTP site,¹³ or shared drive, so that it may be accessed by other county agencies, such as the Tax Assessors office.

II.C. Davidson County: Register of Deeds Technology Overview

On December 6, 1998, the ROD transitioned from a paper filing system to a computerized system with Document Technology Systems (DTS) as its software database provider.

DTS is a software development company founded in 1996 and headquartered in Cuyahoga Falls, Ohio. DTS provides application software solutions and related services to governmental clients in eight states. The Land Records System – TrakRecord Unlimited- automates the critical functions of a land records office with a flexible workflow designed to speed up daily processes. The system provides functionality in support of cashiering, scanning, e-filing, indexing, and web-based public access.¹⁴

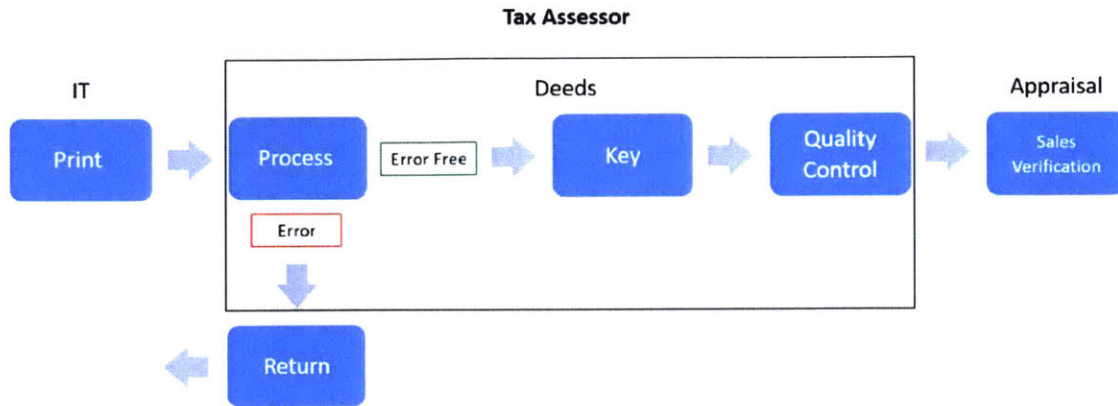
In addition to DTS, ROD personnel use Microsoft Excel spreadsheets to keep track of certain information. Finally, all the information recorded at the ROD is uploaded to an FTP site for inter-agency sharing and backed-up onto compact discs (CD) twice a week.

¹³ The File Transfer Protocol (FTP) is a standard network protocol used to transfer computer files between a client and server on a computer network. FTP is built on a client-server model architecture and uses separate control and data connections between client and the server. "File Transfer Protocol." *Wikipedia*. Wikimedia Foundation, n.d. Web. 9 June 2016.

¹⁴ "About DTS." *About DTS*. N.p., n.d. Web. 9 June 2016.

II.D. Davidson County: Tax Assessor Workflow Analysis

The information at the TA's office flows according to the following diagram:



The first step at the TA's office is to download and print the files recorded at the ROD. The IT department in the TA will access the FTP site, print out the documents, and deliver them to the Deeds Division (DD) in the TA's office. In the DD, led by Brittany Hayes, the information recorded at the ROD is checked against the information currently in the TA's system database. The checked information includes grantee's name, sales price, instrument number, and sale date (which, in this case, is the signature date). The DD will also check the legal description for any discrepancies.

If the provided information matches, the new information is "keyed" into the system and the documents are passed along to quality control. As far as the grantee and the grantor are concerned, once the information is keyed, the conveyance is official according to the county records. Furthermore, the new information will go "live" on the TA's publicly accessible website within 24-48 hours.¹⁵

¹⁵ "Assessor of Property for Nashville & Davidson County TN." *Assessor of Property for Nashville Davidson County TN*. N.p., n.d. Web. 10 June 2016.

If the provided information does not match what's in the TA's system, the documents are returned to the submitter with a letter explaining the issue. If and when the preparer of the documents re-submits, he or she would begin the recording process over again starting with the ROD.

According to Hayes, the majority of documents match without any issues.¹⁶ In fact, the TA may see only one document a week with information that does not match. There is no way to determine the cause for the discrepancy in information. Most of the time, Hayes ventures, it's a clerical error committed by the individual preparing the documents. Other instances vary, depending on the situation. For example, when a property has been inherited, the inheritor may not change the name on the title into his or her own name. As a result, when the inheritor later attempts to sell or convey the title, that information does not match the existing information in the system. Note that this illustrates the most important caveat of title recording: *there must always exist a constant chain of title.*

The final step in the process for title conveyance is quality control. Upon approval, the quality control staff double-checks that the new keyed information has been entered correctly. Quality control will pass along the information to the appraisal department for sales verification data, such as purchase price.

II.E. Davidson County: Tax Assessor Technology Overview

Brad Pigue, technical services manager at the Davidson County Tax Assessor's office, explains that the original "upgrade" away from a purely paper system was to the Land Information

¹⁶ "Deeds Manager Brittany Hayes, Office of Tax Assessor." Personal interview. 14 June 2016.

System (LIS).¹⁷ LIS is a geographic information system for cadastral¹⁸ and land-use mapping, typically used by local governments. LIS consists of an accurate, current and reliable land record cadastre.¹⁹ Its attribute and spatial data that represent the legal boundaries of land tenure provide a vital base layer capable of integration into other geographic systems or as a stand-alone solution to retrieve, create, update, store, view, analyze and publish land information.²⁰ The LIS system, implemented in the mid-1970s, ran on dumb terminals. Since it was a government system, there were a lot of agency stakeholders invested in its effectiveness. It provided the entire county with the ability to enter deed transactions, permits, etc., which could then be accessed by participating agencies. This process, as well as any technology decisions that affect the county, is driven by Metro ITS, the county's inter-agency information technology services department.

Beginning in 1999, some 30 years after the implementation of LIS, the TA transitioned from dumb terminals to personal computers (PC). The first software update occurred in 2005, when the office installed oracle-base software Kiva by Accela. The upgrade from the homegrown LIS to Kiva marked the first time the TA went with an independent, third-party program.

According to Pigue, Kiva was developed primarily as a permitting system. Although it did have land-management functionality, that portion of the system was retro-fitted to accommodate the permitting piece. In other words, the parcel chain was "shoe-horned" into the system protocols. This made it messy and inefficient. Furthermore, Kiva did not "patch," or allow for recurring updates. This created all sorts of issues. For example, a computer at another agency in Davidson

¹⁷ "Technical Services Manager Brad Pigue, Office of Tax Assessor." Personal interview. 14 June 2016.

¹⁸ (of a map or survey) showing the extent, value, and ownership of land, especially for taxation.

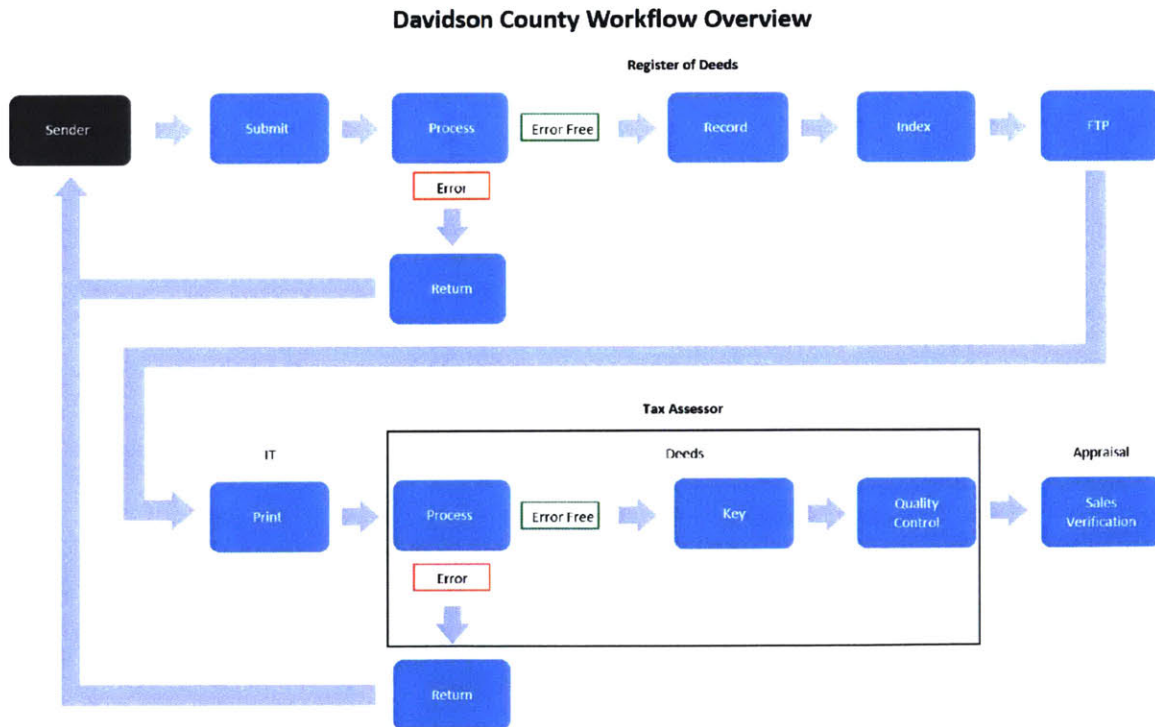
¹⁹ A register of property showing the extent, value, and ownership of land for taxation.

²⁰ "Land Information System." *Wikipedia*. Wikimedia Foundation, n.d. Web. 9 June 2016.

County could be running a different version of the software, making the information non-interoperable. Moreover, as previously noted, Kiva runs on an Oracle platform. This makes it more expensive to operate than such other database platforms as Microsoft SeqL.

In 2015, Kiva stopped providing credit card processing services. As a result, the TA migrated to Cityworks by Azteca Systems at the beginning of 2016. [Since this software is new an analysis of its functionality is not yet possible.]

The following is a complete overview of the workflow for recording titles in Davidson County, TN:



III. Title Insurance: Introduction

Title insurance is meant to protect an owner's or a lender's financial interest in real property against loss due to title defects, liens, or other matters. It will defend against lawsuits attacking the title, or reimburse the insured for the actual monetary losses incurred (up to the dollar amount

of insurance provided by the policy). Title insurance is a product developed and mainly sold in the United States as a result of the relative deficiencies in this country's system of maintaining land records.

There are two types of policies – ones that protect either owners or lenders. Nearly all institutional lenders require buyers to secure title insurance policies that will protect their interests in the collateral of loans secured by real estate. Some mortgage lenders, especially non-institutional lenders, may not require title insurance. Buyers purchasing properties for cash or with a mortgage lender often want title insurance (an owner policy), as well.

Title insurance exists in the U.S. in great part because of the way U.S. land records laws are structured. As noted above, the U.S. primarily operates under a land recording system, whereby information pertaining to titles is recorded by government agencies at the county level and is publicly available.

Title insurers conduct a title search on public records before they agree to insure the purchaser or mortgagee of land. Specifically, after a real estate sales contract has been executed and escrow opened, a title professional will search the public records to look for any problems with the home's title (as outlined in the upcoming section).

More than one-third of all title searches reveal a title problem that title professionals will insist on fixing before the transaction closes. For example, a previous owner may have done a renovation on the property, but didn't pay the contractor (resulting in a mechanic's lien), or the previous owner may have failed to pay local or state taxes (resulting in a tax lien). Title professionals seek to resolve problems such as these before the transaction closes – otherwise,

their employer (i.e. the title insurer), will be required to fix such title defects by paying such unpaid fees or taxes.

Title insurance policies are fairly uniform, and backed by statutory reserves. This is especially important in large commercial real estate transactions, where the buyer and their lender have considerable sums of money at stake. The insurer also pays for the defense of its insured in legal contests.

III.A. Title Insurance: Current System

Although the majority of titles are easily rendered “clean” (and many of the issues with a dirty title are rectified ahead of time), due to the variety of property rights many things can go wrong with real estate title – ranging from a claim for unpaid real estate taxes to the unexpected appearance of someone claiming to have an easement.

A title insurer or title insurance agent must review a daunting assortment of public documents relating both to the insured property itself and to all parties who ever had an interest in the property. These documents include deeds, mortgages, municipal tax rolls, judgments filed in a number of state and federal courts, and various other legal instruments. In order to locate all the documents relevant to a particular piece of real estate, also known as conducting a title search, the insurer or agent must go to the recorder’s office, the courthouse, and various other locations to physically look through the appropriate files. Otherwise, it must maintain a specially-indexed copy of the public records on its own premises, called a “property plant” or “title plant.” The plant must be kept up-to-date by obtaining copies on a regular basis of all new documents filed and updating the indices to reflect these new documents.

In some cases, the insurer or agent employs a hybrid approach. It maintains a “back title plant” which extensively indexes the data collected in the course of all the searches it has previously completed concerning the property of interest and goes to the public record to search the period of time subsequent to the latest data in its own files.

It is common for real estate titles to suffer from purely technical defects that are unlikely to ever have any practical consequences. Excluding such conditions from coverage would destroy the value of title insurance. On the other hand, it is essential that title insurers, like other insurers, exclude known conditions from coverage that have a high probability of causing an actual economic loss to the insured.²¹

A report produced by Goldman Sachs, entitled, “Blockchain Putting Theory into Practice,” neatly outlines the steps involved when a property owner is required by the financing institution to obtain title insurance in a real estate transaction (residential or commercial):

1. The property owner submits a title order entry to a title insurance company.
2. The title insurer then conducts an automated search and examination process using an electronic title plant.
 - a. About 70 percent of policy requests are found to be without defect, and thus are forwarded for processing.
 - b. However, approximately 30 percent of policy requests are found to have title defects of some type.
3. In these instances, title companies rely on an in-house network of labor to manually review (abstractors) and clear (curators) title issues.

²¹ Lipshutz, Nelson R. "The Role of Title Insurance in Mortgage Finance and Home Ownership." (n.d.): n. pag. *Regulatory Research Corporation*. Dr. Nelson R. Lipshutz. Web. 12 July 2016.

- a. This process typically takes 4 – 12 days. Once the title is determined to be clear of outstanding liens or encumbrances, the title company will issue a policy against the security of the title.
4. The property buyer pays the insurer a one-time fee for the policy at closing, which typically ranges between \$1,000 and \$1,800 (0.4 percent- 0.6 percent of home value assuming a \$275,000 property).²²

The expense component of title insurance is expanded even further by the fact that the title insurer or title insurance agent is frequently also responsible for the closing of the real estate transaction, a responsibility that encompasses correction of any serious title problems prior to closing; drafting, or at least collecting, all the relevant documents, including deeds and mortgages; maintaining the escrow account; conducting the settlement itself; and recording the documents establishing the new ownership, releasing the mortgage liens of lenders who have been repaid, and recording the lien interests of the new lenders. As the secondary mortgage market has come to dominate mortgage lending (particularly residential), the complexity of the closing documentation package that must be assembled has increased.

III.B. Title Insurance: Pain Points

The U.S. property recording system is organized as a “chain of title,” with historical transfers of property title being manually recorded on an ongoing paper trail that is stored in local jurisdictions. This makes the title search process labor-intensive and costly. There are a number of contributors to this problem, but three issues seemingly justify (at least currently) the cost of title insurance:

²² The Goldman Sachs Group, Inc. "Blockchain: Putting Theory into Practice." *Profiles In Innovation* (2016): 8+. 24 May 2016. Web. 8 July 2016.

- *Decentralized property record keeping* – Given the fact that property records are stored at the county level, title companies must build and maintain their own title plants in order to index the public records geographically, with the aim of increasing search efficiency and reducing claims.
- *Mistakes from paper-based recording practices* –30 percent of property titles are found defective at the time of a real estate transaction. It is believed that this is partly a consequence of manual, paper-based recording (as well as decentralization), wherein deeds, mortgages, leases, easements, court orders, and encumbrances associated with a are exposed to human error.
- *High-cost of property transactions* – Due to the significant costs associated with property title searches as a result of factors cited above, and, among others, title insurance premiums primarily reflect the elevated underwriting expense and distribution cost rather than the inherent actuarial risk. Residential and commercial property owners pay title premiums whether they are purchasing or refinancing a property, with residential purchase premiums roughly twice as high as “refi” premiums. As a result of these factors, title insurers employ many people to examine and “cure” the property title before underwriting an insurance policy against it. In fact, the cost of involving abstractors, curators, search and examination personnel, and lawyers, as well as sales and marketing professionals, represents an estimated 75 percent of industry premiums. This relatively high fixed cost structure directly results in higher premiums for the end consumer.

III.C. Title Insurance: One Local Firm's Experience²³

Pete Weiss, of Nashville-based Weiss & Weiss, Attorneys at Law, has been working in the real estate title field since 1970, when he worked at a title company while attending law school.

Currently, he performs title searches, drafts title insurance policies, and executes title settlements and title escrow holdings.

Weiss's initial reaction to the concept of blockchain was to associate it with "abstracting," the manual system, he says, that dates back to "the creation of Earth."²⁴ An abstract of title is the condensed history of the title linked to a particular parcel of real estate. It consists of a summary of the original grant and all subsequent conveyances and encumbrances affecting the property along with a certification by the abstractor that the history is complete and accurate. The abstract of title furnishes the raw data used in preparing a title insurance policy for the parcel of land in question. A *property* abstract (as opposed to an abstract of title) is a collection of legal documents that chronicle transactions associated with a particular parcel of land and generally include references to deeds, mortgages, wills, probate records, court litigations, and tax sales—basically, any legal document that affects the property.²⁵ In other words, it tracks the provenance, the origin or earliest known history, of title.

According to Weiss, copier machines, computers, scanners, and the Internet are all relatively new technologies in the grand scheme of land administration. The original legal processes were all written out by hand with pen and ink. Moreover, if someone wanted a copy of a document, it had to be handwritten, as well. Weiss recalled a time when he would leave a list of deeds for

²³ "Pete Weiss." Personal interview. 20 June 2016.

²⁴ See Appendix G for the title transfer record of Nashville founder John Donelson to Andrew Jackson.

²⁵ "Property Abstract." *Wikipedia*. Wikimedia Foundation, n.d. Web. 22 June 2016.

copying with the ROD and, once a week, “a computer the size of a classroom” would make the copies. Today, almost everything necessary for a title search is accessible from anywhere at the click of a mouse.

When conducting a title search, Weiss starts with the owner-of-date and works backward through time. His first step is to check the deed of the current owner. That deed will include a “derivation clause,” a provision in a deed of trust that gives information about the transfer of a property that includes, among other pertinent data, an instrument number. Weiss can then reference that instrument number to pull the previous deed, check that owner, and find the instrument number for the deed before that, and so on. This process is done to first check that there is no break in the chain of title and conducted until the point when the title searcher knows it’s clear. Weiss didn’t provide exact parameters as to how far back is “far enough,” stating that depending on the particular property and the deed, a title searcher will “just know when it’s been enough time.” Ideally, a chain of title will go back to its original conveyance. He also explained that statutes of limitations in the title code can be applied under certain circumstances or may even be used to “cure” title even when it’s not clean.

After a title search has gone “all the way back” (or far enough back to confidently satisfy the title searcher that the chain of title is clean enough), the searcher begins to move forward through time from that determined end point in history to present day. During this progression, the searcher is now checking for liens. A lien is a notice attached to a property stating that money is owed to a creditor. Before a property can be sold and given clear title to the buyer, the lien must be paid off.²⁶

²⁶ "Types of Property Liens | Nolo.com." *Nolo.com*. N.p., n.d. Web. 22 June 2016.

No title is ever 100 percent cleared, Weiss claims, adding that some titles can never be cleared. For example, he notes that a person in Tennessee can pass away without leaving a will or any document indicating the next of kin. Although a death notification is published in the local paper, next of kin living, say in California, may not be aware of said relatives passing or be aware that they are the legal next of kin. In either case, they would have a legal claim to the deceased's property, even after it was sold at auction (since vacant properties accrue property taxes, they can be sold at tax auctions to remit tax liens). If someone were to subsequently purchase the property, they would most likely want to get title insurance. But here, a title insurance company would have to determine whether or not they want to insure it given the circumstances outlined above.

III.D. Title Insurance: An Underwriter's Perspective²⁷

Mike Davis, an executive with leading title insurance underwriter Old Republic National Title Insurance Company, charges that fraud is rampant in the real estate title industry. Every day, there is a new scheme performed by a growingly sophisticated network of perpetrators, Davis claims. By way of illustration, he cites the example of individuals who scope out properties that are vacant or house people on extended vacations. The culprits might then "assume the identity" of ownership over the empty house and try to transact a quick, cash-only sale.

According to Davis, any party participating in a real estate transaction might be capable of engaging in a fraudulent scheme of some sort. For instance, during a closing, a seller may leave the room with a check and electronically deposit the money into their account via their smart

²⁷ "Mike Davis, AVP & Underwriting Counsel, Old Republic National Title Insurance Company." Personal interview. 7 July 2016.

phone. Then, upon returning to the room, he or she may request a wire transfer of funds, rather than a check – thus receiving a double deposit. International criminals posing as buyers have often deceived local banks with wire-transfer schemes, including the following: A “buyer” wires \$500,000 for a property to a local bank. Upon receipt of the funds, the bank receives a message that the actual closing price is \$400,000, and it is asked to wire back the \$100,000 difference. After the return wire is completed, the scammer cancels the original wire of \$500,000, netting the banks \$100,000.

Sometimes, middlemen, such as brokers, act nefariously: A broker agent might broker mortgages through multiple banks, providing duplicated packages to an unsuspecting buyer at closing. He or she keeps one package while the buyer pays off the other. Suddenly, the buyer begins receiving notices of delinquent payments on the duplicate package while having no idea what the bank is talking about.

Even relatively conventional methods of scamming, such as e-mail hijacking, represent challenges that title insurance companies must overcome. Typically, hackers will send emails from dummy accounts that are created to mimic a lender’s email address, providing instructions for making changes to important transaction details, such as a “new” routing number for the transaction funds.

Although blockchain technology proponents believe that it could end the need for title insurance, surprisingly, Davis claims to be a “fan” of Bitcoin.²⁸ He maintains that, “Anything that can cut down on fraud is huge for everyone.” However, he acknowledges, the challenge lies in changing the system – especially since the key players include government agencies, which almost by

²⁸ A type of digital currency in which encryption techniques are used to regulate the generation of units of currency and verify the transfer of funds, operating independently of a central bank.

definition, are change averse. Nonetheless, as Davis makes clear, the majority of the fraud his and other title insurance underwriters experience generally takes place before any documents even make it to the governmental title recording agencies, such as the ROD in Davidson County. Davis' affinity for Bitcoin stems from the desire for a "better transmission system for currency than we currently have."

III.E. Title Insurance: Old Republic's Work Flow & Technology

When an order is received by a receptionist, it is entered into the system and placed in a search queue. In the case of Old Republic, that system is RamQuest, one of the three primary search systems (and also partially owned by Old Republic). [The other two large search systems are SoftPro (owned by Fidelity, Old Republic's largest competitor) and TSS TitleExpress.]

A searcher is then assigned the order from the search queue and begins the process of checking the online indices in order to develop a chain of title. Depending upon the request, the searcher might look at everything attached to the title going back 10, 30, or 60 years in order to identify items that are "affective" (i.e. affect the property). The goal of the search is to develop an abstract. The abstracts, along with a list of "exceptions" and "requirements" are passed on to underwriters. The exceptions are items that will not be covered under the title insurance policy, (e.g. water-main easement that preclude development); and the requirements are steps that need to be taken so that the title company can issue the policy (such as deeds of trust on the property that need to be satisfied and released).

Underwriters take problem files, determine whether they can be fixed and how, and assess the risk of insuring the title. In many cases, the remedies are clear-cut and the process is relatively routine. However, in cases of more complex risk, the underwriters determine their exposure,

where the exposure might come from, and whether they can adequately insure against it. After a thorough analysis, the results are used to produce a “title commitment.” This is a contract underwritten to lay out the specific exceptions and requirements.

Once the exceptions are understood and accepted, the requirements are fulfilled, the title commitment –along with the other closing documents – are compiled and sent to the ROD. The title insurance policy itself is only produced after everything else is recorded at the ROD.

Davis notes that the premium collected on the title insurance policy is a onetime payment and the policy remains in force as long as the purchaser owns the property. Moreover, it remains in force for as long as the purchaser’s heirs own the property – or should the title be transferred to a new owner using a warranty deed.

Human input and judgement play a large role in determining the accuracy of a land registry system. Searches can be deceptively complicated. And a searcher’s daunting task is to connect the right dots in the right way with the right person. Keying in “Michael Davis” as “Michael,” ”Michel,” or just plain “Mike,” may mean the individual is never found in the system. In this regard, Davis claims that using the old manual indices was actually easier because the errors were most likely still on the same page and could be identified quickly.

A title search is really an examination process and a search process. In the case of inherited land, an heir apparent may want to develop the property or sell it, but first the title insurer needs to verify that the person has the right to do so. A vacant property will continue to vest and may unknowingly pass through various family members. A family tree needs to be constructed, lining up living heirs and dates of deceased heirs. Depending upon who passed away, and when, a property’s ownership might pass down different branches of a family tree.

Before computers, abstractors offered services to assemble all the available documentation dating back, say, for 40 years, and then a team of attorneys would pore over them to determine what does or does not apply. Today, that process would be considered too slow and too costly. Instead, the process is more seamless. With title plants, online indices, and access to the Internet for research, searchers are able to examine title while conducting the search.

III.F. Title Insurance: Summary

According to Steve Gottheim, senior council for the American Land Title Association (ALTA), the role of the title insurance industry is not as well known or understood as it should be. Since lenders require title insurance, buyers and sellers feel that they are forced to pay high premiums for riskless policies. This is partly why the title insurance industry suffers from a perception problem. However, it is conceivable that title insurance plays a larger role in the grand scheme of public land records, and that of a well-functioning economy, than publicly recognized.

For starters, the process of conducting a title search helps maintain public records, which is beneficial for all users: buyers, sellers, lenders and insurers. A well-maintained title record makes it easier to conduct business by making the process of establishing clean title easier.

The other roles that title insurance play can be derived from understanding the cause of title insurance losses. One cause of title insurance losses is the search process that misses defects in the public record. Another cause is deception or fraud. Both of these examples are directly affected by the state of public records. In the first case, it is easy to make mistakes when a record is in disrepair. In the second case, it is easier to commit fraud where mistakes are rife in a record system that is in disrepair. It follows, then, that the easier it becomes to take advantage of the

system, the more actors there will be who are inclined to do so.²⁹ Perhaps this is why 30 percent of all title insurance losses are fraud related.

Interestingly, even though title insurance is affected by fraud, the title search process is also the first place where a fraud comes to light. A title search, by definition involves a title examination conducted by investigators. Even though errors can be made, more often than not, the searches identify any suspicious actors through prior liens, judgements, or court proceedings.

According to Nelson R. Lipshutz, if title insurers and title insurance agents weren't conducting searches, the frequency of title defects would double in 12 years, from approximately 25 percent [at the time of the study in 2003] to roughly 50 percent. Furthermore, for owner-occupied single-family residences, the defect rate would rise to about 65 percent in the same period of time.³⁰

This is partly due to the curative nature of title searches. Not only do title insurers and title insurance agents examine the public record on an ongoing basis, they are constantly repairing it. This is necessary not just to detect deceit and error, but because the accuracy of public records naturally deteriorate with the divergent events of everyday life: Property owners marry and divorce, have children (legitimate and illegitimate), and die; a wide variety of other disputes can also lead to claims against real property.

International economist Hernando de Soto believes that accurate maintenance of public records is critical to the viability of a modern economy. De Soto acknowledges that the U.S. public record system is incredibly reliable, especially compared to the defective state of property

²⁹ Lipshutz, Nelson R., 9.

³⁰ Ibid. 5.

records in the rest of the world, where it is virtually impossible to validate the legitimacy of any proposed financial transaction.

Professor De Soto notes:

Few seem to have noticed that the legal property system of an advanced nation is the center of a complex web of connections that equips ordinary citizens to form ties with both the government and the private sector, and so to obtain additional goods and services. Without the tools of formal property, it is hard to see how assets could be used for everything they accomplish in the West. How else could financial organizations identify trustworthy borrowers on a massive scale? How could physical assets, like timber in Oregon, secure an industrial investment in Chicago? How could insurance companies find and contract customers who will pay their bills? How could information brokerage or inspection and verification services be provided efficiently and cheaply? How could tax collection work?...

...In addition to public record-keeping systems, many other private services have evolved to assist parties in fixing, moving, and tracking representations [i.e, titles] so they can easily and securely produce surplus value. These include private entities that record transactions, escrow and closings organizations, abstractors, appraisers, title and fidelity insurance firms, mortgage brokers, trust services, and private custodians of documents. In the United States, title insurance companies further help by issuing policies to cover parties for specified risks, ranging from defects on titles to unenforceability of mortgages and unmarketability of title. By law, all these entities have to follow strict operating standards that govern their document-tracking capabilities, physical storage facilities, and staffing."³¹

De Soto highlights many germane benefits of an accurate public record keeping system. He also expressly states that the legal property system is at the center of the complex web that forms a well-functioning economy, even going so far as to acknowledge the title insurance industry for their contribution in protecting the system. This is because De Soto understands that a stable economic system makes widespread American home ownership possible and enables Americans to use their home equity to provide liquidity that can be used for improving their lives. Perhaps that is why De Soto has become such an early and vocal proponent of blockchain technology.³²

³¹ Soto, Hernando De. *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. New York: Basic, 2000. 60-62. Print.

³² "Hernando De Soto Polar / Blockchain Work." *Wikipedia*. Wikimedia Foundation, n.d. Web. 28 July 2016.

IV. Blockchain: Introduction

“Imagine, for a moment, a global, online ledger, or network of ledgers, listing every single transaction in the world. It's verified immediately by other people using the system, which protects people's privacy, but is transparent enough to allow for oversight from anyone. No one group regulates it, so it's neutral and accessible to anyone with a computer. That is the world that visionaries of the blockchain foresee.”³³

When first explaining blockchain, it is difficult to figure out the right starting point. In the most basic explanation, blockchain technology is a tool for the management of information, specifically the records of transactions. This is because the blockchain is a distributed database holding a public ledger of all transactions. What makes the blockchain a transformative innovation is that every node on the network has a complete or partial copy of the blockchain and all historical transactions. These transactions are also timestamped on the blockchain. This eliminates the need for a central database and ensures that a single user is unable to fraudulently manipulate the data.

Another approach is to view the blockchain as an economic layer for the internet, providing a protocol for tokens of value to be transferred on a peer-to-peer (P2P) basis without the need for central agents.³⁴ Not only can these tokens be used as a form of currency and a payment system but tokens can represent other forms of value such as stocks, bonds, votes, and in the case of this paper, real estate title information.

³³ "Not Just Bitcoin: Why The Blockchain Is A Seductive Technology To Many Industries." *NPR*. NPR, 4 May 2016. Web. 15 June 2016.

³⁴ Anand, Aanchal, Matthew McKibbin, and Frank Pichel. *Colored Coins: Bitcoin, Blockchain, and Land Administration*. Draft. 2015.

This is why the blockchain is often referred to as the “financial internet.” As Patrick Byrne, CEO of Overstock.com, notes: “If the advent of the Internet allowed for the transfer of *information*, blockchain allows for the transfer of *value*.”³⁵

Building on Byrne’s analogy comparing blockchain to the Internet, at the latter’s inception, a Hypertext Transfer Protocol (HTTP) layer was designed to allow information to be organized digitally. Layers and applications were then built on top of HTTP, spawning the Internet as it is popularly known and used today. Blockchain, then, may be thought of as a “value transfer protocol.” Just as layers and applications were built on HTTP, innovative layers and applications were and continue to be created on top of the blockchain protocol. By this logic, many now believe that the next history-changing or so called “disruptive” technology is well on its way.

Although blockchain is often thought to be a futuristic technology, it’s actually a combination of existing ones, including some that date back as far as the 1970s. In other words, the building blocks of blockchain, such as encryption layers, are hardly novel. The significant innovation is how the technologies are organized so that blockchain allows for a network of computers to interface seamlessly *without a central server*. As Christian Saucier, CTO of Ubitquity, a blockchain-based platform for real estate transactions, put it, blockchain is the first, true peer-to-peer connection.³⁶

IV.A. Blockchain: How It Works

Blocks and Hashes

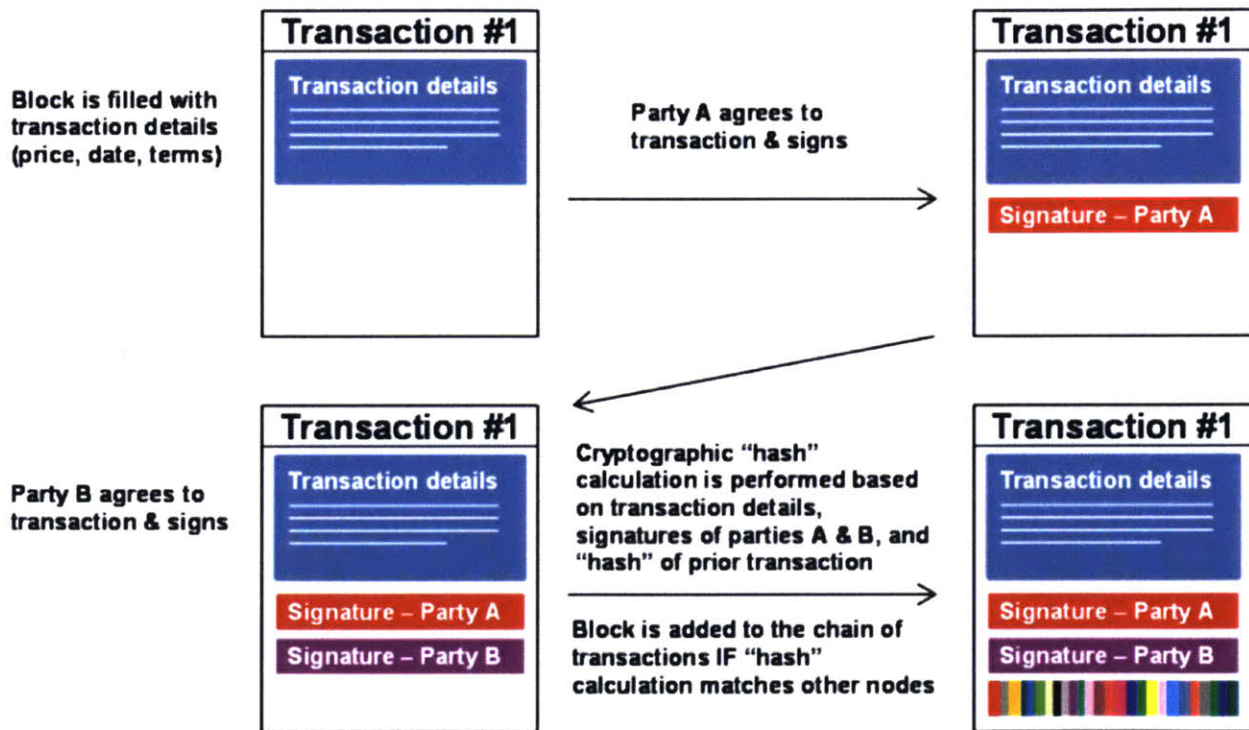
A blockchain functions by storing its transaction data in digital containers called “blocks” (Appendix H). Each block created is linked to the parent block through unique digital

³⁵ Byrne, Patrick. "Patrick Byrne, MIT Blockchain Independent Study Group." Group Meeting. 26 Apr. 2016.

³⁶ Saucier, Christian, and Matthew McKibben. "Ubitquity." Telephone interview. 30 June 2016.

fingerprints called “hashes” (Appendix I). These hashes are publically timestamped in a header at the top of each block of information. This history of transactions stored on the blocks can be linked back to the initial or “genesis” block. The information stored in blocks is resilient against tampering and corruption even by those who store and process the information. This is made possible by independent nodes that come to a decentralized consensus for all transactions which have occurred.³⁷

Illustration of how a single block in the blockchain is built and validated



Source: Goldman Sachs Global Investment Research

Keys, Tokens, and Transactions

One of the most important aspects of a blockchain system is the keys of ownership and the ability to transfer the units of account or digital tokens to other users. This is accomplished

³⁷ Antonopoulos, Andreas M. *Mastering Bitcoin: Unlocking Digital Cryptocurrencies*. Print.

through a technology called “public key cryptography.” Two keys, one public and one private, are utilized and stored in a simple database called a “wallet.” The public key creates a publicly shareable address for the user (normally represented by a unique string of numbers and letters). The private key is the information used to sign the public key and create a unique digital signature. This signature, once submitted, is used to create a transaction on the network.

Digital tokens are the units of account that are being kept track of on the blockchain. With different blockchain systems, the supply of tokens can be specifically regulated according to rules created by its designers. The digital tokens are divisible, fungible (within their network) and exchangeable with other networks depending upon the parameters defined by those exchange markets. Companies around the world create such exchanges and charge fees buying and selling the different digital tokens – either with one another or with governmental currencies. Part of the revolutionary breakthrough of digital value exchange is that it addresses the two primary sources of weakness or vulnerability in traditional means of value exchange (i.e. banks, credit cards, paper ledgers):

1. Requiring a trusted third party to confirm transactions, verify contracts, and approve remittances involving two or more parties.
2. Allowing different, and potentially conflicting, transaction records to be stored by the transacting parties and allowing for each record to be subject to alteration.

Each of these problems are addressed via blockchain protocols and secured by advanced cryptographic features not available through many previous protocols. Overall, it is the advent of increased decentralization through the use of distributed ledgers made possible by advanced

consensus mechanisms that creates a greater system of interoperability, openness, scalability, and efficiency.³⁸

Consensus: The blockchain ledger is replicated across multiple locations (only six are shown here for simplicity), and each maintains its own copy, which is separately updated based on new transaction data.

Below is a sequence of three transactions. In the first two transactions, data and signature information are properly validated by all six nodes with matching “hash” values. However for Transaction #3 at Location #5, the hash does not match the others, and will be corrected by the others via “consensus.”



Source: Goldman Sachs Global Investment Research

IV.B. Blockchain: Public or Private?

Similar to a database, a blockchain can be private or public, or alternatively, “permissioned” or “permissionless.” A group of the largest banks around the world is working on a private, permissioned blockchain for its own internal use. However, a register of deeds may use a public, permissionless blockchain to provide universal access to title information. Note that public blockchains behave in the same way as private ones – except that they do not require user identities to be validated against the list of authorized “members.”

³⁸ Subramanian, Karti, Mike Mulhall, and Joe Wilson. *Investigating the Potential Role of Digital Currency Technology in Mexico*. Landscape Analysis. Draft ed. N.p.: n.p., 2016. Print

Bitcoin, for example, is a public ledger that can be read from or written to by anyone who wishes to transact, making it an ideal vehicle for public transactions among individuals who don't know one another. In fact, the public nature of the Bitcoin ledger is one of the most appealing and novel features of the distributed database model. Yet for many high-volume commercial transactions (for example, in securities transactions among members or information sharing among commercial partners in a supply chain), where transactional privacy is important, a private blockchain can be utilized among participants where trust has already been established.

IV.C. Blockchain: Limitations

As with all new technologies, for blockchain to gain widespread traction in the real world, some significant challenges will need to be solved, including standards, privacy, speed and performance.

Special-purpose blockchains will need to be created for a wide variety of applications. In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries – particularly in cases where multiple blockchains will need seamless interoperability.

Blockchain will also need to overcome conflicts and differences in business processes, considering a blockchain database is only as good as the data and the business processes that underlie it. Failure to reach a consensus among counterparties as to business processes or to resolve commercial conflicts could significantly hinder blockchain's adoption.

Furthermore, since verification involves significant computational work, the nodes (computers on the network) are compensated for contributing their computing power. Whether that compensation takes the form of monetary rewards (e.g. miners of the Bitcoin blockchain are

compensated with Bitcoin for performing the computational work), additional uses of the service, or any other form depends on the protocol of the blockchain. The compensation of nodes assures continued participation. Should participation cease, the chain effectively ends and becomes useless as a service since storage and verification tasks would go unperformed. Privacy is a difficult challenge to overcome because different layers of anonymity can be established by the blockchain protocols and it is unclear whether increased anonymity will attract or detract members from participating. For example, applying a distributed database to commercial transactions raises the question of whether organizations want to share information about the parties doing business. This folds into the conversation surrounding public and private blockchains.

Any distributed database is inherently slower than a centralized one, raising the question of whether blockchain is appropriate for high-speed, high-volume applications. Although many blockchain variants, such as Ripple and Ethereum, promise to enhance performance by means such as increasing the block size, the question remains whether it will be able to compete with current databases built specifically for commercial applications. [A comparison of transaction speed will be drawn in the upcoming Bitcoin section].

Another problem for blockchain is that the speculation around what blockchain can do is so enticing that “fans” are promoting blockchain applications without actually understanding how blockchain works. Eric Piscini, a principal at Deloitte, agrees that the hype surrounding blockchain is causing some confusion about what the technology is good for and what it isn’t. “Everybody comes to us saying, ‘We have a problem, and we need the blockchain to fix it.’”

Piscini added. “Half the time, they need something else to fix it,”³⁹ (implying a better version of their current non-blockchain system). As is often the case with nascent technologies, it is important to patiently and diligently navigate through the noise in order to discover the true underlying value.

For instance, although blockchain supporters tout the security benefit of using a private key to verify a specific party in a transaction, this additional level of security also has limitations. A private key is essentially an additional source of personal identification, such as a bank account number or Social Security number. There is currently no recourse available within the blockchain technology should a private key be lost or stolen. At best, a person losing a private key will be required to obtain a new one to add to the blockchain. At worst, the loss or compromise of a private key represents a complete loss of control over all of one’s transactions within the blockchain. Moreover, a malicious party could masquerade convincingly as the user until the private key is deactivated in the same manner a thief could continue spending on a stolen credit card until it is canceled.

Currently, some blockchain-based services do store passwords on a private database in case of the loss or theft of private keys. However, using a centralized private server to store information inherently defeats the purpose of a decentralized system.

³⁹ Kharif, Olga. "Blockchain Goes Beyond Crypto-Currency." *Bloomberg.com*. Bloomberg, 19 May 2016. Web. 16 June 2016.

V. Bitcoin: Introduction

The three largest cryptocurrencies by current market capitalization are Bitcoin, Ripple, and Ethereum. These currencies also represent the three largest blockchains, as blockchain is the underlying technology that enables cryptocurrencies to operate.

This paper will use the largest of the three, Bitcoin, as the basis for examples of applications and opportunities pertaining to blockchain projects in land administration. Bitcoin also offers an interesting basis for research, as it is widely considered to be the original commercially applied use of blockchain.

The Bitcoin revolution began in 2008 with the publication of the white paper “Bitcoin: A Peer-to-Peer Electronic Cash System” by an unknown person (or group of people) under the pseudonym Satoshi Nakamoto. To Nakamoto, Bitcoin meant the first “purely peer-to-peer version of electronic cash [that] would allow online payments to be sent directly from one party to another without going through a financial institution.”⁴⁰ Perhaps, more importantly, his idea represented the first practical solution to the so-called “Byzantine Generals’ Problem”⁴¹ – a venerable computer science puzzle that had been thought to be unsolvable prior to Bitcoin.

Essentially, it centers around the need to rely on a group of independent, non-trusted actors to verify that a given scenario is valid.⁴² This scenario is difficult to effectuate if there are mischievous actors within the group or if the method of agreeing upon the scenario is not secure. Bitcoin solves this problem by introducing a “Proof-of-Work” (POW) chain which mandates

⁴⁰ Nakamoto, Satoshi. "Bitcoin: A Peer-to-Peer Electronic Cash System." *Legitimate Applications of Peer-to-Peer Networks* (n.d.): n. pag. *Bitcoin.org*. Web. 22 May 2016.

⁴¹ *Ibid.*

⁴² Lamport, Leslie. "A New Solution for the Byzantine Generals Problem." *Decision Support Systems* 1.2 (1985): 182. *Microsoft*. Microsoft. Web. 6 July 2016.

third-party actors verify transactions to indicate *proof* that they are invested in the protocol they are claiming to support and they do this (the consensus mechanism) by solving difficult problems in a specified amount of time. This proof of work relies on the computational power of each node in the network. It also allows for the verification of transactions between two parties without incurring the cost of a third party as verifier.⁴³

In other words, a POW is a mathematical task that is difficult, costly, and time-consuming to produce but easy for others to verify. For example, suppose that a document is represented on a blockchain by the set of numbers: 02 12 20 16 (these numbers could represent information unique to the document, such as the public key sequence for a particular transaction). As previously noted, hashing the document consists of performing a mathematical operation to the numbers, such as summing the numbers to 50. As long as the nodes on the network all come-up with 50, there is consensus. If a million nodes on the network come-up with 50 but one node yields 49, the hash for that node will be changed to 50, also per the consensus mechanism. At this point, it is impossible to tell with any degree of certainty what the original numbers are. For example, if a node started with the number 50, it is impossible to go back and determine what numbers were added together to result in 50.⁴⁴

In the case of Bitcoin, the original input can be millions of numbers and the mathematical operation will be more complicated than a simple summation, potentially involving hundreds of steps (e.g. take the square root, divide by 3, add 45,345, etc.). [The proof of work algorithm used in Bitcoin is called Hashcash⁴⁵ and was developed by Adam Back in 1997].⁴⁶

⁴³ "How Does Bitcoin Work?" *FAQ*. N.p., n.d. Web. 6 July 2016.

⁴⁴ "Impossible" in this case means that it currently cannot and has not been done.

⁴⁵ "Proof of Work." *Bitcoin Wiki*. N.p., n.d. Web. 6 July 2016.

⁴⁶ "Hashcash." *Hashcash*. N.p., n.d. Web. 7 July 2016.

The result is a technological innovation where, for the first time, it is possible for a distributed network of individuals – thousands of computers (nodes) situated around the world – to reach agreement (consensus) about every transaction that takes place, to record those details, and to make those records mathematically impossible to forge.⁴⁷

V.A. Bitcoin: Benefits

The Bitcoin protocol is a technological breakthrough that enables attributes of value transfers that have previously been either too expensive or otherwise infeasible, including: greater payment freedom, transparency of transactions, increased decentralization of payment verification, and lower transaction fees.⁴⁸ Together, these attributes combine to create a medium of value transfer that can potentially offer a greater degree of payment freedom than any previous value-exchange technology.

Bitcoin can be transferred between any two nodes on the protocol – this allows any person to pay any other person at any time without regard to borders or existing financial systems. Such a frictionless transfer of value lowers transaction fees, as third-party transaction verification is no longer needed. Transactions, such as remittances (which otherwise might carry significant fees) may be completed for fractions of a cent. Additionally, the lack of reliance on third-party verifiers helps de-centralize the network, rendering it less vulnerable to being negatively influenced by any single actor, whether incompetent or malicious.

⁴⁷ "Byzantine Generals Problem." *Dug Campbell*. N.p., n.d. Web. 8 July 2016.

⁴⁸ "What Are the Advantages of Bitcoin?" *FAQ*. N.p., n.d. Web. 8 July 2016.

The result is a common distributed ledger, containing an “immutable” record of all Bitcoin transactions, providing full transparency of when and by whom value was exchanged. This also allows for every transaction that has ever taken place on the network to be fully audited.

V.B. Bitcoin: Limitations

The scalability and security of the Bitcoin protocol are potentially limiting for widespread use. As a previously noted limitation to blockchain, Bitcoin shares the issue of scalability (size). Currently, the Bitcoin protocol can process about five to seven transactions per second; contrast this with Visa’s estimated 56,000 transactions per second capability.⁴⁹ What’s more, some Bitcoin transactions can currently take minutes, or even *hours*, to be approved. While solutions to this scalability problem have been proposed – for instance, by increasing the size of transaction “blocks” – software development for the Bitcoin protocol has been slow. This is partly due to a fracturing of the Bitcoin community. In this instance, some Bitcoin developers argue that increasing the block size will allow for more transactions per second, while others are concerned that a larger block will create more problems than it solves, such as risking consensus failure.

As of April, 2016, more than 70 percent of the transactions on the Bitcoin network were going through just four Chinese companies, known as Bitcoin mining pools – and most of that 70 percent flowed through only *two* of those companies. This near-monopoly provides them with virtual veto power over any changes to the Bitcoin software and technology. Such concentrated clout also raises worries about Bitcoin’s independence and decentralization. According to Cornell Professor Emin Gun Sirer, who has studied Bitcoin, “the concentration in a single

⁴⁹ "Visa, Inc. at a Glance." (n.d.): n. pag. Visa Inc. June 2015. Web. 12 July 2016.

jurisdiction does not bode well. We need to pay attention to these things if we want decentralization to mean anything.”⁵⁰

VI. Blockchain: Title Registry Applicability

The concept of a transparent, decentralized public ledger could be applicable to land information management, where the land registry serves as a database of all property rights and historical transactions. The most prominent benefit of using blockchain technology is migrating away from centralized databases. In addition to the previously established added levels of security, auditability, and transparency that blockchain technology provides, a blockchain land registry would be less vulnerable to misuse by system administrators and record destruction as a result of natural or man-made disasters.

Practical applications for blockchain in land administration include:

- Time stamping of transactions (akin to virtual notarization).
- Disaster recovery (system does not rely on a single centralized data center).
- Immutable ledger of historical transactions.
- Utilizing blockchain applications to manage registry details.⁵¹

Although title recording is the responsibility of government agencies, private companies and non-profit organizations with stakes in the title industry have also shown interest in pursuing blockchain applications either for monetary gain or civil benefits. Economist Paul Romer extends De Soto’s aforementioned theory on the correlation between an accurate record keeping system and a well-functioning economy to include technology:

⁵⁰ Popper, Nathaniel. "How China Took Center Stage in Bitcoin’s Civil War." *The New York Times*. The New York Times, 02 July 2016. Web. 6 July 2016.

⁵¹ Anand, Aanchal, Matthew McKibbin, and Frank Pichel.

“Economic growth is driven by the coevolution of two sets of ideas, technologies and rules [systems]. Governments can increase the rate of growth – in ways that benefit all citizens – by creating systems of rules that are both encouraging of and responsive to new technologies.”⁵²

If nothing else, Romer is recommending the pursuit of new technologies, encouraged by government actions (perhaps in the form of blockchain friendly legislation), to promote economic growth for the benefit of all citizens.

VI.A. Blockchain: Title Registry & Colored Coins

In a 2012 presentation in London, Bitcoin developer Mike Hearn popularized the concept of “Smart Property,”⁵³ a contract of sorts that creates a decentralized system of exchange for any asset:

“Smart property is property whose ownership is controlled via the Bitcoin blockchain, using contracts. Examples could include physical property such as cars, phones or houses. Smart property also includes nonphysical property like shares in a company or access rights to a remote computer. Making property smart allows it to be traded with radically less trust. This reduces fraud, mediation fees and allows trades to take place that otherwise would never have happened. For example, it allows strangers to loan you money over the internet taking your smart property as collateral, which should make lending more competitive and thus credit cheaper.”⁵⁴

“Colored coins” is a concept that grew out of smart property and can be used to represent and track specific assets (e.g. shares in a company, commodities, etc.) using the blockchain. By “coloring” a token to represent an asset, it can be exchanged on the Bitcoin blockchain, just like Bitcoin, with all the benefits of a Bitcoin transaction. Thus, creating a decentralized system of asset management that uses the blockchain as its ledger.

⁵² Goodenough, Oliver R. *Digital Legal Institutions*. Proc. of Law, Justice, and Development Week, Washing, DC. 4. *Global Forum on Law, Justice, and Development*. LJD. Web. 14 July 2016.

⁵³ Smart property was first proposed by Nick Szabo in his 1997 paper, “The idea of smart contracts.”

⁵⁴ “Smart Property.” *Bitcoin Wiki*. N.p., n.d. Web. 6 July 2016.

Colored coins can also be thought of as a layer to Bitcoin that makes it more useful. It enables a user to determine and attribute value of an asset into a token (or many tokens) for exchange or distribution. For example, a token can be colored to represent ownership of a single property, or many tokens can be colored to signify shared ownership in a building.

With regard to land administration, property title can be attributed to a token – which can include public registry details such as size, GPS coordinates, year built, etc. – and the exchange of the token can be tracked every time it changes hands through a series of transaction outputs.

When a property is first associated with a coin, it creates a “genesis transaction,” meaning that it belongs to the initial owner recorded by the system. When the property is sold or transferred, the transaction output belonging to the previous owner is “spent” and, at the same time, a transaction output belonging to the new owner is created. In this case, if someone needs to identify an owner of a property, he or she can simply go through the transaction history – starting from the genesis transaction and finishing at the open, or “unspent,” transaction output (i.e. the owner of the open transaction output *is* the current owner of the property). Moreover, the current owner is able to *verify* ownership by “signing a message” with his or her private key associated with that address on the blockchain. The important take away is that colored coins can provide an easy, secure way to register and transfer a property.⁵⁵

Smart property protocols have other land administrative benefits, such as providing verifiable digital signatures of a notary, a county clerk, or a land administrator, as well as signatures of property buyers or sellers, thus enabling the complete cycle of digital real estate transactions, including the transfer and sale of property. [In fact, anyone on the Internet should be able to use

⁵⁵ Mizrahi, Alex. "A Blockchain-based Property Ownership Recording System." *A Blockchainbased Property Ownership Recording System* (n.d.): n. pag. *ChromaWay*. Web. 28 Apr. 2016.

such a public system to easily verify and trace the ownership history of each token, or coin, using available online software known as “block explorer.”] ⁵⁶

It is noteworthy that in the colored coin system (as is the case in most blockchain applications), property ownership is associated with a certain *private key*, rather than with an individual person. It is also assumed that only one person is in possession of that private key. Thus, a potential pitfall is lost or stolen private keys (i.e. by inadvertently surrendering account passwords).⁵⁷

VI.B. Blockchain: Title Registry & Applying Colored Coins to Davidson County

Here is a hypothetical case example of how the Davidson County registry system described earlier might use the color coin system: A person who wishes to register his or her property would come to the registry bringing along all the documents now required that prove that he or she is the rightful current owner (e.g., deeds, etc.). The ROD would record the information and share it with the TA, as outlined previously. The TA would determine that the information provided is correct and create a color coin (initiate a genesis transaction output) with all the pertinent information embedded within it representing the property. This transaction would be digitally authorized using the assessor’s public key as the signature, after which the assessor would transfer the coin to the current owner's Bitcoin address, thus establishing that transaction point as the open, or “unspent” transaction and the person at that address as the property owner. Once this information is in the blockchain, the owner can transfer property without any further interaction with the registry. Moving forward, each new transfer of property would build-out the chain of title on the blockchain.

⁵⁶ A program or website that lets users search and navigate a blockchain.

⁵⁷ Mizrahi, Alex.

As more and more transactions occur on blockchain, increasing the amount of verified information – the system will become increasingly robust and more widely trusted. At its core, blockchain is a continually-growing digital register of transactions. Thus, theoretically, the more reliable and sustainable a blockchain becomes, the more superfluous the role of the third-party recording agents, such as the ROD or TA, becomes.

One possible problem is that a registry can transfer the colored coin token to the wrong address. In order to prevent this from happening, an owner can keep an eye on the blockchain for his property identifier by following the Bitcoin transactions online.⁵⁸ Dispute resolution mechanics is also a major issue that still needs to be considered and resolved before this system can go live in a wholesale manner (however, such a discussion is well beyond the purview of this document).

VI.C. Blockchain: A Hybrid Model for Title Registry

Another approach to introducing blockchain applications to the land registry process involves working within the existing system by combining elements of the current model with elements of blockchain technology. For example, once new information is confirmed by the TA to be accurate and is keyed into its database, this information can also be hashed on the blockchain by using existing services, such as proofofexistence.com, that allow you to essentially save a document to the blockchain (the process is similar to uploading a file to a cloud drive such as Dropbox or Google Drive). The hash, representing a title or deed associated with a particular land or property asset, is time-stamped upon submission. Since the hash is the result of a complex mathematical puzzle based on the elements of the uploaded document, any changes to

⁵⁸ All transactions on the Bitcoin blockchain can be viewed in real-time online.

the document would change the hash, revealing any foul play, and thus, making the document tamper-proof.

VI.D. Blockchain Limitations to Applicability in Title Registry

Land title organizations, such as Gottheim's ALTA, have been following the blockchain phenomenon since 2013. According to Gottheim, the bold predictions of dramatic changes to the finance industry, title recording systems, and title insurance industry have yet to produce any tangible results. However, on July 15, 2016, blockchain start-up Ubitquity announced that it had successfully executed the first property ownership transfer on the Bitcoin blockchain. Their platform securely records, tracks, and transfers deeds by creating a ledger entry on the Bitcoin blockchain. According to Ubitquity founder and CEO Nathan Wosnack, "Our long-term goal is to digitize titles to all assets (in this case real estate) and provide an immutable record of clear ownership in perpetuity, powered by the Bitcoin blockchain."⁵⁹

Detractors of blockchain technology point out that land administration challenges are largely not technical problems, rather governance issues. After all, digital registries are a relatively new phenomenon, only becoming standard in some developed jurisdictions over the last twenty years. Prior to the implementation of digital land information systems, land recording agencies were still largely able to manage rights related information in a relatively expedient and transparent manner, as in the case of Davidson County, Tennessee.

Furthermore, many of the potential blockchain applications for land administration can be adequately addressed using existing off-the-shelf technology combined with better information

⁵⁹ "Ubitquity Records First Real Property Ownership Transfer on Bitcoin Blockchain." *EconoTimes*. N.p., 12 July 2016. Web. 12 July 2016.

technology practices and improved governance. Modern land administration systems are already equipped with security measures that make modifications by unauthorized users difficult and easily traceable. Today's basic IT best practices assure that data is backed up regularly and stored offsite or in the cloud. Moreover, time-stamping transactions could occur when documents are formally registered, or via existing notary services.

Bottom line: Overall, the current system *does* work.

To move forward with a blockchain-based system would introduce new and additional hurdles. Without getting lost in the psychology of human nature and the natural resistance to change, there also are industry-specific hindrances that would need to be overcome, starting with convincing all the players in the real estate space that this new technology is the future of record keeping in one form or another.

For example, the mortgage lenders who traditionally require title insurance when they provide residential or commercial real estate financing may not be receptive to the introduction of blockchain as a substitute medium for current property title searches. They could potentially push back on the new technology because it is foreign to them (and banks, almost by definition, are conservative and risk adverse). That being said, banks do comprise the largest investor segment funding blockchain start-ups, with Goldman Sachs participating in the \$50 million funding round of blockchain start-up Circle last year.⁶⁰

Finally, infrastructure development presents a relatively high hurdle. A standalone blockchain-based infrastructure that could meet existing title industry standards would be needed to facilitate widespread commercial adoption. Considerable capital would be needed to create this

⁶⁰ Perez, Yessi B. "8 Banking Giants Embracing Bitcoin and Blockchain Tech." *CoinDesk RSS*. N.p., 27 July 2015. Web. 28 July 2016.

specialized infrastructure, as well as to train, maintain, and oversee the individuals who would use it. Where such significant investment might come from is a major question.

The other related open question would be: How could one quantify the return on investment? Thus, how might Davidson County (or even the State of Tennessee) benefit economically from adopting blockchain? Two answers are possible: One would be from the potential benefits blockchain technology brings to governmental functions (such as the registry system proposed above); the second involves the potential benefits that might accrue from legal recognition of blockchain for such *private* uses as title dispute resolution. As discussed above, benefits of the exclusive use of blockchain in governmental functions are not currently sufficient to recommend adoption by Davidson County (although it may be heading in that direction). However, the case for potential economic benefit from enabling private sector blockchain activity – such as title insurance – based on Tennessee statutory recognition could be both direct and immediate, albeit impossible to quantify at present.

VII. Blockchain: Title Insurance

Homeowners buying or re-financing a property are subject to significant transaction costs, including title insurance, wherever the title search process is complicated and labor-intensive. The previously mentioned Goldman Sachs report reveals that a blockchain-based land registration system (in conjunction with associated business process changes) has the potential to decrease title insurance premiums and generate an estimated \$2-4 billion in cost-savings in the U.S. (largely by reducing errors and manual effort).⁶¹

⁶¹ Goldman Sachs Group, Inc., 33.

As discussed, the list of possible title defects includes outstanding liens, easements, or other unaccounted for encumbrances. Relative to other types of insurance products, the premiums for title insurance are largely determined by the insurer's underwriting costs (as opposed to the actuarial risks of expected losses). Because title insurers conduct a search of public records prior to insuring the title, they must absorb relatively high fixed cost structures – which, in turn, raise premium rates. Here, the adoption of blockchain has the potential to substantially lower transactional risks associated with the existing property registration system in the U.S.; this would create significant cost-efficiencies that could then be passed along to the consumers (or be used to increase profits).

Blockchain also has the potential to eliminate, or at the very least reduce, transactional risk – the risk associated with the time delay between entering into a contract and settling it⁶² – attributed to the existing land registration system. If property records were stored on a blockchain (and the information necessary for establishing clear title was readily accessible and trusted among all parties), the process of transferring property title would be optimally efficient and secure.

Blockchain, in fact, could theoretically replace locally-maintained real estate records as the primary source of property title information. (In this regard, in particular, it will be interesting to see how the pioneering Ubitquity blockchain property transfer case plays out overtime).

In theory, with all present and past real estate transactions meticulously stored on an immutable and decentralized ledger, blockchain could ultimately render all paper-based property records obsolete. Since the network relies on consensus, there would be no disagreement as to the ledger's integrity. Title searching would also become near-instantaneous while associated human

⁶² "Transaction Risk Definition | Investopedia." *Investopedia*. N.p., 24 Nov. 2003. Web. 28 July 2016.

error and even title fraud risk would ultimately vanish. That being said, entering and reconciling property data into any blockchain will require human intervention. Thus, at least for the time, human error cannot be entirely erased, however, it can be significantly reduced.

A shared database of blockchain real estate transactions could also make property title searches more transparent. By aggregating localized public records with a commonly accessible format, blockchain could reduce the need for title insurers to build and maintain electronic title plants for indexing.

Furthermore, a unique, private key could make it simple to identify and differentiate among people with the same name (i.e., John Smith) and eliminate human input errors associated with spelling (i.e., “Michael” vs. “Michel”).

By eliminating these problems, blockchain could fundamentally disrupt the current system of title searches. As a result of greater data integrity and accessibility, substantially less specially-trained personnel (e.g., examination personnel, curators, and abstractors) would be needed to examine and “cure” property title records. Consequently, blockchain would significantly reduce both labor costs and the actuarial risk itself. Goldman Sachs pegs such reduced underwriting expenses at an estimated \$2.3 billion (based on 30 percent reduction in fixed headcount personnel, combined with a 20 percent reduction in variable expenses from agent commission, sales, and marketing).⁶³

Blockchain could also significantly lower the number of insurance claims by mitigating the underlying actuarial risks through the greater historical transparency and immutability of a blockchain-based property registration system. Goldman Sachs has estimated that claim losses

⁶³ Goldman Sachs Group, Inc., 37.

could decline by as much as 75 percent. Such a massive decline, they project, could realize annual industry wide cost-savings of some \$550 million. Assuming that the volume of title insurance policies underwritten each year remains relatively stable, the market for that product could potentially shrink by approximately 26 percent from \$11.4 billion today to \$8.4 billion in the near future as a result of widely- adopted blockchain efficiencies.⁶⁴

VIII. Conclusion

Blockchain-based land registry offers a number of clear advantages over conventional centralized database systems currently utilized in the Davidson County, Tennessee, ROD and TA’s offices – as well as, the “title plants” operated by the title insurance companies. First and foremost is the *security* advantage. Since blockchain relies on encryption to validate transactions by verifying the identities of all parties involved, “false” transactions cannot be added to the blockchain without the consent of all the parties involved. This would immediately resolve many of the fraud issues the title insurance industry now encounters due to identity-theft and fraudulent-payment schemes.

Further protection is built into the current blockchain system because each “hash” depends on the transaction data, the identities of the parties involved in the transaction, and the result of previous transactions. Thus, it ensures that a malicious actor cannot retroactively alter past transactions. Such an attempted change to historical transaction data would impact the current value of the hash, causing it to “mismatch” with all other copies of the ledger, which would trigger a “red flag” during the consensus mechanism process. This critical characteristic of system immutability would revolutionize the process of identifying, creating, and maintaining chain of

⁶⁴ Goldman Sachs Group, Inc., 38.

title and could be utilized today by working with third-party blockchain land registry companies that offer the hashing service, such as Ubitquity⁶⁵ or Factom.⁶⁶

System-wide *transparency* represents yet another distinctive advantage for blockchain relative to conventional centralized databases. Since, by its very nature, blockchain is a distributed database that is maintained and synchronized across a network of computers (nodes), all transaction data must remain consistent among all parties in order to be added to the blockchain in the first place. This means that, by design, multiple parties can access the same data (in some cases locally within their organizations) – thus significantly increasing the level of transparency. By contrast, conventional systems often depend upon multiple “siloes” databases that are generally not visible outside a single organization.⁶⁷

This relates directly to another important factor in considering a blockchain based land registry system: *efficiency*. Conceptually, maintaining multiple distributed copies of a database (ledger) with blockchain would not appear to be more efficient than a single, centralized database – or even a shared public database. However, in the real world, organizations already keep duplicate databases containing the same transaction information – and in many cases, such data are conflicting, necessitating costly, time-consuming reconciliation. Employing a distributed database system, such as blockchain, across an enterprise would minimize the need for manual reconciliation situations. In addition, blockchain can eliminate duplicative tasks across multiple organizations, such as is the case with the Davidson County ROD and TA, where the same data has to be manually input and verified twice.

⁶⁵ <https://www.ubitquity.io/home/index.html>

⁶⁶ <http://factom.org/>

⁶⁷ Goldman Sachs Group, Inc., 9.

Blockchain's vast potential lies in its ability to provide a fundamentally new type of database technology that can be distributed across organizations (or county, state, and country borders).⁶⁸ When assessing title registration systems individually, on a county-by-county basis, the existing system may seem sufficient. However, in the larger purview of the entire United States, the title registration system is fragmented across multiple government agencies using a variety of different database systems. A public, *permissionless*, blockchain system, however, would be the optimal platform for a *national* title registry – in theory, rendering the ever-growing title plants of the national title insurance companies, the private third-party vendors, such as the ones discussed in the ROD and TA technology sections, and the online national title projects, such as Loveland,⁶⁹ woefully obsolete.⁷⁰

The major issues facing the title insurance industry (and driving up its cost structure) also present a strong case for the ancillary benefits that blockchain could bring to a universal registration system. Prior to a closing, the lender, buyer, seller, and title company rarely interact, if at all. Thus, until that point, there are limited, if any, shared resources, information exchanges, or actor verification. With a blockchain title registry system, the bank, title insurer, registry, or any other involved party whose computer systems don't currently talk to one another, can now all freely connect and collaborate throughout the title transfer process. Furthermore, these parties can also create their own digital footprints on the blockchain without having to access another system or tediously exchange information by physically mailing files or emailing PDFs back and forth. Moreover, their individual private keys will serve to verify their authenticity and authority, thus eliminating further levels of potential miscommunication or fraud.

⁶⁸ Goldman Sachs Group, Inc., 3.

⁶⁹ www.makeloveland.com

⁷⁰ Lipshutz, Nelson.

Although adoption of blockchain technology may be years away from reaching a critical mass within the real estate world, the current growing interest in blockchain-based solutions to industry problems everywhere is undeniable. With venture capital investments in bitcoin and blockchain-related start-ups surpassing \$1.1 billion dollars (\$380 million of which was raised in 2016 alone), it is clear that the private sector believes in bitcoin and blockchain.⁷¹ Giants of the computer industry are also betting on blockchain. Microsoft, which began offering tools for developers to quickly build such systems in the fall of 2015, now hosts some 5,000 blockchains on its servers – up from a mere 50 less than an year earlier.⁷²

“It’s insane. The demand is off the charts,” says Jerry Cuomo, vice-president for blockchain technologies at IBM, which has developed open-source blockchain code that now has an estimated 1,000 active users.⁷³ The list of growing blockchain-based companies does include real estate title recording start-ups, such as Ubitquity (U.S.), ChromaWay (Sweden), Bitland (Ghana), and Bitfury (Republic of Georgia). In fact, Xinyuan Real Estate Co., a major Chinese real estate developer and property manager listed on the NYSE, announced on July 18, 2016, that it has launched the first blockchain-powered real estate finance technology platform in partnership with IBM. The announcement states, “with IBM providing the blockchain and smart contract technologies and Xinyuan building the real estate information database, the property evaluation system, the transaction system and the risk control modules, the company expects that the platform will be able to support various types of applications, including consumer finance, investment and financing as well as industrial finance, by connecting investment and financing institutions, credit bureaus and merchants. The Company anticipates that this platform will

⁷¹ "Bitcoin Venture Capital Funding." *CoinDesk RSS*. N.p., n.d. Web. 20 July 2016.

⁷² Kharif, Olga.

⁷³ *Ibid.*

contribute to the technological infrastructure of real estate finance and provide Xinyuan and other real estate developers with new patterns of real estate operations.”⁷⁴

Furthermore, the blockchain-based applications and systems being developed with and by such entities as IBM, Microsoft, and the aforementioned start-ups will have user interfaces that closely resemble current websites and applications – so end-users will be able to easily exploit the distributed-database power of blockchain without having to understand how it works, any more than typical drivers have to understand what is transpiring beneath the hoods of their cars.

The potential for a blockchain-based real estate title registry is a function of its ability to solve two problems: trust and proof of concept. In other words, how can people trust the actors involved and what provides a better, more secure, and less expensive option for data storage and retrieval. In Davidson County (and most of the U.S.), land records are now readily available at the ROD and online. Trust is not an issue here, since the government acts as an unbiased third-party recorder. Would a blockchain title registry system be more cost-effective for Davidson County than the system that currently exists? Right now, one could not make such a business case – which is often the problem when dealing with first-generation products, especially ones that are highly conceptual. Although, it is safe to assume that there would be significant costs associated with completely transferring the entirety of a title record database over to a blockchain built and maintained for the purpose of government record keeping, this is not the recommended course of action.

Certain actionable steps could, and should, be taken now in anticipation of the potential transition toward blockchain registry systems. For example, state legislatures need to begin

⁷⁴ "Xinyuan Real Estate Co., Ltd. Announces Blockchain-Powered Real Estate Finance Technology Platform." *PR Newswire*. N.p., 18 July 2016. Web. 20 July 2016.

legally recognizing the authenticity of digital proofs of ownership. In the U.S., where title disputes are resolved through litigation, it will quickly become important for a blockchain hash to be recognized as legally admissible evidence in court.

A recent report commissioned by the State of Vermont entitled, “Blockchain Technology: Opportunities and Risks,” has studied how closely a blockchain hash resembles what is currently a legal “record.”⁷⁵ The Vermont study determined that *accuracy* and *trustworthiness* (especially in the context of electronic records) are key elements. Trustworthiness is determined based on a record’s reliability, accuracy, and authenticity:

Reliability is defined as the trustworthiness of a record as a statement of fact, based on the competence of its author, its completeness, and the controls on its creation; accuracy is defined as the correctness and precision of a record’s content, based on the above and on the controls on the recording of content and its transmission; and authenticity is defined as the trustworthiness of a record as a record, meaning that the records is what it purports to be, free from tampering or corruption, based on the competence of its keeper(s) through time (i.e. creator and/or preserver) and on the reliability of the records system(s) in which it resides.⁷⁶

As the authors further explain, “blockchain technology does not address the reliability or accuracy of a digital record. Instead, it can address a record’s authenticity by confirming the party or parties submitting a record, the time and date of its submission, and the contents of the record at the time of submission.”

As with all databases, manual or digital, reliability is always vulnerable to the old GIGO Principle: “Garbage In, Garbage Out.” This principle holds true to blockchain-based databases as well. As long as protocols are properly followed, the input of bad data will be accepted by the

⁷⁵ Condos, James, William H. Sorrell, Susan L. Donegan, and Oliver Goodenough. *Blockchain Technology: Opportunity and Risks*. Rep. N.p.: n.p., n.d. Print.

⁷⁶ Duranti, Luciana, and Corinne Rogers. "Trust in Digital Records: An Increasingly Cloudy Legal Area." *Computer Law & Security Review* 28.5 (2012): 522-31. Web.

network and duly added to the blockchain. Furthermore, if a document containing false information is hashed as part of a properly formatted transaction, the network will record it. Similarly, a blockchain network cannot distinguish between transactions performed by a legitimate user or a malicious actor with unauthorized access to that individual's private key. In other words, a blockchain-based database system does not correct or clean-up existing trustworthy and reliability issues that are found within current database information.

However, as the Vermont report concludes (and has been postulated here), "Where blockchain technology does provide an advantage is in its ability to evaluate the authenticity of records ... a transaction that has been verified and added to a valid blockchain is mathematically secure. The hash of a document existing outside the blockchain and the hash registered within the blockchain will be identical if the documents are identical. If the documents are different (due to forgery, corruption, or other problems) the hashes will not match. Thus, the blockchain can provide an immutable registration of a record, to which future records can be compared for authenticity. Any presumption of validity around records registered in a blockchain must be limited to authenticity."

This critical and well-founded distinction forms the basis for legislative language, recommended by the report authors for consideration by the State of Vermont (Appendix J).

Meanwhile, in Tennessee (and among other states) the existing legal framework for use and validity of electronic transactions and records is currently set forth in the Uniform Electronic Transactions Act ("UETA").⁷⁷ Although not specifically identified, blockchain technology

⁷⁷ Uniform Electronic Act Tenn. Code § 47-10-1-101 et seq.

would appear likely to be governed by the statutes covering electronic records, signatures, and contracts under the UETA.⁷⁸

Although the UETA does cover many of the types of transactions being developed and envisioned by those already utilizing blockchain technology, the authors of the Vermont report are quick to point out that it does not cover everything. A transaction under UETA is “an action or set of actions occurring between two or more persons relating to the conduct of business, commercial, or governmental affairs.”⁷⁹ However, blockchain could potentially be utilized by a *single party*, who may wish to register certain information in a blockchain (such as a will or other document of value), or by *no party at all* (imagine a “smart contract” between two devices). Blockchain-specific legislation, while not necessarily an urgent priority, will eventually be required in order to account for such single- or zero-party transactional records.⁸⁰

At the moment, there is no need to jump from the current state of excited speculation about blockchain to the urgent need to overhaul complete systems immediately. It is the position of this paper that a blockchain-based land registry system *is* the future of real estate title management. However, the path to implementing such a system should be *gradual* and *phased*.

By implementing the proposed hybrid-system, forward-looking government agencies, such as the ROD and the TA in Davidson County, could continue their current practices and use their existing systems while taking advantage of the available, and proven, blockchain benefits, such as time stamping records and creating immutable hashes of documents. By working with third-party blockchain real estate service providers, such as Ubitquity, there would be no additional

⁷⁸ Uniform Electronic Act Tenn. Code § 47-10-1-107 et seq.

⁷⁹ Uniform Electronic Act § 16 et seq.

⁸⁰ Condos, James, William H. Sorrell, Susan L. Donegan, and Oliver Goodenough.,12.

hardware or software costs,⁸¹ as well as no additional labor costs, associated with building and maintaining an independent blockchain system.

Furthermore, the best way to implement the hybrid system is one real estate transaction at a time. Although all the information from a current database could hypothetically be imported into a blockchain-based land registry application, this would be a daunting and time consuming process and is still subject to concerns of reliability and accuracy. By starting with a single transaction, a title transfer verified by the TA with a title commitment from a title insurance agency could be added to a blockchain ledger. As more and more title transfers occur using this method, the system will continuously grow, making it more trustworthy and increasing the ease of use over time.

Ultimately, title is at the heart of every real estate transaction. It impacts all aspects of the real estate industry. Accordingly, if there is a way to make the process of transferring title faster, safer, and more reliable, why wouldn't it be in everyone's best interests to pursue it?

⁸¹ Ubitquity currently does not charge government agencies for the use of their application.

Works Cited

- "About DTS." *About DTS*. N.p., n.d. Web. 9 June 2016.
- Anand, Aanchal, Matthew McKibbin, and Frank Pichel. *Colored Coins: Bitcoin, Blockchain, and Land Administration*. Draft. 2015.
- Antonopoulos, Andreas M. *Mastering Bitcoin: Unlocking Digital Cryptocurrencies*. N.p.: n.p., n.d. Print.
- Arrunada, Benito. "A Transaction Cost View of Title Insurance and Its Role in Different Legal Systems." *Geneva Papers Geneva Papers on Risk and Insurance - Issues and Practice* 27.4 (2002): 582-601. Web.
- "Assessor of Property for Nashville & Davidson County TN." *Assessor of Property for Nashville Davidson County TN*. N.p., n.d. Web. 10 June 2016.
- "Bitcoin Venture Capital Funding." *CoinDesk RSS*. N.p., n.d. Web. 20 July 2016.
- "Block." *Bitcoin Wiki*. N.p., n.d. Web.
- "Blockchain Definition | Investopedia." *Investopedia*. N.p., 13 June 2014. Web. 20 May 2016.
- Booker, Renee, and E. Hubbard. "What Is a Master Deed." *WiseGeek*. Conjecture, n.d. Web.
- Byrne, Patrick. "Patrick Byrne, MIT Blockchain Independent Study Group." Personal interview. 26 Apr. 2016.
- "Byzantine Generals Problem." *Dug Campbell*. N.p., n.d. Web. 8 July 2016.
- "Chief Deputy of Operations Kimberly LeGate, Register of Deeds." Personal interview. 7 June 2016.
- "The Complete Guide to Quit Claim Deeds." *Quitclaim Deed*. N.p., n.d. Web.
- "Consensus." *Bitcoin Wiki*. N.p., n.d. Web.
- Condos, James, William H. Sorrell, Susan L. Donegan, and Oliver Goodenough. *Blockchain Technology: Opportunity and Risks*. Rep. N.p.: n.p., n.d. Print.
- "Davidson County Register of Deeds." *Nashville Register of Deeds*. N.p., n.d. Web. 1 June 2016.
- "Davidson County Register of Deeds Remote Filing Service." *Nashville Register of Deeds Remote Filing*. N.p., n.d. Web. 2 June 2016.
- "Deed of Trust." *LII / Legal Information Institute*. N.p., n.d. Web.
- "Deeds Manager Brittany Hayes, Office of Tax Assessor." Personal interview. 14 June 2016.
- "Deputy Register Tami Frazer, Register of Deeds." Personal interview. 7 June 2016.
- "Derivation Clause Law & Legal Definition." *Derivation Clause Law & Legal Definition*. U.S. Legal, n.d. Web.
- Duranti, Luciana, and Corinne Rogers. "Trust in Digital Records: An Increasingly Cloudy Legal Area." *Computer Law & Security Review* 28.5 (2012): 522-31. Web.
- "File Transfer Protocol." *Wikipedia*. Wikimedia Foundation, n.d. Web. 9 June 2016.
- The Goldman Sachs Group, Inc. "Blockchain: Putting Theory into Practice." *Profiles In Innovation* (2016): 8+. 24 May 2016. Web. 8 July 2016.
- Goodenough, Oliver R. *Digital Legal Institutions*. Proc. of Law, Justice, and Development Week, Washing, DC. 4. *Global Forum on Law, Justice, and Development*. LJD. Web. 14 July 2016.
- Goodenough, Oliver R. "Technology, Data and Computation to Promote the Rule of Law." *Digital Legal Institutions*. Proc. of Law, Justice, and Development Week, Washing, DC. N.p.: n.p., n.d. 4. Print.

Gormley, Joe. "ICBA Summary of the TILARESPA Integrated Disclosure (TRID) Rule." *ICBA Summary of the TILA- RESPA Integrated Disclosure (TRID) Rule* (n.d.): n. pag. Independent Community Bankers of America, Oct. 2015. Web. 9 June 2016.

"Hashcash." *Hashcash*. N.p., n.d. Web. 7 July 2016.

"Hernando De Soto Polar / Blockchain Work." *Wikipedia*. Wikimedia Foundation, n.d. Web. 28 July 2016.

"How Bitcoin Works." *Bitcoin Wiki*. N.p., n.d. Web.

"How Does Bitcoin Work?" *FAQ*. N.p., n.d. Web. 6 July 2016.

"Installment Contracts." *Attorneys' Title Guaranty Fund, Inc.* N.p., 01 May 2002. Web.

Kharif, Olga. "Blockchain Goes Beyond Crypto-Currency." *Bloomberg.com*. Bloomberg, 19 May 2016. Web. 16 June 2016.

Lampert, Leslie. "A New Solution for the Byzantine Generals Problem." *Decision Support Systems* 1.2 (1985): 182. *Microsoft*. Microsoft. Web. 6 July 2016.

"Land Information System." *Wikipedia*. Wikimedia Foundation, n.d. Web. 9 June 2016.

Lipshutz, Nelson R. "The Role of Title Insurance in Mortgage Finance and Home Ownership." (n.d.): n. pag. *Regulatory Research Corporation*. Dr. Nelson R. Lipshutz. Web. 12 July 2016.

"Mike Davis, AVP & Underwriting Counsel, Old Republic National Title Insurance Company." Personal interview. 7 July 2016.

"Miners." *Bitcoin Beginners FAQ- Blockchain.info*. N.p., n.d. Web.

Mizrahi, Alex. "A Blockchain-based Property Ownership Recording System." *A Blockchain-based Property Ownership Recording System* (n.d.): n. pag. *ChromaWay*. Web. 28 Apr. 2016.

Nakamoto, Satoshi. "Bitcoin: A Peer-to-Peer Electronic Cash System." *Legitimate Applications of Peer-to-Peer Networks* (n.d.): 109-22. *Bitcoin.org*. Web. 22 May 2016.

Nakamoto, Satoshi. "Bitcoin: A Peer-to-Peer Electronic Cash System." *Legitimate Applications of Peer-to-Peer Networks* (n.d.): n. pag. *Bitcoin.org*. Web. 22 May 2016.

"Not Just Bitcoin: Why The Blockchain Is A Seductive Technology To Many Industries." *NPR*. NPR, 4 May 2016. Web. 15 June 2016.

Perez, Yessi B. "8 Banking Giants Embracing Bitcoin and Blockchain Tech." *CoinDesk RSS*. N.p., 27 July 2015. Web. 28 July 2016.

"Pete Weiss." Personal interview. 20 June 2016.

Popper, Nathaniel. "How China Took Center Stage in Bitcoin's Civil War." *The New York Times*. The New York Times, 02 July 2016. Web. 6 July 2016.

"Proof of Work." *Bitcoin Wiki*. N.p., n.d. Web. 6 July 2016.

"Property Abstract." *Wikipedia*. Wikimedia Foundation, n.d. Web. 22 June 2016.

"Recorder of Deeds." *Wikipedia*. Wikimedia Foundation, 19 May 2016. Web. 1 June 2016.

Saucier, Christian, and Matthew McKibbin. "Ubitquity." Telephone interview. 30 June 2016.

"Smart Property." *Bitcoin Wiki*. N.p., n.d. Web. 6 July 2016.

Soto, Hernando De. *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. New York: Basic, 2000. 60-62. Print.

Subramanian, Karti, Mike Mulhall, and Joe Wilson. *Investigating the Potential Role of Digital Currency Technology in Mexico*. Landscape Analysis. Draft ed. N.p.: n.p., 2016. Print.

"Table 4.18. Communications Data for Key Partners and Partners Countries." (n.d.): n. pag. Davidson County Register of Deeds. Web.

- "Team Leader of Information & Research Tim Hill, Register of Deeds." Personal interview. 7 June 2016.
- "Technical Services Manager Brad Pigue, Office of Tax Assessor." Personal interview. 14 June 2016.
- "Transaction Risk Definition | Investopedia." *Investopedia*. N.p., 24 Nov. 2003. Web. 28 July 2016.
- "Types of Property Liens | Nolo.com." *Nolo.com*. N.p., n.d. Web. 22 June 2016.
- "Ubitquity Records First Real Property Ownership Transfer on Bitcoin Blockchain." *EconoTimes*. N.p., 12 July 2016. Web. 12 July 2016.
- Uniform Electronic Act Tenn. Code § 47-10-1-101 et seq.
- Uniform Electronic Act Tenn. Code § 47-10-1-107 et seq.
- Uniform Electronic Act § 16 et seq.
- "Visa, Inc. at a Glance." (n.d.): n. pag. Visa Inc. Web. 12 July 2016.
- "Warranty Deed." *Deeds.com*. N.p., n.d. Web.
- "What Are the Advantages of Bitcoin?" *FAQ*. N.p., n.d. Web. 8 July 2016.
- "What's the Difference Between a Property Deed and a Title?" *What's the Difference Between a Property Deed and a Title?* Rocket Lawyer, n.d. Web.
- "Xinyuan Real Estate Co., Ltd. Announces Blockchain-Powered Real Estate Finance Technology Platform." *PR Newswire*. N.p., 18 July 2016. Web. 20 July 2016.

Appendix A: Real Estate Terminology

Abstract. An abstract of title is the condensed history of the title to a particular parcel of real estate, consisting of a summary of the original grant and all subsequent conveyances and encumbrances affecting the property and a certification by the abstractor that the history is complete and accurate.⁸²

Deed. Deeds are the actual legal documents that transfer title from one person to another. According to the *Statute of Frauds*, it must be a written document. In most states, deeds must be recorded in the courthouse or assessor's office to make them fully binding, but a failure to file them does not impact the transfer of title. In this case, it means that the deed is not perfected or is not "clean." An imperfect deed does not mean that there is a problem with the title, it means there is a problem with the way that the paperwork surrounding the deed was handled.⁸³

Deed of Trust. A deed of trust is a type of secured real-estate transaction that some states use instead of mortgages. A deed of trust involves three parties: a lender, a borrower, and a trustee. The lender gives the borrower money. In exchange, the borrower gives the lender one or more promissory notes.⁸⁴

Derivation Clause. A derivation clause is a provision in a deed of trust that provides information about the transfer of a property such as the source of the title. It provides details about the name of the previous grantor and the recording date of the deed. In short, it provides information about how the title is derived.⁸⁵

⁸² "Property Abstract." *Wikipedia*. Wikimedia Foundation, n.d. Web. 22 June 2016.

⁸³ *Ibid.*

⁸⁴ Deed of Trust." *LII / Legal Information Institute*. N.p., n.d. Web.

⁸⁵ "Derivation Clause Law & Legal Definition." *Derivation Clause Law & Legal Definition*. U.S. Legal, n.d. Web.

Installment Deed. An installment contract (also called a “land contract” or “articles of agreement for warranty deed” or “contract for deed”) is an agreement between a real estate seller and buyer, under which the buyer agrees to pay to the seller the purchase price plus interest in installments over a set period of time.⁸⁶

Instrument. For discussion purposes here, an instrument may be considered any document that is recordable at the Register of Deeds. A deed will include an *instrument number* that is used as a reference to that particular document.

Master Deed. This type of deed will show the division of property into separate units, as well as indicate where the common areas will be on a proposed development. As with all deeds, any restrictive covenants will also generally be noted on the master deed.⁸⁷

Quitclaim Deed. The quitclaim deed is a type of legal document used to transfer interest in real estate from one person or entity (grantor) to another (grantee). Unlike other real estate deeds, it conveys only the interest the grantor has at the time of the deed’s execution and does not guarantee that the grantor actually owns the property or has good title.⁸⁸

Title. Title is a person or entity’s legal ownership rights to something. For real estate purposes, title refers to ownership of a property, meaning that the owner has rights to use that property. It may be a partial interest in a property or it may be full ownership. Having title provides the owner with the right to access the land and potentially modify it as he or she sees fit. Title also means that the owner can transfer that interest or the portion of interest owned to others.⁸⁹

⁸⁶ "Installment Contracts." *Attorneys' Title Guaranty Fund, Inc.* N.p., 01 May 2002. Web.

⁸⁷ Booker, Renee, and E. Hubbard. "What Is a Master Deed." *WiseGeek*. Conjecture, n.d. Web.

⁸⁸ "The Complete Guide to Quit Claim Deeds." *Quitclaim Deed*. N.p., n.d. Web.

⁸⁹ "What's the Difference Between a Property Deed and a Title?" *What's the Difference Between a Property Deed and a Title?* Rocket Lawyer, n.d. Web.

Legally, one can never transfer more interest than is owned, although a transfer can be less than the full title.

Warranty Deed. This type of deed guarantees that the grantor (seller) holds clear title to a piece of real estate and has a right to sell it to the grantee (buyer). The guarantee is not limited to the time the grantor owned the property as with a special warranty deed; rather, it extends back to the property's earliest title. Of all the real estate deeds, general warranty deeds provide the most protection to the grantee.⁹⁰

⁹⁰ "Warranty Deed." *Deeds.com*. N.p., n.d. Web.

Appendix B: Blockchain Terminology

Block. Transaction data is recorded in files known as blocks, which are organized into a sequence to form a chain of blocks (hence, the name “blockchain”). A transaction's presence in a block confirms when and in what sequence it occurred, as well as a reference to the immediate preceding block. Blocks are created by users known as “miners.”⁹¹

Consensus. The blockchain is “the trust machine” in a sense that no one person or entity is required for the records to be recorded and verified. Instead, consensus rules enforce the validity of a block and its transactions. For example, the Bitcoin consensus rules require that blocks only create a certain number of bitcoins. If a block creates more bitcoins than is allowed, all full nodes will reject this block, even if it is accepted by every other node and miner on the network.⁹² The process utilizes a complex mathematical calculation, known as a “hash,” which is performed each time a transaction is added to the blockchain, and depends on the transaction data, the identities of the parties involved in the transaction, and the result of previous transactions. The fact that the current state of the blockchain depends on previous transactions ensures that a malicious actor cannot alter past transactions. This is because if previous transaction data is changed, it will impact the current value of the hash and not match other copies of the ledger. The hash with the discrepancy will be changed to match the other hashes performing a consensus function.

Hash. A cryptographic hash function takes inputted data (i.e. grantor, time and date, etc.) and transforms it using complex mathematics into a compact string of information that is effectively impossible to reverse engineer. The slightest change to the input data changes the hash

⁹¹ "Block." *Bitcoin Wiki*. N.p., n.d. Web.

⁹² "Consensus." *Bitcoin Wiki*. N.p., n.d. Web.

(unpredictably), essentially rendering a hash tamperproof. Therefore, a hash assures that the system only confirms matching information.⁹³

Keys. Each party to a transaction has two keys: a public key, which is known to the world, and a private key, which is kept secret. These keys are digital certificates stored on the user's computer systems that allow for the encryption and decryption of data. A sender uses his or her key to encrypt the transaction data. The recipients, in this case all nodes in the network, use the public key to decrypt information required by the blockchain's protocol to validate the transaction. Examples of required information include the digital signature of the sender, knowledge that the sender has not previously sent a conflicting update, and that nothing else in the update is invalid. This technology is nearly identical to that used in many existing digital signature or e-sign technologies; a sender generates a digital signature from his or her private key which can then be verified by anyone using his or her public key. This technique is an essential and proven technique for securing communications over potentially insecure channels and has been in use in the public and private sector for decades.⁹⁴

Miners. Miners are individuals who utilize computer processing power to repeatedly calculate hashes, which in turn, are formed into blocks. For their work, miners who create a successful block earns incentives such as Bitcoins. The term is analogous of gold miners who would mine for gold that were turned into coins.⁹⁵

⁹³ "How Bitcoin Works." *Bitcoin Wiki*. N.p., n.d. Web.

⁹⁴ Condos, James, William H. Sorrell, Susan L. Donegan, and Oliver Goodenough., 8.

⁹⁵ "Miners." *Bitcoin Beginners FAQ- Blockchain.info*. N.p., n.d. Web.

Appendix C: Warranty Deed

WARRANTY DEED	
	State of Tennessee) County of Davidson)
THE ACTUAL CONSIDERATION OR VALUE, WHICHEVER IS GREATER FOR THIS TRANSFER IS \$ _____.	
_____ Affiant	
SUBSCRIBED AND SWORN TO BEFORE ME, THIS ___ Day of _____, 2016.	
_____ Notary Public	
My Commission Expires _____ (AFFIX SEAL)	

THIS INSTRUMENT WAS PREPARED BY:		

Nashville, Tennessee 37203		
ADDRESS FOR NEW OWNER(S) AS FOLLOWS:		
	SEND TAX BILLS TO:	MAP-PARCEL NUMBER
(NAME)	"NEW OWNER" (NAME)	Map & Parcel No.
(ADDRESS)	(ADDRESS)	
(CITY) (STATE) (ZIP)	(CITY) (STATE) (ZIP)	

FOR AND CONSIDERATION of the sum of ten dollars (\$10.00), cash in hand paid by the hereinafter named Grantees, and other good and valuable considerations, the receipt of which is hereby acknowledged, the undersigned, I _____, hereinafter called the Grantor, has bargained and sold, and by these presents do transfer and convey unto, _____ hereinafter called the Grantees, their heirs, successors and assigns, a certain tract or parcel of land located in _____, _____ County, Tennessee, and being more fully described, as follows:

LEGAL DESCRIPTION TO BE INSERTED

Being the same property conveyed to _____, by Deed from _____, of record in Instrument No. _____, Register's Office for Davidson County, Tennessee.

This conveyance is subject to any and all zoning regulations, building restrictions, the plan of record, if any, and any and all easements and or rights-of-way and other matters of record, which may be applicable the subject property.

BEING unimproved property
Improved property

(House Number) (Street) (City or Town) (State) (Zip)

TO HAVE AND TO HOLD the said tract or parcel of land, together with the appurtenances, estate, title and interest thereto belonging to the said Grantees, their heirs, successors and assigns, forever; and the undersigned does covenant with the said Grantee that it is lawfully seized and possessed of said land in fee simple, has a good right to convey it, and the same is unencumbered and does further covenant and bind itself, its successors and representatives, to warrant and forever defend the title to the said land to the said Grantees, their heirs, successors and assigns, against the lawful claims of all persons whomsoever. Wherever used, the singular number shall include the plural, the plural the singular, and the use of any gender shall be applicable to all genders.

IN WITNESS WHEREOF, the undersigned have executed this instrument, this ___ Day of _____, 2016

Appendix D: Special Warranty Deed

SPECIAL WARRANTY DEED	State of Tennessee) County of Davidson) THE ACTUAL CONSIDERATION OR VALUE, WHICHEVER IS GREATER, FOR THIS TRANSFER IS \$ _____ _____ Affiant SUBSCRIBED AND SWORN TO BEFORE ME, THIS Day of _____, 2016. _____ Notary Public My Commission Expires: _____ (AFFIX SEAL)
------------------------------	--

THIS INSTRUMENT WAS PREPARED BY:		

ADDRESS FOR NEW OWNER(S) AS FOLLOWS:	SEND TAX BILLS TO:	MAP-PARCEL-NUMBER
(NAME)	"NEW OWNER"	Map & Parcel Nos.
(ADDRESS)	(NAME)	
(CITY) (STATE) (ZIP)	(ADDRESS)	
	(CITY) (STATE) (ZIP)	

FOR AND CONSIDERATION of the sum of ten dollars (\$10.00), cash in hand paid by the hereinafter named Grantee, and other good and valuable considerations, the receipt of which is hereby acknowledged, we, _____, hereinafter called the "Grantors", have bargained and sold, and by these presents do transfer and convey unto, _____, hereinafter called the "Grantee", its successors and/or assigns, certain tracts or parcels of land in Davidson County, State of Tennessee, in and to:

LEGAL DESCRIPTION TO BE INSERTED

Being the same property conveyed to _____, by Deed from _____, of record in Instrument No. _____, Register's Office for Davidson County, Tennessee.

This conveyance is subject to any and all zoning regulations, building restrictions, the plan of record, if any, and any and all easements and/or rights-of-way and other matters of record, which may be applicable the subject property.

BEING unimproved property
 Improved property

 (House Number) (Street) (City or Town) (State) (Zip)

TO HAVE AND TO HOLD the said tract or parcel of land, together with the appurtenances, estate, title and interest thereto belonging to the said Grantee, its successors and assigns, forever; and we do covenant with the said Grantee that we are lawfully seized and possessed of said land in fee simple, have a good right to convey it, and the same is unencumbered unless otherwise herein set out; and we do further covenant and bind ourselves, our heirs and representatives, to warrant and forever defend the title to the said land to the said Grantee, its successors and assigns, against the lawful claims of all persons whomsoever. Wherever used, the singular number shall include the plural, the plural the singular, and the use of any gender shall be applicable to all genders.

IN WITNESS WHEREOF, the undersigned have executed this instrument, this ____ Day of _____, 2016.

Appendix E: Quitclaim Deed

Map & Parcel Nos. _____

State of Tennessee)
County of Davidson)

The actual consideration or value, whichever is greater, for this transfer is \$ N-O-N-E.

Affiant

Subscribed and sworn to before me this ____ Day of _____, 2016.

Notary Public

My Commission Expires: _____

THIS INSTRUMENT HAS BEEN PREPARED SOLELY FROM INFORMATION
PROVIDED BY AND AT THE DIRECTION OF THE PARTIES TO THE TRANSACTION
BY:

ADDRESS NEW OWNER(S) AS FOLLOWS: SEND TAX BILLS TO:

(Name)

"NEW OWNERS"
(Name)

(Street Address)

(Street Address)

(City) (State) (Zip Code)

(City) (State) (Zip Code)

QUITCLAIM DEED

FOR AND IN CONSIDERATION of the sum of One Dollar (\$1.00), and other good and valuable consideration, the receipt of which is hereby acknowledged, _____, hereinafter called the "Grantor", does hereby quitclaim and convey all of its right, title and interest to _____, hereinafter called the "Grantee", its successors and assigns, in and to:

PROPERTY DESCRIPTION TO BE INSERTED

Being the same property conveyed to _____, by Deed from _____, of record in Instrument No. _____, Register's Office for Davidson County, Tennessee,.

This conveyance is subject to any and all zoning regulations, building restrictions, the plan of record, if any, and any and all easements and/or rights-of-way and other matters of record, which may be applicable the subject property.

Witness my hand this ____ Day of _____, 2016.

{Grantor[s]} _____

Appendix F: Register of Deeds Correction Form



**BILL GARRETT
REGISTER OF DEEDS**

P.O. Box 196398 Nashville, TN 37219-6398 615-862-6790 www.nashville.gov/rod

Tami Frazer, Deputy Register

Date: _____ Company: _____

Please return this form with the revised document(s) to the address above.

The enclosed document(s) were not accepted for recording due to the following reason(s):

- Document is missing the following
 - Date of execution **TCA 66-5-109**
 - Name and address of:
 - Preparer of instrument **TCA 66-24-115**
 - New owner **TCA 66-24-114**
 - Party responsible for property taxes **TCA 66-24-114**
 - Oath of Consideration: Incomplete/ Missing **TCA 67-4-409(a)(1)**
 - Map and parcel number: Incorrect/ Missing **TCA 66-24-113(b)**
 - Legal Description is acquired
 - Exhibit(s)/ Rider(s) are missing
 - Derivation Clause: **TCA 66-24-110** Incorrect/ Missing/ Incorrect reference number
 - Signature: Missing
 - Notary Acknowledgement: **TCA 66-22-107/108** Incomplete/Notarize / Notary Seal/Expiration
 - Name of party being released or assigned
 - Required language: "Maximum principal indebtedness for Tennessee Recording Tax purpose is \$ _____." **TCA 67-4-402(b)(2)**
 - Document reference instrument number: should be 15 digits/ Missing/ Invalid
 - Incorrect County
 - Incorrect recording fee, correct fee is \$ _____ Short \$ _____
 - Trustee name **TCA 66-24-123**
 - Document is not Legible **TCA 66-24-101(b)(1)**/ Should be an original
 - Separate documents are required for UCC-1 and UCC-3
 - Check must be made payable to the Davidson County Register of Deeds
 - Modification Agreement over 60 days Penalty \$250 or double tax **TCA 67-4-409(b)(8)/(b)(12)**
 - Records should be resigned and notarized. Please see attached Memo **TCA 66-22-101**
 - Quit Claim Deeds cannot include a habendum clause. ("To Have and To Hold")
- Miscellaneous: _____

- PLEASE INCLUDE A SELF ADDRESSED STAMPED ENVELOPE FOR DOCUMENT RETURN.

If you have questions, please contact **Tami Frazer at 615-862-6790**.

For document requirements and fees please visit our website
www.nashville.gov/rod

Appendix H: Example of Blockchain “Block”

Example of a block on the Bitcoin blockchain:

Block	#125552
BlockHash	00000000000000001e8d6829a8a21adc5d38d0a473b144b6765798e61f98bd1d
# of Transactions	4
Height	125552 (Mainchain)
Block Reward	50 BTC
Timestamp	May 21, 2011 1:26:31 PM
Merkle Root	2b12fcf1b09288fcaff797d71e950e71ae42b91e8bdb2304758dfc2b620e3
Previous Block	125551
Difficulty	244112.48777434
Bits	1a44b9f2
Size (bytes)	1496
Version	1
Nonce	2504433986
Next Block	125553

Source: Blockchain Technology: Opportunities and Risks, Appendix A

Appendix I: Example of Blockchain “Hash”

The following is a cryptographic hash of *this* document:

a456697ac0426efb13005fa79f9add9ada28140730873eda45a03759950fe4e2

By making a minor change to this document (in this case, adding the aforementioned hash to the text) produces the following result using the same algorithm:

db80648f14d023d35fd8f5ed52ff59bd253f8a57bbabddd1c379f49372682d86⁹⁶

As evidenced above, the two hashes are not the same and there is no known way to reverse-engineer the original content from the cryptographic hash.

⁹⁶ The hashes were made by proofofexistence.com, using the SHA-256 algorithm.

Appendix J: Possible Statutory Language for Blockchain Recognition⁹⁷

The Committee is providing the following language as an example of what could be considered as an enactment for providing recognition of the validity of blockchain approaches for the purposes of establishing the authenticity of records. The Committee views this as a possible starting point for the normal processes of legislative drafting.

§11. BLOCKCHAIN ENABLING

(a) In this section, “blockchain technology” means a mathematically secured, chronological, and decentralized consensus ledger or database, whether maintained via Internet interaction, peer-to-peer network, or otherwise.

(b) Presumptions and admissibility:

(1) Extrinsic evidence of authenticity as a condition precedent to admissibility in a Vermont court is not required for a record maintained by a valid application of blockchain technology.

(2) The following presumptions shall apply:

(A) a fact or record verified through a valid application of blockchain technology is authentic;

(B) the date and time of the recordation of the fact or record established through such a blockchain is the date and time that the fact or record was added to the blockchain; and

(C) the person established through such as blockchain as the person who made such recordation is the person who made the recordation.

⁹⁷ Condos, James, William H. Sorrell, Susan L. Donegan, and Oliver Goodenough.

A presumption does not extend to the truthfulness, validity or legal status of the contents of the fact or record. A person against whom the fact operates has the burden of producing evidence sufficient to support a finding that the presumed fact, record, time or identity is not authentic as set forth on the date added to the blockchain, but the presumption does not shift to a person the burden of persuading the trier of fact that the underlying fact or record is itself accurate in what it purports to represent.

(c) Without limitation, the presumption established in this section shall apply to a fact or record maintained by blockchain technology to determine:

(1) contractual parties, provisions, execution, effective dates, and status;

(2) the ownership, assignment, negotiation, and transfer of money, property, contracts, instruments, and other legal rights and duties;

(3) identity, participation, and status in the formation, management, record keeping, and governance of a business corporation, nonprofit corporation, partnership, limited partnership, limited liability company, general cooperative association, limited cooperative association, unincorporated nonprofit association, statutory trust, business trust, common-law business trust, estate, trust, association, joint venture, public corporation, government or governmental subdivision, agency, or instrumentality, or any other legal or commercial entity;

(4) identity, participation, and status for interactions in private transactions and with a government or governmental subdivision, agency, or instrumentality;

(5) the authenticity or integrity of a record, whether publicly or privately relevant; and

(6) the authenticity or integrity of records of communication.

(d) The provisions of this section shall not create or negate:

(1) an obligation or duty for any private party, government, or governmental subdivision, agency, or instrumentality to adopt or otherwise implement blockchain technology for any purpose authorized in this section; or

(2) the legality or authorization for any particular underlying activity whose practices or data are verified through the application of blockchain technology.