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Web 3.0 and Decentralized Applications †

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Abstract: The web we use today has seen many iterations over the years since the original concept of the World Wide Web was introduced in early 1990s.The first emergence of the web was called the static web or Web 1.0, which was read-only. A further iteration of the web then came along and was called the Social Web or Web 2.0, which was interactive in nature and the users could do more than read static pages. This was readable and writable, and saw the emergence of numerous social platforms. Web 3.0 offers an unmediated read–write web, or, to put it another way, a decentralized Internet. This paper provides a brief idea of how the journey of the web has so far transitioned from Web 1.0 through Web 2.0 and now onto Web 3.0, and what all lies ahead in future with emerging technologies and Web 3.0.

Keywords: Web 1.0; Web 2.0; Web 3.0; dapps; Ethereum; smart contracts; blockchain

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1. Introduction

You have probably seen or heard the term Web 3.0 drifting on the internet. Simply put, Web 3.0 is the new phase in the evolution of the internet and the web. The development of Web 3.0 has the potential to bring reform to the internet and web that we experience today. So, to see these paradigm-shifting changes, we need to first understand the previous versions of the web through time.

Figure 1 is a graph depicting the rise of searches for the term Web 3.0over five recent years (2015–2020). We can clearly see there has been huge rise in searches for Web 3.0 over the years, showing how the term Web 3.0 is being searched for by users worldwide. The source of this result is Google Trends [1,2].

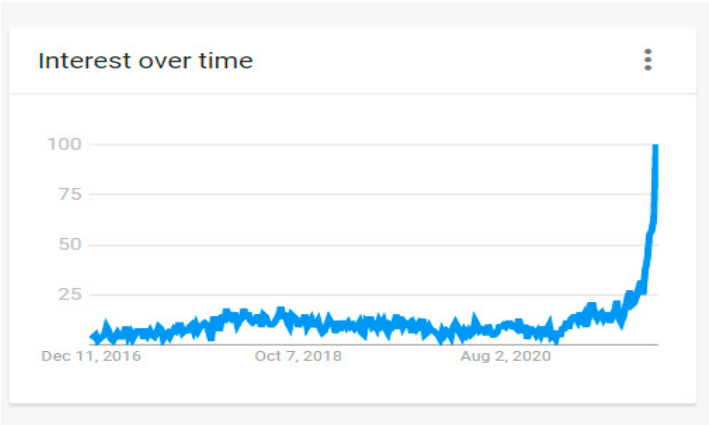

Figure 1. Results from Google Trends for the term Web 3.0 worldwide over five years.

The web has changed a lot over the years, and web-based applications are nowadays entirely different from the early days of the web. The journey of iterations of the web over

the years is often categorized into three phases: Web 1.0, Web 2.0 and Web 3.0 as shown in Figure 2.

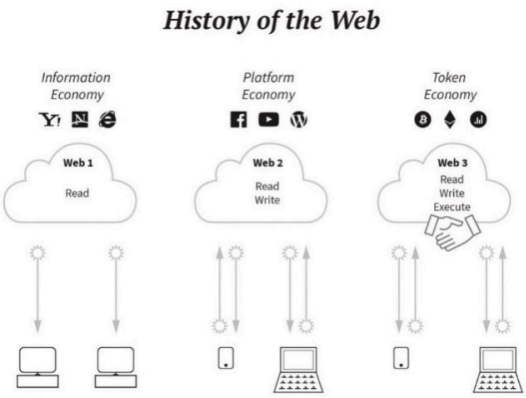

Figure 2. Web History as per time.

2. Web 1.0

Web 1.0 refers to the earliest iteration of the World Wide Web. Web 1.0 included websites serving static content, unlike the dynamic content we have today. Web 1.0 can be considered a read-only version of the web, where the content of a website was served from a static file system rather than databases.

Most users at that time where passive consumers of the content, i.e., they could not interact or do much with the content that was available to them. Thus, it can be stated that the users of Web 1.0 were consumers and the developer were the creators. It was constructed on a set of open protocols, such as HTTP for webpages, SMTP for email, SMS for messaging, IRC for conversation, and FTP for file transfer, on top of which anybody could build directly [3].

Web 1.0 had its own sets of problems and challenges. To develop a presence and content for Web 1.0 was a very technical process, so Web 1.0 was stateless, i.e., websites that time were unable to capture user data including state information. Thus, the website owners and developers had no idea about how the browser used the content, hence they sought feedback to improve experiences for the users.

This was studied and Web 1.0 continued from 1991 to 2004, until things changed with Web 2.0.

3. Web 2.0

Picking up where Web 1.0 fell short, Web 2.0 has been all about interactivity of users with the web. Most of us have real hands-on experience of Web 2.0, as it currently comprises most of the web today. Web 2.0 brought a paradigm shift to the web, where users can now also be creators, unlike earlier times when this was restricted to the developers. So, it can be seen that it was an interactive and social web [4,5]. Web 2.0 was more user-oriented, users started creating content themselves with the introduction of platforms like Facebook, Twitter and YouTube, and the internet space become more collaborative and social. With Web 2.0, the web was no longer read-only, it become read- and write-accessible to users. This new iteration of the web led to the rise of corporate internet giants such as Google, Facebook, Amazon, etc. In addition to this, Web 2.0 made e-banking and electronic payments possible. Web 2.0 opened up a whole new world of opportunities and services for end users. Users are no longer the passive consumers of the web; they create for the web and share with the whole world.

However, this more collaborative and more social web came with a price. While users were able to create content on these platforms, the owners of the platforms were now also able to access the information and data of the users [6].

Security and Privacy Concerns

Data from the users is the key entity of this new web, leading to its exploitation. The centralization of web and user data by the internet giants is where users have made compromises to access these platforms. In Web 2.0, users do not have much control of how their data is used by companies and platforms. More data generated by users leads to more personalized ads targeting users, and therefore exploiting users for more revenue has been a common practice in Web 2.0 [7]. These platforms benefit from constantly tracking and saving user data. This centralized control over the web allows governments to intervene in the lives, opinions and thoughts of the users. They hold the power to seize bank accounts or the social media accounts of users as per their convenience.

As access to user data became a powerful asset for companies, data breaches began to occur. Applications built over Web 2.0 often experience data breaches and data leaks of users' data, which can sometimes include very sensitive data such as card credentials, passwords, etc.

This S-curve (Figure 3) shows how the platform's growth lies in first attracting a set of users, then extracting data from users and competing with counter parts for audiences and profits.

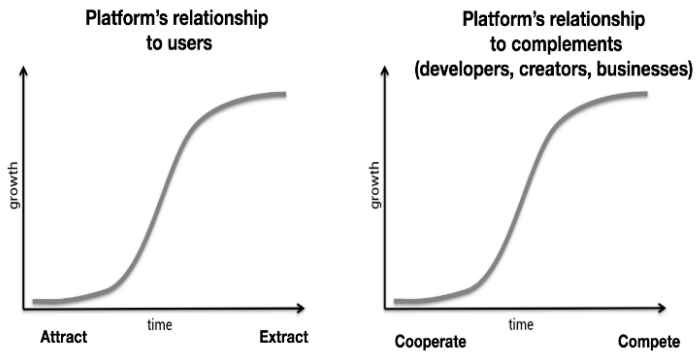

Figure 3. S-curve showing a platform's relationships with users.

This all results in users giving up their privacy and control of their data, and becoming vulnerable to security breaches. A comparison between Web 2.0 and Web 3.0 is shown in Figure 4 on 4 par meters.

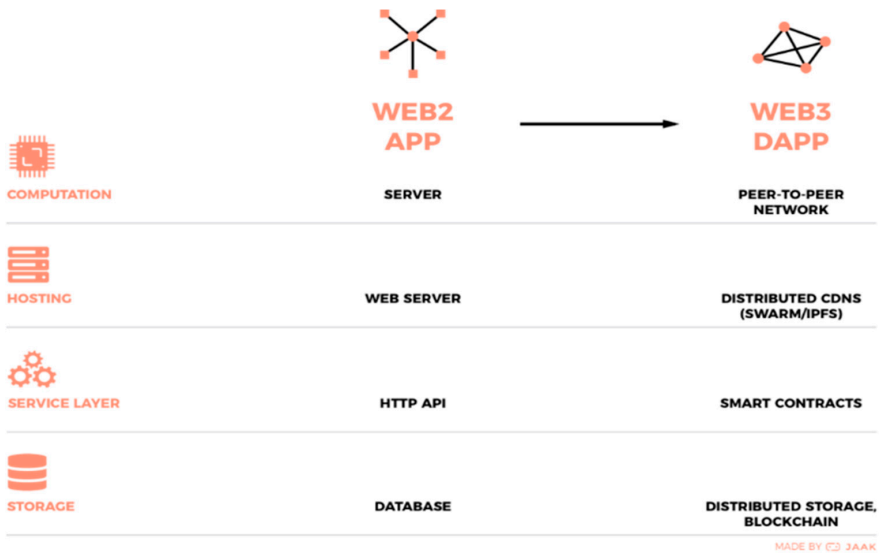

Figure 4. Comparison between Web 2.0 and Web 3.0 Apps.

4. Web 3.0

Web 3.0 is the next iteration of the web. Web 3.0 is still developing and under construction at a rapid speed. Web 3.0 could be considered a rethink of Web 2.0 with decentralization as its foundation. Web 3.0 could potentially help users take control of their data from centralized corporations which currently dominate most of the web that we use and interact with. Web 3.0 is a way for users to avoid comprising their privacy to access the internet, unlike today's scenario. Web 3.0 is the next phase of the web, which is built on top of crypto-economic networks such as Bitcoin and Ethereum. Crypto networks combine the greatest aspects of the first two internet eras: they are community-controlled, decentralized networks with capabilities that will someday outstrip even the most advanced centralized services. With dynamic applications, interactive services, and "machine-to-machine" interaction, this represents the "executable" phase of the World Wide Web. Web 3.0 refers to the future and is a semantic web. Figure 5 represents between Web 1.0, Web 2.0 and Web 3.0. Web 3.0 allows computers to analyze information in the same way that people do, allowing them to develop intelligently and disseminate relevant content customized to the requirements of consumers [8,9].

Web 1.0	Web 2.0	Web 3.0
Mostly Read-Only	Wildly Read-Write	Portable and Personal
Company Focus	Community Focus	Individual Focus
Home Pages	Blogs / Wikis	Live-streams / Waves
Owning Content	Sharing Content	Consolidating Content
WebForms	Web Applications	Smart Applications
Directories	Tagging	User Behaviour
Page Views	Cost Per Click	User Engagement
Banner Advertising	Interactive Advertising	Behavioural Advertising
Britannica Online	Wikipedia	The Semantic Web
HTML/Portals	XML / RSS	RDF / RDFS / OWL

Figure 5. Comparison between Web 1.0, Web 2.0 and Web 3.0.

5. Results

The term "decentralization" refers to the fact that the internet is governed by a large number of people. Decentralization is essential for ensuring that the internet stays a public resource that is healthy and accessible to all of us, rather than being dominated by a few firms and governments throughout the world. Developers in Web 3.0 don't create applications that run on a just one server or store data into a single database. Web 3.0 applications, on the other hand, operate on blockchains, decentralized P2P (peer-to-peer) networks, or a mix of the two, resulting in a crypto-economic protocol like Ethereum. Decentralized Apps, known as D Apps or dapps, are web applications created and distributed in this manner. Developers are motivated and compete to deliver the greatest quality services to everybody on the network, in order to create a stable and secure decentralized network.

The backend code of a dapp runs on a decentralized peer-to-peer network, in contrast to an app whose backend code is hosted on centralized servers. To make calls to its backend, a dapp can contain frontend code and user interfaces written in any language (much like

an app). Its frontend can also be hosted on a decentralized storage system such as IPFS. Dapps run on Ethereum, an open, public, decentralized platform that is controlled by no individual person or organization. Regardless of the context in which they are run, dapps perform the same purpose. Dapps are Turing complete, meaning they can perform any action given the necessary resources. Dapps run in a virtual environment called the Ethereum Virtual Machine, which ensures that if a smart contract has a problem, it will not disrupt the blockchain network's usual operation.

To understand the architecture of dapps we need to understand certain key technologies and terms used in the development of dapps that are published on the main net.

5.1. Blockchain

A blockchain is a distributed database that is updated and shared across a network of computers. Data and state are kept in "blocks", which are collections of data and state. To transmit ETH to someone else, it is first necessary to add the transaction data to a block. The term "chain" alludes to the fact that each block references its parent cryptographically. To put it another way, blocks are linked together. The data in a block cannot be changed without affecting all following blocks, which would necessitate network unanimity.

Each new block, as well as the chain as a whole, must be agreed upon by every computer in the network. These machines are referred to as "nodes". Nodes guarantee that everyone who interacts with the blockchain has access to the same information. Blockchains require a consensus mechanism to achieve this distributed agreement. Ethereum's current consensus mechanism is proof-of-work. Anyone who wishes to add additional blocks to the chain must first solve a complex challenge that takes a lot of processing resources. Solving the riddle "proves" that you used computing resources to do the "job"; mining is the process of doing so. Mining is usually done by trial and error, but adding a block earns you ETH. New blocks are broadcast to the network's nodes, which are then examined and validated, bringing the status of the blockchain up to date for everyone

The proof of work algorithm used in mining is called "Ethash". It is defined as:

$$(m, n) = PoW(H_{\not{n}} H_n,\ d)$$

where,

m = mixhash,
n = nonce
$H_{\not{n}}$ = new block's header
H_n = nonce of block header
d = a large dataset (DAG)

5.2. Smart Contract

On a blockchain network, smart contracts are computer programs that are housed and executed. Each smart contract is made up of code that specifies criteria that, when satisfied, cause certain events to occur. Smart contracts allow several parties to reach a shared outcome in an accurate, timely, and tamper-proof way, by execution on a decentralized blockchain rather than a centralized server. Because smart contracts are not controlled by a central administrator and are not exposed to single points of attack by malicious parties, they offer a strong foundation for automation. Smart contract applications, when used in multi-party digital agreements, may minimize counterparty risk, boost efficiency, cut costs, and provide new levels of transparency to operations.

For building smart contracts on Ethereum, there are developer-friendly languages such as Solidity. Solidity is a statically typed curly-braces programming language for creating Ethereum-based smart contracts. A sample coding of smart contract is shown in Figure 6.

```
// SPDX-License-Identifier: GPL-3.0
pragma solidity >=0.4.16 <0.9.0;

contract SimpleStorage {
    uint storedData;

    function set(uint x) public {
        storedData = x;
    }

    function get() public view returns (uint) {
        return storedData;
    }
}
```

Figure 6. A basic smart contract in Solidity.

5.3. Ethereum Virtual Machine (EVM)

The Ethereum Virtual Machine (EVM) is a computing engine that functions as a decentralized computer with millions of applications that may be executed. It serves as the virtual computer that underpins Ethereum's complete operating system. It is thought to be the portion of Ethereum that handles smart contract execution and deployment. The EVM's job is to provide additional features to the Blockchain so that consumers have fewer problems with the distributed ledger. The EVM is used by every Ethereum node to maintain blockchain consensus.

A contract written in smart-contract coding is transformed into what is known as bytecode. The data is then translated into opcodes that the EVM can understand. The operation codes are then used by the EVM to accomplish certain tasks. As a result, the EVM functions as a large decentralized or master computer on the blockchain, performing a variety of tasks.

5.4. Frontend

The client-side technologies enabling interaction between the user and the smart contract backend are referred to as the frontend of a dapp. Between a centralized and a distributed app, the frontend is the most comparable feature. HTML, CSS, and JavaScript are the most frequently utilized frontend technologies in dapps today. When creating dapps, web developers may utilize familiar tools, frameworks, and libraries to ensure compatibility. One of the most frequent tools for interfacing with Ethereum Smart Contracts via a web-based interface is the web3.js,ether.jsJavaScriptlibrary.

5.5. Data Storage

The real or virtual servers that store an app's data are referred to as data storage. The high cost of gas in Ethereum, along with the limited block gas cap, renders "on-chain" storage untenable. As a result, most dapps employ "off-chain" storage services, which implies that the majority of massive data is stored outside the blockchain as shown in Figure 7, with just the necessary transaction information being stored on the blockchain. Data can be kept either centrally (as in a standard cloud service) or in a decentralized manner (on a peer-to-peer (P2P) network). Swarm is Ethereum's native peer-to-peer storage platform, however there are more robust storage solutions available, such as IPFS.

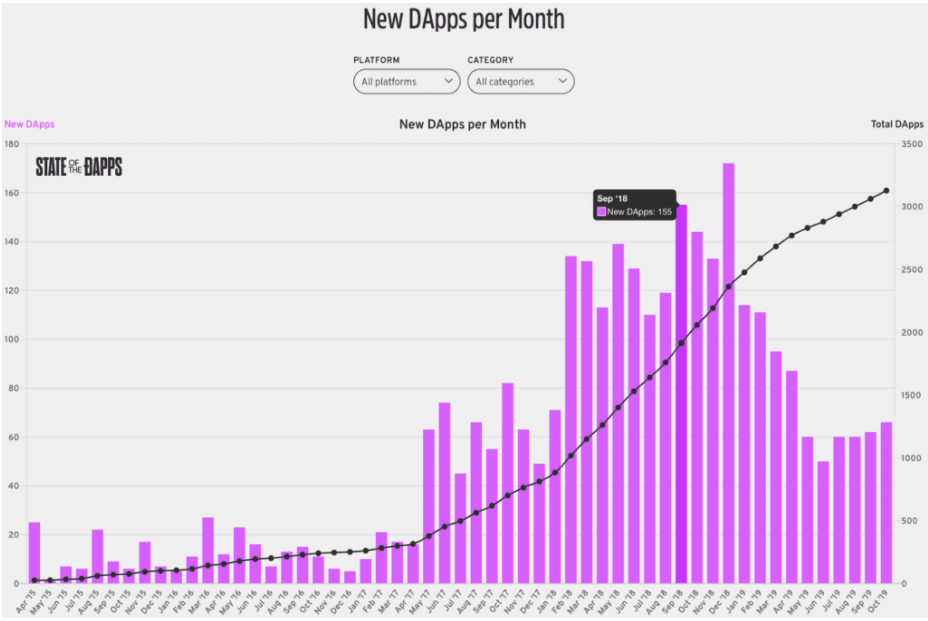

Figure 7. State of dapps.

6. Challenges of Web 3.0

6.1. Issues Concerning Mass Adoption

Considering the current circumstances, not everyone is familiar with blockchain technology or the decentralized web. Most internet users are unlikely to accept a rapid move. In order for the decentralized web to become a true revolution, people must first be willing to adapt. Today's centralized social media platforms, such as Facebook and Twitter, have grown extremely popular among the general public. People may object to the concept of replacing the present platform with a blockchain-based application, which is a major worry. The decentralized web's technical viability will not be a compelling incentive for everyone to adopt it. Unless they have a pressing and personal need for the decentralized web, people may decide to maintain the current status quo.

6.2. Issues Concerning Latency

Today's centralized systems are equipped with cutting-edge technologies that improve network speed. However, this is not the case with dapps or networks. Latency is a problem for decentralized networks and apps. When compared to a centralized app, the number of requests processed per second by a decentralized app is substantially lower. We have a startling fact to share: Bitcoin handles 3–4 transactions per second on average, but PayPal processes 193 transactions per second. At present, sites on a decentralized network can be very slow to load.

7. Conclusions

In this study we reviewed the history of the web and how it underwent iterations over time to reach the current version we use today. The World Wide Web has evolved from being read-only, where users were merely consuming information from static pages, to its second iteration of a more interactive web, where users could for the first time create and communicate as well as consume, due to the emergence of this giant social platform. With each iteration a few recurring problems were solved, but each came with its new set of problems. Web 3.0 currently is in the early stages of development and adoption by the common users of the web, although this development has been progress in gata steady pace. Web 3.0 has brought a vision of a decentralized internet where the user owns their own data and uses the web with no central body governing the space, thus promoting the growth and development of dapps. These dapps are being built on top of blockchain

technologies and supported by the crypto-economic networks. We will see more users on these decentralized sites as blockchain technology and dapps grow more mainstream. It is critical to deliver a positive user experience and to disseminate information about these platforms, so that the general public feels comfortable entering this new paradigm.

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