Beginning with Web3

An essential guide to building dApps in the new internet era

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Dedicated to

My beloved wife:
Queenie
and
My daughter ***Grace*** *and my son* ***Jerry***

About the Author

Ken Huang is the author and chief editor of 8 books on Generative Artificial Intelligence and Web3, published respectively by international publishers including Springer, Cambridge University Press, John Wiley, and China Machine Press. He currently serves as the CEO of the AI and Web3 consulting and education company DistributedApps. AI, based in the United States. Additionally, he holds multiple roles including the expert member of the Blockchain Committee of the Chinese Institute of Electronics, the Co-Chair of AI Organization Responsibility Working Group at Cloud Security Alliance and Chair of the Blockchain Security Working Group at the Cloud Security Alliance, GCR. He is also a core contributor to the Generative AI Working Group at the NIST and a core author of the OWASP Top 10 for LLM Applications.

Ken Huang has been invited to provide speaking and consulting services at institutions including the University of California, Berkeley, Stanford University, Peking University, Tsinghua University, Shanghai Jiao Tong University, China Pacific Insurance, and the World Bank in the past.

Moreover, he has given keynote speeches at international conferences, such as:

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- The American ACM AI & Blockchain Decentralized Annual Conference 2019
- IEEE Technology and Engineering Management Society Annual Meeting 2019
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Lastly, my appreciation extends to all the readers who have shown interest in this book. Your support and encouragement have played a pivotal role in making this project a reality. Thank you for believing in the importance of this work and for your invaluable support.

Preface

Beginning with Web3 is your comprehensive guide to navigating the complex yet captivating world of Web3 and blockchain technology. This book is designed to provide you with a deep understanding of the decentralized web, equipping you with the knowledge and skills necessary to develop **decentralized applications** (**dApps**). From the foundational principles of Web3 and the Ethereum blockchain to the intricacies of security, storage, and development tools, this guide is a gateway to the future of the internet. As you embark on this journey, you will discover the challenges and opportunities of Web3 development, inspiring you to contribute to the growth and innovation of this exciting domain. Let us explore the new era of the internet together and build the future, one dApp at a time.

This book has three distinct sections, each dedicated to a different aspect of Web3 development. This organization helps readers systematically grasp the breadth and depth of Web3, from foundational concepts to the development of decentralized applications and beyond. Below is an overview of each section and its chapters:

Section I: Foundations of Web3 and Blockchain
This section lays the groundwork for understanding Web3 and blockchain technology, providing essential knowledge needed to navigate the decentralized web.

Chapter 1: Introduction to Web3 - This chapter offers a primer on the decentralized internet, outlining the shift from traditional web paradigms to the Web3 philosophy.

Chapter 2: Understanding the Ethereum Blockchain - This chapter focuses on Ethereum, introducing its key components and importance in dApp development.

Chapter 3: Web3 Node Infrastructure - The chapter explains the role and types of nodes in maintaining a decentralized network.

Chapter 4: Wallets and Key Management in Web3 - This chapter covers the critical aspects of securing digital assets through effective wallet and key management techniques.

Section II: Security and Storage in Web3
This section discusses the security challenges and storage solutions in the Web3 ecosystem, emphasizing how to protect dApps and utilize decentralized storage.

Chapter 5: Security in Web3 Development - This chapter highlights the importance of security, detailing common threats and mitigation strategies.

Chapter 6: Introduction to Decentralized Storage - This chapter introduces decentralized storage, explaining its benefits and operational mechanisms.

Section III: How to Develop Web3 Applications
Guides readers through the practical aspects of Web3 application development, from utilizing development tools to creating specific types of dApps.

Chapter 7: Tools for Web3 Development - The chapter provides an overview of essential development tools and their applications in building dApps.

Chapter 8: DeFi and NFT dApp Development - This chapter discusses the development of DeFi and NFT applications, two of the most prominent use cases in Web3.

Chapter 9: Building dApps on Popular Chains and Protocols - This chapter explores dApp development across various blockchain platforms beyond Ethereum.

Chapter 10: ChatGPT and Web3 Development - This chapter looks at the integration of AI, specifically Generative AI application such as ChatGPT, into dApp development, highlighting new possibilities.

Each section of **Beginning with Web3** is carefully designed to progress readers from foundational knowledge to practical application, ensuring a comprehensive understanding of how to build, secure, and innovate within the Web3 space.

Beginning with Web3 simplifies the complexities of Web3 development, providing a clear path from foundational concepts to advanced application building. By the end of this book, you will be well-equipped to contribute to the revolutionary world of Web3. Let us embark on this journey to build the future of the internet, together.

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The code bundle for the book is also hosted on GitHub at
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Foundations of Web3 and Blockchain

This section lays the groundwork for understanding Web3 and blockchain technology, providing essential knowledge needed to navigate the decentralized web.

CHAPTER 1

Introduction to Web3

Introduction

This chapter provides a comprehensive introduction to Web3, the next evolution of the internet. We will trace the progression from the early read-only internet (Web1) to the social, participatory platforms of Web2, and finally to the emerging decentralized and user-controlled vision of Web3.

The fundamental principles and technologies driving this paradigm shift are explored in the chapter, including decentralization, blockchain, smart contracts, and peer-to-peer networks. We will compare the Web2 and Web3 models, analyzing how Web3 addresses the centralization of power and lack of user control that characterize today's internet landscape.

While Web3 promises a more open, decentralized, and user-centric web, we will also critically examine the challenges and tradeoffs involved in this transition. As we stand at the cusp of this new internet era, this chapter aims to provide a solid foundation for understanding the possibilities and complexities of Web3.

Structure

The chapter will cover the following topics:

- Evolution from Web1 to Web3

- Fundamental principles of Web3
- Comparing Web2 and Web3
- Role of blockchain in Web3
- Understanding smart contracts and peer-to-peer networks

Objectives

By the end of this chapter, readers will be able to comprehend the evolution of the internet from its origins as Web1 to the social, participatory platforms of Web2, and now the emerging paradigm of Web3. They will be able to understand the fundamental principles underpinning Web3 including decentralization, user control, privacy, and trustless systems.

Readers will be able to recognize core Web3 technologies like blockchain, smart contracts, and peer-to-peer networks and how they enable a decentralized web. They will be able to appreciate how Web3 differs from Web2, particularly regarding centralization of power and user control over data. Readers will gain insight into the role of blockchain as the foundational infrastructure for Web3 and the associated technical challenges. They will also understand how technologies like smart contracts and peer-to-peer networks interact to enable decentralized applications.

After going through this chapter, the reader will be able to identify key opportunities and challenges involved in the transition from Web2 to Web3, and be equipped with the foundational knowledge to explore the technologies and implications of Web3 further.

Evolution from Web1 to Web3

This section traces the development of the Internet from its early stages as Web1, through the interactive platform of Web2, and finally to the decentralized and democratized vision of Web3.

Birth and growth of Web1

This subsection delves into the initial days of Web1, examining its design, functionality, and limitations.

The advent of the **World Wide Web**, or what we now refer to as Web1, was a revolutionary moment in the history of technology and communication. First proposed by *Tim Berners-Lee* in 1989 at CERN, the European research organization, Web1 began as a project to facilitate information sharing among scientists in universities and institutes worldwide.

The initial design of Web1 was quite rudimentary, with web pages consisting of simple text and hyperlinks. These pages were static, meaning they were pre-built and did not change in response to user interaction. Users could read and navigate the information, but they could not contribute or change the content. Web1 was largely a read-only platform, a digital library where people could find information but had minimal ways to interact with it.

The primary language used to create these web pages was the **Hyper Text Markup Language** (**HTML**). HTML allowed web developers to structure text, insert hyperlinks, and later, add images. Despite its simplicity, HTML was a powerful tool for presenting information on the web. It provided the basic structure for web pages and set the foundation for more complex web development tools and languages to come.

The functionality of Web1 was primarily centered around information retrieval. Search engines like AltaVista, Yahoo!, and later Google, were developed to help users find relevant information amidst the rapidly growing volume of web content. The function of these search engines was to crawl the web, indexing pages to make them searchable by keyword. This marked a significant step in making the internet more accessible and useful to the average user.

However, Web1 had its limitations. The lack of interactivity was a major drawback. While users could read and navigate between pages, they could not contribute their own content or interact with other users. Web1 was largely a one-way street, with information flowing from webmasters to users, but not the other way around.

Web1 also lacked the sophisticated design capabilities that we take for granted today. Early web pages were primarily text-based, with few images and virtually no multimedia content. The layout and design options were limited, creating a plain and homogeneous browsing experience. As a result, Web1 was not particularly engaging or immersive, especially compared to what was to come with Web2.

Security was another concern with Web1. As the internet began to grow, so did the risks associated with data privacy and security. However, the security protocols and infrastructure necessary to protect user data were only partially developed during the Web1 era. This led to various security challenges, some of which persist to this day.

Despite these limitations, the birth and growth of Web1 represented a monumental shift in the way information was shared and accessed. It democratized access to information, enabling anyone with an internet connection to access a wealth of knowledge from anywhere in the world. Web1 set the stage for the more interactive, user-centered versions of the web that were to come. As we move further into the era of Web3, it is important to remember and understand the roots of the internet in Web1, as it laid the groundwork for all subsequent developments.

Transition to Web2

The transition from Web1 to Web2 marked a profound shift in the way people interacted with the internet. Where Web1 was a largely static, read-only platform, Web2 evolved into a dynamic, participatory medium. This transition was not abrupt but rather a gradual shift fueled by advances in technology and changing user expectations.

The dawn of Web2 brought with it the concept of the **participatory web**. Users were no longer mere consumers of information, but they also became creators and contributors. This was made possible by the advent of platforms that allowed user-generated content. Social media platforms like Facebook, Twitter, and Instagram, blogging sites like Blogger and WordPress, and video-sharing platforms like YouTube transformed the internet into a space of active participation.

The rise of social media was a defining aspect of the Web2 era. These platforms provided users with tools to connect, share, and engage with each other in ways previously unimaginable. They gave voice to individuals, allowing them to share their thoughts, experiences, and ideas with a global audience. At the same time, they also created new channels for information flow, altering traditional media landscapes and giving rise to phenomena like viral content and influencer culture.

The emphasis on user participation also had a significant impact on businesses. Traditional business models had to adapt to the new digital landscape. Companies began to recognize the importance of online presence and started to leverage social media platforms for marketing, customer engagement, and brand building. The power of online reviews and ratings became evident as they significantly influenced purchasing decisions.

Web2 also ushered in the era of **web applications**. These were interactive programs that ran within the browser, providing richer and more engaging user experiences. Examples include Gmail, Google Maps, and Facebook. These applications utilized technologies like **Asynchronous JavaScript and XML (AJAX)**, which allowed web pages to update and display new data without the need for a full-page refresh, making the user experience much more dynamic and interactive.

However, this new era had its own challenges. The explosion of user-generated content led to concerns about data privacy and security. As users began sharing more personal information online, the risk of data breaches and misuse of information increased. The shift towards free, ad-supported services also raised questions about data ownership and surveillance.

In conclusion, the transition to Web2 marked a significant evolution in the Internet's history. It moved us from a static, one-way information highway to a dynamic, two-way interaction platform. It democratized content creation, empowered users, and transformed business models. As we look towards the future of the internet in Web3, understanding the journey and impact of Web2 is crucial.

Emergence of Web3

As the internet continues to evolve, we are now witnessing the emergence of Web3. This new iteration of the web represents a significant shift from the interactive, user focused

Web2 to a decentralized and autonomous system. Web3 is envisioned as a truly open and permissionless network, one that extends the user-centricity of Web2 while addressing its limitations.

The primary driver behind the shift to Web3 is the desire for greater decentralization. Web2, for all its advances, still relies heavily on large, centralized entities that control platforms, data, and services. This centralization has raised concerns about data privacy, ownership, and monopolistic control. Web3 aims to address these issues by moving away from centralized control and towards a decentralized network where no single entity has absolute power.

Web3 also seeks to enhance privacy and give users more control over their data. The Web2 model relies heavily on the collection and monetization of user data, often without explicit consent or compensation for users. Web3 proposes a new model where users maintain control of their own data, deciding who can access it and how it can be used. This change aims to restore data ownership to individuals and reduce the power of large corporations.

Another key feature of Web3 is the concept of a trustless system. In a Web3 world, trust is built into the system itself through cryptographic guarantees rather than being dependent on intermediaries. This allows for peer-to-peer interactions and transactions without the need for a trusted third party, reducing the potential for fraud and enhancing security.

Web3 also brings with it the potential for more economic inclusivity. By utilizing blockchain technology and cryptocurrencies, Web3 can facilitate peer-to-peer transactions without the need for traditional financial institutions. This could potentially provide financial services to those who are currently unbanked or underbanked, democratizing access to financial resources.

The rise of Web3 technologies, such as blockchain, smart contracts, and **decentralized applications** (**dApps**), are critical to this transformation. Blockchain provides decentralized infrastructure, smart contracts enable autonomous transactions, and dApps provide user interfaces that tie everything together.

However, the transition to Web3 is not without its challenges. Technical complexity, scalability issues, regulatory uncertainty, and public understanding are all hurdles that need to be overcome. Furthermore, while the promise of decentralization is appealing, it also raises new questions about governance, accountability, and security that are yet to be fully addressed.

The shift from Web2 to Web3 is driven by the pursuit of greater decentralization, enhanced user privacy, and increased control over data. In Web3, the concept of a trustless system comes to the fore, with cryptographic guarantees replacing the need for intermediaries. The economic inclusivity that Web3 can potentially offer, facilitated by blockchain technology and cryptocurrencies, also represents a significant step forward.

Yet, the transition to Web3 is not straightforward and is fraught with challenges. Technical complexities, scalability issues, regulatory uncertainties, and a general lack of