



**Santa Clara University**  
**COEN 233: COMPUTER NETWORKS**

# Web 2.0/3.0

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# Audience

This document is intended for consumers of internet services of world wide web, enthusiasts and those who would like to understand the evolution of web from those static pages of Web 1.0 to dynamic more realistic online services in Web 3.0.

The audience require basic knowledge of computer networks or web technologies. The document acts as guide for everyone without any prior knowledge. This document does a deep dive into the history and evolution, the architecture, and eras of Web and how it is affecting the daily lives of people.

This report along with the various features and usages of Web technologies throughout these years, it will also provide you with the challenges in the Web evolution and the development and innovation of various technologies to mitigate those issues. The Audience will enjoy reading the transitions of Web and understand the ideas behind the structures and frameworks of web.

## Table of Contents

Audience .....	2
1. Introduction.....	5
1.1 How this document is organized: .....	5
1.2 History of Web.....	6
1.3 The Eras of Web .....	6
1.3.1 Web 1.0.....	7
1.3.2 Web 2.0.....	7
1.3.3 Web 3.0.....	7
2. Web 1.0.....	8
2.1 Web 1.0 to 2.0.....	8
3. Web 2.0.....	9
3.1 Challenges of Web 1.0.....	9
3.2 Web 2.0 Evolution .....	10
3.3. Technology behind Web 2.0 .....	10
4. Web 2.0 Applications and Examples .....	12
4.1 Applications .....	12
4.2 Examples.....	12
4.3 The Ideas behind Web 2.0 .....	13
5. Challenges with Web 2.0 and evolution of Web 3.0.....	15
6. Web 3.0.....	17
6.1 Need to Decentralize.....	17
6.2 The Decentralized Web.....	17
6.2.1. Blockchain Network .....	18
6.2.2. Protocols in a decentralized network .....	19
6.2.3 The Token Model.....	19
6.3 Elements of Web 3.0.....	20
7. Future of Web 3.0 .....	21
8. Conclusion and Future Aspects.....	22
Acronyms.....	24
References.....	25



## Table of Figures

Figure 1: Tim Berners Lee at CERN © <i>CERN Geneva</i>	6
Figure 2 : The Evolution of Web (Source: Fabric Ventures)	6
Figure 3: Web 1.0 Source: Wikiversity	8
Figure 4: Web 1.0 - One Way Communication (Read-Only)	9
Figure 5: Web 2.0: Source: Wikiversity	12
Figure 6: Web 2.0 Elements	13
Figure 7: Web 3.0: Source: Wikiversity	17
Figure 8: Blockchain Transaction Process (Bitcoin): Source: Investopedia	18
Figure 9: Elements of Web 3.0	20
Figure 10: Evolution from Web 3.0	21
Figure 11: Web of contents to Web of things to Web of Thoughts	22

## Table of Tables

Table 1: Web 1.0 vs Web 2.0 (based on initial brainstorming) Source: O'Reilly.com .....	9
Table 2: Web 2.0 Technologies Source: [2] .....	11
Table 3: Pros and Cons of Blockchain Technology .....	20
Table 4: Summary of the Web eras 1.0, 2.0, 3.0: Source: [3] .....	23

# 1. Introduction

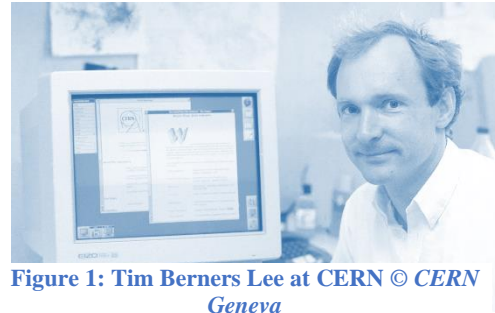
Tim Berners Lee with his colleagues at CERN created Web. This was primarily adopted at the time for the automated sharing of information between scientists all around the world. Since then, the web has progressed from a read-only platform (Web 1.0) to a read-and-write environment (Web 2.0), and finally to a live semantic customized web (Web 3.0). (Web 3.0). We often use the terms "internet" and "www" interchangeably, but they are not the same thing. While the internet is a vast network of networks where computers are connected to speak with one another, the World Wide Web is the concept of accessing information over the internet.

## 1.1 How this document is organized:

- In Chapter 1, we will discuss the introduction of web, its history and a brief introduction to the 3 eras of web.
- In Chapter 2, we explain in detail about Web 1.0 and the evolution to web 2.0
- In Chapter 3, we will discuss about the challenges and drawbacks of Web 1.0 that led to the introduction of Web 2.0 and its widespread usage across the globe and the technology behind Web 3.0
- Chapter 4 will describe the various usages of Web 2.0 , with examples.
- Chapter 5 will describe the challenges in Web 2.0 that is leading to a new era of Web, called as Web 3.0.
- Chapter 6 will explain the idea of Web 3.0 as known to us and its usage.
- Chapter 7 will discuss about the prospects of Web 3.0
- In Chapter 8, we conclude about our study on Web technologies and how it affects our day-to-day life.

## 1.2 History of Web

Tim Berners Lee and his colleagues started the development of the web in 1989 at CERN. For the communication between servers and clients, a protocol was developed, known as Hyper text Transfer Protocol, which was released to the world in 1992.



The first web browser was Mosaic, which helped in the widespread use of internet to retrieve information over the network. After this, Netscape Navigator was found in December 1994, which used to have hyperlinks to other web pages. Thus, users could open new pages without going to another window.

Internet Explorer was released to the general by Microsoft Corporation in 1995 and soon it became very popular. Following this, Apple Safari was found in 2003 as a default web browser on Macintosh. Google Chrome, which was released in 2008, became the most used and popular, user-friendly web browser.

## 1.3 The Eras of Web

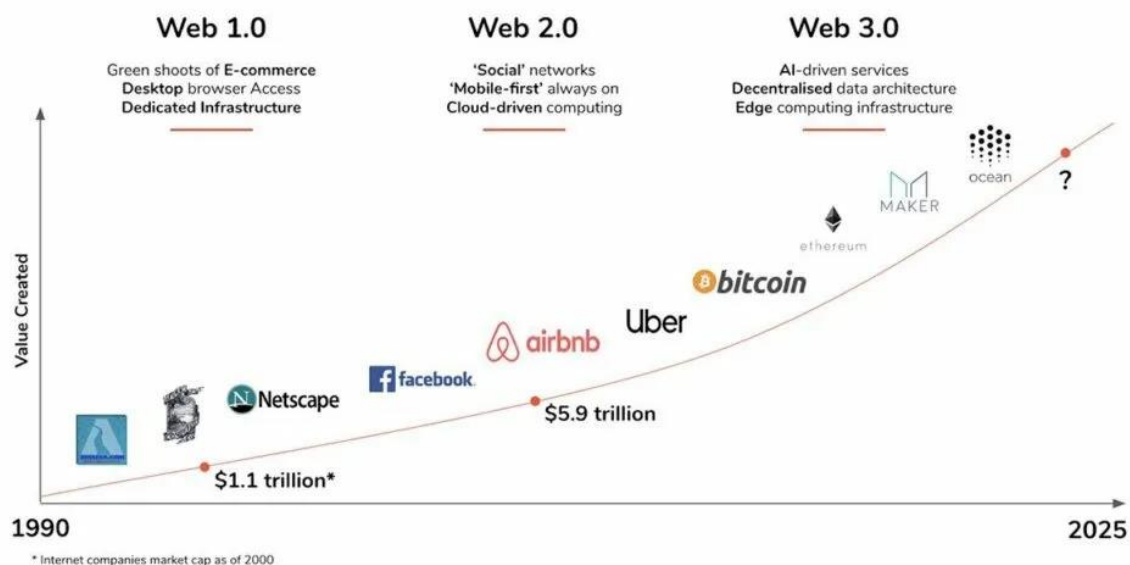


Figure 2 : The Evolution of Web (Source: Fabric Ventures)

### **1.3.1 Web 1.0**

The web was introduced with the purpose of sharing information, in which there were static pages, and the user could read only. There were no other algorithms, media or advertisements. Web 1.0, which was there from 1989 to 2005, was more like a learning tool.

### **1.3.2 Web 2.0**

Following the challenges and drawbacks in Web 1.0, Web 2.0 was developed in 2005, where user could interact with the websites. It has social media, and html that is programmable and engaging. It is the popular place to create contents, e commerce platforms, music and entertainment. Now, millions of users can view the content in an instant on the web browsers. The explosion in the usage of websites happened because of the ease in the availability of internet and smart phone technologies. Nowadays, people can view, edit, create contents, buy and sell things online, meet people online through social media, and almost everything. All the biggest giants in the tech industry like Google, Meta etc. are businesses working on the internet and web 2.0 and are transitioning towards Web 3.0.

### **1.3.3 Web 3.0**

Web 3.0 is the disruptive idea in the evolution of web, which is created based on decentralization and bottom-up approach of designing the websites. It uses Artificial Intelligence and Machine learning to help the computers better understand the requirements, make it more interactive (like metaverse), and create data while engaging with the users. It relies on Virtual Reality and Augmentation and takes the privacy of the users and their data very seriously.

## 2. Web 1.0

The initial stage in the evolution of web and the internet is Web 1.0 (the first Generation). It started at DARPA.

Web 1.0 helped users throughout the world to read or retrieve information from the web and gain knowledge. It was a one-way communication, from the producer of the content on the website to the consumers reading it.

Technologies like HTTP, URL, HTML were used to create contents and the scripting software's like PHP, ASP, JavaScript etc. were used at the server's and client's side. At that time, there were only static pages with limited information shared over the internet.

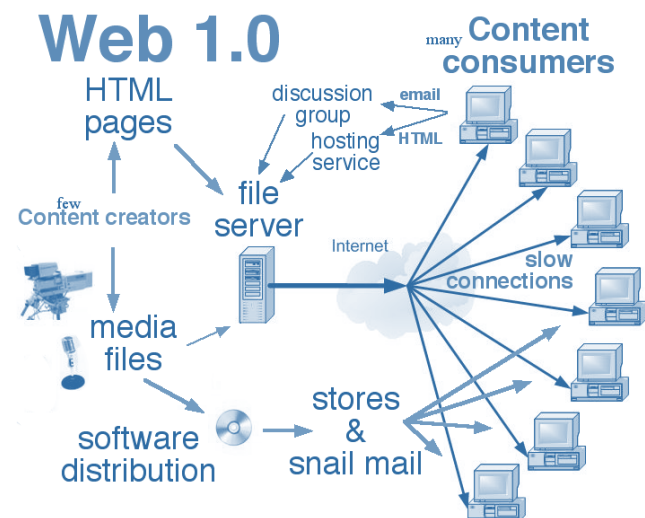


Figure 3: Web 1.0 Source: Wikiversity

This idea of Web 1.0 became more and more popular among the users when various browsers were introduced starting from Mosaic to Netscape navigator to Internet Explorer.

### 2.1 Web 1.0 to 2.0

While Web 1.0 being a static online website, web 2.0 was introduced with the technology of dynamic pages where users could not only read the information, but also share and create contents on the websites. Web 2.0 helped revolutionize the internet usage among everyone, starting from students, teachers, scientists to businesses, freelancers, content creators and common people.



## 3. Web 2.0

The term Web 2.0 was coined by O'Reilly in 2004, after the collapse of the Dot-com Bubble and with the advent of exciting new applications and features on the Web. At the conference, O'Reilly and Dale Dougherty brainstormed to get the following points, based on the differences at that time.

Web 1.0		Web 2.0
DoubleClick	-->	Google AdSense
<del>Ofoto</del>	-->	Flickr
Akamai	-->	BitTorrent
mp3.com	-->	Napster
Britannica Online	-->	Wikipedia
personal websites	-->	blogging
evite	-->	upcoming.org and EVDB
domain name speculation	-->	search engine optimization
page views	-->	cost per click
screen scraping	-->	web services
publishing	-->	participation
content management systems	-->	wikis
directories (taxonomy)	-->	tagging ("folksonomy")
stickiness	-->	syndication

Table 1: Web 1.0 vs Web 2.0 (based on initial brainstorming) Source: O'Reilly.com

### 3.1 Challenges of Web 1.0

- Web 1.0 was mainly for sharing information across the world and was just a one-way communication platform, i.e., only the producers of the content could upload their views and facts about any topic and the users could only read them, without being able to share or edit that form their end. Thus it was just a Client pull model, where only the client(users) could request from the server(content creators) and get the required information/data.



Figure 4: Web 1.0 - One Way Communication (Read-Only)

- It was a slower version of Web and every time any new data was to be updated, the contents had to be refreshed online.
- There were very few content creators while the network of users consuming the information on the web was huge. This used to make the network slower, and the users had to wait long for the resources.
- Thus, it was majorly a publishing platform, where consumers could only read and not interact online.

## 3.2 Web 2.0 Evolution

The above main points, led to the development of many online applications and features that helped evolve the Web into Web 2.0 version.

Now the users could not only read, but they could also write or modify the contents online. Thus it became a collaboration platform, helping more and more information being shared online from different parts of the world.

During Web 1.0, Netscape was the figurehead among others, promoting web as a platform, while Google has been the same in the era of Web 2.0, with web application a service. We discuss more on the new applications and innovations during Web 2.0 that has led to such a massive usage of Web throughout the globe.

## 3.3. Technology behind Web 2.0

Web 2.0 mainly uses the following technologies:

- Rich Web technologies like: Adobe Flash, JavaScript, Microsoft Silverlight
- It also uses the earlier web technologies like Ajax, RSS and Eclipse

The technology infrastructure of Web 2.0 consists of: [3]

- Ajax: The internet technology in Web 2.0 is built on this. AJAX is Asynchronous JavaScript and XML. The webpages became faster and required less data when the pages had to be reloaded, than the earlier HTML design.

- REST: REST is Representational State Transfer. This is a way for retrieving information from the webpage.
- DOM: DOM is Document Object Model. This describes XML in tree format.
- Content Syndication: For creating the services technologies like RSS, ATOM etc. were used.
- XML: Used for creating custom markup languages
- CSS: Cascading Style Sheet is used to style the pages.

For evaluating the services on this platform, the 7C Framework was developed as below [2]. This enabled us to understand the different elements related to Web 2.0 technologies.

<b>7C Framework Element</b>	<b>Related web 2.0 Technologies</b>
<b>Context</b>	AJAX, Flash, Silverlight
<b>Content</b>	Wiki, Blog
<b>Customization</b>	Mashup
<b>Community</b>	Social Networking
<b>Communication</b>	RSS, ATOM
<b>Connection</b>	Mashup
<b>Commerce</b>	AJAX, Flash, wiki, Blog, Social Networking, RSS, Mashup

Table 2: Web 2.0 Technologies Source: [2]

## 4. Web 2.0 Applications and Examples

### 4.1 Applications

Web 2.0 grew exponentially with lots of applications and developments in this area. Tech Giants like Google, Amazon, Apple, Netflix, Meta are all the disruptive innovations.

Now, we not only have resources to read like Wiki (from Web 1.0), but we have applications for almost every work from daily lifestyle (like Uber) to social media (Twitter, Meta) to entertainment (YouTube, Netflix) businesses (Amazon, Google) etc. Applications like WhatsApp, Gmail etc. have become a very important part of our life.

The ease of mobile internet availability, social media and powerful mobile devices like android and iPhone have resulted in the increased consumption of information online.



Figure 5: Web 2.0: Source: Wikiversity

### 4.2 Examples

- While we synonymously call Google as a web browser on the desktop or phones, it is basically an intermediary between the user and the online services provided through large database systems.





The buyers and sellers both come on the same platform, increasing the traffic and usage of these sites.

- This era relies heavily on data. The user generated data is used indirectly through analytics and used for various purposes like recommendations of products, advertising and marketing strategies etc.
- Open Access, Open source etc. helped in the reuse of data.
- While more and more people consume contents online and contribute to the network, it increases its usage, thus leading to a huge network throughout the world

## 5. Challenges with Web 2.0 and evolution of Web 3.0

While Web 2.0 is an open-source platform, where the participation of the users has been the key to its popularity, it poses some challenges and security risks also.

We discuss the different scenarios as below:

- There are users who are hackers too, who can upload some information or content online and other users who click it or download it risks their data as they have also downloaded some malicious software, which gives them access to their whole computer or data.
- Sometimes, users try to get free antivirus software online, that they get on some social media sites and end up getting Trojan horse virus.
- There have been cases, when the virus leads to hacking the user's keystrokes on their device, which gives the hackers access to the user's credit card information, passwords etc.

There are few challenges related to the above scenarios discussed from a technical perspective: [3][4]

- Cross Site Request Forgery: In this type of attack, the hackers acquire access to the user's Webpages through the cookies or some IP address. They can now bypass the firewall to the online marketplace sites and can perform malicious activities like stealing money, buy stuff through the ecommerce sites, steal data from some company intranet, without the user knowing about it.
- SQL Injection: The hacker can introduce his own sql query through some data and then have access to the victim's webpages, database and their operating. This can also lead to the user's computer crashing and the user losing all their data. The hacker, through JSON sends a JavaScript code and when the user uses the websites, the attacker asks the user to open some link, leading to giving them access to the websites opened.
- Cross Site Scripting: Hackers can gain access to the user's computer through some malware with the contents downloaded by the user.
- Flaws related to the authentication and authorization are also a part of Web 2.0, as there is no limit on the age for the passwords, sometimes, the length is fixed, thus leading to the hackers guessing it through computational programs or the profile identification details are same throughout some session.
- Mashups: This being one of the facilities of Web 2.0, where services from many websites are combined to get them at once which enriches the user's experience but imposes security challenges for the creators of the contents.

- Centralized data: Since the data is centralized on a single server and to retrieve them from different IP address, it requires a lot of bandwidth, which becomes very costly as a whole. This can also lead to the internet being slower.
- Sometimes, to mitigate the threats from some incoming websites or due to some political reasons, the websites are censored, or the particular IP addresses are stopped from sending any information, which can be a limitation on freedom of speech too.

To mitigate these drawbacks, a lot of work is being done by the tech companies, so that the user's online experience is secure, or they are aware of the security issues. We have seen Google authenticating the logins made on any different device other than which is authorized or sending alerts about the saved passwords being at threat. Some company intranet users are required to change their passwords at frequent intervals. Apart from these, a lot of work is required to safeguard user's data, which is available to almost everyone, either through social media sites or ecommerce sites. The companies have access to our activities through cookies and our participation online.

Web 3.0 is gradually being introduced to us claiming the security of user's data and information. While being decentralized platform, Web 3.0 is mainly about using blockchain network technology among others that we talk about in the next section.

## 6. Web 3.0

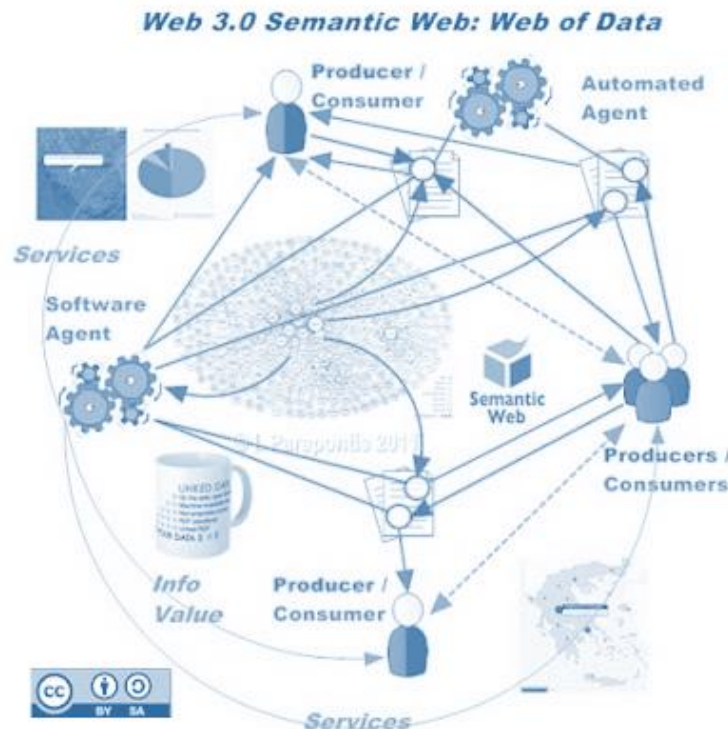


Figure 7: Web 3.0: Source: Wikiversity

### 6.1 Need to Decentralize

In 2016, the Web inventor, Tim Berners Lee in the conference – world wide web consortium said that it is time to re-decentralize the web so that the power is brought back to the people using it. He showed his concern about the centralization of the web, which has unintentionally led to become anti-human.

As Tim understood how powerful the web is to transform the societies, various businesses and the government, he could also think of it as a destruction object for the world if it goes to malicious or wrong people. We could see this when there was some news that the Russian hackers were involved in the 2016 elections for President of USA, or that Facebook had shared data of millions of users for political use to Cambridge Analytica, that was also working for Trump's campaign.

### 6.2 The Decentralized Web

We see that there is an urgent need of having a decentralized web to mitigate the security risks and other challenges, but what is Decentralized web exactly. It is an interconnected system, with every user being the owners privately and will not be dependent on a single server or resource. It can provide private and secure availability for information and resources. The architecture is such that no single person can control it to achieve results in their own favor.

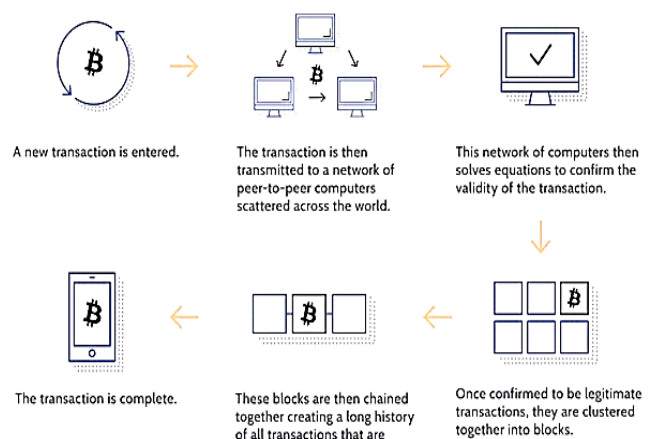
To achieve a decentralized web, blockchain technology is developed, which mainly works on protocols (for e.g.: Bitcoin etc.)

### 6.2.1. Blockchain Network

Blockchain is a peer to peer network. The structure is based on a no trust policy framework for the transactions. The database system is distributed and is shared among the nodes(computers/servers). Every node has a ledger, which is maintained by every node in the whole network of blockchains. No single person has control.

In a Blockchain, the data or information is stored in groups called blocks. These blocks have some capacity to store the information, and when that level is reached, it is added to the chain, by linking it to the previous block in the network. The same process is applied to every new transaction or information. This kind of architecture maintains the timeline of the block added to the blockchain, which cannot be reversed. Thus, each block inherently contains a timestamp. It is kind of an immutable transaction, as it cannot be deleted or altered later. Blockchain is also called DLT. The most common use nowadays is in Cryptocurrency Ledger maintenance.

Thus, when there is any request for a transaction by any node, this request will be shared throughout the network. Since the blockchain is built on a no-trust policy framework, all the computers/nodes in the chain need to authenticate the transaction source. The miners in the network use complex mathematical computation, which is immutable as it is passed through hashing algorithm to find a solution. A digital signature is used for the same and since this was generated with the request message of



**Figure 8: Blockchain Transaction Process (Bitcoin):**  
Source: Investopedia



the sender and the public key, no one can alter the same otherwise the transaction will be invalidated. The algorithm used by Bitcoin for generating this signature is based on Elliptic Curve Digital Signature Algorithm (ECDSA), which helps maintain the security also while using it for verification purposes.

This idea of solving a mathematical computation can lead to vagueness when two or more blocks are to be added together at the same time. This is mitigated by the concept of adopting the longest chain during the addition of blocks to the network. The race of this addition of blocks requires a lot of computation power and also the possibility of this happening is comparatively lower. Thus, making it secure as if any hacker wants to add any malicious information/block in the network, it will have to acquire 51% of the computational power, which is kind of not achievable. Blockchains will help in promoting democracy as there are no single owners of the data, and every user is the rightful owner of their own information.

### **6.2.2. Protocols in a decentralized network**

The Internet protocols that were created initially for Web 1.0 and further used in Web 2.0 like Hyper Text Transfer Protocol (HTTP) were capable of decentralization. But till Web 2.0, we only knew how the data is to be delivered to the users and not how it was stored. Here came the requirement for a shared data layer. Tech Giants like Google made this data layer to store the information generated from the users thus making Server farms or Humongous Databases leading to centralized web. But what was actually required was to create a shared data layer where the databased is to be extended among the various nodes in the network, which can ensure to maintain the fidelity of the data. Thus, if any hacker tries to change any data, other nodes will not be altered, and they can search the node containing wrong information through cross referencing each other. Some protocol examples where the blockchain technology is used are Bitcoin or Ethereum.

### **6.2.3 The Token Model**

During the Web 2.0 era, the companies or people who developed the applications on the protocols such as HTTP, TCP IP earned from the value generated by these IP's. Now it is changing gradually, where the creator or developer of these innovations in the protocols in the blockchain are being incentivized. This is done through Tokens. Tokens are the tradable assets in the blockchain protocols, for example Ethereum's computational power. The price of these tokens increases as the demand and popularity of these tokens increase.

The Blockchain technology has shown how we can secure our data and improve the web's utility, but it has both pros and cons as mentioned below.

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Transactions are private and secure</li> <li>• Better Accuracy, less human involvement for verifying transactions</li> <li>• Decentralization makes it harder to alter</li> <li>• Reduced cost – no 3<sup>rd</sup> party</li> <li>• Transparency maintained throughout network</li> <li>• Good banking alternative, for keeping users' data and transactions secure</li> </ul>	<ul style="list-style-type: none"> <li>• Mining costs higher</li> <li>• Number of transactions lesser due to its inherent structure</li> <li>• Regulations are ambiguous in different locations</li> <li>• Too much storage capacity required</li> </ul>

Table 3: Pros and Cons of Blockchain Technology

## 6.3 Elements of Web 3.0

The basic elements of the Web 3.0 are:

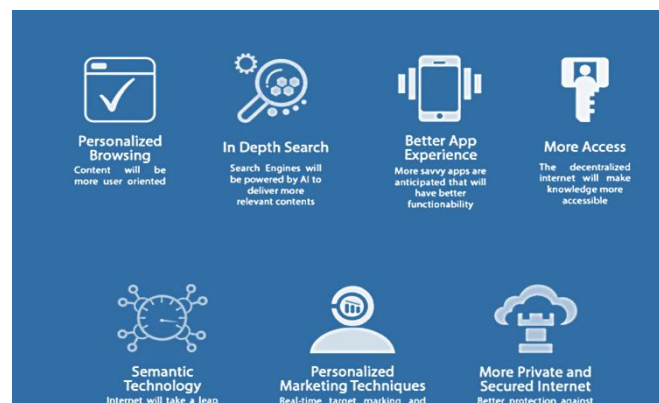


Figure 9: Elements of Web 3.0

- Social Media intensive – Users have been connected to each other various types of social media platforms. Companies like Meta are planning more development in this field to improve the experience of the users.
- Semantic Web – This means computers can understand the deeper meaning behind the words, much like humans.
- Metaverse, Web 3D – Virtual Reality, Augmented Reality, Artificial Intelligence – All these have become popular in Web 3.0 to live in a virtual world
- Media centric – Every media (audio, video, images) can be analyzed through different technologies to provide information about the same through Artificial Intelligence.

## 7. Future of Web 3.0

While the decentralized web features and the blockchain technology helps in great deal towards the security of the transactions, Data privacy can become a bigger issue here. Also, since there is a lot of interactive features with collaboration between the users for better online experience, this has become popular among the users and the hackers on the same level.

One of the limitations of using decentralized web through Blockchain Networks is storage. To mitigate this, one of the technologies that was suggested in the papers [5] is of IPFS. IPFS is Inter Planetary File System. It is peer to peer system of files, is distributed throughout and can connect all the computers used in the computations in the network with the same system. This is a protocol which can use hash of the information to make it accessible to the user and not the IP address (which can be location specific). Thus, this solves the issue of storage. Also, since this is distributed and is a peer to peer network, this can save bandwidth too.

The future of Web is Web 4.0 where everything combined with Web 3.0 will be used to form a more virtually real worlds, where people will be living inside them in their avatars. The experiences will be really different, when each object will be connected using IP's.



Figure 10: Evolution from Web 3.0

## 8. Conclusion and Future Aspects

The evolution of web from Web 1.0 to Web 3.0 has led to a lot many changes in the way we interact online. With the development in technology, almost every aspect our life has become dependent on the online platforms (from WhatsApp, Uber, Google Maps, YouTube, Zoom, etc.). Also, as we saw during the lockdown in the pandemic, there was increased dependency on the internet for working from home, which also led to a lot of developments in the field of online platforms for office related work.

Here it is shown how the web has expanded from its initial days to present status and future.

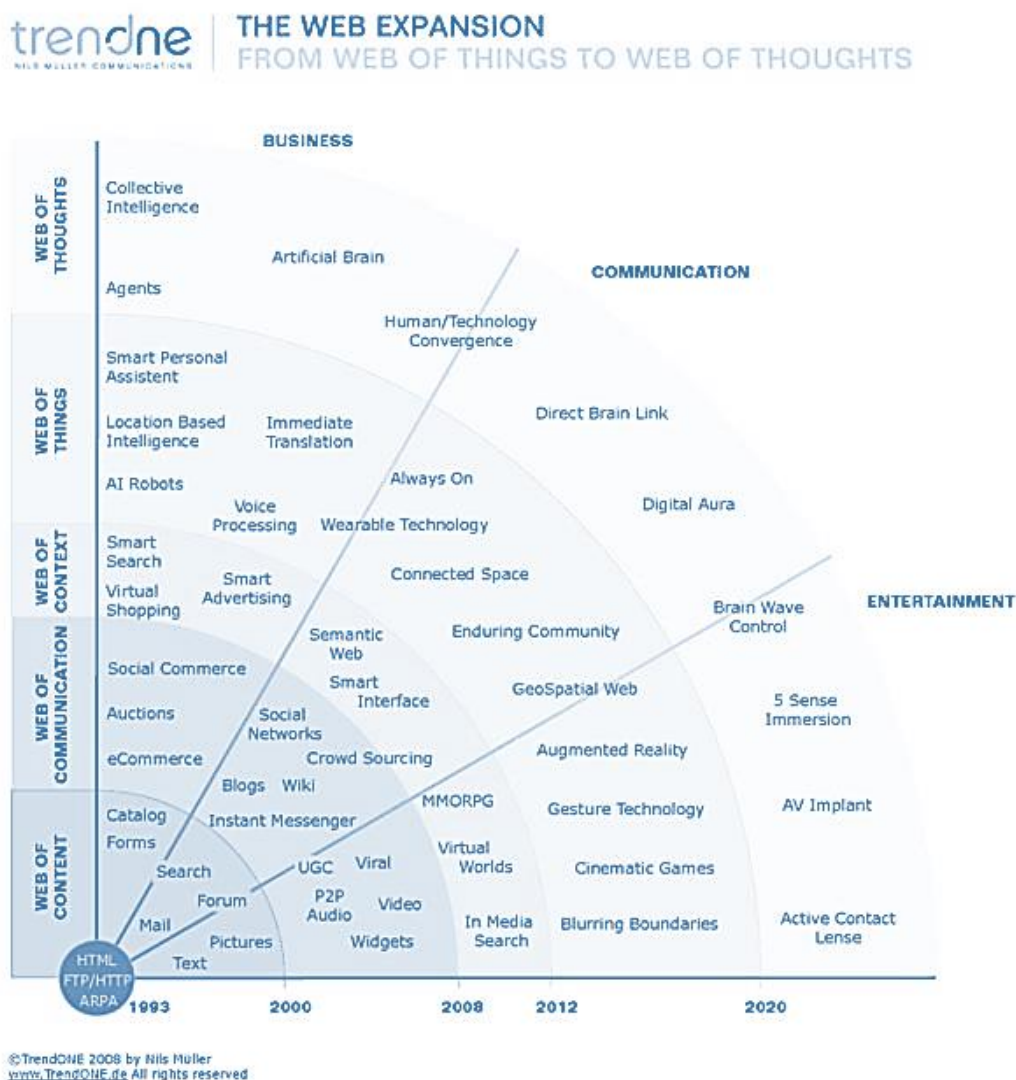


Figure 11: Web of contents to Web of things to Web of Thoughts

Here we summarize the important aspects of the Web from web 1.0 to web 3.0.

Web 1.0	Web 2.0	Web 3.0
Read only – Static Web	Read & Write – Interactive Web	Read & Write – Intelligent Web
Company Oriented	Community Oriented	Individual Oriented
Low Portability	Medium Portability (mobile)	High Portability
Professionally developed resources	User developed open network	Used developed smart technologies
Basic browsing and search	Advanced browsing and search	Semantic search technologies
Low data richness (HTML)	Medium Data Richness (XML)	High Data Richness (RDF)
Hub & Spoke architecture	Service oriented architecture	Web Oriented architecture
Sliced Data	Interlinked data	Worldwide database

**Table 4: Summary of the Web eras 1.0, 2.0, 3.0: Source: [3]**

The future of Web 3.0 going to be the fourth generation of Web. The "Symbiotic Web" is another name for Web4.0. The symbiotic web concept is that once metadata is organized (web 3.0), humans and robots can work together in harmony. This means we'll be able to create more powerful interfaces, such as mind-controlled interfaces. Web 4.0 is currently a concept in development.

The transition from Web1.0 to Web 4.0, like other paradigm revolutions, will have a social, cultural, and political impact. This necessitates taking into account the Web's technological and content architecture.

The Web changes in response to its users' requirements, and technological evolution is still based on the traditional adage of "survival of the fittest," which applies to all the web services.



# Acronyms

Acronym	Full Form
<b>AJAX</b>	Asynchronous JavaScript and XML
<b>ASP</b>	Active Server Pages
<b>ATOM</b>	Atom Syndication Format
<b>CERN</b>	French "Conseil Européen pour la Recherche Nucléaire", or European Council for Nuclear Research
<b>CSS</b>	Cascading Style Sheets
<b>DARPA</b>	Defense Advanced Research Projects Agency
<b>DLT</b>	Distributed ledger technology
<b>DOM</b>	Document Object Model
<b>ECDSA</b>	Elliptic Curve Digital Signature Algorithm
<b>HTML</b>	Hyper Text Markup Language
<b>HTTP</b>	Hyper Text transfer Protocol
<b>IP</b>	Internet Protocol
<b>IPFS</b>	InterPlanetary File System
<b>PHP</b>	PHP
<b>RDF</b>	Resource Description Framework
<b>REST</b>	REpresentational State Transfer
<b>RSS</b>	RDF Site Summary or Really Simple Syndication
<b>SQL</b>	Structured Query Language
<b>TCP IP</b>	Transmission Control Protocol Internet Protocol
<b>URL</b>	Uniform Resource Locator
<b>XML</b>	Extensible Markup Language

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