Chapter 3

Case Studies and Thought Starters

This chapter will present eight case studies. These case studies will explore the current environment and how blockchain may be employed. However, at the time of publication, to the best of our knowledge, none of these blockchain applications have been implemented. In other words, it might be advisable to think of these case studies as thought starters. Interested readers may want to employ them to educate themselves or perhaps to explore the feasibility of these ideas. So, proceed with caution and enjoy the exploration.

1. Library Acquisitions

Libraries manage significant amounts of money through our budgets, and one of the most substantial budget lines is in acquisitions. The complex process of library acquisitions is well documented, leading from product development by a vendor to library subscription or purchase to the eventual sunsetting of the product or subscription. This process can span several decades or take place rather quickly. So how might blockchain be applied? One scenario would be to employ it for contract management related to the content covered by the contract. This works particularly well in scenarios where content is delivered digitally. Traditionally, a library finds out about a content collection that a vendor has developed. The library evaluates the product, enters negotiations with the vendor, and agrees to a price, and then that collection becomes accessible. A few years pass, the collection is in use, and the contract gets renewed following a new negotiation. As part of the new contract, new items may be added to the collection, old ones may be removed, and access may be renegotiated from single user to unlimited users. Over time, libraries create many of these contracts and systems. In an ideal situation, these contracts are well documented, accessible, and properly enforced. In real life, several points of failure can occur. Contracts are signed and subsequently lost, perhaps even just kept in a well-meaning signer's inbox. Agreements specify rules and limitations for the content. However, the systems used by libraries may or may not be able to comply with the rules.

If vendor contracts could be encoded in a blockchain, then with the right permissions in place to protect privacy and confidentiality, there would then be a permanent unalterable record of the original. Smart contracts in the blockchain could be established to facilitate access to the materials and provide updates. Whether a library buys access to 100 e-books or 10,000 journal articles, smart contracts embedded in the blockchain could facilitate the execution and access to the content. In other words, perfect compliance with the contract would be guaranteed to the library and the vendor. Since blockchain is incredibly scalable, expanding the number of titles or articles mediated by the blockchain would not pose a challenge. So if an original contract specifies a small number of items and a subsequent contract specifies a greater number, entries could be batch loaded into the blockchain. In the scenario of a shrinking contract, a batch action could also update the availability of content. If access rules change (e.g., from a one-user license to an unlimited-concurrent license), then a batch upload to the blockchain could update the smart contracts in the block to instantly update the accessibility.

Another benefit of blockchain would be the possibility of using cryptocurrencies for payment. If a library and a vendor transact in the same currency, the benefits would be limited (e.g., a purchase in US dollars from a US-based institution). However, often libraries work across boundaries—for example, a Canadian library buying content from a US vendor, a European library buying content from an Asian vendor, and so on. In those scenarios, contracts are subject

to fluctuations in the exchange rate between the currencies of the countries. In a low volatility environment, this poses no risk, but in environments where exchange rates can vary significantly over time, this can pose significant problems. For example, if the US dollar rises by 20 percent over three years in relation to the Canadian dollar, then the cost of the contract to a Canadian library buying from a US vendor would rise by 20 percent. Furthermore, there are often charges for the exchange of currency, which also increases the cost of the transaction. These kinds of fluctuations and fees are difficult to absorb in library budgets. If cryptocurrency were to be used, then there would be no exchange fees as no exchange of currency would take place. The only possible complication would be fluctuation in the exchange rate between the countries' currencies and the cryptocurrency.

For various reasons, blockchain would make a lot of sense in an acquisitions scenario. How strongly a library or vendor feels about the need to remain in compliance with the rules specified by the contract would determine whether blockchain would work well. Because this scenario is limited to verification between the vendor, the library, and the users of the content, a private blockchain would be feasible here. Making that decision would limit the processing and computing required, which would also limit the cost associated with power consumption. Typically, usage for licensed content is limited. Much of the content that is licensed is used seldom, but it needs to be available and discoverable. The blockchain could help with facilitating this access and discoverability. However, due to the low volume of transactions expected and who the stakeholders are, most of the computing could be handled in-house via a private blockchain.

A library would have to implement the blockchain for contract management. The system would have to be able to handle multiple vendors and enable blocks to be programmed to handle the rules set out in every contract. The library would then have to develop a compatible authentication system to allow its users to authenticate and discover content. The vendors would then have to collaborate on developing an authentication method that matches the verification provided from the blockchain for access to the content requested. There are many obvious benefits to a system like this, as opposed to many libraries' use of spreadsheets and inbox searches. If libraries were adroit at creating and maintaining these records through relational databases where all of these contracts, access parameters, and vendor relationships could live, then there might not be a need for a blockchain. However, that is not usually the case, and we have to consider ways to make this process easier and more consistent, almost from scratch.

2. Collections Maintenance

Libraries own and subscribe to many materials. Typically, the materials we have access to, whether owned or leased, are stored in a catalog of some kind. The catalog is typically provided by a third-party vendor, which sells it as an integrated library system (ILS) or library management system (LMS). Depending on the type of ILS, the size and complexity of holdings, and other factors, access to the collection can be reliable or not. Holdings data may or may not be complete. We often ask questions in libraries related to collections. Questions may be at the macro level: How many items do we have in our collections? They may be at the item level: When was this book processed? When was it purchased, and for what price? Questions may also be cross-institutional: Can we compare our holdings to those of other institutions? Lastly, we may also ask questions related to usage: How many times was this item borrowed? How many items in our collection have been accessed more than twice?

Blockchain would allow every item in our collections to be individually tracked. A block created for every holding would include data about the original acquisition, the item itself (either in MARC, RDA, or a new metadata schema), and transactions. Every time an activity takes place, the event would create a new block in the blockchain for that holding. For example, an item is borrowed. A new block would be added to the blockchain. At a minimum, this block would contain data on the item borrowed and the public key of the borrower. Unlike in current use cases, where libraries often struggle with how to treat this user data, in blockchain we would not be able to trace back to the private key. So, while the public key can be queried by those authorized to look up information on public keys, the privacy of the borrower is preserved. Employing the blockchain would allow for rapid queries and analytics. Furthermore, a well-designed blockchain could replace the ILS/LMS providers as "middlemen," and libraries could (finally) design their own tools to take care of our systems needs. A blockchain could be established at the individual library level or within counties or universities. However, a global public blockchain for all libraries would be ideal.[1] In that scenario, every library would enter its holdings. That way, collection and holdings data could easily be analyzed across any institution or organization in the world. Besides the local impact, implementing blockchain this way could also have a significant impact on interlibrary loan (ILL). Here items could be identified much more quickly and the process of lending and borrowing in ILL could be automated through smart contracts with lending institutions. Libraries could automate the process of verifying partners, keeping track of net borrowing versus net lending, and send materials. As in other scenarios, the privacy-by-design

features of blockchain would serve well here.

Blockchain most certainly makes sense for this purpose. However, the scale of implementation required to make this scenario work seems daunting. A global public blockchain could address issues of interoperability between different blockchains. Blockchain as a technology is a conceptual setup influenced by different design decisions at every step of implementation, which can influence how different branches of the blockchain operate and talk to each other. A smaller implementation at a state or provincial level would also be feasible, and a likely step in a larger process, but ultimately the greatest benefit would come from a global network. That way all the world's library holdings could be documented, analyzed, verified, and tracked. This would be a great feature in cases where collections get damaged, stolen, or destroyed.

Implementation in this case would be fairly straightforward, as we could simply transfer existing record-keeping mechanisms to the blockchain. Just as with MARC or RDA, we have established protocols for cataloging and recording bibliographic collections. The major challenges would be related to the migration of existing records to the blockchain and the immense collaborations required to be successful. However, if a tool could be developed to batch upload records, this could be a frictionless transition for most libraries, which could yield significant benefits. Once the blockchain had been implemented, then libraries could either connect with third-party off-the-shelf interfaces or could develop their own customized applications. Privacy concerns around how these records would interact with the blockchain would be addressed through the blockchain's built-in privacy mechanisms. As in cryptocurrency transactions, it would be virtually impossible to trace the transactions back to the individual unless the owner of the private key elects to make their key known. Blockchain accomplishes this via the use of public and private keys that each user has. One analogy is of a one-way road by which the private key generates a public key to verify the original transaction, but the public key cannot be turned back and be connected to the private key. Thus, any analytics or tracking of the material cannot be traced back to an individual. However, analytics at the item level could be recorded and analyzed.

3. Special Collections and Archives

Special collections and archives possess rare and distinct materials. This makes their collections unique to the overall collection development process that the information profession usually engages in. These materials have been acquired under various circumstances that may or may not be documented. If purchase or donor agreements exist, they may or may not be easily available. This can lead to confusion. At what price was a collection acquired? Who was in charge of the acquisition? A collection has been donated, but what was the donor agreement? Can the collection be divided up, or must it be kept intact? How and where can it be displayed? Furthermore, proving the provenance of these materials can also be a challenge. What is the history? How has the history been verified?

In the case of archival materials, what are the retention rules? Who has access to the materials?

How are these special collections and archival materials discoverable? How are they made accessible, and to whom?

Blockchain could address the majority of these concerns. For example, if a library acquires an important historical artifact, then the library could encode the transaction and the contract in the blockchain. Additional data related to the purchase, such as cost, time, and date, can be noted. From there, the material can be made accessible through the same discovery mechanisms used in regular collection development. Alternatively, special interfaces could be developed, for example to link blockchain and discovery mechanisms. When questions arise about where or how the materials were acquired, the blockchain records attached to each item would be able to answer these questions. In worst-case scenarios, such as theft or damage, the item can be traced through the blockchain to its rightful owner. For example, if a rare book is stolen and the thief tries to sell it, then any potential buyer could verify whether the item is as described and whether it is legally for sale. This process is currently being employed in art auctions. On November 13, 2018, Christie's auction house raised over $317 million when the Barney A. Ebsworth collection was auctioned. The sale was recorded in a blockchain platform provided by Artory, a company specialized in the art market.[2] The process employed in the registry is very similar to the process special collections and archives could use. An event related to an item takes place—for example, a donation to an institution or a valuation. This triggers the creation of a new block in the registry where the original items have been recorded. The new block is added to the ledger related to the item and is now part of the blockchain. Because it is part of the blockchain, the item is now discoverable, and all events related to it are traceable.

As the Christie's example and the Artory platform show, blockchain could be a transformative technological innovation for special collections all over the world. As collections are acquired and developed, much data is accumulated. Agreements accompanying the collections, appraisals, historical documentation of the artifacts, and other materials could all be tracked and maintained in the blockchain. Through a

centralized registry, collections would become more discoverable. Once collections are discoverable, the metadata would become searchable and new opportunities for scholarship and research would open up.

4. Scholarly Record

Blockchain technology can have a significant impact on the scholarly record. In a very simplified model, for example, a scholar could establish an idea in the blockchain. This would provide a record of when the idea was first established. Then, as the idea leads to written drafts, progress on research and other impacts of the research can be tracked by creating records in the blockchain. As a project reaches milestones, including publications and patents, these can be tracked in the blockchain and linked to ISBNs or DOIs. Connections with tracking services such as ORCID and OSF can also be made. Thus, the scholarly output can be linked and analyzed, allowing scholars to get credit for their work. In addition, if a blockchain-based system is established, further analysis can be conducted across topics, authors, disciplines, publishing outlets, and any media that may be used. This could revolutionize the way scholarly output is measured and analyzed, leading to whole new ways of measuring impact.

At the level of output, blockchain could also be utilized by authors to create and manage copyright licensing that extends beyond the traditional publisher model. Access to content can be managed through smart contracts that could be embedded in the blockchain for a particular scholar, article, journal, or publisher. For example, an article gets published in a traditional journal; the journal allows the self-archiving of the prepublication version of the article in the author's institutional repository. Then, the author chooses to archive a copy and wants to mediate access via a Creative Commons license. The article is now freely accessible through the repository. Any download of the article could be noted in the blockchain. If the article is cited or otherwise used in advancing other research or publications, then that interaction could also be linked in the blockchain. The primary investigator of the original research now receives credit, and the impact of the research could be measured in new and unambiguous ways. On the matter of receiving credit for research, the recording of ideas is similar to a patent registry. Those first to develop an idea and submit it receive the credit for the original idea. If an idea registry is created, disputes about first ideas could be easily resolved. However, on a more positive note, a searchable and discoverable registry of ideas could lead to new collaborations and initiatives. Since ideas precede research and publications, early indicators of new discoveries could also be created, thus pointing to new areas of discovery and reducing lag in the publication cycle.

The establishment of this system would not be complicated; however, the larger benefit could be achieved when the network's effects kick in. The larger the system gets and the more users that participate, then the larger the system's impact is. If it could be established as a standard similar to how the patent office works and if funding agencies and institutions would buy into its adoption, it could accelerate, and the benefits could be realized sooner. Perhaps the critical question is who would establish this system. Would the system be developed by academic institutions or by funding agencies? In either situation, what would be the scope of the system? Would there be regional limitations or disciplinary focus areas? Those decisions would have a significant impact on how this system would work. Some of these impacts are considered in chapter 5 of this report.

5. Analytics in the Library

The business of libraries has become increasingly complex. The days of set budgets funded on a recurring basis are long gone. Today's libraries exist in a world where the need for advocacy has become the norm. Libraries have to meet performance metrics and deliver statistics in order to provide evidence for the value they add. However, library analytics and assessment are still a challenge. The evidence and metrics we collect in our field are limited, often focused on counting physical items and simple measures such as circulation data and gate counts. However, there is much more data to be collected in libraries. From the get-go, variation in knowledge of research methods and quality control of assessment surveys or designs makes the quality of data in libraries vary significantly. Data that connects the services libraries offer with the value we add is often difficult to collect and remains limited. Using blockchain, we could start collecting data that measures interactions with services and link it with data from other parts of the organization and community. In addition, the data collected by libraries is stored in a variety of places, often linked with sensitive data or not conforming with privacy standards, which can pose all kinds of problems. This combination of data repositories includes paper records in filing cabinets and spreadsheets on laptops, computers, shared servers, personal hard drives, USB keys, and cloud-based services. Some of our storage solutions are owned by individuals, some are owned by our institutions, and some are owned by third-party providers. To be fair, much of the data collected by libraries does not require protection, high degrees of security, or access controls around it. On the other

hand, frequently the tools we have available are inadequate for protecting the data that needs to be protected. As a consequence, we often have shied away from collecting data that could aid us in providing better services to our clients and partners.

Blockchain could help with analytics in the library by providing the database infrastructure that would allow data to be collected, stored, and made accessible to authorized participants. Through smart contracts, permission could be granted and only trusted members could access selected data, while other data could be made available more broadly. Examples of data that would need to be protected include individual user data, demographic information, and other sensitive information. Data requiring less protection could be related to general collections statistics or user data at an aggregate level. Through blockchain, the data that has been collected could be secured and hosted in a way where only those with the right permissions get access. The data could be accessed through APIs or other interfaces that allow for different display and analysis options. Hosting the data via blockchain also accomplishes another goal. Rather than having multiple places where data is stored with the very real possibility of losing track of data sets, the blockchain could create a singular point of access. As a result, data inventories could be completed at the press of a button, compliance requests would become quickly accessible, and data discovery would be significantly improved.

Blockchain could also be used to empower the subjects of data collection. An example would be a student who early in their academic career participated in a survey. Subsequently the student participated in many more surveys and other ways with the library—perhaps coming to a tutoring service, borrowing laptops, and so on. If the student's participation in these activities is linked to the blockchain data via their public key, the student could review years later which data has been collected and could make informed decisions using their own data. Since libraries and our institutions are increasingly moving into new areas of data analytics, this kind of user control could be innovative and very high impact.

6. Reward Programs

As we discussed in chapter 2, incentivizing distributed computing is integral to the maintenance and success of cryptocurrency blockchains. With this in mind, libraries could create tokens based on blockchain technology. A token could be set up to measure engagement with the library and library services. In theory, the token could also be expanded to take into account interactions with services beyond the library. For example, a public library could set up a token for its community, or an academic library could set one up for the campus, university, or college. In the academic scenario, students could earn tokens for attending events or workshops hosted by the library. They could earn rewards for borrowing equipment, participating in efforts to improve the library, and so on. As student earn these credits, they could exchange them for rewards, be inducted into an academic society, or be invited to special events. In this sense, the token would mimic the model set by the cryptocurrency community, where these rewards can serve as incentives and nudges to encourage participation.

Blockchain is an effective way to track data records or interactions with library services and collections. Blockchain allows analytics to be performed on transaction data, for example: How many people participated in this workshop? How many times was equipment borrowed by undergraduate students?

Here the question of privacy will probably be a primary concern for many librarians. The short answer provided by proponents of the technology is that blockchain provides the ability to track these interactions on an anonymous basis. Privacy is built into the blockchain by default. In fact, blockchain allows users to control their data to a much greater extent than anything we can offer right now. An example would be a student who enters university and during the library orientation agrees to be interviewed on video and signs a waiver. During a later visit, the student is asked to participate in a survey, which has another waiver attached. On subsequent visits to the library, the student attends a workshop and uses the tutoring service. The student also visits the library every Tuesday after class, and the library tracks the visit data from card swipes on entry and exit. In the course of all of these interactions, the student generates a lot of data. Nearing graduation, the student sees the video agreed to during the first year but doesn't recall giving permission for the video to be used. The student can now enter their profile stored on the blockchain and review the agreement. The student can decide to revoke that permission. The student then realizes that over several years of coming to the library, lots of data has been collected, and is curious about how and when this data was used. The blockchain would allow the student to query in which research studies their data was used. The student might even be able to review decisions that were made based on the data to which they contributed. Blockchain in effect allows the student to own their data and to allow or disallow usage of the data captured.

From the library's perspective, the data and agreements generated provide a safeguard for the institution as well as the ability to perform analytics. We can query without having to worry about violating user privacy because, as explained earlier, privacy is a foundational feature of the blockchain.

7. A Unified/Verified Library "Card"

Libraries interact with patrons or users usually via user accounts that are verified using an issued unique user ID and a library card. This card allows patrons to interact with the library's system and services. They can borrow materials online and in person. They can authenticate themselves online and gain access to databases or materials. This system works well and has worked well for many years. However, improvements can be accomplished via blockchain.

One major area where blockchain could improve the borrowing experience is through its privacy applications. The ALA *Library Bill of Rights* emphasizes "the right to privacy and confidentiality in their library use."[3] Currently, a patron's borrowing history is stored on servers and in library information management systems. These systems may be very sophisticated and may be set up to delete borrowing histories on some regular interval after a loan has been completed. However, there are weak points in this system. The user data is gathered when a borrowing transaction happens and is then available for some time after the transaction has concluded. We say "some time" to be purposely vague because these retention timeframes are not usually made explicit and vary from system to system. The data may be stored on a library's or a third-party server, which may be hackable, can be subpoenaed, and is more than likely backed up in more places than the average librarian or user realizes. Borrowers may benefit from accessing their borrowing data. However, once it has been deleted, we have made it inaccessible to them and to ourselves. Through the use of private and public keys, we could develop a system that would allow borrowing to take place but for the borrower's identity to be protected. Moreover, the data would be stored with the users' public keys, which they could use to access their own history and review their own data.

Another benefit of blockchain would be creating a verified system of library users that could allow users from different borrowing systems to enjoy benefits in other systems. A borrower from one state who travels to another may be able to access services immediately and without a local library card. In an academic library setting, a borrower from one institution could travel to another institution and be automatically authenticated in that library's system.

8. Blockchain for Information Literacy

Libraries are an important part in digital and information literacy education. Blockchain can be utilized to create systems to verify information. A blockchain-based system could be created that allows news articles to be uploaded, time-stamped, and verified. A reader who wants to access the material can confirm via the blockchain that the content is unaltered from the original. The article can be protected from being altered, and the distribution of fake articles could be prevented. The same goes for video and audio content. The creation of deepfake videos, where videos include seamless, digitally created content, could also be made significantly more difficult. The creator of an original video can establish via blockchain the original video. Suppose that later, a modified deepfake version were created of this original content and entered the mainstream. Using the blockchain, the video could be verified against the content that has been uploaded in the blockchain and exposed as a fake.

From a user perspective, authentication to read original material could be managed through the use of the private and public key framework. Users concerned about censorship or confidentiality could use their private key and a privacy browser to create a public key to access information that otherwise may be inaccessible to them. While metadata such as IP-based location could still be tracked, the authentication to the individual user would be obscured and privacy would be ensured.

One interesting approach to this challenge is the News Provenance Project, which is supported by the *New York Times*.[4] The project is in its infancy but is looking to address the issue of fake news via metadata that is encoded in blockchain. The challenge with this system is the massive amounts of news and the rapidity with which news is being created, which pose a challenge when it comes to keeping the network current. Many other systems are being explored and developed to address the issue of fake news, and it remains to be seen if any of them will succeed.

Moving Forward

These eight case studies are brief thought starters to introduce possible applications of blockchain in libraries. Any of the concepts can be extended to special collections, archives, museums, or other memory institutions. More importantly though, the big questions that need to be answered in all of the use cases or any others that will emerge are (*a*) whether blockchain-based technology is the best solution for the problem that needs solving, and if the answer to this question is yes, then (*b*) whether there is a cost-benefit analysis that skews the answer in favor of a blockchain implementation. Since we are still in the early stages of this technology, there is not a lot of information available about the true cost of developing solutions and the challenges that will be encountered. For that same reason, there are also not too many experts in the field who have the experience and ability to develop these

technologies for libraries. That all being said, the goals of this chapter were to spur on the imagination and provide thought starters in the hope that the ideas will inspire and maybe lead to the eventual development of blockchain-based applications for libraries.

Notes

1. A public blockchain for all libraries not to be confused with a blockchain only for public libraries.
2. Artory home page, last accessed September 8, 2019, https://www.artory.com; "The Barney A. Ebsworth Collection Sale—A Landmark for the American Art Market," Christie's, last accessed September 8, 2019, https://www.christies.com/features/Barney-Ebsworth-Collection-results-9552-3.aspx.
3. American Library Association, *Privacy: An Interpretation of the Library Bill of Rights* (Chicago: American Library Association, adopted June 19, 2002; amended July 1, 2014, and June 24, 2019), www.ala.org/advocacy/intfreedom/librarybill/interpretations/privacy; American Library Association, *Library Bill of Rights* (Chicago: American Library Association, adopted June 19, 1939; amended October 14, 1944, June 18, 1948, February 2, 1961, June 27, 1967, January 23, 1980, and January 20, 2019), www.ala.org/advocacy/intfreedom/librarybill.
4. News Provenance Project, "About," accessed September 7, 2019, https://www.newsprovenanceproject.com/About.