Blockchain Technologies

Gunjan Chhabra
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Understanding the Metaverse

Applications, Challenges, and the Future

Springer

Blockchain Technologies

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This book series aims to provide details of blockchain implementation in technology and interdisciplinary fields such as Medical Science, Applied Mathematics, Environmental Science, Business Management, and Computer Science. It covers an in-depth knowledge of blockchain technology for advance and emerging future technologies. It focuses on the Magnitude: scope, scale & frequency, Risk: security, reliability trust, and accuracy, Time: latency & timelines, utilization and implementation details of blockchain technologies. While Bitcoin and cryptocurrency might have been the first widely known uses of blockchain technology, but today, it has far many applications. In fact, blockchain is revolutionizing almost every industry. Blockchain has emerged as a disruptive technology, which has not only laid the foundation for all crypto-currencies, but also provides beneficial solutions in other fields of technologies. The features of blockchain technology include decentralized and distributed secure ledgers, recording transactions across a peer-to-peer network, creating the potential to remove unintended errors by providing transparency as well as accountability. This could affect not only the finance technology (crypto-currencies) sector, but also other fields such as:

Crypto-economics Blockchain
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Blockchain Technology and It's Future Applications
Implications of Blockchain technology
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Blockchain Architecture
Blockchain Business Models
Blockchain Consensus
Bitcoin and Crypto currencies, and related fields

The initiatives in which the technology is used to distribute and trace the communication start point, provide and manage privacy, and create trustworthy environment, are just a few examples of the utility of blockchain technology, which also highlight the risks, such as privacy protection. Opinion on the utility of blockchain technology has a mixed conception. Some are enthusiastic; others believe that it is merely hyped. Blockchain has also entered the sphere of humanitarian and development aids e.g. supply chain management, digital identity, smart contracts and many more. This book series provides clear concepts and applications of Blockchain technology and invites experts from research centers, academia, industry and government to contribute to it.

If you are interested in contributing to this series, please contact msingh@endicott.ac.kr OR loyola.dsilva@springer.com

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To my family, thank you for encouraging me in all my pursuits and inspiring me during this journey. I am especially grateful to my parents and wife, who supported me emotionally. I always knew that you believed in me and wanted the best for me.

—Dr. Gunjan Chhabra

This book is dedicated to my beloved Parents-Sh. Vijay Kaushik, Smt. Saroj Kaushik,
Wife-Priyanka, and daughter Kashvi. May god always bless us, Har Har Mahadev!!

—Keshav Kaushik

Foreword

Welcome to the cutting edge of the digital era, where virtual and real reality collide and infinite possibilities beckon. Throughout the book, readers are going to take a voyage into the metaverse on the pages that follow; this is a place that exists outside the boundaries of our physical reality and has the power to drastically alter it.

The concept of the metaverse has captured the imagination of visionaries and technologists alike, offering a glimpse into a future where digital environments seamlessly blend with our everyday lives. This book serves as a guide through this immersive landscape, offering insights into its origins, evolution, and transformative potential.

As we delve into these pages, readers will learn about the complex network of technologies that support the metaverse and various implementations, from blockchain to AI to augmented and virtual reality. Readers will investigate the ramifications of this digital frontier in a variety of fields, including business, entertainment, healthcare, and education.

But this journey is not merely one of exploration; it is a call to action. As we confront the challenges of security, privacy, and identity within the metaverse, we must also envision its vast potential for positive change. From revolutionizing industries to fostering global collaboration, the metaverse holds the key to unlocking a future limited only by our imagination.

So, Dear Readers, I invite you to join this intellectual odyssey as we unravel the complexities, envision the possibilities, and navigate the uncharted territories of the metaverse.

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Preface

This book serves as a guide through the immersive landscape of the metaverse, a paradigm-shifting concept that is reshaping the way we perceive and engage with the digital world. Within these pages, we embark on a journey that unravels the origins and evolution of the metaverse. From its conceptual foundation to the intricate web of integrated technologies driving its development, we explore the transformative forces of augmented reality (AR), virtual reality (VR), mixed reality, and the convergence of technologies that define the metaverse.

The narrative unfolds systematically, shedding light on the interconnectedness of the metaverse, non-fungible tokens (NFTs), and the evolution toward Web 3.0. Chapters delve into the depths of digital twins, metaverse services, and the far-reaching implications for education, healthcare, business, and entertainment. As we navigate this digital landscape, we confront pressing issues of security, privacy, and identity. From the intricacies of social interactions to the challenges of combating cyber frauds and safeguarding data, this book provides a nuanced understanding of the complexities inherent in the metaverse.

The journey extends into the future, exploring the metaverse's potential applications in travel, tourism, smart cities, and military defense. We examine the role of blockchain in shaping the metaverse's futuristic landscape, along with the legal and jurisdictional considerations that accompany this emerging digital frontier. This book is more than a mere exploration; it is a roadmap for those eager to comprehend the intricacies of this transformative digital universe. The narrative looks beyond the present, addressing the challenges and future prospects that await us as we embrace the metaverse. Embark on this intellectual journey with us, as we unravel the complexities, envision the possibilities, and navigate the uncharted territories of the metaverse. Your understanding of this digital frontier commences here.

Dehradun, India — Gunjan Chhabra
Punjab, India — Keshav Kaushik

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About the Editors

Dr. Gunjan Chhabra is a Ph.D. in computer science and engineering, working as Associate professor in the Department of Computer Science and Engineering, Graphic Era Hill University, Dehradun. He has a teaching experience of 10 years, and an area of his expertise is algorithms, image processing, and machine learning. He has published ten patents, with four granted patents from IPR. Also, he has published several research papers in various renowned journals. Additionally, he has authored three textbooks on the domain Internet of Things, smart technologies, and machine learning. He has also mentored many projects in different domains of computer science to solve real-world problems. Under his guidance, his students have successfully incubated their ideas.

Keshav Kaushik is an accomplished academician, cybersecurity, and digital forensics expert currently serving as an Assistant Professor at the Amity School of Engineering and Technology, Amity University Mohali, Punjab, India. As a key member of the Cybersecurity Centre of Excellence, he has been instrumental in advancing the field of cybersecurity through his dedicated teaching and innovative research. In addition to his academic role, he holds the prestigious position of Vice-Chairperson for the Meerut ACM Professional Chapter, highlighting his leadership and commitment to the professional community. His academic journey includes a notable stint as a Faculty Intern during the Summer Faculty Research Fellow Programme 2016 at the Indian Institute of Technology (IIT) Ropar, reflecting his continuous pursuit of knowledge and professional development. His scholarly contributions are extensive and impactful, with over 135 publications to his credit. This includes 25 peer-reviewed articles in SCI/SCIE/Scopus-indexed journals and 50+ publications in Scopus-indexed conferences. He is also an inventor, holding one granted patent and six published patents, alongside five granted copyrights. His editorial expertise is showcased by publishing 30 books and 25 book chapters, further cementing his reputation as a thought leader in the field. His professional certifications are a testament to his expertise and commitment to excellence. He is a Certified Ethical Hacker (CEH v11) by EC-Council, a CQI and IRCA Certified

ISO/IEC 27001:2013 Lead Auditor, a Quick Heal Academy Certified Cyber Security Professional (QCSP), and an IBM Cybersecurity Analyst. His recognition as a Bentham Ambassador by Bentham Science Publishers and his role as a Guest Editor for the IEEE Journal of Biomedical and Health Informatics underscore his influence and authority in cybersecurity. He is a dynamic speaker, having delivered over 50 national and international talks on cybersecurity and digital forensics topics. His mentorship was acknowledged during the Smart India Hackathon 2017, under the aegis of the Indian Space Research Organization (ISRO), with a certificate of appreciation from AICTE, MHRD, and i4c. A two-time GATE qualifier with an impressive 96.07 percentile (2012 and 2016), he has also received accolades from the Uttarakhand Police for his significant contributions to cybercrime investigation training. With a career marked by significant achievements and a profound impact on cybersecurity and digital forensics, he continues to inspire and lead in both academic and professional circles.

Introduction to Metaverse

Umesh Gupta and Abhinendra Singh

Abstract Sharing information has been one of the main goals for ages. The need for more efficient and interactive sharing methods increased as time passed. This gave birth to the "World Wide Web", which enabled searching for information amongst different documents. Initially, everything was static, meaning users could only read the information from the web. With the growth of social media, a new Web model emerged: a two-way flow of information. Now, users not only read information from the web but can also share it. The productivity level can be increased tremendously by integrating various technologies like Artificial Intelligence, Virtual Reality, Augmented Reality, Blockchain and Internet of Things (IoT). With these new technologies, a new era of the web is emerging in which, instead of traditional 2D websites, a 3D virtual space will be created where users can meet their friends face-to-face via virtual avatars, create, buy and sell digital artefacts or tokens (NFTs). This chapter aims to cover these new emerging technologies and what difference they can make in lives and the whole working structure of the Internet.

Overview

It all started on October 29, 2021, when Facebook changed its logo and name to "Meta" boosting. Some governments even started taking various initiatives to accelerate metaverse adoption. Metaverse sounds like science fiction in which there is a virtual world, and everything is like a game, but there is an increasing trend of its application in commerce. But till now, metaverse is more of a concept, so this chapter will take the reader on a journey to all the aspects of metaverse, what benefits it can provide, and will there be any future consequences? With this imagined virtual space, there will be an increase in the use of digital currencies like Non-Fungible Tokens (NFTs), creating opportunities for various artists to commercialize their products like art pieces, music, memes,

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etc. This space also comes with lots of responsibilities and requirements, first and foremost is safety and another quite important need is the end of centralization i.e., decentralized surfing on the web in which flow of information is not restricted and controlled by only one party. Users can roam around space and buy land and properties as NFTs. This version is called "Web 3.0", in which the user will own the internet and can regulate it on their information record. This Web version will be centred on blockchain technologies, thus allowing the decentralized ownership of information, services, or platforms. Metaverse and Web 3.0 will be omnipresent in the future; we do not know many things about these new buzzwords since they are in the very early stages. There might be many changes in what we are expecting from them. There can be various problems faced while building them. But we can only say that these new technologies can drastically change how we surf the internet and buy something. It is also possible that the schools will be shifted to this virtual space, one can travel around the world and many more things. This chapter will try to answer all the questions in the readers' minds regarding these new techs.

> the Web as I envisaged it, we have not seen it yet. The future is still much bigger than the past.—Tim-Berners Lee.

The web has come a long way; it was in 1989 when Tim Berners-Lee, a computer scientist working at CERN, made an automated information-sharing system that enabled a connection between various universities and institutes, thus helping scientists to share information. It was marked as the beginning of the World Wide Web or "Internet". From this point, there is no looking back; with many new technologies like Artificial intelligence, Blockchain, Internet of Things (IoT) and Augmented Reality, a new web is emerging with a new level of user interaction and security. From traditional 2D websites, we are moving towards a virtual 3D space where one can interact with friends. Let's dive into the detail of these new emerging technologies.

1 Web 3.0

1.1 Brief History

The Web can be defined as sharing information, documents and resources between users through an international network (Internet). It can also be considered an ample storage of information stored on the servers and accessed by the clients through the internet. Since its development, the web has evolved a lot. The earlier web was only the collection of some text designed and formatted on Hyper-Text Markup Language

(HTML) [1]. Firstly, it was only intended for sharing information and was in read-only mode, meaning it was not interactive. It was March 1989 when Berners-Lee discussed a system called Mesh. The main idea of Berners-Lee behind the web was a common information space in which one can communicate with each other by sharing information [2]. Till now, we have two eras of the web, which are as follows:

- **Web 1.0**: It was the first unidirectional web model, i.e., the user can only read the information and not upload anything. It used HTML, HTTP and URLs. Some other protocols like XML, XHTML and CSS were also used—some merged technologies between the server and client, like ASP, PHP, JSP and CGI. JavaScript and VBScript were used on the server, and Flash on the client side. This web was very slow; it was not responsive. Users must refresh the page unnecessarily to see any new information uploaded.
- **Web 2.0:** With the growth of social media in the 2000s, a new model of the web emerged, which was Web 2.0, also called Participative and Social web; this allowed the user to read as well as upload information on the web. Web 2.0 uses AJAX technologies like JavaScript, XML, DOM, REST and CSS. This web concentrates more on user interaction, User Generated Content (UGC) and connectivity with other systems. Hacking is one of the key and main issues of this web as this web has more interaction and less control.

1.2 What is Web 3.0?

Until now, the web was just an information-sharing platform where users read and upload their information. But now there was a need for an intelligent web to understand the user's words and give them more efficient and accurate results. Another issue with the past web version was hacking, where an unauthorized third party can manipulate and steal any user's data. Thus, Web 3.0, a decentralized, open to everyone, built on the top of blockchain technologies, is emerging as the new generation of the web. It aims to end centralized companies, where users control their data and transactions.

1.3 Web 3.0 Technologies

This web is an intelligent and innovative web that can interpret and process information like humans. Thus, many technologies are being used in developing this web, such as human-like interpretation ability, which will be achieved by Natural Language Processing, which aims to process and handle text data and help to find meaning.

i. Blockchain technology

It is one of the recent technologies which aims to provide a trusted data-sharing and record-management system. It is a colossal transaction ledger, replicated across

multiple users in which no third-party company has any intervention. Thus, it is a decentralized transaction and data management technology without third-party control for data and user trust [3]. The system is made such that every transaction is given a time stamp; thus, without approval, the data cannot be altered or modified. This will ensure the credibility of the information when performing any transaction over a network.

Let us try to understand with an example; let us assume that a student graduated, and the recruiter requests an official document or proof of graduation. This transcript can be directly collected from the university, where the university acts as a trusted intermediary between the student and the employer, ensuring the information is authentic and trustworthy. There can be one question: why can't the employer ask the student to submit a copy of the transcript? The answer is "Trust", as the student can change the content for their benefit. So, briefly, the true service provided by a third party is trust, which is precisely the Blockchain proposition.

Definition Blockchain is a transactional database technology that is a decentralized way to validate and allow reliable and consistent transactions across the participants, also known as nodes [4].

Before moving forward, there are a few things one should know. As discussed previously, blockchain is a distributed technology. Each peer maintains a copy of the ledger to prevent a single-point failure. Now, if a new thing comes to the blockchain network, each node must agree or disagree on whether it is valid or invalid. This process is used to get agreement on its validity among a distributed system. This is called the *Consensus algorithm.* One can think of it as a group of friends trying to decide which place they can go for their holidays.

There are major Blockchain Key elements, which are as follows:

a. *Distributed ledger:* A shared database in the decentral network stores all the transaction information. It is a replicated, shared and synchronized spread across many sites, countries, or institutions. On the other hand, unlike a centralized database, a distributed ledger has no controlling authority or administrator since it is replicated across a distributed computer node, so it requires a peer-to-peer (P2P) computer network and Consensus algorithms [5].

The distributed ledger based on the P2P network which is spread on multiple nodes. Each node duplicates and stores a similar copy of the ledger and independently updates itself, thus ensuring no central authority. Let us see if it works; a ledger has been updated (Fig. 1).

Now, it will be broadcasted to the P2P network in which each node will process a new update transaction independently, and then, using the consensus algorithm, a correct copy of the updated ledger is determined.

- *Smart contracts*: These are executable codes that run on the decentralized network Blockchain that enforce an agreement between the fraudulent parties; this is done without any central authority [6]. It replaces paper contracts with digital contracts and gives network automation. These contracts can guarantee the reduction of

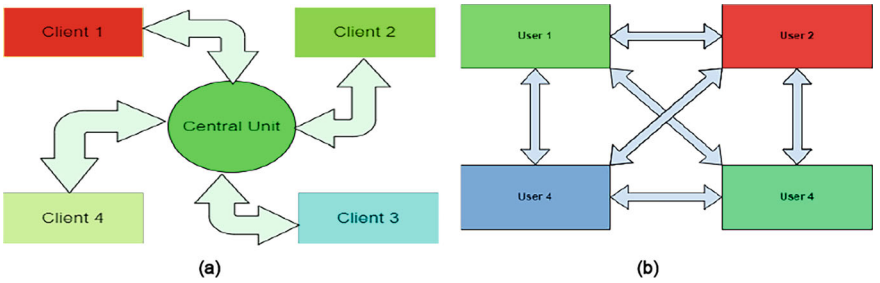

Fig. 1 **a** Centralized system, **b** Decentralized system

human errors to avoid disputes in these contracts. To prevent alteration by any party, these contracts are copied to each node of the network. Programmatically, these contracts store information, process inputs and write outputs using some pre-defined functions. Some examples of pre-defined functions:

- Constructor function: This enables intelligent contract creation. So, to host a new contract, this function is invoked through a transaction, and the transaction's sender becomes the contract's owner.
- Self-Destructor function: The owner can only invoke this function to destroy the contract.

These contracts contain state variables, functions, function modifiers, events and structures that control and execute various actions. One contract can also be called by another contract.

- *Public key cryptography*: This security feature gives the Blockchain network members a key that gives them unique identification. There are two types of keys: the public key common to everyone on the network and the private key unique to the members. These keys are used to access any data in the ledger.

Blockchain integration in Web 3.0 will enable secure transactions since data will be managed and validated in this decentralized peer-to-peer network. Various layers of blockchain are shown in Fig. 2.

ii. Artificial intelligence/Machine learning

Artificial intelligence is a machine mimicking how humans think, understand and implement things. It is one of the definitions that has surfaced worldwide in the past decades. Simply artificial intelligence (AI) combines computer science and user data, thus making the computer machines learn and solve problems. It has sub-fields, which are Machine learning (ML) and Deep learning (DL):

- *Machine Learning (ML)*: This algorithm teaches the machine to handle the data more efficiently. Since finding patterns in the data and extracting relevant data is often very complex, we use Machine learning algorithms that understand the complex data easily in such scenarios. With abundant available data, Machine

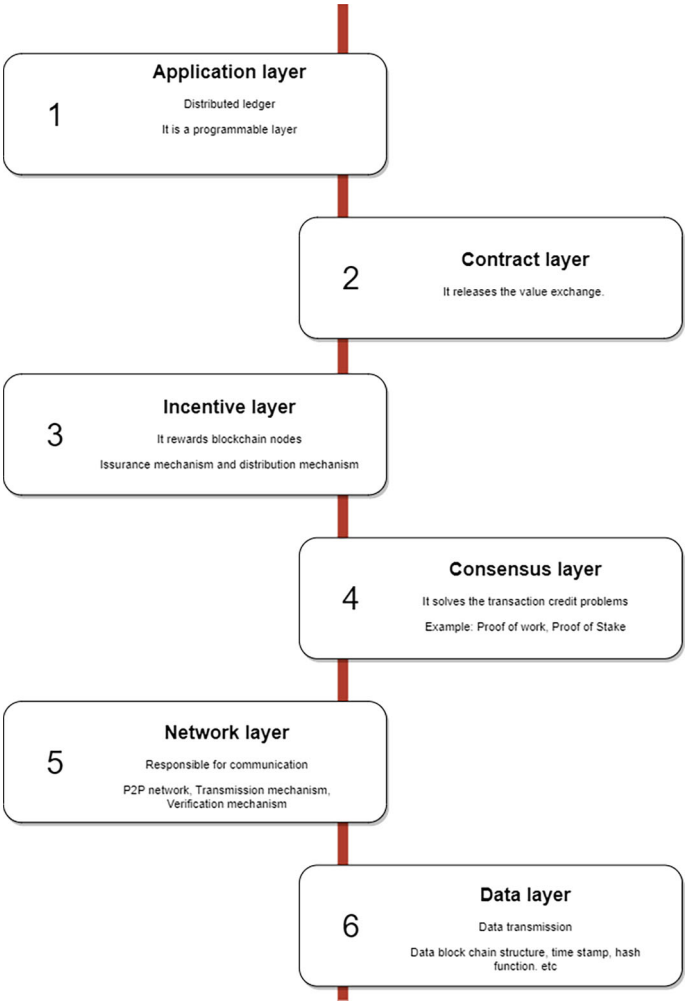

Fig. 2 Layers of blockchain

learning algorithms are now applied in various fields. Machine learning models solve multiple problems, such as classifying the data or classes. There are many types of Machine learning algorithms, as shown in Fig. 3.

- *Deep learning:* This method trains computers to process data like a human brain. This model can recognize complex patterns in images, text, sounds and other forms of data. This model contains multiple processing layers, enabling the machine to learn from the data with different levels of abstraction. Human neural networks inspire deep learning algorithms.

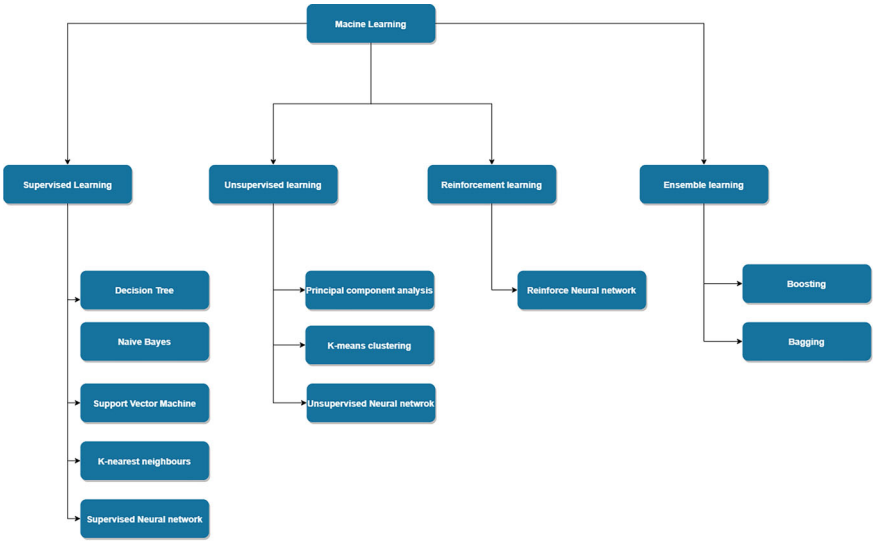

Fig. 3 Various machine learning algorithms

Web 3.0 aims to understand the "meaning" and "emotions" of the data. Thus, using an AI algorithm will enable us to create a web not concerned with data structure but with "*Meaning*".

1.4 How Will Web 3.0 Work?

The conventional layouts and delivery of the webpages defined using HTML will be same in Web 3.0. Still, changes can be expected in how they connect with the data sources and where they reside. This web with different data connection techniques also aims towards a Semantic web, which means it will study the relationship between the words. Let us see an example,

I Love Decentralization.
I < 3 Decentralization.

The above two sentences seem different, but their semantics are the same, or both are saying the same thing. Since Web 3.0 will be the future of the web, it will be better to understand how Web 3.0 works by comparing it with the existing web form, web 2.0, refer Table 1.

Table 1 Difference between Web 2.0 and Web 3.0

S. no.	Web 2.0	Web 3.0
1	**Centralized** All the services and platforms are governed by a central authority that always acts as an intermediary between the users	**Decentralized** A peer-to-peer network with a distributed system will be used where users control their data and transactions
2	**Flat currency** The currency that the government issues is used, like the Indian Rupee	**Cryptocurrency** Using blockchain technology (as mentioned in Sect. 3.1), digital currencies such as Bitcoin are used
3	**Cookies** This is used to see and track the users who visit any site, to understand the pattern in which the user is surfing, and to provide personalization accordingly	**NFTs** This is a unique token given to a user; these tokens are assigned some values that can provide the users with some perks
4	**CSS and Ajax** This web is defined using this layout that sees which form data is used and not the meaning	**AI (Artificial Intelligence)** This smart web can understand the meaning and emotion of the data and not only the structure
5	**Relational database** These central databases store the data in one or more tables of columns and rows. The relationship is logically established between different tables	**Blockchain** A distributed ledger will be used to store the data (Sect. 3.1)
6	**Social Network** This web created a new space where each user relates to other users and can share their information	**Metaverse world** This emerging world is a virtual space that is comprised of Virtual Reality and Augmented Reality
7	**IPv4 addressing space** Web 2.0 uses a 32-bit address space, which provides 2^32 unique addressing space	**IPv6 addressing space** In Web 3.0, the address space is increased to 2^128

2 Non-fungible Tokens

Earlier, when blockchain technologies did not exist, a system for verifying and securing digital assets was not very safe, and there was always a chance of tampering by unauthorized parties. Owing to this problem, NFTs were introduced, tokens that represent digital assets and are made above blockchain technology, giving them a unique ID and a decentralized ledger thus preventing tampering by any third party.

Definition These are assets that are based on the blockchain. Each token has been given a unique identification code and metadata, distinguishing every token from one other.

Let us understand NFT, word by word:

- Non-fungible: In terms of economics, the item is unique and distinguishable; any other item cannot replace it. For example, the Rupee bill is fungible as other rupee bills can interchange it.
- Tokens: According to the Oxford Dictionary, it is a piece of an item of any form that can be used to buy something of a specific value.

2.1 Brief History

In the world of digital currencies, in May 2014, the first NFT was developed by Kevin McCoy and Anil Dash; it was then registered on the Namecoin blockchain and sold for $4. At that time, it was not called NFTs, but they called it "monetized graphics".

In 2015, the first NFT project was developed and demonstrated as DEVCON 1 in London. This project's name was Etheria, 457 purchasable and tradable hexagonal tiles. In the first four years of its launch, Etheria remained unsold. After all this year, it was March 13, 2021, since by this time, interest in digital currencies and NFTs increased, so within 24 h, all the tiles were sold for US$ 4 million. Thus marked the beginning of the NFTs.

In 2017, CryptoKitties, an online game, was profitable because of tradable Cats. It was in 2021 that a JPEG digital picture was sold for $69 million, even at the time of the pandemic. This boosted the interest of the whole world in this technology and thus started a new form of currency (one can say), NFT. It is a type of currency derived from the smart contract of Ethereum.

2.2 Ethereum

NFT is based on blockchain technologies, and NFTs are a new emerging digital asset that people can sell and buy, so there is a need for a blockchain above which all the stated things can be done securely. Thus, **Ethereum,** a community-run technology software that provides a platform for developing and deploying Dapps (Decentralized Applications) [7, 8], is designed to enable NFT transactions.

It is a blockchain network with Turing-complete programming and various abstract layers to allow everyone to own ownership, transaction formats and state transition methods. It is a platform where anyone can build and deploy a decentralized application. This is the only blockchain with a programming language that enables users to write smart contracts and DAPPs to create rules for ownership and transactions.

2.2.1 Ethereum Features

a. Ether

Like the real-life scenario, one needs payment to do a task. Ether is Ethereum's currency, used as payment for resources and fees for performing any transaction on the network. It is used to pay for transactions and buy GAs, which is a payment for the computation of any transaction; we will explore "Gas" in the later part of this chapter. The value of Ether works similarly to a stock market, but the only difference is that the prices are more liquid, which means prices change very frequently. Overall, we can say that it is a fuel of the Ethereum network.

b. Smart contracts

As mentioned in Sect. 3.1, these are executable codes that facilitate the exchange of any info or assets (in the case of NFTs) between the users. It consists of various terms and conditions that should be agreed upon by the parties in the network. It is far more secure than traditional contracts, as they can't be altered once they are executed, and payment done on the top of a contract is permanently registered, so if in future there is any change in the contract, transactions related to the original contract will not be altered. One more thing that makes it more beneficial is that its verification process is carried out by anonymous parties, making it decentralized.

c. Ethereum Virtual Machine (EVM)

As mentioned in the previous sections, smart contracts are programs written in a programming language (Solidity in Ethereum) executed to enable and register it to the network. So, for any programming language, there needs to be an engine that understands the language of smart contracts. Thus, Ethereum Virtual Machine (EVM) is a runtime environment that provides a compiler for Ethereum-based smart contracts and provides deployment features.

The language used to develop the smart contracts is converted to bytecode, which is understood and executed by the EVM. Another thing about the EVM is that it is a sandbox environment, which means it is a stand-alone environment for testing and development. Before deploying the smart contract in the leading Ethereum network, one can verify and test the contract several times.

Let Us Now Understand the Working of the EVMs:

Let us consider a scenario where Ansh wants to pay 20 Ethers to Rahul. This transaction will be executed using a fund transfer smart contract between Ansh and Rahul; this contract will be sent to the EVM for validation. Validation is done by the Proof-of-work consensus algorithm (Sect. 3.1). Miner nodes in the Ethereum network check and validate the transaction. All the nodes on the network will execute these contracts using their respective contracts.

- **Proof-of-work**: It is a technique to verify any new transaction added to the blockchain network. Since blockchain has no centralized authority, this technique ensures the integrity of the new data in the network.

The miners in the network are the participants who are allowed to check and verify the transactions. Their goal is to validate the blocks. They use various hashing algorithms like the Ethash algorithm, which returns an appropriate hash value. A hash value is considered suitable when it is less than the pre-defined target per the proof-of-work consensus. Miners in the network compete to get a block verified, and once a miner succeeds in proving a block, they are rewarded.

- **GAs**: It is the fuel of the Ethereum network; users need to pay "GAs" to get any transaction done. The transaction fees are calculated using Eq. 1.

$$\text{Ether} = T * \text{fees} = \text{Gas limit} * \text{Gas price} \tag{1}$$

where, (i) **Gas limit** = Amount of gas fuel used for the computation.
(ii) **Gas price** = Amount of Ether a user is required to pay.

d. Decentralized applications (DApps):

It is a decentralized application that is developed on blockchain. Let us understand by comparing it with the traditional applications currently used. When we log in to a conventional application, the web app is rendered using HTML, and it will call the APIs, which will access the centrally hosted data.

In the case of the DAPPs, the APIs are replaced with smart contract-based APIs that fetch data from the blockchain. These are more secure applications as it is not controlled by a single supreme central authority but rather by a decentralized and more transparent system.

e. Decentralized Autonomous Organizations (DAOs)

It is a system based on the blockchain that gives people the facility to coordinate and self-govern themselves using self-executing rules (Smart Contracts) [9, 10].

- **D—Decentralized**: It is called decentralized because it works over a blockchain, which is a decentral server-less infrastructure. The decision-making depends not on any authority but on various collective agreements of the multiple members. This considerable dependence is achieved by a voting mechanism in which network members can participate. Let us see how this voting system works.

People add funds to the DAO as it requires payments to execute and make decisions. Now, each member is given tokens that talk about that member's share in the DAO. Now, as the traditional voting systems work, the maximum votes decide the fortune of the decision. Thus, if anyone tries to tamper with the information in any network node, it will not affect the information. Once the information is deployed to the network, it is copied to every node, and each node validates it.

- **A—Autonomous**: It is called so because it is not dependent on its creator unless explicitly declared in the code. One more thing about autonomous is that since it is built on a blockchain, no authority can turn OFF the DAO. If its members are active, DAO will operate all the facilities.

f. A project on Ethereum

Now, we will make a simple, smart contract using a language called Solidity. Solidity is a statistically typed curly braces programming language used to develop smart contracts and runs on the EVM (Sect. 2.2.1).

This project is a primary **counter-smart contract**, built on solidity language and remix IDE and is deployed on Remix VM (Merge). The basic structure of the solidity program is as follows.

- The first line of the program is always the declaration of the version of the solidity used; in this version, 0.5.1 version is used.
- The main smart contract code is enclosed in a contract counter function. We will start declaring all the state variables and functions inside this.
- We have first declared a count variable with a uint data type (unsigned integer) with an initial value of 0.
- Now in Solidity, any new function is declared using the function keyword, so an Increment function is displayed in which the counter is increased. One can see that there is one more thing in the function ***emit Increment (count)***; this line calls the event named Increment, events in the solidity and Ethereum allows anyone in the blockchain to subscribe to the smart contract and can see the value of the count.
- In a similar way, the decrement function is declared.
- A getCount function is declared, which will display the value of the count.
- Lastly, project is first compiled to see whether there are any errors; once compiled, it is deployed in the blockchain, which comes with the remix IDE, i.e., Ethereum.

Here is the program:

```
//declaring the version of the solidity
pragma solidity 0.5.1;
contract Counter
   event Increment(uint value);
   event Decrement(uint value);
 uint count = 0;
   function increment() public{
      count = count + 1;
      emit Increment(count);
   }
   function getCount() view public returns(uint){
      return count;
   }
   function decrement() public{
      count = count - 1;
      emit Decrement(count);
   }
}
```

2.3 NFT Marketplace

As discussed earlier, NFTs are digital assets and can be anything.mp3 file, digital art, etc. But just creating these will not make it an asset; one must sell it somewhere from where others can buy it. Thus, the NFT marketplace comes into the picture; it is like the traditional shops where NFTs are stored and can be sold and brought.

Once NFT is created, it is "Minted" in the network. *Minting is a process by which digital art is uploaded on the Ethereum blockchain***.** Briefly, the NFT marketplace is an NFT exchange platform. Like a normal marketplace, there are some prerequisites for the NFT marketplace.

- **A crypto wallet**: It is a storage of all the private keys (passwords that give access to the cryptocurrencies the user has) that allows safe access to the crypto. One can send, receive and spend crypto. It is like a bank account in the physical world. Various crypto wallets are available; one must choose the wallet according to its compatibility with different blockchain networks. Earlier crypto wallets were compatible with only one cryptocurrency. Now, we have various wallets compatible with more than one cryptocurrency.

  There are types of crypto wallets, let's compare these.

- **Some amount in the wallet**: The wallet should be pre-funded before you create, mint or buy any NFT from the marketplace.
- **A user account**: One must create an account on the marketplace; this account will handle the details about NFTs the user has brought, minted, etc.

Thanks to the increased interest in NFTs shown by users worldwide. Owing to such huge interests and users buying and selling it, numerous NFT art marketplace platforms exist where one can create, sell and buy NFT. Some of the famous marketplaces are being compared in Table 2.

Table 2 Hot wallet and cold wallet differences

	Hot wallet	Cold wallet
Price	It is a free wallet that can have some pay interest on stored crypto	These are not free
Use	These are more useful for trading as they are convenient to access	They are more suited for long-term storage
Cybersecurity	This wallet is connected to the internet, so they are vulnerable to hacking	It is the most secure type of wallet as it's not connected to the internet and has various layers of security
Loss protection	It has a backup and recovery system, though it could be better	The backup and recovery options are for lost passwords but not for lost devices
Efficiency	Since they are already connected to the internet, they are easily accessible. Thus, the exchange is easy	Connecting them to the internet requires extra work like USB, Wi-Fi, etc.

2.4 NFT Applications

A. Digital Art

These are any creative content uploaded on any virtual or digital medium; it can be anything: music, films, paintings, images and many more. Just like physical arts, anyone can sell and buy these. If people can buy and sell physical and digital art, why are these decentralized tokens and NFTs needed? The answer is that in normal art, be it physical or digital, the original art can be stolen or copied and sold. In NFT, each art is given a unique signature, which allows it to be differentiated from any other art. Thus, NFTs enable the authenticity of the produced item, which is also very helpful for the artists, not only securing the art from theft but giving them a massive profit as it has a concept of royalty; in this, the artist receives an amount whenever his art is transferred to a new owner. The most notable sale of digital art in history till now is of art made by Mike Winkelman (also known as Beeple), which caused a sale worth $69 million (Table 3).

B. Licenses and Certification

This is a very time-saving application of NFTs, as it helps minimize the time and effort of the companies who spend much time verifying critical documents. It can also support various institutions in tracking the records of all the certificates issued since each certificate is assigned a unique signature, which can be used to check its authenticity.

C. Virtual World

A new emerging world in the internet will be a virtual place where people can buy and sell assets in the physical world. NFTs in this world will help Maintain and track

Table 3 NFTs marketplaces

S. no.	NFT marketplace	Blockchain	Crypto	Launch	Accepted type
1	OpenSea	Ethereum	$ETH $WETH $DAI	2018	Image, audio, video
2	Variable	Ethereum	$ETH $WETH $DAI	2020	Image, audio, video
3	SuperRare.Co	Ethereum	$ETH	2018	Image
4	Foundation	Ethereum	$ETH	2020	Image
5	Marketplace	Ethereum	$ETH $DEFI	2018	Image
6	Hic et Nunc	Tezos	$XTZ	2021	Image, audio; video
7	KnownOrigin	Ethereum	$ETH	2020	Image
8	CryptoPunks	Ethereum	$ETH	2017	Image

financial transactions and also authenticate them. Since NFT is developed on the blockchain, hiring an external auditor to evaluate the assets is unnecessary.

Until now, we have learnt about many new technologies like Web 3.0, a decentralized and intelligent web that will remove every third party's intervention in any transaction between the two users. It will be handled by the self-made rules of the users in the form of a smart contract. Then we explored the NFTs, which are non-fungible tokens that can be of any form of digital assets with a unique signature that anyone can sell and bring. Together, these technologies lead to another big emerging technology, or a world just like the physical world, but fully virtual. Let us explore this new virtual world, also known as Metaverse.

3 Metaverse

In this world of social networks, people share their activities or things happening with everyone on a platform from which anyone can see and react. Now let us imagine a space where people can interact with each other by becoming virtual people, also known as Avatars; this imagination is now becoming a reality and thus opening a new area for research and development, which is famously known as **Metaverse**.

3.1 What is Metaverse?

Metaverse is a world that is present virtually where billions of people can do daily life chores and interact with each other while sitting in one place in the physical world. In this world, the people will be in their virtual form, also called "*Avatars*". The term "Metaverse" originated from the science fiction novel *Snow Crash* [11] by Neal Stephenson. Metaverse is comprised of two words: "*Meta*", which means beyond, and "*verse*" is taken from the word "*Universe*".

Definition It is a single, shared, immersive, persistent, 3D virtual space where humans can perform all the real-world things, but without actually moving.

This definition was just one way of describing Metaverse; here are some more:

- Metaverse is a mixture of virtual worlds and augmented real worlds.
- Metaverse is a persistent platform, which means it is available whenever someone wants to visit it.
- Metaverse is an integrated system that uses X-tended Reality (XR) and other technologies.
- Metaverse is tightly related to the Reality, actions and interactions that can be exchanged with the real world. Everyone will have a digital twin, which will allow more possible communication.

The metaverse is nascent, or you may say it does not exist. But with the development of various technologies like Blockchain, Artificial intelligence, Augmented Reality and Virtual Reality, it is believed that the metaverse will happen one day. It will be a space that will change how people live, shop, learn, etc.

3.2 Why Metaverse?

As mentioned, this term was first found in a science fiction novel; at that time, no one believed it would be proclaimed the future of the internet. It was October 2021 when Facebook, the social giant, changed its name to "*Meta*" and announced plans to invest around $10 billion in this technology or a concept. This grabbed the attention of everyone towards this emerging, fascinating world.

Just before the Facebook move in 2020, since the world was hit with COVID and everyone was locked in their rooms, no one was allowed to go out, this was the time when people realized that there is a need for a virtual world in which they can roam around freely, learn, work and earn just by sitting at a single place in their house.

This concept has been known for many years, but till now, it was just an idea. The development of various technologies like Virtual Reality, Augmented Reality, Artificial intelligence, etc., gave it some life, though still there is no Metaverse. But computer scientists are predicting or claiming it to be the future of the internet.

3.3 Metaverse Technologies

The development of any technology is dependent on various other technologies that are used to operate it. For example, high-rise buildings can only be built with the invention of lift technology. Similarly, Metaverse is also dependent on various technologies with which it will be fully functional and can provide an immersive experience to the user.

- **Hardware**: Metaverse is a virtual space that requires some intermediate device that will connect the user in the physical world with the virtual world. These are various types of VR/AR/MR headsets; mobile phones also need to be developed so that they can navigate the Metaverse. Different enterprise hardware is also required to help the industry use AR-based environments. Some hardware like Hand-Based input devices, Motion Input devices and non-hand-based input devices.
- **Immersive technologies**: Extended Reality is a comprehensive technology under which there are a series of immersive technologies, electronic and an environment where the data is projected. It also includes AR, VR and MR.
  - **Augmented Reality (AR)**: This is a mixture of physical and virtual worlds in which the devices spatially project the devices' digital artefacts. These devices can be mobile phones, tablets, or glasses. It is a technology that merges the

real and virtual worlds. An example of augmented Reality is the new feature in Google, which shows various digital artefacts of animals on the physical world surface (see Fig. 4b).

- **Virtual Reality (VR)**: It is a separate digitally created space in which the users are immersed and are in a different world located somewhere else. Users can operate things similarly to the physical world using multisensory equipment such as VR headsets and immersion helmets. These can be anything from interacting with a virtual object. There are many developments in this field; now, mobile phones have a 360° gyroscope sensor, which helps see around the virtual world just by moving it in different directions.
- **Mixed Reality (MR)**: This technology is very complex, and it's still not clear how it will shape or what it is exactly. This technology has many definitions and keeps changing with the continuous advancement of various other technologies. It is an advanced AR iteration in which the digital artefact can be projected on the real-world surface, examine the surroundings and interact with them, like hiding behind an object, etc. [12].
- **Computing power**: As mentioned earlier, Metaverse will be a persistent world, which means it can be accessed or viewed at any time; so, to accomplish this, the computing power should be very high to ensure the smooth functioning of all the functions from complex mathematical calculations, data synchronization to Artificial intelligence. The requirement of advanced computation is essential for the seamless functioning of the Metaverse.

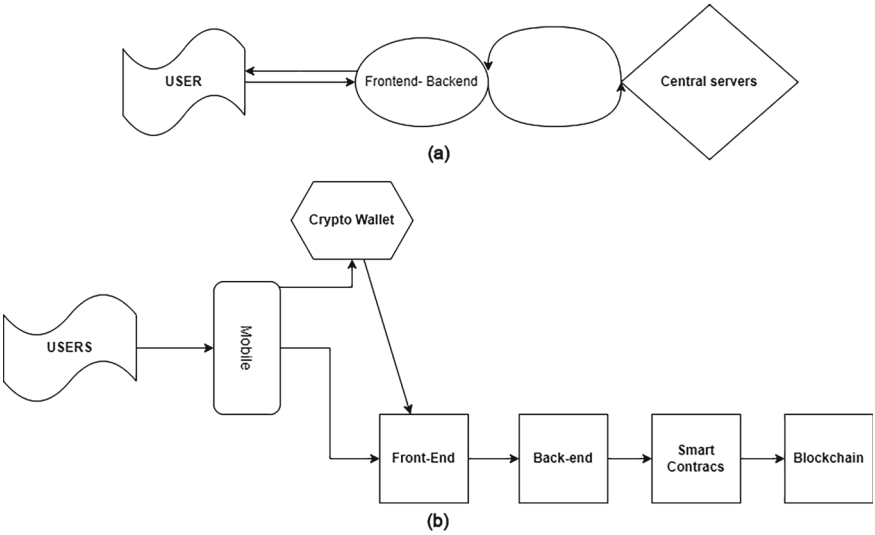

Fig. 4 **a** Centralized app flow; **b** decentralized apps (Dapps)

(a) (b)

Fig. 5 **a** AR glasses (Bennett University Lab); **b** Google AR search feature (Bennett univ. hall with Google AR feature)

Fig. 6 Oculus Quest 2 VR headset (Bennett University Lab)

There are some more technologies with which Metaverse can become a highly efficient, flexible and secure world (Figs. 5 and 6).

3.4 The Ecosystem of the Metaverse

The economy is one of the backbones of a real world society, people manufacture products, sell them to various distributors who take them forward and sell them in the different markets, where everyone can buy them. In the same way, the virtual world (Metaverse) component is its economic system, which will make the Metaverse just like the real world. This ecosystem consists of four parts: Digital creation, digital asset, digital market and digital currency; this will form the basis of this ecosystem (Table 4).