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GOVERNANCE OF THE INTERNET'S SECOND ERA

A Multi-Stakeholder Approach to the Stewardship of Blockchain and Cryptocurrencies

Ontario

BLOCKCHAIN
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Executive Summary

Like the first generation of the Internet, this second generation promises to disrupt business models and transform industries. Blockchain (also called distributed ledger), the technology enabling cryptocurrencies like bitcoin and ether, is pulling us into a new era of openness, decentralization, and global inclusion. It leverages the resources of a global peer-to-peer network to ensure the integrity of the value exchanged among billions of devices without going through a TTP (trusted third party). Unlike the Internet alone, blockchains are distributed, not centralized; open, not hidden; inclusive, not exclusive; immutable, not alterable; and they are secure. Blockchain gives us unprecedented capability to create and trade value in society. As the foundational platform of the Fourth Industrial Revolution,[1] it enables such innovations as artificial intelligence (AI), machine learning, the Internet of Things (IoT), robotics, and even technology in our bodies, allowing more people to participate in the economy, create wealth, and improve the state of the world.

However, this extraordinary technology may be stalled, sidetracked, captured, or otherwise sub-optimized depending on how well the stakeholders behave in stewarding this set of resources—i.e. how it is governed.

Like the first era of the Internet, this blockchain era should not be governed by nation states, state-based institutions, or corporations. How we govern the Internet of Information as a global resource serves as a model for how to govern this new resource: through a multi-stakeholder approach using what we call "global governance networks" (a concept developed in our multi-million dollar program that investigated multi-stakeholder networks for global problem solving.)[2] We discuss seven types of networks: standards networks such as the Internet Engineering Task Force; knowledge networks such as the Internet Research Task Force; delivery networks such as the International Corporation for Assigned Names and Numbers; policy networks such as the Internet Policy Research Initiative at MIT; advocacy networks such as the Alliance for Affordable Internet; watchdog networks such as the Electronic Freedom Forum; and networked institutions such as the World Economic Forum.

We explain the core differences between the Internet of Information, which is a network of similar networks, and the blockchain, which is a balkanized Internet of Value where real assets are at stake. Then we cover what we have found to be the most urgent threats to this resource—threats we view as governance challenges. By governance we mean stewardship, which involves collaborating, identifying common interests, and creating incentives to act upon them. We do not mean government, regulation, or top-down control. We explore governance needs at three levels: platform, application, and the ecosystem as a whole.

Unlike the Internet of Information, which is a vast network of similar networks, this Internet of Value requires stewardship at not just one level, but three. At the platform level, we look at Bitcoin's scalability issues and energy consumption, Ethereum's switch to proof-of-stake and crisis management by consensus, and Hyperledger's call for both urgency and moderation around standards. At the application level, we look at the need for oversight, skilled talent, and user-friendly interfaces. At the overall ecosystem level, we look at the need for a proper legal structure, regulatory restraint, diversity of viewpoints, and scientific research in tandem with business development. We introduce each of the eight stakeholders in the ecosystem: innovators, venture capitalists, banks and financial services, developers, academics, NGOs, government bodies, and users or citizens.

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We apply our previously developed Global Solution Networks (GSN)[3] framework to blockchain governance. We urge stakeholders in the space to codify their common ground through standards networks; welcome stakeholders with radically diverse views of what needs to be done through networked institutions; respect members' interests and constraints through advocacy networks; ensure that no one does any harm through watchdog networks; participate in policy debates and coordinate regulation through policy networks; get up to speed through knowledge networks; and keep incentives for mass collaboration in mind through delivery networks. Finally, we outline the most pressing governance work to be done if we are to preserve and steward this new global resource to achieve its vast potential.

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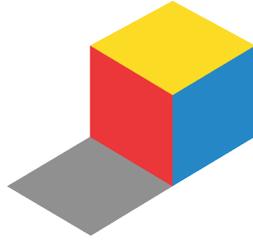
The Blockchain as a New Global Resource

The Internet is entering a second era that's based on blockchain. The last few decades brought us the Internet of Information. We are now witnessing the rise of the Internet of Value. Where the first era was sparked by a convergence of computing and communications technologies, this second era will be powered by a clever combination of cryptography, mathematics, software engineering, and behavioral economics. It is blockchain technology—also called distributed ledger technology. Like the Internet before it, blockchain promises to upend business models and disrupt industries. It is pushing us to challenge how we have structured society, defined value, and rewarded participation.

Blockchain emerged in the wake of the global economic crisis, when a pseudonymous person (or persons) named Satoshi Nakamoto released a new protocol for "A Peer-to-Peer Electronic Cash System" via a cryptocurrency called bitcoin.[4] Cryptocurrencies (digital currencies) are different from traditional fiat currencies because no government issues or controls them. They're not saved in a pocket somewhere; they're represented by transactions recorded in a blockchain—like a global spreadsheet or ledger—which leverages the resources of a large peer-to-peer network to verify and approve each transaction. Satoshi's protocol established a set of rules—in the form of distributed computations—that ensured the integrity of the data exchanged among billions of devices without going through a TTP.

This new resource has six critical qualities:

1. **Blockchain is distributed**: Each blockchain, like the one that controls bitcoins, runs on computers operated by individuals around the world so there is no central database to hack or shut down. We can send money—and soon any form of digitized value, from stocks and bonds to intellectual property, art, music, and even votes—directly and safely between users without going through a bank, a credit card company, PayPal, Western Union, social network, government, or other middleman. Of course, this does not mean that middlemen will disappear. Rather, the technology provides profound opportunities for innovative companies and institutions in the middle to streamline processes, increase their metabolism, create new value, and enter new markets.

2. **Blockchain is encrypted**: it uses heavy-duty encryption involving public and private keys (rather like the two-key system to access a safety deposit box) to maintain virtual security. We needn't worry about the weak firewalls of the US Democratic National Party, a thieving staffer at Morgan Stanley, or a perversely incentivized employee at Wells Fargo.

3. In many cases, **blockchain is public**: anyone can view it at any time because it resides on the network—not within a single institution—that is charged with auditing transactions and keeping records. No one can hide a transaction, and that makes cryptocurrency more traceable than cash. It is open source code. Anyone can download it for free, run it, and use it to develop new tools for managing transactions online. Private blockchains have emerged that don't use cryptocurrency for consensus.

4. For the most part, **blockchain is inclusive**. Satoshi imagined that the typical person would be interacting with the blockchain through what he called "simplified payment verification" mode

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that can work on a mobile device.[5] That means that anyone with a flip phone can participate in the global economy, no documentation is required to be trusted.

5. **Blockchain is immutable**. Within minutes or even seconds, all the transactions conducted are verified, cleared, and stored in a block that is linked to the preceding block, thereby creating a "chain." Each block must refer to the preceding block to be valid. This structure permanently time-stamps and stores exchanges of value, preventing anyone from altering the ledger.

6. **Blockchain is historical.** If we wanted to steal a bitcoin, we'd have to rewrite its entire history on the blockchain in clear view. Because the blockchain is a distributed ledger representing a network consensus of every transaction that has ever occurred, we must preserve the blockchain in its entirety. That means that storage matters.

This is much more than the financial services industry. Innovators are programming this new digital ledger to record anything of value to humankind—birth and death certificates, marriage licenses, deeds and titles of ownership, rights to intellectual property, educational degrees, financial accounts, medical histories, insurance claims, citizenship and voting privileges, location of portable assets, provenance of food and diamonds, job recommendations and performance ratings, charitable donations tied to specific outcomes, employment contracts, managerial decision rights, and anything else that we can express in code.

So important is this new resource that some have called the blockchain a public utility like the Internet, a utility that requires public support. Paul Brody, principal and global innovation leader of blockchain technology at Ernst & Young, thinks that all our IoT appliances should donate their processing power to the upkeep of a blockchain:

> "Thanks to the smartphone business driving very low cost systems, your lawnmower or dishwasher is going to come with a CPU that is probably a thousand times more powerful than it actually needs, so why not have the appliance mine? Not to make money, but to contribute to the security and viability of the blockchain as a whole."[6]

We've never had this capability before—trusted transactions directly between two or more total strangers, authenticated by mass collaboration, and powered by collective self-interest, rather than by corporations motivated by profit or governments motivated by power. It is the culmination of what Alan Turing started, a true paradigm shift ushered in by decentralized ledger technologies.

In this report, our goal is not to provide specific proposals, though we have suggested a few possible directions. Our goal is to describe the landscape, provide a taxonomy for rich discussions, map the diverse players to the taxonomy, suggest the topics of concern, and identify the requirements for better stewardship. We encourage all players—not just those in financial services—to think about the whole ecosystem and not simply their own narrow interests. We believe that this rising tide should lift all boats.

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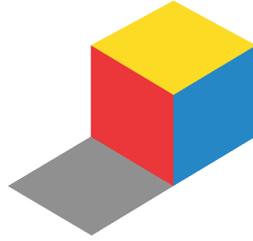
New Thinking on How to Steward a Global Resource: The Internet as a Case Study

Governance of critical global resources—water, forests, fisheries, and the Internet itself—has been a key focus of our research over the last five years. When we use the word "governance" we mean stewardship, which involves collaborating, identifying common interests, and creating incentives to act on them. We do not mean government, which involves legislating and regulating behavior and punishing those who misbehave.

Governance means stewardship, not government and not regulation.

Since the end of World War II, state-based institutions have administered most of the world's important resources. Two of the most powerful of these institutions—the International Monetary Fund and the World Bank—were born at the Bretton Woods Conference in 1944. The United Nations and other groups under its umbrella, including the World Health Organization and the World Trade Organization, were given wide latitude to exercise what became a monopoly on global problem solving. These organizations were hierarchical by design—hierarchies were the dominant paradigm during the first half of the war-torn 20th century.

But, while necessary at the time, these industrial-scale solutions are insufficient to the challenges of the digital era. The rise of the Internet marked a significant departure from the traditional culture of governance. "We reject kings, presidents, and voting," said MIT computer scientist David Clark in 1992. "We believe in rough consensus and running code."[7] That was the mantra for stewardship of the first generation of the Internet when few could imagine how it would transform human existence. Clark's words embodied a philosophy for the leadership of a global resource that was radically different from the Bretton Woods model, yet one that engendered a remarkably effective governance ecosystem.

That the Internet has become a global resource in so short a time is astounding. And it is thanks, in no small part, to strong leadership and governance and in spite of the powerful forces against it. In our 2013-2015 research we set out to do the definitive investigation into Internet Governance—who exactly was providing this stewardship to ensure the development and continuance of the Internet, and what made the ecosystem tick? No government or group of governments controls the Internet or its standards, though several US government agencies once provided its funding.[8] Instead, a vast ecosystem of companies, civil society organizations, software developers, academics, and state-based institutions collaborate in transparent, distributed forums that defy measurement by traditional command-and-control frameworks. In the infancy of the Internet as a global resource, this ecosystem has proven that diverse stakeholders, loosely organized in open networks that operate by consensus, could effectively steward a global resource.

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We have identified the seven key network types in the collaborative ecosystem that controls the Internet of the 21st century:

STANDARDS NETWORKS

1 Standards networks are non-state, non-profit organizations—such as the Internet Architecture Board (IAB) and the Internet Engineering Task Force (IETF)—that develop technical specifications and standards, the building blocks of the product and infrastructure development that leads to mass adoption. To succeed as standards networks, the IAB and IETF regularly engage the expertise of individuals, civil society organizations, and private sector enterprise. Similarly, the World Wide Web Consortium (W3C) develops, tests, and implements standards that promote the Web's evolution and ensure its interoperability.

KNOWLEDGE NETWORKS

2 The primary function of knowledge networks is to conduct research and develop new ideas that can help solve problems. For example, the Internet Research Task Force (IRTF) investigates emerging technologies with potential relevant to the Internet. If IRTF creates a specification suitable for standardization, then it proposes it to the IETF. With this knowledge, savvy users can realize the upside of new global resources while minimizing the downside. Internet2 is a global research and education network designed to remove barriers to acquiring new knowledge and evaluating its impact.

DELIVERY NETWORKS

3 This class of networks actually delivers the change it seeks, supplementing or even bypassing the efforts of traditional institutions. For example, the International Corporation for Assigned Names and Numbers (ICANN) delivers domain names. Supporting delivery networks include African Network Information Centre (AfriNIC), American Registry for Internet Numbers (ARIN), Asia-Pacific Network Information Centre (APNIC), Latin America and Caribbean Network Information Centre (LACNIC), and Réseaux IP Européens Network Coordination Centre (RIPE).

POLICY NETWORKS

4 These networks support policy development or seek alternatives for policy, with or without the support of government. The goal is to inform, if not shape, the policy-making processes of corporations and governments to make them more transparent, shared, and inclusive. For example, Internet & Jurisdiction facilitates transnational cooperation on cybersecurity, human rights, and other legal and economic policies.[9] The Internet Policy Research Initiative at the MIT Computer Science and Artificial Intelligence Lab also works with technologists and policy makers to increase the integrity of interconnected digital systems. In 2016, seventeen public interest groups collaborated to develop the Internet Policy Platform, which featured specific policy initiatives on Internet access, choice, free speech, privacy, and transparency.[10]

ADVOCACY NETWORKS

5 Advocacy networks seek to change the agenda or policies of governments, corporations, and other institutions. Among them are Internet.org and the Alliance for Affordable Internet, which advocate for greater inclusion. The Industrial Internet Consortium, a relatively new open group of researchers, companies, and public agencies, is advocating the adoption of Internet applications across various industries to accelerate the Internet of Things.[11]

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WATCHDOG NETWORKS

6 These networks scrutinize organizations to ensure that they behave appropriately. Topics range from human rights, corruption, and the environment, to financial services and commercial practices. In the process, they drive public debate, boost transparency, and ignite movements for change. Perhaps the most vocal watchdog of civil liberties online is the Electronic Frontier Foundation.[12] It scrutinizes corporate and government policies and holds them accountable through litigation and grassroots activism.

NETWORKED INSTITUTIONS

7 Some networks provide such a wide range of capabilities that we describe them as "networked institutions." They are not state-based but true multi-stakeholder networks. The value they generate can range from knowledge, advocacy, and policy to actual delivery of solutions. The Internet Society, for example, excels at incorporating the many views of diverse stakeholders, not just the efforts of the IAB, the IETF, and the IRTF, but also the International Telecommunications Union (ITU), the Organization for Economic and Cooperation Development (OECD), the World Intellectual Property Organization (WIPO), and several other United Nations commissions.[13] The UN's Internet Governance Forum also engages participation across stakeholder groups. In the early days of the Internet, governments demonstrated both restraint and foresight. They showed restraint by limiting regulation and control throughout the Internet's evolution, and they showed foresight by allowing the system to flourish without trying to impose rules and regulations. Now the Internet has permeated every aspect of our lives, and courts and legislators have commenced to recognize new claims—such as the right to be

Most Governments showed both restraint and foresight in regulating the Internet.

forgotten—and impose local rules that can create conflicts in the global realm of the digital. As the best example of a true networked institution (not controlled by nation states), the World Economic Forum (WEF) has stepped up to caution against such uncoordinated legal efforts that only fragment the Internet—creating what some are calling the "Splinternet,"—thereby stunting the "Internet's enormous capacity to facilitate human progress."[14]

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Blockchain Governance Challenges

In our earlier research, we determined that stewardship of the Internet of Information was relatively simple compared to what the nascent Internet of Value would need. True, the Internet has been a vast "network of networks" with intricate issues of standards and other governance challenges. But we all basically use the same coherent platform globally. On it rests the World Wide Web and countless other applications.

The Internet is a network of similar networks.

Blockchain, at least at this stage of its development, is more balkanized and complex. The economic stakes are higher. "This is very different from the somewhat hippy style that the open source, free software Internet movement had," Joichi Ito, director of the MIT Media Lab said. "We're going a little too fast in promising our investors a functioning infrastructure…. Many companies are raising money as if they're ready for production…. These guys are all under the microscope, under the gun. Many of them are heavily funded and it's really hard."[15] "Bitcoin is a car going down the road at 1,000 mph," said Matthew Roszak, co-founder of Bloq, Inc. "Developers are not the drivers of this car, yet they are tasked with repairing and upgrading this car without turning it off, stopping it, or rebooting it."[16]

The blockchain is a ledger of different and sometimes competing ledgers.

Most developers prefer it that way. They think Bitcoin is already very well regulated by mathematics, which is not subject to the whims of governments. Other developers take issue with the word "governance," because they feel it implies that the technology is broken and needs to be fixed or that the process has stopped working and needs to be saved. They prefer the word "stewardship" —and appropriately so.

Where the Internet democratized information, the blockchain democratizes value and cuts to the core of legacy industries like banking. It also pertains to the management of money, wealth, intellectual property, and other forms of value, categories for which many societies expect governments to protect the public interest. So we all need to acknowledge that, while governments and regulators alone lack the knowledge, resources, and mandate to govern this technology effectively, government participation and even regulation is likely to have a greater influence over blockchain technologies in order to ensure that we preserve both the rights and powers of consumers and citizens.

People in free societies have the right to free speech and the power to express it on the Internet of Information. But they do not have the power to protect it from piracy, hacking, or censorship. One of the defining characteristics of an open, permissionless blockchain is that no one has the right to anything. There are really just powers; what you have the power to do, what you can do. Joi Ito put it in these terms: "You can regulate networks, you can regulate operations, but you can't regulate software."[17] On the Internet of Value, people will have the power to express themselves and the power to preserve their expression without restriction.

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These differences don't require government to control, oversee, or somehow govern the blockchain revolution. The genius of distributed ledgers is that the technology (and everything that happens with it) is, and must be, distributed. Power is distributed. Heavy handed government intervention would kill this embryonic technology in its egg.

We do, however, need self-organizing, bottom-up, and multi-stakeholder governance. In fact, this type of governance is the best protection from government interference and subjugation. According to Primavera de Filippi, faculty associate at the Berkman Center at Harvard and a permanent researcher at the National Center of Scientific Research in Paris, the absence of a formalized governance structure has two possible effects: either blockchain-based communities have difficulty acting or reacting expeditiously or else informal and invisible power dynamics emerge, often more centralized than they appear.[18] That bears repeating: without governance, invisible powers could emerge.

In our research, we found ourselves exploring three levels of blockchain that warrant stewardship. The first is the platform level, the protocols of blockchains such as Bitcoin, Ethereum, Ripple, or Hyperledger. While we may speak of virtual currency as a financial instrument and blockchain as a payment system—and, therefore, relevant narrowly to banking and finance—we think of them more broadly as an ownership claim on a particular technology platform, a claim represented by a token that comes with decision rights and usually an incentive to ensure the platform's long-term success. So what we discuss throughout this report applies to all domains, not just finance.

Figure 1. Blockchain: Three levels of governance
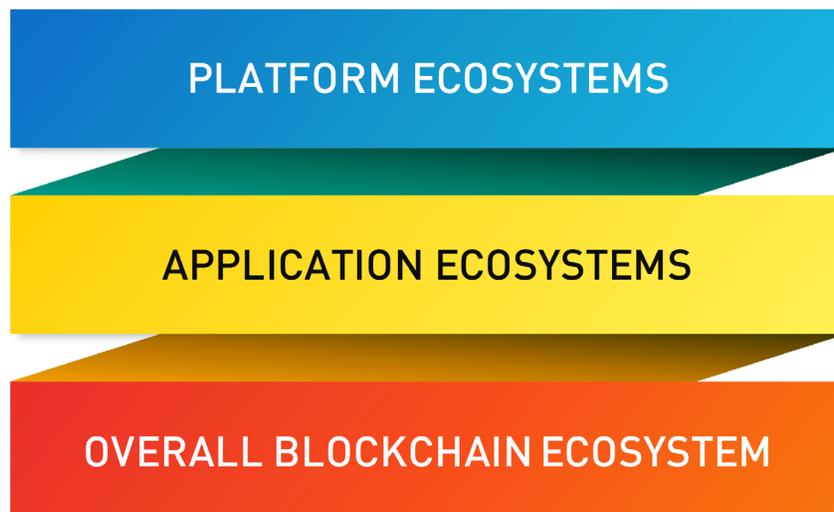
The second is the application level, the tools that run on platforms; tools such as smart contracts, that require massive cooperation between stakeholders to function. As with the Internet, entrepreneurs have been quick to seize blockchain business opportunities and innovate business practices. The recent rise of so-called "initial coin offerings" is turbo charging growth at the application layer, raising regulatory questions, and accelerating the need for multi-stakeholder governance. With the Internet of information, various companies, governments, non-governmental organizations (NGOs), and individuals could simply build an application using either the Web or more proprietary mobile platforms like IOS or Android. However, because blockchain is all about value, developers are building applications, networks, and projects within particular ecosystems—sometimes with a complex assembly of stakeholders who create, exchange, and manage value.

Consider the Belt and Road initiative—the new Silk Road Economic Belt and Maritime Silk Road proposed by China—to link Asia, Europe, and Africa. The Hong Kong Monetary Authority (HKMA) led an initiative to

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develop a proof-of-concept distributed ledger platform for trade finance. The goal was to increase efficiency and productivity by increasing the transparency and trustworthiness of information for regulatory reporting by putting it on blockchain, thereby eliminating the need for a central authority. The HKMA continues to sort through the legal, regulatory, and governance issues of using blockchain.[19] Launching this type of application requires massive collaboration among companies, governments, and other entities. Similarly, this resource will need constant care and tending to onboard more and more users over time. It illustrates the profound differences between managing information-creation versus value-creation activities. The latter require deep negotiation, contractual and jurisdictional understandings, and ongoing stewardship of application-level ecosystems.

The third is the overall ecosystem, the ledger of ledgers connecting (or not) Bitcoin, Ethereum, Hyperledger, Ripple, Tendermint, and other platforms. We found that many of these are quite different in their worldviews and choice of protocols, but present a common set of issues that we think a variety of stakeholders—including consumers and citizens—should understand and be able to discuss. In this section, we cover what we have found to be most urgent for survival in the near term and critical for sustainability in the long term; and the list is by no means exhaustive.

Level One: Stewardship of platforms

Today, there are countless blockchain platforms and countless more in development. The current top ten cryptocurrencies represent the top ten platforms where cryptocurrency represents both value and ownership in the platform. We will review the top two platforms that have tokens trading on the marketplace—Bitcoin and Ethereum—and two platforms, Cosmos and Hyperledger, that seek to provide interoperability among other platforms.

Table 1 Top Ten Cryptocurrencies, as of June 17, 2017

Rank	Name	US$ Market Cap	US$ price	Circulating Supply
1	Bitcoin	$43,630,891,619	2660.98	16,396,550 BTC
2	Ether (Ethereum)	$34,736,739,597	375.25	92,569,593 ETH
3	XRP (Ripple)	$10,215,346,626	0.266787	38,290,271,363 XRP
4	Litecoin	$2,428,105,598	47.06	51,592,007 LTC
5	ETC (Ethereum Classic)	$1,950,098,114	21.04	92,694,964 ETC
6	NEM	$1,848,834,000	0.205426	8,999,999,999 XEM
7	Dash	$1,295,180,283	175.78	7,368,399 DASH
8	IOTA	$1,177,470,178	0.423622	2,779,530,283 MIOTA
9	BitShares	$888,444,894	0.342215	2,596,160,000 BTS
10	Stratis	$766,295,675	7.79	98,428,282 STRAT

Source: https://coinmarketcap.com/currencies, accessed June 17, 2017.

"The platforms that win will be the ones that fulfill both the operational and governance needs of the application, because no one will do an equity settlement on a platform that cannot provide, say, the privacy legally required by capital-markets regulators," said Jesse McWaters of the World Economic Forum. "The capital-markets regulators are not going to change their view on what should and should not be private because of blockchain."[20]

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Perianne Boring, founder and president of the Chamber of Digital Commerce, which has over a hundred members from the digital asset, blockchain, and traditional capital markets industries, said, "At the platform level, efforts to assist with scaling and interoperability are in most high demand."[21]

Bitcoin

Bitcoin, the largest cryptocurrency and platform by value, volume, and hashing rate (a measure of participation), started as an experiment in monetary theory in which the network functioned in service to the bitcoin token of value. Satoshi Nakamoto attempted to align stakeholder incentives through the code itself, and the technology thrived in its early years, blossoming into the ecosystem we know today.

In our research, we found that code alone has been insufficient. Open source collaboration is a great organizing principle but it's not a *modus operandi* for making big decisions and moving forward. Open source projects like Wikipedia and Linux, despite their meritocratic principles, still have the benevolent dictators Jimmy Wales and Linus Torvalds. To many observers, Bitcoin has a governance crisis. As with all disruptive technologies, competing interpretations of Satoshi's vision have emerged. Even the core blockchain contingent has begun splitting into different crypto-camps, each advocating a separate agenda.

At one time, the Bitcoin Foundation funded development of the Bitcoin Core protocol (the common standards used by the community), but it nearly collapsed from its own mismanagement—board member Mark Karpeles was arrested in Japan for embezzlement through his Mt. Gox cryptocurrency exchange. Recognizing the profound importance of this technology, MIT created the Digital Currency Initiative (DCI), which gave a home to some of the Bitcoin Core developers ("core devs"). "We stepped in immediately and provided them with positions at the MIT media lab, so they could continue to independently work on supporting the core development of Bitcoin," said Brian Forde, the former White House insider and blockchain advocate who until recently headed the DCI.[22] For core devs, their ability to work autonomously was central to the design. Joichi Ito at the MIT Media Lab said, "We are now supporting Cory Fields, who's one of the core devs; Wladimir van der Laan, who's the lead developer of Bitcoin; Tadge Dryja, who was the inventor of the Lightning Network. He had originally done a start-up, but now he's joined us to be a researcher. And he's hired Robleh Ali, who was the head of digital currencies from the Bank of England."[23] It is a formidable group.

"Making decisions in a decentralized system is not easy," said Roszak of Bloq, Inc. "The bitcoin ecosystem is currently facing some significant growing pains as the number of transactions has been growing exponentially— over 200,000 transactions per day." Roszak views this growth as "a clear measure of success and a testament to bitcoin's adoption and evolution." He told the U.S. House of Representatives, "As it grows, it faces governance challenges, which it is currently struggling to overcome. These challenges, I would imagine, are similar to those faced by the US Congress on a daily basis. This industry needs a *call to action* to resolve its differences and find a path forward."[24]

"Just because you're decentralized doesn't mean you're disorganized," said Pindar Wong, chairman of VeriFi (Hong Kong) Ltd., former vice-chair of ICANN, and trustee of the Internet Society. "People believe, mistakenly, that the blockchain ecosystem, specifically the Bitcoin system, is disorganized. They get that impression from the very voluminous and heated debates around this very contentious technology. These disputes—the so-called scaling wars, the block size debate—are examples of a healthy ecosystem."

Decentralized doesn't mean disorganized.

In our decades of research in technology and innovation, deadlock has rarely been a positive, particularly when both sides are accusing the other of spreading falsehoods, censoring opinion, and trolling (that is, making provocative or deliberately offensive comments online with the primary intent of upsetting or angering an individual or group and the secondary intent of sounding unnecessary alarms, raising baseless doubt, or distracting attention from real issues) rather than seeking common ground on which to have a civil conversation.

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"Any consensus mechanism that you have is going to be susceptible to marketing—where powerful interests spend money trying to convince people to do a certain thing," said Stephen Pair of BitPay.[25] Consider this April 2017 exchange on Twitter regarding upgrades to the Bitcoin protocol:

Roger Ver, Bitcoin angel investor, tweeted,

> **Roger Ver** ✔
> @rogerkver
>
> Bitcoin Unlimited is production ready. It's already producing 40% of all the blocks. More than any other version of Bitcoin[26]

Philip Francis, a digital assets investor, replied,

> **Philip Francis**
> @philfrancis77
>
> Come on Roger, you can't actually believe BU [Bitcoin Unlimited] is production ready. It's either pure delusion or you're purposely trying to break Bitcoin[27]

Adam Back, CEO of Bitcoin-based Blockstream, responded to two Twitter users,

> **Adam Back**
> @adam3us
>
> [Ver]'s paying people to put BU coinbase string. Then trumpeting stats. It's bug filled, untested, far from production. Even algo[rithm] is defective[28]

Ver retweeted Back with this comment,

> **Roger Ver** ✔
> @rogerkver
>
> Adam, you are telling lies about me again. I've paid no one to put BU in the Coinbase string. I await your retraction and apology[29]

Based on our findings, we believe the Bitcoin community needs a shared and inclusive vision for the future and a mechanism not just for sorting the important signals from the noise of trolls on social media, but also for mobilizing to address them as an ecosystem. We're not saying that anyone should force anyone else to do anything.

Our concern is that, with every major disagreement, absent a compelling vision beyond the libertarian dream, the network will continue forking into competing chains, each potentially less secure than the previous, putting the enormous value of the platform at risk. Indeed, libertarianism may blind its adherents to their need from time-to-time for stewardship, and the attitude is one that precludes widespread adoption and investment. If the Bitcoin network is to grow, there are several critical challenges to address. Here are the three most contentious:

GOVERNANCE CHALLENGE: HOW TO SCALE WITHOUT WEAKENING THE NETWORK

For years now, the question of whether to increase the one megabyte block size has been a divisive subject with no resolution in sight. Brian Forde, the former director of MIT's DCI, said, "If you look at the block size debate, is it really a debate about block size? In the media, it's a debate about block size, but I think what we're seeing is that it's also a debate on governance."[30]

In August 2015, then-core developer Gavin Andresen advocated Bitcoin XT, a fork of the blockchain that allowed for eight-megabyte blocks. It was a controversial compromise that didn't take.[31] The biggest pushback came from the mining pools in China. Serious bitcoin miners, like hard-core online gamers, need not only seriously powerful computers to find a correct hash but also seriously high-speed bandwidth to broadcast it quickly across the network. China is an

Serious miners need seriously powerful computers and seriously high-speed bandwidth.

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exception to Nielsen's law of Internet bandwidth: bandwidth in China doesn't increase by 50 percent each year. If the block size increase is too large, it would put low-bandwidth Chinese miners at a disadvantage compared with miners in other parts of the world. Receiving new blocks to build upon would take longer; and when they did find a new block, they would take longer to send it out to the rest of the network. These delays would ultimately result in the network's rejecting some of their blocks. They would lose out to miners with more bandwidth whose blocks propagated faster.

Opponents of larger block sizes argue that people shouldn't be using bitcoins to buy cups of coffee or other everyday purchases. "Some developers want every single person in the world to be running a fully validating node that sees every single transaction and has absolutely no trust on anybody else," said Andresen. "The volunteer contributors who have been actually making the software work for the last few years are worried that they personally may not be able to handle larger blocks if transaction volume ramps up.… I don't have a whole lot of sympathy for that."[32] In other words, if the Bitcoin blockchain were to scale and remain secure, then the community couldn't have it both ways. Some nodes would run full protocols and process more transactions into increasingly larger blocks, and others would run simplified payment verification models and trust that 51 percent of full nodes get it right. Besides, the two billion people currently excluded from centralized payment systems would more likely use cryptocurrencies for smaller than average transactions.

In April 2017, two different camps of core devs emerged again to address block size by launching different updates to the Bitcoin core protocol. The first was referred to as "segregated witness" (SegWit), proposed by Blockstream co-founder Pieter Wuille and favored by many core devs. SegWit would free up block space by separating (segregating) the signature (witness) information from the transaction data so that the network could double the number of transactions processed per second. This solution would maintain decentralization of power across the network. The other, Bitcoin Unlimited (BU) advocated by investor Roger Ver, would let miners vote on increasing the block size whenever needed, thus ceding to them the power to control the number of transactions in a block.[33]

In May 2017, a group of bitcoin miners and startup executives met and agreed on what they considered a win-win resolution to the block size stalemate, essentially a proposal, "Segwit2Mb combined soft/hard fork," posted for peer review in March 2017 by RSK Labs developer Sergio Demian Lerner.[34] Investment firm Digital Currency Group claimed that, as of May 25, 2017, the signatories to this agreement represented 20.5 million bitcoin users, 58 companies in 22 countries, 83 percent of hashing power, and US$5.1 billion in monthly onchain transaction volume.[35] Yet none of the current Bitcoin core developers have signed on. Samson Mow, chief strategy officer of Blockstream, a blockchain company that neither attended the meeting nor signed the proposal, cast doubt on whether the proposal had the majority of support needed to influence the Bitcoin network's destiny. Matthew Corallo, co-founder of Blockstream and currently an engineer at ChainCode Labs, expressed disappointment in people ignoring Bitcoin developer feedback. He said there were better technical solutions to the problem. Jeff Garzik, founder of Bitcoin startup Bloq,Inc., argued that the proposal was attracting new companies to fund technical efforts that would ultimately improve the open source code. He signed the agreement, as did Erik Voorhees, founder and CEO of coin exchange ShapeShift. Voorhees told CoinDesk that, while he supported SegWit, he didn't care which solution was chosen as long as a solution was chosen to end the deadlock and increase the block size.[36] Jamie Smith, global chief communications officer of Bitfury, conveyed Bitfury's utmost respect for the Bitcoin Core developers: "We are working to create an agreement and technical roadmap [for the proposal] that suits everyone and is best for the future of Bitcoin. We are confident that the road ahead is paved with promise and endless possibility."[37]

Such a fork would be similar to a stock split.

We see at least four possible outcomes: (1) miners rally around BU, (2) SegWit, as the better technology, prevails, (3) the chain forks and they fight it out in the market, or (4) the sides cooperate and reach a compromise that both can support, the success of which plants the seed for some governance mechanism. We support option four, but we think option two most likely. Pair of BitPay believes that if a substantial portion of the community feels it would be better served by a different set of consensus rules, then it will very likely create a

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fork with its preferred set of rules. The fork would likely compete with and either overtake or co-exist in perpetuity with the original chain, each finding its own market. "Such a fork would be very similar to a stock split," he said.[38]

WITHOUT GOVERNANCE, INVISIBLE POWERS COULD EMERGE

In our research, we found this recent exchange on Twitter. It is both illuminating and representative of the debate and Bitcoin's implicit need for stewardship:

Ryan X. Charles, a software engineer formerly at BitGo Inc., called out the Bitcoin Core developers,

> **Ryan X. Charles** ✓
> @ryanxcharles
>
> Bitcoin Core needs to be called out for their antisocial culture. Yes, they are good security engineers. No, that doesn't make trolling OK.[39]

He was referring to alleged trolling to promote the adoption of SegWit.[40]

Jameson Lopp, software engineer at BitGo Inc., sought clarification:

> **Jameson Lopp** ✓
> @lopp
>
> Seems like you're trying to blame the actions of a few on a larger group. I'm a minor contributor; are you saying I'm responsible?[41]

> **Ryan X. Charles** ✓
> @ryanxcharles
>
> I'm sure many or most Core devs are genuine, but a handful of toxic influential devs encourage me to look elsewhere for protocol leadership.[42]

There it was—the absence of leadership in the Bitcoin community.

> **Jameson Lopp** ✓
> @lopp
>
> I agree, though I don't think calling out 'Core' makes much sense - calling out individuals makes more sense.[43]

> **Ryan X. Charles** ✓
> @ryanxcharles
>
> I will do so when the time is right. It makes sense to call out Core for bad culture in the same way as calling out Uber.[44]

Zooko Wilcox-O'Hearn, the founder of z.cash, tweeted,

> **zooko**
> @zooko
>
> Does it? Companies have a structure specifically designed for accountability. If there's a problem, it's the CEO's fault by definition.[45]
>
> ... In contrast 'Bitcoin Core' is a fuzzily-defined set and nobody says 'the buck stops here.[46]

It was an excellent question: Could we really compare the words and actions of a few members of a large open decentralized and liable-free network with the culture of a corporation like Uber accountable for its operations in the world?

John Light, co-founder of Bitseed.org, chimed in,

> **John Light**
> @lightcoin
>
> The closest we have to that in Core is Lead Maintainer @ orionwl [Wladimir J. van der Laan]. Maybe Core should have Lead Community Maintainer(s) too :)[47]

We read that as another suggestion for leadership.

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Said van der Laan, aforementioned "lead maintainer" of the Bitcoin Core protocol and a member of the MIT Digital Currency Initiative.

> **Wladimir**
> @orionwl
>
> There is not one bitcoin community, nor even one bitcoin core community. Things have grown past that a long time ago, [48]
>
> Some rely on heavy moderation, some on self-regulation, and that's exactly how it should be. I don't get this call for central control."[49]

In other words, to each his own, as long as it's not centralized. Then Charles made a critical distinction:

> **Ryan X. Charles** ✓
> @ryanxcharles
>
> Leadership and control are not the same thing.[50]

Zooko suggested a representative body with some responsibilities:

> **zooko**
> @zooko
>
> It would be *possible* to set up a system in which 'Bitcoin Core' has publicly verifiable membership and spokespeople. But you don't want. ?[sic][51]

Matt Corallo, a developer at ChainCode, asked,

> **Matt Corallo**
> @TheBlueMatt
>
> But, really, do you *want* Core folks to be tied to a hierarchy like BU [Bitcoin Unlimited], instead of speaking for themselves?[52]

So Bitcoin Unlimited was perceived as a hierarchy. Zooko suggested,

> **zooko**
> @zooko
>
> Let's separate out whether it is possible to have such controls and whether it is desirable. I think people are shifting between the two
>
> I assert that it is possible, and I argue that it might be better in at least some ways.[53]

So some type of stewardship could be positive for the platform. Corallo disagreed on both counts:

> **Matt Corallo**
> @TheBlueMatt
>
> It is neither possible nor preferable." He explained, "Not possible in part because of the group contributing now - we'd all fork and go create a competitor that had no strict hierarchy again" and "Not preferable as it results in a system with little advantages over other systems.[54]

In the gauntlet-throwing tone typical of these threads, Daniel Robert Plante raised another issue, and it's a big one:

> **Daniel Robert Plante**
> @Daniel_Plante
>
> Then do it Matt. Fork. No permission. It's what Satoshi would do/did. But do you believe you have a grasp on the needs of the future?[55]

He nailed it. If someone didn't agree on a way forward as the future emerged, then he or she was more than welcome to fork and create a new chain.

To us, this Twitter exchange reveals the lack of a shared view of what the community will require of its technology and a desire for leadership that can rise above the individual camps and seek common ground and a unifying

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vision. Nature abhors a vacuum. In this absence of explicit governance, we may be witnessing the emergence of what Professor de Filippi called "informal and invisible power dynamics."[56]

GOVERNANCE CHALLENGE: HOW TO MAINTAIN INCENTIVES FOR MASS COLLABORATION

We found that miners do have an incentive to maintain the Bitcoin infrastructure because, if the network fails, all the unconverted bitcoin they've earned (or could earn) through mining would be lost, worthless, or at risk. Before we dig into incentives, let's be clear about the service that miners provide: it is not transaction validation. Every full node can validate transactions. Rather, miners preserve the distribution of power—the power to decide which transactions to include in each block, the power to mint coins, the power to vote on the truth.

Any design change to the original Bitcoin protocol, whether through an altcoin or an upgrade, must keep in mind appropriate economic incentives to sustain hard core miner decentralization so that the network gets good value from miners in exchange for the large sums of bitcoin. To Bitcoin core developer Peter Todd, that means that smaller miners in geographically dispersed locations should be able to compete nose-to-nose with larger miners that are geographically centralized, that is, large mining pools in Iceland or China.[57]

Is that possible? As the number of new bitcoins minted halves every four years, what will happen when the reward drops to zero? The mining cycle depends on the market price of bitcoin. When the price drops, some bitcoin miners park their supply, but they continue to play the lottery until the price increases. Other miners can't afford to park and play; they just dry-dock their mining rigs or divert their processing power to another altchain that might be more profitable. Still others join mining pools, pooling their computing power with nodes with the hope of increasing their odds and at least getting some fraction of the winnings rather than nothing at all.

One answer is fees. Satoshi wrote, "There will be transaction fees, so [mining] nodes will have an incentive to receive and include all the transactions they can. Nodes will eventually be compensated by transaction fees alone when the total coins created hit the pre-determined ceiling."[58] So once all bitcoins have been minted, a fee structure could emerge if the core developers agree on one. The Bitcoin Unlimited upgrade would give miners the power to set transaction fees now. Because each block has a fixed maximum size, there is a limit to how many transactions a miner can include. Therefore, miners will add transactions with the highest fees first, leaving those with low or zero fees to fight for whatever space might be left over. If your transaction fee is high enough, you can expect a miner to include it in the next block; but if the network is busy and your fee is too low, it might take two, three, or more blocks before a miner eventually records it in the blockchain.

What do fees mean for people who can't afford fees today? Won't levying fees lower the blockchain advantage over traditional payment methods? According to venture capitalist Pascal Bouvier, the "fees reflect the marginal cost of verifying a transaction." Without fees to incentivize miners, and as the block reward keeps halving, the hash rate would likely drop. And if the hash rate drops, network security declines.[59]

A theoretical "51-percent" attack could hijack block generation.

That leads us to the theoretical 51-percent attack, where a huge mining pool or a cartel of large mining pools controls 51-percent of the hash rate. With that much firepower, they would constitute a majority vote of miners and could hijack block generation and thrust their version of the truth onto the Bitcoin network. They wouldn't necessarily get rich. Far from it. All they could do is to reverse their own transactions within a previous block, rather like a credit card chargeback. Let's say the attackers bought some big-ticket item from the same merchant, waited until it shipped, then attacked the network to get their money back. That wouldn't mean tacking its own block to the end of the blockchain. That would mean going back and redoing the block that contained all their purchases as well as all subsequent blocks, even as the network continues to generate new blocks. When the cartel's branch became longer, it would become the new valid one. Satoshi bet on that being wildly more costly than mining new coins.

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"Trying to bootstrap or change a network protocol [such as IPv6] is just a monumental task," said Austin Hill, a blockchain entrepreneur. "You just don't want to be making changes *ad hoc* or very fast on an ecosystem that's managing anywhere from three to ten billion dollars' worth of people's wealth and assets."[60] At the end of the day, said Andresen, "That governance model is driven very much by what code the people actually want to run, what standards people want to implement in the equipment they sell." He said that Bitcoin, like the Internet, will "have a similar messy, chaotic governance process that will eventually come down to what codes the people choose to run."[61] That worked well for the Internet of Information, which had decades to evolve before commercial adoption, but it could prove risky for assets on the Internet of Value, which companies have already adopted and deployed in commercial ventures.

GOVERNANCE CHALLENGE: THE ENERGY CONSUMED IS UNSUSTAINABLE

Our research findings are unequivocal; the proof-of-work method has been critical to building people's trust in these primordial days of the Bitcoin blockchain. Years from now, we will look back and appreciate the genius of its deployment, from minting and allocating new bitcoins to assigning identity and preventing double spending. Pretty remarkable. And pretty unsustainable, according to critics of cryptocurrencies that use proof-of-work to keep the network safe and pseudonymous.

Hashing, the process of running pending transactions through the secure hash algorithm 256 (SHA-256) to validate them and solve a block, burns a lot of electricity. Some people in the blockchain ecosystem are making back-of-the-envelope calculations that become memes in the community. Estimates liken the Bitcoin network's energy consumption to the power used by nearly seven hundred average American homes at the low end of the spectrum or to the energy consumed by the island of Cyprus at the high end.[62] That's more than 4.409 billion kilowatt-hours,[63] a Godzilla-sized carbon footprint. And it's by design. It's what secures the network and keeps nodes honest.

Energy use to power blockchain leaves a Godzilla-sized carbon footprint.

In early 2015, *New Republic* reported that the combined processing power of the Bitcoin network was hundreds of times greater than the aggregate output of the world's top five hundred supercomputers. "Processing and protecting the more than $3 billion worth of bitcoins in circulation requires more than $100 million in electricity each year, generating a volume of carbon emissions to match." The article's author, Nathan Schneider, wrote what has been on our minds ever since: "All that computing power, which could be curing cancer or exploring the stars, is locked up in machines that do nothing but process bitcoin-type transactions."[64] As citizens who care about our planet, we should all be concerned.

The more people who adopt bitcoin, the more energy is consumed. There are two issues, one around the electricity used to run the machines and another around the energy used to cool them so that they don't fail. Here's a rule of thumb: for every dollar a computer burns up in electricity, it needs fifty cents to cool down.[65] The acute drought in California has raised serious concerns over using precious water to cool data centers and bitcoin mining operations.

As the value of bitcoin increases, the competition for mining new bitcoin increases. As more computing power is directed at mining, the computational problem that miners need to solve becomes more difficult. One measure of the total processing power of the Bitcoin network is the hash rate. When we were writing our book in 2015, Gavin Andresen told us, "Let's say we have millions of transactions per block, each paying an average of a dollar transaction fee. Miners would be paid millions of dollars per block, and they would spend a little less than that in electricity to do that work. That's how the proof-of-work economics work out. It really is the price of bitcoin. And however much reward is in a block, that is what drives how much hashing is done."[66]

The hash rate has been increasing considerably over the last two years, rising from 1.5 exahashes per second in mid-2016 to 4.2 exahashes in May 2017. That's more processing power than the most powerful supercomputers on the planet.[67] And the trend is toward using more energy, not less. "If Bitcoin really does become a global team

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network, I think we will need to slowly move away from proof-of-work as the only way it's secure," said former core dev Andresen. "In the very long run, maybe we will move away from proof-of-work as the way the network is secured, and we'll combine it with something else."[68]

"The cost for having no central authority is the cost of that energy," said Eric Jennings, CEO of Filament, an industrial wireless sensor network.[69] That's one side of the argument. The energy is what it is, and it's comparable to the cost incurred in securing fiat currency. Think of the big vaults, the bunkerlike architecture with majestic Grecian facades, HVAC systems pushing frigid air into bright lobbies, competing branches on every corner, and ATMs in between.

Now let's consider computer architecture itself. The BitFury Group has built a massive parallel bitcoin problem solver with application specific integrated circuits (ASICs) that are energy efficient and designed solely to mine bitcoins. Its founder and CEO, Valery Vavilov, argued that machines and mining operations overall will continue to get more energy efficient and environmentally friendly. Some of that depends on relocating to cold climates where energy is cheap and preferably renewable, such as hydro or geothermal, and where either Mother Nature handles the cooling or manufacturers figure out an efficient way to capture the heat. BitFury, for example, has two data centers—one in Iceland and another in the country of Georgia—with plans for additional centers in North America. And it acquired the Hong Kong-based start-up Allied Control, which specializes in immersion cooling technology.[70] And so BitFury is working to reduce the ecological impact of the Bitcoin infrastructure.

Even if these initiatives limit mining's carbon footprint, we still have the rapid consumption and disposal of these continually upgraded devices. Miners who want to make a career of it must continually upgrade and specialize their systems. Most mining equipment has a useful life span of three to six months.[71] Vendors such as MRI of Australia are applying new approaches to recycling, first disassembling rather than shredding all these computing components, and then managing resulting waste streams. Such creative processes are enabling them to reclaim precious metals and reuse up to 98 percent of product by weight.[72] Unfortunately, hardware recycling is still not widely available to most consumers of computing and communicating technology.

Mining equipment has a useful life of 3 to 6 months

Ethereum

In our research for *Blockchain Revolution* in 2015, when everyone was talking about the Bitcoin phenomenon, we spent time learning about Ethereum and projects in that ecosystem.[73] It turned out to be time well spent. Ethereum is emerging as one of the most important blockchain platforms today. Ethereum started as an open source software platform for decentralized applications, where stakeholders needed ether, the token, to pay for computational steps and storage operations on the platform, said Joseph Lubin, co-founder of the Ethereum Project. "We earned revenue, US$18 million, by selling a token. Before running the sale, we needed a legal structure that would (a) protect those funds and (b) be the legal entity that could shepherd the platform, potentially for a long time. We did discuss and commit to decentralized governance once we built sufficiently capable tools."[74]

The Ethereum Foundation, a non-profit consisting of 40 or so developers and researchers, was part of the plan. According to co-founder Vitalik Buterin, the Foundation's core tasks include (a) research on the next version of Ethereum protocol and standards, (b) co-development and maintenance of the six different clients such as C++ and Go, and (c) community outreach to both newcomers and existing community members, publishing transcripts of core developer calls, promoting developer events, and keeping channels of communications open.

For example, if a company wanted to issue its own asset on top of Ethereum, it would write a piece of code that basically implements a bank so that the company could conduct transactions that decrease its own balance and increase other people's balances.[75] There are an infinite number of ways to do that, most of which are not compatible with one another. Some blockchains, like Mastercoin and XC, have a transaction type for issuing and transferring assets specific to their platforms.

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Ethereum is a general-purpose code platform. So its developers wanted the most common way to be some compatible standard. Someone from the Ethereum community proposed such a token standard as a document on GitHub two years ago. The Foundation helped to standardize it and then put it to the community for rigorous review. The ERC-20 standard resulted from this collaborative effort. It's by and for Ethereum people, so that other Ethereum people can better interact with each other."[76]

Another kind of standard enables the Ethereum ecosystem to interact with outside ecosystems and support outside standards. For example, the Foundation is considering integrating a set of optimized operations into the Ethereum virtual machine so that it can more easily process RSA cryptography, a fairly popular kind of cryptography used in other mainstream applications and named after Ron Rivest, Adi Shamir, and Leonard Adleman who created the first practical public-key system for communications.

The foundation collaborated with the Enterprise Ethereum Alliance (EEA), the platform's technical steering committee with over one hundred member organizations. Its vision is to understand industry requirements, leverage existing standards, and develop new open source standards alongside the Ethereum Foundation's platform level work, all to provide roadmaps for deployment of enterprise- and industry-wide applications on the blockchain. EEA is an inclusive organization with a rotating board comprised of behemoths like Microsoft (represented by senior blockchain executive Marley Gray) and startups like Nuco (represented by CEO Matthew Spoke). EEA members recently agreed to experiment with Boardroom as a means of stewarding development. Boardroom is a decentralized governance system that can implement 14 different rule sets for, say, adding and removing stakeholders, allowing any of those actors to submit a proposal for Ethereum improvement, and supporting different kinds of voting systems for passing or rejecting proposals and agreeing on standards.

Governance challenge: How to address major threats by consensus

Ethereum's governance mechanisms faced a big test early on. In May 2016, a new breed of organization, called the DAO, for decentralized autonomous organization, crowdfunded a record-breaking $160 million from tens of thousands of global investors. What distinguished the DAO from all other startups was the absence of management. The DAO was a blockchain application, a collection of smart contracts that ran on the Ethereum blockchain. Its stakeholders—human beings—could review and vote on proposals for how the DAO allocated its funds.

The hacker drained US$70 million into a separate DAO, creating an existential crisis.

The DAO allowed token holders to withdraw their ether from the DAO through a "split function." This function allowed users to revert the process and get back the ether they sent to the DAO. In June 2016, a hacker exploited the function by asking the DAO to return ether multiple times (a "recursive call") before the DAO could update its own balance. The hacker succeeded in draining around US$70 million of ether from the DAO into a separate DAO where, per the terms of the smart contract, it would have to sit for 28 days before the hacker could send it to another account.

That gave the Ethereum community several weeks to decide what to do, if anything. Members began circulating proposals. One proposed a soft fork designed to blackball any transaction from the DAO, but a few members discovered a bug that would have opened the DAO up to a denial-of-service attack.[77]

Another proposed a hard fork in the codebase designed to claw back all the ether hacked from the DAO through the recursive call exploit and to implement a new contract with only a "withdraw" function. DAO token holders could request a refund of one ether for every 100 DAO tokens. Those who had paid more than one ether for 100 tokens could request a refund of the difference.

"Virtually everybody agrees that you shouldn't fix an application-layer problem with a protocol-level solution," said Joe Lubin. "Initially, most of the core Ethereum people did not want to have a fork, did not want to bail out…

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the promoters, developers, and investors….They should have taken the serious losses as an appropriate teaching signal."[78] But it was an existential threat. "If the hacker's goal was to destroy Ethereum, then the hacker could have staged denial-of-service attacks for many years, messing up the network's ability to process transactions efficiently. We would have been chasing this person in and out of different smart contracts, in a sort of a cat and mouse game," Lubin said.[79]

Lubin identified six different classes of stakeholders—developers, exchanges, miners, mining pools, token holders, and other community members—who weighed in to the very vigorous debate over whether to fork. Those who argued for the hard fork sought to prevent the hacker from taking control of a very sizable portion of all the ether in circulation. Those who argued against sought to prevent what they considered to be censorship of the Ethereum blockchain. Some viewed the code as the law: the terms of the DAO contract, however flawed, should stand, and those who invested would have to suffer for the greater good of Ethereum's reputation as an immutable chain.

The six stakeholder groups voted overwhelmingly (89%) in favor of the hard fork. Users of the Ethereum platform then had to decide for themselves whether to use the forked version or continue on the non-forked version, now known as Ethereum Classic. The Foundation itself, which is a legally conservative, risk-averse entity, did not take a position early on. Instead, it gathered information. After the vote, it acknowledged Ethereum Classic's

Don't fix an app-layer problem with a protocol-level solution.

right to exist. "I don't think the verdict is in on whether it was good governance, but it was quite decentralized governance, and I continue to applaud Vitalik for the studied approach he takes to decision making and the care he takes in not issuing rash communications," said Lubin.[80] He continued:

> These systems are complex and subtle and they're protecting important and valuable assets in cryptography that we need a few hundred or so global experts to take a good look at and try to beat the **** out of them for three or five years. Then we'll have some well-vetted frameworks that we can all share that handle certain foundational functions like escrowing money, enabling deposits and withdrawals, issuing new token allocations, etc. Layers of increasingly sophisticated functionality will have to be built and the deeper layers will need to be very well vetted so that they don't need to change much, because many will build on them.[81]

Ethereum is by no means alone in anticipating and responding quickly to worst-case scenarios. Other core developers and blockchain companies have moved quickly to secure their networks. For example, in 2014, thieves stole eight million VeriCoins, a proof-of-stake cryptocurrency, from the MintPal exchange. Within days of the attack, VeriCoin developers released new code that forked the VeriCoin blockchain prior to the hack—like Ethereum, they rolled back time—and collaborated with exchanges to make sure it was adopted.[82]

What they could do differs from what they have, as a group, committed to do in the interest of preserving the resource, and that is to engage the community in reaching consensus on key issues. That's stewardship.

## Governance challenge: Managing the switch to proof-of-stake

The first version of the Ethereum blockchain—Frontier—also uses proof-of-work. For Vitalik Buterin, the concern about energy consumption is legitimate and worth solving. That's what other chains have done: explored alternative consensus algorithms for securing the network while retaining decentralization. The open source nature of the Bitcoin protocol makes it technically easy to do. Remember, the purpose of consensus algorithms is to distribute the authority to decide on the state of the blockchain to a decentralized set of users. To the mind of Buterin, there are only three securely decentralized sets of users, and each set corresponds to a set of consensus algorithms: owners of computing power, with standard proof-of-work algorithm; stakeholders, with various proof-of-stake algorithms in wallet software; and members of a social network, with a "federated style" consensus algorithm.[83] Note that only one of those consensus mechanisms includes the word "power."

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The developers of Ethereum expect to replace Frontier with Caspar, a proof-of-stake mechanism. Proof-of-stake requires miners to invest in and hang on to some store of value (i.e., the native token of the blockchain such as ether) in order to vote on the state of the chain. They are no longer miners; they are validators. They needn't spend energy to vote. If they break the rules, they may lose their holdings. The plan is to phase in the proof-of-stake. According to Coindesk's Alyssa Hertig, "Since [Casper] has been pushed back several times, detractors see this hybrid as the latest evidence that proof-of-stake won't ever be fully implemented successfully on Ethereum." Thoughtful discussions have sprung up on Reddit such as "Fundamental problems with Casper" and "Vlad Zamfir said it's a reasonable possibility Casper won't be implemented on Ethereum… is this cause for concern?"[84] The latter referred to a couple of tweets by Vlad Zamfir who, according to Ethereum's blog, has worked on proof-of-stake blockchain architecture since September 2014.[85]

Zamfir tweeted,

> **Vlad Zamfir**
> @VladZamfir
>
> I sold most of my ether at least [four] times… incl[uding] before this rally really started ($16) … lol :(But I absolutely will walk if I stop having sufficient hope that the Ethereum community will adopt Casper-style PoS and sharding. Which I think is a serious possibility, given how much money we are giving Ethereum miners.[86]

Buterin tweeted to Zamfir,

> **Vitalik Buterin** ✔
> @VitalikButerin
>
> You think our large PoW rewards make it more likely Casper will stall? That is so interesting; I completely disagree.[87]

Zamfir replied,

> **Vlad Zamfir**
> @VladZamfir
>
> Interesting! I think the more money miners have the more incentive they have to participate in governance. Where their incentive is to block.[88]

Others shared that view:

> **mikeinspace**
> @mikeinspace
>
> You're never going PoS. You'll personally be forked before that happens, maybe literally by angry miners.[89]

Of these alternatives to proof-of-work, veteran cryptographer Austin Hill cautioned against using other methods for securing consensus. "Experimentation with your proof-of-work algorithm is dangerous, and it's a new area of computer science."[90] It adds a dimension to innovation: not only must developers worry about whether their new features and functions will work in their own right, but they must also check how the choice of consensus algorithm keeps them secure and distributed to the most appropriate economic set.

Where 51-percent attacks on proof-of-work models stem from concentrated mining power, attacks on proof-of-stake models come from concentrated coin control, and coin exchanges are typically the biggest stakeholders. In some jurisdictions, exchanges must be licensed and are under regulatory scrutiny. They also have reputations at stake, and so they have multiple incentives to protect the value of their brand and the value of the coins held in account wallets. However, with more coins in circulation, a greater diversity of value, and more strategic assets registered on PoW and PoS blockchains, an attacker might not care about any of these costs.

Finally, there is the considerable task of bringing along a super-majority of Ethereum stakeholders to the proof-of-stake model since it may run atop the Ethereum platform like a smart contract reminiscent of the DAO. Unlike Bitcoin, whose visionary Satoshi Nakamoto has receded from the debate and left others to interpret his vision, Ethereum's creator, Buterin, is very present, very communicative, and working tirelessly on both the technical and the theoretical aspects of the platform. He is enormously influential and inspiring, not just because of his

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brilliance but because of his basic decency, his concern for human rights and the health of the planet. He may not be the ultimate arbitrator as Linus Torvalds is over Linux, but Buterin certainly stewards the Ethereum ecosystem.

Tendermint

Tendermint is what co-founder and chief technology officer Ethan Buchman called "general purpose blockchain middleware," that is, software that operates between blockchain protocols and blockchain applications, so that developers can create applications in their programming language of choice for their environment of choice.[91]

Buchman said that Tendermint met "the highest standards of security," meaning that it worked even if a third of the nodes in a network arbitrarily failed.[92] Large distributed peer-to-peer networks, where parties could have wildly different types of machines in wildly different circumstances, need such a high level of fault tolerance, including attacks that can turn machines into malicious nodes. He referred to this ability to tolerate arbitrary failure as "Byzantine fault tolerance," a theory put into practice in distributed ledgers such as Bitcoin and Ethereum.

Tendermint has two components: Its proof-of-stake consensus mechanism ensures that every faultless machine records the same transactions in the same order. Its application interface enables machines to process transactions in any programming language. It emerged, as many alternatives to Bitcoin did, as a proof-of-work blockchain with a native token, the atom, which users bonded in a security deposit (which they could lose if they misbehaved) in order to participate in consensus. Tendermint has developed into "a general purpose blockchain consensus engine that can host arbitrary application states. That means it can be used as a plug-and-play replacement for the consensus engines of other blockchain software."[93]

In September 2016, Tendermint won an innovation award and an RMB20,000 prize at the International Blockchain Week Demo Day in Shanghai, where it announced plans for a new Cosmos Network.[94] Buchman described Cosmos as "the Internet of Blockchains…designed to solve many of the outstanding problems in the cryptocurrency community, including scalability, interoperability, security, and flexibility."[95] To fund its development and launch, Cosmos, the entity building out the Tendermint protocol, held an initial coin offering of atoms in April 2017 and raised $16.8 million in 28 minutes.[96] Cosmos coalesced around what Buchman called "a crisis of legitimacy of our institutions and a crisis of value of our mediums of exchange," as a means of developing currencies that supported community values, and of keeping organizations transparent and accountable. Its website refers to Cosmos as "a heterogeneous network of proof-of-stake blockchains that can interoperate with one-another."

> **Making progress on interoperability is growing in urgency.**

"There are lots of discussions about interoperability," said David Treat, managing director of Accenture financial services, "but with limited progress to date, as the primary platforms and codebase creators are still focused on achieving their first production versions and building marketshare. Given current progress on the first wave of production systems, making progress on interoperability is growing in urgency."[97]

Hyperledger

Hyperledger is an open source collaborative launched to advance blockchain technologies across such industries as banking, Internet of Things, manufacturing, and supply chains. The collaborative, hosted by the Linux Foundation, is focusing on distributed ledgers and smart contracts, separate from cryptocurrencies, for scenarios where participants in a network want to share a record-keeping system and to automate additional transactions on top of that shared ledger.

Its CEO, Brian Behlendorf, sees distributed ledger technology as an operating system for decentralized market places and digital communities, "foundational in the same way that the Linux operating system is foundational in

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the cloud, the same way that Internet protocols are foundational."[98] Developers could build a cryptocurrency or a system for tracking other digital assets on top of it.

Behlendorf told us, "We don't believe in one big chain to rule them all; we believe in adapting the governance models that exist today and facilitating them using this technology."[99]

As a project of the Linux Foundation, Hyperledger's charter borrows from the Linux governance framework. Its mission is clear: to create "an enterprise grade, open source distributed ledger framework and code base" and "an open source, technical community," and to "promote participation of leading members of the ecosystem" and "host the infrastructure for [the project], establishing a neutral home for community infrastructure, meetings, events, and collaborative discussions and providing structure around the business and technical governance."[100] The charter provides for a governing board, its composition, conduct, and responsibilities. Like the Internet Engineering Task Force, it provides for a technical steering committee and a process for reaching consensus, and voting, if necessary, on changes to the codebase. It also provides for a marketing committee and an end user technical advisory board for industry outreach and education. Finally, it sets forth codes of conduct, including transparency, so as to preclude the formation of trusts.

Its membership already exceeds 130 different organizations, from IBM and Intel, to J.P. Morgan and Wells Fargo. Casey Kuhlman, CEO of Monax Industries, explained why his start-up joined Hyperledger: "[T]o get our software into production in enterprises, we need not only to prove the technology itself, but also to develop the mechanisms to build and deliver that software collaboratively." Kuhlman observed, "The old one-to-one approach dominated by account managers walking the halls of incumbent enterprises pitching the IT company's 'new' thing may still work for a lot of technology, but it isn't likely to work for blockchains and smart contracts."[101] It was an astute observation: to cross that chasm of obscurity between the fanatic early adopters and the more pragmatic early majority of adopters, we need to collaborate. Collaboration is the glue that will make this technology stick.

> **Collaboration is the glue that will make this technology stick.**

GOVERNANCE CHALLENGE: THE NEED FOR INDUSTRY STANDARDS AS SOON AS POSSIBLE

In our research, the development of industry standards emerged as a big issue. Behlendorf sees two major challenges. "In any one marketplace or ecosystem, we want everyone using the same code, the same chain, and the same kinds of transactions to get the efficiency," he said. That means engaging industry-specific associations and educating them on the trade-offs between (a) sharing enough data in the chain to reassure everybody of the integrity of, for example, the provenance tracking process, and (2) providing enough confidentiality to participants that competitors cannot figure out each other's businesses or deduce terms of agreement with other members of the market or ecosystem.

Designing these systems to be both confidential and auditable is a big challenge. Not just a technology challenge, but a business challenge. How much data will companies share to make the whole effort meaningful? Behlendorf did not know. "We might have some proof-of-concepts, we might have people playing on the perimeter, between one or two partners in an ecosystem, but we really want to get the whole of the industry to adopt a common standard and give an industry the time to convert," he said.[102]

Jesse McWaters of the World Economic Forum agreed on the magnitude of this challenge. He used the creation of a know-your-customer (KYC) utility for financial institutions as an example. "Literally everyone agrees that it's a good idea," he said. "Blockchain is a great way of running such a KYC utility, but coming to agreement on how we're going to use the utility is the actual impediment. Getting all of the requisite parties, getting the network effect of banks, to agree that they're all going to use this standard is the hard part, and blockchain doesn't actually do anything to fix that problem for us."[103]

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Industries also differ in their need for speed. For the Bitcoin blockchain network, the process of clearing and settling transactions takes about ten minutes, which is far faster end-to-end than most payment mechanisms today. But clearing transactions instantaneously at the point of sale is not the issue; the real problem is that ten minutes is simply too long for the Internet of Things when devices need to interact continuously. Former core developer Gavin Andresen said that solving for a trillion connected objects is "a different design space from Bitcoin," a space where low latency is more critical and fraud is less of an issue or where parties could establish an acceptable level of trust without the Bitcoin network

Ten minutes is simply too long.

Ten minutes is also too long for financial transactions where timing matters to get an asset at a particular price, and where latency exposes traders to time-based arbitrage weaknesses such as market timing attacks.[104] The immediate solution for entrepreneurs has been to fork the Bitcoin code base. That is, to modify the source code by tweaking a few parameters, and to launch a new blockchain with an altcoin in place of bitcoin as incentive to participate. Litecoin is a popular altcoin with a block time of 2.5 minutes, and Ripple and Ethereum are entirely reengineered blockchain platforms that have latency of seconds, not minutes. So does each industry need its own blockchain?

GOVERNANCE CHALLENGE: PREMATURE ANOINTMENT OF ANY PROTOCOL AS AN INDUSTRY STANDARD

Our research revealed the downside of arriving quickly at industry standards. "The space is still so young that the desire for standards, while well-placed, runs the risk of hardening projects that have really just come out of the lab," said Behlendorf. The second big challenge he sees is preventing widespread adoption of an inferior technology. "People were in such a rush to take credit-card orders over the Internet that they would use anything we came up with." The result was the suboptimal Internet security paradigm still in use. Behlendorf still feels bad about the cookie header, intended as short term memory for storing items in a virtual shopping cart but deployed as "a tracking device that has turned the Web into a giant surveillance machine." People have all but written off the possibility of anonymity on the Internet.

"Anybody running systems in this space needs to anticipate a period of five or ten years of fairly rapid progress in the underlying technologies," Behlendorf said. "Right now we should be in a 'let a thousand flowers bloom' mode, and let these technologies find their footing." The ones that fail will become obvious. The ones that succeed will have a choice, either to remain independent or to merge with somebody else. Sorting the winners from the losers requires more than "white papers, essays, and academic research," he said. It requires "people going out and exercising the different stacks, seeing what they're good for, fixing bugs, and adding features." That means deployment, real production experience.

Here's where knowledge, advocacy, and stewardship of standards processes are critical. "We need to avoid making serious architectural decisions that first become legacy and then become hindrances. That means conducting experiments and then throwing away the failures as quickly as we can. And it's harder to throw away failures once they've become industry standards," Behlendorf said.[105]

It's harder to throw away failures that have become industry standards.

"I think it's okay at this point to have a number of different consensus systems out there competing. But you don't want protocols competing for very long, because then you can't build anything," said Joi Ito. "I have a feeling, though, that we may be still a few years out before we settle on what we think the wireline layer is going to be. If you look at the layers of the Internet now, it wasn't predetermined exactly how the layers were going to be cut, right?" IBM's Token Ring "was sort of layer two and layer three together. It wasn't obvious where the

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layers would be cut." Similarly, with blockchain technology, "Where does the accounting live? What should the accounting do?"[106]

Behlendorf said, "This stuff is ready to leave the lab as the web was in 1993 or 1994. Let's just make sure we don't encumber it with too much legacy and too much commitment."[107]

GOVERNANCE CHALLENGE: THE LACK OF ROBUST INFRASTRUCTURE

To paraphrase science fiction author William Gibson, the future is here; its infrastructure is just unevenly distributed. For example, had Greek citizens known about bitcoin during their country's economic crash in 2015, they still would have been hard-pressed to locate a bitcoin exchange or a bitcoin ATM anywhere in Athens. They wouldn't have been able to transfer their drachmas into bitcoins to hedge against the plummeting fiat currency. Computer scientist Nick Szabo and information security expert Andreas Antonopoulos both argued that robust infrastructure matters can't be bootstrapped during catastrophes. Greece's blockchain infrastructure was lacking at the time of the crisis, and there was insufficient bitcoin liquidity for an entire population to move its troubled fiat currency into it.

The blockchain also falls short on security controls for such a massive bump in usage. It lacks the transactional capacity to on-board millions and millions of people. Such an immature technology would be susceptible to capacity problems, system failures, unanticipated bugs, and, perhaps most damaging, the huge disappointment of technically unsophisticated users—none of which it needs at the moment.

GOVERNANCE CHALLENGE: THE LACK OF CONSTRUCTIVE DISCOURSE

"The current challenges do not really reside in any specific technical component," said Roszak of Bloq, Inc., and the Chamber of Digital Commerce. "The issues reside in the human factor of communication and finding a way of building consensus during the early days of this $6.5 billion railway. The debates, fights, and passions involved are in many ways a feature and not a bug of the network."[108]

Debate is a feature, not a bug.

"If I were to criticize the blockchain technical community, it's not very respectful," said Pindar Wong. "There's a lot of bravado, a lot of posturing, as you would expect, and it doesn't even involve tech." He mentioned the practice of shouting people down in public. When we asked whether that happened frequently, he said, "Go online; ALL CAPS, all of the time." So we did and found many a heated thread related to Bitcoin blocksize. So nasty have the exchanges become that Andreas Antonopoulos, technologist, serial entrepreneur, and author of *Mastering Bitcoin*, recently tweeted, "I wish people wouldn't put me in mentions when bashing @rogerkver. I am never ok with personal attacks or abuse. Stop it."[109] A person with the Twitter handle @veryevilone replied, "Roger has been happy to attack other people and insult their intelligence. He is not interesting and he doesent [sic] deserve respect"[110] to which Antonopoulos responded, "Lack of respect is a measure of the speaker, not a reflection of the subject. I will block accordingly."[111] He wanted no part in hostilities and would block those who did.

"The rough-and-tumble should not exclude people who want to contribute," said Wong. That's an important point. The nature of the discourse may put off otherwise really talented developers. Some might say, "Stay out of the kitchen if you can't stand the heat." Others might say that it's a hostile tactic for defending one's position. When it comes to solving big and important problems, hostility is a failed strategy. Deep thinkers like Antonopoulos opt out. Wong added, "At the very risk of being facetious, I would say we all need training in active listening….We're hearing what we're expecting to hear, not necessarily what the person is meaning to say." Meeting people in person helps to understand what they mean online. "If anything, one of the big rewards as a volunteer in scaling is to see people meet each other and come out with, 'You're an asshole, I'm an asshole,

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but we can now be assholes together. Maybe we agree on something now.' That's humanity at work, and I think that's wonderful."[112]

Level Two: Stewardship of applications

"Traditionally, centralized organizations were responsible for the 'coordination' and 'governance' of online applications," said Primavera De Filippi. "Today, with blockchain technologies, we are witnessing the emergence of global networks or organizations that operate in a distributed manner without any centralized middleman" to mediate the rollout of new tools that sound great.[113] Our research bears this out. To understand what we mean by blockchain applications, consider this analogy: Email is to the Internet what cryptocurrencies are to the blockchain—the first application. And just as postal mail (now "snail mail") was to email, digital currency is an application with a physical world antecedent—fiat coins and bills (soon to be "slow dough" or "anonymoney")—that helps all stakeholders to wrap their heads around it. But compelling analogies can lead to faulty thinking, induce a false sense of security, or limit the imagination altogether, as the "page" metaphor for Web screens did by anchoring minds to a print medium (e.g., "landing page," "page views," "retail catalog") and then using the Web primarily as a publishing platform and somewhat belatedly as a town hall, a crowdfunding event, a collaborative workshop, a multi-player arena, or a worldwide genomic laboratory. Of the asset classes on blockchain platforms), the rising popularity of the initial coin offering (ICO) is a case in point.

Compelling analogies can lead to faulty thinking.

| Table 1 | Top Ten Cryptocurrencies, as of June 17, 2017 |

Rank	Name	Platform	US$ Market Cap	US$ price	Circulating Supply
1	Golem	Ethereum	$493,919,905	0.595621	829,252,000.00
2	Augur	Ethereum	$336,539,500	30.59	11,000,000.00
3	Gnosis	Ethereum	$270,024,758	244.46	1,104,590.00
4	Basic Attention	Ethereum	$220,787,000	0.220787	1,000,000,000.00
5	MaidSafeCoin	Omni	$219,171,586	0.484301	452,552,412.00
6	Iconomi	Ethereum	$209,038,380	2.4	87,000,000.00
7	Ardor	Nxt	$199,448,251	0.199648	998,999,495.00
8	DigixDAO	Ethereum	$185,485,200	92.74	2,000,000.00
9	Veritaseum	Ethereum	$143,919,531	74.58	1,929,609.00
10	SingularDTV	Ethereum	$129,022,800	0.215038	600,000,000.00

Source: https://coinmarketcap.com/assets, accessed June 17, 2017.

GOVERNANCE CHALLENGE:
OVERSIGHT OF APPLICATIONS WHOSE OFF-CHAIN EQUIVALENTS ARE REGULATED

The ICO is an application whereby organizations of any size can raise money peer-to-peer by offering tokens or coins in a new venture, project, or network. In 2016, blockchain organizations raised nearly $200 million

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through ICOs. These aren't just new cryptocurrencies masquerading as companies. They represent digital rights management platforms (SingularDTV), distributed venture funds (the DAO) and even new platforms for investing in ICOs (ICONOMI). The euphoria around them is palpable. "The token launch (as some are calling certain forms of these ICOs), the first killer app for crowd funding, is a powerful tool to enable the ecosystem to build itself out, with the issuance of protocol tokens," said Lubin of Ethereum.[114]

ICOs have been likened to an initial public offering (IPO), the process through which a privately held firm raises capital through public markets by issuing stock that investors can buy. Here's where the analogy breaks down: IPOs are highly regulated affairs, involving a number of intermediaries, such as investment bankers, exchange operators, auditors, lawyers, and crowd-funding platforms (such as Kick-starter and Indiegogo), whereas ICOs are not. IPOs are issuances of securities, mostly equities. With ICOs, the classification really depends on the purpose of the coin. ICOs can be very equity-like, where tokens represent a fractional ownership in the underlying value of an organization, subject to profit or loss, and presumably—at a later date—entitlement to shares of profits.

However, often ICOs are not offering equity-like value at all. Augur did one of the first ICOs granting token owners the right to participate in its prediction markets. Still others are offering something more akin to access for developers to build applications and for users to run them. Bilaji Srinivasan, partner at Andreessen Horowitz, likened them to a "paid API key." He said, "When you buy an API key from Amazon Web Services for dollars, you can redeem that API key for time on Amazon's cloud. The purchase of a token like ether is similar, in that you can redeem ETH for compute time on the decentralized Ethereum computer network. This redemption value gives tokens inherent utility."[115]

While the definitions are still evolving, the value is clear, which is why the New York-based venture capital firm Union Square Ventures (USV) broadened its investment strategy so that it could buy ICOs directly. Menlo Park-based venture capital firm Andreessen Horowitz joined USV in investing in Polychain Capital, a hedge fund that buys only tokens.

Blythe Masters, consummate Wall-Street-insider-turned-blockchain-pioneer, expressed her concern: "Newcomers are simply able to do things that regulated institutions are not able to do. But one needs to think very carefully about why those regulations exist, and what purpose they serve, before one can conclude that exposing consumers to unregulated financial activities is a good thing."[116]

...think very carefully about why regulations exist before exposing consumers to unregulated financial activities.

Lubin, of Ethereum, does not even call them financial instruments: "There are no investors. There are stakeholders who bought a software product called 'ether' that enables business and software developers to build on and use the decentralized application platform."[117] Stress-testing and debugging are left to the issuers, not to independent bodies with expertise in software auditing. There is potential for these new instruments to blow up in less-than-savvy investors' faces and give ICOs a bad name before they have a chance to do any good in the economy.

Patrick Murck, special counsel at Cooley LLP and a fellow with Harvard University's Berkman Center, said that some of these tokens are securities and are already regulated under existing rules. Some are not and should not be regulated. Law enforcement didn't need new rules to catch criminals on the Bitcoin blockchain. The US Securities and Exchange Commission didn't need a new process for reviewing Tyler and Cameron Winklevoss' application to start a bitcoin exchange traded fund. The SEC posted the application, invited public commentary, and issued its decision: No. It ruled that bitcoin markets were largely unregulated, and so such a fund would be unduly risky.

Should issuers of ICOs or funds pegged to crytocurrencies let the buyer beware? Should regulators come in and write the rules? Or should key stakeholders come together and provide community guidelines and oversight?

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GOVERNANCE CHALLENGE: THE LACK OF SKILLED DEVELOPERS

"At the application layer," said Perianne Boring, founder and president of the Chamber of Digital Commerce, "business and technical skills to bring these projects to market are important."[118] Our findings were unambiguous on the need for skilled workers. The space needs talent, and talented people from anywhere in the world can contribute. Despite flair ups on social media, many of the exchanges (on GitHub, for instance) among developers are educational, and those like Matthew Corallo of Chaincode Labs are known for encouraging new developers.[119]

Decentralized governance systems for decentralized infrastructure

Brian Behlendorf at Hyperledger would like to see "many more developers who are familiar enough with the technology and the concepts that they can move among different technologies."[120] For example, if you know how to build mobile apps, you actually have a range of different technologies to do that. If you work at a place like Uber, you might know how to build an IOS app and an Android app and bounce between them and make them look consistent. So being multilingual is not a unique challenge, but understanding what works in a mobile setting is the hard part.

He estimated that there are only one- or two-thousand developers who understand how to build blockchain applications, whether on Ethereum, Hyperledger, or other platforms. He would like that number to increase substantially: "We are ready for the crowd to show up." A subset of those will build the infrastructure, "those second-tier developers, the ones who come in and jump into the black box, so to speak, and make it work better, faster, more feature-full." The space also needs people with production experience, and that's a function of time. The demand begs for creative education programs, perhaps enabling young, talented coders to earn their degree or other relevant professional certifications through their contributions to blockchain projects.

GOVERNANCE CHALLENGE: THE LACK OF USER-FRIENDLY INTERFACES

Our research indicated that there's much work to be done in basic user interface and experience. Many of these apps are inaccessible to the average person. There's not enough wallet support, and many interfaces are user-unfriendly, requiring a high tolerance for alphanumeric code and geekspeak. Most bitcoin addresses are simply strings of between twenty-six and thirty-five characters beginning with a one or a three—quite tedious to type. As Tyler Winklevoss said, "When you go to Google.com, you don't type an IP address into your web browser. You type in a human-readable name, something that you can remember, that's mapped to its IP address. The same should be the case with bitcoin addresses. Actual bitcoin addresses shouldn't be exposed to the average user. Little things like that make a difference."[121]

Level Three: Stewardship of the ecosystem as a whole

"Because they lack a central point of control, these networks, applications, and organizations require new distributed governance systems to coordinate on matters such as interoperability, privacy, and security, in a collaborative manner," Primavera De Filippi said. "We need to figure out new decentralized governance systems that can be easily deployed on top of these decentralized infrastructures."[122]

The ecosystem needs "a proper regulatory framework that understands and accommodate blockchain technologies," De Filippi said.[123] Such a framework would mitigate some of the strong legal uncertainty surrounding these emergent technologies, thereby helping startups and larger companies alike to move beyond the proof-of-concept stage. Proper legal and regulatory frameworks also favor long-term, more sustainable, and more technically sound business models over short-term, high-risk ones.

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GOVERNANCE CHALLENGE: THE LACK OF A PROPER LEGAL STRUCTURE FOR STEWARDSHIP

De Filippi and Cardozo Law School professor Aaron Wright, co-authors on a forthcoming Harvard University Press book on blockchain, questioned whether the current legal framework could handle the questions raised by smart property deployed globally at scale. Smart contracts both define and manage ownership rights. Their code makes no assumptions about the assignment of rights, and code can't arbitrarily seize, divest, or transfer these rights. For example, if, during the process of land registration, government officials assigned the ownership of a parcel of land to someone who wasn't the legal owner of that parcel, that person would have absolute sovereignty over the parcel, and the legal owner couldn't simply reverse the assignment.

Right now there is a lack of legal recourse in a world of irrevocable transactions and un-voidable smart contracts. According to De Filippi and Wright, "People are, indeed, free to decide the particular set of rules by which they want to abide, but—after the choice has been made—can no longer deviate from these rules, to the extent that smart contracts are automatically enforced by the underlying code of the technology, regardless of the will of the parties."[124] This very high degree of certainty—mathematical certainty—as to the outcome of a transaction or a smart contract is unprecedented in society. It delivers greater efficiencies and effectively eliminates nonperformance risk because we have no choice of breach, no choice of damages. But that's also a downside. It allows no room for human beings. To Josh Fairfield of Washington and Lee University School of Law, that means, "More messiness, not less. We're going to see more fights. 'You didn't actually renovate my house, I want my money back.' We're going to see more human messiness, but more human messiness doesn't mean the technology is bad."[125]

But will people actually take the counterparty to court? De Filippi estimated that in the analog world, 80 percent of contract breaches aren't enforced because they're too costly to pursue in court, too expensive to take into proceedings. Why should those numbers improve in a blockchain world? When the code indicates that the contract has been fully executed, except one party is dissatisfied with the outcome, will the dissatisfied party actually pursue a lawsuit? Will the courts recognize the case? Will the small business owner back away from the corporate legal team of Dewey, Cheatham and Howe or—with his modest resources—even be able to identify his anonymous counterparty, so that he could file a lawsuit in the first place?

"The courts are going to get it wrong. They've already started to get it wrong, applying intellectual property rules to anything that is intangible. They think that physicality is the dividing line between virtual property and intellectual property, and it's not," said Josh Fairfield. "There's no intellectual property element, there's no part of a bitcoin that is intellectual property, there's no creative spark for copyright, there's no patentable idea, there's no patent, there's no trademark."[126] So their challenge is formidable. They must oversee the unforeseeable. On the one hand, they must avoid stifling innovation by overreacting to worst cases—human trafficking, illicit drug trade, gunrunning, child pornography, terrorism, tax evasion, and counterfeiting, for instance. On the other hand, they must not twist new but unproven applications such as blockchain-based platforms for identity management to restrict civil liberties. There must be a stable approach to regulation, legislation, and the international negotiation of treaties in order to minimize regulatory uncertainty so that investors will continue to support the technology's global development.

The common law is technology law.

Fairfield focused more on process: "The common law isn't affecting technology law; the common law is technology law. The common law is the process of adapting human systems to technological change… the real fight is how do we take old rules meant for old technology and adapt them rapidly and competently," so that they are recognizable when we start using them but iterated so that they're state of the art when the technology really hits.[127]

Last but not least (and this should be no surprise), identity matters big-time—or at least how we construct it on the blockchain matters. If we combine a precisely coded version of personhood with a precisely coded version of society, we get the stuff of science fiction novels and Arnold Schwarzenegger movies. De Filippi and Wright

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conjured images of "self-enforcing contracts, walled gardens or trusted systems, owned and managed by a sophisticated network of decentralized organizations that dictate what people can or cannot do, without any kind of constitutional safeguards or constraints." In other words, a machine-driven totalitarian regime.

GOVERNANCE CHALLENGE:
PREMATURE LEGISLATION OR REGULATION WILL STIFLE THE BLOCKCHAIN REVOLUTION

In 2013, Benjamin Lawsky, the former superintendent of financial services for the State of New York (NYDFS), reviewed New York's existing statutes governing money transmissions and found them woefully inadequate for virtual currency.[128] The department initially wanted to regulate this technology by enforcing rules written around the time of the American Civil War. Those laws couldn't possibly address any kind of digital technology like the Internet, let alone bitcoin traded on a blockchain. "The more I learned, the more interested I got in how powerful this technology is, and I saw all the various applications and platforms that were going to be built over time," he said. If he "could get regulation right, to make sure the bad stuff we didn't want to see happening in the ecosystem was avoided, and at the same time not have regulation be too overbearing, then we had a real chance of helping a very powerful technology make serious improvements to our system."[129]

Lawsky concluded, "Maybe we need a new type of regulatory framework to deal with something that is just qualitatively different?"[130] His proposal, the BitLicense, was the first serious attempt to provide a regulatory lens onto this industry. A controversial piece of law, it revealed how even well-intentioned regulations can produce unintended consequences. When the BitLicense went into effect, there was a mass exodus of companies such as Bitfinex, GoCoin, and Kraken from New York; they cited the prohibitive cost of the license as a main cause. The few that stayed were well-capitalized and more mature businesses.

"There needs to be a balanced approach applied so as to not impair investment flows, job creation, and innovation," Matthew Roszak told the Committee on Energy and Commerce of the US House of Representatives. "There are currently over 1,000 startups betting their lives on blockchain-enabled technologies. Applying light touch regulation—similar to the [United Kingdom], Singapore, and Canada—with a 'wait and see attitude' (much like the early Internet) will create jobs for Americans and help keep innovation in the United States."[131]

Jurisdiction already matters when it comes to using bitcoin. Some governments have banned it or banned state banks from exchanging it. Jerry Brito of the cryptocurrency policy think tank Coin Center said, "In a typically Chinese way, it's not illegal, but it could be at any moment and everybody knows it."[132] China has allowed a serious professional mining community to flourish and those mining pools have become quite influential in debates over upgrades to the Bitcoin protocol. What happens to blockchain security if China suddenly bans mining, too? Other jurisdictions have moved to define bitcoin narrowly, as the US Internal Revenue Service has done. The IRS has labeled bitcoin as an asset for calculating taxes on the appreciation of value.

Don't regulate what you can't control... you're just going to get embarrassed.

"Whatever the particular policy issue is, if you don't understand the technology and you don't understand the implications, you're setting yourself up for failure," said Brito of Coin Center. "If you don't understand it, you can introduce law and policy that's going to harm the development of the technology."[133] Pindar Wong recalled a phrase from his Internet governance days: "Don't regulate what you can't control, because you're just going to get embarrassed."[134] Given the interdependence of economies around the world, we have a sense of urgency around global coordination of any policy-setting.

GOVERNANCE CHALLENGE: BUSINESS DEVELOPMENT OUTPACES SCIENTIFIC RESEARCH

Unlike the Internet, which had a long incubation period with much experimentation in non-profit mode before venture capitalists started to invest heavily in dotcom start-ups, blockchain technology is already supporting

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business applications. A lot of money has flowed to blockchain entrepreneurs with high expectations for business results. "We're investing as if it's 1999, but the standards are 1989," said Joi Ito of MIT Media Lab. There's so much we don't know about this resource.

For starters, how will it affect human behavior? We mean behavioral change in a deeper sense than Netiquette. Today, many people count on their bank or credit card company, even talking with a real person, when they make an accounting error, forget their passwords, or lose their wallets or checkbooks. Most people with bank accounts in developed economies aren't in the habit of backing up their money on a flash drive or a second device; securing their passwords so that they needn't rely on a service provider's password reset function; or keeping these backups in separate locations so that, if they lose their computer and all other possessions in a house fire, they don't lose their money. Yet, without this discipline, they might as well stuff their mattress with cash. On the blockchain, such distributed applications ("dapps") will reside with each user and run on the user's machine—regardless of service provider—rather than on the Web and in the cloud. Yet, 230,000 users of Microsoft Windows 7 in 150 countries had not developed the essential habit of keeping their computer software up-to-date and were victims of the WannaCry ransomware attack with an estimated total damage of US$4 billion.[135]

In developing economies, those who still rely on barter may be able to make a behavioral leap of sorts, leap-frogging not only a whole generation of technology, but also a century of banking habits and attestation practices that might otherwise become liabilities in a blockchain world. In other words, their lack of access to traditional financial or other centralized resources may put them at a behavioral advantage on the blockchain. With greater freedom—better privacy, stronger security, and autonomy from third-party cost structures and system failures—comes greater responsibility. For those consumers who don't trust themselves to keep safe backups of their private keys, third-party storage providers could provide backup service.

There is also a societal dimension that we don't yet understand. Money is still a social construct representing what a society values. It is endogenous to that society, it manifests because of human relationships, and it adapts to evolving human needs. "You can't take the social out of money," said Izabella Kaminska of the *Financial Times*. "A lot of these protocols attempt to do that by creating an absolutist and very objectified system. It just doesn't reflect the world as it is." She pointed to the euro system as an example of how one size—one set of protocols—doesn't fit all countries.[136] She echoed what Antonopoulos said about the very human need for societies to forgive and forget in order to move on. "There's a very long tradition in finance of obliterating records, because we as a society believe that it's wrong to persecute or discriminate against individuals for something

Creating a system that never forgets is slightly sociopathic

they did ten or fifteen years ago. We have this whole debt jubilee-esque mentality because we think people should be given another chance. Creating a system that never forgets is slightly sociopathic," she said.[137] Is that where we're heading? Is that what we want?

GOVERNANCE CHALLENGE: LACK OF DIVERSITY OF VIEWPOINTS

As many have observed, the blockchain movement is overpopulated with men. In technology, compared to other sectors of the workforce, people of color are under-represented by 16 to 18 percent, and women hold only 25 percent of all computing jobs.[138] "Everyone in Silicon Valley complains of the gender bias, and perhaps in the blockchain ecosystem even more so," said Pindar Wong. "That's unhealthy. We're not getting enough diverse views. Going back to cybernetic first principles, Ashby's Law of Requisite Variety,[139] we need a variety of viewpoints, be it male, female, gay straight, old, young, whatever you want to perceive it to be." When problem-solving has deadlocked, a key question to ask is, "Do we have enough variety in the room or online?" The goal is to maintain requisite variety to avoid thinking errors, said Wong. "You avoid thinking errors by having a wide variety of views that get equal treatment."[140] No discrimination.

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There are certainly high-profile women who have founded and are managing companies in the space: Blythe Masters, CEO of Digital Asset Holdings; Cindy McAdam, president of Xapo; Melanie Shapiro, CEO of Case Wallet; Joyce Kim, executive director of Stellar Development Foundation; Elizabeth Rossiello, CEO and founder of BitPesa; and Pamela Morgan, CEO of Third Key Solutions. Many of them have suggested that the industry is very welcoming to all voices, male and female alike. Venture capital in blockchain is also gaining in diversity. Arianna Simpson, former head of business development at BitGo, is now an investor in the sector. Jalak Jobanputra is an investor whose VC fund focuses on decentralized technology. But how diverse is the developer community? In our research, we came across comments like this that resonated: "More women…in the #blockchain ecosystem would mean better collaboration, more sensible governance."[141] Studies have shown this to be true.[142] We need to attract more women and more minorities to the ecosystem, with groups such as Women in Blockchain advocating their achievements.

GOVERNANCE CHALLENGE: POWERFUL INCUMBENTS WILL USURP DOMAINS

A question that kept coming up for us was, "What's to prevent the behemoths of the old, closed paradigm—huge corporations or powerful nation-states—from appropriating applications or the networks they run on for their own narrow interests?" For example, a repressive state could aim all its state processing assets and all its mining pools at the Bitcoin blockchain to stage a 51-percent attack or at minimum destabilize the process. Or a wealthy despot who has decided that immutable posts on the blockchain are eroding his power; this despot could seize all the mining power within reach and purchase the rest from countries that still tolerate his bad behavior in order to put himself over the 50 percent hash rate threshold. He could then decide which transactions to include in blocks and which to reject. With controlling interest, he could also decide whether to fork the code and introduce a few prohibitions, maybe blacklisting addresses associated with gambling or free speech. Do honest nodes adopt this centrally controlled fork, or do they fork over to a new code? Andrew Vegetabile, director of the Litecoin Association and senior systems engineer at Avionics Test and Analysis Corporation, said there would be no escape from such a scenario because the despot would have control of 51 percent of the network. And he needn't represent a government; he could be one of the world's wealthiest people or an executive of a highly profitable company with substantial purchasing power.[143]

Incumbents have taken notice of ICOs. Companies like Goldman Sachs, NASDAQ, Inc., and Intercontinental Exchange (the American holding company that owns the NYSE), which dominate the IPO and listing business, have been among the largest investors in blockchain ventures. At some point they could attempt to defend their territory, either gobbling up the most successful of new ventures or lobbying to make sure existing regulations for well-established firms apply to small start-ups, and then suing any start-up that survives the regulatory inquisition. This litigate-not-innovate strategy may buy them time to sort out a strategy. Or it may simply drain the incumbent of whatever real value it contains.

Think of those twin tyrants: legacy systems and active inertia. Academics have thoroughly documented the effects of lock-in and switching costs and have identified the challenges of postmerger systems integration. Organizations with huge technology investments in their installed base may be more likely to throw more money at their old system, sharpening their knives for the pistol fight rather than conducting strategic experiments on the blockchain. "If money and power do try to capture the network, the miners would stop them by going to the real version of Bitcoin and initiating a fork,"[144] according to Keonne Rodriguez, senior manager digital and user interface/user experience lead at Synechron.

GOVERNANCE CHALLENGE:
THE DICTATOR'S LEARNING CURVE, QUANTUM COMPUTING, AND UTTER FAILURE

Scenarios emerged in our research that didn't fit cleanly into any bucket, and so we have put them here, loosely under the categories of unknowns and unintended consequences. Artificial intelligence expert Steve Omohundro threw this phrase at us: the dictator's learning curve, or how cave dwellers end up with space age technology. Think about all the AI labs out there staffed by the world's smartest PhDs with access to the world's most

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powerful computers. PhDs might fork the Bitcoin code or write a smart contract that controls a drone's delivery of a package, while bitcoin is held in escrow until that exact moment when the package arrives. Let's say these PhDs post that software as open source code on the Internet, because that's what they do to move their ideas forward; they share ideas. So now ISIS doesn't need an AI lab, it doesn't need a software development team. It just needs to substitute a grenade for the package. That's the dictator's learning curve, and it's not steep. But don't blame the code or the culture of sharing. It's not necessarily what we do with the code; it's what we don't realize we're doing with it— the unintended consequences of a friction-free world.

We only learn once we make mistakes.

Looming in the distance is quantum computing, the cryptographer's Y2K problem. It combines quantum mechanics and theoretical computation to solve problems—such as cryptographic algorithms—vastly faster than today's computers. Said Omohundro, "Quantum computers, in theory, can factor very large numbers very rapidly and efficiently, and most of the public key cryptography systems are based on tasks like that. And so if they turn out to be real, then the whole cryptography infrastructure of the world is going to have to change dramatically."[145]

Pindar Wong spun a worst case scenario. "It could break," he said. The whole experiment with blockchain technologies could fail. In his view, "that would be a good thing, because we only learn once we make mistakes. If we make mistakes early enough, then the cost is much less than if we let them fester." Bitcoin is not even a decade old, its market capitalization is "a rounding error on a rounding error in the global financial system," he said. "It's materially irrelevant. We haven't moved all of e-commerce onto any blockchain platform."

So what might we learn? "One reason why this technology works is that it has socially engineered the game mechanics based on one assumption; that there are more good people than bad people," Wong said. "If that turns out to be wrong, that there are actually more bad than good people, then we will have learned something."[146] As satirist James Branch Cabell observed, "The optimist proclaims that we live in the best of all possible worlds. The pessimist fears this is true."

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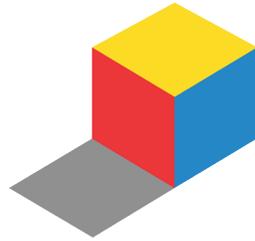
The Players in The Blockchain Ecosystem

Although blockchain technology emerged from the open source community, it quickly attracted many stakeholders, with different backgrounds, interests, and motives. Each has a role to play. There are early signs that many of the core stakeholders see the need for leadership and are stepping up. "Any person or organization that is working to promote the acceptance and use of blockchain-based technologies is a steward of the ecosystem," said Perianne Boring of the Chamber of Digital Commerce.[147] Here are the players and their perspectives on governance:

Blockchain Innovators

Vanguards in the industry—from Erik Voorhees, CEO and founder of ShapeShift, to Roger Ver, an investor also known as "Bitcoin Jesus"—believe any form of formal governance, regulation, or oversight is not only foolish, but antithetical to the principles of blockchain. However, as the industry has expanded, many entrepreneurs are seeing a healthy dialogue with governments—and a focus on governance more broadly—as a good thing. Companies like Coinbase, Circle, and Gemini have joined trade organizations; and some even maintain close relations with emerging governance institutions such as the Digital Currency Initiative at MIT.

Venture Capitalists

What started as a clique of cryptoinsiders snowballed into technology's most influential VCs such as Andreessen Horowitz. Then financial services titans joined the mix: Barclays, Deloitte, Goldman Sachs, NYSE, UBS, and Visa, among others, have made direct investments in start-ups or supported incubators that nurture new ventures. Pension funds are entering the fray. OMERS Ventures, the billion-dollar venture arm of one of Canada's largest public sector pensions, made its first investment in 2015. Jim Orlando, who runs that group, is looking for the next killer app that "does for blockchain what the Web browser did for the Internet."[148] Investment has exploded. According to data in PricewaterhouseCoopers' DeNovo platform, "funding in blockchain companies increased 79 percent year-over-year in 2016 to US$450 million."[149] Tim Draper of Draper Fisher Jurvetson told us that, if anything, "financiers are underestimating the potential of blockchain."[150] Digital Currency Group, a venture firm founded by Barry Silbert, has appointed academics and other nontraditional advisers to its board to accelerate the development of a better financial system through both investment and advocacy.

Banks and Financial Services

Before 2015, few major financial institutions had announced investments in the sector. In its Global FinTech Report 2017, PricewaterhouseCoopers reported that 77 percent of survey respondents in financial services expected "to adopt blockchain as part of an in-production system or process by 2020."[151] Today, Bank of Montreal, BNY Mellon, CIBC, Commerzbank, Commonwealth Bank of Australia, ING, Macquarie, Mitsubishi UFJ Financial Group, Mizuho Bank, Nordea, RBC, Société Générale, State Street, TD Bank, UniCredit, Wells Fargo, and dozens of others are investing in the technology and wading into the leadership discussion. Many of

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the world's biggest banks have signed up to the R3 CEV consortium. Stakeholders must remain cautious of any powerful incumbents looking to control this technology, just as they had to proceed cautiously in the early days of the Internet.

Coders and Developers

Blockchain developers lack formal oversight bodies such as ICANN, the IETF, or W3C to anticipate development needs and guide their resolution—and the Bitcoin community prefers it that way. Members do have a few norms such as participating in online forums, posting protocol improvement proposals publicly for peer review, discussing and addressing other members' concerns, advocating for particular solutions, testing proposed code, and jumping in to debug code—not just suggesting but implementing a fix. Bypassing peer review is a real no-no, while trolling to improve ideas is OK.[152] When we spoke with Bitcoin core developer Gavin Andresen in 2015, he was at the center of the block-size debate. He told us, "I'd prefer to stay in the engine room, keeping the Bitcoin engine going" rather than spending every waking moment advocating for Bitcoin's future.[153] At the time, he viewed the Internet governance network as a useful starting point. "I always look for role models. The role model is the IETF."[154] It's "kind of chaotic and messy," he said, but it works and it's reliable. However, in the absence of clear and transparent leadership, Andresen either found himself or put himself too much in the spotlight. It was a Catch-22 of sorts that cost him his developer privileges.[155]

Academics and Scholars

Academic institutions are funding labs and centers to study this technology and collaborate with colleagues outside their silo. Joi Ito, director of the MIT Media Lab, saw an opportunity for academia to step up: "MIT and the academic layer can be a place where we can do assessments, do research and be able to talk about things like scalability without any bias or special interests."[156] Notable universities such as Stanford, Princeton, Duke, and NYU also teach courses on blockchain, Bitcoin, and cryptocurrencies.[157]

Nongovernment Organizations

The year 2015 proved transformative for the burgeoning constellation of NGOs and civil society organizations focused specifically on this technology. Groups include Jerry Brito's Coin Center and Perianne Boring's Chamber of Digital Commerce. These groups are gaining traction in the community. Brito said, "Governance comes into play when there are serious decisions that need to be made and you need a process or institution for that to happen."[158]

Governments, Regulators, and Law Enforcement

The Internet of Value will deal with money, stocks, bonds, and other financial assets as well as deeds, votes, identities, and other assets that governments tend to originate, register, or otherwise oversee to preserve the public interest. When it comes to transactions involving these assets—the foundation of our economies—they would be right to express both curiosity and concern for the common good.

For example, central banks are taking different steps to understand this technology. Benjamin Lawsky, former superintendent of financial services for the State of New York, said strong regulations are the first step toward industry growth.[159] Carolyn Wilkins, the senior deputy governor of the Bank of Canada, believes central banks everywhere should seriously study the implications of moving entire national currency systems to digital money. The Bank of England's top economist, Andrew Haldane, has proposed a national digital currency for the United Kingdom.[160] The deputy chief of the Bank of Russia, Olga Skorobogatova, said that it was "time to develop national cryptocurrencies," and the People's Republic of China has been experimenting with Ethereum to develop a digital Yuan.[161]

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Governments around the world are uncoordinated in their approach to blockchain—some favoring *laissez-faire* policy, others diving in with new rules and regulations such as the BitLicense in New York. Some regimes are openly hostile; increasingly a fringe response. Even those stakeholders who resist government intervention acknowledge the merit of regulator participation in governance debates. Adam Draper, a prolific VC in the industry, reluctantly acknowledged, "Government endorsement creates institutional endorsement, which has value."[162]

Consumer and Citizens—Users

All of humanity and every company and institution will use this technology as foundational. People have a legitimate right to care about identity, security, privacy, human rights in general, fair adjudication, and the long-term viability of this resource. Yet there is no shared taxonomy or categorization of the space: Does blockchain refer to the Bitcoin blockchain or the technology in general? Is it big "B" Blockchain or little "b" blockchain? Is it a currency, commodity, or technology? Is it all of these things or none of these things?

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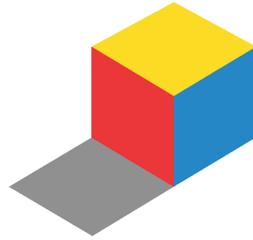
The "Global Solution Networks" Framework Applied to Blockchain

We've outlined the major issues and a few successes in addressing them. They are significant. To date, many are still unsolved, with only pockets of collective movement to resolve them. We cannot underscore it enough: for this technology to reach its next stage and fulfill its long-term promise, we still need coordination, organization, and leadership. Human beings must step up and lead.

Questions persist over how much leadership will come from the Internet governance community, and rightly so. Initially, many organizations involved in Internet governance viewed digital currencies and blockchain technologies as outside their purview, but that is changing. Vint Cerf, who co-created the Internet itself and led the creation of the Internet Society and the Internet Engineering Task Force, suggested that a good starting point for blockchain would be to create a "birds of a feather" (BOF) interest group within the IETF.[163] The W3C has made Web payments a priority, and blockchain is central to that discussion.[164] Additionally, the UN's IGF has hosted sessions about blockchain and Bitcoin in which participants have explored new decentralized governance frameworks enabled by the technology.[165]

Here's the thing: many of our concerns about the first generation of the Internet have come true. Large corporations and authoritarian regimes have captured much of the technology and are using it in their vast private empires to extract most of the value. They have closed off opportunity and privatized much of our digital experience. We use proprietary stores or government-owned channels to acquire new apps for our phones, tablets, and watches. Search engines and marketing (or propaganda) departments alike interrupt our content with advertising and state messaging. Big organizations that promote and prosper from consumer data are notoriously secretive about their activities, plans, and information assets. To be sure, some of these behemoths have opened up voluntarily, but many others have merely reacted to the exposure from whistleblowers and investigative journalism. Such disclosures are dwarfed by efforts to hide operations and conceal information. Simply put, these stakeholders haven't been good stewards of the public trust, and existing Internet governance networks haven't been effective in representing all interests equally.

Case in point: the banking industry. "Banks are traditionally secret keepers," according to Kaminska of the *Financial Times*. She explained that banks make good judgments about whom to lend to and how to process payments when they have good access to private information, and they get that information by promising to keep the secret. The more secrets they hold, the greater the information asymmetry and the greater their advantages, but those advantages have harmful systemic implications in both civic and commercial spheres.[166]

Pindar Wong, former board member of the Internet Society, was quite reflective: "I spent most of my adult life trying to build an Internet, and it turned out that Internet actually shouldn't be trusted. It is, in fact, a trustless Internet. I grabbed this blockchain technology with two hands and have run with it as fast as I can because, in some sense, it is a second bite of the cherry. It's penance. It's the ability to right a wrong, which I didn't know that we were making with the Internet."[167]

So we cannot leave governance of such complex global innovations solely either to governments or to the private sector: political and commercial interests have proven insufficient to ensure that this new resource serves society.

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Rather, and more than ever, we need multi-stakeholders to collaborate as equals and provide global leadership. We need all three pillars of modern civilization—the private sector, the public sector, and civil society—to participate in stewarding this new global resource. According to *The Economist*, "'Multi-stakeholderism' may be, like democracy, the worst form of governance except for all the other ones."[168] We believe that non-state, multi-stakeholder networks (which we call global solution networks or GSNs) are the most effective means we have to steward global resources.

Table 1   Seven Global Solution Networks types
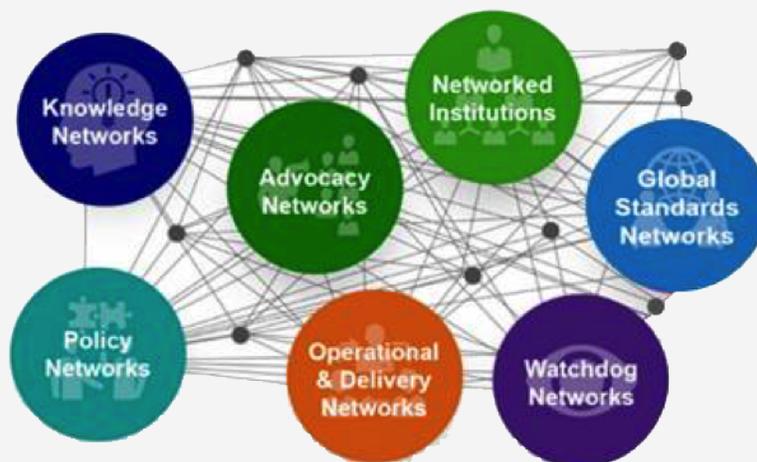
Source: Global Solution Networks, gsnetworks.org

Overall, the expression "If there is a will, there is a way" applies. The smartest technologists on the planet are working on creative solutions to some of these challenges. Further, as computers become inexorably smarter, they will undoubtedly provide their own solutions. Investor Roger Ver said, "Say the smartest human has an IQ up close to 200. Imagine artificial intelligences with an IQ of 250, or say 500, or 5,000 or five million. There will be solutions, if we humans want them."[169] In this section, we look at how diverse stakeholders can come together and forge new understandings and new action plans.

Global Standards Networks:
Don't deify differences, codify common ground

The most urgent need is for standards at both platform and application level. Gavin Andresen was among the original core developers who believed leadership was required to move the agenda forward on common standards. "Maybe you can design light socket set waves by committee, but you can't design software standards that way," he said. Pointing to the early days of the Web, Andresen said, "The Internet model shows that you can have technologies where consensus does arise, even though there's no one clear leader," but that "you can either have a process, or a person, or a process that ends in a person. You definitely need one or the other."[170] Consensus mechanisms alone can't support standards development.

"We're missing a Jon Postel," said Joi Ito of one of those "[US Department of Defense]-funded guys who were slightly hippy but thought this government work was kind of cool," an attitude Ito would not use to characterize

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either the Bitcoin core developers, who can be "hard to talk to," or the Chinese miners, who can be "very aggressive." In contrast, Postel was a tireless steward who, for decades until his death, shepherded the Internet Assigned Numbers Authority and served as the Request-for-Comments Editor, managing and maintaining the Internet's documents of record.

"When you're dealing with a technology that is so leading edge, groundbreaking, and relies on cryptography, you need to think slightly differently. I'm trying to think slightly differently and break away from what I called binary thinking. Binary thinking is black and white, are you secure or insecure, and

You don't need everyone to participate.

I don't think those lead to very fruitful debates," said Pindar Wong. "When you're dealing with a technology as sophisticated as Bitcoin, which is the only blockchain we currently know that works, that is unhackable, you're dealing with nuance, with very sophisticated discussions in a highly technical domain that you don't need everyone to participate in. Everyone has the opportunity to participate, but you don't need everyone to participate."[171] Who should participate? Within the Bitcoin ecosystem, there "is a very exceptionally smart and gifted group, the brightest people in the room," Wong said.

"When it comes to governance, we cannot expect a small group of engineers to figure out a perfect protocol for economic transactions and social interactions. This is not an engineering problem," said Primavera De Filippi. It is "a social and political problem." She recommended "involving all relevant stakeholders across diverse disciplines in a neutral forum."[172]

Yale Law School professor Elizabeth Stark, another emerging star in governance, took up the mantle of convener-in-chief for the industry. Like another prominent woman—Dawn Song, MacArthur fellow and computer science professor at Berkeley, and an expert in cybersecurity—Stark came from a distinctly academic background but has other ambitions. To solve the blockchain's scalability issue, she organized Scaling Bitcoin, convening developers, industry players, thought leaders, government officials, and other stakeholders in Montreal, and collaborated on the Bitcoin Lightning Network.

In financial services, both R3 CEV and Hyperledger are tackling critical standards issues. Invariably, there will have to be standards networks on a variety of things, from the blockchain protocol that forms the basis of the financial services industry of the future, to common standards for privacy and payments in the Internet of Things.

While each of these groups attacks the problem from different angles and with different agendas, each shares a common goal to make this technology ready for prime time—by building infrastructure, developing standards, and making it scalable.

Networked Institutions:
Welcome stakeholders everywhere

Members of the blockchain ecosystem need opportunities to collide, so to speak, with other stakeholders so that they can hear each other's concerns and positions. When asked what we need most, Perianne Boring said, "A public dialogue on the importance of encryption. With many high profile terrorist attacks, like Manchester [England], there is a renewed call throughout the world to ban encryption. This is a grave mistake. Cybersecurity attacks, like identity theft and ransomware, continue to be a multi-billion dollar drain on the economy." Decentralized, blockchain-based security systems could address cybersecurity issues head on. "The blockchain industry is not participating in the global encryption debates, and they should be," she said.[173]

Joe Lubin called for decentralized inclusiveness:

> We set out at the start of Ethereum to be as inclusive as possible, so any person or company that might want to be exposed to the technology should be able to use it. There were certainly

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some crypto-anarchists in the space broadly who were disgusted that banks might be spoken to or that we, any of us, would educate or collaborate with a bank, let alone a central bank. But if this technology is to have a profound impact on the planet, then it needs to be, or it should be, everywhere and widely distributed in terms of different use cases.[174]

The World Economic Forum has been a vocal proponent of blockchain technology. The blockchain was front and center at Davos in January 2016. Jesse McWaters, financial innovation lead at the WEF, believes blockchain technology is a general-purpose technology, like the Internet, which we can use to make markets radically more efficient and to improve access to financial services. He tells non-technologists in the finance sector, "Don't worry about blockchain. Don't worry about block size or any of that nonsense. What you should really care about is the future-state architecture of your industry. Focus on the characteristics you need the future-state infrastructure to have. That has a governance component to it."[175]

It needs to be everywhere.

A great example of this mindset is Moog, Inc., a US$2.5 billion provider of precision motion control equipment and a leading supplier in additive manufacturing (3D printing). It is using governance to attract the right platform partners. The company envisions a blockchain-enabled digital supply chain where it can exchange intellectual property on a point-of-use/time-of-need basis as both a producer and consumer. "Users must have absolute control of the value created by their IP," said George Small, principal engineer at Moog.[176] "We are focusing on governance first as a means to building a consortium" of industry equals who have earned their community's trust and would like to help create such an IP exchange. "Stewardship must be transparent, fair, and stable," he said. "We will not be able to build upon a moving target or one that fails to support absolute trust across ecosystem members." Collaborators such as Hyperledger are providing the infrastructure. The governance body of the consortium will provide what Small referred to as curation, meaning human interaction and arbitration as needed. "The network will not reach its full potential" if certain members can gain unfair advantage through their status or visibility.[177]

The WEF predicted that within a decade, we could store ten percent of global gross domestic product on blockchains.[178] As an organization, the WEF has championed and advanced big issues such as income inequality, climate change, and even remittances. Other networked institutions, from the smallest groups to the biggest foundations in the world, such as the Clinton Foundation and the Bill and Melinda Gates Foundation, would be wise to champion this technology to advance such big issues as financial inclusion and health care delivery. Networked institutions often have a role to play in influencing government policy-making, making them a critical link and strategic partner in overcoming a number of major showstoppers.

Advocacy Networks:
Respect members' interests and constraints

There is strength in numbers when it comes to advocating for the ecosystem. Stakeholders cannot focus narrowly on their concerns and hope to achieve results. Advocacy networks arise from disillusionment with traditional political and civic institutions, making them a logical fit for the blockchain community, which is trying to upend how those traditional institutions solve problems. However, in these early days advocacy networks must work with government as a partner.

To advocate for the blockchain ecosystem, Perianne Boring founded the Chamber for Digital Commerce, a trade-based association in Washington, DC. Within a year, CDC attracted a high-profile board (e.g., Blythe Masters, James Newsome, George Gilder). The movement needed "boots on the ground in Washington to open a dialogue with government," she said. With her background in journalism, Boring focused on messaging, positioning, and polish. Her organization is "open to anyone who is committed to growing this community," she said, and it is now a leading voice in policy, advocacy, and knowledge in the burgeoning blockchain governance ecosystem.[179]

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Stakeholders may have very different cultures from one another. "You can get to a point where you have transparency in certain things. You don't need transparency in everything. You wouldn't want to run a bank consortium necessarily that way, at least, in the legacy world," said Joe Lubin of Ethereum. "We found out with all the different banks in the alliance that they have some very rigorous constraints, that it's not natural for them to operate with us freewheeling blockchain start-ups and that we need to respect their constraints."[180]

Non-profits focused on human rights and economic empowerment can especially benefit from advocacy networks. For example, BitPesa, the universal payment and trading platform, operates mainly in sub-Saharan Africa. It belongs to multi-stakeholder groups like the US State Department's taskforce on Africa, where it sits alongside IBM, Microsoft, and other tech firms that have greater influence over African governments and can lobby on BitPesa's behalf.[181]

Narrow focus cannot hope to achieve results.

Advocacy networks are closely tied to policy networks, and Coin Center and the Chamber of Digital Commerce are taking the lead in this area. We could also include here COALA, MIT's Digital Currency Initiative, and others. Advocacy is critical to scaling blockchain technology. In the absence of strong advocates who speak up for stakeholders and stand up for stakeholder rights, governments and other powerful institutions could try to stifle, twist, or usurp this powerful open network to their exclusive advantage.

Watchdog Networks:
Do no harm

Watchdog Networks

Blockchain is in a Wild West phase. People are experimenting because they can, some making extraordinary claims. Not all participants are equally versed in the technology. The ecosystem needs the equivalent of an Electronic Freedom Forum to watch what organizations are doing in the space.

"Governance comes into play where there are serious decisions that need to be made, and you need a process for that to happen," said Jerry Brito, one of the most prominent legal voices in the space—first at the Mercatus Center at George Mason University and now as director of Coin Center, a not-for-profit advocacy group.[182] He recommended starting with the Hippocratic Oath: First, do no harm. The current bottom-up approach that Bitcoin's core developers are using "is showing a little bit of its rough edges right now with the block size debate. It's going to be very difficult to get any consensus," Brito said, but he doesn't think any organization could or should impose order on it. "We want to help develop that forum and foster a self-regulatory organization if it comes to that."[183] By self-regulatory organization, he means "self-regulation by the companies in the industry, specifically of their consumer protection and privacy practices" and not of core protocol development, which he thinks "is best left to an admittedly messy open source process" outside the scope of Coin Center's policy mission.[184]

The Blockchain Alliance is a partnership between law enforcement, NGOs, trade organizations, and the private sector and is the first true advocacy network to form in the space. Coin Center and the Chamber of Digital Commerce, with support from

Let's not regulate out of fear.

BitFury, Bitfinex, BitGo, Bitnet, Bitstamp, Blockchain, Circle, Coinbase, and others have partnered with US law enforcement agencies such as the Department of Justice, the Federal Bureau of Investigation, the Secret Service, and the Department of Homeland Security.

These watchdogs have an important advocacy role as well. In the aftermath of the Paris terrorist attacks, some European lawmakers, regulators, and law enforcement blamed bitcoin as the source of terrorism financing. The Blockchain Alliance called for patience: "Let's not regulate out of fear," they said.[185] Other than the self-policing role of community members who convene, collaborate, and debate on forums and on Reddit, few other watchdog

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networks have stepped up. Partnerships with law enforcement are a helpful start, but the blockchain ecosystem needs fully independent organizations, perhaps traditional watchdogs such as Amnesty International and Human Rights Watch, to sound the alarm when corrupt and unscrupulous governments find ways to use blockchain as a surveillance tool.

What about central banks as watchdogs? They have considerable regulatory power in their respective countries, but they do not operate in silos. They coordinate and collaborate with other central banks and with global institutions like the Financial Stability Board, the Bank for International Settlements, the International Monetary Fund, the World Bank, and others. We need stronger global coordination to address blockchain issues. Today, central bankers are asking important questions. Carolyn Wilkins, senior deputy governor of the Bank of Canada and a central banking veteran, told us, "It's easy to say that regulation should be proportionate to the problem, but what is the problem? And what are the innovations that we want?"[186] These are great questions that we could address more effectively in an inclusive environment.

Policy Networks:
Participate in debate and coordinate regulation

Rather than simply regulating, governments can improve the behavior of industries by making them more transparent and boosting civic engagement—not as a substitute for better regulation but as a complement to the existing systems. We believe effective regulation and, by extension, effective governance come from a multi-stakeholder approach where transparency and public participation are valued highly and weigh heavily in decision making.

Open-mindedness is a virtue. Elizabeth Rossiello, founder and CEO of BitPesa, described how her organization does its on-the-round due diligence and makes sure that its operations comply with existing laws. Where appropriate laws don't yet exist, BitPesa has a hand in writing them. It does a comparative check, works with companies in other regions, and understands what they've been doing with their governments. For example, in India, companies are writing their own regulations for this type of payments network, and so BitPesa is collaborating and sharing knowledge.[187]

Primavera De Filippi of the Berkman Center at Harvard has emerged as one of academia's clearest and most eloquent voices on governance. She said that we cannot establish "a proper policy and regulatory framework for blockchain technologies…at a local or national level." She recommended international cooperation, multi-stakeholder dialogue, and a forum for "lawyers and engineers to talk more with each other and understand each other's language better."[188]

De Filippi formed the Coalition for Automated Legal Applications (COALA) with her colleagues, lawyer-turned-entrepreneur Constance Choi of Seven Advisory, and Adroit Lawyers' Amor Sexton, the leading digital currency lawyer in Australia. They have led a series of blockchain workshops at Harvard, MIT, and Stanford, as well as in London, Hong Kong, and Sydney. Through COALA, part of the UN's Internet Governance Forum, they liaise with key stakeholders, regulators, and policy makers to help them understand the impact that blockchain technology might have on existing legal and political institutions. De Filippi said, "We invite them to contribute to the elaboration of policies, regulations, and standards for this emergent ecosystem."[189]

Today, a nascent policy network is emerging. Coin Center, a not-for-profit policy group in Washington, DC, focuses on five core verticals: innovation, consumer protection, privacy, licensing, and anti-money laundering/know your customer (AML/KYC). The Chamber of Digital Commerce, a trade organization, focuses on promoting the acceptance and use of digital currencies.[190] When the Chamber opened its doors in 2014, the public policy community was skeptical, even fearful, of bitcoin and blockchain. A US Senator was calling for a ban on bitcoin. "We attributed this sentiment to a general misunderstanding and miscommunication from highly publicized events including Silk Road and Mt. Gox," said Chamber founder, Perianne Boring. Since then, the Chamber has made huge strides in educating the community. "In the past twelve months, we have held over a hundred

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briefings for policymakers at the state, federal, and international level. Today, we have many bitcoin and blockchain champions through the world's policy community; we even have a Congressional Blockchain Caucus."[191]

There is even a Congressional Blockchain Caucus.

The United Kingdom has its own Digital Currency Association, as do Australia and Canada, who speak for industry. Promoting and uniting many strong voices in the policy arena will ensure that blockchain has a better chance of fulfilling its potential.

Knowledge Networks:
Know what you don't know

Knowledge Networks

"The scale of the transformation under way in a new global *modus vivendi* is barely understood. Education is key," said a vice chairman in the corporate banking sector. "That transformation requires collaboration between the public and private sectors, which was not needed—and was not possible—over the past two decades before the emergence of the new technologies." He expected members of the ecosystem to learn "through mistakes, some of them affecting civil liberty and personal privacy. Enlightened organs of the public and private sectors will increasingly work together on anticipating, avoiding, mitigating, or correcting these mistakes."[192]

There are hundreds of pilots underway. For example, Bitfury's Blockchain Trust Accelerator, in partnership with the New America Foundation and the National Democratic Institute, is creating responsible, innovative, and cutting-edge pilot projects to advance knowledge for the global good.[193] Brian Behlendorf of Hyperledger hopes that communities will share what they've learned from both their successes and failures—what works, what doesn't, and what needs to be fixed in terms of architecture and product. Knowledge networks support this iterative learning, sharing, and developing of evidenced based policies. They give advocates relevant information for lobbying efforts and serve as a repository of data that standards networks, such as the International Organization for Standardization, can use to develop specifications for DLTs, FinTech, and blockchain technologies.

What works, what doesn't, and what needs to be fixed.

The Coalition for Automated Legal Applications (COALA) is doing foundational research "to ensure that blockchain-based applications can operate in the current regulatory framework and interact with existing institutions governed by the rule of law." It has launched initiatives such as COALA-ID, a blockchain-based framework for credentials management and access control in collaboration with MIT; Elethron, a blockchain-based system for renewable energy trading in collaboration with Commonwealth Bank of Australia and Hewlett-Packard; and COALA LEX, an interface between smart contracts and legal contracts to bridge the gap between traditional legal frameworks and blockchain technologies. COALA intends to elaborate upon "meta-languages for hybrid techno-legal agreements" and develop "an open source library of standardized and certified smart contract modules." COALA has representation at technical standards-setting bodies such as W3C and IETF, and has partnered with such academic institutions as Harvard, Stanford, Cambridge, and Oxford Universities, University of California at Berkeley, University College London, National Center of Scientific Research, and Hong Kong University of Science and Technology, all "to drive scientific and fact-based research for the blockchain ecosystem."[194]

"There should be a forum to present proposals or ideas," Tyler Winklevoss of Winklevoss Capital said.[195] Both formal and informal knowledge networks provide such forums. Through collaborative research, experimentation, and deliberation, they create and disseminate new knowledge to other GSNs, stakeholder groups, and the broader

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public. For example, MIT's Digital Currency Initiative is uniting and exciting academics and universities globally. Informal meetups like the San Francisco developer meetup and the New York developer meetup are also making knowledge a priority. Blockchainworkshops.org has convened stakeholders to share key lessons. Reddit, the online community, is also a medium for debate in the space, and GitHub is a repository of conversations about code and the code itself. The Blockchain Research Institute is commissioning research on how the blockchain will transform core verticals in the economy and core functions in organizations. Its publishing program will feature white papers, case studies, and conferences.

COALA also provides an open, neutral, and collaborative forum for discussions around the core issues of legal and technical interoperability. "We gather together a global community of blockchain experts, including lawyers, academics, institutional leaders, policymakers, computer scientists, and entrepreneurs," De Filippi of COALA said.[196]

Joi Ito of the MIT Media Lab underscored the need for basic research that was solution neutral. "I intentionally divested all of my shares in Bitcoin related companies, like Guard Time and Blockchain, because I felt that I had to be able to speak without having a conflict [of interest]. Some people think that was a little bit overboard. At least for our core team, we decided that it was important. When we talk to some of the more careful people like the central banks, we're not trying to sell them anything."[197]

Ito has worked to build "some capacity and some funding that was relatively neutral." He envisaged communities of academic expertise around whichever standards develop, a community at each layer—platform, application, industry—that could facilitate standards conversations as they came along. The lab is also trying to help its ninety member companies to understand how they might participate in this open standards process."[198] He reiterated the neutrality of solutions; the lab would have no skin in the game. "It's important to have people who can have non-financially motivated, non-conflicted points of view on both the technology and the standards," he said.[199]

Operational & Delivery Networks

Delivery Networks:
Keep incentives for mass collaboration in mind

How do we ensure that the incentives are adequate for distributed mass collaboration, making the technology ready for primetime? We need an "ICANN moment" for blockchain, where organizations will form to deliver essential functions. However, while ICANN and many other GSN types in the Internet governance network are distinctly American, blockchain leaders should push to make these organizations international. Joichi Ito said, "I do think there's already a big push to make governance non-American and international from the beginning because that's one thing we learned from ICANN, that it's hard to get out from under America once you get started as part of America." 200 COALA is a global organization that performs a few key roles: It disseminates knowledge, influences policy, advocates for blockchain technology, and supports the development and deployment of blockchain-based applications, all critical to overcoming major potential showstoppers.[201]

"The much greater focus on smart-contract auditing is incredibly important. There's a maxim in the cryptography space: 'Don't roll your own crypto.' So, you really want to use extremely well-vetted software packages," said Joe Lubin.[202] The ecosystem could use far more independent cryptographic auditors to provide this vital function. It's more than quality assurance.

Don't roll your own crypto.

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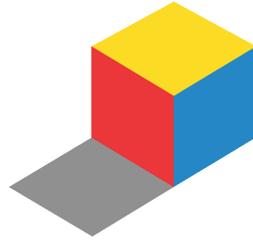
Summary: What needs to be done

While our goal was to create a language and structure to think about stewardship of blockchain—and not to make specific recommendations to particular stakeholders—some sensible next steps did emerge. The time for global action is now. We believe people, institutions, and industries throughout the world need blockchain technology and we must do all we can to make it available. Here is a set of actions we believe will move this technology forward. Our hope is that these will prompt discussion and provide positive steps that could be taken.

Networked Institutions:

To attract the necessary level of stakeholder participation, we recommend that respected global networked institution such as the World Economic Forum, the Internet Society, or the United Nations Internet Governance Forum convene, through an online platform and a series of meetings, a discussion of the governance issues outlined in this report. The goals would be (a) to include key players in the room, (b) To provide participants with the taxonomies and frameworks developed in this report so that everyone has a shared understanding of governance challenges and solutions, and (c) to forge some informal actions to improve governance, primarily at the overall ecosystem level, but possibly at the two other levels of governance.

Standards Networks:

To break the deadlock of Bitcoin platform development, we recommend the creation of the Bitcoin Engineering Task Force as a loosely self-organized, grass roots technical group comprised of the nine stakeholder groups. It would not be a formal body with a board of directors or any hierarchy. It could operate as a working group of the IETF, W3C or other appropriate organization. Its mission would be the adoption of standards and the engineering and sustainability of blockchain technology, and it would develop, test, and implement new protocols and standards, according to broad consensus of its membership prior to implementation. Instead of formal membership, attendance at BETF meetings and participation in any BETF online forum would be open to all volunteers. Participants would contribute as individuals, not as representatives of companies or organizations. The community could learn much from the consensus mechanisms and decision-making processes of the IETF and other standards bodies such the W3C.

Advocacy Networks:

To forestall regulatory, legislative, judicial, or executive action that might stifle further innovation, blockchain needs stronger advocacy. The policy and advocacy work of the Chamber of Digital Commerce is exemplary, but the ecosystem needs more. We encourage organizations in every country to join the Chamber and participate in its work. Networked institutions with global influence could convene heads of state and chief executive officers so that they might discuss their common interests in developing this new global resource. Collaboration with these leaders could develop a roadmap and action plan for future

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government officers, representatives, and judges at the municipal, state, national, and regional level designed to help them monitor blockchain initiatives, assess potential harms and unintended consequences, engage the blockchain community in discussions, and coordinate with their peers in other jurisdictions prior to issuing legislation or regulation of the technology.

Policy and Watchdog Networks:

To address the need for better monitoring of blockchain problems and challenges, there is much to do. Consider initial coin offerings. The first jurisdiction to come up with a workable policy for ICOs will attract a flood of ICO activity and economic development for that state. Also consider the environmental impact of blockchain technology. We recommend forming a multi-stakeholder network to look both at the energy consumed by mining and also at the energy expended in current production lines and service delivery methods where industries intend to deploy blockchain technology. The goal would be to explore methods for capturing the heat produced by mining, harnessing the unused computing power of appliances, and for reducing energy consumption across whole systems. We would like policymakers to collaborate more deeply and more rapidly.

Delivery Networks:

The Hyperledger Project, the Enterprise Ethereum Alliance, and the Trusted IoT Alliance are three important organizations providing feedback on protocols and doing work at the applications level. Every company, not just technology companies, but users of these applications, should join these open initiatives, depending on the platform(s) they have chosen. To build out the necessary infrastructure, we recommend greater outreach to industry associations at both corporate and professional levels, including outreach to the professional services firms that support them. The goal would be identifying projects as bold and forward-looking as the Belt and Road Project, where blockchain technology could facilitate collaboration, consensus-building, transparency of reporting, and other aspects to increase the efficiency, effectiveness, and accountability of project management.

Knowledge Networks (Education):

To address the urgent need for diverse talent and expertise in the ecosystem, every university should be organizing blockchain courses in their computer science programs and strategic courses in their business programs. There should be a massively open online course (MOOC) or series of courses available for credit and certification. We recommend forming an industry/academic collaborative to encourage the development of advanced programming skills in the blockchain space around the world, potentially modeled after, led by, or including such organizations as Coursera, edX, Khan Academy, Stanford Engineering Everywhere, Udacity, and other nonprofit open education platforms. Such a collaborative would also support the development of course shells and teaching materials across areas of the academy: not just computer science, mathematics, and engineering, but finance, accounting, operations and logistics, marketing, law, economics, sociology, and medicine. Above all, it would be inclusive, with additional outreach to girls, women, and their teachers in regions of need, perhaps in partnership with UN Women.

Knowledge Networks (Applied Research):

Blockchain may be the least known and least understood technology of the Fourth Industrial Revolution. Artificial intelligence, for example, has become a mainstream topic even though it may ultimately have less impact on our economy. To address the need for better strategic knowledge about blockchain transformations, we need better use-case research and awareness-building programs. The Blockchain Research Institute has launched a program of

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40 projects to explore blockchain transformation of industries, government, competitiveness, and management challenges.

Knowledge Networks (Scientific Research):

To accelerate research so that knowledge catches up with investment, we recommend funding fundamental research projects such as those underway at the MIT Media Lab. All member countries should be conducting, categorizing, and analyzing experiments with blockchain technology—organizations, networks, and individuals around the world—so that no country or region comes to dominate the technology or its area of expertise. The goal of such research would be to identify key gaps in scientific knowledge and expertise, create a set of principles for ecosystem players to help them self-organize and address these gaps, and create a comprehensive "network of networks" to help coalesce the scientific community.

All stakeholders in the ecosystem—at all three levels—must understand these governance challenges and opportunities. Today, most players are focused on building their own companies, organizations, or platforms and paying little attention and devoting little effort to the challenges of building a healthy ecosystem. No organization can succeed in an ecosystem that is failing or stalled. Every organization should assign resources, however small, to participate in ecosystem governance.

This second era of the Internet promises to create new opportunities for a more prosperous world. Prosperity is about one's standard of living. To achieve it, people must have the means, tools, and prospects for creating material wealth and thriving economically. For us it includes more—security of the person, safety, health, education, environmental sustainability, chances to shape and control one's destiny and to participate in an economy and society. This is the promise of the blockchain, the promise of a future where there is prosperity for everyone. But we must act now.

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About the Authors

Don Tapscott is the CEO of the Tapscott Group, a think tank exploring the Digital Economy, and author of 16 books about the Digital Age. He is an Adjunct Professor at the Rotman School of Management, University of Toronto, the Chancellor of Trent University, and a Senior Advisor to the World Economic Forum. In 2013 he founded the Global Solution Networks program, a $5 million investigation into multi-stakeholder networks.

Alex Tapscott is a globally recognized thought-leader, investor and writer focused on the impact of emerging technologies on business, society and government. He is the Founder and CEO of NextBlock Global, an investment company actively managing a diversified portfolio of digital assets. Alex is a founding member of the World Economic Forum's Global Future Council on Blockchain, and a special advisor to Elections Canada.
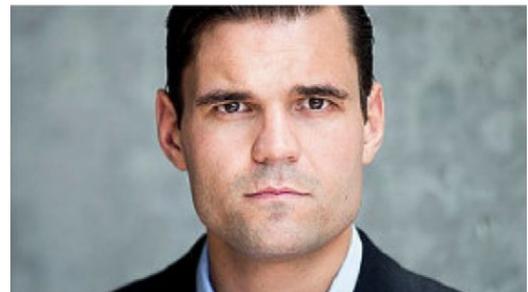
Together they began investigating blockchain in 2013. They are authors of the 2016 bestselling book, *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business and the World*. In 2016 they convened the first meeting of The Muskoka Group, a collaboration to promote blockchain stewardship. In 2017 they launched the Blockchain Research Institute—a knowledge network conducting 40 projects about the strategic implications, opportunities and challenges of this technology.

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Appendix: Global Solutions Networks

Knowledge Networks

Bitcoin Wiki

Accessible globally and updated through decentralized academic peer review, its entries span blockchain protocol specifications, cryptocurrency, data mining, and links to blockchain company directories.

Bitcoin and Blockchain Leadership Forum (Bank of England)

Founded by the Digital and Social Media Leadership Forum, this group operates under the very popular membership-model, in which participants collaborate on blockchain research projects and showcase proofs-of-concept for advanced applications of decentralized ledger technologies (DLTs).

Blockchain Association of New Zealand (BANZ)

Membership of BANZ, a non-profit blockchain research association in New Zealand, includes law firms, developers, academics, and companies that pool resources to build blockchain applications for specific industries such as agriculture and supply chain management.

Blockchain Canada

Founded by Ethan Wilding and Alan Wunsche to aggregate information about blockchain technology, this Toronto-based non-profit organization maintains a blockchain repository that helps policy-makers pass legislation that will enable cryptocurrency adoption.

Blockchain Collaborative Consortium (BCCC)

Founded by Yoichiro "Pina" Hirano, this Japanese organization facilitates information exchanges about DLT among stakeholders in the financial industry, ultimately to create blockchain-neutral solutions for industries and to integrate Japan's knowledge with the rest of the world.

Blockchain Education Network (BEN)

BEN began as a Facebook messenger group of student leaders from MIT, Stanford, Delaware, Michigan, and Penn State and has expanded into a 1,000-member community with initiatives to boost morale, encourage participation, and share blockchain know-how.

Blockchain Research Institute (BRI)

This non-profit organization identifies subject matter experts to research and develop reports and case studies on blockchain topics of critical interest to leaders of business, government, and NGOs.

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DC Blockchain Center

This resource for technology providers and governments educates entrepreneurs and policy makers on the potential benefits of blockchain and provides a platform for the public and private sectors to collaborate on blockchain use-cases.

Dubai Future Foundation

Run by the Global Blockchain Council, a public-private initiative, this group is exploring blockchain-based solutions to replace outdated bureaucratic and business frameworks. Pilot projects include health records, diamond trading, title transfers, business registration, wills, and shipping.

Financial Blockchain Shenzhen Consortium

This consortium provides access to relevant blockchain information and collective project-testing in the financial sector. Its efforts have resulted in a prototype blockchain platform for securities trading and related new services in credit, digital asset registry, and invoice management.

Github

This open source, online software development tool serves as a repository for code and a platform for code development, peer review, and problem solving. Unlike client-server systems, every Git directory resides on every computer as a full record and complete history of every change to the code.

Global Solution Networks (GSN)

Founded by Don Tapscott, GSN seeks to (a) identify, analyze, and summarize the potential components of a global governance network, (b) place the requisite tools in the hands of global problem solvers, and (c) facilitate connections among multi-stakeholder networks. https://gsnetworks.org

Cryptocurrency Collaborative Research Chair (IOHK and Tokyo Institute of Technology)

Under an agreement signed by IOHK CEO and Co-founder Charles Hoskinson, and Yoshinao Mishima,President of Tokyo Institute of Technology, this research chair, unlike traditional academic-corporate research partnerships, has open source and patent-free R&D so that industry participants can share research findings.

MIT Media Lab Digital Currency Initiative (DCI)

This global hub supports deep research in such areas as healthcare and medical records, global rights management, decentralized publishing, user-controlled credit identities, central bank and digital currency adoption, and securitized financing for solar microgrids.

The Muskoka Group

Founded by blockchain practitioners, advocates, theorists, and policy experts in 2016, this group supports the global solutions network framework and multi-stakeholder approach to stewardship of blockchain technologies as a global resource used for achieving prosperity worldwide.

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P2P Foundation (P2P wiki)

Known for hosting Satoshi Nakamoto's first paper on the Bitcoin protocol, the P2P Foundation hosts wiki-sites on various use cases for decentralized, commons-based societies, where peers review insights via such wiki portals as P2PF Blog, P2PF Wiki, and P2PF Lab.

Post Trade Distributed Ledger (PTDL) Settlement Group

Launched by 40 financial institutions and prominent market infrastructure stakeholders, this group identifies best practices for leveraging DLT and strategies in order to overcome barriers to widespread adoption.

Reddit

This online platform describes itself as "the front page of the Internet where conversations begin," with communities forming around cryptocurrencies (DogeCoin, LiteCoin), blockchain platforms (Bitcoin, Ethereum), and ecosystem issues (block size, consensus mechanisms).

Trust in Digital Life (TDL) Blockchain Working Group

A membership association founded by the Intel Corporation, TDL consists of industry leaders and academic institutions that exchange research on customer, market, and technology insights into improving DLT, in order to expedite a trusted single European digital market.

UCL Centre for Blockchain Technologies

Launched by the University College London, the center generates multi-disciplinary, multi-stakeholder research across such topics as cryptography, law, smart contracts, automation, and sociological impact of decentralized decision-making systems.

Operational and Delivery Networks

Blockchain Alliance

Co-founded by Coin Center and the Chamber of Digital Commerce, this group seeks to protect public safety on the blockchain, to detect and combat blockchain-related criminal activity, and to promote a long-term vision for regulatory efforts that do not stifle DLT innovation.

Decentralized Arbitration and Mediation Network

Launched by Third Key Solutions LLC, the network is developing decentralized dispute-resolution frameworks and an opt-in decentralized justice system designed and used by the blockchain community for commercial transactions.

Ethereum

The Ethereum virtual machine is a decentralized platform for uploading and running programs, conducting transactions, executing smart contracts, and automating traditional processes like settlement, accounting, and supply-chain tracking.

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Enterprise Ethereum Alliance

This consortium of Fortune 500 companies, cryptographers, academics, and veteran Ethereum developers delivers protocols and standards for decentralized applications, interoperable across industries on the Ethereum blockchain.

Hyperledger Project

Launched by the Linux Foundation, this project is creating open source protocols and standards for blockchain interoperability across industries; platforms that developers can use to build applications for global business transactions.

Industrial Internet Consortium

Co-founded by AT&T, Cisco, GE, IBM, and Intel, this non-profit group seeks to identify requirements for open interoperability standards and common architectures across industries to connect physical and digital assets and capabilities on the Industrial Internet of Things.

R3CEV LLC (R3)

This consortium of banks and financial services firms is designing an open source distributed ledger to record, manage, and synchronize financial agreements securely, transparently, and efficiently among financial institutions only.

Trusted IoT Alliance

Cisco Systems Inc., Bosch Ltd., Foxconn Technology Group, Gemalto, and several other companies have set up a consortium to develop a shared blockchain protocol for IoT and to secure and improve IoT applications.[203]

Policy Networks

Australian Digital Currency Commerce Association

ADCCA promotes industry best practices and consistent regulatory frameworks to shape the policy-making process and advocate for appropriate blockchain regulatory framework for FinTech businesses in Australia.

Coin Center

The center makes sure policy makers understand the advantages of cryptocurrencies before issuing regulation. With the Uniform Law Commission (US), it drafted the "Model Regulation of Virtual Currency Business Act." It has created a state digital currency regulation tracker.

Digital Assets Tax Policy Coalition

Formed by the Chamber of Digital Commerce and Steptoe and Johnson LLP, this Washington, DC-based coalition develops effective US tax policies for the growing virtual currency markets, policies that work for both industry and government.

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Global Blockchain Forum

This initiative of the Chamber of Digital Commerce promotes industry best practices and consistent regulatory frameworks across jurisdictions to shape blockchain regulation and coordinate advocacy around the world.

Smart Contract Alliance (Chamber Working Group)

This initiative of the Chamber of Digital Commerce promotes acceptance and use of smart contract technologies by (a) developing policy related to smart contracts, (b) identifying best practices and advancing interoperability, and (c) engaging public policymakers and regulators.

Advocacy Networks

Bitcoin Foundation

Formed to standardize, protect, and promote development of the Bitcoin core protocol, this non-profit, member-driven organization offers a range of resources: best practice guides, educational resources, meeting minutes, a speaker's bureau, workshops, and conferences.

Blockchain Association of Canada

BAC supports employment growth and career opportunities in blockchain technologies. Its members speak at issue-based conferences in Canada and participate in discussions with the Canadian government on critical policy issues.

Blockchain Trust Accelerator (New America and Bretton Woods II)

Co-founded by New America, the Bitfury Group, and the National Democratic Institute, this initiative created a new business model for strategic capital ownership. Its model addresses the root causes of volatility.

Chamber of Digital Commerce

CDC advocates for appropriate rather than oppressive regulation of cryptocurrencies and blockchain technologies. It represents diverse views in the blockchain space, acts as a reliable source of information for lawmakers, and offers a suite of services in government affairs.

Global Blockchain Business Council

Found by BitFury, GBBC brings together the world's leading businesses and business leaders to highlight the latest innovations and advances in blockchain technology, advocate for its global adoption, and provide a forum for education, collaboration, and dialogue.

State Working Group

This initiative of the Chamber of Digital Commerce advocates for digital currencies and decentralized ledger technologies to US state and local governments and suggests appropriate state and local legal and regulatory requirements.

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Wall Street Blockchain Alliance

This non-profit trade association speaks with such blockchain stakeholders as market participants, policymakers, and technology innovators and produces reports of its findings. It also hosts Wall Street Education Day to educate the public and advance mainstream adoption.

Standards Networks

Coalition for Automated Legal Applications

COALA assembles domain experts, global institutions, and leading academic research institutions to develop blockchain standards and applications enabling innovative legal and policy frameworks.

Cryptocurrency Certification Consortium (C4)

Co-founded by Andreas Antonopoulos and Vitalik Buterin, this non-profit organization certifies professionals who intend to offer cryptocurrency-related services. Those who have demonstrated proficiency receive Certified Bitcoin Professional designations.

CryptoCurrency Security Standard (CCSS)

Funded by C4, CCSS is an open standard that helps secure information systems that use cryptocurrencies. It has evolved into 32 controls for anyone building a new system on the blockchain. The standards cover the entire lifecycle of the crypto private key usage in blockchain applications.

Digital Assets Accounting Consortium

This working group of the Chamber of Digital Commerce advocates for updated Generally Accepted Accounting Principles, practices, and reporting standards for digital assets in collaboration with the Association of Independent Public Accountants and Financial Accounting Standards Board.

Institute for Innovation and Data Driven Design (ID3, iDcubed)

Affiliated with the MIT Media Lab, this non-profit organization develops and field-tests legal and software trust frameworks for data-driven services, infrastructures, and enterprises.

International Securities Association for Institutional Trade Communications (ISITC Europe Blockchain Working Group)

ISAITC represents financial institutions and technology providers striving to improve the financial industry in Europe. Its blockchain working group is creating a list of benchmarks to help standardize blockchain tools.

International Standards Organization (ISO)

This independent international NGO brings together experts from 164 national standards bodies to develop market-relevant international standards and support innovation.

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ISO/TC 307 (ISO Initiative) (Blockchain Standards Committee)

ISO established three new technical committees (TCs) for developing international standards for decentralized ledger technologies: one for blockchain and electronic distributed ledger technologies, one for chain of custody, and one for organizational governance.

World-Wide-Web Consortium (Blockchain Community Group)

WC3 hosts several decentralized community groups to develop standards, guidelines, software applications, and protocols. Its blockchain community group is working on, for example, message format standards and guidelines for blockchain storage.

Networked Institutions

World Economic Forum (WEF)

WEF is an independent international organization committed to improving the state of the world by engaging all four pillars of society—business, political, academic, and civic leaders—to shape global, regional and industry agendas.

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Acknowledgments

Notice

The opinions expressed it this report are those of the authors. Comments, suggested changes and additions to this report are welcome at info@tapscott.com.

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BLOCKCHAIN RESEARCH INSTITUTE

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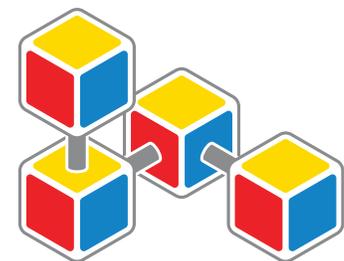
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