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Applications of Blockchain Technology in Business

Challenges and Opportunities

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This book is dedicated to:
Delaura and Madison

Preface

A Note to Our Readers

Blockchain technology is one of the most revolutionary innovations of this century. It not only provides operational and regulatory verification efficiencies; it also enhances tractability and visibility throughout the supply chain. This robust technology is recognized as a powerful database that could easily combine with big data. Furthermore, blockchain technology, as portrayed in the sparse academic and in the wider trade literature is found to reshape and decentralize many industries besides financial institutions. However, the technology is young, misunderstood, and untested—the effects are found to be conditional. Interest in exploiting blockchain in other industries, such as manufacturing and healthcare, is increasing, and deployments are starting to gain momentum. The adoption rate, however, is slow, and organizations are only beginning to scratch the surface of the potential applications of this remarkable technology. Implemented properly, the business benefits can be substantial. The purpose of this book is to do a systematic literature review and explore how blockchain technology can enable or streamline various industries. This book explores the changing dimensions of blockchain, underscores the importance of this revolutionary technology, reviews its timeline from inception to maturity, examines its possible applications in different industries, identifies determinants of implementation success, and highlights some of its potential benefits.

What You Will Find in the Book

The book discusses the various ways that blockchain technology is changing the future of money, transactions, government, and business. The first two chapters walk through the foundation of blockchain. Chapters 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 look at applications of blockchain in different industries and highlight its exciting new business applications. We show why so many companies are implementing blockchain and present examples of companies who have successfully employed the technology to improve efficiencies and reduce costs. Chapter 13 highlights blockchain's powerful potential to foster emerging markets and economies including smart cities, value-based healthcare, decentralized sharing economy, machine-to-machine transactions, data-sharing marketplace, etc. Chapter 14 offers a conceptual model, provides information and insights, and covers a step-by-step approach to plan and develop blockchain-based technology.

Target Audience

This book is for everyone who wants an overview of blockchain technology and how it will potentially change and disrupt many industries. The target audience of this book is an inclusive one. Professionals and researchers working in the field of information and technology will gain insight into the potential applications of this technology. The book also provides information for technology educators, researchers, entrepreneurs, and practitioners to advance the understanding of blockchain and its impact in the economy. Practitioners will find this book an essential resource and reference guide for the design and successful implementation of blockchain technology in an organization. Academicians can use this book as a supplement to teach technology-related courses in undergraduate or graduate classes.

About the Authors

Mohsen Attaran is the 2004–2005 Millie Ablin Outstanding Professor of Management at the California State University, Bakersfield. He is the Author/Coauthor of 4 books, over 120 peer-reviewed research papers, 4 book chapters, and 10 commercial software packages. He has been a consultant for public and private organizations and has conducted numerous in-house workshops and seminars in information technology, process improvement, and project management for Fortune 500 companies. He is Founder and President of IES, Inc., a web and mobile app development company, and has founded, launched, and managed several businesses in his career in a variety of technological fields.

Angappa Gunasekaran is Dean and a Professor at the School of Business and Public Administration, California State University, Bakersfield. Prior to this, he served as the Dean of the Charlton College of Business at the University of Massachusetts Dartmouth from 2013 to 2017. He has over 350 articles published in peer-reviewed journals. He has presented 50 papers, published 50 articles in conferences, and given a number of invited talks in many countries. He is on the editorial board of several journals. He has organized several international workshops and conferences in the emerging areas of operations management and information systems.

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Bakersfield, CA, USA

Mohsen Attaran
Angappa Gunasekaran

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Chapter 1
Introduction

Distributed ledger technology (DLT), more commonly called “blockchain,” has captured the imaginations and wallets of the financial services institutions. A blockchain is defined as a decentralized, continuously growing list of records, called “blocks,” across a peer-to-peer network that are linked and secured using cryptography. Each block typically contains a cryptographic hash of the previous block, a timestamp, and transaction data, and contains the information from all previous blocks and transactions to create a network or chain. Once the blockchain processes the information, every computer in the network locks in at the same time, creating a permanent, hard to alter digital record. Each blockchain system determines who can add new blocks to the chain, and how the procedure is done. (Lee Kuo Chuen 2015)

Blockchain offers special qualities that make it better than traditional database as shown in Fig. 1.1.

An important feature of a blockchain is that it is resistant to modification or changes to the data. It is a decentralized, distributed ledger system that can record transactions between two parties efficiently and in a verifiable way. Blockchain is typically managed by a peer-to-peer network and is verifiable using a consensus-based approach for keeping the ledger accurate (Fig. 1.2). The nature of the transaction is immediately transparent on the entire blockchain. Transactions use cryptographic protocols to ensure that the recorded data in any given block cannot be altered retroactively without the alteration of all subsequent blocks, which requires collusion of the network majority (Chang 2017). As a result, the most important feature of blockchain is that it cannot be corrupted. Altering any unit of information on the blockchain would be difficult to impossible (Zheng et al 2017). Blockchain is the biggest development in information technology. For the first time in human history, we are able to create a permanent record of every transaction, governed by the unyielding laws of mathematics.

According to Google Trends, Bitcoin Internet searches were double the Blockchain searches in early 2018. Google Trends suggests that ‘Bitcoin’ is nearly

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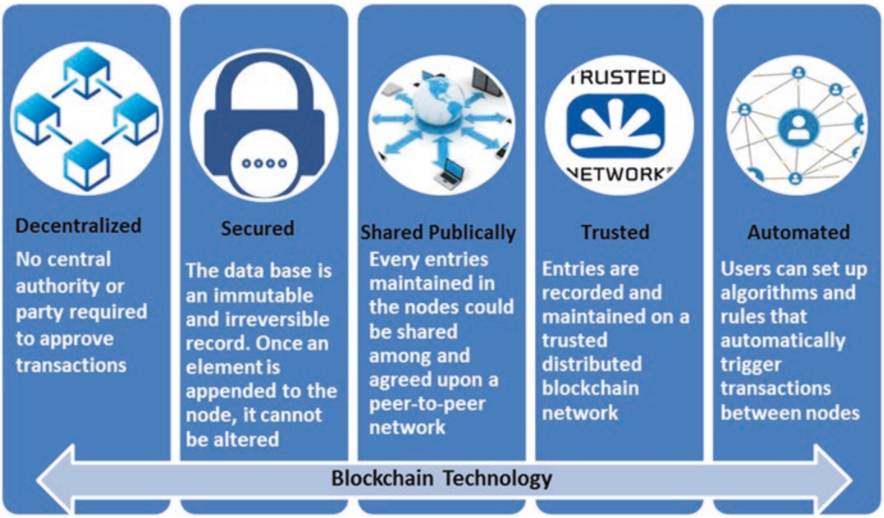

Fig. 1.1 Special qualities of blockchain

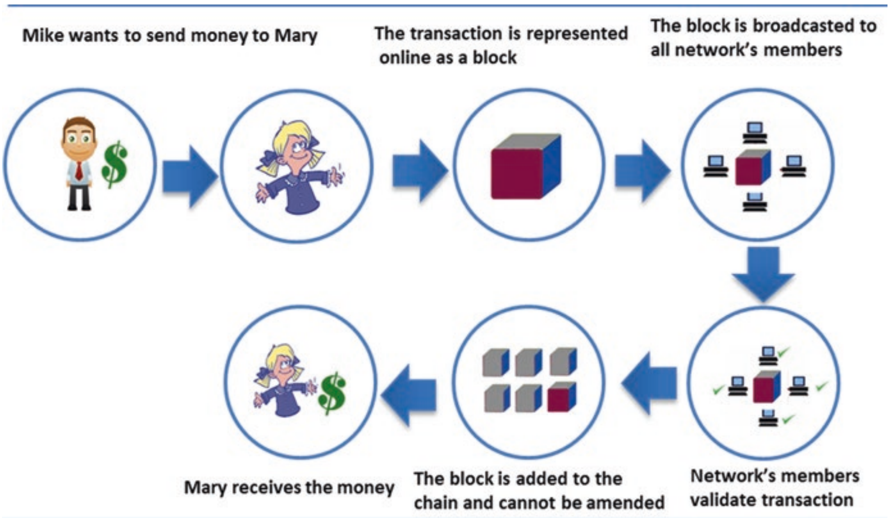

Fig. 1.2 The distributed ledger

10-times more popular than terms like 'cryptocurrency' and 'blockchain.' Bitcoin was ranking high (Top 10) on Google Trends, hitting over 100K+ searches in the beginning of 2018. In light of these data, it can be said that the interest in blockchain on Google seems to be related to the interest in bitcoin and cryptocurrencies (Cavicchioli 2019). China was one of the countries with the most searches for the word blockchain. However, since early 2018, popularity of bitcoin on Google search has decreased and the gap between blockchain and bitcoin has decreased.

HSBC, one of the world's largest banking and financial services firms, commissioned a study of more than 12,000 people in 11 countries and territories looking at their perceptions and use of technology. Among the people surveyed, 60% had never heard of blockchain technology, and 80% of those who had could not explain how it works. However, blockchain is making significant headways into the finance and trade industries (HSBC 2017).

In 2016, World Economic Forum (WEF) released a report regarding the future of financial infrastructure that was based on over 12 months of research, engaging industry leaders and subject matter experts. Creating this report involved extensive outreach and dialogue with the financial services community, innovation community, technology community, academia, and the public sector. The project explored the landscape of disruptive innovations in financial services, and its findings included (World Economic Forum 2016):

- Many banks experimented with blockchain. 80% of banks planned to initiate DLT projects by 2017
- 90+ central banks engaged in DLT discussions worldwide
- Global interest in blockchain was increasing. 24+ countries were investing in DLT
- Blockchain research was also on the rise. 2500+ patents filed over the 2013–2016 period
- Venture capital investment in blockchain was on the rise, with over $1.4 billion in investments over the 2013–2016 period
- Consortium efforts increased substantially. 90+ corporations joined blockchain consortia
- 10% of global gross domestic product (GGDP) will be held in blockchain technology

The analysis has yielded six key findings regarding the implications of blockchain-based technology on the future of financial services:

- Blockchain has great potential to reduce costs and increase efficiencies through the establishment of new financial services processes
- The technology should be viewed as one of many technologies that will form the foundation of next generation financial services infrastructure
- Blockchain-based financial services infrastructure will redraw processes and call into question orthodoxies that are foundational to today's business models
- Blockchain has potential applications in different industry, each leveraging the technology in different ways for a diverse range of benefits
- Digital Identity, a critical enabler offered by blockchain, has broader applications. Blockchain-based technology has the ability to amplify benefits.
- Successful blockchain applications require deep collaboration between incumbents, innovators, and regulators, adding complexity and delaying implementation.

Harvard Business Review considers blockchain a foundational technology, akin to the computer networking technology of the 1970's that laid the groundwork for the development of the Internet (Iansiti and Lakhani 2017). Gartner, the world's leading information technology research and advisory company, estimates the impact of blockchain on the world economy will grow to slightly over $360 billion by 2026 and will be on the order of $3.1 trillion by 2030. Gartner encourages Chief Information Officers (CIOs) to embrace blockchain to explore strategic business initiatives, capture future value, and mitigate competitive threats. Google, Intel, and Microsoft have already put $4.5 billion towards blockchain adaption (Panetta 2018b). According to one recent survey by WEF, 10% of global gross domestic product will be held in blockchain technology by 2027 (World Economic Forum 2016). In a 2017 IBM survey of 200 global banks and 200 other global financial markets, nearly 65% of banks surveyed were expecting to have blockchain solutions in production by the end of 2020 (Parker 2017). Similarly, Goldman Sachs Investment Research projects that the implementation of blockchain technology could streamline the clearing and settlement of cash securities, saving capital markets $2 billliom in the US and $6 billion globally on an annual basis. Finally, according to an Aite Group prediction, investment in new blockchain-enabled financial technologies will reach $400 million by 2019 (Accenture 2019).

It is necessary for CIOs to understand what blockchain is, how the technology works, and how it can be utilized to further mission-critical business priorities. However, according to a Gartner 2018 CIO Survey, only 1% of CIOs surveyed indicated any kind of adoption, and only 8% were in short-term planning and pilot execution. The majority of responding CIOs (77%) said their enterprise had no action planned to investigate or develop the technology (Panetta 2018a).

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Chapter 2
The Evolution of Blockchain

In his 2016 book, Mougayar analogized the evolution of blockchain to the World Wide Web. He argued that before the Web, we had the Internet—the network connecting computers. The Web came along a few years later and was the first layer on top of the Internet and allowed us to put content on the Internet that was easy to visualize, publish on, and share. More features were added to the Web including ecommerce, communication, and social media. Blockchain technology is a new layer that sits on top of the Internet, yet doesn't need the World Wide Web—it is on par with the Web. On the long-term, blockchain has the potential to be of the same magnitude of the Web as a space — similar to what the Web gave us back in 1993–1994. (Mougayar 2016).

The following section provides a timeline for blockchain from inception to maturity. The rise of cryptocurrencies is also discussed. Fig. 2.1 summarizes the development history of blockchain. The rise of blockchain can be divided into two periods—creation and growth, as discussed below:

Creation (2008–2010)

Blockchain was introduced in 2008 by a person or group of people known by the pseudonym Satoshi Nakamoto in a paper titled, "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto 2008). The author(s) laid out the framework for blockchain and detailed methods of using a peer-to-peer network to generate a financial database, "a system for electronic transactions without relying on trust." This database would contain digital records—or blocks of transactions—using a secured method of cryptography. On January 2009, Satoshi Nakamoto mined the first bitcoin transaction: the Genesis Block (block number 0), which had a reward of 50 bitcoins (Wallace 2011). The first bitcoin transaction took place between Satoshi Nakamoto

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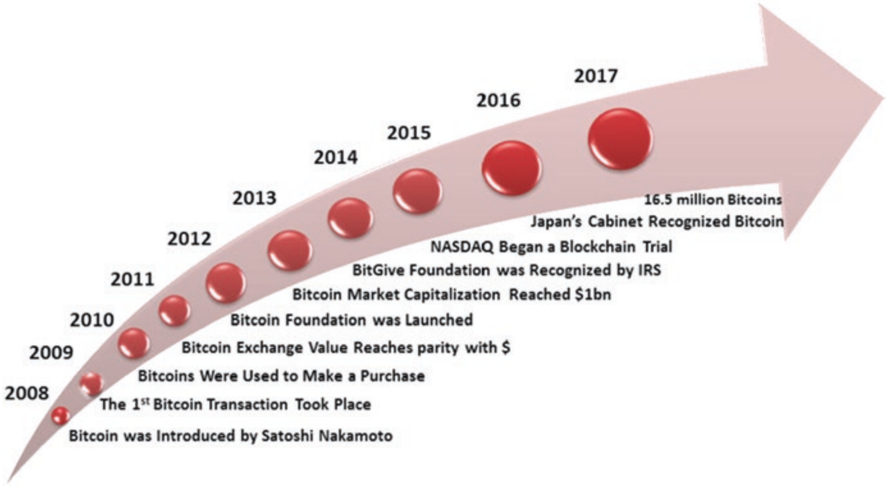

Fig. 2.1 Bitcoin and blockchain from inception to maturity

and a programmer named Hal Finney, the first supporter, adapter, and contributor to bitcoin, on 12 January 2009 (Peterson 2014). The first bitcoin exchange market was established in October of that year. In 2010, bitcoins were used to make the first purchase of a product. 10,000 bitcoins were used to buy two pizzas from Papa John's (Wallace 2011).

Growth (2011–2018)

In 2011, other cryptocurrencies started to emerge. A non-profit group, the Electronic Frontier Foundation, started accepting bitcoins. Additionally, Bitcoin's exchange value reached parity with the U.S. dollar (Rainey 2011). In 2012, a global bitcoin payment service provider, BitPay, reported having over 1000 merchants accepting bitcoin under its payment processing service (Browdie 2012). In November, an open source web company, WordPress, started accepting bitcoins (Skelton 2012). In the same year, the Bitcoin Foundation was launched to provide standardization, protection, and promotion of bitcoin as the open source protocol (Matonis 2012). In 2013, the market capitalization of bitcoin reached $1 billion, and it was announced that the first bitcoin charity, BitGive Foundation, would be established. Additionally, companies like WooCommerce began to process online orders made with bitcoin. In 2014, the BitGive Foundation was recognized by the IRS as the first bitcoin charitable organization and was granted 501(c)(3) status (Macheel 2014). The number of merchants and organizations accepting bitcoin increased at a rapid rate. For example, BitPay announced that 12,000 merchants had signed up for their service (Burniske 2015). The Sacramento Kings announced that they would accept bitcoin as a form of payment for tickets and merchandise (Rovell 2014). By 2015, it was estimated that 160,000 merchants accepted bitcoin payments. In the same year, NASDAQ began a blockchain trial (Burniske 2015). In 2016, the Cabinet of Japan recognized bitcoin as having a function similar to real money (Kyodo 2016), and Russia legalized the use of bitcoin (Kharpal 2017). The number of bitcoin ATMs reached 771 worldwide (Buntinx 2016). In 2017, the number of businesses accepting bitcoin continued to increase. The number of bitcoins in circulation reached 16.5 million (Linuma 2017). Bitcoin has gained more legitimacy among financial companies.

The Rise of Cryptocurrencies

Around the same time blockchain was introduced to the public, a digital currency called bitcoin was proposed. Bitcoin is a cryptocurrency that allows peer-to-peer transactions without third party involvement. Bitcoin is the first application of blockchain technology that emerged in 2009, and the most widely used cryptocurrency in the world. At the moment, it has the highest market capitalization and highest value per unit. Bitcoin was rated as the top performing currency in 2015 (Desjardins 2016) and the best performing commodity in 2016 (Adinolfi 2016). At the end of 2016, the value of bitcoin transactions hit $92 billion compared with the $411 trillion in total global payments (Iansiti and Lakhani 2017). Bitcoin's biggest year was 2017 where the currency processed $2 billion worth of transactions per day (Torpoy 2017). Bitcoin is growing fast and increasingly important in contexts such as instant payments and foreign currency and asset trading, where the present financial system has limitations.

The evolution of bitcoin price index from April 2017 to April 2019 was very volatile. The price index is calculated by taking an average of bitcoin prices across leading global exchanges. The bitcoin price index was $1349.19 in April 2017. The highest bitcoin index value was $13,860.14 in December 2017. The index lost nearly 36% of its value from January to December 2018. However, it seems the inexvalue is increasing in 2019. The bitcoin index value for the end of April 2019 amounted to $5151.43 (Statista 2019).

There are more than 1500 cryptocurrencies people can mine or exchange for money. According to some estimates, the total cryptocurrency market cap will be $1 trillion by the end of 2019. The act of discovering new crypto coins (or digital coins) is called mining. The process of mining crypto coins is complex and time-consuming. To mine crypto coins, a high-powered computer solving complex mathematical equations is required. The miner gets a block reward, paid out in virtual coins, when they solve one of the equations.

Obstacles to Rapid Adoption

According to Gartner, blockchain's underlying concepts are misunderstood, its current tools are immature, and their application in mission-critical business operations is unproven (Tucci 2018). Similarly, IBM surveyed 200 financial institutions in 16 countries on the barriers to implementing blockchain technology. The top three barriers identified were regulatory constraints, immature technology, and lack of a clear ROI. Insufficient skills, lack of executive buy-in, and insufficient business cases were also mentioned as other relevant barriers (Yerramsetti 2017).

Awareness of DLT has grown rapidly, but significant hurdles remain to large-scale implementation. Those include (WEF 2016):

- An uncertain and inharmonious regulatory environment
- Lack of collective standardization efforts
- An absence of formal legal frameworks

For the blockchain revolution to be successful many barriers—technological, governance, organizational, and even societal—will have to be removed (Iansiti and Lakhani 2017). These barriers and hurdles are discussed below:

1. **Lack of Understanding and Trust in Technology**: According to an HSBC's survey, blockchain is the least understood new technology, followed by robo-advisor (automated investment advice). The study indicates that in order to establish trust and accelerate adoption, it is essential to increase people's knowledge and understanding of new technologies, build predictability, and reassure users about security (HSBC 2017). Current blockchain technology is neither scalable nor complete (Tucci 2018).
2. **Data Interoperability:** Since blockchain is a DLT, the need to agree on the structure and format of the data could pose a challenge (Tucci 2018).
3. **Solution Challenge:** Building a flexible blockchain-enabled application that is integrated with a company's business processes requires enormous resources. Many companies cannot afford to allocate those resources (Tucci 2018).
4. **Security Vulnerabilities:** Blockchain code is still in its early stages and might be liable to security vulnerabilities and hackers attack. Another risk for blockchain is the double-spending attack where an attacker goes on to make more than one transaction while utilizing only one coin and discrediting the "fair" exchange (Pinto 2019).
5. **Regulatory Environment:** An uncertain and inharmonious regulatory environment is stalling adoption. The global management consulting firm McKinsey & Company identified decentralized ownership, international justification, and encryption and user anonymity as other challenges to unlocking the potential value of blockchain (McKinsey and Company 2017).
6. **Formal Legal Frameworks:** Absence of formal legal frameworks adds complexity and could delay implementation.
7. **Collaboration**: According to World Economic Forum's analysis, successful applications of blockchain require deep collaboration between incumbents,

innovators, and regulators (WEF 2016). Businesses will need a network of business partners to make blockchain applications viable. Getting competitors to cooperate could be challenging (Tucci 2018).

8. **Slow Bitcoin Processing:** The existing network for blockchain currencies can only process a handful of transactions per second. A bitcoin transaction could take from minutes to an hour. Storage methods and processing capability of blockchain networks need to be improved for mass adoption of blockchain currencies.
9. **Energy Footprint:** While blockchain is a game-changing technology, mining bitcoins requires enormous amounts of energy output. According to a 2014 study, the power used for bitcoin mining was likely to take up as much electricity consumption as the entire country of Ireland in 1 year. (O'Dwyer and Malone 2014).

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Chapter 3
Blockchain Principles, Qualities, and Business Applications

Blockchain Qualities

The two most interesting qualities of the blockchain are decentralization and immutability. A traditional network structure is the "client-server" structure where there is a centralized server and everyone who wants to connect with the server can send a query to get the required information. In order for this type of network system to work, it is critical that the server function continuously. Since servers handle a lot of sensitive material, anyone can hack the server and get those pieces of information. Blockchain technology relies on peer-to-peer network architecture as shown in Fig. 3.1.

This network partition workload among participants who are equally privileged "peers," eliminating one central server. Instead there are several distributed and decentralized peers. If one of the peers in the network goes down, you still have other peers from which to download. Plus, it is not prone to censorship (Blockgeeks 2019). Figure 3.2 summarizes the characteristics of traditional and decentralized networks.

In the context of blockchain, immutability means that once something enters into the blockchain, it cannot be tampered with. Blockchain technology has special qualities that can prompt expanded efficiency and cost reduction for many businesses. Those qualities are:

- Process integrity
- Valuable redundancy
- Shared control
- Data security (transparent and incorruptible)

Blockchain technology has other special qualities that can prompt expanded efficiency and cost reduction for many businesses. Those qualities are shown in Fig. 3.3

M. Attaran, A. Gunasekaran, *Applications of Blockchain Technology in Business*, SpringerBriefs in Operations Management,
https://doi.org/10.1007/978-3-030-27798-7_3

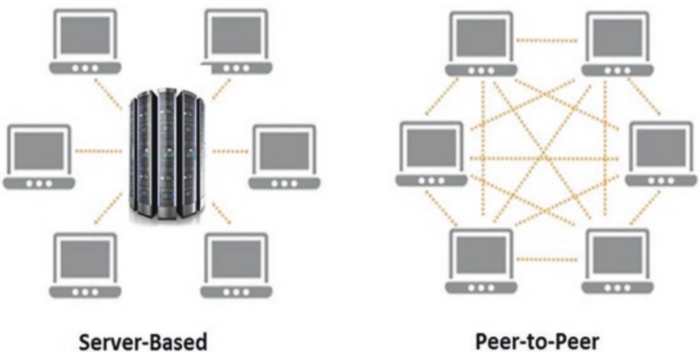

Fig. 3.1 Peer-to-peer network

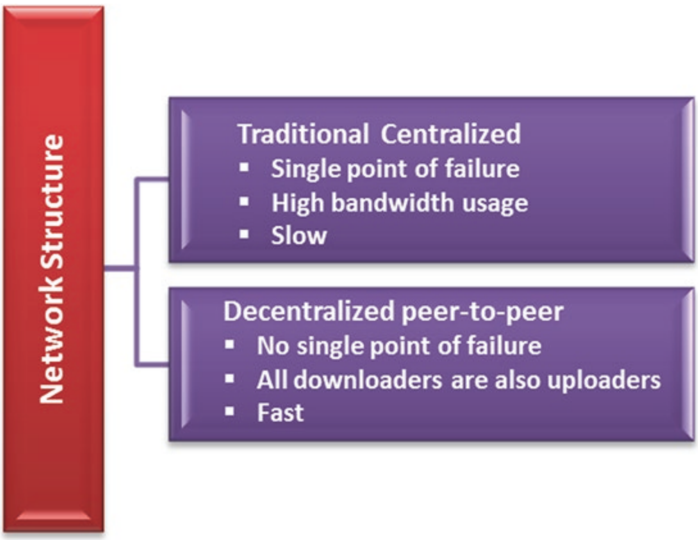

Fig. 3.2 Centralized vs. decentralized Peer-to-peer networks

Blockchain Basic Principles

In a recent article published in Harvard Business Review, the authors suggested five basic principles underlying the blockchain technology (Iansiti and Lakhani 2017):

1. **Distributed Database:** The ledger is replicated in a large number of identical databases. Each participant in a blockchain has access to the entire database and no single participant controls the data or the information. Transaction records of a partner can be verified directly without a need for third-party intermediaries.

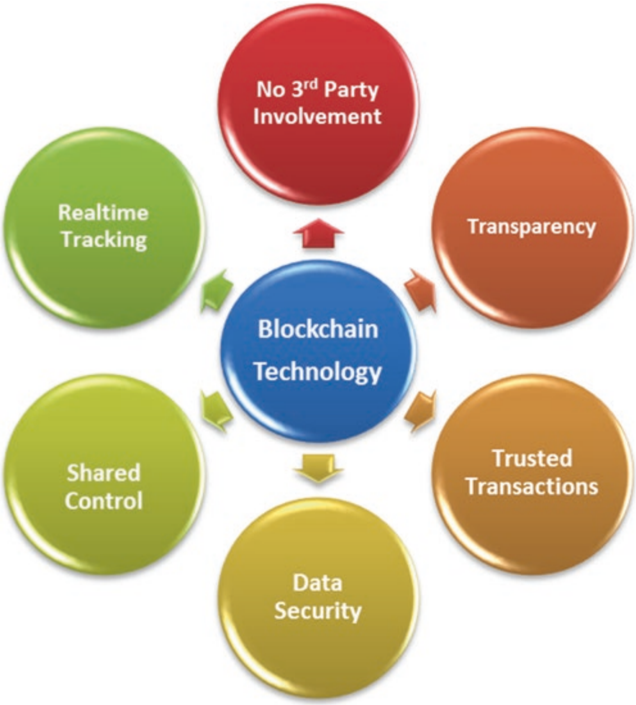

Fig. 3.3 Blockchain advantages and potentials

2. **Peer-to-Peer Transmission:** Communication occurs directly between peers without the need for central coordination. Peer nodes simultaneously functioning as both "clients" and "servers" to the other nodes on the network (Fig. 3.1).
3. **Transparency with Pseudonymity:** Transactions occur between blockchain addresses and are visible to anyone with access to the system. When changes are entered in one copy, all other copies are simultaneously updated. Users on a blockchain have a unique alphanumeric address that identifies them. Users can remain anonymous or provide proof of their identity to others.
4. **Irreversibility of Records:** Once a transaction is entered in the database, the records cannot be altered. Various computational algorithms are deployed to ensure that the recording on the database is permanent and available to all others on the network.
5. **Computational Logic:** The digital nature of the ledger means that users can set up algorithms and rules that automatically trigger transactions between nodes.

We added one more principle to the above list that underlines the technology:

6. **Transaction Speed:** Transactions on the blockchain-based system are completed and verifiable within seconds without human intervention.

Three Main Types of Blockchains

There are three main types of blockchain as described below:

- **Public blockchain:** These blockchains are intended to dispose of the requirement for a middleman and designed to be accessible by anyone with a computer and Internet access. Public blockchains are most applicable where a pure decentralized transaction is needed. Examples are Bitcoin blockchain and others like Ethereum, IOTA, and more. Some public blockchains limit the access to just reading or writing. Bitcoin, for example, uses an approach where anyone can write. These public blockchains are slow and resources intensive due to the computational capacity and power that's required to carry these redundant transactions, however, they are very secure (Pinto 2019).
- **Private blockchain:** In a private blockchain, a company sets up a permission network where all the participants are known and trusted. Access to the networking system is restricted. An invitation or permission needs to be obtained by the participants in order to join. The verification process may be allowed to be performed by only certain nodes through administrators (Pinto 2019). This is useful when the blockchain is used between companies that belong to the same legal entity. Private blockchain offers several benefits, including faster transaction speeds, privacy of the data/content, and a centralized control over providing access to the blockchain. Private blockchains are appropriate for more traditional business and governance models. For example, governments could use a private blockchain for voting polls and save billions at the same time because the voting becomes fully resistive against corruption and truly secure (Thompson 2016). Much of the private blockchain-based application is taking place in the financial services. NASDAQ, Bank of America, JPMorgan, the New York Stock Exchange, and Fidelity Investments are all testing private blockchain technology as a replacement for paper-based and manual transaction processing (Iansiti and Lakhani 2017).
- **Hybrid Blockchain:** This type of blockchain offers the benefits of both public and private blockchains. Hybrid blockchain consists of the public blockchain (that all participants are a part of) and a private network (permission or invitation-based) that restricts participation. Highly regulated enterprises and governments can benefit from a hybrid blockchain. The technology enables flexibility and control over what data is kept private versus shared on a public ledger. There are several real-life examples of hybrid blockchain. For example, XinFin is a hybrid blockchain built on both Ethereum (a public blockchain), and Quorum (a private blockchain). XinFin have completed a dozen pilots across supply chain logistics, aviation, and international trade, and finance settlements. Ramco Systems, a $1 billion global enterprise software company, provides XinFin hybrid blockchain solutions to its clients to implement blockchain-based supply chain logistic solutions (Freuden 2018).

The three main types of blockchains also have disadvantages. For example, a public blockchain draws a lot of computational power to maintain the distributed ledger. The electricity needed to run each transaction increases with every new node joining the network. Moreover, a public blockchain is very slow and wasteful compared to private blockchains. However, they are still very fast and cost efficient compared to the accounting systems used today (Thompson 2016).

Popular Blockchain Platforms

There are many popular blockchain platforms. Table 3.1 provides a list of some of the leading and most popular blockchain platforms and a brief overview of their applications (Purkayastha 2018; Sharma 2017). Some of these platforms are open source, which enables organizations and developers to speed up their development and reduce the initial development cost. The success of the open source Bitcoin blockchain technology has encouraged organizations to consider other open source blockchain platforms.

Blockchain Across Major Industries

Cryptocurrencies serve as only one of the ways that blockchain technology can be used. The technology has far-reaching applications and has the potential to disrupt existing technologies and services, shaking multiple industries to their very core. It is a technology that can handle all types of data and contracts. Blockchain has use cases in many industries where tracking information and executing contracts are needed. However, it is a widely misunderstood invention that has the capacity to change the digital world. Some label blockchain technology as the most important invention since the Internet (Mougayar 2016).

Blockchain technology has attracted the attention of many industries. The technology could potentially be used in trading and settlement applications, smart contracts relating to financial derivatives, real estate, bonds, music distribution, digital voting solutions, decentralized patient records management, identity verification purposes, banking fraud detection, land rights management, corruption control, etc. (Finasko 2017). Blockchain enables digital asset transactions with extremely low costs. This feature makes the technology ideal for micropayments for music, gift cards, loyalty points, and mobile games. Blockchain-based smart contract technology has the potential to facilitate and accelerate the contract management process. Blockchain can make the process of lending money faster and less complicated, without the involvement of any third party to scrutinize the paperwork and ask unnecessary questions

Table 3.1 Blockchain technology popular platforms

Platforms	Description	Type of Network
Ethereum	• An open blockchain platform that lets anyone build and use decentralized applications • No one controls or owns it • It is adaptable and flexible	• Public, Smart Contract-based
MultiChain	• A platform for the creation and deployment of private blockchains within or between organizations. • An enhanced version of the Bitcoin core software for private financial transactions.	• Private, Permissioned
Hyperledger	• An open source collaborative effort created to advance cross-industry blockchain technologies • Promotes a range of business blockchain technologies, including distributed ledger frameworks, smart contract engines, utility libraries, and sample applications.	• Both Private and Public
HydraChain	• An extension of the Ethereum platform that helps to create a permissioned attached to the distributed ledgers	• Private Chain
IOTA	• Based on a concept of blockless distributed ledger called Tangle. • A key enabler for machine economy and supports small nanopayments without any fees	• Public, Permissioned
Factom	• Blockchain-as-a-service (BaaS) platform that helps build blockchain capabilities into applications without cryptocurrency or infrastructure • Provides complete environments for exploration, prototyping, and production use cases	• Both Private and Public
IBM Blockchain	• Built on top of the HyperLedger project • Offers additional security and infrastructure facilities for enterprises.	• Peer-to-peer lending through bitcoin
Azure BaaS	• Microsoft Azure cloud offers an assorted set of blockchain platforms in the form of blockchain-as-a-service (BaaS) solution for enterprise class applications	• Both Private and Public
SAP Leonardo	• Includes some blockchain capabilities, and integrates them with other breakthrough technologies such as the IoT and ML	• Both Private and Public

Source: Purkayastha 2018; Sharma 2017

from the borrower. Another area where blockchain can be very effective is land title registration. As publically accessible and distributed ledgers, blockchains can make recordkeeping less costly and more efficient. A number of countries, including the Republic of Georgia, Sweden, and Honduras, have been experimenting with blockchain-based land registry projects (Bagley 2016). It is also argued that blockchain technology is reshaping the landscape of entrepreneurship and innovation by giving innovators the capability to create digital tokens to represent scarce assets. The technology gives innovators a new way to develop, deploy, and diffuse decentralized applications (Chen 2018). Larios-Hernández argues "blockchain entrepreneurship can generate semi-formal financial services that bring financial aspirations closer to people." He believes blockchain encourages a new type of inclusive entrepreneurship and is a suitable solution for financial inclusion of the bottom of the pyramid (Larios-Hernández 2017). In a 2017 report submitted to a quarterly meeting of the Federal Advisory Committee on Insurance, McKinsey & Company identified two major areas of blockchain applications (McKinsey and Company 2017):

- Recordkeeping: storage of static information
- Transactions: registry of tradable information

Additionally, the study identified several categories where blockchain is most applicable. Table 3.2 provides a summary of real-world examples and applications of this technology. The following chapters provide a brief overview of possible uses for blockchain technology in various industries.

Table 3.2 Real-world applications of blockchain technology across different categories

Categories	Description	Real-World Applications
Static Registry	• Manages registry of asset ownership • Provides automation on specific assets	• Tracking of containers during the shipping process • Gift and ownership • Digital assets (stocks, bonds, shares)
Digital Identity	• Stores, confirms, and distributes identity-related info • Easily revises personal data or other data	• Enables user to easily access proof of bank/credit card identity
Smart Contracts	• Creates and executes semi-autonomous contracts on distributed digital platform • Projects for implementation of confidential smart contracts	• Cash equity training • Insurance claim payouts • Music distribution • Self-executing wills • Hyperledger fabric
Dynamic Registry	• Exchange of physical and digital assets	• Streamlined low-transaction settlements to address liquidity mismatches in loans
Payments Infrastructure	• Efficient payment transfers with improved record keeping	• Peer-to-peer lending through bitcoin
Verifiable Data-Copyright Protection	• Low-cost notary services • Easy access to secure, dynamic information	• Events tickets • Storage of intangible assets • Protection of intellectual property • Registry of independent artists' work

Source: McKinsey and Company 2017

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Chapter 4
Financial Services: The Largest Blockchain Market

Financial Services

Blockchain technology could be used in the insurance, payments, and financial services industries to store property records, clear and settle accounts, and ensure the validity and execution of contractual arrangements. Blockchain enables contracts to be executed when special conditions are met or when a financial instrument meets a certain benchmark.

Blockchain improves the authentication and consensus about data integrity. Blockchain's ability to execute peer-to-peer share settlement almost instantaneously makes the technology appealing for stock trading. This could lead to the reduction of fees by clearinghouses and the removal of auditors and custodians (Bagley 2016).

R3, an industry consortium of more than 40 banks, was established to research and develop blockchain technology for financial applications and to invest in promising early-stage initiatives. R3 has identified use cases where blockchain solutions can lower infrastructure and regulatory compliance costs and provide value by making interoperability between internal systems easier. Numerous stock and commodities exchange organizations, including the Australian Securities Exchange, Frankfurt's stock exchange, and the Japan Exchange Group are experimenting with blockchain applications for services they offer (Velasco-Castillo 2016).

Similarly, McKinsey & Company analyzed how blockchain technology may disrupt a range of industries by the year 2020. The study emphasized the insurance and banking industries, and points out that the established banking industry is investing money in blockchain technology, expected to reach $400 million during 2019. By 2020, based on the current rate of evolution, McKinsey is expecting blockchain technology to reach its full potential and generate $80 billion to $110 billion in impact. More specifically, McKinsey highlighted seven use cases, referred to as "genuine use cases," that will be the most pursued and will generate the most revenue by 2020. These seven blockchain use cases focus on financial services

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Table 4.1 Financial services generating biggest revenues using blockchain technology

Sectors	Advantages	Net Gains/Savings
Trade Finance	• Lower costs • Speeds up turnarounds	• Revenue boost of $14 billion–$17 billion
Cross-Border B2B Payments	• Lower costs and fees	• Saving of $50 billion–$60 billion
Cross-Border P2P Payments	• Lower costs • Improves speeds	• Saving of $3 billion–$5 billion
Repurchase Agreement Transactions	• Lower operational costs • Lower systematic risks	• Saving of $2 billion–$5 billion
Over-the-Counter Derivative	• Reduces operational costs	• Saving of $4 billion–$7 billion
Anti-Money Laundering Management	• Reduces duplicated effort • Smooths the onboarding process	• Saving of $4 billion–$8 billion
Identity Fraud	• Fewer damage payouts • Happier customers	• Saving of $7 billion–$9 billion

Source: Parker 2017

applications. Their advantages and the net gains they are expected to generate are summarized in Table 4.1 (Parker 2017).

According to a WEF study, blockchain technology is not a panacea, but one of many technologies that could form a foundation for the next generation of financial services infrastructure. The technology has capacity to drive simplicity and efficiencies in financial services infrastructure and processes, as discussed below (WEF 2016):

1. **Operational Efficiencies:** Blockchain could reduce or eliminate the manual efforts required to perform reconciliation and resolve disputes
2. **Regulatory Efficiencies:** Blockchain simplifies and automates the compliance process, enabling real-time monitoring of financial activity between regulators and regulated entities
3. **Verification and Validation Efficiencies:** Blockchain disintermediates third parties that support transaction verification and validation, and could reduce clearing and settlement time
4. **Settlement Time Reduction:** Blockchain could remove friction and accelerate settlement by providing near real-time transfer of funds between financial institutions
5. **Fraud Reduction:** Blockchain could minimize fraud by establishing full transaction histories within a single source of truth
6. **Reduce the Need for Intermediaries:** Blockchain provides the ability to autonomously execute financial agreements in a shared and trusted environment
7. **Increased Transparency Between Market Participants:** Blockchain enables market participants, encompassing regulators and regulated entities, to have access to a public record of activity in the ecosystem in real time.

Global Trade and Commerce

Traditional trade financing is where financial institutions provide credit facilities in order to guarantee exchange of goods. The process is a centuries-old industry that has not seen much change with the growth of global trade flows. In the traditional trade process, release of funds is dependent on the delivery of documents and data to financial institutions, introducing the potential for human errors and fraud. In a recent report, Deloitte identified some of the challenges with traditional trade financing that increase transaction times and produce the real possibility of fraud (Deloitte 2017).

- Manual creation and distribution of contracts
- Significant version control of financing instruments as changes are made
- Delayed payments caused by multiple layers of verifications by multiple intermediaries
- Delayed timeline due to multiple checks by intermediaries and numerous communication points
- Duplicative documentation due to the inability of banks to verify their authenticity
- Miscommunication and the propensity for fraud due to existence of multiple platforms across countries

Blockchain technology has the potential to address some of these challenges and shortcomings. The technology could eliminate much inefficiency currently experienced in international trade. The benefits of lower costs and improvements to security through reduction of errors, risk, and time, enable a company to achieve greater efficiency and have more predictable working capital.

Deloitte has suggested a blockchain-based infrastructure that has the potential to drive efficiencies, reduce cost base, and open up new revenue opportunities, like newer models of credit and funding, guarantees backing the trade. Deloitte suggested the following advantages for blockchain-based trade financing (Deloitte 2017):

- **Real-time review:** Financial documents accessible through blockchain are reviewed and approved in real time. All parties work off same ledger, all online and instant. There are no physical documents or transportation. No risk of duplication or loss
- **Transparent factoring:** Blockchain provides a real-time and transparent view into accessed invoices on subsequent short-term financing. All supply chain partners update data in real time within one system
- **Disintermediation:** Blockchain does not require a trusted intermediary to assume risk, eliminating the need for correspondent banks
- **Reduced counterparty risk:** Blockchain tracks bills of lading, eliminating the potential for double spending
- **Decentralized contract execution:** Blockchain updates status in real time, reducing the time and headcount required to monitor the delivery of goods

- **Proof of ownership:** Blockchain provides transparency into the location and ownership of the goods
- **Automated Settlement:** Smart contracts eliminate the need for correspondent banks and additional transaction fees and reduces transaction fees
- **Regulatory transparency:** Regulators are provided with a real-time view of essential documents
- **Immutable data:** Verifiable and immutable data to reduce fraud risk

Recent commercial implementations of blockchain-based trade financing may be a good indicator of what is to come. In 2016, Commonwealth Bank, Wells Fargo, and Brighann Cotton pioneered blockchain-based trade transaction. The transaction involved the shipment of cotton from Texas to China using a blockchain technology. This marks another step in evaluating technology that, over time, could support the evolution of trade finance. While significant regulatory, legal, and other concerns remain to be addressed with the technology, the application of blockchain and smart contracts is a significant development towards revolutionizing trade transactions that could deliver considerable benefits throughout the global supply chain (CBA Media 2016).

Several companies including Fidelity Investments, Bank of America, JPMorgan, and the New York Stock Exchange are developing and testing blockchain-based technology and tools as a replacement for manual transaction in such areas as trade finance, foreign exchange, cross-border settlement, and securities settlement. NASDAQ is working with Chain.com, a blockchain infrastructure provider, to offer technology for replacing paper-based processing and validation of financial transactions. The Bank of Canada is experimenting with a digital currency called CAD-coin for interbank transfers. Finally, Stellar, a grassroots nonprofit organization, aims to bring affordable financial services to people who have never had access to them. Initially focused on Nigeria, Stellar offers its own digital currency, called lumens, and provides affordable financial services, including banking, micropayments, and remittances. It allows users to retain on its system a range of assets, including other currencies, telephone minutes, and data credits. (Iansiti and Lakhani 2017).

Insurance Industry

Insurance companies face competitive challenges such as poor customer engagement, limited growth in mature markets, and the growing trends of digitization. Blockchain technology offers potential advantages for the insurance industry, including innovating insurance products and services for growth, increasing effectiveness in fraud detection and pricing, and reducing administrative cost (Lorenz et al. 2016). The false claims and scams that happen every day in the insurance industry are causing companies huge losses. Blockchain can help insurance companies overcome issues like this, as it brings transparent information about transactions and creates a sense of trust. Since the data in the blockchain is trustable and is from

Table 4.2 Blockchain potentials for insurance industry

Sectors	Key Benefits	Potential Use
Product Development and Distribution	• Reduces commission and operations costs • Increases customer trust	• Offers P2P insurance • Offers smart contracts
Pricing/Underwriting	• Reduces operations cost • Includes external data for automatic pricing	• Offers on-demand/usage-based or micro insurances • Offers P2P insurance underwriting • Offer smart contracts
Payment and Collections	• Reduces costs • Increases speed for payments	• Automated payments through smart contracts
Claims Processing	• Lower average claims cost • Improves identification of claims events	• Automated claims handling with smart contracts or with sensors
Administration and Back Offices	• Reduces admin costs • Speeds up process for onboarding	• Onboarding of the new customers • Verification of policy-holder identity
Risk Capital and Investment Management	• Reduces admin costs • Increases reliability and auditability • Speeds up of financial transactions process	• Uses smart contracts to automatically determine payouts

Source: McKinsey and Company 2017

a verified source, underwriters can automate some aspects of underwriting, and lower costs and fees. Blockchain can also improve claims processing by taking inputs from a variety of different sources without tampering with any information. Insurers can use the data available in the blockchain to track the usage of an asset. Therefore, claims verification can be faster, less expensive, and more efficient.

Table 4.2 summarizes blockchain potentials for the insurance industry (McKinsey and Company 2017).

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Chapter 5
Manufacturing and Industrial

While the majority of blockchain applications are in the financial industry, interest in exploiting blockchain in the manufacturing industry is increasing. Blockchain technology holds a great deal of potential for a range of activities in the manufacturing industry and has the ability to radically change the face of manufacturing.

Distributed ledgers can be used in solving manufacturing challenges especially in supply chain management, including tracking containers during the shipping process and recording important product information throughout the supply chain. Consumer demands for better service levels, meaning having the right product on the shelves, are rising. The unending cycle of rising supply chain costs impacts the bottom line of all players involved. Manufacturers, retailers, and distributors have identified supply chain cost reduction as a critical issue to address. Additionally, excellent supply chain performance has strategic value that could lead to (Attaran and Attaran 2007):

- Rapid financial payback, often within months
- Improvements in productivity and profits
- Improvements in customer positioning and product quality
- Enhancements in long-term relationships with suppliers

Over the years, technologies such as GPS tracking, radio frequency identification (RFID), barcodes, smart labels, location-based data, wireless sensor networks, and cloud technologies have played a part in a digital supply chain to unify information, processes, monitoring, real-time inventory levels and customer interactions with the product.

The following sections provide overview of possible usage for blockchain-enabled technology in the manufacturing sector of the economy.

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Supply Chain Transformation in the Global Economy

Companies are challenged to keep critical products and supplies moving, manage inventory levels effectively, maintain productivity, and keep emergency transportation costs in check. Many companies continue to initiate supply chain improvement initiatives. The reason? The growing recognition that excellent supply chain performance has strategic value that could lead to:

- Rapid financial payback, often within months
- Improvements in productivity and profits
- Improvements in customer positioning and product quality
- Enhancements in long-term relationships with suppliers

Rising supply chain costs impacts the bottom line of all players involved. Moreover, Consumer demands for better service levels, which represent having the right product on the shelves, are rising. Excellent supply chain performance has strategic value that could lead to rapid financial payback, often within months and Improvements in productivity and profits (Attaran and Attaran 2007).

Sharing data not only improve efficiencies in the transaction process and the creation of a market but also enables tight collaboration between buyers and sellers. A growing body of literature examines the value of information sharing in managing a supply chain. More specifically, research has shown that information sharing can reduce the so-called "bullwhip effect" so often observed in supply chains (Attaran and Attaran 2007; Cachon and Fisher 2000; Chen et al. 2000; Iyer and Ye 2000). Similarly, other researchers study the value of sharing demand and inventory level information and examine the effect of collaborative forecasting on supply-chain performance (Cachon 2004; Aviv 2001, 2002; Taylor 2001; Song and Zipkin 1996). However, in many global supply chains, the processes in place are time-consuming and expensive. They don't always prevent growing problems such as counterfeit products, fragmentation and falsification of data, lack of transparency, extensive settlement times, and incorrect storage conditions. For example, the availability of counterfeit products is an extensive problem for major retailers. Research shows that fake products sold by five major online retailers—Amazon, Walmart, eBay, Sears Marketplace, and Newegg —can be harmful to your health. Of the 47 products purchased from these retailers, 20 were counterfeit (Hoffower 2018).

Supply chains are already transforming. The Internet has created a platform for buyers and sellers to evolve into collaborators. The following transformations are taking place that changes global supply chains (Rijmenam 2018):

- Consumer demands for better service levels are rising
- Wholesale companies are more and more selling directly to consumers
- e-Commerce companies, such as Amazon, are promising to same-hour delivery
- 3D printing is replacing physical inventory with digital inventory
- Organizations are moving from products to solutions
- Data security and cybersecurity are the major challenges to global supply chain

The above changes and transformation in the global supply chains are making them more complex than ever before. This requires new technologies to ensure the provenance and security of data and products across different countries. Blockchain technology enables organizations to develop new applications that can significantly improve the supply chain. Blockchain provides transaction transparency, data security, and seamless trust, resulting in reduced costs, more effective supply chains, and satisfied customers (Rijmenam 2018). Blockchain enables supply chain partners to share data in a more trusted way leading to improved collaboration. Blockchain will be truly transformative technology for the supply chain industry. The next section discusses in more details the positive contribution of blockchain technology in global supply chain.

Blockchain for Supply Chains

Blockchain technology has great potential in solving three supply chain issues: traceability and transparency, counterfeiting, and efficiency play (Somapa et al. 2018; Panetta 2018). Today's supply chains tend to feature a wide array of complex agreements and contractual obligations with orders being placed across multiple channels. This mix of manual and digital processes leads to data silos, workarounds, and limited transparency and, in general, inefficiency across the whole supply chain ecosystem. Blockchain technology introduces order, simplicity, trust, visibility, and automation to what otherwise is a chaotic environment. Blockchain dramatically streamlines paper-based processes while at the same time introduces greater security and visibility. The technology digitally models real-world relationships across the face of global supply chain ecosystem.

Blockchain can holds details of each component part and makes it accessible to each manufacturer in the production process. Blockchain enables firms to see across tiers in the supply chain, both upstream and downstream (O'Leary 2017). Blockchain serves as an alternative and can improve and speed up information sharing, and replace paper tracking and manual inspections systems that make supply chains vulnerable to inaccuracies (Williams et al. 2013; Gupta 2017). This potential for information sharing can be seen as a strengthening of the overall ability to control the supply chain and its activities. Blockchain helps to build and execute smart contracts, and creates trading-partner visibility and more efficient collaboration. Blockchain's peer-to-peer transactions eliminate the need for intermediaries, therefore reducing the cost of each transaction (Koonce 2016). The technology enables a single point of contact for data, eliminates the central authority needed to validate transactions, allows decisions based on total supply chain information, and enables collaboration with partners (Subramanian 2018). Additionally, blockchain record-keeping procedures that keep track of transactional data in a secure, verifiable, and permanent manner produce a chain of records and ownership that is much less vulnerable to fraud and cybercrime and difficult to hack and alter. The technology establishes trust among partners by ensuring that every transaction is recorded and stored in multiple locations across the entire distributed network. Administrative functions will be drastically reduced or eliminated due to the increased visibility of transactions and the potential to avoid non-value-adding activities. This, in turn, will increase supply chain efficiency and will reduce system complexity. Blockchain also builds comfidence into the journey of a product. Customers get to know about what the product is made of, where it came from, and its impact on the environment. Producers and retailers benefit from better product tracking and by empowering customers with this new information. Additionally, blockchain technology enables producers and retailers to get insight into exactly what customers want and can tailor their goods and services accordingly (Adams et al. 2017; Bridgers 2017; Seidel 2018; Shermin 2017; Watson and Mishler 2017). Figure 5.1 summarizes real-world examples of how blockchain is changing supply chain management (Singh 2018).

There are currently examples of companies that are using blockchain technology to improve supply chains efficiencies. For instance, the German-based personal care company Beiersdorf experimented with blockchain to create open pallet exchange. Information regarding pallets containing beauty personal care products are digitized daily. By scanning a QR-code, it is possible to send, receive, and settle the shipment of pallets. All the information processed manually is now recorded on a trusted distributed blockchain network. Sharing data in a trusted way saves time and leads to improved collaboration (Saxena 2018). In 2017, EZ Lab developed a platform for the wine industry called Carto. This platform is based on Ethereum. Farmers, vintners, and retailers are able to register with an encrypted digital signature so that consumers are able to verify what they are purchasing. This platform helps the wine industry prevent widespread

Fig. 5.1 Practical examples of blockchain in supply chain management. (Source: Singh 2018)

counterfeiting. The platform has been well received by the wine industry, and has processed over $200,000 worth of wine sales since 2017. In another example, Carrefour, a multinational retailer, is using an Ethereum-based blockchain platform to track the veracity and condition of free-range chickens. Unveiled in June 2018, customers scan a QR code on the packaging using their smartphone to access information about the chicken's birth and the time it was placed on the shelf. Finally, EY Global, a multidisciplinary professional service organization, created Tesseract, a transportation industry-focused blockchain to help further fractional vehicle ownership. Vehicles and trips are digitally logged on the blockchain and transactions are automatically settled between owners, operators, and third-party service providers. User can use this blockchain-enabled platform to track ownership, usage, and applicable payments across any combination of individual vehicles or fleets (Meisler 2019).

Blockchain for Logistics

Blockchain technology can also be used in logistics to reduce the paperwork, provide important information more rapidly, prevent shipping fraud, and dramatically reduce shipping costs. Few companies have recently tested the applications of blockchain in logistics. IBM and the shipping company Maersk concluded that blockchain efficiently tracks containers during the shipping process, thereby reducing the effort necessary for shipments (Sandner 2017).

Table 5.1 provides a summary of applications of blockchain technology in supply chain management (Sandner 2017; Groopman 2017).

Table 5.1 Applications of blockchain in supply chain management

Phases	Applications and Key Benefits
• **Product inception** • **Product development** • **Product distribution and transformation** • **Product trade financing** • **Product retail and use** • **Product recycling/ aftermarket** • **Contract handling** • **Automated storage management**	• Efficient tracking of containers across multiple constituencies • Accurate recording of all important product information • Supports security and compliance adherence • Provides transformation efficiency • Expedites reconciliation of the contract and the transfer of money • Improves anti-counterfeit measures • Inexpensive registration of digital assets • Easier contract handling giving faster transportation processes and cheaper products • Better successful delivery rate

Source: Sandner 2017; Groopman 2017

Internet of Things (IoT) Defined

The term "Internet of Things" was coined by Kevin Ashton, cofounder and executive director of the Auto-ID Center at MIT in 1999 (Rouse and Wigmore 2016). Among the earliest object with IoT is ATM machines dated back to 1974. The "Internet of things" (IoT) is the concept of connecting any device with an on-and-off switch to the Internet and or to each other. The term refers to devices that collect and transmit data via the Internet. This includes everything from cellphones, coffee makers, washing machines, wearable devices, and industrial equipment, such as car engines, jet engines, or an oil rig drill. The concept is based on a general rule that "anything that can be connected will be connected" (Fig. 5.2). IoT could be considered to be a giant network of connected people or "things". The connections are between things-things, people-things, or people-people (Morgan 2014). IoT consists of different devices including sensor-connected IOT devices, gateway devices, cloud, and analytics as shown in Fig. 5.3 (Gupta 2017).

IoT Technologies and Trends

Extreme market competition and a dynamic business environment have forced companies to adopt state-of-the-art practices to optimize both the cost and operational efficiency of their information technology platform. IoT has emerged as a differentiating factor in business competition in the past few years (2012 and beyond). According to some estimates, in the next 20 years, IoT will add $10–15 trillion to global GDP. According to a Cisco estimate, devices connected to the

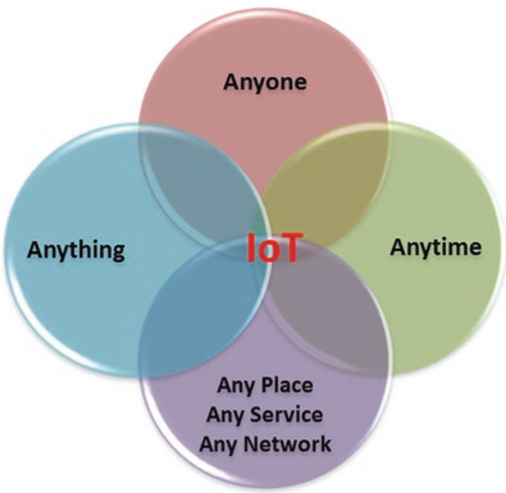

Fig. 5.2 Connected network of people and "Thing"

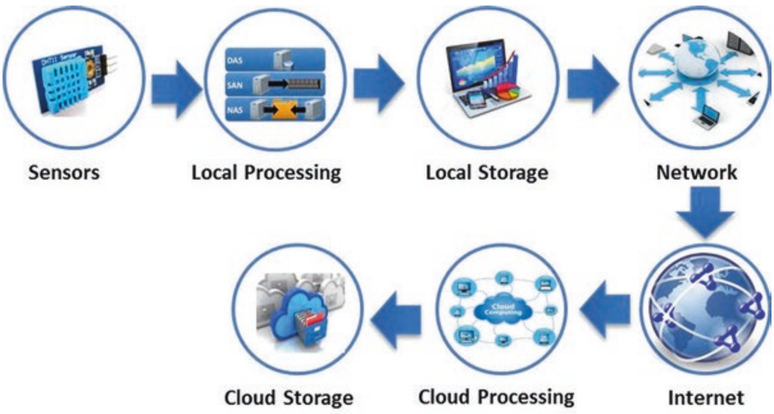

Fig. 5.3 IoT architecture

Internet were 500 million in 2003, 12.5 billion in 2010, 25 billion in 2015, and will be over 50 billion by 2020—that is up to seven connected "things" for every person on the planet (Evans 2011). Yet, according to another study conducted by marketsandmarkets, the IoT market size is estimated to grow from $157.05 billion in 2016 to $ 661.74 billion by 2021, at a compound annual growth rate of 33.3% from 2016 to 2021 (Mukherjee 2016). Nearly 6 trillion dollars will be spent on IoT solutions over the next 5 years. IoT has the potential to impact the way we work and the way we live. The widespread adoption of the IoT will take time, but the time line is advancing. According to another recent estimate, up to 28 billion devices will be connected to the Internet with two thirds of them being devices traditionally not Internet enabled, such as sensors, terminals, household appliances, thermostats, televisions, automobiles, production machinery, urban infrastructure and more (Banafa 2016).

IoT on the Verge of Mainstream Adoption

Today IoT-enabled devices have become broader, deeper, and cheaper. Readers and sensors are using less power, growing more intelligent, operating faster and at longer distances, and able to handle interference. This means better systems performance, greater capability to use sensors and tags with more data, and easier integration into existing systems without reprogramming. Sensors and tags are rapidly becoming cheaper (Attaran 2017b).

DBS Group Research has identified the Internet of Things (IoT), Artificial Intelligence (AI), Blockchain, and Augmented Reality (AR) as likely technologies to reach the mass adoption stage in Asia over the next 5–10 years (DBS Asian Insights 2018). According to theory of "Diffusion of Innovation," adopters of any new innovation can be categorized as Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. Based on the bell curve, the adoption is slow at the start, faster as adoption increases, and then leveling off until there is only a small percentage of a laggard (Rogers 2003). IoT achieved mainstream global consumer adoption rate of 14% in 2017. With growing uptake, the IoT is likely to reach an adoption rate of 18–20% by the end of 2019. By 2030, the global adoption of consumer IoT technology will reach 100% (DBS Asian Insights 2018).

There has been a tremendous growth in applications software in recent years. IoT is in its infancy, but the use cases will grow exponentially over the next few years as more and more devices become connected, opening new opportunities for innovation with smart products. In the past few years, technologies like Augmented Reality (AR), Industrial IoT (IIoT), edge computing, and Low Power Wide-Area (LPWA) were introduced that will shape the next stages in IoT development. AR enables IoT data in the form of text, graphs, images, and videos to be visualized using smart phones, tablets, or smart glasses. Today, most AR applications serve consumer markets. In the near future, the technology will be used in enterprise markets once AR technologies are paired with IoT and other application data (Attaran 2017b).

IoT technology is the driving force in our current industrial revolution, referred to as Industry 4.0. In Industry 4.0, industrial processes and the associated machines are becoming smarter and more modular, providing greater flexibility for meeting customer demand. The resulting systems could monitor, collect, exchange, analyze, and instantly act on information to intelligently change their behavior or their environment. Low-Power Wide-Area (LPWA) technologies will be suitable for application segments that only have batteries or energy capture for power, require low costs for connectivity hardware and services, and seek the simplicity of a wide area connection. All of these factors lower the total cost of ownership of IoT solutions and make the technology affordable for markets of asset tracking, agriculture, and environmental monitoring (ABI Research 2016).

Blockchain for IoT

Blockchain technology has enormous potential to help the Internet of Things. IoT devices collect megatons of data and information that needs to be processed and stored securely. Blockchain provides several great ways to help IoT. The technology eliminates the central hub and acts as a bridge between all IoT devices. It also allows for secure and robust communication with all connected devices simultaneously. An IoT-enabled blockchain could be used as a shared ledger to record shipping containers as they move through system. Additionally, blockchain technology solves the identification problem of IoT devices and reduces the vulnerability during this process (Gupta 2017). Using the blockchain, the device will remain protected through ownership rights that could easily be transferred to someone else. Both features reduce IoT costs and increase efficiency (Table 5.2).

Blockchain-based technology has many advantages for IoT as described below:

Table 5.2 Applications of blockchain in IoT and industry 4.0

Phases	Applications and Key Benefits
• **Device identification over blockchain** • **Elimination of the central hub** • **Communication with all connected devices** • **Protection through ownership rights**	• Acts as a bridge between all IoT devices. • Sensors that timestamp data on the blockchain and save them from manipulation • Reduces the vulnerability • Formation of marketplace to enable customers to sell their data from IoT devices • Platform to save IoT data on a private blockchain and share it with all business partners

Source: Gupta 2017

1. **Improving Reliability.** Blockchain technology is the missing link to improve scalability, privacy, and reliability concerns in the Internet of Things. Blockchain technology allows for significant savings to IoT-enabled industry by improving tracking of billions of connected devices, enabling the processing of transactions, and coordinating between devices. Additionally, blockchain's decentralized approach eliminates single points of failure and creates a more resilient ecosystem for devices to run on. The cryptographic algorithms used by blockchains, makes consumer data more private and secure (Banafa 2018).

Blockchain technology has the capability to not only automate the entire process, but also to make it significantly more effective through intelligent data collection. The technology is rapidly maturing and delivering on numerous organizational benefits.

By using connected IoT sensors, we can see where things are and determine their condition along every step of the way. Blockchain assisted by IoT can track everything within an indelible record. This allows for critical considerations within product safety and quality, for example, knowing if a shipment on time. Or if food, drugs—even wines— is being transported or stored at the correct temperatures. These technologies allow concerns to be addressed effectively (Meisler 2019).

2. **Dealing with IoT Deployment Challenges.** While the Internet of Things has enormous promise, there are also numerous challenges in applying IoT technology in a way that would allow for its significant and rapid growth. IoT provides many opportunities but also many concerns with many billions of devices being connected. As devices become more connected, security and privacy become the primary concern among consumers and businesses. The major challenges include technological maturity, global standardization, government regulations, and cost, as described below.
3. **Handling Big Volume of Data.** The amount of data that IoT devices might report back to a cloud server could easily overwhelm a relational database. Companies offering IoT-enabled devices need to be prepared to store, track, analyze, and make sense of the vast amounts of data that will be generated. The real value that IoT creates is at the intersection of gathering data and leveraging it. Big Data demand large-scale computing and storage infrastructures for

processing and data explorations. Cloud infrastructures are used for back-end computing and for the development of analytics for both scientific and business computing. Cloud-based applications are also used to interpret and transmit the data coming from all these sensors. However, it is anticipated that IoT's billions of connected objects will generate data volume far in excess of what can easily be processed and analyzed in the cloud, due to issues like limited bandwidth, network latency, etc.

Handling the enormous volume of existing and projected data within the IoT ecosystem is and the inevitable complexities of connecting to an unlimited list of devices is daunting. Managing IoT information at all levels is complicated because IoT data flows across many administrative boundaries with different policies and intents. The generation and analysis of data is essential to the IoT ecosystem. Consideration must be given to protecting data throughout its life cycle. The objective is to get data securely to the right place, at the right time, and in the right format. The existing security technologies are not robust enough in mitigating IoT risks. According to International Data Corporation (IDC) 90% of organizations that had implemented IoT, suffered an IoT-based breach of back-end IT systems by 2017 (Banafa 2018).

Blockchain could hold big volume data created by IoT in a secure, decentralized way that drastically reduces the chances of leaks or hacks. Blockchain validates data by using decentralized consensus algorithm and cryptography, making it almost impossible to manipulated because of the huge amount of computing power required. Chap. 10 of this book discusses in details how blockchain improves data security and reduces the chances of data breach and leakage.

4. **Collaboration, Communication, and Connectivity.** To work efficiently, IoT requires collaboration, coordination, and connectivity for each piece in the system, and throughout the system as a whole. This includes:

   - **Integration.** All devices must work together and be integrated with all other devices
   - **Communication.** All devices must communicate and interact seamlessly with connected systems and infrastructures in a secure way

The traditional centralized IoT network is expensive, time-consuming, and difficult to maintain and manage. Devices are connected, identified, and authenticated through cloud servers that provide huge processing and storage capacities. Traditional IoT solutions are expensive because of networking equipment, infrastructure, and maintenance costs associated with centralized clouds. The amount of communications that will have to be handled for the growing needs of the huge IoT ecosystems will increase those costs substantially. Moreover, cloud servers could be a bottleneck and a single point of failure that can disrupt the entire network (Banafa 2018).

Blockchain best helps IoT handle communication and connectivity. Blockchain technology can ommunicate with all IoT devices simultaneously. It can save money because it eliminates the central hub and acts as a bridge between all IoT devices.

5. **Security and Cyberattacks.** IoT is a wireless technology and poses potential security concerns. Among the risks are the compromise of data during wireless transmission, storage of data, and security of storage sites. IoT devices and services are turning physical objects that used to be offline into online assets communicating with enterprise networks. Therefore, they are prime target for cyberattacks on businesses. Security remains a primary concern for businesses contemplating IoT adoption.

The technology opens up companies all over the world to more security threats. IoT-enabled devices are vulnerable to hackings that could cause both companies and customers harm. IoT devices that aren't properly secured can be easily accessible to the outside world and create a wealth of opportunities for hackers, therefore, it is important to ensure that devices have a mechanism to recognize an attack. The following personal data could be at risk: location data, registration details (name, DOB, address, etc.), banking details, sensitive personal health information, contact details, viewing habits, life and health risks, habits and consumption, etc. Businesses will have to respond to new threats by broadening the scope of their security strategy. Gartner predicted that by 2017, more than 20% of businesses would deploy security solutions for protecting their IoT devices (Banafa 2018). IoT security market is maturing. According to Gartner, the IoT security market will grow to $3.1 billion in 2021. The five-year growth rate through 2021 is estimated at 28%. (Marsala 2018). Currently, there is no government regulation around the IoT and there is also no organized effort by manufacturers to make these devices more secure (Meola 2016). It is the responsibility of companies to embed methods of protecting critical information into technology architectures, business-model-innovation processes, and interactions with customers. IoT vendors have addressed security issues by employing a variety querying protocols, jamming, and other techniques.

Blockchain technology could help settle scalability, privacy, reliability concerns, and improve security of the IoT ecosystem. Blockchain can hold the big volume of data IoT create in a secure, decentralized way that drastically reduces the chance of hack or leaks. The technology would eliminate single point of failure and create a more resilient ecosystem for IoT devices to run on. The cryptographic algorithms used by blockchain technology would make consumer data more private.

6. **Privacy Issues and Government Regulations.** The use of IoT could have profound social implications. Without safeguards in place, IoT technology has the capacity to compromise consumer privacy and threaten civil liberties. Consumer groups have expressed concern over the privacy invasion that might result with widespread application of IoT-enabled devices. On December 6, 2016, a group of consumer watchdogs filed a complaint with the Federal Trade Commission over the My Friend Cayla doll and the i-Que robot both made by Genesis Toys. The doll and the robot are internet-connected toys that children can talk and interact with. The complaint claims the toys subject young children to ongoing surveillance, and unfairly and deceptively collect, use, and disclose audio files of children's voices, violating privacy and consumer protection laws. Furthermore, they claim that the children's recorded conversations are uploaded to Nuance, a

voice technology company that uses the recordings to improve the products it sells to military, government, and law enforcement agencies (Criss 2016).

When it comes to IoT privacy issues, Blockchain can be very helpful. Blockchain technology allows the user to make an informed choice about what is shared. Blockchain could be the key to proving identity, limiting how information proliferates, and therefore making information more secure. With existing technologies, there is always some central point of trust or authority that is prone to compromise, making the whole system insecure. Blockchain solve this problem by distributed file sharing and immutable record of the history of smart devices (Powers 2019).

Blockchain Role within the IoT Ecosystem

A decentralized approach to IoT, such as blockchain networking, would solve many of the problems and issues discussed above. A standardized peer-to-peer communication network can process hundreds of billions of transactions between IoT devices. The decentralized network will distribute computation and storage needs across the billions of devices that form IoT networks and significantly reduce the costs associated with installing and maintaining large centralized data centers. This will prevent failure in any single node from collapsing the entire network by supporting the following fundamental functions (Banafa 2018):

- Peer-to-peer messaging
- Distributed file sharing
- Autonomous device coordination
- Immutable record of the history of smart devices
- Consensus-driven timestamping
- Audit trails for troubleshooting purposes

Blockchain peer-to-peer network support all of the above functions. It is public, decentralized, immutable, and secure. It provides scalability, privacy, and reliability needed to secure IoT deployment. It is an ideal technology to become a fundamental element of IoT solutions.

The Combination of 5G and Blockchain Technology

The mobile industry is developing and preparing to deploy the fifth generation (5G) networks. The evolving 5G networks are becoming more readily available as a major driver of the growth of IoT and other intelligent automation applications. 5G systems are promised to be in the market by the end of 2019 and there are design innovations across diverse services. The 5G technologies include all type of advanced features which makes 5G technology most powerful and in huge demand in near future. 5G technology has a bright future because it has extraordinary data capabilities and has ability to tie together unrestricted call volumes and infinite data broadcast within latest mobile operating system (Bhalla and Bhalla 2010; Mishra 2018). The key enhancements are landline placement and more advanced antenna technology. Additionally, 5G systems provide enhanced mobile broadband, dynamic low latency, wider bandwidths, device-centric mobility, simultaneous redundant and reliable-device-to-device links, and shared spectrum.

5G's lightning fast connection and low-latency is needed for advances in intelligent automation—the IoT, AI, driverless cars, digital reality, blockchain, and future breakthroughs we haven't even thought of yet. Many of these technological developments will come to maturity when commercial 5G networks are widely deployed. As mentioned in this chapter, IoT devices will utilize Blockchain as a layer of security. Blockchain serves as foundational layers for these devices where they can leverage the security, decentralization, immutability and consensus arbitration of blockchains. The majority of IoT transactions and contracts occur on second-layer networks, with the opportunity to settle payment channels and transaction disputes on-chain. 5G enhances the network capacity of IoT. Furthermore, 5G will directly assist blockchains by increasing node participation and decentralization, as well as allowing for shorter block times all of which, in turn, further supports the IoT ecosystem (Whittle 2019; Sloane 2019).

Blockchain for Industrial Internet of Things

Industrial Internet of Things (IIoT) describes industrial transformation in the connected context of machines, cyber-physical systems, advanced analytics, AI, people, cloud, and so forth. IIoT (or Industrial Internet or Industry 4.0) consists of various smart sensors and devices distributed throughout industrial system to collect massive amount of data that can be used to identify bottlenecks, detect malicious behavior, and troubleshoot problems, consequently improving efficiency and control of the industrial process. IIoT is being applied in multiple industrial sectors, including manufacturing, logistics, transportation, energy, and utilities. However, IIoT implementation across various industries is not without its challenges. According to a 2016 IDC study, data integration and efficiency is the number one barrier to IIoT implementation. It is the eternal challenge of moving from data to business value that becomes clear in the IIoT context. Another executive survey by Morgan Stanly revealed that data security and cybersecurity were the major challenges to IIoT adoption (i-SCOOP 2017).

The convergence of IIoT and blockchains can potentially overcome the deficiencies of IIoT. Blockchain technology is transforming IIoT by enabling anonymous and trustful transactions in a decentralized and trustless environment. Consequently, blockchain-based IIoT platforms help to reduce system risk, alleviates financial fraud, and cuts down operational cost. Finally, blockchains are suitable for timestamp sensor data for industry IIoT applications. The Super Computing Systems

AG proposed the usage of sensors that can save and thereby timestamp their data on a blockchain. As a result, it can be ensured that the data was not manipulated afterwards and that all standards were met (Sandner 2017).

Blockchain is especially useful in a situation where IIoT data is used to trigger a transaction, especially if the transaction stems from the execution of a smart contract. Blockchain technology and IIoT can be used to streamline an otherwise manual and lengthy process. For example, Ondiflo is developing a Blockchain-based IIot platform for a water hauling application in the oil and gas industry. The IIoT sensors will be placed inside water tanks located on oilfields and will send a signal to a transmission box regarding the water levels inside the tank. The data will be pushed to a cloud, which in turn will feed the Blockchain network and triggers a smart contract, informing all stakeholders that it is time to either fill up or empty the tank (Roquefort-Villeneuve 2018).

Blockchain Role in Edge Computing

Another related technology that is also growing fast is edge computing or fog computing. Championed by Cisco, IBM, and Dell, client data is processed at the periphery of the network, as close to the originating source as possible. To enable quicker response time, intelligence is pushed from the cloud to the edge, localizing certain kinds of analysis and decision-making. The sheer number of networked devices in the IoT, growth of mobile computing, and the decreasing cost of computer components all are driving forces behind the move toward edge computing architecture. Since transmitting massive amounts of raw data over a network puts tremendous load on network resources, it is much more efficient to process data near its source and send only the data that has value over the network to a remote data center. You can leverage resources such as laptops, smartphones, tablets and sensors. The benefits include faster response time. Edge computing delivers the fast sub-second response times a centralized cloud platform cannot. The technology reduces the latency that arises when data travels significant distances between the user or the source of data and the application in the data center. Time sensitive data will be processed in an edge computing architecture at the point of origin or sent to an intermediary server located in close geographical proximity to the client. Less time sensitive data is sent to the cloud for historical analysis or long-term storage. Edge computing offers several advantages, such as improving time to action, reducing response time down to milliseconds, while also conserving network resources (Alvebrink and Jansson 2018). For example, edge computing plays a crucial role in real-time operating systems for Akamai Technologies, Inc. in Cambridge, Massachusetts. The company collects the data at an aggregation point close to the user and transmits in real time only the data points that require immediate attention. Less time sensitive data from a sensor is sent to a centralized data warehouse for analysis or storage (Laskowski 2015).

The emergence and applications of blockchain have significantly changed the way of data access and storage. As blockchain advances evolve in terms of scalability, privacy, efficiency, flexibility, availability, and high dependability, blockchain technology will play an important role for secure decentralization in edge computing. Furthermore, blockchain technology makes verification and monitoring of shared information entirely traceable and easily verifiable—a huge benefit for companies looking to improve monitoring and data control while sharing information on edge computing.

3D Printing Technology and Trends

Three-dimensional printing (3D printing), also known as additive manufacturing (AM) or rapid prototyping, has been around for decades. Instead of printing layers of ink on paper, a 3D printer uses materials to build a three-dimensional object (Berman 2012). The terms 3D printing and additive manufacturing have become interchangeable. The terminology "additive manufacturing" refers to the technology, or additive process, of depositing successive thin layers of material upon each other, producing a final three-dimensional product. Each layer is approximately 0.001–0.1 inches in thickness (Wohlers Report 2013). A variety of materials can be utilized, including plastics resins, rubbers, ceramics, glass, concretes, and metals (Bogue 2013). Most commercial 3D printers use a computer-aided design (CAD) to translate the design into a three-dimensional object. The design is then sliced into several two-dimensional plans that instruct the 3D printer where to deposit the layers of material. 3D printing technology has been in existence for over 30 years, but after the expiration of one of the technology's last patents in 2009, there has been tremendous industry growth, as well as huge advancements to make it more efficient and cost effective. 3D printing facilitates easy on-demand manufacturing of replacement parts. The technology makes it possible to have parts printed in remote locations by local distributors and service providers. Therefore, the delivery of goods is no longer a restriction. This results in shortening of the supply chain and saving, as shipping and stockpiling inventory is not necessary. The need for large bulk inventories will be outdated. In the past few years, many companies have embraced 3D printing and are beginning to enjoy real business benefits from the technology. The technology is maturing and is slowly reemerging as a valuable way to improve internal efficiencies. It is now one of the hottest and most interesting advancements in the design and marketing world today (Attaran 2017a).

The breadth and impact of 3D printing continues to expand as the technology gains acceptance and functionality, making it a feasible means of production in a variety of industries. While 3D printing is primarily used as a way to make low-cost prototypes and mockups, the technology is multifaceted and has many possible uses. There are two main categories of applications: rapid prototyping and component manufacturing (Bogue 2013). The application of either rapid prototyping or component part production across industries by means of 3D printing includes aerospace, automotive, medical, architectural, retail, service, and novelty industries (Attaran 2016).

While 3D printing is a breakout technology poised to change manufacturing for a variety of industries, implementation of the technology is only in its infancy. There are numerous challenges in applying 3D printing in a way that would allow for its significant and rapid growth. The major obstacles of implementing 3D printing are intellectual property (IP). Any product that is 3D printed will have some form of design on a digital platform. This increases the chance that the design could be leaked from the company. A digital design has a vast reach over the Internet; this was evident by the 100,000 downloads of the printable pistol (Bogue 2013). Once the design is obtained, it is very easy to print and resell the product. As access to the technology grows in the private sector, issues surrounding intellectual property will intensify as more people gain access to IP designs and the technology. When 3D printing gets to the stage where large amounts of products are being printed at home, additional considerations will need to be taken into account. One such consideration is who will be liable for malfunctions in the product? Does the liability fall onto the owner of the design, the manufacturer of the printer, or the individual user printing the product? (Royte 2013)

Blockchain and 3D Printing

Blockchain technology can greatly ease the deployment of distributed 3D manufacturing value chains. The technology enables low-cost, distributed, and assured integrity for contracts, product histories, production processes, and more. Blockchain technology can protect high-value design files from theft or tampering through end-to-end encryption. Blockchain smart contracts allow these files to automatically negotiate terms and conditions without the need for a middleman and can also automatically locate the most appropriate printer (Cognizant Consulting 2017). Moog Aircraft Group is example of a company that is using blockchain in combination with 3D printing to print aircraft parts exactly when they are needed, saving on inventory and logistic costs. Blockchain securely transfers the data to a verified 3D printer, enables authentication of the part, and helps technicians ensure that it was not counterfeit before the installation into an aircraft (Sandner 2017). Table 5.3 provides a summary of applications of blockchain technology in 3D printing (Sandner 2017; Groopman 2017; Cognizant Consulting 2017).

Table 5.3 Applications of blockchain in 3D printing

Phases	Applications and Key Benefits
• **Protection of design files** • **Validation of product information** • **Distributed and assured integrity for contracts** • **Assurance that the printer can precisely meet desired specifications** • **Secure transfer of data to a verified 3D printer**	• Protection of design files from theft or tampering • Allows automatic negotiation of terms and conditions without the need for a middleman • Automatically locate the most appropriate printer • Ensuring safe 3D printing of aircraft parts via blockchain • Reduced reliance on third-party participants

Source: Sandner 2017; Groopman 2017; Cognizant 2017

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Chapter 6
Government and Public Sector

Improving Record Management

Blockchain can help government activities across multiple use case categories as a static store of secure information or a dynamic store of tradable information. One area in which blockchain can help government is record management. National, state, and local governments are in charge of keeping up people's records, such as birth, passing dates, and property exchanges. Some of these records still exist in paper form. Modifying and updating these records is tedious, superfluous, and frustrating. Blockchain technology can rearrange the record-keeping and make the records more secure. Marriage, death, and birth certificates could be stored in the blockchain network, where one's data will be recovered safely. Decentralized file storage, where data is distributed throughout the network, protects files from getting hacked or lost. Many local, city, and state governments have shown interest in storing and managing government records on blockchain. For example, the states of Vermont and Delaware, as well as the city of Dubai, are planning to use blockchain technology for government records including property ownership records, utility bills, and permits (Van der Meulen 2018).

Blockchain and Smart Contracts

American computer scientist Nick Szabo proposed the idea of smart contracts in 1994 (Giancaspro 2017). Smart contracts are self-executing contracts with the terms of the agreement between buyer and seller being directly written into lines of code and exist across a distributed decentralized blockchain network. A smart contract resides on a specific place on the blockchain with a unique address. Nodes invoke the contract by sending cryptocurrency to the address and then the consensus

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protocol takes care of the verification process. (Luu et al. 2016). Ethereum is the biggest and most popular blockchain system that supports the use of smart contracts. Ethereum is an open system that encourages developers all over the world to develop new smart contracts (Li et al. 2017).

Smart contracts come with advantages as described below (Li et al. 2017):

- **No need for the third party.** The contracts can be verified without a legal authority
- **Improved traceability.** The information of smart contracts is stored on the blockchain as all other transactions, and the behaviors are recorded
- **Improved security.** The consensus protocol and private key cryptography makes sure that the smart contracts operations run safely and securely.
- **Decentralized development**. Many enthusiasts all over the world are working on improving smart contracts

Despite the advantages and promising possibilities of smart contracts, there are some risks and disadvantages. Hackers have successfully hacked blockchain systems in the recent past. There are reports of cybercriminals using smart contracts for money laundering, which is difficult to prove because of the anonymity of public blockchain systems. Another significant problem is scalability. As smart contracts are being adopted in multiple business areas there is a risk that the current computer infrastructure will have difficulty keeping up with the development pace (Li et al. 2017; Giancaspro 2017).

The implications of using smart contracts are fascinating for the economy. Contracts are important part of any business—from incorporation to buyer-supplier relationships to employee relations. Automating them will change traditional firm structures, processes, and intermediaries, such as accountants and lawyers, whose role would radically change (Giancaspro 2017). Smart contracts can be used for paying security deposits in an escrow system, as financial instruments, or autonomous governance applications. A blockchain notary service provides a secure and inexpensive proof of existence for written documents related to someone's work or for protecting intellectual property. Furthermore, smart contracts can protect copyright, eliminating the risk of file copying, and would speed up the sale of creative works online (Bagley 2016). Business or governments can use the smart contracts to bypass regulations and reduce the costs. Blockchain can also be used for digitalized passports. The technology provides secure storage of ID credentials. Individuals will need to provide minimum information for proof of identity. Additionally, blockchain can be used for identity and access management. The U.S. Department of Homeland Security (DHS) has used blockchain technology to effectively deliver a "single sign-on" experience (Van der Meulen 2018). New York City's Department of Homeless Services use cryptocurrency to securely administer help via credits for social or humanitarian aid (Panetta 2018).

Blockchain can also be used to create and store legally binding digital wills, leaving no questions as to who should receive what assets. Elections are expensive and difficult to monitor. Secure voting is another area where blockchain can help. The technology provides a fraud-proof, anonymous digital voting solution to help conduct fair elections. Sierra Leon was the first government to have used the technology for elections at a national level. The Ukrainian government has conducted blockchain pilots for regional elections and Brazil has shown interest in conducting national referenda using blockchain-enabled voting (Van der Meulen 2018).

Transparency in Government Services

There are examples of blockchain-enabled technology to improve transparency in government services. For example, Followmyvote.com is a peer-to-peer, election-voting platform that utilizes blockchain, offering full transparency to the whole election process. It is open source, cost-effective, and convenient, reducing opportunities for voter fraud and increasing turnout through improved accessibility to democracy (Singh 2018; Marr 2018). Finally, Democracy.earth is an open-source, peer-to-peer platform that aims to build democratically structured organizations—and potentially even states or nations—using blockchain tools. The advantages include liquid democracy, data ownership, and borderless governance (Singh 2018; Marr 2018). Table 6.1 summarizes blockchain applications in different sections of government.

Land Right Management

A number of governments around the world suffer from bad land registry records. There are hundreds or even thousands of years of land records, making keeping track of land ownership difficult. Factors contributing to the growing problems faced by land registry officials are:

- Discrepancies with the paperwork
- Forged documents and counterfeit titles
- Occasional loss of all documents

For developing countries notoriously bad land registry records, government corruption, the use of paper-only systems, and natural disasters all contribute to the growing problems faced by land registry officials in these nations. Blockchain-based technology is a cost-effective solution to these problems (Hamilton 2019).

The transparent nature of blockchain makes it an effective technology for use in public records systems, title registry, and land right management. Blockchain is more efficient, reliable and cost-effective than current models in use. It provides immutable records, secure access and storage, user friendliness, and operational simplicity. Blockchain technology allows users to easily secure the deeds of transactions by entering the details and uploading them on distributed document storage with immutable logs.

Table 6.1 Blockchain applications in government

Categories	Description	Real-world applications
Record management	• People's records, such as birth and passing dates, marital status, or property exchange can be recorded safely.	• Rearranges people's record-keeping and make it more secure for national, state, and local governments
Identity management	• Stores, confirms, and distributes identity-related information • Easily revises personal data or other data	• Individuals need to provide minimum information for proof of identity • Provides a secure and inexpensive proof of existence
Government services	• Improves transparency in government services	• Governments are using the technology to improve public safety, welfare, and transportation
Digital voting	• Provides anonymous digital voting solution to the whole election process to help conduct fair election	• Governments are using the technology to reduce opportunities for voter fraud and increase turnout
Smart property	• Creates digital assets such as stock, bonds, land titles, etc.	• Helps government to digitally record assets
Payments infrastructure	• Efficient payment transfers with improved record keeping	• Government agency can collect dues, taxes and other payments fast and safe
Copyright protection	• Low-cost notary services • Easy access to secure, dynamic information	• Protects copyright, eliminating the risk of file copying • Protection of intellectual property • Registry of independent artists' work

Source: Singh 2018; Marr 2018

Blockchain allows the user time stamp a particular document or service or ownership where, that time stamp cannot be changed. That is the major difference between a blockchain and a database. In a database, a record can be erased and the value can be changed without anyone knowledge because not all databases have an audit trail—there is no history of what was changed and when it was changed. Security against these types of abuses is a basic element of a blockchain, ensuring a truthful, historical record.

Propy is a real-life example of application of blockchain in land right management. Propy is a Silicon Valley blockchain-based startup company that deploys smart contracts on the blockchain. The company provides blockchain–based services, including deed registry and title registry. Blockchain deed registry secures the deeds of ongoing or closed transactions. Deeds are uploaded on distributed document storage with immutable logs. Blockchain title registry allows counties in the U.S. and across the globe to record a property ownership data on blockchain rather than conventional databases (Propy 2019). Blockchain land registry continues to be an area of huge development. Several states, including Wyoming and Vermont, have shown a growing interest in blockchain technology. In January 2019, Propy partnered with the clerk's office in South Burlington, Vermont to develop a secure distributed ledger of the city's property ownership information. Currently, the city spends thousands on storing and protecting these records, and is interested in the cost savings a blockchain-based system brings to the equation. Countries around the world recognize the undeniable advantages that blockchain technology provides to the land registry. Officials in India, Netherlands, Sweden, United Kingdom, Columbia, and Dubai are seeking to change land registry systems with the integration of blockchain technology to register land and property sales (Hamilton 2019).

Real-World Use Cases

The following section describes the real-world blockchain use cases and blockchain applications in different global governments (Marr 2018; Singh 2018):

1. South Korea. Samsung is creating blockchain solutions to improve transparency in government services including public safety, welfare, and transportation.
2. Estonia. The Estonian government is working with Ericson Company on an initiative to create a new data center to move public records onto the blockchain.
3. United Arab Emirates (UAE). Their goal is to become a first blockchain-powered state. In 2016, Dubai formed a committee of 30 government agencies to investigate blockchain-enabled opportunities across healthcare, shipping, business registration, etc. As discussed in Chap. 7, UAE is the first country in the world to use blockchain technology for organ donation.
4. United Kingdom: The UK Department of Work and Pensions is investigating using blockchain to create more transparent government services to record and administer benefit payments.

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Chapter 7
Healthcare and Life Sciences

Recordkeeping

Blockchain is suitable for any kind of digital data where shared write access for a number of parties is necessary and where authentication and consensus about data integrity are important. As publicly accessible ledgers, blockchain can make all kinds of recordkeeping more efficient and provides a solution to recordkeeping problems in the healthcare industry. Blockchain technology is being considered for securing healthcare records, DNA data, personal information, and, essential medical history information. Big hospitals can use blockchain to store details about patients' records. This way, patients and doctors can directly check those records anytime, anywhere through the network (Finasko 2017).

The number of hacked healthcare records and medical data breaches are on the rise. According to the HIPPA Journal, the number of reported breaches in healthcare industry rose from below 20 in 2009 to more than 350 in 2017. In 2018, hackers exposed sensitive medical records of 1.4 million patients from the UnityPoint Health hospital network. This was the largest medical data breach in the U.S. in that year. The hacked records included lab results, treatments, patient's social security numbers, and insurance information (Davis 2018). Blockchain technology provides data security and integrity and keeps private data out of the wrong hands.

Blockchain enables hospitals, financiers, and other parties in the healthcare industry value chain to share information without compromising data security and integrity. Better data collaboration between providers increases the probability of an accurate diagnosis and the likelihood of successful treatments, and enables healthcare facilities to deliver cost-effective care. In an IBM study of over 200 life sciences executives in 18 countries, 73% of those early adopters, called "First Movers" in the study, expect that blockchain will help them overcome bureaucratic processes and legacy systems that slow down their ability to innovate and adapt. First Movers

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Table 7.1 Blockchain potentials for healthcare and life sciences

Categories	Potential Use	Key Benefits
Patient	• Patient empowerment • Gives patients the opportunity to share their data securely across their healthcare providers	• Increases patient trust • Improves patient access to trusted data • Facilitates better collaboration • Increases transparency • Improves and personalizes the patient experience • Increases efficiency and reduces operations costs
Regulation and Compliance	• Compliance tracking • Smart contract-based check	• Establishes a trusted audit trail verifiable in real time • Establishes a platform to automatically enforce privacy regulations • Enables tracking of who has shared data and with whom, without revealing the data itself
Intercompany Process	• Transfer of funds • Medical devices supply chain • Temperature-controlled supply chains • Services	• Facilitates automated payments through smart contracts • Increases speed for payments • Provides full transparency of assets across the supply chain all the way to the patient • Brings all transactions into a single platform, making planning and compliance easier
Administration and Back Offices	• Revenue management	• Improves efficiencies in tracking and tracing areas where leakage occurs • Reduces admin costs • Increases reliability and auditability • Speeds up financial transactions process
Pharmaceuticals	• Verifies drug provenance • Creates an industry-wide, single source of aggregate information	• Tracks and traces pharmaceuticals • Helps prevent the transport and sale of counterfeit products • Makes it is possible to detect the full spectrum of complications related to pharmaceutical treatment

Source: IBM Institute for Business Value 2018

expect to have a blockchain network in production by 2020. They hope that the technology will bring them closer to the patient, in an industry where there is a widespread lack of consumer trust (IBM Institute for Business Value 2018). Table 7.1 provides a summary of applications of blockchain technology in healthcare and life sciences.

Pharmaceuticals

Pharmaceutical research communities can also use blockchain for securing medical and health-related supply chain data. Blockchain is seen as improving the ability to identify the origin and authenticity of medical products, which improves supply chain security (Bocek et al. 2017; Shanley 2017; Vecchione 2017). Blockchain also makes it possible to detect the full spectrum of complications related to pharmaceutical treatment, as controlled substance abuse is becomes more common.

Blockchain-based technology is used to share data in a more trusted way in pharmaceutical industry. Modum.io is a Zurich-based start-up company founded in 2016 that offers next generation solutions for supply chain intelligence and automation for a wide range of applications related to sensitive goods in various industries including pharmaceuticals. With the help of SAP Software Solutions and Swiss Post, Modum.io developed MODSense, a blockchain-based solution that offers temperature monitoring within the pharma supply chain for sensitive products. The solution can be to a wide range of things, including medical supplies, the cold-chain transportation of vaccines, clinical trials, medical samples, and perishable foods. Preprogrammed quality requirements are validated immediately and automatically. Data is immutable on the blockchain, managed securely and is easily accessible. MODSense ensures that the recorded temperatures cannot be tampered with and that stakeholders know how a certain product was handled during transportation (Modum 2019). In another example, the pharmaceutical company Bayer developed a blockchain solution to track materials through its supply chain ecosystem. The aim was to develop an easy flow of materials and information for a product, and work closely with suppliers and distributors to directly inform industry partners on potential product issues. The solution identified the whereabouts of product faster than usual and helped achieve a new level of efficiency and security within the pharmaceutical supply claim (Rijmenam 2018).

Public Health

Healthcare issues associated with opioid overdose have become epidemic. Blockchain technology can create an industry-wide, single source of aggregate information about any controlled substance purchase for each dispenser. With such information, the seller can use analytics to determine how many opioids are too many for a dispenser to order (IBM Institute for Business Value 2018).

Organ Transplant

Another example of how blockchain is transforming the healthcare industry is in the area of organ transplants. Organ transplants are complicated. Organs deteriorate quickly and donated organs must be from someone with a compatible blood type. According to University of Michigan Transplant Center, a heart or lung is usually transplanted in less than 10 h. Without an efficient system, lifesaving organs are going to waste. More than 120,000 people are on the waiting list for an organ transplant and 22 of those people, on average, die every day. Organtree is the world's first decentralized organ donation database company using blockchain technology to connect donors, patients, and healthcare facilities. Blockchain enables Organtree to increase the number of matches and make the transplants much faster and simpler than before (Organtree 2019).

United Arab Emirate (UAE) is the first country in the world that will use blockchain and AI for organ transplant. UAE partnered with Dhonor Healthtech, a leading national company focused on global healthcare blockchain solutions. The main objective is to provide a safer and optimized organ donation procedure. Further objectives are to build the standards that will improve the matching of organs with patients, organ verification, and transplant optimization using AI and blockchain. The plan is also to connect to seven hospitals across the UAE that provide donor transplant operations. Blockchain will ensure that organs being donated are verified using DNA that has already been uploaded onto the blockchain. Hospitals can verify that the DNA of the organ they have matches the DNA information of an organ donor on the blockchain. Blockchain and AI enable hospitals to optimize the process of matching organs from donor to patients (Abdul Malak 2019).

Figure 7.1 summarizes health-related Blockchain products (Marr 2018a; b).

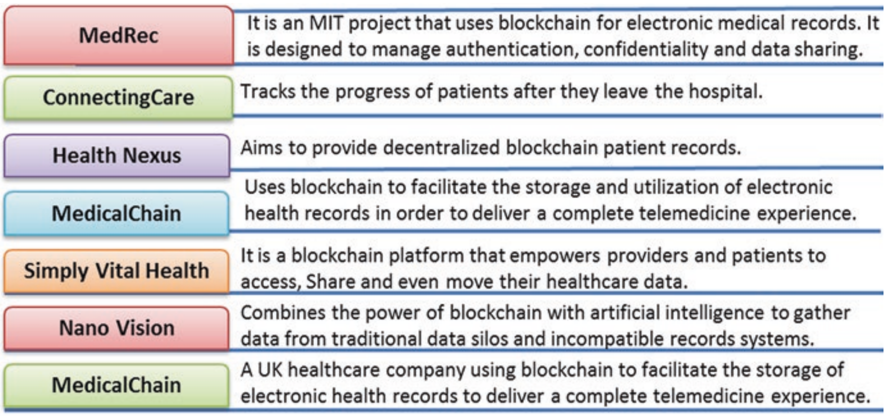

Fig. 7.1 Practical examples of blockchain in healthcare

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Chapter 8
Consumer Goods and Retail Industry

Improving Business Efficiency

Blockchain technology has large-scale implications and the capacity to greatly improve efficiencies for a range of activities in the retail industry. As discussed earlier, the most logical advantage of blockchain is expediting the transfer of funds between two parties. Blockchain makes it possible for retailers to accept cryptocurrency payments. The technology could remove excessive fees from banks by acting as third parties during transactions. It would also drastically speed up lengthy processing and settlement times, especially in situations where a payment is moving across borders. With banks removed from the equation, most customer transactions processed over a blockchain can be settled within a matter of seconds saving time and money for retailers. Finally, using smart contracts with blockchain could also mean instant payments, automated refunds, and more (Hodges 2017).

Blockchain can also be very effective in monitoring and improving transparency and efficiency for enterprise supply chains. The technology removes paper-based trails, enables retailers to locate items in real time, and pinpoint inefficiencies within supply chains quickly. Blockchain also makes tracking shipments easier. Every logistical stage of a product's journey will have real-time information, resulting in fewer stolen, lost, or damaged goods. The technology enables suppliers to track factors such as temperature and humidity throughout the shipping route (Accenture 2019; Hodges 2017).

Blockchain could further improve inefficient paper and card-based loyalty rewards programs offered by many retailers to incentivize consumers to return to a certain store to do their shopping. The technology creates a token-based system and stores these tokens within a blockchain, allowing retailers to use a digital currency that would be awarded with customer purchases. This eliminates the fraud and waste commonly associated with paper-based rewards programs (Williams 2018). Blockchain makes it easier to confirm consumer or employee identity for security

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reasons. The technology brings consistency and an accurate record to companies that have struggled to achieve this using traditional technology method. Table 8.1 summarizes blockchain technology implications for consumer goods and retail companies (Accenture 2019; Williams 2018; Hodges 2017).

Table 8.1 Blockchain use cases in retail

Categories	Potential Use	Key Benefits
Transparency	• Allows supplier, manufacturer, retailer, and end consumer to trace a product's journey	• Consumers could trace the origins and histories of products
Counterfeit Goods	• Reduces counterfeit goods	• More easily record stolen merchandise
Warranties	• Moves product warranties from paper onto the cloud • Keeps warranties up-to-date and easily transferable	• Consumers can maintain a virtual warranty wallet, saving retailers and manufacturers administrative work
Shipping	• Connects all parties of the international trading supply chain.	• Enables direct communications between involved parties • Enables retailers to locate items in real time • Allows for a direct exchange of documents between parties • Increase reliability and auditability • Pinpoints inefficiencies within their supply chain quickly • Reduces admin costs
Customer Loyalty Programs	• Boosts customer loyalty	• Allows consumers to store ubiquitous loyalty points within a single wallet • Points and rewards become easier to track and redeem
Cryptocurrencies	• Accepts cryptocurrencies for small businesses	• Great novelty payment method • Easy to accept
Payments &Fund Transfer	• Transfer of funds between two parties	• Transactions can be settled in seconds saving time and money for retailers • Removes excessive bank processing fees • Speeds up financial transactions process
Consumer Privacy	• Protects consumer privacy	• Stores consumer information in a single, decentralized, unhackable ledger

Source: Accenture 2019; Williams 2018; Hodges 2017

Real World Examples

The following are real-world examples of how blockchain is changing the retail industry (Singh 2018):

- Loyyal is an example of a blockchain-based universal loyalty platform that offers retailers sophisticated loyalty packages. The platform allows consumers to combine and trade loyalty rewards in new ways (Marr 2018a).
- OpenBazaar is a decentralized peer-to-peer e-commerce application that runs on a Bitcoin blockchain. It is a free online marketplace with no platform fees that uses cryptocurrency only. This opens a global marketplace to individual or small retailers. The platform allows users to create their own store, sell their items, and reach a new audience. Powered by blockchain, the platform offers full customization and peer-to-peer network. Using blockchain technology allows OpenBazaar to eliminate the need for banks or credit cards (Marr 2018a).
- Blockpoint can be used to create payment systems. The platform allows mobile wallet, loyalty program, gift cards, and other point-of-sale functionality (Marr 2018a).
- Warranteer is a blockchain-based application that allows consumers to access information regarding the products they purchased and get service in the case of product malfunction (Marr 2018b)

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Chapter 9
Food Industry

Evolving World Food Supply Chain

Urbanization and consumer habits of the millennial generation have increased the number of people buying and eating food prepared in public places. Globalization has triggered growing consumer demand for a wider variety of foods, resulting in an increasingly complex and longer global food supply chain. The industrialization of agriculture and animal production to meet increasing demand for food creates challenges for food safety. Climate change resulting in temperature changes modify food safety risks associated with food production, storage, and distribution. More and more people are becoming increasingly concerned as to the source of their food. In October 2006, multiple states in the U.S. suffered a major E-Coli outbreak where nearly 200 people were affected and three of whom died (World Health Organization 2017). Supply chains in the food industry are highly complex and can cross multiple national borders. Tracing food back to its origin can be a slow process, during which entire industries may shut down. Good collaboration between governments, producers, and consumers helps ensure food safety.

Food Safety Concern

According to World Health Organization (WHO), globally 600 million or one in 10 people fall sick each year as a result of poor food quality, and nearly half a million people die during that same period from a foodborne disease. In addition, while many people worldwide are still malnourished, nearly one-third of the food produced is lost or wasted. Children under 5 years of age carry 40% of the foodborne disease burden. It is argued that these diseases impede socioeconomic development by straining healthcare systems. Similarly, safe food supplies support national

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economies, trade, and tourism, as well as contribute to food and nutrition security. Good collaboration between governments, producers and consumers helps ensure food safety (World Health Organization 2017).

Blockchain Solution for Food Management

There are many issues with existing food supply chains, but blockchain can be a solution to solve these problems by tracking the transport of food products from origin to supermarket. Blockchain technology can greatly enhance food traceability and reduce time wasted by dealing with endless red tape and hierarchy. Blockchain digitally connects and keeps digital product information, such as farm origination details, batch numbers, factory and processing data, expiration dates, storage temperatures, and shipping detail along every step of the process. Each piece of information provides critical data points that could potentially reveal food safety issues with the product. When the information captured in each transaction is agreed upon and there is a consensus, it becomes a permanent record that cannot be altered. This helps assure the accuracy of the information. Blockchain can also help retailers better manage the shelf life of products in individual stores. The technology is considered as a potential enabler of transparency and traceability with the ability to increase product integrity, minimize fraud, and maximize consumer safety (Williams 2018; Coyne 2017; Yuva 2017; Arnold 2017).

Big shopping chains like Walmart are trying to incorporate the blockchain into its food management system. As an example, Walmart used blockchain to trace a package of mangoes back to the farm of origin. Where traditional methods of manual tracking would have taken almost 7 days, using blockchain the process took 2.2 s. (Arnold 2017).

OriginTrail is an example of a blockchain platform in the food industry that lets consumers know where their purchases came from and how they were produced (Marr 2018).

The advantages of using blockchain in food systems are as follows (Blockgeeks 2018):

- Enhances food safety
- Ensures fresher food
- Reduces food waste
- Stops food fraud
- Promotes responsibility among the food producers

To help improve food industry supply chain ecosystems, SAP Software Solutions launched a farm-to-consumer blockchain initiative together with 10 customers to improve material provenance and traceability. One such company is Kellogg's, which wants to ensure food quality and safety along with achieving full transparency within the industry. Blockchain has the potential to improve how products move from farm to plate, offering upstream and downstream provenance and genealogy. Full transparency and traceability enable peer-to-peer collaboration among industry partners and improve food safety (Saxena 2018).

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Chapter 10
Blockchain and Cybersecurity

The Rise of Cybersecurity Threats

Computer exploitation is on the rise. Advanced adversaries are becoming more capable and destructive. Organizations must become increasingly effective at mitigating their information security risks. Effective cybersecurity is more important than ever as immeasurable amounts of personal and potentially incriminating data are currently stored in websites and social media platforms. The Internet is full of powerful hacking tools and hackers are using them extensively to cause damage to individuals and organizations. Attacks are becoming stealthier, having a greater financial impact, and causing broad damage. Reports of organizations being hacked and suffering reputational damage have become commonplace. According to Symantec, cybersecurity threats in some categories rose to 600% in 2017 (Symantec 2019). A continuous stream of cybersecurity breaches in 2017 underscores our inability to provide adequate security for our online information. Organizations are spending significant time, financial, and human resources to combat cyber threats and combat cyberattacks, however some companies are still getting compromised. The traditional prevention approach to security architecture has failed to prevent hackers from intrusions. Blockchain technology is that proactive approach to security needed to enhance the capabilities of organizations to detect and prevent threats that will inevitably slip through existing defenses.

Americans are increasingly installing the smart home devices like Google Home and Amazon Echo, thermostats, doorbells, and other household devices. These devices connect to the Internet and can be controlled and monitored remotely via smartphone apps. According to a data report, the number of smart speakers like Amazon Echo and Google Home installed in U.S. homes almost doubled—from 36 million in 2017 to 66 million in 2018. The majority of owners use these speakers to stream music or answer questions. Nearly 40% are used to help control owners'

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connected smart homes. Of U.S. smart speaker households, 35% owned multiple devices in 2018 (Kinsella 2019).

These smart home devises are providing unprecedented convenience for homeowners on the go, but they also represent new frontiers for Internet hacking. While there are no statistics about the number of smart devices that have been hacked, experts anticipate the problem will grow along with the proliferation of smart devices. There are numerous reports of hacked smart home devices. According to the Chicago Tribune, in January 2019, a Lake Barrington, Illinois couple overhead a male voice speaking to their 7 month-old baby through the baby monitor. They also noticed their Nest thermostat had been cranked up to 90 degrees. Then the same man's voice began yelling vulgarities at them from the downstairs Nest security camera. It turned out that the couple's devices had been hacked, giving the hacker almost full control (Marotti 2019). The hacker could watch, listen, talk, and change the temperature via devices on the network. This is just one example of the dangers that occur as the smart home devices expand and security concerns around it multiply.

There are several reasons why home devices may be vulnerable to hacking (Marotti 2019):

- These devices are designed for convenience. Manufacturers are concerned about implementing security steps that consumers may find frustrating.
- Manufacturers are not as well versed in how to securely connect their device to the Internet.
- Some consumers fail to follow the security steps for connecting the device to the Internet and adequately securing them.
- Most consumers are not considering these devices as something that needs protection the same way laptops or smartphones do.

Blockchain and Cybersecurity Risks

Blockchain technology can reduce cybersecuity risks in different ways. The technology provides a hack-proof authentication that protects user and company data from cyberattacks. It provides data integrity in the financial industry that both stakeholders and regulators need. Supply chains such as pharmaceuticals, electronics, diamonds, and luxury items need transparency to work correctly. Blockchain improves transparency in supply chains, can identify counterfeits, and provides a global solution.

The most promising blockchain real-world cybersecurity use cases are listed below (Singh 2018; Marr 2018).

- **GuardTime.** A cybersecurity blockchain project that aims to create "keyless" signature systems to secure the health records of one million Estonian citizens.

- **REMME.** A cybersecurity blockchain project with the goal to improve the current standards of security for both users and companies by replacing logins and passwords with SSL certificates stored on a blockchain.
- **Blockverify.** A blockchain-based anti-counterfeit solution to identify counterfeits and offer a non-duplicate environment. It also provides the integrity required to run the supply chains with 100% transparency. Blockverify is used for electronics, pharmaceuticals, and luxury items.
- **PeerNova.** A blockchain-based technology that provides financial institution a way to verify and secure data, and address their audit, reconciliation, and compliance.

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Chapter 11
Data Management

Big Data

The term "big data" was coined in mid-1990s and is defined as collections of data so large, complex, and dynamic that they exceed the processing capacity of the conventional database architectures of organizations (Weiss and Indurkhya 1998). According to Gartner, the world's leading information technology research and advisory company, big data is comprised of high-volume, high-velocity, and high-variety data (the '3 Vs', as shown in Fig. 11.1 (Gartner IT Glossary 2019). These data sets are too large to be handled easily and flow in and out with excessive speed, making them difficult to analyze. The range and type of data sources are too great to assimilate (Diebold 2012).

The typical organization is therefore challenged in managing big data effectively, as it simply does not fit into the strictures of current database architectures. At the same time, big data draws from multiple sources and transactions and contains valuable patterns and information. The act of gathering and storing large amounts of data for eventual analysis is not new. Since the 1950s, businesses have been using basic analytics to uncover hidden patterns and trends, show changes over time, and confirm or challenge theories (Asllani 2015). As enterprises amass broader pools of data in big data platforms, they have increased opportunities to mine those data for predictive insights. As they cannot manage the data effectively with their current database architecture, they need to seek alternative ways to process the volume (Bayrak 2015). A well-defined data management strategy is essential for the successful use of big data in corporations (Bughin 2016). Data and analytics are playing increasingly important roles in improving competitive advantage (Taylor 2012), and corporations see big data and the ability to analyze it as an important driver of innovation and a significant source of value creation (Tan et al. 2015).

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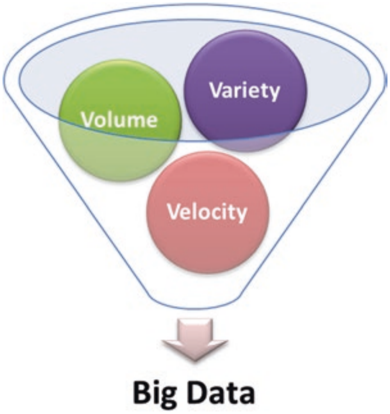

Fig. 11.1 Big data defined

Blockchain for Big Data

Blockchain is changing how the world approaches big data, and its technology could be well combined with big data. Blockchain could be used to store important data and ensure that the data is original as it is distributed and secured. Additionally, user trading patterns and transactions on blockchain could be extracted and used for big data analytics. Finally, as more and more blockchain applications for different fields are appearing, traditional industries could make use of blockchain to improve performance.

Blockchain can be used internally as a database for applications like managing physical and digital assets, recording internal transactions, and verifying identities. This may be an especially useful solution for companies struggling to reconcile multiple internal databases.

Blockchain is one of the fastest growing technologies to help secure and protect data through cryptography. The technology can be used in any market, sector, or application that needs to securely exchange data in a decentralized format.

Contracts, transactions, and the records of them are among the defining structures in our business, legal, and political systems. They govern interactions among nations, organizations, communities, and individuals. These critical tools—and the bureaucracies formed to manage them—have not kept up with the economy's digital transformation. Blockchain technology has the potential to solve this problem (Iansiti and Lakhani 2017).

International Data Corporation (IDC) estimated that worldwide revenues for big data and business analytics will grow from $130.1 billion in 2016 to more than $203 billion in 2020, at a compound annual growth rate (CAGR) of 11.7%. According to IDC, blockchain spending will rapidly expand during 2017–2022 forecast period, with a five-year CAGR of 73.2%. IDC further expected worldwide blockchain spending to reach $1.5 billion in 2018—double the amount spent on the emerging technology during 2017 (Rengegowda 2018).

The real value of data on the blockchain is the quality of data and how it is stored on the public ledger. *Blockchain technology* gives greater confidence in the integrity of the data we use. The technology provides immutable entries, consensus-driven timestamping, audit trails, and certainty about the origin of data. That means data will become far more valuable since it is being captured and validated on the blockchain. Path is an example of a blockchain platform that helps companies improve the data sets they analyze and leverage for their products and services. Using a Path platform, a company is able to get deeper insights into how its website performs around the world, or how long it takes for its application to load, how cluttered its network gets at certain hours of the day, etc. (Cole 2018).

Currently, the most transformative blockchain application is smart contracts. Smart contracts are self-automated computer programs that can carry out the terms of any contract. They are automated contracts and self-executing with specific instructions written in its code that get executed when certain conditions are made. Although smart contracts come with many advantages, we are decades away from widespread adoption. They will not be effective without institutional buy-in and a high degree of coordination and clarity on how smart contracts are designed, verified, implemented, and enforced (Iansiti and Lakhani 2017).

Cloud Computing Technology (CCT)

The term "cloud" is used to refer to different types of platforms for distributed computing—a cluster of servers, network, software, interface, etc. that users require to execute a particular task. "Computing" refers to the delivery of this package as a service that users can utilize as they wish (Attaran 2017). The user does not need to own a massive computing infrastructure. Rather, the user can utilize a similar infrastructure owned by a third party, and pay only for the amount of computing needed. This pay-per-use model allows convenient, on-demand network access and timesaving in building huge computing infrastructure. This enables the user to concentrate efforts on critical business activities (Mell and Grance 2011). The user accesses information online in a 24/7 format from a variety of devices—desktop, laptop, tablet, and smartphone (Bask 2015)

The National Institute of Standards and Technology (NIST) describes five characteristics of a cloud-computing model. (Mell and Grance 2011):

1. **On-demand self-service.** Server time, network storage, and other computing resources are obtained and configured, as needed. No human interaction with the service provider is required
2. **Broad network access,** The service is accessed over a network using multiple platforms (e.g., mobile phones, tablets, laptops, and workstations)
3. **Resource pooling.** Resources are pooled to serve multiple users. No user has exclusive use of the underlying hardware or software resources. According to demand, physical and virtual resources are assigned and reassigned dynamically

4. **Rapid elasticity.** Resources scale rapidly up and down with demand, since they are elastically provisioned and released
5. **Measured service.** Metering is used to automatically optimize resource use (e.g., storage, processing, bandwidth, and active user accounts). There is a direct relationship between use and cost.

According to a 2016 Gartner report, CCT is perhaps the most promising and anticipated technology to come around in a number of years (Smith 2016). For some businesses, making a heavy move toward a cloud structure is a way to significantly cut hardware costs. For others, CCT streamlines operations and speeds up development cycles. Properly planned and implemented, CCT has the potential to drastically improve operational efficiency of businesses.

Cloud-Based Blockchain

In the past few years, centralized proprietary services offered on the Internet are being replaced with decentralized open ones—inefficient monolithic services replaced with peer-to-peer algorithmic markets. Blockchain technology first decentralized money with bitcoin and is now moving ahead to decentralize other aspects of business process. The technology is being used to scrutinize every process and application in various industries in order to improve them. As a result, decentralized storage networks (DSN) are emerging to challenge the giant traditional cloud storage companies like DropBox, OneDrive, and Amazon. These companies have relied on centralized services where clients give up sovereignty of their data and are at the companies' mercy. DSN aggregates storage offered by multiple independent storage providers and self-coordinates to provide data storage and data retrieval to clients. With the rise of decentralized cloud storage services powered by blockchain, the days of stress over data theft, hacking, and copying clients' data and selling it elsewhere will be gone (Khatwani 2018).

Blockchain-based technologies have proven the utility of decentralized transaction ledgers. They liberate data from silos, work offline, route around censorship, and gives permanence to digital information. Blockchain technology can help business simplify complex business processes and stay ahead in the industry. Blockchain enables financial services, manufacturing, healthcare, government, and retail to realize the potential of blockchain capabilities in the cloud. Those include faster and more secure transactions, streamlined and automated back office operations, and reduced costs.

Blockchain technology offers great data integrity advantages for big data, including:

- Greater confidence in the integrity of the data
- Immutable entries
- Consensus-driven timestamping

- Audit trails
- Certainty about the origin of data

Beyond data integrity, the inherent immutability that blockchains offers leads to more confidence in training and testing data and the models they produce. Additionally, blockchain-based technology could make an impact in the cost of storing data and in the amount (and quality) of data available. Cost savings in data storage will come from the disintermediation of centralized cloud storage providers. This should also create downward pricing pressure on software-as-a-service (SaaS) providers as they move to decentralized storage providers. This decentralized approach could reduce the costs of storing data by 90% compared to Amazon Web Services (AWS) (Epstein 2017). Beyond data privacy and security, if the data center's power goes down or data become corrupted, the blockchain's algorithms ensure data is distributed widely enough to maintain high availability (Mallon 2018).

Cloud-based blockchain services are emerging from both start-ups and large platforms like Amazon and Microsoft (Iansiti and Lakhani 2017). Microsoft's blockchain as a service (BaaS) platform is backed by Microsoft Azure, which provides hybrid cloud capabilities, extensive compliance certification portfolio, and enterprise-grade security. Other decentralized solutions like Storj, Sia, MaidSafe, and FileCoin are starting to provide services in the enterprise storage space (Epstein 2017). Some of these decentralized cloud storage solutions offer a single trading platform and a marketplace for hosts to rent out extra space on their personal computers to clients who wants to use it.

In the future, public blockchains will ultimately defeat private blockchains. The technology has the potential to move us from proprietary data silos to blockchain-enabled shared data layers. In this scenario, the power of those who owned the data will shift to those who can access the most data and who can gain the most insights most rapidly (Epstein 2017). When data moves onto open blockchains, having the data is no longer a competitive advantage. Interpreting the data becomes the advantage. Additionally, customer data will not belong to organizations, it will belong to each individual and the customer of the future will grant access to others as necessary (Epstein 2017). A massive amount of storage space is unused in data centers and hard drives around the world. Using blockchain technology, companies can tune their storage strategy to suit their needs, creating a custom balance between redundancy, speed of retrieval, and cost.

Some companies specialize in combining big data and blockchain to bring all the benefits of decentralized systems, while also offering new insights and increased profits to businesses. Table 11.1 summarizes examples of blockchain-based decentralized data storage providers that are delivering savings for big data and competing with traditional cloud storage solutions (Mallon 2018; Kh 2019).

Table 11.1 Big data blockchain-based projects

Company	Services Provided
Omnilytics	• Combines blockchain with big data analytics • It uses artificial intelligence (AI) and Machine Learning (ML) with marketing, trend forecasting, auditing, and applications
Datum	• It is a decentralized storage network • Enables individuals to monetize their own data in an open marketplace
Storj	• It is a decentralized data storage provider • Provides saving for big data in comparison to traditional cloud storage companies • It is the largest, cheapest, and most secure cloud service • Does not create a free market space for lending client extra space
Sia	• It is a decentralized peer-to-peer cloud storage solution that aims at reducing cost and increasing the security of stored data • It creates a marketplace for hosts and users via the token economics of Siacoin • Hosts can rent out extra space on their PC to the Sia decentralized network and get paid in Siacoin. Similarly, client who want to use space pay Siacoins to a host
Filecoin	• It is a decentralized storage network that turns cloud storage into an algorithmic market • Miners earn Filecoin by providing storage to clients. Clients spend Filecoin hiring miners to store or distribute data
Rublix	• Aims to unite cryptocurrency investors across the world • Offers a simple trading platform that verifies the authenticity and credibility of traders • Provides access to market information to reduce the current market confusion
InboundMuse	• It provides a wide range of services related to artificial intelligence and blockchain • The company has domain expertise in finance, digital marketing, and recruitment
Hidden Brains	• Provides expertise in healthcare, real estate, logistics, education, energy, and other industries

Source: Mallon 2018; Kh 2019

Monetizing Big Data

Many of the world's largest tech companies are looking to collect behavioral data during regular customer interaction with their products. This information is collected from monitoring social media and the way customers use their web pages. Companies perform analytics to draw insight from this data and to develop a plan of action to streamline the client's experience. Blockchain can also be a link for big data processors. The technology created a system where content creators are able to sell content without needing a central authority to monitor it. Companies that create large amounts of data are able to profit from it directly by setting their own prices and selling it to firms who need it (Piletic 2018).

Big Data Analytics

Analytics, in the form of business intelligence, is defined as a set of technologies, processes, and tools that use data to predict likely behavior by individuals, machinery, or other entities. By using the right analytics, big data can deliver richer insights and uncover hidden patterns and relationships. More data could translate into more possibilities for a business only if it can discover the meaning inside of it (Minelli et al. 2013).

Since the 1950s, decades before anyone used the term big data, businesses were using basic analytics to uncover hidden patterns and trends, show changes over time, and confirm or challenge theories. The new benefits that modern data analytics brings to the table are speed and efficiency. The ability to work faster—and stay agile—gives organizations a competitive edge. Over the past decade, data exploded and became big, and business intelligence has been revolutionized. Widespread access to the cloud, insightful data visualizations, interactive business dashboards, and rise of self-service analytics made the technology available and affordable for businesses of all sizes. Suddenly advanced analytics is not just for the analysts (Gaitho 2017). Analytics is commonly used in finance, marketing, human resources, healthcare, government policies, and every industry where data is generated (DeAngelis 2015; Decker 2017).

The past few years have seen an explosion in business use of analytics. Corporations around the world are using analytical tools, including business intelligence (BI), dashboards, and data mining to gain a better understanding of their present customers and to predict the needs of those who will potentially become customers. With the help of new analytics tools, enterprises can leverage big data analytics to drive a host of business objectives, from streamlined operations to improved customer relations (Henke et al. 2016). In fact, big data analytics will transform virtually every business activity, and bring businesses benefits including enhanced customer service, optimized production levels, superior capacity planning, reduced repair and maintenance costs, and improved working capital utilization (Bughin 2016). According to a 2016 Forester study, the top three tangible analytics benefits were identified as: increased margin, profitability, and increased gross sales (Evelson and Bennett 2015). Several research studies have documented the advantages and widespread applications of analytics tools in corporations around the world (Evelson and Bennett 2015; Gaitho 2017; Lebied 2016; Eckerson 2016; Henke et al. 2016; Minelli et al. 2013).

Analytics is constantly evolving. It has changed dramatically over the years and is advancing rapidly today. There are four categories of analytics: descriptive, diagnostics, predictive, and prescriptive (Attaran and Attaran 2018). These categories build on each other and enable enterprises to make faster and smarter decisions. As organizations evolve, they move from focusing on historical "what" and "why" questions to a more forward-looking predictive and prescriptive predictions. Descriptive analytics is the simplest class of analytics. It allows you to condense big data into smaller, more useful nuggets of information. The purpose of descriptive analytics is to summarize what happened in the past and uncover patterns that offer insights. It uses data modeling, reporting, visualization, and regression to collect and store data in an efficient way, to create reports and presentation information, and to identify trends. Since data is scattered in large numbers of disparate data sources, analyzing all relevant information can be a challenge for most organizations. Most descriptive analytics are exact (number of likes, number of clicks, etc.) because they are defined by a single, deterministic model that does not allow contradicting results. It is estimated that more than 80% of business analytics, most notably social analytics, are descriptive (Attaran and Attaran 2018).

Diagnostic analytics is the next step up in data reduction and it is used for discovery. It examines data or content to answer the question: Why did it happen? Diagnostic analytics takes a deeper look at data to attempt to understand the root causes of events and behaviors in an organization. To optimize diagnostic analytics, it needs to be extended to operational employees of the organization. The result of the diagnostic analytics is often an analytic dashboard that is used for discovery or to determine why something happened (Attaran and Attaran 2018).

Predictive analytics analyze current and historical data to provide insights into what will happen and why it will happen in the future with an acceptable level of reliability. It attempts to accurately project the future conditions and states. It does not predict one possible future, but rather multiple futures based on the decision-maker's actions. It utilizes a variety of statistical, modeling, data mining, text, media mining, forecasting, and predictive modeling to identify probabilities of potential outcomes and/or likely results of specific operations. Predictive analytics can only forecast what might happen in the future, because all predictive analytics are probabilistic in nature. Predictive analytics can help businesses with a wide range of problems. Businesses are using predictive analytics to analyze historical data and facts in order to better understand clients' needs, market potentials, products, suppliers, and partners, and to identify potential risks and opportunities for a company (Attaran and Attaran 2018; Lebied 2016). Other businesses use this type of analytics for predicting which customers are most valuable, scheduling preventive maintenance, and detecting fraud. Airlines use these analytics to decide how many tickets to sell at what discounted price for a flight. Similarly, hotels use it to predict the number of guests they can expect to book on any given night to maximize revenue.

The emerging technology of prescriptive analytics goes beyond descriptive and predictive models and shows the likely outcome of each decision. It goes a step further in the future and attempts to answers what should be done and why. It employs data techniques such as decision modeling, graph analysis, simulation, neural networks, heuristics, and ML to suggest actions that the organization could take to achieve the desired outcome (Attaran and Deb 2018). Prescriptive analysis tries to evaluate the effect of future decisions in order to adjust the decisions before they are actually made. Future outcomes are taken into consideration in the prediction. Prescriptive analytics are commonly used in organizations to optimize scheduling, production, inventory and supply chain design, and other organizational activities to deliver what the customers want, and meet and exceed customers' expectations. Prescriptive analytics is the most valuable kind of analytics and usually results in rules and recommendations for next steps. However, it is largely not used (Attaran and Attaran 2018). A 2012 survey by Gartner shows most large retailers still focus on measurement of the past, with only 13% of them making extensive use of predictive analytics. Less than 3% of large retailers are using prescriptive analytics tools, such as decision/mathematical modeling, simulation, and optimization (Hetu 2015). Another study shows that by 2020, 40% of new investment in analytics tools will be in predictive and prescriptive analytics.

Blockchain and Big Data Analytics

Both blockchain and big data analytics deal with data. The latter analyses data for predictions and actionable insights while the former records and validates data for integrity. They both use algorithms to govern the interactions with different data segments. Big data analytics transform raw data into easy-to-understand and actionable insights and, like any other technology, have its own challenges and limitations. Some of these challenges include inaccessible data, dirty data (duplicate and incorrect data), and privacy issues. Dirty data is considered as the biggest challenge to big data analytics. According to Kaggle in a 2017 industry-wide survey of 16,000 data professionals, dirty data was the most common problem for workers in the data science realm (Kaggle 2017). Big data analytics is focused on making predictions from large amounts of data while blockchain is concerned with validating data. Blockchain manages and operates data not in a centralized manner where all data is brought together. It does it in a decentralized manner where data may be analyzed right off the edges of individual devices. Blockchain integrates with other technologies, like CCT, AI and the IoT. Additionally, blockchain generates immutable data that are validated, structured, and complete.

There are several ways blockchain can bring a whole new way of managing and operating big data analytics (Sarikaya 2019):

1. **Data integrity and trust**. Data recorded on the blockchain have gone through a verification process that ensures its quality and reliability. Blockchain technology generates validated data that are structured, complete, and transparent to ensure data integrity and trust, and prevent malicious activities.
2. **Preventing hacking.** Blockchain peer-to-peer distributed networks use consensus algorithm to verify transactions. It is impossible for a single node or unit to

pose a threat to the data network. Furthermore, it is almost impossible for a single party to alter the validation criteria and allow unwanted data in the system.

3. **Performing predictive analytics.** As discussed earlier in this chapter, predictive analysis uses large sets of data to determine with good accuracy the outcome of social events, such as customer preferences, customer lifetime value, dynamic prices, etc. Blockchain provides structured data gathered from individuals or individual devices. Data recorded on the blockchain can be analyzed to reveal valuable insights into the behaviors and trends and can be used to predict future outcomes. Because blockchain uses distributed network and huge computational power even smaller organizations can undertake extensive predictive analysis projects. Organizations can use the computational power of numerous computers connected on a blockchain network as a cloud-based service to analyze big data in a scale that would not have been otherwise possible.
4. **Real-time data analysis.** Blockchain transactions are made in real-time and are settled and verifiable within seconds. In the same manner, a blockchain-enabled system can help organizations achieve real-time analysis of large-scale data. The speed and accuracy of blockchain allows organizations to observe changes in data and enables them to make quick decisions.
5. **Data-sharing management.** Blockchain securely stores data obtained from data studies in its network. This prevents project teams from repeating data analysis already carried out by other teams or reusing data. Also, a blockchain platform can help businesses trade outcome of their analysis and monetize their work.
6. **Audit trails.** Activities and transactions that take place on the blockchain network can be traced for transparency.

Challenges for Blockchain in Data Analytics

As blockchain technology matures, big data analytics will be one of the areas that will benefit the most. Currently, existing peer-to-peer blockchain networks can only process small amount of data and a handful of transactions per second. Storage methods and processing capability of blockchain networks will need to be improved to deal with large volumes of data collected per second for big data and other data analysis tasks. Additionally, data storage on a blockchain is expensive compared to traditional means (Sarikaya 2019).

Blockchain and Ricardian Contracts

Ian Grigg, a pioneer in financial cryptography, introduced Ricardian contracts in 1995. A Ricardian contract uses cryptographic signatures and is a “form of digital documents that act as an agreement between two parties on the terms and condition for an interaction between the agreed parties” (Alam 2018). Ricardian contracts not only define intentions, but also execute instructions automatically when certain pre-conditions have been met. Ricardian contracts have several advantages (Alam 2018; Rijmenam 2018):

- They are easy-to-read legal contract for lawyers and the parties involved
- They are both machine-readable, as well as human readable
- Ricardian contracts can be easily hashed, signed, and can be saved on the blockchain
- In case of a dispute among parties involved, the case can be decided in court. This is not possible with smart contracts since they are not legally binding agreements.
- Ricardian contracts are extremely secure.
- Ricardian contracts come with a legal framework, since lawyers are required to create and deploy them. This adds clarity for all stakeholders.

The above benefits of Ricardian contracts make them a prerequisite for fast, efficient, and secure transactions and will be blockchain's killer application. We will see more implementations of Ricardian contracts in decentralized applications in the future.

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Chapter 12
Blockchain for Gaming

The Booming Gaming Market

The gaming industry is being rapidly transformed by the introduction of new technologies such as AI, VR, and AR. Blockchain technology has the potential to redefine the future of gaming by turning what has been seen as a leisure activity into a potentially economic endeavor (Gilot 2018). According to an online survey of 5000 people released by Electronic Entertainment Design and Research in 2018, nearly 70% of the American population, or roughly 211 million people, play video games on at least one type of device. The results showed that 90% of those surveyed play games on their smartphones, tablets, or both. The study also found that U.S. gamers spend an average of 12 h per week on video games (Crecente 2018). Video game engagement continues to grow and that could mean big returns for the gaming industry.

The gaming sector is thriving. As technology expands so will gaming products, video content, virtual reality, and video game tournaments flourish. These are just some of the ways the gaming industry is turning into a recurring revenue model and capitalizing on increased demand. According to Newzoo's Global Games Market Report, 2.3 billion gamers from around the world spent around $138 billion on games in 2018. This figure represents a 13% increase from the previous year, or an extra $16.2 billion. The report expects that consumer spending on games will grow to $180.1 billion by 2021, a Compound Annal Growth Rate of +10.3% between 2017 and 2021 (Wijman 2018).

Despite the gaming industry's promising outlook, large sums of money are lost to unrealized gains. Based on 2015 research conducted by Apsalar (a mobile marketing cloud company), for every legitimate virtual item sold and downloaded, there were 7.5 virtual items downloads lost to fraud. This number was much higher in countries like China where there were 273 fraudulent virtual items downloaded for every legitimate one. Additionally, fraudulent in-app purchases allow some players to gain an unfair advantage. This corrupts the economics of the game and ruins the

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experience for other players. Attack techniques faced by mobile gaming apps industry are constantly changing to evade existing detection approaches. There is a real cost associated with lost virtual goods, and huge negative impact on both user growth and gaming industry profit (Xie 2015).

Benefits of Blockchain Gaming

Blockchain technology has the potential to disrupt the gaming industry by enabling developers and players to interact with gaming platforms in a new way. The use of blockchain will have a massive impact on all aspects of the gaming world. Gamers were among the early adopters of cryptocurrencies as they were already familiar with in-game virtual currency models and understood the benefits of integrating cryptocurrency networks into the domain.

Blockchain can transform the gaming industry in the following ways (Gilot 2018; Katalyse 2018):

1. **Allows full control of virtual assets.** Currently, gamers don't actually own their purchased virtual assets (games) and they are not allowed to buy, sell, or trade assets outside of the game. This is because gaming companies often store in-game assets on centralized servers to protect assets from being duplicated. Blockchain technology allows full transparency and decentralized control of virtual assets, enabling players to have ownership of their virtual assets and exchange these assets with other players. Gamers have the flexibility of using their virtual assets across different games, instantly.
2. **Rewards interaction with video games.** Blockchain-based technology enables players to earn tokens for playing, reviewing, or sharing games on social media. Gamers' activities can be tracked and players can be incentivized to provide reviews and feedback to developers, leading to the improvement of the games.
3. **Builds credibility and accountability.** Blockchain uses a peer-to-peer network and is an immutable ledger. It records all transactions, including gamers' interactions, player history, and trading of in-game items, and allows players to use their account across multiple games services. These records are publicly available, therefore encouraging players' good behavior within the community and promoting transparency within the gaming ecosystem.
4. **Improves security to reduce fraud.** In the past, expensive virtual games were often copied by fraudsters and resold, making these games neither unique nor valuable. Blockchain technology creates an immutable, encrypted ledger of a virtual asset and to whom it belongs, making duplicating, hacking, and stealing keys impossible.
5. **Provides transparent and faster payments.** Blockchain provides a safe environment for players to make their purchases faster, while ensuring their payments are secure. The technology enables developers to process nano-payments instantly thus eliminating the need for credit or debit card companies. This pro-

vides an opportunity for developers to quickly reinvest money into game launch marketing. Without debit or credit card company minimums, players can make purchases no matter how small. Additionally, blockchain fortifies payment in a manner that scammers cannot hack. Blockchain makes it close to impossible to steal information or manipulate the market.

6. **Creates more exciting gaming universe.** Blockchain technology provides a better option of storing data generated in games in digital assets form. The technology will make it possible for the gaming companies to put their terms and conditions fortified via smart contracts, to join hands and create parallel gaming universes.
7. **Allows for unrestricted gaming economies.** Blockchain technology provides unrestricted gaming economies and does not require policing. The technology enables developers to collect ongoing royalties for items on trade across the gaming industry. Developers can decide whether to allow the trading of items with no restrictions or to stop the selling of the assets.
8. **Offers proof of limited supply and asset scarcity.** Game developer can use blockchain technology to create rare virtual assets or to customize certain assets such as armors, swords, and other in-game cosmetics to make them more valuable. As an example, the CryptoKitties game used this technology to store cute cats that a user could obtain and trade. The company's "Genesis Cat" was met with unexpected success, becoming the top selling cat going for $115,000. Proof of limited supply fueled the high demand (Katalyse 2018).
9. **Democratizes the gaming industry.** Voting is quite popular within online gaming. The current methods of corruption and manipulating of votes result in unreliable feedback from the voting system. Blockchain has the potential to democratize voting in games. Blockchain features a decentralized smart contract that makes it difficult to tamper with the voting system.

Obstacles Facing Blockchain Gaming

The intersection of blockchain technology, cryptocurrencies, and gaming is promising and will facilitate a new gaming landscape. However, the emergence of the blockchain gaming trend is not without its hurdles as described below (Curran 2019):

1. **Scalability.** Scalability issues are legitimately prohibiting the development of many games at this point.
2. **Sustainability**. There is currently an overall lack of sustainability for blockchain-based games. Many once hopeful decentralized applications built on top of Ethereum have fallen into obscurity after launch. There is obvious lack of users for blockchain games and decentralized asset exchanges.
3. **Centralized games advantages**. At the moment, centralized games and gaming platforms have clear advantages over blockchain-based games.

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Chapter 13
New Business Applications for the Blockchain

Until recently, blockchain technology was primarily of interest to financial institutions. The ability of blockchain to authenticate digital information and create smart contracts is leveraging the usefulness of technology on a world-changing scale. The new breed of programmable blockchain platforms, such as Ethereum, which provides decentralized computational power, is making the technology applicable to a wide range of cases and industries.

Blockchain is commonly associated with the bitcoin cryptocurrency. The potential future environment for blockchain economy is a scenario in which cryptocurrency replaces current monetary systems on a global basis. This will have profound implications for the future exchange of value (Rouse 2018). Blockchain's digital democratization and its important feature as an unalterable and nearly impossible to hack digital ledgers is expected to foster emerging markets and economies as described below.

Decentralized Sharing Economy

Distributed ledgers enable peer-to-peer payments, opening the door to direct interactions between involved parties, and creating a truly decentralized sharing economy. For example, OpenBazaar uses blockchain technology to create a peer-to-peer eBay. Users can transact with OpenBazaar vendors without paying transaction fees (Bagley 2016).

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Neighborhood Micro-Grids

This concept refers to neighbors who are empowered to produce, consume, and purchase power within their community. Blockchain technology enables the buying and selling of excess energy generated by solar panels using transactive energy platforms. LO3 Energy, a young New York company, is developing applications for a distributed energy supply system that draws on renewably generated sources for a more resilient, customer-driven economy. In 2016, the company enabled the small-scale trading of environmentally friendly electricity among neighbors who didn't have their own solar systems and those who produced excess solar electricity in Brooklyn, New York (Breuer 2017).

Data-Sharing Marketplace

Today, people are using social media platforms like Facebook to exchange their personal data for free. Historically, the users who generate the personal data have not been included in the selling and buying of that data. Blockchain technology enables people to manage and sell the data that their online activity generates. The key precondition for creation of a personal-data marketplace is user privacy. A blockchain network guarantees that there is always a smart contract between the data buyer and sellers that governs how consumers' personal information will be used. The companies Wibson and Opiria each announced the release of blockchain-based, decentralized personal-data marketplaces (Egorova 2018; Wibson 2018). Both marketplaces are supporting consumers' ability to securely sell validated personal information in a trusted environment. Individuals can connect to data sources such as Facebook, monitor offers from data buyers, and sell their personal data. Businesses can buy personal data directly from consumers using bitcoins or token, the internal currency used for rewards. Consumers receive payment for sharing access to their data when the transaction is confirmed. The founders of Opiria claimed that the global trading volume of personal data has reached $250 billion (Egorova 2018). Finally, IOTA, the 10th largest cryptocurrency company, released its blockchain-based data marketplace. It is an open-source network designed to allow companies to sell or share unused data and to collaborate or inspire innovation within the industry (Williams 2018).

Machine to Machine Transactions

Machine to machine (M2M) refers to a technology that enables networked devices to remotely exchange information and perform actions without human assistance. Manufacturers use the real-time communication abilities of M2M to allow them to remotely track their supply chains and monitor warehouse operations from any location. M2M communication is often used for warehouse management, traffic control, logistic services, supply chain management, fleet management, and telemedicine (Rouse 2010). M2M transactions is another emerging aspect of the blockchain technology where machines could use blockchains to become autonomous market participants with their own bank accounts (Rouse 2018). It is expected that advances in AI will enable machines to lease themselves out, pay for their own maintenance, purchase their own replacement parts, and keep their own transactional records using blockchain (Rouse 2018).

The French automaker, Renault, is piloting a digitized car maintenance program that uses blockchain technology to log all car repair and maintenance history in one place. The next stage of this pilot program is vehicle-based microtransactions—integrating the IoT with the exchange of value. Another example of blockchain application is blockchain-enabled tollbooths, introduced by Oaken Innovation Company for Tesla cars. The tollbooths and cars both have Ethereum nodes, which use smart contracts to trigger M2M transactions as the cars pass through the tollbooths (Groopman 2017).

Smart Cities

Smart cities are using information and communication technologies to increase operational efficiency, share information with citizens, and improve both the quality of services and citizen welfare. Blockchains are suitable for autonomous transactions between networked devices and machines. An electric car could pay a charging station for electric power or pay a toll for crossing a tollgate. The German utility company, RWE, is exploring the idea of blockchain-enabled smart charging stations. Bankymoon, a South African company, allows users of smart meters to pay for electricity with bitcoin (Velasco-Castillo 2016).

Digital Medicine

According to Wikipedia, digital medicine combines a prescription medication with an ingestible sensor component. After a user ingests the pill, the pill starts to transmit data to a patch, which is then stored on a person's smartphone in an app. Digital medicines are designed to communicate to mobile and/or web-based applications about what and when a patient has taken a specific dose of medication at a certain time and sends that information to other components of the digital system that can also show how a patient's body is responding (Chapman 2018). While there is only one "e-Pill" on the market right now, there is a good chance that all our medicine could perform these tasks in future. This will generate large amounts of medical data and will require a high-security place to store them. This is where blockchain will have its chance to shine.

An Open-Source World

Our economy relies on paper contracts and proof-of-identity cards for everything. These records are easy to lose track of, simple to manipulate, and not safe from professional hackers. Blockchain technology is a game changer. For the first time, we can create a permanent, safe record of every digital transaction, exchange of values, goods and services exactly as it occurs. This makes fraud, hacking, and information loss impossible. Blockchain has the potential to make life simpler and safer.

Value-Based Healthcare

The medical sector has been moving away from paper and toward digital applications for years. Blockchain technology has made record keeping more efficient and provides a solution to record-keeping problems in the healthcare industry. Blockchain is being considered for a system called value-based healthcare where patients pay for the value of care received rather than the medical processes themselves. Russia and Dubai are experimenting with the decentralized Robomed Network that uses smart contracts to allow patients to pay for the results of their treatments rather than the number of treatments received. As of last year, the Robomed Network had almost 9000 patients and 30,500 treatments performed (Williams 2018).

Energy Sector

For years, the energy sector has been moving from paper and toward digital applications. Blockchain technology can execute and record energy trades on a single ledger in a transparent and immutable platform. Blockchain is also a very efficient mechanism for conducting microtransactions. Microtransactions on the order of a few cents 100 times a day on a credit card would not be cost-effective. In Brooklyn, New York, there is an area where neighbors are buying and selling energy from each other in microtransactions using the blockchain as a platform—a few cents here and a few cents there (Shin 2016).

The technology also improves transparency and provides a means of more easily analyzing vast amount of data for compliance. Finally, blockchain enabled smart contracts are more legally binding and help reduce contract disputes for energy transactions. (Williams 2018).

Payroll Service

Blockchain can save major costs for companies that regularly pay wages to international workers or contractors. The main problems are speed to get funds to the contractor and the excessive exchange rate. Blockchain could be used as an application to compensate employees and pay wages in a timely manner and at minimum cost. Bitwage is the world's first bitcoin-based payroll service. The Bitwage platform receives wages from employers and then pays these wages to employees in each of their respective local currencies. The blockchain-based platform eliminates the costly fees associated with transferring money internationally for employers and employees alike, as well as the time it takes for funds to move from bank to bank (Rampton 2019). There are several businesses already using the service provided by Bitwage, including Wisconsin-based coffee company Colectivo and real-time Internet marketing company Rockerbox, based in New York.

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Chapter 14
Implementing Blockchain in Your Enterprise

Most executives are scrambling to educate themselves on how to lead their companies into the blockchain future. Adoption of technology by enterprises is on the rise. In a recent survey conducted by Juniper Research, employees of companies with more than 20,000 people were asked whether they were looking to incorporate blockchain. The survey found that 57% were interested in incorporating blockchain technology in their organizations. Additionally, 76% of the employees responded that blockchain could be "very useful" or "quite useful" to their company (Blockgeeks 2018).

How do you implement blockchain in your organization? This chapter identifies opportunities and threats, discusses decision criteria to prioritize your blockchain implementation approach, and covers a step-by-step method to plan and develop blockchain-based technology for your organization.

Identifying Opportunities and Threats

William Mougayar, a venture capitalist at Virtual Capital Ventures and an advisor to some of the better-known blockchain organizations, published a book in 2016 arguing that blockchain has "polymorphic capabilities." (Mougayar 2016). He compares blockchain to the Internet, maintaining that at the beginning few understood it. He sees the vast potential in blockchain and believes the scope and magnitude of this technology are going to be similar to the Web back in 1993–1994. He argues that executives need to think about blockchain in a holistic manner. Most executives involved with blockchain only consider the technology for its cryptocurrency or distributed ledger aspects. He believes the technology has more to offer, and that if executives fully understood it, they would be able to apply it to a variety of situations (Mougayar 2016).

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In order for executives to successfully implement blockchain, their workplaces must be enhanced by context, structured and unstructured information, and consistent coverage of information flows. The lack of a clear distinction between tools and business needs can also make an information management system ineffective. Without a proper business case, business need, and business goal, technology delivers only limited value. An on-going employee education on the proper usage of technology is a necessary foundation for productivity and quality improvements.

There are numerous challenges for businesses to incorporate blockchain technology. We believe the most important challenges facing organizations are:

- Lack of understanding of blockchain's potentials and a lack of technical expertise among employees and leadership
- Mistaken view of blockchain technology as a short-term cost center instead of a long-term investment
- Lack of leadership and purpose
- Lack of budget
- Lack of staff resources
- Lack of sense of urgency to compete differently
- Human barriers—politics, egos, fear, and skepticism

Before incorporating the blockchain, it may make sense to calculate how much it will cost to implement this peer-to-peer network approach. Executives must account for costs beyond hosting, licensing, and implementation. For example, energy costs and storage cost will rise as the transaction volume increases. A blockchain database must store data indefinitely, which means that the database will grow substantially over time, as will the storage costs.

Determining Use Cases and Impact on Processes, People, and Partners

A leading-edge workplace transformation initiative, including implementation of blockchain-based technology, should take a holistic and cross-functional approach, spanning people, places, and technology. Not all organizations, however, experience success in implementing workplace transformation projects. Increasingly, digital projects are not strategically focused. All too often, organizations overly concentrate on technology rather than on the people using the systems. Technology, alone, will never be the solution to all problems. As with any new investment, the key is to ensure that selected technology reflects the overall business strategy, and that it will significantly add value (Perks 2015). Therefore, to implement blockchain technology successfully, a cross-functional delivery team that includes senior leaders as well as IT, HR, and marketing should be formed. This team should assist future projects by providing access to expert knowledge, helping with the discovery of project-critical information, and enabling more efficient ways of working.

The team should create a digital workplace strategy that clearly articulates the business focus and guides the development of digital solutions.

To be able to implement blockchain technology successfully, organizations need to view this technology in three ways (Mougayar 2016):

Technical. Blockchain is a backend database that has a distributed ledger, as used in accounting

Business. It is an exchange network for transferring value between peers. Peer-to-peer interactions are authenticated on the blockchain

Legal. It doesn't require a middleman to validate the transaction. It validates a transaction and can make it valid from a legal point of view

Sometimes, systematic change is better for the overall growth of an enterprise than a piecemeal approach to incorporating new technology. As discussed in previous chapters, there are multiple forms of blockchain-based technology with many useful qualities, as well as some shortcomings. For example, public blockchain is unable to handle huge amounts of transactions and data, which is a primary requirement for many companies. On the other hand, private blockchain is labeled as fancy implementations of a shared database. Critics argue that there are far simpler implementations of a shared database that one can incorporate instead of a blockchain (Blockgeeks 2018).

A Conceptual Model for Implementation

Gartner recently conducted a 12 month survey of enterprises with cloud management strategies and identified the three phases of cloud adoption strategy. We adopted this model and modified it to fit the leading-edge blockchain transformation initiative described below and summarized in Fig. 14.1 (Smith 2016):

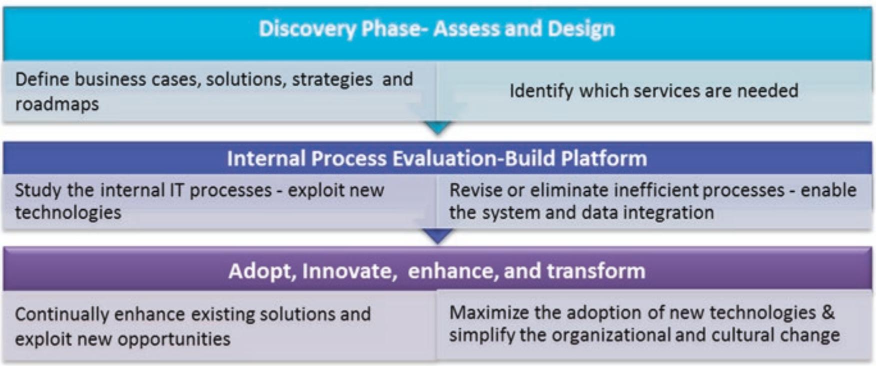

Fig. 14.1 Blockchain implementation phases

Phase 1: Discovery Phase Some companies want to use the blockchain to improve or lower the cost of a particular process. Other companies want to innovate without any legacy systems or existing regulations tying them down. An important step for successful implementation of blockchain technology is about opening the minds of managers and employees. The executives need to take a hard look at their business and define business cases, solutions, strategy, and roadmaps. The workplace strategy should set clear priorities and serve as a blueprint for the roles and relationships of each department. It is important to define a clear business case and determine timings for the enterprise blockchain strategy. Business should identify which digital services, workplace tools, and solutions meet the company's needs. The most impactful deployments start with users fully understanding their desired business outcomes. This requires asking questions such as what services users need, how much of each service will be consumed, when each service will be consumed, which users will consume each service, and what is a reasonable price for each service.

Answering the following questions would be helpful during the discovery phase. (Blockgeeks 2018):

- Is your company ready for incorporating a blockchain?
- Do you need to have a clear audit trail for your company?
- Does your company deal with huge amounts of data where time and speed is important?
- Does your company deal with a lot of throughputs?
- Does your company use third party for most of its operations?
- Can your company handle the costs associated with blockchain integration?
- Can you get your whole team up to speed with this shift?
- Will your clients stay loyal to you through this transition?
- Will your existing business process be able to handle disruption?
- Will your employees and managers be able to adapt to this change?
- Should you move slowly or change the entire infrastructure of your company by introducing blockchain technology?

Employees need to understand the following questions (Mougayar 2016):

- What is the technology?
- What can we do with the blockchain?
- What are the possibilities out there?

The training of managers and IT staff hold the key to the blockchain's implementation success. It is important that managers and leaders of the various divisions understand the technology and know how it is going to change the processes inside the organization. Software developers and IT consultants must also have the coding skills necessary to build and maintain the blockchain. Additionally, make sure that employees are blockchain savvy and understand the technology and its implications for the enterprise.

Phase 2: Internal Process Evaluation Executive or relevant employees should work with the CIO and business stakeholders to document and analyze the internal processes that will be affected by the selected blockchain solutions. This might bring to light the need to flatten, reconfigure, realign, refine, or eliminate inefficient processes and target repetitive manual processes for automation. Executives need to understand that to increase efficiency in their organization, reworking certain legacy-based solutions might be the answer. This might mean that implementing a new technology like blockchain may not be the best immediate solution. The types of security that will be applied to the deployment must also be addressed. Companies should enable and bring together user-friendly systems, data integration, social, mobile, analytics, and cloud computing technologies to create a digital workplace that responds to the informational needs of employees. Companies should also integrate social collaboration technologies such as voice, video, messaging, and workspace tools in order to make knowledge sharing more effective. Finally, companies should provide the requisite platform to access and secure information across multiple devices and channels.

Phase 3: Adopt, Enhance, and Transform Companies should continually enhance existing procedures, maximize the adoption of blockchain solutions, and ensure user adoption. As the needs of workers evolve, companies should continually exploit new opportunities and deliver a consumer-like experience and a consistent user experience across multiple platforms for internal employees. Corporations should simplify the organizational and cultural changes that hinder the adoption of blockchain technology. They should engage with users to understand their needs and articulate how the blockchain technology enables them to work productively. Firms must ensure employees have access to training that enables them to use the blockchain solutions to their advantage, and that technical personnel and trainers are properly trained to support the blockchain technology. Additionally, firms must provide policy training for employees on the types of information they should or should not share, on the handling of personnel data, and on the avoidance of potentially damaging their organizational data.

Guarantying Blockchain Transformation Success

In order to fully reap the benefits of blockchain-based solutions, organizations need to take a holistic view of the scope of the projects, exploit different technologies, identify needed services, and maximize the adoption of new technologies. The following section reviews some of the factors that will guarantee a successful blockchain technology transformation.

1. **Understanding the Hype Behind the Technology.** There has been a lot of hype behind blockchain and that puts unfair expectations on the technology. While blockchain is a great innovation, it is by no means a panacea. The technology is still very young and there are many new applications that need to be explored and improved upon. Blockchain will become more powerful as it becomes more

widely adopted. Implemented properly, the technology has the potential to reduce cost, improve efficiency, and increase profitability.

There are many relatively inexpensive tools and solutions already available to create applications without the need for extensive technical knowledge. Additionally, many providers of blockchain-based technology and software developers are making the blockchain more accessible. These companies can act as a consultant and help executives implement blockchain inside their organizations.

2. **Ready employees and clients.** On a more psychological level, introducing blockchain into your business could be intimidating. It is important that employees are mentally ready and customers understand the advantages of the technology. A Juniper Research survey found that 35% of the companies considering or actively deploying blockchain believed that blockchain integration would cause disruption to their internal operations. Moreover, 51% felt that implementing blockchain would cause a "significant disruption" to their partners and/or customers. For example, existing customer systems may no longer be compatible with the upgraded, blockchain incorporated systems. These fears are not unfounded. Besides scalability concerns, interoperability is one of the biggest worries for customers (Juniper Research 2017).
3. **Change management.** According to Forbs, 84% of technology transformation efforts fail. A 2017 survey showed that many organizations consider technology transformation as an integration of digital technologies and merely as IT transformation (Solis and Littleton 2017). Their objective is to optimize IT services for organizational needs and they do not recognize that a successful technology transformation is, first and foremost, a cultural and organizational transformation rather than a technology-driven endeavor. Implementing a leading-edge workplace technology transformation—including implementing blockchain technology—requires managing change effectively. Effective technology transformation requires businesses to develop and realign priorities, and operate with a sense of purpose and urgency (Solis and Littleton 2017). Many organizations fail at change because leaders have not given change management the proper attention. Effective change management increases the success of the implementation and the acceptance of changes. Ineffective change management can affect employees negatively and makes the next change objective that much more difficult to implement. Additionally, the fear of managing the change is a leading cause of anxiety in managers. There are several models for successful change management (Markovic 2008; Marek 2017; Decker 2017). Figure 14.2 highlights a sample model.
4. **Critical factors to consider.** To improve the chances of successful implementation, it is important to take these critical steps (Hamburg 2019):

   - Take a cross-functional and holistic view of the organization's digital workplace and involve representatives from key stakeholders to the blockchain delivery team

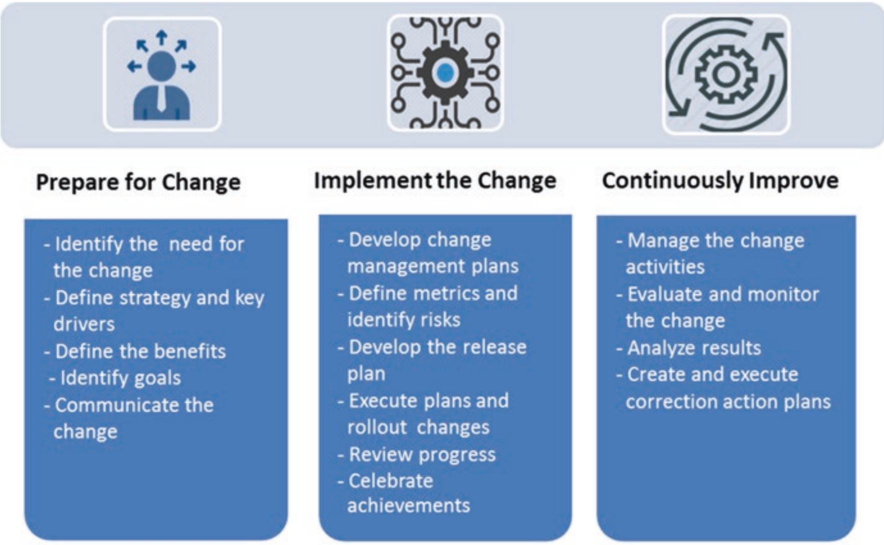

Fig. 14.2 Steps for implementing change management

- Ensure that the project is enterprise-wide and encompasses a significant proportion of the workforce
- Help to improve employee and customer experiences in using the blockchain
- Choose blockchain tools that are easy to use
- Expect changes to occur across all the pillars of transformation including strategy, people, process, and technology
- Respond rapidly as new blockchain-related technology and opportunities emerge

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Chapter 15
Summary and Conclusions

Blockchain technology is revolutionary. It will make life simpler and safer, changing the way personal information is stored and how transactions for good and services are made. Blockchain technology creates a permanent and immutable record of every transaction. This impenetrable digital ledger makes fraud, hacking, data theft, and information loss impossible. The technology will affect every industry in the world, including manufacturing, retail, transportation, healthcare, and real estate Companies as Google, IBM, Microsoft, American Express, Walmart, Nestle, Chase, Intel, Hitachi, and Dole are all working to become early adopters of blockchain. Nearly $400 trillion across various industries is set to be transformed by blockchain.

Blockchain technology provides verification efficiencies, including operational, regulatory, enhanced visibility, and traceability. This technology is also a powerful database that could easily be combined with big data. Blockchain solutions can help cut costs and make many services more competitive. While blockchain technology has reshaped and decentralized financial institutions, its application possibilities are far more robust. Currently, it is being actively considered by the food and beverage, automotive, electronics, aerospace, and defense industries to secure quality, safety, batch and lot, and traceability information along the supply chains. Companies like IBM and Microsoft are providing blockchain solutions to a number of enterprises (Velasco-Castillo 2016).

The positive effects, however, are conditional. We have found a set of potential cohesive effects of blockchain technology on several industries, and have highlighted successful implementations of blockchain solutions in the manufacturing and service sectors of the economy. Furthermore, this book reviews new business applications of blockchain and argues that blockchain's digital democratization is anticipated to foster emerging economies and markets, such as the personal data marketplace, neighborhood micro grids, machine-to-machine transactions, and smart cities.

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Blockchain technology is in a very early stage of its development. The hype around blockchain is high, and best practices are hard to come by. Much of the technology remains immature and untested. According to Gartner, only 10% of organizations will achieve any radical transformation with the use of blockchain technologies through 2020. Very few examples of the technology have been implemented, and therefore effects are often anecdotal and, notably, not fully tested. In our literature search, we found few papers published in peer reviewed academic journals or as academic working papers exploring advantages and limitations of firms implementing blockchain technology.

This book presented an important early academic contribution to a field dominated by narratives and promises made by consultants. We urge future research to test the enabling and constraining effects of blockchain and search for more empirical evidence of its successful implementations in different industries.

Future Directions

As discussed in this book, the core technology to build cryptocurrencies is blockchain. Bitcoin has brought attention to this underlying technology, and the increased use of cryptocurrencies will help blockchain grow. The number of merchants accepting digital currencies such as bitcoin has only increased at a modest annual rate. Mass adoption of bitcoin has not happened yet because in its current form, bitcoin is not capable of fulfilling the role of money. The existing bitcoin network can only process 4–6 transactions per second. That means most bitcoin transactions take 10 min to be approved. In contrast, credit card networks can process 2000 transactions per second making credit card approval less than 10 s. Merchants will need to see improvement of storage methods and processing capability of blockchain currencies for the exponential growth needed for mass adoption. By improving the main disadvantages of bitcoin, a big breakthrough could finally be here soon.

In June 2019, Facebook revealed the details of its cryptocurrency called Libra, with a public launch set for 2020 (Libra Association 2019). Libra allows users to buy items or send money to individuals with nearly zero fees. The Libra Association is an independent entity of founding members tasked with governing the coin. It is a nonprofit organization that will be responsible for recruiting additional members to act as validator nodes for the blockchain. Each founding member of the Libra Association has invested at least $ten million into the project's operations. More than a dozen companies back Libra, including Visa, MasterCard, PayPal, Western Union, Uber, eBay, Spotify, and Vodafone. This is the first major operation by a large, multinational platform to develop its own digital cryptocurrency. The association will promote the open-sourced Libra blockchain and sign up businesses to accept Libra for payment. It will also provide customer discounts and rewards. Facebook defines Libra's mission as "to enable a simple global currency and financial infrastructure that empowers billions of people." (Libra Association 2019).

Libra payments are permanently written into the Libra blockchain, which is a cryptographically authenticated database that acts as a public online ledger that is operated and constantly verified by founding members of the Libra Association.

Existing cryptocurrencies like Bitcoin and Ethereum are susceptible to huge and unpredictable price swings, making it tough for merchants to accept them as payment. The Libra blockchain is built to handle 1000 transactions per second—much faster than Bitcoin's 7 transactions per second or Ethereum's fifteen. Facebook is hoping Libra will become simpler to set up, more ubiquitous as a payment method, more efficient with fewer fees, more accessible to the unbanked, and more flexible. Libra holds the promise of disrupting how things are bought and sold by eliminating transaction fees common with credit cards; however, Libra's transactions are not entirely free. They incur a tiny fraction of a cent fee to cover the cost of processing the transfer of funds, similar to fees charge by Ethereum. This small fee is much less expensive than the 7% average remittance services charged for sending money internationally (Constine 2019). Additionally, Libra can offer the 1.7 billion people who lack bank accounts a financial services alternative by being their online identity provider. Libra's growth will elevate the "crypto" acceptance in both public and private organizations, and will have a potential long-term economic significance. It will be interesting to see how regulators and users respond.

Blockchain requires industry collaboration. To be successful with blockchain technology, it is important to work together. Blockchain, by its nature, requires organizations to collaborate with industry partners, customers, and even competitors. Only through decentralized collaboration with stakeholders, do the benefits of blockchain become truly visible. One example of this type of collaboration is the new initiative by the EU's European blockchain partnership called International Association for Trusted Blockchain Applications (INATBA). It is the result of close collaboration of 26 EU countries. The international association will act as a linking organization for blockchain startups, large firms, non-profit organizations, policymakers, and regulators. The main objectives are to understand and support blockchain, to provide the developers and users a global forum to interact with regulators and policy makers, and to take blockchain technology to the next stage (Rijmenam 2018).

According to an article in the Harvard Business Review, widespread blockchain-led transformation of business and government is still many years away. That is because blockchain is considered a *foundational* technology that has the potential to create new foundations for our economic and social systems. It will take decades for blockchain to reach its full potential and be fully adopted into our economic and social infrastructure. (Iansiti and Lakhani 2017). The addition of technologies like AI and ML could offer a boost in blockchain applications. Combining multiple smart contracts with AI and analytics has the potential to automate decision-making capabilities and result in a new organizational design that is completely run by computer code. Blockchain combined with other technologies will become a game changer.

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