Smart Contracts Annotated Bibliography

An annotated bibliography is a list of citations to books, articles, and documents. Each citation is followed by a brief (usually about 150 words) descriptive and evaluative paragraph, the annotation. The purpose of the annotation is to inform the reader of the relevance, accuracy, and quality of the sources cited. Cornell University Library

Contributors: Please consider adding entries to this annotated bibliography (AB) as you read and research articles. This AB will serve as a reference for papers and presentations we collaborate on together and as individuals. APA style.

Annotations

Allen, D., Berg, C., Davidson, S., Noval, M., & Potts, J. (2019, May). International policy coordination for blockchain supply chains. *Asia & the Pacific Policy Studies,* https://doi.org/10.1002/app5.281 | Full text

> This document begins by introducing the historical evolution of global trade, and the developments of the standardized shipping container and global trade coordinating bodies. Authors point out that these occurrences allowed economical trade progression to occur, and explain how this supported trade cost reductions, as their implementations were directly correlated with reduced *transportation costs* and *regulatory costs*. It is then illustrated that *information costs* are a current hindrance to favorable trade costs, and that blockchain technology could resolve the issue.
>
> Authors reason that with security and integrity being inherent to the blockchain structure, it could be utilized to create distributed ledgers of information and facilitate the implementation of decentralized ledger governance. The conjecture is that this would ensure the meeting of consumer demands for information availability and international government requirements for domestic regulation satisfactions, thus supporting the reduction of *information costs.*
>
> The impediments of *regulatory uncertainty* and *different parties have to join forces* are introduced with possible ways to resolve them, as it is declared that several countries within the Asia-Pacific Economic Cooperation (APEC) have already begun to initiate regulatory and fiscal policies supporting the utilization of blockchain. A discussion of open versus closed standards is also explored, as the authors conclude open standards would be the most supportive option for blockchain application.
>
> I found the article to be a comprehensive and objective analysis of the need for blockchain within the global trade industry, issues this would entail, and circumstances that would need to take place to work through those concerns. It would be an instrumental piece to read for any individual involved within the global trade industry, or attempting to resolve real-world, universal obstacles utilizing blockchain.

Azzi, R., Chamoun, R.K., & Sokhn, M. (2019 June). The power of a blockchain-based supply chain. *Computers & Industrial Engineering,* https://doi.org/10.1002/app5.281 | Full text

> The authors, a group of researchers from the University of Beirut and University of Applied Sciences Western Switzerland, take an empirical approach to the analysis of blockchain applications in the supply chain management (SCM) context. The paper begins with a literature review of common problems in both SCM and blockchain development before examining two case studies, namely *Ambrosus* and *Modum*, two Swiss startups “that merge IoT, blockchain technology, and real-time sensors” for track and trace. In addition to the challenges of choosing the right blockchain for the right problem, the authors highlight the challenge of validating data before it is irrevocably committed to the blockchain. Both companies opted to have a secondary storage type due to the high costs and low capacity of data storage on the blockchain. *Ambrosus* developed its own blockchain written in Solidity on top of Ethereum, allowing them to run their smart contracts on their own platform and eventually copy it over to the Ethereum main network.
>
> Overall the article was an informative examination of two real-world blockchain applications and the problems they faced with both their underlying blockchain platforms and the services built on top. There were a few typos in the paper, and the authors repeatedly referred to Hyperledger as a single entity rather than mentioning a specific project. They also made an uncited claim that I am not sure is valid - “Hyperledger will stop working when the number of servers and nodes reach a certain threshold because the number of dropped consensus messages will increase due to channel request congestion.”
>
> This paper would be a useful resource to anyone looking for a more concrete discussion of the unique problems that arise from using a blockchain-based supply chain.

Chang, S.E., Chen, Y., & Lu, M. (2019). Supply chain re-engineering using blockchain technology: a case of smart contract based tracking processes. *Technological Forecasting & Social Change*, 144, 1-11. https://doi.org/10.1016/j.techfore.2019.03.015 | Full text

> The first seven pages of the article are an overview of general information regarding blockchain, smart contracts, and supply chain logistics. Beginning on page 8 potential recommendations are offered; however, they are primarily generalist. The reason I note this article within the AB is what the authors intend to study is interesting. The paper does not act as a 'case' as it offers in the title.
>
> The intent of the paper is to address real-time tracking in supply chains to reduce the wait for confirmation of information. The aim of the study is to investigate an alternative private-chain to enhance transparency and distributed collaboration of the supply chain process to include: *1) investigating the feasibility of a blockchain-based tracking process; 2) establishing a blockchain-based business process re-engineering (BPR) framework; 3) evaluating the potential benefits and values of such framework; and 4) shedding light for creating blockchain-based applications in different industries.*
>
> I consider this type of article as an "about" article. There are terms, ideas, and information relevant to the problem if you are interested in validating how you view the supply chain. That said, the details expected in a case are not available.

Christidis, K., Devetsikotis, M. (2016 May). Blockchains and Smart Contracts for the Internet of Things. ***IEEE Access***, https://ieeexplore.ieee.org/abstract/document/7467408 | Full Text

This paper starts off with one of the better high-level overviews of blockchain technology that I have read. The authors provide a great explanation of the basics around networking, protocols, smart contracts, and more. Following this overview, they discuss the benefits and challenges of using blockchain alongside IoT technology. A few real-world examples are discussed such as Slock.it, a company that allows users to control access to a smart lock by paying in Ether. The last section of the paper discusses some important deployment considerations that any administers of a blockchain network should consider.

As of Nov 2019 this paper was one of the most cited articles on the topic of Smart Contracts on Google Scholar. Both authors are also highly reliable - Christidis is a co-creator of Hyperledger Fabric, and Devetsikiotis is Department Chair of Electrical and Computer Engineering at the University of New Mexico with numerous publications related to IoT.

I would highly recommend this paper to anyone that would like to understand the basics of the underlying technologies that support a blockchain. As far as discussion around blockchain and IoT, the paper was a little sparse. I would recommend it as a good overview of the topic, and perhaps a good resource to find more in-depth papers on blockchain and IoT in the References section.

Junis, F., Prasteya, F.M.W., Lubay, F.I., & Sari, A.K. (2019 June). A revisit on blockchain-based smart contract technology. https://arxiv.org/ftp/arxiv/papers/1907/1907.09199.pdf | Full text

Authors open their discussion by explaining that blockchain has grown from digital currency to smart contract utilization by a wide range scope of industries. It is then brought to light that, with this change, there is an issue of blockchain smart contract research not being collocated for concentrated review by experts, and it is proclaimed that this document will explore research gap issues related to this.

The report delves into a cited example of Nakamoto's original proposal that the inherent processes of blockchain could be utilized to avoid duplicate digital spending, which then leads into an evaluation of how various entities have begun to utilize this concept within the format of smart contracts. A breakdown ensues of how the related issues of duplication, Sybil-attack, transaction isolation, and immutability are being resolved by blockchain industry leaders.

I liked the way the article followed this by giving referenced examples of the tokenization of real-world assets and virtual assets, which brought together the initial ideas presented before diving into the final sections concerning the analysis of four classes of smart contract issues: codifying, security, privacy, and performance. The paper tied this together at the end with mentions of various researched problem-solving proposals, and a conclusion that demonstrates further comprehensive studies need to occur for blockchain-based smart contract technology to be universally actualized.

It seems to me that this article would be helpful to a wider audience, as ideas are presented simply enough that one could consider the effectiveness and foresee possible issues concerning blockchain use across multiple applications.

Hartel, P., & Schumi, R. (2019 September. Gas limit aware mutation testing of smart contracts at scale. https://fr.arxiv.org/abs/1909.12563

The authors have focused their work on the testing of smart contracts to ensure not only their validity but also the validity of the testing tools themselves. If the tools are inaccurate or not up to the task of ensuring the data integrity of smart contracts, financial losses can occur, and trust in the system will be lost.

The authors conducted a test on a larger group of smart contracts picked from Truffle-tests-for-free. The goal was to form a baseline for mutation testing. The goal of the test and the results that were obtained is to assist developers in creating a mutation tool for the programming language Solidity so that tests can be greatly improved.

This article helped me to understand how the current checks and balances in the smart contract system operate and how much more work needs to be done to ensure their integrity. I would agree on the need for more effective development level tools.

Hasan, H., AlHadhrami, E., AlDhaheri, A., Salal, K., & Jayaraman, R. (2019). Smart contract-based approach for efficient shipment management. *Computers & Industrial Engineering*, 136, 149-159. https://doi.org/10.1016/j.cie.2019.07.022

In this paper, the authors present a proposal for a blockchain based shipping management system. They detail a process upon which users can initiate peer to peer efficient shipping monitoring. In addition, they discuss the value of utilizing IoT technology with blockchain to create a system that can not only track the location of an item, but various environmental stimuli from temperature, humidity, sudden drops, etc. They also discuss a proof of concept case study which was designed to track that pharmaceuticals remained at a safe temperature from manufacturer to warehouse, hospital, and finally patient.

The article is informative and thorough in its discussion on implementation, this demonstrates a high level of knowledge by the authors. The authors are very credible on the subject and each of them have several other publications in other industry respected publications. The source is neutral in its presentation of both the current state of the technologies of RFID, IoT devices, and blockchain ability to support the ideas presented, as well as the current uses.

This source is very helpful because it directly relates to a subject that is important to companies across almost all industries. It demonstrates a system where users of the system can have a much greater insight on the conditions of their products as they are shipped around the world. Although the technologies in this paper are ones that have existed for quite some time, the novel combination can benefit all shippers.

Kim, M., Hilton, B., Burks, Z. and Reyes, J., Integrating Blockchain, Smart Contract-Tokens, and IoT to Design a Food Traceability Solution, *2018 IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)*, Vancouver, BC, 2018, pp. 335-340. doi: 10.1109/IEMCON.2018.8615007, https://ieeexplore.ieee.org/document/8615007

This paper describes the problem of how data for tracking agricultural data for the food supply chain is not standardized globally and how this creates inefficiencies. The authors propose using IoT sensors to automate logistical data collection, standardizing the tracking data using the GS1 protocol, and recording this information using ERC-721 non-fungible tokens on the Ethereum network. The application interface to the smart contracts is called Harvest Network.

The authors describe the tools and high-level architecture for implementing their solution to the problem. It would have been interesting to get a more detailed case study on one of their implementations, or some "lessons learned" from their implementation in the field. Unfortunately, in Dec 2019, the harvestnetwork.io URL takes you to a blank page, so perhaps the project is no longer active.

The ideas are interesting and some introduction is provided regarding the GS1 protocol and tokenization using ERC-721 Non-Fungible Tokens on the Ethereum network.

Liang, Z., Huang, Y., Cao, Z., Liu, T., & Wang, Y. (2019 February). Creativity in trusted data; research on application of blockchain in supply chain. *International Journal of Performability Engineering*, 15(2), 526-535. https://doi.org/10.23940/ijpe.19.02.p17.526535 Full text

This document talks about creativity in software development and designing new functions in specific regards to supply chain. It is discussed that the sharing of data and confirming that the data is not modified in any way while it is being shared is what brings it back to blockchain. Standard use supply chains are compared with how back and forth data must be transferred and how easy it is to lose where the data came from, who created it and where it needs to go next. After studying the supply chain functions, the document shows how blockchain management could be utilized in a way to streamline and provide full tracking of the information and how it can tie to new software development as it is created for supply chain management.

When comparing to other sources, this one does provide a reliable source. Information and data that is presented is all backed up with additional sources that are also credible. The information presented is neutral and not biased and is being presented as an improvement. The author does not appear to have any reason for the supply chain management to be utilized in either format.

Macrinici, D., Cartofeanu, C., & Gao, S. (2018 October). Smart contract applications within blockchain technology: a systematic mapping study. Telematics and Informatics, 35, 2337-2354. https://doi.org/10.1016/j.tele.2018.10.004

The authors chose to look at a collection of sixty-four different studies done concerning the usage of smart contracts in blockchain technology. The systematic mapping study was designed to offer a broader perspective that focused on trends, methods and approaches.

According to the authors the most common issue relating to smart contracts themselves revolves around the programmability of the smart contracts. The study also attempts to identify smart contract research gaps such as scalability, performance issues and the lack of studies outside of the Ethereum platform.

The takeaway for me was the combination of factors involving security and privacy. This has been an issue that I have seen repeatedly in my research into blockchain technology and smart contracts in particular. More research needs to be put into place regarding the real world usage of smart contracts.

Mell, P., Dray, J., & Shook, J. (2019). Smart contract federated identity management without third party authentication services. https://arxiv.org/abs/1906.11057 full text

This document discusses the use of an identity management system (IDMS) and utilizing a smart contract on a blockchain. The purpose is to eliminate the use of third-party authentication to reduce cost to the user and to enhance the security. It allows for a user to have a single login authentication source for multiple uses. Sections of the document break down the IDMS contract and how it is to be utilized with the contract.

It is mentioned several times throughout the document that this is a conceptual design but use strong references to back up the theory on how this can be used. By referencing whitepapers and Sovrin.org, the authors provide a strong sense of reliability on the information that is provided. The source seems to be neutral with only leaning towards the idea that the information being used for access should be controlled and owned by the user and not by the third-party companies, however, this is due more to the topic than the authors' writing style.

Prause, G., & Boevsky, I. (2019). Smart contracts for smart rural supply chains. Bulgarian Journal of Agricultural Science, 25 (No 3), 454-463. Retrieved from https://www.researchgate.net/publication/333798861_Smart_contracts_for_smart_rural_supply_chains | Full text

The paper discusses how smart contracts and blockchain technology can be applied to smart rural supply chains and what new business models for rural companies can look like. The authors, from Bulgaria and Estonia, describe rural challenges that mirror the challenges in the rural community I live in, in California. The reference to IoT as delivery robots was not expected, although the interpretation is interesting and references to 'big ag' ring true.

The authors do not discuss implementation details; however, they offer intriguing ideas. They view the biggest opportunity of blockchain technology and smart contracts in the rural supply chain sector in the restructuring of agricultural commodity trading markets. They note 'big ag' domination allows them to dictate the rules and processes in the agriculture sector, often managed with their own IT systems and organizational structures. Smart contracts can, for example, work to consolidate and organize transportation systems with a trusted and automated execution of transactions with safeguarded information and money streams.

I recommend this article as informative and relevant for rural logistics considerations and challenges.

Sato, T., Himura, Y., & Nemoto, J. (2019 January). Design and evaluation of smart-contract-based system operations for permissioned blockchain-based systems. https://arxiv.org/abs/1901.11249 - Full text

This document is about a possible method for designing smart-contract-based systems and the way they operate. It is discussed that cross-platform Blockchain is not the best or smoothest possible way of evaluating the contract but instead they utilize what they call in-blockchain and out-blockchain with the out being third parties that have systems designed to detect triggered events. According to the document, this triggering will allow for a faster response with times as low as 3 seconds. They determined that this was due to a single system not having to manage all nodes but only parts of the nodes and bringing the information back to where it is required and that with the triggering, it does not rely on human interaction and can be automatically done.

The information provided in this document seems to have been tested and is not just a theory. Times and tracking have actual case studies that provided the data which makes them more than just estimates. The systems that are demonstrated are also reliable in that they do exist in real world scenarios and are also not theory designed systems that may or may not actually work.

With good demonstrations and graphics, this document will assist people in deciding what resources and what parts of a system to place in blockchain and what parts do not need to be. By providing the actual scenarios, it gives good examples of strong and weak systems that can be used.

Siris, V.A., Dimopoulos, D., Fotiou, N., Voulgaris, S., & Polyzos, G.C. (2019 May). Interledger smart contracts for decentralized authorization to constrained things. https://arxiv.org/abs/1905.01671 | Full text

After discussing various negative tradeoff issues concerning the offloading of blockchain smart contract authorization from constrained Internet of Thing (IoT) devices to a single authorization server (i.e. execution costs, delays, data reduction), authors state their ambition of presenting designs that more effectively perform this task instead utilizing multiple authorization servers (AS). The stated intention for resolving these tradeoffs is to exemplify constrained IoT device interconnection using a decentralized authorization method with multiple blockchains that constitute two interledger mechanisms.

The level of deliberation appears to be meant for those that have already obtained intermediate to advanced knowledge of blockchain, smart contracts, and constrained IoT devices. However, with some additional research, a reader with novice awareness of these subjects would be able to follow and learn more about the aspects of the presented issue. Further, despite a compelling presentation and references listed at the end of the writing, my attention was drawn to the lack of cited sources listed in the article. This absence was initially noted upon reading the Introduction section, which proposed claims of high computation costs, transaction fees, and delays that occur with the utilization of Ethereum as Bitcoin.

I did find the report to be educational as to the various processes involved while implementing blockchain smart contracts in conjunction with constrained IoT devices. What's more, is I have been persuaded that experimenting with the interconnection of multiple blockchains to improve smart contract efficiency is a worthy pursuit.

Wang, X., Yang, W., Noor, S., Chen, C., Guo, M., & van Dam, K.H. (2019). Blockchain-based smart contract for energy demand management. *Energy Procedia*, 158, 2719-2724. Retrieved from https://www.sciencedirect.com/science/article/pii/S1876610219311063

This paper discusses the feasibility of a system of automated trading of power resources utilizing blockchain as the trading medium. The authors present the different electrical demand profiles of residential, commercial and industrial users and propose a game theory model which aligns the goals of all users to reduce their load, thereby saving money. In addition to the demand being requested through the blockchain to the utility provider, they present a case study in which users in a microgrid can make spot-trades based on changing needs on a daily basis.

The authors received financial support for the project through a grant provided by the Ministry of Education Academic Research Fund of Singapore. The authors are very credible on the subject as some of them have several other publications on the same subject matter. The source is neutral in its presentation of both the current stated of blockchain ability to support the ideas presented, as well as the challenges that will be faced. They even note the limitations the current infrastructure that will limit the adoption of the ideas presented.

This source is very helpful because it tackles a subject which is assumed to be best managed by large utilities and governments. It gives a new perspective that the users in a system will best manage demand when given the ability to make choices and save money. The idea of placing smart contracts with demand into an open market to be filled by those that have excess can be helpful in many different projects.

Wang, Y., Bracciali, A., Li, T., Li, F., Cui, X., & Zhao, M. (2019) Randomness invalidates criminal smart contracts. Information Sciences, 477, 291-301. https://doi.org/10.1016/j.ins.2018.10.057

This paper discusses the use of random factors based on PublicLeaks to minimize the ability of those using smart contracts for criminal activities. While it talks of the mitigation of criminal acts via smart contracts it does not give guarantees, but instead looks at them from a risk management viewpoint.

Much of the paper works upon the idea of entering additional factors such randomness. While this may prove somewhat effective the statement of, "As with real-world crimes, CSCs are not as powerful as assumed." Is not an overly realistic view. Another statement concerning machine learning as an additional method for ferreting out criminal activities and disallowing their usage of the system is actually a far more effective and realistic method for control.

This source has helped me with a better understanding of both sides concerning both legal and illegal applications of smart contracts. While the authors believe in the usage of smart contracts as a way to improve trust in blockchain transactions via adding randomness, they also feel more must be done to ensure their legitimate non-criminal usage.

Westerkamp, J., Victor, F., & Küpper. (2019 January). Tracing manufacturing processes using blockchain-based token compositions. *Digital Communications and Networks*, https://doi.org/10.1016/j.dcan.2019.01.007 | Full text

This paper discusses the current traceability that exists in modern supply chains as well as the mechanisms that provide provenance in both manufacturing and high value goods. The authors contend that in today's world, there is more demand by consumers to not only know the source of the end product, but also the source of its components. The authors propose a prototypical implementation of a supply chain traceability system that models the manufacturing process as token recipes. These recipes take source tokens as inputs to make a completed product.

The authors all have a multitude of publications and are fro the University of Berlin. Based on the subject matter of the other publications, they seem highly credible to weigh in on this topic. The source is neutral in its presentation of both the current stated of manufacturing traceability as well as in the presentation of their solution.

This source would be extremely helpful in the implementation of a traceability system in any manufacturing which requires the knowledge of the source of components that make up a finished product. The examples that were given were clear and can aid in implementing of any manufacturing project.

Yoo, M., & Won, Y. (2018 November). A study on the transparent price tracing system in supply chain management based on blockchain. Sustainability 2018, 10 (4037), https://doi:10.3390/su10114037

This article discusses the usage and application of smart contracts to increase transparency in supply chain management systems. By keeping all aspects of the supply chain, including all applicable costs open to view, the authors believe that consumers and manufacturers alike will benefit. The theory was applied in a testbed setting, the authors hope to apply the test to SCM in actual operation in the future.

The research received no outside funding but was supported by the Korean Ministry of Science and ICT (MSIT). Given that this was a test run of their theory, the overall concept shows promise. They do point out specific strengths and weaknesses concerning both blockchain and the usage of smart contracts.

Although transparency is a solid goal for all transactions, the idea that imposition can be made upon businesses to only look for appropriate levels of profit shows a lack of business understanding. "...we propose a price tracing system that can prevent wholesale firms from making extra profits by automating some transactions and integrating them, thus making the pricing information in the SCM transparent."

Zakhary, V., Agrawal, D., & El Abbadi, A. (2019 September). Transactional smart contracts in blockchain systems.https://arxiv.org/abs/1909.06494v1 | Full text

By detailing the incongruities within smart contract programming efforts, authors introduce the concept of the Transactional Smart Contract (TXSC) framework as a resolution. Issues of concurrency control and isolation anomalies are defined in the paper concerning the two circumstantial blockchain occurrences of Single Domain Transactional Functions (SDTF) and Cross-Domain Distributed Transactional Functions (CDTF).

Specific program examples of these problems are cited and impartially reviewed, with detailed explanations given of blockchain processes as they are unraveled to explore solutions. The article goes on to explain the role of the Database Management System (DBMS) to support ACID (atomic, consistent, isolated, and durable) properties within a blockchain, and how the TXSC framework can supplement this process to resolve complications through the implementation of proper transactional semantics.

With proof of concept (PoC) examples referenced, I found this writing to be enlightening as to the need for comprehensive semantics and framework standardization requirements for blockchain transactions. It appears the practices detailed are likely applicable within actualized use-case scenarios. As a whole, the report seems to be geared toward examination by those with intermediate and advanced knowledge of blockchain transactional application but could be followed by a layman within minimal research into the subject.

Annotated Bibliography - Example format

- 2 to 4 sentences to summarize the main idea(s) of the source.
  - What are the main arguments?
  - What is the point of this book/article?
  - What topics are covered?
- 1 or 2 sentences to assess and evaluate the source.
  - How does it compare with other sources in your bibliography?
  - Is this information reliable?
  - Is the source objective or biased?
- 1 or 2 sentences to reflect on the source.
  - Was this source helpful to you?
  - How can you use this source for your research project?
  - Has it changed how you think about your topic?

Links to articles for possible inclusion and addition, please read articles of interest and create associated annotations.

Brammertz, W., & Mendelowitz, A.I. (2017 September). From digital currencies to digital finance: the case for a smart financial contract standard. The Journal of Risk Finance, 19 (1), 76-92. https://www.emerald.com/insight/content/doi/10.1108/JRF-02-2017-0025/full/html

Full text

Liu, X., Muhammad, K., Lloret, J., Chen, Y., Yuan, S. (2019). Elastic and cost-effective carrier architecture for smart contract in blockchain. Future Generation Computer Systems, 100, 590-599. https://doi.org/10.1016/j.future.2019.05.042

Full text

Additional articles on Interoperability not yet noted in this Confluence page