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HTML5 and the evolution of HTML; tracing the origins of digital platforms

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ABSTRACT

HTML (Hypertext Markup Language) has experienced a major transformation during the last decade prior to releasing its latest version known as HTML5 (Hypertext Markup Language 5). Several elements conceived around HTML during this period introduced significant problems in the development of the standard due to an increasing fragmentation and complexity in protocols, platforms, devices and systems. With the setting up of the WHATWG (Web Hypertext Application Technology Working Group) and the popularization of HTML5, initial disagreements between W3C (World Wide Consortium) and other digital platforms around the strategy to follow were put to an end. However, the development of HTML5 has opened up doors to profound changes in the way that web standards are produced and the role of the Web as a techno-social platform. For shedding some light on these issues, this paper provides a retrospective throughout a historical revision of the evolution of HTML, shedding some light into the technical, economic and social factors that helped to create a "Living Standard". For achieving this objective, the paper is built on the empirical evidence gathered from 21 interviews carried out with different HTML5 experts as well as a documentation analysis around the hypertext standard. This contribution stresses how the platform economy paradigm emerged thanks to different factors contributing to the increasing centralization that can be observed nowadays. Lastly, it is argued that the role of organizations like W3C and others should be strengthened for avoiding the oligopolistic practices of digital platforms in future episodes of socio-technical controversies.

1. Introduction

Hypertext Markup Language (HTML) has been the official hypertext standard since the beginning of the Web. Tim Berners-Lee is considered the first pioneer in proposing the idea of connecting files into different computers throughout hyperlinks [1] establishing a language that can intertwin different web pages. In the last years and thanks to the rising of HTML5, its associated technologies (CSS3, JavaScript, etc.) and features (video, canvas, etc.), HTML has experienced a great transformation that defies the previous conception of hypertext as a standard valid for interconnecting documents throughout different computers. This innovation in standards has not only opened up doors to a great change in the conceptualization of hypertext but also in the development of standards through more agile and lean methods for involving users feedback and ideas into standardization processes that are currently demanded by the emerging data economy [2]. Due to these technical reconfigurations, the Web and its role as a techno-social platform in society has also been revisited within the increasing complexity and fragmentation introduced by mobile devices and digital platforms [3–5].

The objective of this paper is to provide a retrospective throughout a qualitative approach case study for understanding how HTML5 favored the rise of an emergent economy oriented to data [2] and where main proponents of this paradigm are also framed as "platform economy" representatives [6–8]. To achieve that aim, this study is built up around empirical evidence gathered throughout 21 semi-structured interviews conducted to different HTML5 experts plus a literature review on technical documentation associated to the development of the standard.

The text is structured as follows: The next section situates the evolution of HTML till the development of HTML5, the third section explains the methodology, the fourth section presents the findings of the interviews and the fifth section encapsulates the discussion about the implications of the development of HTML5 before recapping a brief conclusion.

2. Situating HTML and its evolution

Hypertext as a concept was originally proposed by Vannebar Bush in his famous essay entitled "As We May Think" where he theorized about a machine that can serve to personal uses called Memex [9]. This personal device could allow people to store books, movies as well as looking

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for information in an agile way [10]. Theodor Nelson was another great ideologist of the hypertext with his project Xanadú.[1] An initiative started in 1960 with the aim of creating a global and unique document (a docuverse) where all the literature and knowledge of humanity could be gathered thanks to a vast network of interconnected computers [11]. Nelson also used the hypertext term to refer to *"a body of written or pictorial material interconnected in such a complex way that it could not conveniently be presented or represented on paper"* [12].

Other innovations such as HyperCard [13,14] and the emergence of DNS on the Internet in the 80's favored the evolution to the practical implementation of this theoretical idea of linking documents throughout machines. In 1989, Tim Berners-Lee and his research group at CERN launched the Hypertext Transfer Protocol (HTTP) and HTML which was also based on SGML (Standard Generalized MarkUp Language). This was a generic language that allowed to define document structures of all kinds and designed to function at any kind of machine. The idea of grounding HTML in SGML was to build up an independent language from the browser or the application used for interpreting the information displayed in the screen [15]. To attach the development of HTML to the already existing SGML was a success because it facilitated the diffusion of the new language as it shared several features with the old one. In addition, the simplicity of the "anchor element" to create hyperlinks contributed to promote its diffusion and adoption [16]. In addition, the establishment of a mailing list by Tim Berners-Lee in September 1991 for discussing about future improvements also contributed to its popularization.

George P. Landow, a famous scholar of HTML, has indicated many times that hypertext allows to connect verbal texts as well as texts with other materials such as images, videos, sounds, maps and many other elements, creating what he refers to as hypermedia [17]. This author stresses that the hypertext helps to develop a new kind of reader much more in control of his reading path and with new functions that can be previously considered only at the hands of a writer. At the same time, Landow also stresses how hypertext introduces fragmentation in texts which has been also pointed out by other authors [18]. Hypertext is of paramount importance for media as it has created a new environment for contents and new possibilities of interaction with readers. Other authors speak about similar terms such as polymedia [19] or new media [20] for alluring to the new communicative possibilities raised by hypertext as well as stressing the different values associated to these formats such as modularity, automation, numerical representation, variability and transcodification [21]. Hypertext also needs of collaborative writing and many social media platforms [22,23] that appeared during the Web 2.0 phenomenon [24–26] exploited this for accommodating their business models. Blog posts, Facebook updates or tweets become meaningful when other users read, share, comment or rewrite those pieces of information, extending their reach and meanings.

2.1. The problem with Web 2.0 technologies

After this initial stage of the evolution of the Web, a second period commonly known as "Web 2.0" shaped the evolution of HTML during the beginning of the 2000s decade and immediately after the dot com bubble burst [27,28]. In this period, conceptualizations of new business models around platforms were pushed forward, creating tremendous implications in society at a later stage [5–7,25,29–33]. In addition to its different socio-economic impacts, Web 2.0 period also pushed forward several technologies that promoted a significant change in the nature of the Web [13,34,35]. Some of them were an evolution of already existing ones such as Extended Markup Language (XML) but others such as Application Programming Interface (API), Asynchronous JavaScript and XML (AJAX) and Flash[2] created a new technological ground to advance and to promote the concept of Rich Internet Applications (RIA) as a new web development paradigm [36].

"Web application" was the chosen term to refer to solutions developed during this era that wanted to simplify and pack existing technologies into components that can be run by a web browser. Similarly to desktop applications, these innovations allowed to use JavaScript or virtual machines for implementing additional features in browsers that were previously not implemented in the HTML standard. This will extend the reach of websites, its functionalities and user-interaction possibilities. RIAs will also "become the norm" in web development during the Web 2.0 period as this structure will provide new possibilities for websites avoiding at the same time overcharging web servers with unnecessary petitions. RIAs will also set the basis for developing the technological ground for digital platforms that start to emerge during this period on the Internet [4]. These changes favored a "platformization" of the Web in a clear move towards interoperability between different components [37,38].

The increasing popularity of the Web during this period transformed it into a mass media product [26] and press coverages in TV, radio or magazines were dedicated to the appearance of new websites with new features which facilitated the onboarding of new users to the Web that were not previously engaged (see Fig. 1 for instance). During the first days of the Web, this platform was not oriented to non-technical users but thanks to the appearance of User Generated Content (UGC) plat-

Fig. 1. December's Time magazine cover in 2006. Source: Wikimedia.

[1] http://www.xanadu.com.

[2] Flash Player is a proprietary software that allows to play different multimedia contents.

forms during this period such as wikis, blogs or social networking sites, many users without coding skills were seduced to start tinkering with these services [39]. Uploading photos to Flickr or Picasa, videos to YouTube, listening to music in Myspace or making posts in blogger were some of the options that the new websites offered to create a personal space online [5,22,23,30].

In this regard, the importance of multimedia content in the online sphere during this period of the Web history is huge for attracting users to these incipient digital platforms [13,34,35,40,41]. But the introduction of multimedia contents was far from being smooth and it required from several add-ons coming from the proprietary software domain such as Flash [42] or Silverlight [43] for presenting multimedia elements such as videos or animations conveniently in web browsers. These elements were considered "black boxes" as robots from search engines couldn't crawl the information hosted in these elements for developing services that can be monetized [44]. HTML was not equipped with these native capabilities and this would be the main problem that the World Wide Consortium (W3C) and other organizations that contributed to the development of web standards will try to solve. The development of native capabilities in HTML will become the big objective for players involved in the incipient digital economy with the ambition to transform an static standard into a dynamic, augmented and interactive one able to provide the technological basis for digital business models based on data [2,31,34,35].

2.2. The rising of HTML5

The development of HTML5 is a tipping point in the history of the Web for its innovative features but also by the way it was conceived and developed. The origins of this standard lie in a group of professionals coming from Opera Software, The Mozilla Foundation and at a later stage, Apple, that was unsatisfied with the strategy of the W3C for facing the new needs around HTML raised by the Web 2.0 period. The W3C wanted to push forward Extensible Hypertext MarkUp Language 2 (XHTML2) which is a standard with no backwards compatibility with prior versions of HTML and that also demanded a new MIME type.[3] This route implied to abandon the work done with previous versions of HTML.

The call into question was initiated at a workshop hosted by the W3C in June 2014 called "Web Applications and Compound Documents"[4] where several doubts were raised about this approach by different professionals from these organizations (Opera, Firefox and Apple). This event led to a major disagreement with the W3C vision from other organizations such as Google or Microsoft and following that event an independent group known as Web Hypertext Application Technology Working Group (WHATWG)[5] was set up by these dissenting voices after the meeting [45]. The vision of these industry leaders was mainly interested in technical interoperability and backwards compatibility of new languages with previous versions of HTML whilst stressing the open and public character of Web technologies. During the workshop some of the dissenting voices of these group of professionals framed their proposal around 7 principles [46]:

1. *Backwards Compatibility, clear migration path.*
2. *Well-defined error handling.*
3. *Users should not be exposed to authoring errors.*
4. *Practical use.*
5. *Scripting is here to stay.*
6. *Device-specific profiling should be avoided.*
7. *Open process.*

[3] MIME type is a two-part identifier for file formats and format contents that is specified and visible at the top of websites.

[4] http://www.w3.org/2004/04/webapps-cdf-ws/.

[5] https://whatwg.org/.

WHATWG was open to stakeholder collaboration and established several tools, such as mailing lists, to incorporate ideas from different users of HTML around the world, extending the features of HTML and guaranteeing its backwards compatibility with previous versions [47]. The group also worked into several native and multimedia functions of this new version of HTML such as audio, video, canvas and many others "*to transform HTML4 into a standard capable of including new features for modern web application developers*" [48].

Nevertheless, W3C insisted on promoting XHTML2 and other technologies as an alternative for replacing HTML. After two and a half years, slow procedures and not really significant progresses made by the W3C contrasted to high expectations delivered by the great advances posed by HTML5 and the work conducted by the WAHTWG [49]. This led to Tim Berners-Lee to announce that the W3C will join forces with the WHATWG for pushing forward HTML [50]. Three years later, W3C decided to abandon activities on XHTML2 and dismantled related working groups with the sole objective of reinforcing HTML5 activities [51]. Prior to that, the joint efforts of these two organizations produced a working draft [52] and in the following years Mozilla Firefox and subsequently other web browsers started to implement this new version of HTML [53]. This occurred first, as a W3C candidate recommendation in 2011 [54] and finally as an official recommendation in October 28, 2014 [55]. This official recommendation has also been updated with a later recommendation in December 14, 2017 known as HTML 5.2 [56].

2.3. The socio-technical construction of digital platforms

In addition to the technical factors that spurred the rising of HTML5 it is also necessary to pay attention to other socio-economic issues that facilitated the development of this technology. As it has been stressed, during the Web 2.0 period a growing presence of multimedia contents was favored by the increasing onboarding of users without coding skills thanks to the deployment of UGC websites [35,39]. Non-technical users were attracted to the Web thanks to these new services that allowed them to have a digital space for sharing photos with relatives and friends, uploading videos and staying connected with former friends among others. These websites were pushed forward by companies that looked to establish sustainable business models after the bubble burst that swept the 78% of the total value of NASDAQ index between March 2000 and October 2002 [27]. Prior to that event, investors usually funneled money into different Internet companies without a clear business plan but the Web 2.0 period will change that radically as the importance of having a business model and a value proposal will be critical for attracting investors and for business growth [28].

In particular, the combination of the Business Model Canvas (BMC) [57] and the Lean Startup Manifesto (LSM) [58] approaches will exert a significant influence in digital entrepreneurship ecosystems. These two ideas will favor an iterative logic instead of a lineal one for conceptualizing, developing and implementing businesses ideas [28]. In addition, the importance of user-driven innovation approaches [59–61] will grow as they will be considered critical in the different iterations needed for testing technical features but also because of the new business models based on user data. It is also worthy to say that innovational organizations like these have been common in the history of standards [62,63] and attention to them will be paid later on during the text. Many companies raised during this period such as Amazon, Google, Facebook and others previously consolidated such as Apple and Microsoft started their transformation into digital platforms for adopting the two-sided networks market logic. These companies benefitted from the powerful network effects that UGC websites will deliver with the continuous and increasing growth of Internet users in the Web 2.0 period [5,39,64].

Two-sided networks was not a new idea but due to technology [65], digital platforms in this period were able to congregate millions of users of one side (the users of the service) for offering an audience that can be valorized on the other side (advertisers that will pay for accessing that audience). Many of the business models that were put into place during

this period were reliant on advertisement following the success of companies like Google. These practices were oriented to transform into economic value the increasing number of users that were attracted to the Web throughout social media and Web 2.0 services. Here, multimedia contents will be critical in lowering the entrance barriers for the adoption of Web technologies as well as mobile devices will also contribute to this extent. Later on, many of the popular websites raised during this period will be also moving to mobile ecosystems throughout "apps" for increasing their database user whilst offering new functionalities and developing new commercial assets.

All of these events will facilitate the establishment of the so-called "platform economy" for referring to the increasing dominant position of companies that currently based their business models around digital platforms such as Google, Facebook, Amazon, Microsoft, Apple or Netflix [6–8]. These companies are the mostly recognized representatives of a new kind of economy that makes use of technological infrastructures, user data and metadata to develop innovative services associated to innovative technologies. These technologies heavily rely on great quantities of data such as Big Data, Artificial Intelligence (AI), Virtual Reality (VR), Internet of Things (IoT) and others for developing competitive assets for the financial economy.

However, this trajectory needed from a technical ground to be carried out and this is where the paper stands as a retrospective of how all of these factors favored the development of HTML5 as a common ground pushed forward by the major representatives of the platform economy. In the next section, the methodology employed in this study will be developed.

3. Methodology

This study has relied on a qualitative approach combining a literature review with semi-structured interviews conducted with different kinds of experts of HTML5. These two methods have been developed throughout the theoretical lenses that the Social Construction of Technology (SCOT) model provides. This theory developed by scholars such as Wiebe Bijker, Trevor Pinch and Thomas P. Hughes belongs to the larger tradition of Science and Technology Studies (STS) and argues that *"technological artifacts are culturally constructed and interpreted"* [66]. Proponents of this theory also argue that technology is shaped by human actions and by the social context where it has been designed and conceived. In this sense, *"there is not just one possible way or one best way of designing an artifact"* [66]. SCOT proponents argue that in order to understand how a particular technology has been rejected or accepted, the context and the social map of relations where it has been conceptualized should be scrutinized.

SCOT model is not only a theory but also a methodology as it comprises several procedures that must be followed for understanding which factors are critical for technological development. Core concepts in SCOT model such as "interpretative flexibility" (different meanings and interpretations of the technology for its different users), "relevant social groups" (groups of people interested in its development) and "closure and stabilization" (an stage where the controversy by different users ends and the artifact adapts its final format) are relevantly used by researchers for understanding diverse factors that helps or deters a particular evolution of a technology [67]. Other similar approaches such as Actor Network Theory (ANT) [68] and others [69,70] also share this social importance of users and actors around processes of technological development and innovation.

Throughout this theoretical lenses that SCOT model provides, data collection in the first method has been focused on compiling and synthetizing significant documents such as reports, peer reviewed articles, webpages, specifications, norms and standards related with the three blocks of the literature review (HTML, Web 2.0 and HTML5). This material provided an in-depth look to the evolution of hypertext standards whilst paying attention to their main characteristics. The goal of this documentation analysis was to characterize the evolution of HTML from a hypertext-based standard to the acquisition of different multimedia features in its fifth version throughout several APIs as well as paying attention to the different stakeholders involved in its development taking into account the SCOT model. This last objective was critical for identifying which organizations should be addressed throughout the second method employed: the interviews.

From July 2014 till the beginning of 2015, 21 semi-structured interviews were carried out to different experts in HTML5, on a voluntary basis, and selected between different previously identified stakeholders of the Web value chain using the literature review but after that, employing a snowball strategy. The main objective was to recruit the main stakeholders interested in the development of technology such as browser vendors (Opera Software, The Mozilla Foundation), search engines (Google, Yandex), standardization authorities (W3C Spain Office), Internet start up's around HTML5 technology (Ludei, Wimi5, Otogami), industry associations (HTML5 Spain), social media platforms (Tuenti, Karmacracy), smartphone manufacturers (Blackberry), web designers (La Personalité), research institutes and universities (Deusto University, TECNALIA), as well as other individual experts. The goal of this method was also enclosed in SCOT model, paying attention to the different motivations, attitudes and values that these stakeholders had in the future development of HTML5. This heterogeneous and diverse mixture of stakeholders assured to provide a comprehensive vision of different interests around this technology.

The interviews were delivered following a flexible script with specific questions around the attitudes, values and motivations for being engaged in the design, development, use or adoption of the technology. This script was built up for developing the questions around certain domains of interest from a SCOT model perspective [66,67,70], trying to understand which factors were shaping the development of the new technology [68] and what the importance of the user is in the innovation process developed [40,59,60]. Interview contents has been analyzed for determining motivations, drivers and barriers of different stakeholders for being engaged in the diffusion of this technology. Interviews were carried out physically when possible and when not via online throughout a digital platform. Interviews length has ranged from 40 min to 1 h and a half based on the willingness of the interviewees for sharing information and the quality of the conversations regarding the themes proposed. Interviews were recorded and selectively transcribed for summing up the main points of them. All participants have received an Informed Consent Form (ICF) that explains the objectives of the research and data collection and data treatment processes.

Thematic analysis was carried out for analyzing interviews content following several guidelines [71] and the main findings were resumed into templates that gather the main themes observed during the fieldwork. This process was carried out according to existing literature about it [72]. Attention was paid to identify recurring themes associated with ideas and actions that appeared recurrently in the transcriptions in the form of opinions, reflections, conceptualizations and experiences that convey the way that participants understand and are engaged into HTML5 technologies.

4. "Living standard": A new way of making standards?

The development of HTML5 has challenged the already established structures of W3C for promoting web standards development. This new approach defied W3C working groups classical configurations for incorporating needs and demands of browser vendors and other stakeholders in a more agile and pragmatic way. Historically, standardization processes supported by the W3C have been based on two dynamics: the primary one that relies on internal working groups and a secondary one that is pushed forward by external contributions (like HTML5).

Despite W3C working groups are responsible for the majority of web standards produced by the institution, the dynamic triggered by the members of the WAHTWG was not the first time it has happened: *"W3C was betting on XHTML that implied a stricter labeling for making modules*

and creating a puzzle that could be adapted according to what was needed. This external group of experts, that were also W3C members, were working on detecting user needs and creating an informal specification based on them. The W3C realized that the external work that had been carried out was valid and identified the needs of society. A more flexible and lighter programming, less corseted, etc. W3C saw that it had to assume this working group within the W3C groups and invited to evolve the HTML5. This dynamic is not new, because it had already been done, but it is a sign that there are many ways of making standards and that the figure of W3C must be that of responding to the demands and needs of society".

In conducting this external process, WHATWG members seemed to be concerned about establishing open innovation and user-driven innovation mechanisms [59,60] for soliciting users demands and embedding them into the development of HTML5. This new approach proposed by the WAHTWG stressed the growing importance of embedding users into standardization processes as well as the fragmentation and the growing increase of different stakeholders in standardization processes. Historically, rigid approaches and one-sided commercial interests led to major innovations of dominant web browsers such as Internet Explorer or Netscape Navigator for gaining market share. These practices in previous periods were aimed to impose private interests and developed technical documentation only after these independent moves. The working agenda of the WHATWG was oriented to avoid these individualistic approaches for providing a common ground to the already existing web browsers, creating "space for experimentation" without waiting to an official standard's version and with an approach focused on practical features of HTML [35,37]. WHATWG was also focused on incorporating features that can be previously tested beforehand whilst avoiding academic approaches to standardization processes previously used and trying to capture user demands as stated by one of its initial founders: *"We look at what the Web is all the time. In the early days of HTML, it was largely scientist and computer scientist oriented, but when video become popular, we invented the "video" element. We need to see how the Web is evolving and to evolve the markup language to accommodate that".*

In this sense, a new approach to develop HTML5 was conceptualized by the WHATWG in the form of a "Living Standard". This motto means adopting a more experimental approach to standardization that can be benefited from different contributions from W3C working groups, external players and other stakeholders. This "Living Standard" seems to be influenced by business ideas previously exposed in the text and dominant after the dot com bubble burst such as BMC and LSM [28,57,58] and it constitutes the main response from WHATWG for developing, improving and updating HTML to user needs whilst encapsulating the idea of "Web as platform" [26]. A paradigm that reflects the centrality of this techno-social environment as the common ground for different platforms, technologies, services and business models where the data economy [2] has hindered its roots. The importance of consolidating this idea throughout HTML5 was a common statement among the interviewed experts: *"I believe HTML5 "Living Standard" is very much the future of the Web. It represents the best kind of middle ground in terms of having a standard that is used by all, it's universally accessible and it is not on the hands of one company. The success of the Web as a platform. We have proved that is a native platform and companies can build business models on it and apps and things like that".*

The "Living Standard" can be also seen as a new philosophy of developing hypertext standards that has triumphed over the traditional working groups hosted by the W3C [34]. HTML5 is a living standard per se, in which new emerging features are tested in different browsers (Firefox, Opera, Chrome, IE, Safari) and only when these innovations have attracted or demonstrated a significant user's interest as well as their robustness in different browsers are incorporated to the specification. After these processes, the W3C releases an official document to confirm and to document the work deployed before. It is also important to remark that HTML5 standard has included several specifications of different technologies associated to HTML. The development of these technologies has also their own member groups, dynamics and processes of standardization outside the WHATWG.

Of course, the W3C remains to be the key institution in all these processes and dynamics, but the fragmentation provoked by mobile devices, digital platforms, technologies and standards that have been appearing during the last decade has generated a growing complexity (See Fig. 2 and Fig. 3). In addition, the increasing bureaucratization associated to the growing presence of numerous digital players surged during the Web 2.0 period in these committees (digital platforms, Internet startups, smartphone manufacturers, etc.) contributed to a lack of agility. The response posed by industry representatives to this complexity relied on favor more agile approaches to deal with standards instead of still relaying on more academic-oriented approaches like in the early days of the Web. Complexity and fragmentation were commonly observed in several testimonies from research participants and tightly associated to the rising of mobile devices. This variety of possibilities to access the Web was one of the drivers to promote the development of HTML5 in the own words of an interviewee: *"Ten years ago the desktop was the only reference, but the mobile phone of today is like a PC. A netbook, a table, a smartphone … there have a lot of capabilities. In that sense, the influence is not the mobile but the diversity of devices. Modern web development paradigm is based on applications systems. Google, Apple and Microsoft are the ones that are creating the new walled gardens".*

Other participants in the research also stressed that this academic approach focused on XHTML was also an "automated approach" oriented to machines but not to human users because XHTML is a heavy-text and non-friendly standard for web developers. Here, the relevance of human agency in web development seemed to play a role as coding profiles seems to prefer other human-friendly standards. In relation to this, some participants in the research that were also members of the WHATWG explained why they were primarily worried about the direction taken by the W3C as they firmly believe that XHTML was not a feasible solution for maintaining backwards compatibility whilst incorporating significant capabilities in the standard. These testimonies justify their disagreement and explain why they initiated their move against the W3C: *"XHTML wasn't abandoned; it was just never taken up. We didn't really pay it much attention when developing HTML. The W3C made this crazy claim in the late* 90s that *HTML was dead, but that was just silly, and the browser vendors and Web authors mostly ignored it".*

5. Laying the ground for the platform economy

As it has been exposed, the rising of HTML5 has been of utmost importance for the deployment of an emerging data economy. This new

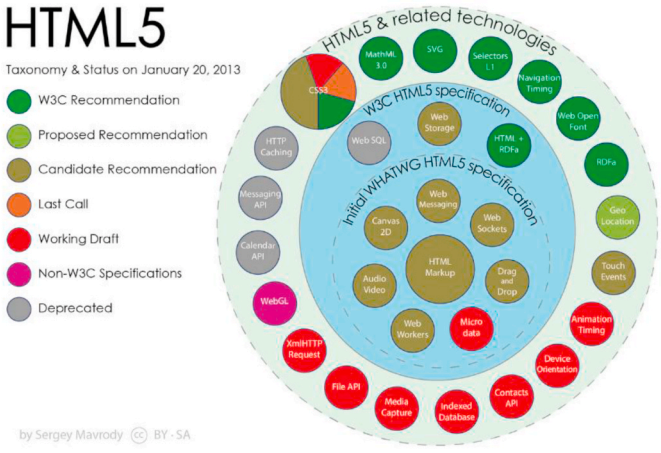

Fig. 2. List of related HTML5 related technologies. Source: Wikimedia.

[6] https://developer.mozilla.org/en-US/docs/Web/Guide/HTML/HTML5.

Fig. 3. Current HTML5 technologies and resources. Own elaboration based on Mozilla HTML5 developer guide[6].

version of the standard has assured interoperability, modularity and backwards compatibility but it has also provided a technological basis that has enhanced the iteration and development of sustainable business models that digital platforms established after the Web 2.0 period [2,4–6,8,30,37,38]. Social media companies such as Facebook or Twitter, search engines (i.e. Google), mobile device manufacturers (i.e. Apple) and others were greatly benefited from the development of a common new ground in the form of a strong new HTML standard. This was critical for facing the complexity and fragmentation introduced by mobile devices in the form of different image resolutions, lower computing processing power, different resolutions and other constraints that pushed a major transformation of hypertext [3,34,35].

To this extent, the decentralization that followed the Web 2.0 period where the PC was not the sole point of entry to the Web anymore [3,26] has also provoked later on a centralization in terms of computing power, computing infrastructures, information brokering and cultural intermediacy in the Web. Now, digital platforms such as Google have positioned themselves as providers of several digital services (in example: searches, docs, maps, mail, videos, AI, etc.) exerting a considerable dominant position on the Internet industry. The "platformization" of different popular websites making their datasets ready and exchangeable throughout APIs [37,38], the development of critical infrastructures such as server farms and data centers and the colossal expansion of two-sided networks [65] have conferred to different digital platforms such as Amazon, Apple, Facebook, Google, Netflix, Microsoft or Twitter with a variety of resources and tools for gathering, processing and using data for different commercial purposes [5–8,37,38]. In this sense, the development of HTML5 has also contributed to this congregation of resources providing native capabilities to the standard but also with the ability for gathering structured data and metadata that can be used by algorithms developed by different players of the emerging data economy in their recurrent user-profiling techniques [2,33].

The establishment of this "platform economy" paradigm by several digital platforms conceptualized during the '00 decade was also shaped in great manner by the development of business models associated to the great onboarding of non-technical users during this decade. Users with no coding skills were attracted by new websites (e-mail, blogs, wikis, social media, etc.) in one of the extremes of these two-sided networks, whilst in the other, more and more advertisers, suppliers, providers and others were attracted to this emerging data economy facilitated by digital platforms [64]. To this extent, it seems contradictory how the initial move towards decentralization facilitated by emerging websites during the Web 2.0 period has ended in a latter socio-technical reconfiguration of the digital sphere and where centralization can be recognized not only from a technical point of view but also from a socio-economic and geo-cultural perspectives. Representatives of the platform economy have been able to offer to their users with value-added Internet tools that are oriented to leisure and work [40,41] whilst its popularization has allowed these companies to acquire a growing dominant position regarding personal and professional information that is exploited in many ways.[7]

Increasing congregation of resources, tools, networks and data is also another argument that facilitated the success of the WHATWG in abandon W3C working groups and delivering a new version of the standard able to meet the pressing needs that fragmentation and complexity posed into the Web 2.0 period. The introduction of lean and agile methodologies in Web standardization but also adopting a user-driven innovation approach was considered critical by many of the interviewees and this perfectly illustrates how these digital players are well equipped with human talent and enough resources for developing technologies that can back up digital business models [6,61,62]. This "Living Standard" is not only an interesting case for the organizational innovations introduced and its orientation to practical needs but also because it is one of the incipient signs of the great power of digital platforms [7]. In this sense, organizational innovations in standardization process are historically common in the development of digital standards and reflect the kind of conflicts that arise between central authorities, user initiatives and commercial interests [62,63]. The WHATWG can be framed as a bottom-up initiative that has been legitimated by HTML users and their relation to hypertext, and where specific meanings, motivations, values and ideas about what HTML is and how it must evolve has prompted the development of the new version and the disagreement with the W3C. These views around technology development and the incipient artifact are also of importance from the SCOT model perspective as a social construction phenomenon and negotiated meanings of technology that have also been historically common regarding other technologies [40,41,66,68,70]. But in this particular case, the introduction of these organizational innovations into standards development stresses how human agency is still really determinant in the Web. The turn to a more automatized hypertext planned by the W3C with XHTML confronted a significant resistance from the web development community. The Web is a techno-social platform where different machines and systems are entangled with users that

[7] For instance, and according to Gartner, Amazon, Microsoft, IBM and Google have a market share in cloud computing services that is above the 60%. See https://www.gartner.com/en/newsroom/press-releases/2019-07-29-gartner-says-worldwide-iaas-public-cloud-services-market-grew-31point3-percent-in-2018.

want to play an active role and where a great component of user agency is still needed in web design, coding and management.

Nevertheless, it is clear that automation is gaining space in the Web as different digital technologies promoted by platform economy proponents such as Big Data, IoT and AI are becoming pervasive in many different protocols, systems, apps and devices with the sole objective of collecting and gathering user data. The "Living standard" also tell us that human factors and the role of the user into the innovation process is still of utmost importance in different cornerstone structures of the Internet such as standards [59,60]. The history of web development is also intimately entangled with the sometimes chaotic and unstructured coding that many non-technical savvy users write in their webpages, but of course this is also the essence of the Web. Breaking backwards compatibility was not ever an option as it also implied a denial of the nature of the Web and the values embedded on this techno-social platform that are sometimes captured in the axiom "rough consensus and running code" [62].

6. Conclusions

As it has been exposed in the text, the rising of HTML5 implies a major reconfiguration of HTML from a hypertext standard to a dynamic one where the role of multimedia content is critical. The promotion of the "Web as platform" [26] paradigm has allowed to technically endow hypertext with different features and capabilities that were not initially conceived in a standard oriented to structure text-based information. The success of HTML5 as a "living standard" also acknowledges the importance of practical and agile philosophies oriented to users for developing web standards, but at the same time it also reflects the increasing power of platform economy representatives thanks to the development of the data economy [2,6–8]. Classical working groups organized by the W3C since the early days of the Web seem to be "victims" of the growing complexity and fragmentation of technologies, platforms, devices and stakeholders around the Internet, but also of the financial interests of platform economy representatives for developing a standard able to map and capture the maximum number of human actions in the digital sphere.

The HTML5 case illustrates the transformations that are been produced by the expansion of the data economy and how new structures and processes are demanded by its main representatives for meeting their own needs regarding innovation. In this sense, since the beginning of the Web this techno-social platform has been extended to a number of different devices such as phones or music players and nowadays this expansion is colliding into watches, TVs, homes and cars. It is not insane to think about future extensions where the Web will be interacting with other devices, platforms and systems yet to be invented. For sure, it is reasonable to argue that this kind of conflicts regarding standardization practices will last and the role of organizations such as the W3C and others that can represent stakeholders that are left out of innovation processes but they are affected by them will be important for maintaining users rights and public values as well as preventing monopolistic approaches in many directions. In the next years, this will be probably one of the big debates around digitalization and society.

Last, it is necessary to stress the limitations of this study as it has adopted a qualitative approach and encouraging at the same time other researchers for conducting quantitative studies that can contribute to generate knowledge in the topic.

Credit author statement

R. Tabarés: Conception and design of study, Acquisition of data, Formal analysis, Drafting the manuscript, Revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published (the names of all authors must be listed)

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