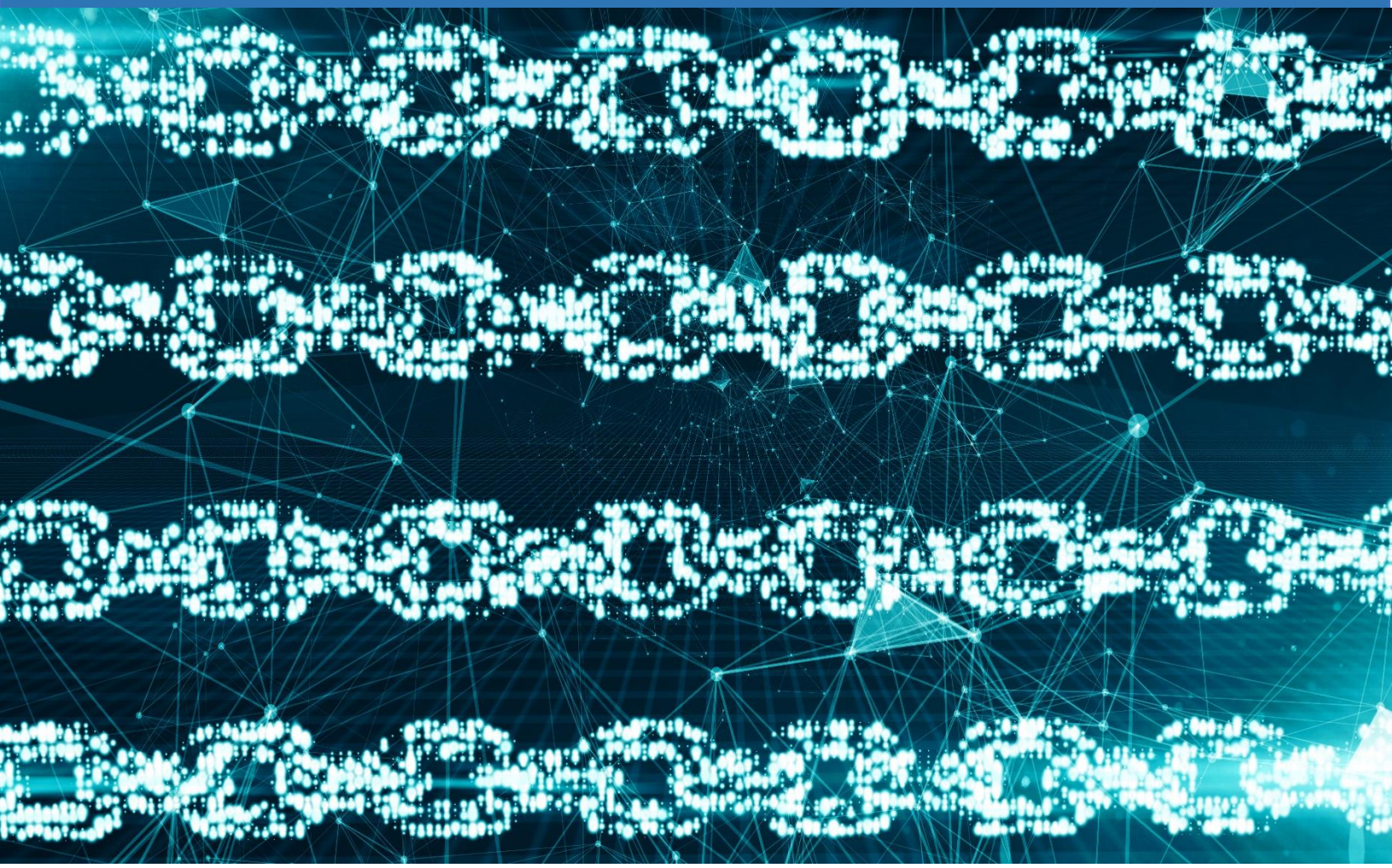
White Paper



REINFORCING THE LINKS OF THE BLOCKCHAIN

November 2017

IEEE

IEEE FUTURE DIRECTIONS BLOCKCHAIN INITIATIVE WHITE PAPER
BLOCKCHAININCUBATOR.IEEE.ORG

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1.ABSTRACT

Blockchain, as an industry, has entered its Cambrian phase. A glut of investor interest has led to an explosion in the technical diversity of projects now underway. During the first half of 2017 alone, over one billion dollars was directed to the funding of blockchain start-ups.[1] This money, which supports the development of competing technologies, is accelerating the speed of fragmentation in the industry. At the heart of the burgeoning innovation in the blockchain space is an undeniable contradiction: though the impulse to compete is at its peak, so too is the need for collaboration.

Blockchain technology is poised to change nearly every facet of our digital lives, from the way we send money to the way we heat our homes. By obviating third parties, blockchains promise to make our systems more efficient. By circumventing censorship, they promise to make our systems more equitable. And if properly implemented, they could make our systems more reliable and secure.

All these changes will arrive more quickly, and their effects will be compounded, if the parties who are now building them work together. Today, that is not the case. Alliances have been announced. But, thus far, what they have added to the industry is more blockchains, more designs, more choices, more competition.

IEEE sees the need for three things: a paradigm for evaluating the design options that are now available, a strategy for adopting technical standards, and a path for continued research in blockchain development.

The purpose of this white paper is to explore the various ways by which the IEEE can lead and support the above initiatives while providing educational materials that will foster the next generation of blockchain engineers.

This white paper summarizes and expands upon a workshop held by IEEE at the end of October in 2017. The workshop was attended by representatives from the IEEE Reliability Society, IEEE Communications Society, IEEE Computer Society, IEEE Society on Social Implication of Technology, the IEEE Standards Association, IEEE Society Engineering in Medicine and Biology Society, IEEE Power & Energy Society, IEEE Technology and Engineering Management Society, IEEE Technical Committee on RFID, IEEE Consumer Electronics Society, IEEE Vehicular Technology Society, IEEE Educational Activities, IEEE Standards Association, and IEEE Technical Activities.

[1] https://www.coindesk.com/1-6-billion-all-time-ico-funding-climbs-as-record-500-million-invested-in-july/

2.MOTIVATIONS

In 2009, as the world was reeling from a meltdown in the financial sector and politicians were musing about what could and should be done, a project called Bitcoin quietly dropped onto the global stage. This technology, which defined an entirely new form of money, was a reaction to the crisis at hand. With a cold sneer, it turned away from the humans that had caused the tumult and embraced a new paradigm, in which both the ruleset of an economy and its execution are provided by software rather than people. Bitcoin sought to do two things: make the rules governing money entirely predictable and transparent and give people the ability to transfer it over the Internet without the need for corporate surrogates.

Within this technology, however, lie the seeds of something much bigger. The nucleus of Bitcoin's architecture, a structure called a "blockchain," is now the basis of proposed applications in nearly every sector. Like Bitcoin, these applications are being designed to remove rent-seeking corporations from digital processes while giving users more control over their data.

Blockchains borrow from research into distributed systems, cryptography, computer security, and game theory, to deliver a new type of shared database. A blockchain-driven database is replicated on multiple computers across many jurisdictions. Additions are made by these same computers, which need share neither an affiliation nor any modicum of trust for the updates to remain secure. These features are widely considered to be a breakthrough in computer science.

As the success of Bitcoin has demonstrated, blockchain technology is useful for projects that require real-time collaboration between mutually-suspicious contributors over the Internet. However, the technology is far from mature. Further development—especially in the areas of usability, security, and privacy—are necessary. At the community level, more work needs to be done to educate both the public and relevant regulators, whose stance regarding blockchain applications is still malleable.

The work to solve these problems is underway, and is already richly funded. However, most of the money entering the blockchain ecosystem is being funneled to individual projects, each of which is trying to fix the systemic flaws of the technology in isolation. New blockchains are created by the day. It is not at all evident whether they are learning from one another's failures and successes. Nor is it clear whether these parallel, often overlapping technologies are being designed to interoperate with one another.

Blockchains are incredibly well equipped to coordinate the activities of mutually mistrusting peers who want to collaborate in an environment with a predefined set of rules. But when the rules themselves—thus the very design of a blockchain—come into question, competitors find themselves once more in the awkward position of having to negotiate and collaborate while somehow protecting their advantages.

The IEEE is in a unique position to bring the users, regulators, researchers, and industry representatives in the blockchain space to the table. As an unbiased haven, the IEEE can act as the steward of blockchain research in many domains. This white paper inaugurates the IEEE's efforts to encourage and assist partnership among all current stakeholders in a way that will best serve the stakeholders of the future.

3.FUTURE APPLICATIONS

Blockchain-based applications benefit from several unique features that are not found in applications built with standard databases. Most of these features can be summarized in the following statement: it does not matter who runs a blockchain because so single entity "owns" it. What this means functionally is that data and programs stored on a blockchain will be safe against removal, and will perform accurately (as written), regardless of who is doing the work of adding new entries and archiving past ones. This is a description of an idealized blockchain system, one in which the incentives of the participants have been properly balanced. But it accurately describes the most popular blockchain platforms in operation today.

3.1 Features of a blockchain

A few things happen when you allow anyone to participate in the operation of a blockchain.

- **Collaboration among competitors -** Entities that would normally be in competition with one another have a common platform in which they can openly collaborate without fear that one will surreptitiously circumvent the rules.
- **Flexibility -** It neither matters who the participants in a blockchain are, nor whether they remain the same over time. Therefore, applications can be built in which the composition of the stakeholders is continuously shifting.
- **Resilience -** An open invitation leads to a diversity of participants, each of which has a full copy of the blockchain running the application. This redundancy makes the system resilient to attacks and resistant to censorship.
- **Distributed Verification -** Programs and data reside in multiple locations and can be verified by many parties independent of one another.

3.2 Industry-specific applications

Every industry stands to benefit from at least one of the above features, should blockchain technology mature. Below we examine a selection of the industries that may be impacted. This list is by no means exhaustive.

3.2.1 Finance

Cryptocurrency was the first blockchain application. Bitcoin gave the individual full possession over her money in the digital realm by making her the owner of a cryptographic key necessary for the transfer of funds. But the transfer between individuals is only the most basic program you can perform on a unit of value. More complex transaction types can be built into a cryptocurrency that replicate the full suite of **financial instruments**, such as **loans, bonds and stocks**, now offered by most institutions.

Blockchains may also increase efficiencies behind the scenes at financial institutions especially in the process of interbank settlement. For example, the Depository Trust and Clearing Corporation in New York City, a company that operates as a third party in the business of securities trading, has plans to begin recording $11 trillion worth of **credit default swaps** in late 2018[2].

Others in the blockchain space are hoping to use the technology to ensure that access to basic financial tools are equally distributed. To this end, companies are leveraging cryptocurrencies to provide low cost **remittance services** for immigrant populations, and **microloans** and banking services for businesses and individuals in underdeveloped nations.

3.2.2 Energy

Blockchain technology will likely change the way that electricity is bought and sold, as well as the way that it is delivered. At the edge of the grid—where electricity dead-ends in our heaters and appliances—consumers are beginning to produce their own electricity. Blockchain technology may provide a way to incorporate these new players into the market, perhaps with the creation of open**, distributed energy trading platforms**.[3]

Blockchain platforms will also likely take some role in replacing the systems that now manage the distribution of electricity. As a smarter grid is built, blockchains may aid in facilitating **dynamic signaling between producers and consumers**, especially as the line between those roles continues to blur.

[2] https://spectrum.ieee.org/telecom/internet/wall-street-firms-to-move-trillions-to-blockchains-in-2018
[3] https://spectrum.ieee.org/computing/networks/blockchains-will-allow-rooftop-solar-energy-trading-for-fun-and-profit

3.2.3 Identity

Bitcoin gave individuals control over when and how they spend their money. Blockchain technology may give individuals the same control over their reputation and credentials by decentralizing the process of authentication and authorization. Today most internet services offer users one of two ways to authenticate their identities. They either require users to create a unique registration for that individual site; or, they outsource this **identity verification** to another larger web service such as Google, Facebook, or Twitter. Blockchain applications have been proposed that allow users to manage accounts containing various authenticated fragments of their identity, which they then can selectively disclose.[4]

Blockchain-based identity management solutions have been proposed as a way to provide **emergency processing of refugees** who were forced to leave their countries of origin without documentation. And in the future, people who use **blockchain identity management** systems, may be able to more easily recover their records in the case of emergencies.

3.2.4 Supply Chains

Blockchains have been proposed as a replacement for documentation processes in the shipping industry, due to the many geographical regions and jurisdictions that a product moves through on its way to the consumer. One break in the chain of documentation can result in delayed shipment and lost profits. Blockchains may provide a way for all **certification and documentation** to be gathered in one place that is accessible to all parties but impossible to falsify.[5]

As products move between ports, blockchains may also provide documentation to the consumer about the **lifecycle of a product**, information that may ethically inform their choices about what to buy.

Blockchains may also aid in securing the pharmaceutical supply chain to reduce the prevalence of counterfeit drugs.[6]

3.2.5 Internet of Things and Edge Computing

The Internet of Things is not a one-way street. It is transforming everyday appliances into Internet portals, while also using those devices to harvest data. For example, cameras in our cars monitor surrounding vehicles and alert drivers when they're getting too close.

Edge computing is a strategy for moving the computations running the Internet of Things onto the devices that are themselves providing data feeds for the system.

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[4] https://techcrunch.com/2017/09/10/the-promise-of-managing-identity-on-the-blockchain/
[5] http://ieeexplore.ieee.org/document/7996119/
[6] http://standards.ieee.org/news/2017/blockchain_adoption_in_the_pharmaceutical_enterprise.html

Blockchains may have some utility as a control system for edge computing. Some work has already been done to use the Fabric distributed ledger (a product of the Hyperledger group) as an executive process control for edge nodes in a distributed IoT architecture. [7]

Blockchains may also provide a way to authenticate users across multiple IoT devices and to secure sessions.

In scenarios where the price of IoT services is determined by rate of usage, blockchains and smart contracts may offer a way to transparently meter service delivery. In all pricing schemes, blockchains may provide a new way to settle debts quickly and securely.

3.2.6 Telemedicine

Individuals receive their healthcare from a diverse collection of providers all of whom need access to the same patient information. Furthermore, these records must be up to date and authenticated by reliable sources.

Practitioners in the field of telemedicine are exploring blockchains as a repository for patient records. Such a tool would remove the healthcare system as the central manager of health-related documents and instead entrust patients with responsibility over their own data.[8]

Though patients would themselves control the transfer of health records on the blockchains, those records would be authenticated by the practitioners who uploaded them.

3.2.7 Radiation-hardened computing

Computing systems that operate near radioactive sources, such those used in space missions and at nuclear facilities, are at a high risk of malfunction. Advances have been made to design electronics that can withstand bombardment from ionizing radiation. But another solution to the problem of securing mission-critical systems in unfavorable environments, is to create a network of redundant systems, one that is tolerant of individual failures. Blockchain networks, due their fault tolerance, may provide a novel solution to this problem.

[7] http://www.telemedmag.com/article/new-kids-blockchain/
[8] http://ieeexplore.ieee.org/document/7968630/

4.CHALLENGES TO GROWTH AND MAINSTREAM ADOPTION

Companies and developers are working to broaden the functionality of blockchain technologies. The prevailing ethos of the community is that no idea is too big. The infrastructure these ideas are built upon, however—the blockchain designs themselves—are not yet able to support the complexities that their inventors have in mind. Important technical developments are still outstanding, regarding the usability and security of blockchain technology.

In addition, there is considerable uncertainty as to how specific applications of blockchain technology will fit into current regulatory schemes.

4.1 Scaling

One undeniable aim of the typical blockchain or cryptocurrency developer is to design a system that will attract as many users as possible. This is perhaps true of any startup. But it is particularly true of blockchain-based startups, which are implementing applications on top of a novel cryptocurrency. In these cases, the demand for the service directly impacts the price of the currency used to operate the application.

While mass adoption at first seems desirable, no blockchain now available to the public is ready to support any amount of heavy traffic. This fact is aptly demonstrated by the constraints of the two most popular blockchains. Bitcoin is able to process around seven transactions per second. Ethereum, while faster, can still only handle around 20 transactions per second. Both rates pale in comparison to the performance of transaction networks such as Visa and Mastercard which process thousands of card swipes per second.[9]

Computing applications will require processing capabilities nanosecond to femtosecond (*ns—fs*) range.

Most of the applications that are being proposed by blockchain startups will require a high capacity for data storage. For example, an application that uses a blockchain to execute insurance contracts and automatically dispense reimbursements for claims will require access to data about the customer profile as well as any other documentation that is relevant to the case. Given the state of the technology, it is not feasible for all this data to be stored on a blockchain. Distributed file storage systems may provide a solution, but they are still under construction.

[9] https://spectrum.ieee.org/computing/networks/do-you-need-a-blockchain

4.2 Security and Reliability

Although the design and code for most blockchains are publicly available, their updates and releases are not formally verified or validated for security and reliability. Such practices have led to coding errors, vulnerabilities, and bugs that have caused substantial financial loss to users.[10][11]

Blockchains are fast becoming a repository for applications known as **"smart contracts."** Smart contracts are transactions that are programmed to follow complex rules, which, in the setting of a blockchain, are then automatically and irreversibly executed. For example, a blockchain could be used to make a transaction that would execute only if the Pittsburgh Steelers were demonstrated to have won the Super Bowl in 2018.

Writing smart contracts is a new skill that is fraught with peril. Once written, these programs are irreversible. Developers must be sure that the code they write does what they think it does. Developers must also understand the business logic of their programs, to ensure that they function exactly as intended.

4.3 Accessibility

Blockchain-based applications require users to learn an entirely different set of security measures than the ones to which they are accustomed. Rather than logging into an account controlled by a third party, blockchain applications grant their users direct access to any information they have stored on a blockchain. It is the responsibility of the user to secure the cryptographic keys that grant them this access. Or, should users choose to entrust a third-party with their cryptographic keys, it is their responsibility to vet those services.

This new paradigm will require an educational campaign. To date, those efforts have been insufficient. Nearly nine years have passed since the Bitcoin project was initiated. Yet, it is still commonplace for individual wallets to be hacked and for third-party services to announce lost funds.

One potential method for encouraging good security practices is the development of a Blockchain Input/Output certificate of authenticity and compliance. This certificate would provide a set of definitions and procedures that could help to standardize the input and output interfaces of blockchains. This would not only help to standardize application interfaces for blockchains, but also provide a way to standardize interoperability between individual blockchains.

[10] https://www.marketwatch.com/story/hundreds-of-millions-of-dollars-in-ethereum-frozen-in-accidental-coding-mistake-2017-11-07

[11] https://www.theregister.co.uk/2017/11/07/parity_wallet_destroys_280m_ethereum/

4.4 Regulation

The same features of a blockchain that make them desirable have also placed them in a legal grey area. It will be necessary to cultivate open and steady communication between regulators and blockchain developers. Both sides face a steep learning curve about how the technology works and what regulations may pertain to its deployment. In some cases, compliance can be ensured through proper implementation. In other cases, the issues may be best resolved by fundamentally adapting the underlying technology.

The following are some of the problem areas that the IEEE has identified.

- **Right to be forgotten –** Blockchains are marketed as indelible, timestamped records of digital events. The term used by developers is "immutability." If a blockchain is immutable, then any new piece of information added will remain there for the lifespan of the technology. In such a system, it is unclear how applications will be built to comply with laws that protect the user's right to be forgotten, such as the General Data Protection Ruled passed by the European Union in 2016.[12]

- **Custody of data –** Data added to a blockchain is replicated on every participating computer. And if the system is entirely open, then every record is also accessible to anyone who cares to download it. Without restrictions, it is neither possible to control nor to detect the physical location of data on the blockchain. It is, therefore, impossible to assign it to a single jurisdiction.

- **Privacy –** Blockchains are fully transparent. While the transaction and data flowing across them is attributable only to pseudonyms, this level of obfuscation is not enough to guarantee sustained anonymity to users. It should be assumed that without enhancements the identity of all accounts on a blockchain will eventually be exposed through network analysis. Without a higher level of privacy guarantees, blockchains will be incapable of complying with consumer protection laws such as the Health Insurance Portability and Accountability Act (HIPAA).

Incompleteness Is an Opportunity

For now, the ambitions of the people working on blockchain technology are more developed than the technology itself. Fortunately, a chain under construction presents an opportunity. The best time to educate and consider best practices is when experimentation is afoot.

[12] http://www.eugdpr.org/

5.CURRENT AND PRIOR EFFORTS

Consortiums and other industry partnerships have already been formed to unite corporations in the blockchain space.

- **Hyperledger –** The **Hyperledger** project has taken shape under the aegis of the Linux Foundation. Hyperledger combines the resources of IBM, Intel, Cisco, American Express, among many other corporations and a handful of academic institutions.[13]

- **R3Cev –** In 2014, some of the largest financial institutions—including J.P. Morgan, Goldman Sachs, and Barclays—joined forces to explore how blockchains might increase efficiencies in the banking sector.[14]

- **Enterprise Ethereum Alliance –** Formed in early 2017, the Enterprise Ethereum Alliance is working on an enterprise version of the Ethereum blockchain. It claims many of the same member that are participating in R3Cev.[15]

The alliances that have been forged thus far in the blockchain industry have set as their primary goal the development of new blockchain designs. Hyperledger has delivered a variant of a blockchain called Fabric, while R3Cevhas its own blockchain-inspired technology called Corda.

What is lacking in the current industry alliances is a group committed to directing both funding and academic resources to pursuits that go beyond mere product development. The IEEE is equipped to provide leadership in supporting research, educating industry, and codifying technical standards and best practices. It is also prepared to act as an ethical steward as blockchain development advances.

[13] https://www.hyperledger.org/
[14] https://www.r3.com/
[15] https://entethalliance.org/

6.IEEE INITIATIVE PROPOSALS

Over the course of a two-day workshop in Washington D.C. on October 27 and 28 of 2017, the IEEE identified ways the organization could participate in the blockchain space.

6.1 STANDARDS

It may be appropriate to propose new standards in order ensure that blockchains are securely built. New standards may also help unite the efforts of various projects which are currently being built on independent blockchains.

The IEEE will begin by recruiting for hybrid working groups from those stakeholders that would most benefit from standards. In parallel, the IEEE blockchain initiative will educate all stakeholders about how standards could help accelerate adoption of the technology.

6.1.1 The following projects are already in progress:

• IEEE P2418™- a standard for the Framework of Blockchain use in the Internet of Things (IoT). The framework addresses scalability, security and privacy issues pertaining to implementation of blockchains with the Internet of Things.[16]

• IEEE P825™ - meshing smart grid interoperability standards to enable transactive energy networks.[17]

• A project was approved in August 2017 to standardize the technology and implementation in supply chains and clinical trials. There are now 5 work streams covering pharmaceutical supply, clinical trials, agri-business, medical devices, and smart contracts for supply chains.[18]

• **“**Realizing the Immersive Future City.” The IEEE Standards Association has received approval to begin Industry Connections Activity surrounding the design and technology implementation issues impacting the “digital citizen.” Work stream 4 in this project will focus on developing a blockchain communication protocol with 360 data perspective.[19]

[16] https://standards.ieee.org/develop/project/2418.html
[17] https://standards.ieee.org/develop/project/825.html
[18] http://standards.ieee.org/about/sasb/iccom/IC17-012-01_SupplyChain_Trials.pdf
[19] https://standards.ieee.org/about/sasb/iccom/IC17-011-01-Connectivity_Harmonization_of_the_Digital_Citizen.pdf

6.1.2 The IEEE is interested in developing standards in the following areas:

• The security of blockchains as well as user interfaces such as wallets, exchanges and payment portals.

• The design of smart contracts. Standards may touch upon the use of proper business logic, the means for verifying smart contract code, and the necessary steps to be taken when linking multiple smart contracts in a single application.

• Data validation.

• Data privacy and giving end-users the capability to selectively disclose their information.

• Interoperability such that functions performed on one chain can be replicated and extended on another chain.

•Interoperability with consumer devices, and secure implementation of IoT.

6.1.3 Using the blockchain to strengthen existing standards**.** As a record-keeping strategy, blockchains pose a novel way to track whether participants are complying with standards that they publicly claim. The following are some of the standards that may be strengthened with implementation of blockchain technology:

• Smart grid standards: P2418 PB25

• Use blockchains to track the lifecycle of consumer electronics, and verify compliance with environmental standards such as #1680.

6.2 EDUCATION

The IEEE is developing a suite of courses about blockchain technology which it plans to sell to corporations that are training internally for blockchain development. Some of the topics being considered for training include:

6.2.1 Blockchain basics – a researcher's guide to how blockchains work.

6.2.2 Law and policy – What are the regulations that pertain to blockchain applications, and how can companies remain compliant?

6.2.3 Best practices for specific verticals — what do you need to know if you're building an application in: Energy, Real Estate, Legal Services, Content management? What are the major projects in these areas?

Considerations

While courses provide a source of revenue for the IEEE, other non-profitable outreach must be pursued to raise the level of technical understanding among researchers, industry actors, regulators, and users. The blockchain industry is enjoying a wave of intense interest and enthusiasm from the public, which has brought with it a deluge of funding dollars.

At IEEE, we should consider how we can educate two different audiences: the business leaders (CEO, CIO, CSO) and the engineers. Unless education efforts successfully highlight the business cases for blockchain technology in a manner that makes sense for someone in the C-suite, adoption could suffer.

On the other hand, there needs to be a parallel campaign to educate the people who are building and using blockchains. If users are left behind, then enthusiasm can easily turn into hype, which carries a further risk of inviting bad actors and scam artists into the space. Those who have observed the cryptocurrency space for several years can attest to the fact that such a cycle has already occurred many times already. But with each cycle comes a greater spotlight, larger quantities of money, and greater opportunities for loss. Fostering a deep technical understanding among all players is the only sustainable way to combat this cycle.

6.3 CONFERENCES

Given that the ripples of blockchain technology break against nearly every shore in the industry, the IEEE initiative will require input from many societies. However, conferences should be planned and organized through the IEEE initiative rather than individual societies to prevent fragmentation and to help the IEEE build a brand in what is already a crowded market of conferences.

6.4 PUBLICATIONS

It is the view of the IEEE that there is a void to be filled between those outlets that are writing in depth about the technical aspects of blockchains and others that flood the space with opinion and non-technical news.

There is a clear disconnect between “industry practitioners” and “researchers” of blockchain that we need to bridge. This can be done by highlighting industry use-cases to drive researchers towards solving the right problems. It’s also necessary to support cutting-edge research to generate more elegant and efficient solutions for existing and new industry use cases.

The IEEE should seek initially to provide publications that help the reader separate the wheat from the chaff. This work can take the form of newsletters with summaries of useful articles, or short pieces that link to bigger publications. It could also include a wiki to aid the novice in navigating the blockchain space.

As a stepping stone to larger, more focused publications, the IEEE should build a body of readers with stories focusing on specific use cases such as product labelling, smart farming, and drug safety.

6.5 MODELLING

Modelling in the blockchain space will be challenging as a perfect model of a blockchain system would replicate the fluctuating economic incentives introduced by the existence of an underlying cryptocurrency. To be truly insightful, models may need to include complexities outside the codified chain.

Furthermore, there needs to be some mechanism for industry practitioners to validate new ideas. A public vetting process needs to be formulated whereby more formal researchers and colleagues can review solutions before they are widely deployed.

6.5.1 First answer the question: what comprises a proper model of a blockchain based system? What are the minimum requirements?

6.5.2 What are the security, reliability, usability, network, and adoption aspects that we need to address for the specific use case?

6.5.3 Test models of the various scaling solutions being proposed by the development community.

6.6 TAXONOMY

There is considerable confusion, even among the most seasoned blockchain developers, about what the word “blockchain” means. The IEEE, with the help of NIST and other standards organizations, can lead this conversation by offering:

- a detailed, technical description of blockchain technology and its many offspring.
- a standardized framework of components and a scheme for classifying blockchain implementations. This is an adjunct to taxonomy and is also fundamental to support both blockchain interfaces and blockchain design functions.

6.7 INDUSTRY PARTNERSHIP AND ENGAGEMENT

Ultimately, if the IEEE does not focus on the people who make the decisions about how blockchain technology is developed, there will be no buy-in from industry.

6.7.1 Blockchain Wiki**.** Among other tools, the IEEE can build an open source code repository and Industry and Research Wiki. This would be a source of information on all the research and developments efforts world-wide as well as a code repository for blockchain projects. The Wiki would function as an open source startup with funding from industry partners.

6.7.2 Hackathons and competitions. Competitions should be designed to encourage participation among entry-level engineers. They should touch on areas beyond cryptocurrency such as the energy, IoT, and automotive industries. These competitions should also be structured to encourage industry to design blockchain applications for the specific problem rather than retrofitting current designs.

6.7.3 Draft a business value paper that C-level executives can use to start conversations with potential funders. When seeking funding for blockchain projects, CEOs needs to understand the business case and business value. The TEMS Society is well positioned to write such a paper.

6.7.4 Create a certificate of authenticity that can be issued to blockchain applications if they comply with a set of standards and procedures for the input and output of data on a blockchain.

6.7.5 Develop a set of guidelines for verifying the code and business logic of smart contracts. Some of the failures that have happened to date, such as the hacking of the DAO autonomous organization on the Ethereum platform in the summer of 2016, were due to unintended consequences stemming from the business logic of smart contracts. If “code is law,” on blockchain platforms, then developers need tools that will help them design smart contracts that enforce both the letter and the spirit of the law.

6.7.6 A repository of blockchain components. Blockchains are quite modular in their design. They borrow components from a diverse set of fields, and some of these parts have been around for decades before being repackaged into a blockchain. At the same time, due to the incentive structures of blockchains, the individual parts behave very differently depending on how they are paired. IEEE could aid design innovation by creating a repository of blockchain components as well as by testing how they perform in various configurations.

7.CONCLUSION

Blockchain development is in its infancy. But already the technology is old enough that the community has bifurcated both culturally and technically. This should not be viewed as a bad thing. When the first blockchain was invented it sought to solve one very specific problem. Today, players in the space are stretching to reorganize every facet of the digital terrain. As the problems take on more definition, it becomes clear that there is not a single solution. At the same time, if the efficiencies gained by one successful blockchain project are to be shared across domains, then developers and industry managers will have to think about interoperability from the very beginning. The above proposals seek to study and identify the bifurcations in the blockchain space while finding new ways to link them together.