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CHAPTER THIRTEEN

Empowering digital twins with blockchain

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Abstract

A digital twin is an exact digital/logical/cyber/virtual representation/replica of any tangible physical system or process. And the digital twin runs on a competent IT infrastructure (say, cloud centers). In essence, a digital twin is typically a software program that takes various real-world data about a ground-level physical system as prospective inputs and produces useful outputs in the form of insights. The outputs generally are the value-adding and decision-enabling predictions or simulations of how that physical system will act on those inputs. These help in quickly and easily realizing highly optimized and organized products with less cost and risk.

The manufacturing industry had embraced the digital twin technology long time back to be modern in their operations, outputs, and offerings. The distinct contributions of the digital twin paradigm, since then, have gone up significantly with the seamless synchronization with a number of pioneering technologies such as the Internet of Things (IoT), artificial intelligence (AI), big and streaming data analytics, data lakes, software-defined cloud environments, blockchain, etc. With the concept of cyber physical systems (CPS) is being adopted and adapted widely and wisely, complicated yet sophisticated electronics devices at the ground level are being blessed with their corresponding digital twins. The digital twins enable data scientists and system designers to optimize a number of things including process excellence, knowledge.
discovery and dissemination in time, better system design, robust verification and validation, etc. In the recent past, with the flourishing of the blockchain technology, the scope for digital twins has gone up remarkably. This unique combination is bound to produce additional competencies and fresh use cases for enterprises. This chapter is to explain how they integrate and initiate newer opportunities to be grabbed and gained for a better tomorrow.

1. Introduction

It is natural that business requirements and people expectations are varying and growing invariably. Breakthrough technologies individually and collectively have been fulfilling them with ease and elegance. With the explosion of IoT devices in our everyday environments, there is a need expressed widely to empower them with required intelligence in order to exhibit adaptive behavior in their actions and reactions. The mandate is to transition connected devices to be smart. The prime and swanky idea toward the smartness is to transition gleaned data into information and into knowledge. The changeover process gets accelerated through a few technological solutions such as machine and deep learning algorithms, integrated data analytics platforms, etc. That is, gathered data is subjected to a variety of deeper and decisive investigations in order to extract useful information and workable insights.

For making IoT devices to be smart, there came a number of ways and means vehemently expounded by many. One of them is to establish digital twins for IoT devices. Digital twins collect value-adding data from their corresponding physical twins continuously and crunch them in order to emit out usable insights out of data heaps. The acquired knowledge gets looped back to the physical devices to adequately nourish them in completing their assignments well. This continuous nurture helps them to behave intelligently according to the fast-changing situation.

However, with digital assets and data growing briskly everywhere, there is a need for utmost security and transparency to realize and reap the promised value for digital artifacts. Blockchain chips in here with its unique competencies and characteristics. Thus, the distinct combination of digital twin and blockchain technologies is being proclaimed and presented as the best-in-class method to eliminate any loophole and to boost the confidence of users on leveraging digital assets for their everyday transactions. In the subsequent sections, we are to discuss how this combination is going to be a great game-changer for myriads of industry houses.
2. Briefing the digital twin (DT) paradigm

As indicated above, digital twins are the digital versions of physical objects. In addition, digital twins comprise the details of the physical objects’ surroundings or processes related to them. That means, digital twins consist of the relevant IT components for status updates and connectivity. They are also stuffed with defined data structures and user interfaces to facilitate knowledge visualization through 360-degree dashboards.

When you are using your smartphone for your communication, computing, and collaboration purposes, surfing the Internet using your laptop for knowledge gain, storing your data in cloud environments for affordability, using social networking tools to socialize, etc., you are actually creating a digital footprint of yourself. This digital footprint is a kind of digital twin. Similarly, you can think of digital blueprints for a building as its digital twin. A computer simulation of an aircraft engine can be as its digital twin.

Digital twin in the human context is all the data footprint that we as human create through our attributes, interactions, and online presence. These decision-enabling elements earnestly get combined with one another and their combined outputs are getting crunched using advanced and real-time AI and data analytics platforms, it is possible to predict our health condition and other leanings accurately.

- **Attributes** could be name, age, gender, address, ideology, language, culture, religion, ethnicity, education, salary, etc. These are actually categorized as base data about us as individuals, and these can go a long way in predicting whether we are prone to any specific health issue. Where we were born and we live lately are also contributing handsomely in arriving at correct prediction. All these data are meticulously gathered and stored digitally. Thus, digital twins are possible for humans also.

- **Interactions**—This is all about our everyday interaction with the world. The details of where and when we are traveling and our eating out come handy in precisely predicting our health status. Our health monitoring wearables can minutely capture a number of our body parameters such as fitness and blood sugar levels, heart-beating rates at different times, etc., and deposited the captured in our own digital twin. There are other electronic instruments, digital assistants, and smartphones to automatically monitor and measure our everyday movements, exercises, work stress, etc. All these are meticulously get aggregated and stocked in
our own digital twin. In conjunction with our unique attributes, digital twin can predict the health state prediction and prescribe of what to do.

- **Online presence**—We have a number of professional and social media applications that ultimately articulate our personality. Thus, human digital twins are also gaining prominence. Digital twin for humans can help predict if someone has a possibility to be down with any life-threatening disease. Also, it can help provide insights on changing lifestyle to stay healthy and live longer.

The digital twin of machines can predict the need for their timely maintenance. Similarly, digital twins help to come out with the next-generation machine design that is versatile, resilient, and robust. Precisely speaking, digital twins are digital replicas of a business, process, or product over its life cycle.

Digital twins are being meticulously built for physical twins. Software experts begin building futuristic digital twins leveraging their education, experience, and expertise on data science, statistics and mathematics, computer algorithms, etc. Digital twins’ developers deeply research the physics that underlie the physical system being mimicked. That information greatly helps to visualize and develop a mathematical model that elegantly simulates the real-world physical system. The mathematical model gets turned into software package to run in the digital space. Maneuvering, managing, and maintaining digital twins are quite easy and fast. Thus, for adding new features to existing physical systems, digital twins contribute immensely in identifying and articulating the pros and cons of incorporating the features. Above all, before building complex and highly integrated systems from the ground up, their digital twins come handy in envisaging the impending risks and opportunities and in answering the difficult questions. All these acquired knowledge through digital twins goes a long way in setting up and sustaining complicated and sophisticated physical systems. Thus, digital twins are being projected as complexity-mitigation mechanism.

Physical systems like aircraft engines are being embedded with a number of multifaceted sensors, which continuously gather a lot of useful information of physical systems and pass it on to the digital twin in real time. This empowers the twin to crunch the received data quickly to offer insights (performance, health condition, security, failure prediction, etc.) to physical system designers and operators.

There is another tweak called as “Predictive twin.” This can model the future state and behavior of the device. This prediction is derived based on historical data from other devices. Predict twins have the inherent capability to simulate breakdowns and other situations that need immediate attention.
Microsoft has come out with another term “Process Digital Twin.” This is the next level compounding product digital twin benefits throughout the factory and supply chain. Process twins can highlight some advanced manufacturing scenarios that product digital twins cannot provide.

In summary, the digital twin typically can include a description of the devices, a 3D rendering, and details on all the sensors embedded in the device. Based on continuously generated sensor readings, the digital twins can simulate real-life options and operations of the device.

3. Digital twins: The industrial use cases

The aspects of digitization and digitalization are grasping the attention of enterprising businesses across the world. Digitization is all about empowering our everyday objects to be digitized. Digitalization is all about deriving digital intelligence out of digital data. The onset of integrated data analytics platforms, the faster maturity and stability of artificial intelligence (AI) algorithms, the realization of highly optimized and organized IT through cloudification, which represents IT industrialization, smartphones, and other I/O devices for enabling IT consumerization, virtualization, and containerization under the scope of IT compartmentalization, etc., have laid down a stimulating and sparkling foundation for the impending digital era. Cities are becoming digitally transformed cities. Similarly, other entities, such as homes, hotels, hospitals, etc., are being transitioned into digitally transformed entities. There are a number of digital innovations and disruptions fulfilling the real digital transformation. Digital life has become the new normal.

The emerging concept of digital twins is one of the transformational technologies toward the realization of digital era. The noteworthy point of any digital twin is that it can be continuously updated with data from its physical counterpart. With trillions of sensors and billons of connected devices, digital twins will be readied and deployed for millions of physical things. An aircraft engine, a human heart, and an entire city can have its own digital twin that mirrors the same physical and biological traits as the real thing.

The implications are definitely profound in many ways. Real-time assessments and diagnostics are now much more precise. Trial and errors, chaos experiments, and course correction can be easily accomplished through digital twins rather than physical twins. Thus, digital twins induce and inspire faster, cheaper, and clever innovations. Digital twins are to change the innovation game by enabling three critical drivers.
Continuous evaluation—Smart sensors being pasted on a product are capable of capturing and continuously updating the product’s digital twin throughout its lifetime. This empowerment goes a long way for the betterment of the products. Predictive maintenance of products is being achieved. For example, advanced cars are being beneficially endowed through their own digital twin. A slew of multifaceted sensors are attached on vehicles to capture the operational value of each of the important components. That is, vehicles on the road can send data to their digital twin to do real-time processing to emit out actionable insights in time. In short, digital twin-enabled vehicles simply enjoy a number of distinct benefits. The fuel efficiency can go up whereas the vehicle performance is bound to rise up considerably.

Faster and cheaper prototyping—The virtual version of any physical system comes handy in producing prototypes easily and quickly. Besides speeding up the innovation, the cost of producing physical products comes down sharply. Oklahoma State University developed a digital twin of an aerosol drug, which is intended to reach lung to annihilate tumor cells. By smartly varying parameters on the digital twin such as inhalation rate and particle size, scientists could clearly increase the number of particles reaching their target from 20% to 90%. There are a number of such promising case studies illustrating the strategic significance of building and running digital twins.

Uninhibited innovation—As inscribed above, the digital twin paradigm has unquestionably amplified the innovation quotient. There are companies exploring the digital twin idea in experimenting and experiencing realistic innovations. Predicting and managing traffic congestion in particular locations are being made possible through the leverage of digital twins. SenSat, a company specializing in creating digital twins of cities, has created a digital twin of Cambridge, England. All the traffic snarls and hiccups get eliminated from the city streets. As a digital and dynamic model, test scenarios can be performed on it to gain a deeper understanding and predict future events. In operation, as the physical asset undergoes changes, these modifications are being minutely captured and handed over to the user on a real-time basis. The overall functional role of a digital twin is three pronged—observation, optimization, and operation. The digital twin technology guarantees to transform the way industrial products and machineries are being instrumented, implemented, integrated, and operated across industries.
4. Digital twin industry use cases

Several business houses are keenly embracing this promising technology phenomenon in order to be ahead of their competitors in the knowledge-driven market condition. A few of them are given below:

- **Manufacturing** across industry verticals is the first and foremost one leveraging this unique technology in order to automate, accelerate, and augment several things in their day-to-day operations. New product designs are being facilitated while manufacturing processes are being continuously studied and optimized through actionable insights emitted by digital twins.

- **Automotive** industry is also seriously and sagaciously experimenting with the digital twin conundrum to develop next-generation vehicles. Increasingly cars are already fitted with advanced telemetry sensors, and their readings are continuously fed into digital twins in real time to bring in decisive and deeper automation especially in transitioning from connected cars to smart cars.

- **Healthcare** is another promising sector tinkering extensively with the digital twin paradigm. The mission-critical medical electronics devices and instruments are being literally empowered through their digital replicas, which are being hosted and run in cloud environments. As there is a need for large-scale IT resources for aiding big and streaming data analytics, cloud centers are being preferred to support and sustain the digital twin idea.

There are band-aid-like sensors being used for tracking various body parameters. The captured health data is transmitted to digital twins, which can quickly crunch the received data and predict if there is any important information with the person’s health. Digital twins can be used to predict different outcomes based on variable data. In manufacturing, with highly instrument devices, the digital twins can simulate and showcase how the devices have performed over time. With such capability, digital twins can easily predict the device performance in future. Similarly, the failure prediction also can be done. With the explosion of IoT devices and sensors/CPS, the popularity of digital twins goes up considerably.

Digital twins of windmills can support predictive maintenance. Sensor and camera data from mission-critical establishments such as nuclear
installations, wind parks and power plants ensure continuous surveillance. Further on, digital twins can proactively and preemptively alert the concerned if there is any nefarious action in and around walled and essential zones. Specialized sensors are being used in cars in plenty these days. There is a statistical information saying that every single sophisticated car involves hundreds of microcontrollers. Increasingly infotainment systems inside any vehicle act as the IoT gateway for taking sensor data to the digital twin to be instantaneously processed to take quick corrective action. The IoT dream is being facilitated through state-of-the-art digital twins. For the connected world, the next logical step is to leverage digital twins adroitly to move toward the projected smart world.

In summary, a digital twin is a dynamic and digital representation of a physical system. A digital blueprint of a house or building can be its digital twin. Similarly, a computer-aided simulation of an automobile transmission system can be considered as a digital twin. In short, things are increasingly becoming complex. Not only visualizing and building but also operating complicated systems has become a tough and time-consuming affair. There are a number of complexity-mitigation techniques and tips. The proven technique of “Divide and conquer” has been the hallmark for software engineering. Modeling, process-centricity, and simulation are the other key methods enabling the construction of complex systems across the industry verticals. With the advancements in the AI space, empowering systems to self-learn and adapt has gained prominence. Digital twins are also being portrayed as one of the pure and sure ways to tackle the increasing complexity of systems and their functioning.

5. Digital twins: The benefits

Digital twins offer a real-time and decisive look at what’s happening with physical assets. The knowledge gained could reduce maintenance costs and pains drastically. For an example, Chevron is rolling out the proven digital twin technology for its oil fields and refineries. Siemens uses digital twins to accurately model and prototype objects, which are not yet manufactured. The information extracted can reduce product defects and hence the time to market gets reduced sharply.

Digital twins enable companies to track the past, current, and future performance throughout the asset’s lifecycle. The asset, for example, a vehicle or spare part, sends its performance data and distinct events directly to its corresponding digital twin, even as the asset moves from the
manufacturer to the dealer and ultimately the new asset owner. Blockchain databases can be used to securely document everything related to the asset and IoT provides the real-time monitoring and updates. Microsoft and VISEO are partnering to use blockchain to connect each new vehicle’s maintenance events to the vehicle’s digital twin. Thus, digital twins are able to streamline additive manufacturing. With a series of innovations and disruptions in the digital space, the world is looking forward toward real digital transformation. The digital twins idea with continuous nourishment is to contribute for the digital transformation, the world is earnestly yearning for.

## 6. Blockchain as a powerful antidote

In the first part of this chapter, we have extensively discussed about the futuristic and fabulous implications of the digital twin paradigm across industry verticals. The perpetual and perplexing question is that if data breaches happen here. As we all know, wrong or corrupted data leads to wrong decisions. Thus, securing digital data and twins gains.

Data is extremely essential for the intended success of the digital twin paradigm. New data streams in the connected world typically comprise the participating physical objects’ attributes, the interaction data with other physical objects, and future states. The data interchange happens between the physical and digital worlds. While digital twin instances (DTIs) are mirroring a physical entity and activity, the digital twin aggregates (DTA) is a composite of individual DTIs to achieve bigger and better things. With this combination and collaboration, a breach of a DTI will compromise one product. A breach of DTA will expose a set of participating products.

The emerging blockchain technology has the innate potential to surmount the safety and security lacunae to put digital twin projects on the track. As blockchain technology is blessed with the decentralization and immutability attributes, digital twins projects can innovate better and faster through the shrewd usage of blockchain.

The cryptographic characteristics of blockchain ensure safe and secure data transfer. By having a robust authentication of users and data sources, data immutability along with the safety of digital twins promises a lot for the digital world. As explained in the previous chapters, through one or other consensus mechanism incorporated in the blockchain technology, multiple stakeholders, collaborators and users, can be brought under one umbrella. The stakeholders have become the gate-keepers enforcing
transparency and accountability. Thus, confidential, customer, and corporate information gets transmitted without any fear.

Through the astute combination of DTAs and blockchain, we can unquestionably expect the blockchain-enabled and path-breaking digital twins. From there, every business domain can visualize next-generation products, processes, operational models, etc.

Blockchain technology is a decentralized ledger with public records of all physical products and their transactions. The data can be viewed and verified publicly. However, modifications to it can be made only by authorized executives, and the ledger retains a history of every modification. In the previous chapters, we have discussed about the power of blockchain in surmounting many current problems and in laying down a breakthrough platform for envisaging and implementing newer use cases. Having understood the impacts, every noteworthy business domain is fast experimenting and evolving a strategic and sustainable blockchain plan. The blockchain technology is being empowered through a smart integration with other pioneering technologies such as the IoT, digital twin, AI, etc. On other hand, these technologies are being succulently and solidly empowered through the sagacious synchronization with blockchain. There are white papers, case studies, research publications, and best practices authored by technical experts, evangelists, and exponents clearly accentuating and eulogizing how the technology combination works wonders for several perpetual problems. In this and subsequent sections, we are to expound and espouse how different popular industry domains are tremendously benefitting out of this unique combination.

Eliminating counterfeits—On the supply chain side, now by combining digital twin and blockchain, businesses, and brands can easily protect their products from being wilfully counterfeited and increase the revenue remarkably. As widely known, one of the biggest concerns for worldwide businesses these days is skilled counterfeiting of their products. With the arrival of advanced technologies and tools, fraudsters can quickly create replicas for various expensive products and sell them to unsuspecting people at a cheaper price. This dangerous situation not only damages the brand name but also causes huge financial losses. Digital twin in conjunction with blockchain can bring forth a competent solution to thwart such frauds. They together guarantee the authenticity of products. As articulated above, digital twins facilitate the digitization of physical artifacts. As explained in the previous chapters, blockchain with its decentralization capability will bring in the much-needed transparency. This strengthen the security of any digital data.
7. The combination of digital twins and blockchain

The advent of the Blockchain technology has redefined the progress of digital twins. At macro level, blockchain enables the storage of information in a decentralized manner with no single point of control. Fresh transactions can be added, but the existing ones cannot be changed or corrupted. This clearly ensures transparency and data integrity.

Creating a digital twin on blockchain would mean that all information regarding a physical product can be saved immutably. Furthermore, the product’s transaction records can be saved. This means prospective buyers can get all the information of the product from its origin and also the journey it took off. This will help create proofs of authenticity and identity.

Consider a premium watch. There exist countless replicas of this costly watch. Fake watches can be made along with fake documents for proving their authenticity. However, creating digital twins on blockchain decimates such fake products and documentations. Digital twins, in a way, act as digital certificates for the digital age. Digital certificates stored and issued with the help of Blockchain will ensure that these certificates can’t be stolen, modified, and used wrongly.

Blockchain is becoming a popular digital technology that allows every transaction to be tracked in an inviolable way. The blockchain technology is gaining the inherent capability to redefine the concept of digital twins. It could turn out to be an indispensable tool to skilfully aid the application of digital twins in the ensuing IoT era. Sectors such as manufacturing, healthcare, and retail are set to benefit immeasurably from these technologies interlinking with one another. There is a tight coupling between the physical world and the digital world.

A digital twin built with traditional technologies must need a central intermediary for stocking digital data and for doing data analytics. Now, with the booming blockchain technology, the aspect of digital twins is bound to go through strategically sound transformation. The security and immutability being guaranteed by blockchain are to take digital twin to the next level in the days to come.

Keeping a digital twin (more specifically digital certificate) on blockchain helps businesses to retain information about their products perpetually and securely. Further on, the data regarding transactions for these products also can be saved in the blockchain database. This allows any perspective buyer to get the complete details including the real manufacturer, who are the other owners of the product, etc., about the product during purchase.
Precisely speaking, it helps establish the authenticity and provenance of the product. It is possible to craft a fake document to prove its authenticity. By creating digital twins/certificates on the blockchain, fake products can be eliminated from the sordid market. An immutable and tamper-proof digital certificate for each of the products is the way forward to nullify any kind of fraud.

Blockchain actually stores digital certificates that embed all the relevant data regarding the products registered by businesses. Blockchain ensures that the data embedded in the digital certificates cannot be copied, modified, and even deleted by others. Businesses can register their items on blockchain platforms. As enunciated above, every concrete product has its corresponding digital twin and in this case, it is digital certificate. The digital certificate gets updated at every stage of the product cycle right from the manufacturing stage. When the product is shipped, the information regarding the place, mode, and shipping destination can be updated with timestamps. When customers buy the product, they can verify the authenticity of the item by verifying the digital twin of the product on the blockchain. After the item is purchased, the ownership gets transferred to the new owner by the authorized salesperson. All the previous data stored is maintained as such. No modification is possible.

Without an iota of doubt, blockchain brings the much-needed reliability and credibility to businesses. Clearly, blockchain is being touted as an anti-counterfeiting and antitheft technology. If businesses across the world implement this with a proper care, then the evil things of faking and falsification can be easily surmounted. The confidence of people on various products gets a strong boost. Buyers get all the right information about any product instantaneously. Unverified ownership will become a thing of the past and people get to know the complete details about every product. This inspiring combination is penetrating into every industry vertical ranging from manufacturing, healthcare, advertisement, and logistics.

**Digital twin and blockchain in logistics**—Supply chain processes can be unequivocally streamlined and secured using digital twin and blockchain together. Shipping containers embedded with a number of IoT sensors are connected to the blockchain platform in order to ensure a complete transparency in the complex logistics process. The products empowered through multiple sensors can have their own digital twins, which land on blockchain. This powerful entitlement helps to track and trace the products. This helps the stakeholders to have complete information about the product and the transportation process. The documentation for the
products also can be stocked in blockchain database eliminating any kind of modification and forgery. The documents with product and payment details can be tracked digitally. The transparency aspect of the logistics sector can be fulfilled through blockchain and digital twin combination.

**Digital twin and blockchain in utilities**—Digital twin and blockchain can be used in the utility sector to help utility operators in efficiently fulfilling their consumers’ requirements. As we know, the production and consumption of power energy varies sharply based on consumer behavior. Nowadays, electricity meters in our homes are being attached with IoT sensors to be transitioned into smart electricity meters. These connected meters can directly communicate the consumption data every few minutes to the smart energy grid. The energy consumption details of every individual consumer can be digitally updated on the blockchain to guarantee transparency. The corresponding digital twin for the smart energy grid can receive and analyze the energy consumption data to extricate actionable intelligence. This gives energy service providers (energy generation, transmission, and distribution) a clear understanding about the consumer behavior. Accordingly, power producers and suppliers can do everything in an optimal manner. On the other hand, consumers based on peak energy costs could adjust the power usage time to time to reduce expenditure on energy.

**Digital twin and blockchain in healthcare**—The use of digital twin and blockchain together can bring in drastic changes for the healthcare industry. As the whole world is severely stricken with Covid 19 virus, the smart combination of multiple technologies is the way forward to comprehensively overcome the grave challenges especially in curtailing the growing fatalities.

For a prime example, the digital twin of a patient’s heart can be realized through the digital version of a pacemaker. This digital twin can specially empower cardiologists, who are carrying out cardiac resynchronization therapy, in precisely identifying the position of leads on the specific patient. All the lead placement positions pinpointed through the digital twin can be tried virtually to determine the best suitable position. This happens well before the real surgery begins. The best suitable position enables the surgeons to complete the operation with all the intended success. Blockchain can safely hold records of the medical history of the patient. The trustworthy and timely data can be accessed anytime by healthcare providers and professionals to ponder about the next course of action in case the person develops any untoward complications in the future.

Thus, digital twins and blockchain can blend together to bring in a bevy of transformational effects across industry verticals. By merging digital
twin with blockchain technology, a secure and decentralized digital ecosystem can be formed and sustained. This solemnly assures businesses and end-users the authenticity of the products and services.

Aircraft industry—The manufacturers of different components of aircrafts are being strictly governed by unambiguously written technical standards. The ultimate aim is to certify and monitor the component production process. Further on, this industry domain increasingly uses additive manufacturing technologies to accomplish rapid prototyping of product components. Aided by highly optimized supply chain, the time to market comes down sharply while not compromising on the product quality. There are recommendations for producing and sustaining digital twins for additive manufacturing. It is recognized that the fusing of digital twin and blockchain can be a trend-setter for many industry sectors.

IBM Watson IoT, a cognitive system that learns from and infuses intelligence into the physical world, is fervently expanding its scope further by creating digital twins by using blockchain. Also, IBM is implementing blockchain to existing digital twins. It is believed that blockchain can substantially increase the cost-effectiveness of digital twins. Utilizing blockchain with digital twins facilitates digital identity and data tracking through blockchain traceability.

With a greater understanding, enterprises are keenly experimenting with the blockchain paradigm, which is fast penetrating and participating beneficially in many business domains. As we all know, Internet is the world’s largest information superhighway. However, data transmission through the Internet, which is the most affordable and global-scale communication infrastructure, is battling a few security and privacy challenges. Blockchain is being projected as the promising savior here. Further on, blockchain-based infrastructure is being pronounced as the next-generation phenomenon for the secure exchange of value.

8. Blockchain and digital twins for enhanced digital value

With blockchain in place, the concept of digital value transfer will be implemented in a completely decentralized way. Crypto chips, which can be easily and quickly implanted on any physical asset, are enabling scores of physical assets getting directly linked to a blockchain platform of choice. The asset can be anything ranging from credit cards, personal devices, consumer electronics, drones, robots, and appliances, medical
instruments, to industry machineries. The metadata of physical assets are being stored in blockchain databases. This guarantees that transactional and operational data actually originate from highly trustworthy sources and spread across with proven integrity. Private keys never leave the crypto chip and hence transaction data is fully encrypted while in transit until it gets formally recorded in an immutable ledger system.

Digital twins are increasingly stored on blockchains. Therefore, digital twins, while gaining the much-needed trust, are used efficiently to regulate business transactions involving multiple participants and parties. With trust enshrined through blockchain, we can safely expect that here will be many more innovations in the flourishing field of digital twin.

9. Digital twins for sharing economy

The realization of industrial IoT (IIoT) has led to smart manufacturing. The industry 4.0 vision gets accelerated through the astute usage of the IIoT competencies. Factory floors are skilfully automated through a variety of IoT sensors and actuators. IoT data, which is typically big in size, is being meticulously analyzed in order to get the useful insights in order to plan and execute appropriate tasks in order to steer businesses in the right direction. Industry machineries are not only connected but also made smart in their actions and reactions. IIoT in consonance with transformative technologies such as AI, blockchain, digital twin, etc., can be a fulsome hallmark for the future of our business powerhouses. However, industry players’ efforts to monetize their industry IoT devices, which they own or use for production were without any grand success thus far. The rise of the sharing economy and its supporting technologies represents a paradigm shift in the access and consumption of IoT systems and services.

In traditional transactions, the transfer of ownership of a product to a buyer is the end of the story for the manufacturer or vendor in the value-creation process. In the new sharing economy, either the asset is a shared entity or the device/asset’s output is portable. For example, a car is a physically portable asset that can be collaboratively consumed. But in the case of a windmill, it is the asset’s output (wind energy) that gets shared across.

The dual concepts of digital twins and machine-to-blockchain networks are portrayed as key technology facilitators for intrinsically empowering industrial IoT devices to participate in the fast-evolving sharing economy. These concepts can support and sustain the distinct ideals of the sharing economy. As the digital era evolves, newer business models are emerging.
One promising model is a service-based business model. This can be deftly applied to individual IoT devices, and this can result in gaining an auxiliary revenue stream based on usage or outcomes. This new paradigm brings two important things. The first one is digital twins, which can virtually articulate the unique capabilities of the IoT device to any prospective buyer. The second is machine-to-blockchain, which facilitates smart and secure monetary transactions.

10. Conclusion

With the flourish of interactive IoT devices, a massive amount of multistructured data gets generated, transmitted, and stored in local and remote storage systems. There are powerful AI algorithms and integrated data analytics platforms for processing IoT data using batch and real-time processing methods to extract actionable insights. On the other hand, there are digital twins being built for IoT devices in order to deeply understand and articulate their structural properties and behaviors in different contexts. Existing and emerging IoT devices and their constant interactions with others in the vicinity and with remotely held applications and data sources/stores are being decisively investigated through their digital counterparts individually and collectively. Digital twins even simulate the working of physical products according to changing situations and hence a lot of useful knowledge gets delineated before the said products are physically manufactured. Thus, the scope of usage and benefits of digital twins are consistently on the rise. However, IoT devices can be remotely pierced through by brilliant hackers damaging the device networks to do irreparable damages to the IoT systems and applications. Similarly, IoT device data, when in transit and rest, can be breached to steal confidential information. Further on, digital twins can be made inaccessible, or corrupted data can be submitted to digital twins to make wrong decisions, etc.

With the faster maturity and stability of blockchain, the IT experts are exploring the possibility of establishing a linkage between digital twins and blockchain in order to ward off the security threats. The combination of these two technologies presents a positive future for the business and IT domains. How the blending of these two path-breaking digital technologies could bring forth a number of digital innovations and disruptions gets detailed in this chapter. The combined entity has laid down a strategically sound platform for envisaging and implementing a number of business, technology, and user cases.
Digital twins are also being continuously updated and upgraded by incorporating the cutting-edge technologies such as machine and deep learning (ML/DL) algorithms, computer vision (CV), and natural language processing (NLP) methods. Thus, with the cool synchronization with blockchain, the digital twin domain is to flourish in the years to come.

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