Blockchain: From Technology to Marketplaces

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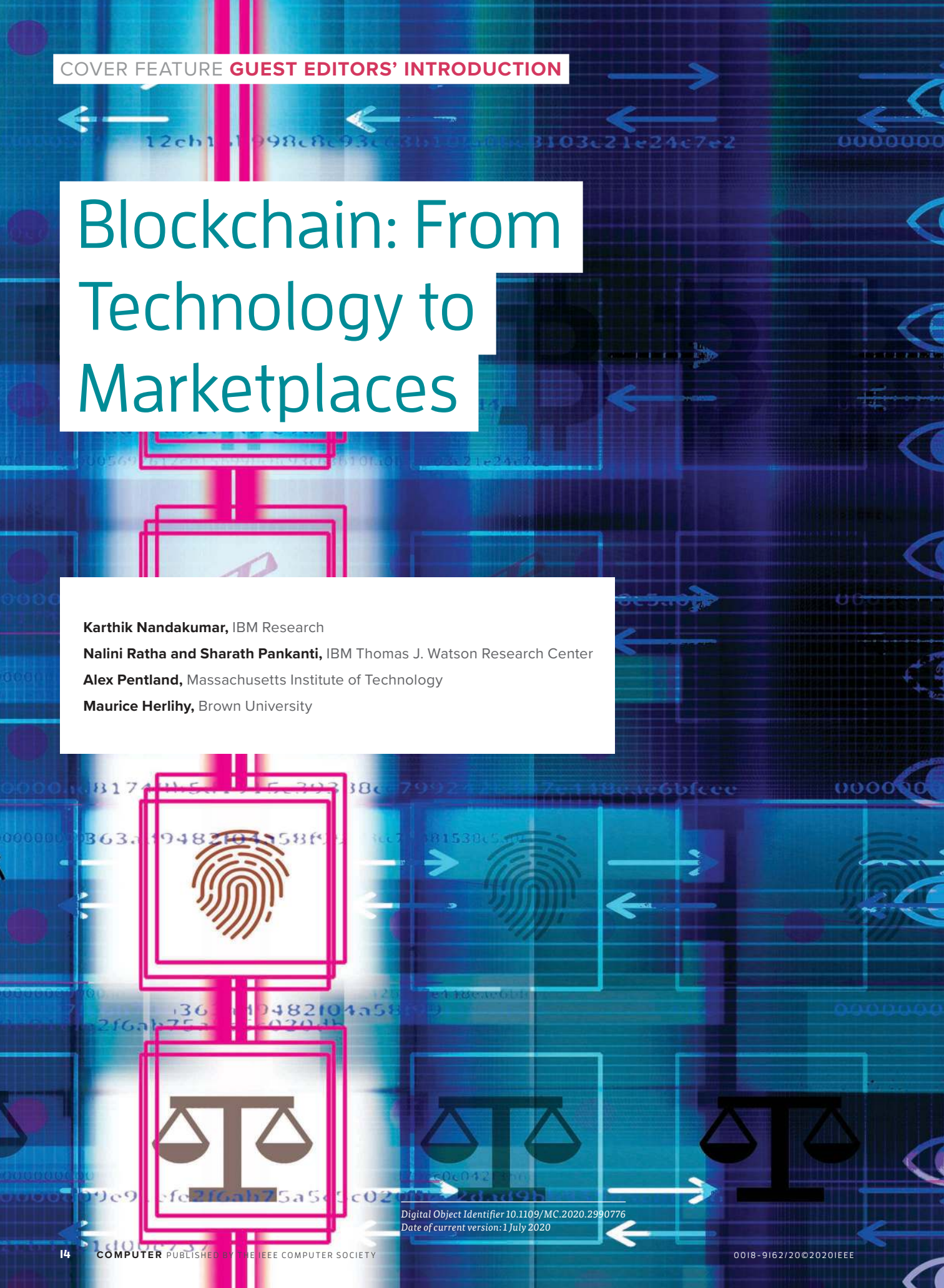

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This theme issue provides a glimpse of the diverse research challenges in adopting blockchain technology into mainstream applications. The four articles focus on the following core issues: scalability, transparency versus privacy, standardization, ecosystem, and integration.

Trust and trust management lie at the heart of today's increasingly decentralized economy. In the past, trust has been enabled through a central authority. Blockchain, in all its variations, is emerging as a foundational technology that allows mutually untrusting parties to reach consensus on a shared digital history without a (central) trusted party. At the core of a blockchain application is a distributed immutable data store, and that is managed through smart contracts. Although blockchain is best known as the underlying core infrastructure of cryptocurrencies, it has many promising applications in other application domains, such as identity management, discovering critical obstacles in a complex supply chain, detecting money laundering and other financial crimes, identifying fake content, and better diagnoses of diseases (see Figure 1).

Several early adopters of blockchain are already reaping business benefits[1] by building solutions centered on trust, openness, and privacy. However, realizing the full potential of blockchain will require a significant level of fundamental advances in science and technology, major changes in business processes to create the right enabling environment, as well as innovative ideas to facilitate the integration of blockchain into real-world applications. This theme issue provides a glimpse of the diverse research challenges in adopting the technology into mainstream applications. Specifically, the four articles in this issue

FIGURE 1. Sample applications of blockchain. A wide variety of applications could significantly benefit from leveraging blockchain infrastructure,[3] which can address issues related to trust, governance, privacy, auditability, and provenance. Blockchain typically acts as a seamless distributed infrastructure that manages how (human or automated) agents as well as organizations interact with data sources/digital assets and physical assets under their control. Four broad classes of blockchain applications are illustrated. 1) Decentralized identity management could alleviate identity theft incidents[4] by prudently using various identifiers including biometrics. 2) Blockchain-based integrity and provenance can alleviate problems related to fake news[5] and other forms of disinformation. 3) Immutable audit trails made possible by blockchain could potentially enable a trusted marketplace for assets and insights.[6] 4) Increasingly adversarial cybersecurity incidents[7] could be addressed by auditable distributed ledgers.

focus on a mix of the following five core issues:

1. *Scalability*: One of the limitations of existing blockchain technologies is their inability to scale up to real-world, high-throughput applications without compromising on decentralization.
2. *Transparency versus privacy*: Another seemingly insurmountable issue is the tradeoff between transparency and privacy that is often encountered in blockchain applications.
3. *Standardization*: In a large family of applications, replacing a conventional centralized infrastructure with a blockchain infrastructure is not possible without standardizing the underlying data formats and interfaces.
4. *Ecosystem*: The efficacy of blockchain is maximized when the entire ecosystem of inter-related different applications could provide significantly better service by overhauling its consistent blockchain-compliant interfaces. Practitioners are recognizing that building an ecosystem is the most critical (and complex) effort for sustaining the benefits of blockchain infrastructure, and we increasingly are hearing the term minimal viable ecosystem in the context of blockchain infrastructures.[2]
5. *Integration*: Two distinct threads of evolution are emerging in the context of integrating blockchain into applications. The first approach can be referred to as transitioning, which involves improving an application by gracefully transitioning from a conventional method with blockchain innovation so both can coexist in the transitional period. The second method is disruptive, which starts with recognizing a gap in a conventional application and bridging the limitation by replacing the conventional method with blockchain.

IN THIS ISSUE

In "Blockchain Architecture for Auditing Automation and Trust Building in Public Markets," Cao et al. showcase how blockchain can enable the automated auditing of transactions as they occur by leveraging the strengths offered by the technology, such as immutability, load balancing, and differential access. This article also proposes a mechanism for privacy-preserving information exchange and highlights some of the scalability issues with existing blockchain protocols. Although their research exclusively focuses on auditing applications, the authors correctly note that similar advantages can be reaped by other applications by appropriately replacing their centralized infrastructures with blockchain.

"PharmaCrypt: Blockchain for Critical Pharmaceutical Industry to Counterfeit Drugs," by Saxena et al., focuses on the problem of counterfeit drugs by first reviewing its widespread existence and the lack of solutions that can effectively ensure that both patients and dispensaries are made aware of the provenance of the drug. Their proposed solution describes a means of overhauling one of the most effective conventional centralized solutions based on radio-frequency identification (RFID) technology and thus enabling a smooth transition to blockchain. They realistically conclude that their prototype is merely a new beginning toward an eventual solution, which requires building a viable ecosystem.

The article "Blockchain for Video Streaming: Opportunities, Challenges, and Open Issues," by Barman et al., presents the role of blockchain technology in video streaming applications. The key message of this article is that a lack of standardization is critically debilitating the adoption of blockchain for media streaming. The authors propose a conceptual, unifying framework and interface for video streaming applications and observe the need for researchers to address several key technical challenges, such as scalability and privacy. They also stress the importance of appropriate business models to bring the technology to the marketplace successfully.

In the last feature article, "Blockchain for E-Health-Care Systems: Easier Said Than Done," Biswas et al. give the readers a glimpse of the complexity of implementing a blockchain solution in the real world. The authors observe that health care is delivered through an ecosystem of closely connected networks of related interoperable services. Hence, the blockchain solutions implemented by individual health service providers must also be interoperable, which requires standards and new protocols for trade and consensus management. Another critical requirement in e-healthcare systems is the privacy of patient data. The authors conclude that to make a blockchain-based health-care solution a long-term success, it is critical to precisely capture and address its plethora of requirements.

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These four articles show that overcoming challenges such as scalability and privacy require core scientific and technological advancements in areas like distributed computing and cryptography. For challenges such as standardization and ecosystem building, a herculean effort at consensus building among a diverse set of stakeholders is required. These advances will enable the transformation of blockchain from a niche technology for cryptocurrencies into a general-purpose technology capable of achieving unprecedented levels of transparency, accountability, and intelligence in the way we do business. We hope that this issue of *Computer* will serve as a valuable resource for the research community. Finally, we enjoyed guest editing this issue and would like to thank the reviewers for their time in shepherding these articles through the review process. Please feel free to contact us if you have any questions.

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A HERCULEAN EFFORT AT CONSENSUS BUILDING AMONG A DIVERSE SET OF STAKEHOLDERS IS REQUIRED.

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