

History and Evolution of the Browser

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Abstract. The report contains the history of the browsers and massive improvements to the web through some of these browsers. Beginning with the first appeared Browsers and how it came to their creation, it continues with describing the fundamental technologies of browsers and features that were implemented later that helped improve the experience of using browsers. At last this report will discuss the future of the browsers. The goal of this report is it to create a summary of the history and evolution of browsers from the beginning till modern times and what might change after that. For that, multiple websites, papers and books were used for source material and summarized into these articles. The report is meant to be for professors and students but furthermore for people without much information technology knowledge to inform themselves about this application, which is one of the most important once on any operating system for over 20 years.

1 Definition

A Browser represents an application that interprets HTML documents and data to render them to a Web page making the Web accessible. A browser grants the user the ability to navigate websites and perform activities within them like view multimedia, link from one site to another, examine one page from another, print documents from said pages, send and receive emails, among many other activities. The most typical browsers are Google Chrome, Mozilla Firefox and Internet Explorer but there exist many more lesser known browsers.

2 History

2.1 The first browsers

The first browser for the web was furthermore an invention of the founder of the web, Tim Berners-Lee. The browser was called *WorldWideWeb* and was introduced to the world in the year 1990 [1]. A few years later, in 1994, the Browser was renamed *Nexus*. The browser *WorldWideWeb* was, apart of the fact that it was the first browser, as well the first HTML editor. To view pictures, you had to follow the link of the picture, download it and open it on the computer. Another browser with an different name but a similar functionality was *Lynx*, which was published 1992 by Thomas Dickey.

2.2 First graphical browsers

When the Web was released, Tim Berners-Lee wanted his invention to succeed. To ensure the success he knew he required more people to get interested. He needed as many developers as possible to work on web based projects, so there is a constant flow of new content, and he needed the general public to get involved with the web to make it a long-lasting success. For that reason Tim Berners-Lee helped many project that tried to produce new graphical based browsers. In the year 1992 many browser were invented by students as small projects with exactly that goal, were *ViolaWWW* or otherwise called *Viola* was one of the most prominent and *Erwise* was one of the lesser known graphical browsers. But not long after *Viola* followed a new competitor.

This new browser was *Mosaic*.

2.3 Mosaic

In January 1993 *Mosaic* was published for free and its distribution numbers skyrocketed. Marc Andreessen and Eric Bina, the developers of the *Mosaic* browser, constructed the browser with the intention that a broader audience could use the World Wide Web. That was only possible when the team of NCSA engineers would make their browser accessible for other systems than Unix. Andreessen and Bina, together with some of their NCSA associates, worked on the versions for Mac and PC which came out in late spring of the same year. With this the user numbers of *Mosaic* rose even higher, with 5000 downloads per month. After the graduation of Marc Andreessen and Eric Bina, they met James H. Clark, the founder of Silicon Graphics, and discussed how to make the Web commercialisable. That set the starting point for a new Browser called *Netscape*. Therefore Andreessen and Bina left NCSA, with some of their colleagues, in 1994 and settled down in Silicon Valley. After the 2 left the NCSA assigned all commercial rights for *Mosaic* to Spyglass, Inc. Spyglass licensed their technology to many other companies, including Microsoft. In the year 1997 the NCSA discontinued the support for the *Mosaic*, shifting their research focus to other developments projects. The last release for the *Mosaic* browser dates back to August 1997 [2].

2.4 Netscape

Netscape marks the beginning of many important events, which shaped the idea of the browser that are known today. The first version of the browser was launched in October 1994 and was programmed by the NCSA team of Andreessen and Bina, that they acquired. In the beginning the team was not sure how to earn money with their browser, but later on, their browser marked the end of research-project status of the Web and started the era of the Web of commercial interest and exploitation. The Browser also invented the cookie feature, which lets the browser save data, and the Secure Socket Layer (SSL), which protects the privacy and integrity of transactions. The first browser was the *Mosaic Netscape* release 0.9. Because of problems with the name, the company adapted

the name *Netscape Communications* and launched by the end of December the *Netscape Navigator 1.0*, what furthermore solved the problem with the name conflict regarding the NCSA Mosaic browser [3].

Because of the few competitors in the field of browsers, *Netscape* became the most popular browser in a short time. The main income for the company was through B2B-business and the stock markets. Especially the stock markets were lucrative, because on the first day (August 9th, 1995) their stock price rose from 28\$ per share to a high of 74.75\$ and at the end of the day they closed off with 58.25\$ [4]. That was a good omen and it didn't end there; yet. They rose in popularity, until Microsoft started competing in the Web sector. Through the competition of Microsoft Netscape Communications started improving their browser with rapid speed, which started the first browser wars [5].

2.5 Internet Explorer

Internet Explorer 1.0 (furthermore called IE) was the first attempt of Microsoft on 17 August 1995 to dethrone Netscape as the market leader on the browser territory. For the first 2 versions of IE, Microsoft used the licensed code of Spyglass Inc., from *Mosaic*, as a starting point. The first version that was mostly independently made in the company, would be IE 3.0. It introduced as the first browser ever CSS and it was the first version that did not use the Spyglass source code; only Spyglass technology. It was in addition the first true competitor for *Netscape*. The following years would become known as the **Browser Wars** between Netscape and IE, where both parties would improve their browser in a rapid pace. The tides turned with IE 4.0, where Microsoft changed their strategy. Before IE 4.0 their browser was a free browser for the home, like Netscape, but Microsoft's browser was inferior in technology and had to be installed first, before you could use it. But IE 4.0 shipped with all Windows and Macintosh PCs', indicating the first browser most people interacted with after they bought a new PC was IE and not Netscape [6]. With that IE dethroned Netscape as the most used browser. After the defeat of Netscape the development of Microsoft's browser slacked down after the release of IE 6.0 in 2001. But this error made it possible for new competitors to emerge and evolve.

2.6 Mozilla Firefox

Mozilla Firefox, originally called Phoenix or Firebird, is the unofficial offspring of Netscape created in the year 1998. The first version of Firefox, Firefox 1.0, was released on 9 November 2004. Shortly before the release of the first full version Mozilla gained a bunch of new users, because of the warning from the US government against the exploit in IE. Firefox and its predecessor were created on the bases of the Netscape source code, which was published on 31 March 1998 in the attempt of Netscape Communications to get more programmers that could improve the code and help defeat Microsoft in the **Browser Wars**. Unfortunately that was not enough to save Netscape. But it does not mean that Mozilla Firefox was going down with Netscape. The reason behind this

was because *Mozilla Firefox* had already its standalone browser, with a big community and enough programmers to keep working on the browser [7] [8]. Another reason is the browser was backed financially by many investors and the Mozilla Corporation, which was founded as a totally owned branch of the Mozilla Foundation. Nowadays Firefox is still fairly popular browser with 6-8%, even while Safari and Google Chrome have a bigger market share.

2.7 Opera

Opera is one of the oldest browsers at present, next to IE. *Opera 1.0* was first released in the year 1995. It was not as widely used as Netscape or IE, but it gained popularity with time. The intention was to build a fast browser on any system. That is why it was built from scratch and not based on the Mosaic code (like IE and Netscape). But *Opera* gained enough popularity with version 2.1, which was released on 9 December 1996 and introduced features like keyboard shortcuts, zoom and sessions [9].

2.8 Safari

Safari is a browser exclusively developed for macOS and iOS, which was released January 7th, 2003. Initially it was published on Mac desktop systems, later on version 3,4 and 5 it was also published on Windows, but after the 5th version the Windows edition was not further supported. The browser was released for the mobile devices of Apple Inc. in the year 2007. Safari was a pioneer in the browser segment, especially in the early years, but now it is struggling to keep up with its competitors. Since then the quality decreased from browser version to browser version, compared to its contestants. The most recent version is 12.1 of the browser for all iOS and macOS systems.[10]

2.9 Google Chrome

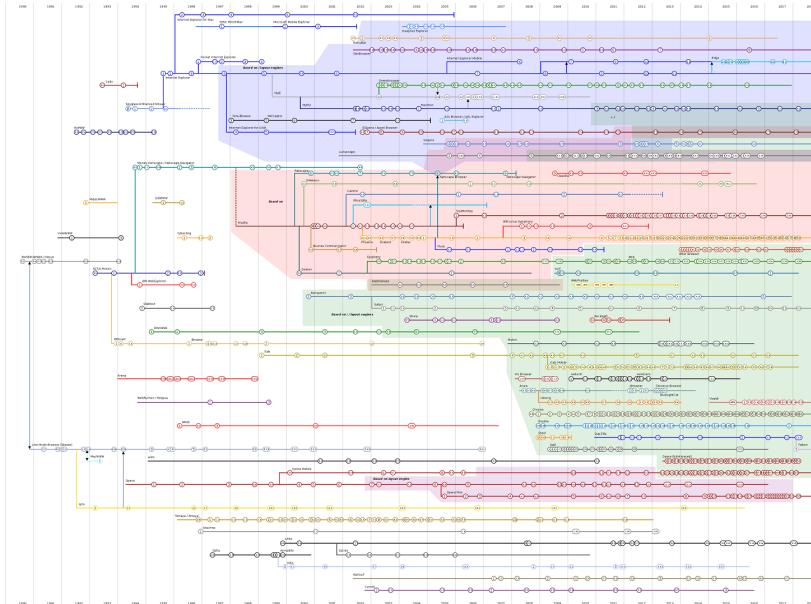
It was rumored in 2004 that Google was working on a browser, but the development only began in the year 2006. The reason why Google wanted to develop their own browser, was because the other options at this time were not that satisfying. The first version was released in 2008 and gained immense popularity. In the year 2012 even surpassed IE in the market share race and since then is dominating the 2nd browser wars and is slowly winning as well. Google furthermore developed an engine for browsers called Chromium, which many browser competitors slowly start using for their own browsers.[11]

2.10 Tor Browser

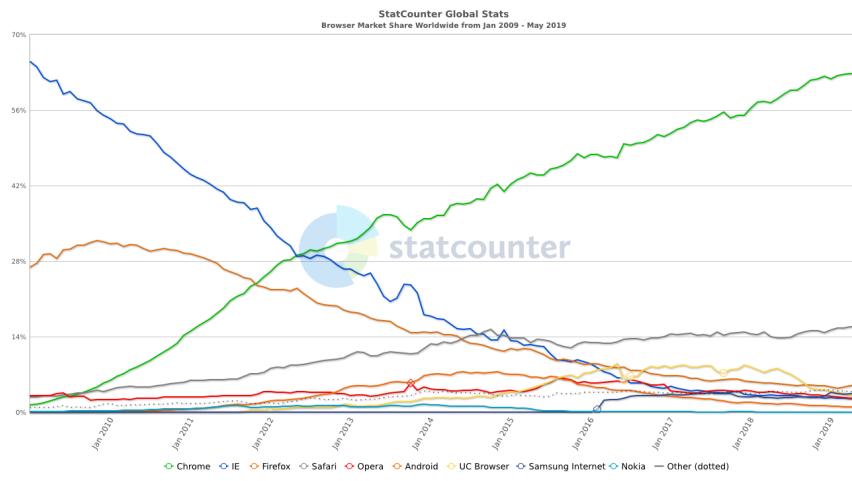
The *Tor Browser* is a browser with one goal: internet user should have access to an uncensored web, without being tracked by anyone. Tor stands for "The Onion Routing", the technology that fuels the *Tor Browser*. October 2002 the Tor

network was deployed but no browser to access it, so people without technology experience were unable to access the network. The work on the *Tor Browser* started in 2008 to help those without the knowledge to do so before. The browser was later on tool to many political movements, like the Arabic Spring in 2010, and popularity after Snowden's revelations in 2013. [12]

2.11 Timeline of all browsers



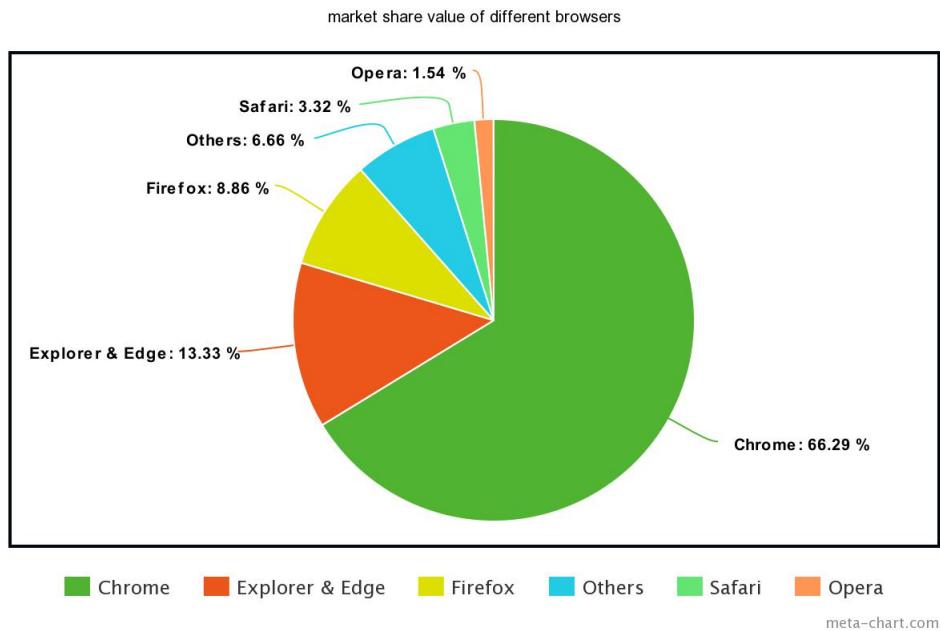
A timeline of all browsers and browser versions ever made. [13]



A market share timeline from 2009 to 2019 for the most used browsers. [14]

2.12 Browser nowadays

Today Google Chrome dominates the browser market, with roughly 60%-65%. Next up is Mozilla Firefox according to the data, with 5%-8%. After that comes Internet Explorer and its successor Microsoft Edge, both with around 5%-7%. Every other browser has less than 5% market share. Another fact to mention is that most browser use Chromium, the browser engine of Google, including Opera, Microsoft Edge and other browsers. The only widely used browsers that don't use Chromium are Mozilla Firefox and Safari.



*The market share value of the different browsers from June 2019.
[15]*

3 Evolution

3.1 The meaning of Evolution

With the release of every new browser and browser version, features and improvements have been added. Browsers became more secured, user and developer friendly, and more efficient. These were implemented by the developers since new technology being released, bugs discovered and in order to stay competitive. All these changes included in a timeline create the Evolution of the Browser.

3.2 Basic Technological Changes

HTTP

HTTP stands for HyperText Transfer Protocol. It is an application-level, request-reply protocol which is typically transported by a lower-level protocol, like TCP. It works like follows: If the client requests a resource, the server replies with information and sometime even with the resource itself [16]. Today one distinguishes between HTTP and HTTPS, where HTTPS means HyperText Transfer Protocol secure because the HTTP is accompanied by an SSL encryption.

HTML

HTML is the abbreviation for HyperText Markup Language. Tim Berners-Lee made this textual format for annotating plain text with informations part of his original Web proposal, and created the first editor and at the same time the first browser around HTML. The first proposal for HTML is dated back to 1993, but today HTML 5 exists; which was standardized in 2014. [16]

URL

URL is the short form for Uniform Resource Locator. The *URL* gives the address where specific resources are located in the Internet and the protocol to access it. The URL contains, furthermore, the port number to access the address, the location of the resource in the server and a fragment identifier [17]. The *URL* is also one part of the initial proposal of the Web from Tim Berners-Lee.

Browser Engines

The browser engine, also called "layout engine" or "rendering engine", is the core component of most major web browsers. The job of a browser engine is the transformation of HTML files and other required resources to an interactive web page. While it is possible to separate the engine for the layout and the rendering of the page, in practice they are mostly coupled and not separated. The browser engine is equally responsible for enforcing the web pages security policy and creating the DOM data structure used in scripts. It is also responsible for handling hyperlinks and web forms. Browser engines may also be reused in other application. An email client, for example, may use such an engine for rendering HTML emails. Another example is the "Electron Framework", which uses the engine of *Google Chrome*, used to create many applications. The layout to be rendered is specified by the CSS file of the web page. There are several different browser engine implementations and the most major web browsers use their own browser engine. Examples are Gecko by Mozilla, WebKit by Apple and Blink by Google. Microsoft used to have their own browser engines Trident and EdgeHTML, but use Googles Blink browser engine now.[18]

3.3 How Patches influenced Browsers

“I call such changes patches, as they are attempts to fix the original design of the web” Marco Aiello The Web was Done by Amateurs (2018, p. 65)

By changing the Web, patches also influenced browsers when they were introduced. Following shows a summary of what these patches were and how browsers evolved and adapted through these changes.

Cookies

Like mentioned before Cookies were introduced with Netscape in 1994 for websites to be able to save data to be remembered for processes on the clients side. The web-browser is being used by the server of the website to save text information on the Computer of the client. These have made it possible to save login and shopping cart informations but as well made webtracking possible. Later they received criticism for being able to damage the users privacy and threatening security when surfing the web. Under the EU’s GDPR Law websites are now forced, now ask and inform users about saving data in their Browser.[16]

SSL

SSL is short for Secure Sockets Layers, which was an introduction of a security system in the Web. A often missconsumption is that SSL would be an application layer based security protocol but that is not entirely true. It actually is used in the session layer which is above the transport layer and beneath the application layer [19]. It was introduced by Netscape and shaped the security protocols we use nowadays. SSL had many flaws that were corrected by its successors TSL, that's why the latest version was deprecated in the year 2015.

Java

In the year 1995, Sun Microsystems published the object-oriented programming language *Java*, inspired by James Gosling. *Java*, formerly called Oak, is able to run on every computer. This is made possible by the Java Virtual Machine, which takes the standard bytecode instructions of the Java program and interprets it. The only problem is that the JVM is not uniformly implemented across all hardware vendors. The combination of Java and the Web is only possible if the JVM is available to the browser on the client side. The Java code is sent with the Web page, where this code is known as Applet. When the browser hits the point where the code should be run, it starts an instance of the JVM and gives it the bytecodes for the execution. [16]

JavaScript Engines

While it would have been possible to couple the handling of JavaScript to the browser engine, every major browser uses a dedicated script engine. This is due

to the fact, that JavaScript, while originally created for use in web browsers, is now also used elsewhere. In the web browser these two engines interact with each other through the shared DOM data structure. The first JS engines started with bare interpreters and evolved to full engines with several additional features. The first JavaScript engine was developed by Brendan Eich, co-founder of the Mozilla project, in 1995 for *Netscape*. It was a bare interpreter for the language he was inventing at this time. The first modern JavaScript engine was Googles V8 engine, created for Chrome in 2008. The key innovations were just-in-time compilation, boosting performance significantly. As a result other browser vendors had to overhaul their interpreters to develop into full JavaScript engines. This leads to the development of the Nitro engine for Apples *Safari* browser. Mozilla used portions of Nitro to improve SpiderMonkey, which resulted from Brendan Eichs original JavaScript interpreter. Opera replaced their interpreter with their Carakan engine, also boosting performance significantly. Since 2017 all major browser have added support for WebAssembly to their JavaScript engines. This gives the ability to execute pre-compiled scripts for performance-critical parts of the web page. The code is executed in the same sandbox as the regular JS code.[20]

3.4 Features

Incognito mode

Private browsing was first added in 2005 by *Safari* on Mac. The feature has since been adapted by many other browsers so that most modern browsers have some form of private browsing.[21]

Bookmarks

Bookmarks were a quite early feature and have been included since *Mosaic* in 1993, although called hotlists back then. Moderner browsers have expanded the feature of bookmarks. *Firefox* for example, introduced so called "Live Bookmarks" which are essentially bookmarks provided as RSS feed.[22]

Browser Extensions

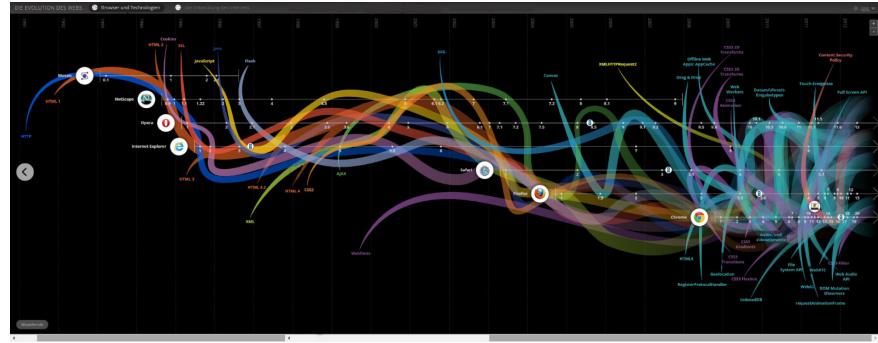
As the first major browser, *Internet Explorer* introduced browser extensions with Version 5 in 1999. The other major browsers also included extensions over the years with Firefox in 2004, Opera in 2009 and Google Chrome and Safari in 2010. Currently most browsers support extensions to customize the user experience.[23]

Tabs

The first web browsers did not have tabs as we know them from most modern browsers. While many may consider *Opera* to be the browser to introduce tabbed browsing, *Opera* had a *Multiple Document Interface* instead. This may seem similar but is substantially different to a *Tabbed Document Interface*. The actual first browser supporting tabs was the *Internet Explorer* Shell "NetCaptor", first

released in 1997. The browser to mainstream browser tabs was, however, Firefox or more specifically its predecessor *Phoenix*.[24]

3.5 Evolution Overview



Evolution of the Browser [25]

4 Future of the Browser

Nowadays there are already many ways to interact with a browser which seems rather futuristic. You can control via voice or by hand gestures. You are not just having your browser on your Computer but also on your phone, your watch and floating in the air in front of you.

4.1 Browsers becoming operating systems

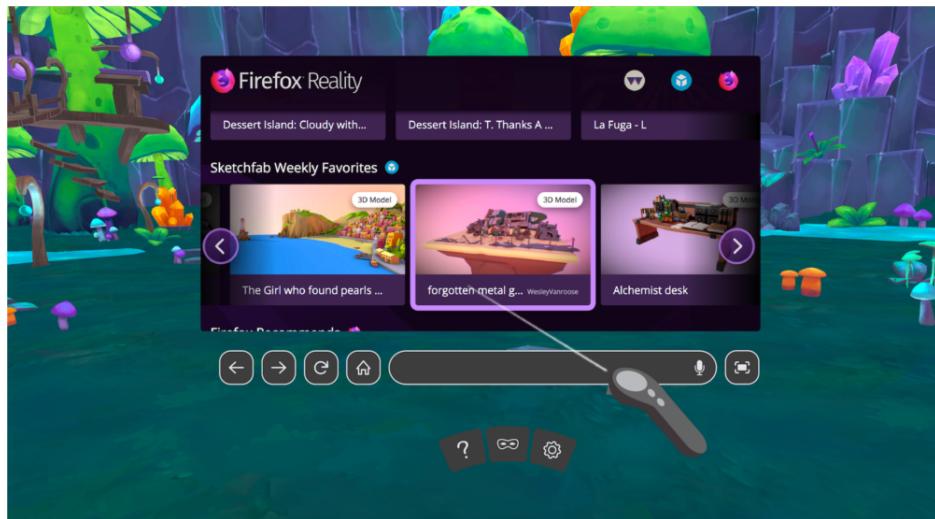
One of Alan Kay's primary criticisms about the Web is the absence of a computational ability for the browser. His vision is for them to be like mini-operating systems and be able to execute locally. So it is possible, for example, to learn a programming language with just writing code on the website and execute it on the computer. The patches were already steps into the proper direction. Another part is to establish websites to be like applications and with web applications such as Google Docs or Microsoft Office Online, the browser is going towards that vision. These make it possible to create, send and receive content such as documents or tables while other people access them simultaneously. It is for sure that more applications like these will be released. A good example for a website supporting Alan Kay's vision is lively-web.org, an open source web programming environment. Everything that is displayed on the website represents an object and can be changed, moved or overwritten and provides immediate feedback to the user. Every text field is able to execute JavaScript. Users can create their own website or application and are capable to edit and download it from everywhere without having to install any software. [16][26]

4.2 New technologies

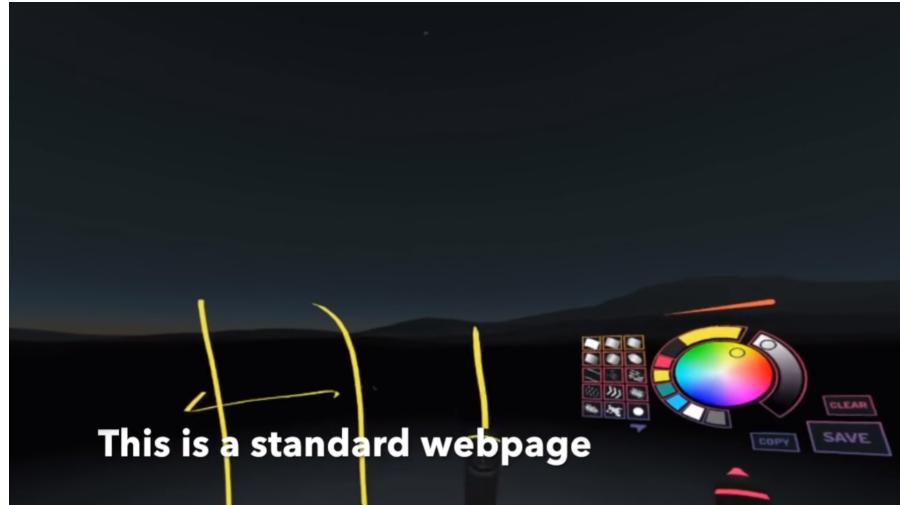
New technologies are constantly thrown on the market and Browsers always have to find a way, to make them accessible to the web, while bringing as many features as possible from other devices and new ones, that fit to the device.

WebVR Browsers

Virtual Reality Browsers are making it possible to access the Web with VR-Glasses. To navigate, the voice or a virtual keyboard can be used. These Browsers make it possible to watch 360 degrees videos or pictures. Developers are able to create WebVR Applications themselves and put them on the web just like a website. Vr-Browsers such as Firefox Reality or Supermedium Browser allow displaying websites not like a 2D Sheet but rather like a 3D environment without having to download content. These environments can represent experiences, like walking in a desert, games or creative activities such as 3D painting as seen in the second picture.[23]



[27] Firefox Reality



[28] Supermedium Browser

AR Browsers

An AR Browser is an application, like any other Browser. The difference is, that AR Browsers are for phone or tablet use only. Their purpose is to display additional informations on a camera screen. These informations, can be 2D markers or 3D objects, for example. Just like most of VR Browsers, they also rely on content creators. [29]

Smartwatches

With the release of smartwatches, companies needed to discover yet another way to display browsers. The portable screen does not offer enough space, to fit the usual user interface or keyboard. One way is adding a website on a connected device to the favorite list so it is possible to navigate the website by just one touch on your watch. However it is possible to connect the smartphone with the watch and use its keyboard.[30]



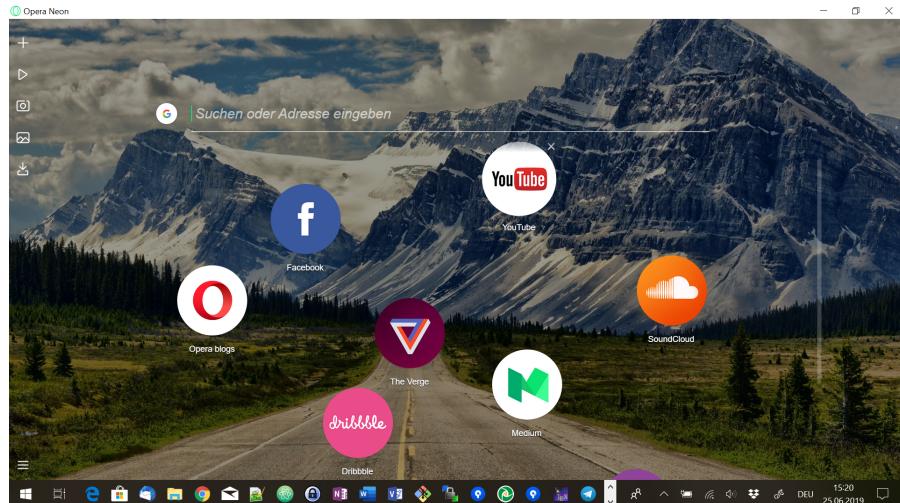
[31] Web Browser for Wear OS on Android

4.3 Quantum computing

Another prominent topic of these times is quantum computing. Quantum computers would make it significantly easier to decrypt keys for the secure transport of data between the browser and external servers. That explains the reason why, since a couple of years institutes around the world, have been looking for algorithms, that are post-quantum secure. It is indicated, that their generated keys can withstand the decryption of a quantum computer longer than algorithms nowadays such as RSA. Browsers will need to adapt to these changes in order to assure security for its customers and stay competitive in the market. [32]

4.4 Next steps for Browsers

Since the introduction of the browser many changes have been made. It gained on speed, performance, security and usability. These attributes will certainly grow in the future. Opera formulated a concept for how they imagine user friendliness will be in the near future with their Browser. It is already downloadable, yet Opera Neon remains a work in progress until now.



Startscreen of Opera Neon

However at the same time the vision of Alan Key has yet to be met. Even though the steps are modest, Browsers are becoming more and more similar to operating systems and closer to the initial vision of Alan Key. But they still have a long way to develop since they were not designed for that purpose.

Web 3.0 is supposed to support the user to deal with the amount of information on the Web. This might also force Browsers to make a change, yet neither into which direction nor to what degree can be determined at this stage. We might indeed observe a completely experimental type though it is necessary to be initiated by one of the major browser companies.[33]

5 Conclusion

The first browser was introduced in 1990. By Tim Berners-Lee, with the purpose, to act as an editor for HTML and to view the contents of the Web. After that, the number of different browsers increased shortly and the plain text-based browser was replaced by the graphical browser. The next topic included the basic technologies of all browsers, namely HTTP, HTML and URL, as well as the Patches of the Web. Basic features of the browsers, such as Tabs, Bookmarks or the Incognito mode were introduced. Finally, the report looked at modern and newer technologies which showed how browsers constantly need to reinvent themselves to stay relevant for the future. The Browser is an application which can not be forgotten on any modern operating system these days, as it is one of the standard programs that is already installed from the beginning. The way we are connected nowadays, is based on that software. After the user installed a operating system one of the first actions is opening the browser, which connect him to the rest of the world.

Nevertheless, it is expected that this application is to become eventually a full-grown operating system itself, throughout its Evolution to fulfill the vision of Alan Key.

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