Global Standards Mapping Initiative:
An overview of blockchain technical standards

WORLD
ECONOMIC
FORUM

Contents

Preface

As blockchain technology continues its evolution, calls for clarity surrounding technical, regulatory and governance models have grown louder. Decisions on these foundational elements will shape the trajectory and potential of the technology.

However, there has been little work to catalogue and evaluate the current bedrock upon which the ecosystem can build, despite the increased activity in each of these arenas. As actors across the world construct innovative solutions to address society's toughest challenges, a baseline is needed to facilitate impactful and responsible innovation.

Cataloguing the status of dozens of standard-setting entities and consortia plus regulations across 129 countries, the Global Standards Mapping Initiative (GSMI) represents an unprecedented effort to map and analyse the current landscape. It is divided into two distinct components:

1. Technical standards

2. Legislation and guidance released by sovereign and international bodies and industry body best practices and standards (including an overview of industry groups and consortia)

The work was a joint effort between the World Economic Forum and the Global Blockchain Business Council, with significant contributions from the MIT Media Lab, ING, Accenture, SDX and the Milken Institute. This cross-organizational effort was a truly global collaboration, as well as an alignment of previously disparate initiatives. We hope this will serve as a model for future ecosystem-wide efforts of a similar nature.

These reports are intended to serve as a comprehensive resource for the blockchain community and beyond to assess the current landscape and evaluate where there may be gaps, overlaps, inconsistencies and conflicts.

(1) Initial analysis

1.1 | Introduction

Over the past few years, blockchain has gone through significant periods of hype and scepticism. Out of this, a few promising use cases and applications have emerged, and the ecosystem is moving forward with designing and building for scale.

However, several questions critical to the success – or failure – of blockchain remain. As catalogued elsewhere, regulatory clarity remains a significant hurdle for many organizations. In addition, technical and governance aspects such as interoperability, security and models for ecosystem collaboration will have significant impacts on the technology.[1,2]

With the exploration of applications such as digital currencies and supply chain management – which would fundamentally alter our ways of interacting and doing business – there is an increasing need for common ground. We are seeing the emergence of initiatives that aim to bring greater definition to the new business models, platforms and infrastructure that blockchain demands and enables.

There are certainly places where standardization is needed now – and others where it is too soon.

Philosophical debates about the technology remain. And it is important that movements towards standardization do not come at the expense of a careful evaluation of trade-offs related to technical architecture and governance.

Decentralized technologies also introduce new possibilities for standard-setting across the ecosystem. As outlined in the paper, new ways of working are challenging existing models that may offer unique features or flexibility. The full scope of pros and cons remain to be seen, so it is important to continue to track the areas where new efficiencies and risks may come into play.

Finally, standards have the potential to help level the playing field in the development of blockchain – but only if they are designed and implemented thoughtfully. Without proactive attention to how standards are created and who is creating them, it is possible that they will be shaped according to specific interests and orientations – and potentially in the image of hegemonic powers or legacy systems.

1.2 | Motivation and scope

There has been a proliferation of activity around technical standardization. This paper attempts to provide an overview of the landscape to: 1) map the technical standardization efforts under way; 2) identify gaps and areas of overlap; 3) identify critical next steps for the ecosystem.

Notably, the aim of this paper is not to pass value judgements on the standardization efforts that are under way, and inclusion in this report is not an endorsement of any activities. Rather, it is an attempt to raise awareness of activities being undertaken and present trends as of the authoring of this report (August 2020). As we have seen in the past, adoption of standards is ultimately determined

by a variety of factors. We expect the mapping to be used by blockchain service providers, policy-makers and standard-setting organizations to inform their approach to standard-setting activities and to the implementation of technical standards.

The paper maps standards that focus broadly on distributed ledger technology (DLT) in order to take a comprehensive view of the evolution of standards. The terms "blockchain" and "distributed ledger technology" are used interchangeably throughout the report for simplicity and succinctness, though the authors recognize the practical distinctions – particularly as they relate to technical standards.

For the purposes of this paper, "blockchain standards" are defined as conventions that guide the development and use of DLT. They are established by industry and traditional standardization bodies. The paper takes a broad outlook on "standard-setting bodies" or "standard-setting entities" in order to map the wide ecosystem contributing to technical standards. This can include traditional standard-developing organizations (SDOs) as well as industry groups and developer communities.
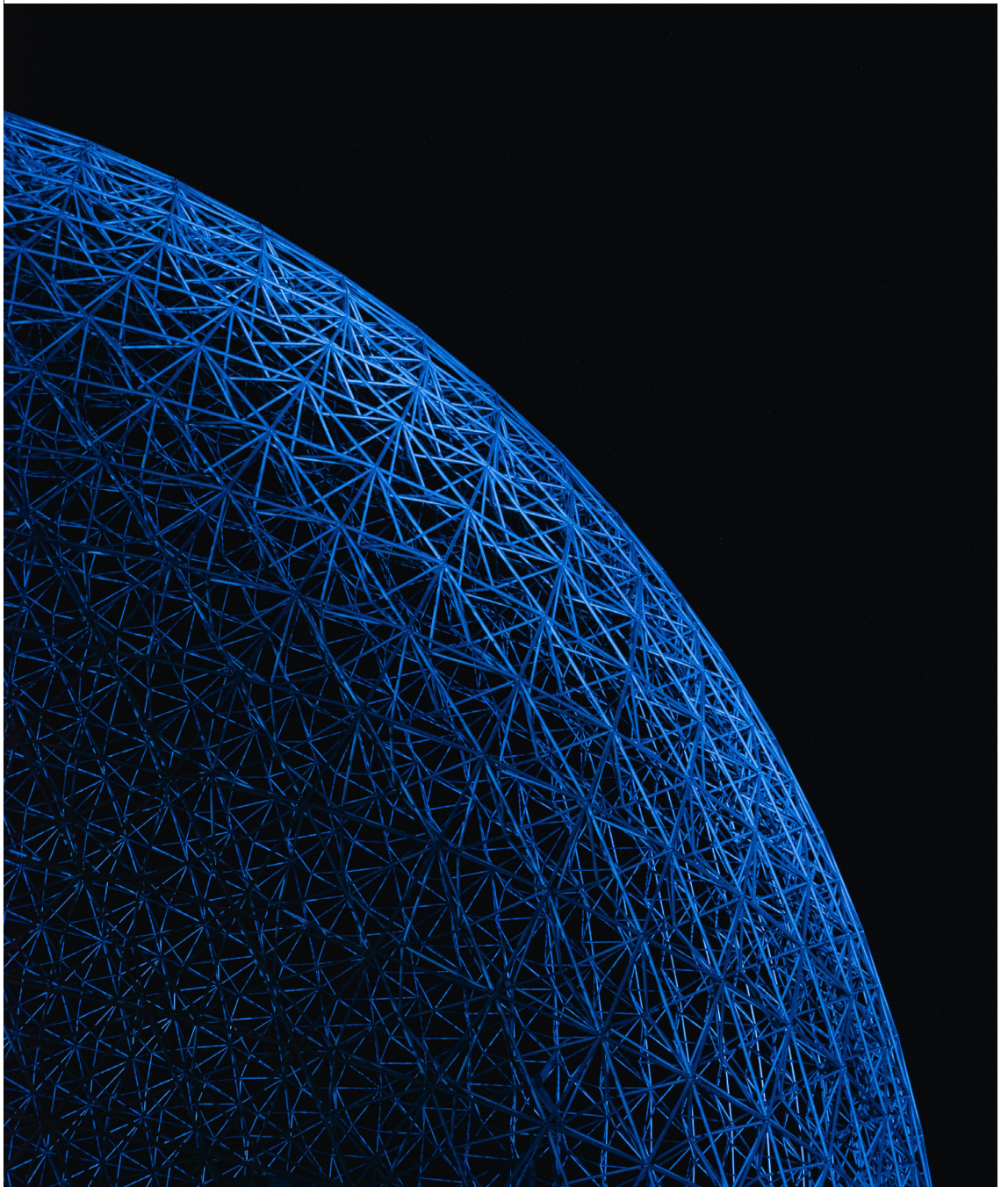
1.3 | Methodology

The mapping is based upon:

1. An in-depth literature review exploring existing efforts being made towards standardization of DLT

2. Technical interviews to validate the observations from desk research and better understand the implications for DLT standards development

② Context

2.1 | The evolving role of standards

The role of standardization in the First, Second and Third Industrial Revolutions is well documented – particularly in their role of establishing an "information infrastructure" upon which new products and marketplaces could be built.[3]

While standards will have a part to play in the Fourth Industrial Revolution – in which emerging technologies are swiftly changing lives and transforming businesses and societies – standard-setting bodies have new challenges ahead. There are unique considerations presented by areas of technological convergence, especially as they relate to highly standardized verticals such as healthcare. Moreover, Fourth Industrial Revolution technologies enable new realities and operating models. For instance, standards related to blockchain must grapple with decentralized governance.[4]

BOX 1 | **Standards in action: emails**

Today, we can send emails to anyone with a valid address – regardless of whether they use the same email client, domain or type of computer. The lay user takes for granted the consistencies across our email sending and receiving experiences: To and From fields, sending to an address with an "@" sign, and a distinction between read and unread emails.

This unified experience is the result of a robust set of standards that specify how an email is processed, transmitted, retrieved and more.

For instance, you can send an email from an Outlook account to a Gmail account with different domain names without any extra friction or steps. Users may recognize acronyms such as "SMTP", "DNS", "POP" and "IMAP".

While this is an overly simplified example, it illustrates how technical standards and protocol facilitate seamless communication and the creation of a market in technical services.[5,6]

It may be helpful to think about the types of standards in terms of their intended function. Appendix A outlines how standards may contribute to objectives of variety reduction, specification of quality and reliability, provision of performance-related information and assurance of interoperability.[7]

2.2 | The evolving development of standards

Standards are generally created and adopted in one of three ways (adapted from the *Handbook of Innovation and Standards*):[8]

– By convention (*de facto* standard) – a practice, behaviour or configuration becomes broadly accepted through repetition and use, for example, designations of right and left

– By fiat (*de jure* standard) – imposed by an edict or regulation by a government or other institution. Examples include Standards Australia's activities and the US Securities and Exchange Commission's *de jure* standards on token management[9]

– By negotiation – as agreed formally among stakeholders in an activity or enterprise, such as those created by formal standard-developing organizations (SDOs) as discussed later in the paper

2.3 | A closer look: blockchain standards

In some ways, blockchain upends traditional models of standard-setting, given the decentralized governance and ability to embed standards within the build of the protocol. Other areas have mimicked structures used to create coherence in distributed systems such as the internet.

Standard-setting

Familiar standard-setting entities, such as the Internet Engineering Task Force (IETF), Institute of Electrical and Electronics Engineers (IEEE) and International Organization for Standardization (ISO), continue to develop voluntary information technology standards.[10] Some, such as ISO and IEEE, among others, have formed dedicated working groups on blockchain and distributed ledger technologies, but their focus areas and outputs are early-stage.[11,12]

Adopting a similar model, some industry-specific standards bodies, such as GS1 (the group that manages the barcode namespace and other supply-chain standards) or the Healthcare Information and Management Systems Society (HIMSS), also have blockchain working groups.[13,14] In the blockchain and related applications arena, a few industry groups, such as the Ethereum Enterprise Alliance (EEA), Interwork Alliance (IWA) and Distributed Identity Foundation (DIF), focus on blockchain standards.[15,16, 17]

Protocol-specific standards processes have also been implemented in a decentralized manner through "improvement proposals". These are managed by the developer community and often facilitated through the open-source platform GitHub. Some examples include Bitcoin Improvement Proposals (BIPs), Ethereum Improvement Proposals (EIPs) and zCash Improvement Proposals (ZIPs).[18,19,20]

| BOX 2 | Case Study: ICOs, CryptoKitties and more – ERC token standards |

Many of the widely recognized applications of blockchain are enabled by ERC token standards, which define the motivation, specification and implementation for Ethereum-based tokens.[21]

Examples of ERC Tokens

Named according to their Ethereum Request for Comment (ERC) identifier, notable examples include (taken from the token standard):[22]

Standard	Abstract	Known for
ERC-20	The following standard allows for the implementation of a standard API for tokens within smart contracts. This standard provides basic functionality to transfer tokens, as well as allowing tokens to be approved so they can be spent by another on-chain third party.	Enabling smart contracts and decentralized finance (DeFi) *e.g. Chainlink, Maker, Augur* Initial Coin Offerings (ICOs) *e.g. EOS, Telegram, Tezos* Stablecoins *e.g. Tether, USDC, Paxos*
ERC-721	The following standard allows for the implementation of a standard application programming interface (API) for non-fungible tokens (NFT) within smart contracts. This standard provides basic functionality to track and transfer NFTs.	Blockchain collectibles and games *e.g. CryptoKitties, Gods Unchained*

Token standards are managed via the Ethereum Improvement Proposals (EIP) process, which is run on GitHub.

Software development

Software development consortia bring together many stakeholders to share and jointly develop underlying software for these networks: think of the Free Software Foundation, Apache Software Foundation and even the Linux Foundation.[23] Usually these consortia do not fund development work or write the software code directly. Rather, they serve an "air traffic control" function in managing software development processes.

Software is usually the adhesive between multiple standards and the end users. Depending on the structure of the process, software development may not need the same consensus orientation as standard-setting initiatives. Additionally, software is continuously updated – for instance, to add new features and fix bugs – while standards have more constraints on releasing updates.

Finally, the approach to intellectual property (IP) management differs. With software, IP is attached to technical contributions (e.g. a GitHub pull request), not each individual component of a broader discussion (e.g. a Slack comment). Therefore, the governance and operational models can be very different between these organizations and standards bodies.[24]

Network governance

Standards are optional by nature – they are either used or not. Historically, there was a need for bodies to adjudicate disputes on a living, breathing network composed of many different participants and agendas.

Organizations such as the Internet Corporation for Assigned Names and Numbers (ICANN), or even informal groups such as North American Network Operators' Group (NANOG) stepped up to fill this need. More involved with formal policy, these organizations need to balance uptime and usability with inclusiveness and value.[25]

At the same time, blockchain network governance introduces a new set of demands and possibilities. At the protocol level, much of the adjudication happens directly within the developer community. However, this does not always bring a diversity of participants and agendas. Moreover, there is currently no inter-protocol governance structure that facilitates the coordination that might be necessary for interoperability and scalability.

2.4 | Beyond standards: industry norms

As with the evolution of any technology, there is a role for both formal standards and more informally established industry norms. For instance, Global Digital Finance's Code of Conduct, Messari's Disclosure Registry and the World Economic Forum's Presidio Principles all represent grassroots efforts to define expectations and values.[26,27,28] While these initiatives are not catalogued technical standards, they aim to influence critical decisions regarding technology and governance.

(3) Key findings

Clearly, there are several approaches to creating standards for blockchain technology. This paper represents an effort to map current activity (as of August 2020) and identify trends within the ecosystem. This section synthesizes key insights from mapping dozens of standard-setting initiatives and their activities by identifying challenges, overlaps and gaps in the landscape.

– Clarity remains a challenge as terminology remains inconsistent, while the scope of blockchain standards remains unclear.

– There are both gaps and overlaps in the standard-setting landscape.

– Representation is inconsistent across attributes such as geography, expertise and role. Plus, intellectual property rights can affect the level of openness in the creation process.

3.1 | Terminology remains inconsistent

Clear and consistent definitions for key aspects of blockchain remain a challenge (notably, this is a challenge identified in standards-related literature dating back to 2017).[29] Between and at times within standard-setting bodies, core definitions can vary. Take two examples of the term "blockchain" itself:

TABLE 1 | Comparison of "blockchain" definitions

	ISO	ITU-T
Definition	Distributed ledger (3.22) with confirmed blocks (3.9) organized in an append-only, sequential chain using cryptographic links (3.16) Note 1 to entry: Blockchains are designed to be tamper resistant and to create final, definitive and immutable (3.40) ledger records (3.44)	A type of distributed ledger which is composed of digitally recorded data arranged as a successively growing chain of blocks with each block cryptographically linked and hardened against tampering and revision

While the definitions are similar – highlighting that blockchains are a type of distributed ledger with cryptographically linked blocks – astute observers will note some differences. For instance, the ISO definition notes "blockchains are designed to be tamper resistant and to create final, definitive and immutable ledger records" in place of ITU-T's "hardened against tampering and revision". The ITU-T definition describes the chain as "successively growing", while the ISO definition opts for "an append-only, sequential chain".

These divergences are also reflected in the reference architecture. For instance, IEEE organizes its draft reference architecture into five "DLT architecture domains" (or viewpoints): 1) platform; 2) data; 3) process; 4) services; and 5) applications.[32] Meanwhile, the ITU-T has identified five "functional components": 1) core layer; 2) service layer; 3) application service platform; 4) DLT applications; and 5) external services.[33] Graphics of the reference architectures are available in Appendix B for comparison.

Though these differences may appear subtle, they could have ripple effects throughout the standards development and implementation process. Each standard-setting entity necessarily builds on top of past work, leaving room for interpretation from subsequent users of taxonomy, compounding these differences.

3.2 | Volume of activity has reflected hype around the technology

The number of standard-setting efforts has corresponded with the hype around the technology. Several efforts that were started at the peak of the buzz around blockchain have since dropped off or have yet to publish any substantive output.

3.3 | Scope of blockchain standards remains unclear

The approach to dividing layers of the technical stack (e.g. standards oriented towards the network versus the application layer) varies between organizations. As such, nuances and dependencies on other standards may get lost in the mix. Consider the example of digital identity management. Because digital identity is foundational, it will inevitably touch every layer of the tech stack. Questions may include: How are identities verified? What level of privacy should be ensured? What data formats are needed to ensure interoperability and data portability? Effective standardization within this space will require alignment throughout the stack and a clear articulation of the layers to which specific standards will apply.

A related question is how blockchain standards interact with industry verticals. Digital currency standards, for instance, must consider payments and financial system standards related to compliance, personal identification, data representation and communication etc., in addition to standards on the technical layer. While some standard-setting bodies have formalized connections to related workstreams, others may be operating in isolation. This is also interesting when considering the convergence with other Fourth Industrial Revolution technologies such as the internet of things (IoT), where standard-setting activity is also nascent.

Finally, blockchain overlaps with other highly technical and standardized fields, such as cryptography. Zero-knowledge proof (ZKP) cryptography is one example, as it has an active community-driven standardization process.[34] While these are not technically "blockchain standards", they have significant implications for blockchain standards and the trajectory of the technology.

3.4 | There is overlap in the standard-setting landscape

Because there are several standard-setting bodies with work under way, there are some areas with a high concentration of activity – and some that have not yet been explored by standard-setting organizations.

Analysis of mapped standards found that the top five areas of overlap are:

1. **Security:** Naturally, security has been a key area of focus for technical standards. Given that not all blockchains are created in the same way, understanding how to ensure security management consistency across different blockchain types is essential to ensuring sustainable use of the platform. However, it remains to be seen how various factors such as consensus protocols and permissioning will affect these standards.

2. **Internet of things (IoT):** An evaluation of the convergence of emerging technologies is crucial to forward-thinking standardization. Technical standards include understanding the requirements for IoT use cases and blockchain and analysing the requirements of interoperability between IoT and blockchain.

3. **Identity:** Considered a fundamental element and application of blockchain, digital identity fundamentals such as circulation protocols, key generation and management, and protocol specifications for mutual identity origins of public keys/addresses generated between

different cryptography have been a core focus of standardization bodies.

4. **DLT requirements:** There is work under way to define software and hardware requirements for operating blockchains. However, much of this activity is protocol-specific and may not necessarily coincide with other aspects, such as governance requirements.

5. **DLT taxonomy/terminology:** Since terminology is the basis for all further standard-setting activities, most entities have started here. But, as described earlier, there are differences in definitions and reference architectures.

While this coalescence may be indicative of high-priority areas for standardization, it also introduces the potential for overlap or conflict in the standard-setting in these arenas. For example, ISO, IEEE, ITU-T and Standards Australia have more than a dozen initiatives related to blockchain security – on top of the improvement proposals related to security at the protocol level. As aforementioned, taxonomies and terminology have already demonstrated this. Since the networking among these initiatives is largely informal, there is potential for outputs that are not fully aligned.

Many of the standards mentioned in this paper have not yet been finalized, so it is difficult to assess the exact level of overlap in content areas. However, these areas should be carefully monitored and coordinated.

3.5 | There are gaps and divergence in the standard setting landscape

Still, there are gaps in the landscape that currently exist due to a combination of technological immaturity, the complexity of the subject matter and differences in fundamental philosophies about the technology.

Identified gaps in standard-setting generally fell into four categories:

1. **When to apply DLT:** The majority of attempts to catalogue the criteria for evaluating the fitness for purpose of blockchain have been informal. Institutions may benefit from guidance on performance expectations and a framework for the evaluation of functional risks.

2. **Core technical elements:** The fundamentals of blockchain technology, such as consensus algorithms and interoperability, have largely

developed through industry players and technical evolution, rather than through formalization and standardization.
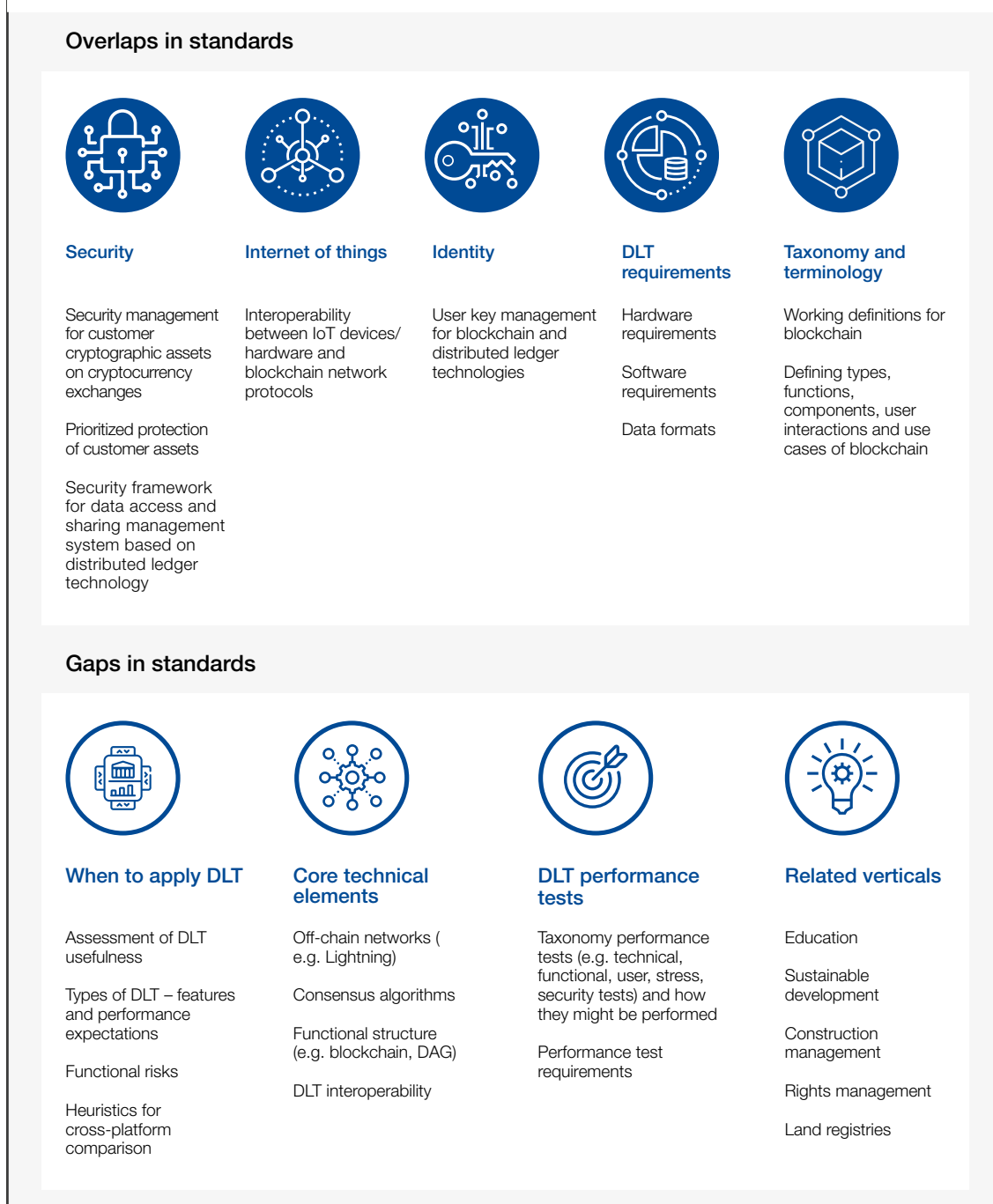
3. **DLT performance tests:** There are currently no standards for what types of tests can and should be performed on DLT platforms. Standards could outline parameters for the types of test (e.g. technical, functional, user, stress or security) and procedural recommendations.

4. **Related verticals:** As previously outlined, standard-setting organizations have already begun exploring connections to industry verticals. However, several verticals remain uncharted territory.

In addition, there are some divergences in terms of what "formal" standard-setting entities, as opposed to industry groups, have chosen to focus on. Token standards and specific use cases such as mobility and supply chains, for example, are more present on the industry side.

The figure below outlines thematic gaps and overlaps as well as sample standards that fit under each category.

FIGURE 1 | Gaps and overlaps in blockchain standards

Overlaps in standards

Security

Security management for customer cryptographic assets on cryptocurrency exchanges

Prioritized protection of customer assets

Security framework for data access and sharing management system based on distributed ledger technology

Internet of things

Interoperability between IoT devices/ hardware and blockchain network protocols

Identity

User key management for blockchain and distributed ledger technologies

DLT requirements

Hardware requirements

Software requirements

Data formats

Taxonomy and terminology

Working definitions for blockchain

Defining types, functions, components, user interactions and use cases of blockchain

Gaps in standards

When to apply DLT

Assessment of DLT usefulness

Types of DLT – features and performance expectations

Functional risks

Heuristics for cross-platform comparison

Core technical elements

Off-chain networks (e.g. Lightning)

Consensus algorithms

Functional structure (e.g. blockchain, DAG)

DLT interoperability

DLT performance tests

Taxonomy performance tests (e.g. technical, functional, user, stress, security tests) and how they might be performed

Performance test requirements

Related verticals

Education

Sustainable development

Construction management

Rights management

Land registries

3.6 | The best methods for standards dissemination/ implementation are up for debate

Some argue that the paywall associated with some standards goes against the ethos of blockchain technology. However, open-source projects face their own set of considerations and constraints.

Decentralization and the current state of blockchain have also meant that there is no dedicated entity responsible for disseminating standards and monitoring their implementation, such as ICANN for

the internet. So, standards implementation is largely left to the organizational and ecosystem level. Since many engage with blockchain via consortia, it is possible that these governance structures inform the organizational standards strategy.

Additionally, the nascency of the technology and the multitude of standard-interested bodies mean that it is unclear whether the forces driving adoption will be a market pull, a market push or a combination of both. With traditional standards, implementation is largely optional and up to the discretion of the core development team. For standards implemented via improvement proposals, there is the option to fork the chain in the event of fundamental disagreements (though the feedback process is intended to account for this proactively).

Moreover, there are technical projects, such as Polkadot and Interledger, which focus on solutions designed to facilitate cross-protocol interactions. So, it could be that technical solutions change the role of technical standards in facilitating interoperability.[35]

BOX 3

Case study: Standards to facilitate implementation of FATF's travel rule

In June 2019, the Financial Action Task Force (FATF) updated its anti-money laundering and counter-terrorism (AML/CFT) recommendations to clarify requirements for virtual asset service providers (VASPs). This included the "travel rule" recommendation, under which service providers would be responsible for sharing identifying information on senders and receivers for transactions between exchanges that exceed $3,000 in value.

The requirement raised questions for VASPs including, but not limited to, standards for inter-VASP messaging as well as for identification of consumers and the VASPs themselves. Quickly realizing the need for cooperation, several industry actors mobilized to fill these gaps and answer key questions.

Industry players underscored the importance of clarity in these matters in order to be able to effectively and meaningfully communicate between VASPs – and to automate the exchange of such messages. Furthermore, standards would facilitate a market for those interested in producing technical solutions to facilitate inter-VASP messaging.[36]

The Joint Working Group on InterVASP Messaging Standards (JWG-IVMS), led by the industry associations Chamber of Digital Commerce, Global Digital Finance and the International Digital Asset Exchange Association, was formed in December 2019 and involved more than 130 technical experts to develop the interVASP Messaging Standard IVMS101. The standard was released in May 2020, with guidance on a common lexicon, data principles, datatypes and defining a data model, among other components.

Sample questions answered by the standard

Examples of questions answered by the standard that could otherwise cause complications in inter-VASP communication:

Topic	Sample question	Standard	Answer
Data requirements	What data should be included to identify someone?	"5.2.2.1 NaturalPerson structure"	Name, address, national identification, consumer identification, date and place of birth, country of residence
Country identification	Should the United States of America be identified as US or USA?	"The value used for the field country must be present on the ISO-3166-1 alpha-2 codes or the value XX"	US
Dates	Does the date 2020-3-5 represent 5 March or 3 May?	"Definition: A point in time, represented as a day within the calendar year. Compliant with ISO 860 … Format: YYYY-MM-DD"	5 March 2020

To date, technical solution providers including CoolBitX's Sygna, CipherTrace's TRISA, Notabene and Securrency have committed to using the IVMS101 standard.[37]

3.7 | Geographic representation within standard-setting initiatives varies

Much of the standard-setting activity today is headquartered in Europe, North America and China. While some bodies have made a deliberate attempt to include global voices in their initiatives via local groups or regional representatives, many do not have the explicit mandate of geographic representation. For instance, of the 11 working groups of the ISO, only one (the ad hoc group on guidance for auditing DLT) has a convener who is not from Europe, North America or Australia.[38] Another example is that the principal authors and researchers of the ITU-T distributed ledger technology reference architecture all hailed from China.[39]

Without this representation – or at a minimum, an opportunity for submitting feedback – it is possible that standards are incongruous with regards to infrastructure, regulatory and/or operational realities within certain geographies. Moreover, core thematic elements of standard-setting work such as privacy contain heavily cultural interpretations and contexts.

3.8 | Expertise and consumer representation vary

Given that blockchain touches upon software, cryptography and economics, a diverse expertise is needed in the standards development process. However, several efforts are oriented towards "technical" steering committees, which may preclude meaningful conversations about incentives and their impacts on end users.

In addition, there are varying levels of involvement among technology consumers. Some standard-setting initiatives have formalized partnerships with consumer-oriented groups. For example, ISO collaborates closely with Consumers International.[40] In the case of open-source, protocol-oriented standards, the contributors are often consumers of the product. At a minimum, the standards processes are made transparent and accessible via GitHub. However, transparency may not be the primary focus during the standard-setting process, which can lead to concerns about consumer protection or even exclusion and exploitation.

3.9 | Intellectual property considerations remain unclear

A well-run standards body creates a standard that is easy to implement, that anyone can implement; in addition, there should be no patent issues – or, if there are, they should be clearly specified.

However, it is important to note that there may be trade-offs between openness and IP ownership. For instance, open processes such as those used by Bitcoin and Ethereum – because participation is fully public without any assignment of intellectual property – risk creating standards that infringe on patents owned by participants. While this has not yet arisen as a substantive issue, it could be a risk in the future.

Conversely, other standards bodies run processes that are arguably more "closed" in the sense that participants in those conversations may need to agree to license any patent IP they hold that is covered by those standards. This means those discussions cannot happen in anonymous environments.

④ | Research summary

Clearly, there are many efforts under way, each with a unique set of procedural requirements and associated strengths and weaknesses.

In order to provide an overview of the current landscape, the following tables summarize some of the major standard-setting efforts under way among formal standard-setting organizations and industry groups and via improvement proposals. The tables are not exhaustive and the organizations are listed in no particular order. Additional information on many of the initiatives is available in Appendix C.

TABLE 2 | **Major standard-setting efforts – formal organizations**

Entity	Geography	Purpose	Topic
IEEE[1]	USA	The purpose of the Institute of Electrical and Electronics Engineers (IEEE) is promoting the development and application of electrotechnology and allied sciences for the benefit of humanity, the advancement of the profession and the well-being of its members	Internet of things (IoT); cryptocurrency exchange and payment; tokens; energy; digital assets
ISO[2]	Switzerland	The International Organization for Standardization (ISO) is an independent, non-governmental, international organization that develops standards to ensure the quality, safety and efficiency of products, services and systems	Security; identity
W3C[3]	USA	The Worldwide Web Consortium (W3C) is developing protocols and guidelines that ensure long-term growth for the web	Identity
IRTF[4]	USA	The Internet Research Task Force (IRTF) aims to promote research for the evolution of the internet	Identity; digital assets
IEC[5]	Switzerland	The International Electrotechnical Commission (IEC) promotes standardization of electrical technology, electronic and related matters	Internet of things (IoT)
IETF[6]	USA	The purpose of the Internet Engineering Task Force (IETF) is creating voluntary standards to maintain and improve the usability and interoperability of the internet	Cryptocurrency payment
ITU-T[7]	Switzerland	The International Telecommunication Union Telecommunications (ITU-T) sector ensures the efficient and timely production of standards covering all fields of telecommunications and information communication technology (ICTs) on a worldwide basis, and defines tariff and accounting principles for international telecommunication services	Security; IoT; identity; DLT requirements

[1] https://standards.ieee.org/

[2] https://www.iso.org/standards.html

[3] https://www.w3.org/standards/

[4] https://irtf.org/

[5] https://www.iec.ch/

[6] https://www.ietf.org/standards/

[7] https://www.itu.int/en/ITU-T/publications/Pages/default.aspx

BSI[8]	UK	The British Standards Institution (BSI) is the national standards body of the United Kingdom. It aims to share knowledge, innovation and methodologies to help people and organizations make excellence a habit	DLT requirements
CEN[9] CENELEC[10]	Belgium	The European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) provide a platform for the development of European standards and other technical documents in relation to various kinds of products, materials, services and processes	Security
Standards Australia[11]	Australia	Standards Australia coordinates standardization activities and facilitates the development of Australian standards	Security; DLT taxonomy
WIPO[12]	Switzerland	The World Intellectual Property Organization (WIPO): 1) promotes the protection of intellectual property throughout the world through cooperation among states and, where appropriate, in collaboration with any other international organization; and 2) ensures administrative cooperation among unions	Application of blockchain to intellectual property
ETSI[13]	France	The European Telecommunications Standards Institute (ETSI) provides the opportunities, resources and platforms to understand, shape, drive and collaborate on globally applicable standards	Permissioned distributed ledgers
SAC[14]	China	The Standardization Administration of China (SAC) exercises administrative responsibilities by undertaking unified management, supervision and overall coordination of standardization work in China	DLT requirements
BRIBA[15]	China	The Belt and Road Initiative (BRI) has established the Belt and Road Initiative Blockchain Alliance (BRIBA) to spur the development of the BRI by leveraging blockchain technologies	DLT requirements
CESI[16]	China	The China Electronic Standardization Institute (CESI) works with standardization, conformity assessment and measurement activities in the field of electronic information technologies. In the past couple of years, CESI has come out with a vision to introduce three blockchain standards on smart contracts, privacy and deposits in a bid to better guide the development of the blockchain industry in the country	Tokens; security
DCSA[17]	Netherlands	The Digital Container Shipping Association (DCSA) seeks to pave the way for interoperability in the container shipping industry through digitalization and standardization	Interoperability
International Chamber of Commerce (ICC)[18]	France	The ICC established a working group called the Digital Standards Initiative (DSI). The purpose of the DSI is to encourage and maintain standards-based interoperability (between blockchain and non-blockchain consortia and networks) in global trade	Interoperability

[8] https://www.bsigroup.com/en-GB/standards/

[9] https://www.cen.eu/Pages/default.aspx

[10] https://www.cenelec.eu/

[11] https://www.standards.org.au/

[12] www.wipo.int

[13] https://www.etsi.org/standards

[14] http://www.sac.gov.cn/sacen/

[15] https://www.beltandroadblockchain.org/

[16] http://www.cc.cesi.cn/english.aspx

[17] https://dcsa.org/

[18] https://iccwbo.org/

TABLE 3 | **Major standard-setting efforts – industry groups**

Entity	Geography	Purpose	Topic
EEA[19]	USA	The Enterprise Ethereum Alliance (EEA) builds, promotes and broadly supports Ethereum-based technology methodologies, standards and a reference architecture	Interoperability; tokens
Hyperledger[20]	USA	Hyperledger is an open-source community focused on developing a suite of stable frameworks, tools and libraries for enterprise-grade blockchain deployments It serves as a neutral home for various distributed ledger frameworks including Hyperledger Fabric, Sawtooth, Indy, as well as tools such as Hyperledger Caliper and libraries such as Hyperledger Ursa	Interoperability; tokens
IWA[21]	USA	The InterWork Alliance (IWA) is working to: develop standards-based interworking specifications; address market requirements and performance metrics; support advances across all platform technologies; and enable multi-party interchanges	Tokens; analytics
JWG[22]	USA and UK	The Joint Working Group on interVASP Messaging Standards (JWG) identified the need for VASPs to adopt uniform approaches and establish common standards to enable them to meet their obligations resulting from the FATF recommendations as they apply to affected entities To tackle this, a cross-industry, cross-sectoral joint working group of technical experts was formed in December 2019 and a new technical standard developed by the group	Tokens
National Blockchain and Distributed Accounting Technology Standardization Technical Committee[23]	China	This is a group of organizations that have joined a national committee focused on creating standards for blockchain technology	DLT requirements; DLT terminology
CDC[24]	USA	The Chamber of Digital Commerce (CDC)'s mission is to promote the acceptance and use of digital assets and blockchain-based technologies. Through education, advocacy and working closely with policy-makers, regulatory agencies and industry, its goal is to develop an environment that encourages innovation, jobs and investment	Digital assets
MOBI[25]	USA	The Mobility Open Blockchain Initiative (MOBI)'s Vehicle Identity Working Group (VIWG) aims to use DLT to make mobility safer, greener, cheaper and more accessible	Vehicle identity; usage-based insurance; electric vehicle grid integration; connected mobility and data marketplace; supply chain and finance; securitization and smart contracts
GDF[26]	UK	Global Digital Finance (GDF) is an industry membership body that promotes the adoption of best practices for cryptoassets and digital finance technologies, through the development of conduct standards, in a shared engagement forum with market participants, policy-makers and regulators	DLT requirements

[19] https://entethalliance.org/

[20] https://www.hyperledger.org/

[21] https://interwork.org/

[22] https://intervasp.org/

[23] https://tech.sina.com.cn/it/2018-05-10/doc-ihaichqz3607998.shtml (Chinese)

[24] https://digitalchamber.org/initiatives/

[25] https://dlt.mobi/

BIG[27]	Canada	The Blockchain Industry Group (BIG) is dedicated to promoting the adoption of blockchain technologies and digital currencies by actively collaborating with and promoting the efforts of our global blockchain community	DLT requirements (in progress)
BIA[28]	Estonia	The Blockchain Industrial Alliance (BIA) seeks to promote cross-blockchain transactions and interconnectivity. The goal of this alliance is to create a globally accepted standard for connecting blockchains and to bring innovations together	Interoperability
BiTA[29]	USA	The Blockchain in Transport Alliance (BiTA) is seeking to develop and embrace a common framework and standards from which transport/logistics/supply-chain participants can build blockchain applications	Interoperability; DLT requirements

BOX 4

Major standard-setting efforts – proposal processes

– Bitcoin improvement proposals (BIPs)[30]

– Ethereum improvement proposals (EIPs)[31]

– zCash improvement proposals (ZIPs)[32]

– XRP ledger amendments[33]

– Libra improvement proposals (LIPs)[34]

(5) Key recommendations

Given that standard-setting activities are in the early stages, there are many unknowns. Still, it is important to plan proactively to ensure that standard-setting initiatives encourage responsible deployments of blockchain.

For all actors, it is important that the use of blockchain and standardization efforts have a clear purpose. Ecosystem participants should identify the high-value use cases of blockchain for their needs, and then identify where standards may accelerate, or address gaps within the development of solutions for those use cases.

5.1 For standard-setting entities

In many ways, best practices for the creation and implementation of standards will reflect those used throughout the long history of technical standards creation. For instance, resources currently exist for assessing the need for standards (versus using or adapting an existing standard), enhancing the role of users and general techniques for technical standard creation.[41,42,43]

Based on the assessment, DLT-specific recommendations include:

1. **Ensure further coordination and collaboration among standard-setting organizations.** As identified in this paper, there are both gaps and overlaps in the current landscape. This may be alleviated through increased cross-entity collaborations – for instance, through a governance board or a recurring dialogue or consultation among working group leaders. This can facilitate the alignment of standards, including but not limited to: 1) harmonized terminology and working definitions; 2) appropriate sequencing of standards development; and 3) minimizing redundancies and maximizing the potential for advancing interoperability.

   To date, much of this collaboration has been on a bilateral basis, such as the partnership between Hyperledger and the Ethereum Enterprise Alliance, or via shared membership in standard-setting committees or working groups.[44] Moving towards a more coordinated approach will be important in proactively identifying strategic priorities for the ecosystem as well as determining the appropriate creation and review processes.

   For example, a standard-mapping initiative like this paper could be undertaken by such a body and updated on a regular basis to increase transparency and communication among standard-setting organizations.

2. **Identify and specify where conversations about standardization may be premature – and where formal standards are unnecessary.** There may be technical aspects of DLT that are not yet mature enough for standardization. Moving towards standardization too early may stifle innovation or lead to skewed or adverse incentives. As such, the time frame in which standards are developed is critical. It is important to carefully scope what these aspects might be and identify a projected timeline for revisiting the topics.

   In identifying a prospective roadmap, conversations about the technology's development and corresponding standards development can continue in parallel. As the technology evolves, standard-setting entities may choose to take a principles-based

approach – first defining high-level principles, then issuing related guidance. Ultimately, the standards can be further specified and codified at a time when the technical aspects have reached sufficient maturity.

At the same time, there may be technical aspects that the market will solve. Much can be learned from the evolution of the internet in evaluating where intervention was and was not needed.

3. **Ensure that language and intended use are precise.** As outlined, there is still debate about key terminology and technical design choices within the DLT ecosystem. Therefore, it is important to ensure that standards articulate their intended audience and intentions as clearly as possible – e.g. identifying the relevant layer in the technology stack or, where appropriate, which protocol(s) or vertical(s) are being addressed in a particular standardization effort.

In addition, in the event that standardization across working definitions is not accomplished in the near term, it is important that those setting standards are transparent in terms of which definitions were used as the basis for the entity's activities.

4. **Proactively plan for the role of decentralization in standards creation and implementation – and innovate accordingly.** Those producing DLT standards will need to consider the implications of decentralized governance for standards creation and implementation. For instance, many decentralized protocols implement changes through community-based improvement proposals. This process varies in terms of architecture and participants from a centrally managed implementation of technical standards.

As such, technical standards should be designed with implementation in mind – proactively identifying where there may be challenges or adaptations in the traditional model. For example: Are there new steps

in the creation and implementation that you should be adding? Are there specific developer communities you should be engaging – and how? How can you account for convergence with other Fourth Industrial Revolution technologies?

5. **Continue to seek diverse input in the development and roll-out of standards.** Many standard-making bodies allow for public review of the standards drafted, and a wide array of countries and organizational domains are being represented in the development of DLT standards. Ensuring diverse representation is critical to preserving the integrity of standards – creating a process by which standards are not designed in the image of particular products, philosophies or geopolitical interests.

Given that standard-setting organizations are predominantly headquartered in Europe and North America, other geographies must be deliberately and carefully included. In addition, it is important to consider perspectives from many areas of expertise, including cryptography and economics as well as consumers. A first step towards this goal might be measuring and identifying any gaps in representation.

6. **Educate industry and policy-makers on the best techniques for standards implementation.** Given the nascency of DLT, standards have the potential to shape the future of the technology on both the product and policy sides. However, the effectiveness of standards will ultimately come down to how they are understood and implemented.

Standard-setting organizations should keep an eye on roll-out and facilitate the creation of user-friendly tools or resources for the implementation of standards. For example, standard-setting bodies could create step-by-step guides and/or capture case studies to illustrate the role of technical standards in action.

5.2 | For entities adopting technical standards

1. **Proactively scope your desired level of engagement with standard-setting.** As outlined in the paper, there are several mechanisms for contributing to or commenting on standards development. Entities should proactively determine their strategy for participating (or not) in these activities. This could include, but is not limited to, identifying desired topics or areas of influence, joining specific industry action groups or appointing technical experts to working groups in the early stages.

The return on investment calculus will vary; however, it is recommended that entities follow the ongoing standard-setting activities to stay apprised of the evolving landscape at a minimum. Entities that are not following this activity may be left behind in important developments, such as those related to cryptography, security or interoperability.

2. **Collaborate with other organizations to set the agenda for standard-setting.** As demonstrated throughout the paper,

development of blockchain standards has been a mix of proactive proposals and responses to specific industry needs or demands. As such, organizations may benefit from joining or learning from an industry consortium. Ecosystems that take a collaborative approach are likely to identify the highest-value gaps in the landscape and the most appropriate venue for the standard-setting exercise. Moreover, this approach can help minimize redundancies and enable a robust set of options for consumers.

3. **Define a process for decision-making and adoption.** Because of the differences in technical and governance architecture across DLT, implementation of standards will vary greatly from entity to entity. Organizations should proactively scan and understand the activity taking place within the standards landscape in order to plan and manage the desired implementation. This will ensure that the appropriate steps are taken not only on the technical side, but on the change management and strategic decision-making sides as well.

As discussed, standards will likely contribute to key features of the technology, including interoperability and scalability in addition to potentially unlocking new products and marketplaces. Those organizations without a strategy may be left behind.

Standards are crucial to the enablement of critical features of DLT, such as interoperability and scalability. A strong set of standards has the potential to unlock new products and marketplaces as part of a larger ecosystem. However, current efforts are still lacking clarity, proper representation and coordination. Recognizing these hurdles is the first step to overcoming them. Standard-setting entities must be diverse and proactive, and strive to create awareness and understanding. Standard-adopting entities must also do their part by engaging in the standards development process and being critical in their selection. Together, a positive trajectory for DLT can be set and its potential realized.

Contributors

Lead researchers and authors

Sumedha Deshmukh
Platform Curator – Blockchain and Digital Assets, World Economic Forum

Océane Boulais
Researcher, MIT Digital Currency Initiative (Global Blockchain Council Fellow)

Tommy Koens
Researcher, ING Group

Acknowledgements

Global Blockchain Business Council Partners

Sofia Arend
Senior Analyst, Global Blockchain Business Council

Sierra Lewis
Program and Community Manager, Global Blockchain Business Council

Sandra Ro
Chief Executive Officer, Global Blockchain Business Council

Mercina Tillemann-Dick
Chief Operating Officer, Global Blockchain Business Council

Editing and graphics

Janet Hill
Head of Editing, World Economic Forum

Alison Moore
Editor

Floris Landi
Lead, Publications and Graphic Design

Michela Dorbolò
Designer

Contact

For questions about this paper or the World Economic Forum's work in Blockchain and Digital Assets, please contact blockchain@weforum.org.

Endnotes

1. Koens, Tommy, et al., "Blockchain Adoption Drivers: The Rationality of Irrational Choices", Concurrency and Computation: Practice and Experience, 23 May 2020, onlinelibrary.wiley.com/doi/full/10.1002/cpe.5843 (link as of 9/9/20).

2. Courcelas, Ludovic, et al., "EU Blockchain Observatory & Forum 2018-2020: Conclusions & Reflections", EU Blockchain Forum, 25 June 2020, https://www.eublockchainforum.eu/reports (link as of 9/9/20).

3. Weiser, Philip J., "Law and Information Platforms", Colorado Law Scholarly Commons, 2017, scholar.law.colorado.edu/articles/563/ (link as of 9/9/20).

4. "The New Industrial Revolution," ISO Focus, 2018, https://www.iso.org/isofocus_131.html (link as of 9/9/20).

5. Gibbs, Samuel, "How Did Email Grow from Messages Between Academics to a Global Epidemic?" The Guardian, 7 March 2016, www.theguardian.com/technology/2016/mar/07/email-ray-tomlinson-history (link as of 9/9/20).

6. Brain, Marshall, and Tim Crosby, "How E-Mail Works", HowStuffWorks, 18 October 2007, computer.howstuffworks.com/e-mail-messaging/email3.htm (link as of 9/9/20).

7. Tassey, Gregory, "'The Economic Nature of Knowledge Embodied in Standards for Technology-Based Industries'", ResearchGate, unknown, 2015, www.researchgate.net/publication/283018422_The_Economic_Nature_of_Knowledge_Embodied_in_Standards_for_Technology-Based_Industries (link as of 9/9/20).

8. Hawkins, Richard, et al., "Handbook of Innovation and Standards", ResearchGate, Edward Elgar, August 2017, www.researchgate.net/publication/319423198_Handbook_of_Innovation_and_Standards (link as of 9/9/20).

9. Michaels, Dave, "SEC Gets Win in Test of Authority to Regulate Cryptocurrency Sales", Wall Street Journal, 24 March 2020, https://www.wsj.com/articles/sec-gets-win-in-test-of-authority-to-regulate-cryptocurrency-sales-11585099706 (link as of 9/9/20).

10. Ling, Hung, and Ajit Jillavenkatesa, "The Standardization Eco-System: Policy and Patents", IEEE Communications Standards Magazine, Vol. 1, No. 4, December 2017, 48–48, ieeexplore.ieee.org/document/8258600, 10.1109/mcomstd.2017.8258600 (link as of 9/9/20).

11. "Standards – IEEE Blockchain Initiative", Ieee.Org, 2016, blockchain.ieee.org/standards (link as of 9/9/20).

12. "ISO/TC 307 – Blockchain and Distributed Ledger Technologies", ISO, 31 August 2020, www.iso.org/committee/6266604.html (link as of 9/9/20).

13. "Blockchain", GS1 –The Global Language of Business, 5 September 2019, www.gs1.org/standards/blockchain (link as of 9/9/20).

14. "Blockchain in Healthcare", HIMSS, May 2020, www.himss.org/resources/blockchain-healthcare (link as of 9/9/20).

15. "Enterprise Ethereum Alliance", Enterprise Ethereum Alliance, 2018, entethalliance.org/ (link as of 9/9/20).

16. "DIF – Decentralized Identity Foundation", Identity.Foundation, 2020, identity.foundation/ (link as of 9/9/20).

17. "IWA – InterWork Alliance", Interwork.Org, 2020, interwork.org/ (link as of 15/9/20).

18. "Bitcoin/Bips", GitHub, September 2020, github.com/bitcoin/bips (link as of 9/9/20).

19. "Ethereum/EIPs", GitHub, 4 September 2020, github.com/ethereum/EIPs (link as of 9/9/20).

20. "Zcash/Zips", GitHub, 30 August 2020, github.com/zcash/zips (link as of 9/9/20).

21. "ERC Token Standards", Ethhub.Io, 2020, docs.ethhub.io/built-on-ethereum/erc-token-standards/what-are-erc-tokens/ (link as of 9/9/20).

22. "ERC", Ethereum Improvement Proposals, 2020, eips.ethereum.org/erc (link as of 9/9/20).

23. "Open Source Organizations", Opensource.com, 2020, opensource.com/resources/organizations (link as of 9/9/20).

24. Maurer, Stephen M, and Suzanne Scotchmer, "Open Source Software: The New Intellectual Property Paradigm", National Bureau of Economic Research Working Paper Series, 17 April 2006, www.nber.org/papers/w12148 (link as of 9/9/20).

25. Internet Systems Consortium, "Internet Governance Activities – Internet Systems Consortium", Isc.Org, 2018, www.isc.org/governance/ (link as of 9/9/20).

26. "GDF Code", Global Digital Finance, 23 July 2020, www.gdf.io/gdfcode/ (link as of 9/9/20).

27. "Messari Disclosures Registry", Messari.Io, 2020, messari.io/registry (link as of 9/9/20).

28. "Presidio Principles: Foundational Values for a Decentralized Future", World Economic Forum, 2020, www.weforum.org/communities/presidio-principles (link as of 9/9/20).

29. Deshpande, Advait, et al., "Understanding the Landscape of Distributed Ledger Technologies/Blockchain: Challenges, Opportunities, and the Prospects for Standards", Rand.Org, RAND Corporation, 18 October 2017, www.rand.org/pubs/research_reports/RR2223.html (link as of 9/9/20).

30. "ISO 22739:2020(En)", Iso.Org, 2020, www.iso.org/obp/ui/#iso:std:iso:22739:ed-1:v1:en (link as of 9/9/20).

31. ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT), "Technical Specification FG DLT D1.1 Distributed Ledger Technology Terms and Definitions", 2019.

32.	Lima, C., "Developing Open and Interoperable DLTVBlockchain Standards [Standards]", in Computer, vol. 51, no. 11, 2018, 106–111, https://doi.ieeecomputersociety.org/10.1109/MC.2018.2876184 (link as of 9/9/20).
33.	Hu, Ning, et al., "Technical Specification FG DLT D3.1 Distributed Ledger Technology Reference Architecture", 2019, https://www.itu.int/en/ITU-T/focusgroups/dlt/Documents/d31.pdf (link as of 14/9/20).
34.	"ZKProof Standards", ZKProof Standards, 18 March 2020, zkproof.org/ (link as of 9/9/20).
35.	World Economic Forum, "Inclusive Deployment of Blockchain for Supply Chains: Part 6 – A Framework for Blockchain Interoperability", April 2020, https://www.weforum.org/whitepapers/inclusive-deployment-of-blockchain-for-supply-chains-part-6-a-framework-for-blockchain-interoperability/related/ (link as of 9/9/20).
36.	Allison, Ian, "Inside the Standards Race for Implementing FATF's Travel Rule", Coindesk, 4 February 2020, www.coindesk.com/inside-the-standards-race-for-implementing-fatfs-travel-rule (link as of 9/9/20).
37.	"InterVASP Messaging", Intervasp.Org, 2018, intervasp.org/ (link as of 9/9/20).
38.	"ISO/TC 307 – Blockchain and Distributed Ledger Technologies", ISO, 31 August 2020, www.iso.org/committee/6266604.html (link as of 9/9/20).
39.	Hu, Ning, et al., "Technical Specification FG DLT D3.1 Distributed Ledger Technology Reference Architecture", 2019, https://www.itu.int/en/ITU-T/focusgroups/dlt/Documents/d31.pdf (link as of 14/9/20).
40.	"International Standardisation Organisation & Consumer Policy Committee", Consumersinternational.Org, 2017, www.consumersinternational.org/who-we-are/partners/iso-copolco/ (link as of 9/9/20).
41.	Duval, Erik, and Katrien Verbert, "On the Role of Technical Standards for Learning Technologies", Ieee.Org, 2008, https://ieeexplore.ieee.org/document/4760130 (link as of 9/9/20).
42.	Hawkins, Richard, "Enhancing the User Role in the Development of Technical Standards for Telecommunications", Technology Analysis & Strategic Management, 2007, www.tandfonline.com/doi/abs/10.1080/09537329508524193 (link as of 9/9/20).
43.	Schmidt, Charles M., "Best Practices for Technical Standard Creation: Guidelines for the Design, Socialization, Formalization, and Adoption of New Technical Standards Approved for Public Release; Distribution Unlimited. Case Number 17-1332. 2017", https://www.mitre.org/sites/default/files/publications/17-1332-best-practices-for-technical-standard-creation.pdf (link as of 10/9/20).
44.	Hyperledger, "Enterprise Ethereum Alliance and Hyperledger to Advance the Global Blockchain Business Ecosystem – Hyperledger," Hyperledger, October 2018, www.hyperledger.org/announcements/2018/10/01/enterprise-ethereum-alliance-and-hyperledger-to-advance-the-global-blockchain-business-ecosystem (link as of 9/9/20).