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Pius Onobhayedo
University of Southern California, ponobhayedo@pau.edu.ng

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Towards a Unified Framework for Media Capacity Characterization: Inferences from Critical Analysis of Media Capacity Theories, Buzzwords and Web History

Pius Onobhayedo
School of Media and Communication
School of Science and Technology
Pan-Atlantic University
Nigeria
Marshall School of Business (Visiting Scholar)
University of Southern California
USA
ponobhayedo@pau.edu.ng

Abstract:

As the Web enters its third decade of existence, I draw attention to the need to better understand the Web as a potential reference case for how an information system transforms through incremental innovations, with particular focus on the Web's advancement as a communication media platform. As a necessary research step in this quest, I critically examine whether one can use existing media capacity theories and media-related buzzwords (such as rich media, multimedia, hypermedia, social media) to characterize Web innovations as media. I examine and clarify these buzzwords' origins, meanings, and relationship with media capacity theories. I also elucidate discrepancies between them. Via inductive reasoning, I synthesize three media capacity dimensions (sensibility support, interactivity support and logistical support) as potential framework for objective media characterization. Each dimension could metamorphize into individual theories or one theory (e.g., sensibility interactivity and logistical support theory (SILST)). I present these dimensions' indicators and demonstrate three-dimensional typology of Web innovation milestones anchored on the three dimensions—a step forward in substantiating the framework's applicability to media capacity characterization.

Keywords: Web History, Web Innovations, Media, Media capacity theory, Interactivity Support, Sensibility Support, Logistical Support, Sensibility Interactivity and Logistical Support Theory (SILST).

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1 Introduction

When the World Wide Web turned 30 in 2019, attention once more turned to the digital revolution that the Web represents. Among the significant buzz on that occasion, the Web's inventor, Sir Tim Berners-Lee, made a call to fight for the Web as a safe, welcoming, and empowering platform for everyone. Along with advocating for people to reflect on how far we have yet to go with the Web, Berners-Lee also invited people to take a moment to celebrate how far we have come (Berners-Lee, 2019). Accordingly, in this paper, I draw closer attention to the innovations that have shaped the Web into a mainstream media platform. The Web's robustness today as compared to when it began makes a case for a potential opportunity to elucidate how a system transforms through incremental innovation.

Many authors have written about the Web's evolution. Among others, Berners-Lee has recounted the innovations that have shaped the Web from its earliest days (Berners-Lee & Fischetti, 1999). Some authoritative sources such as the World Wide Web Consortium and the Web Foundation have also published historical narratives online (e.g., https://webfoundation.org/about/vision/history-of-the-web/ and https://www.w3.org/History.html, respectively). Authors have also written about the Web's evolution from a perspective that considers its progressive impact on society and, in particular, how it has transformed culture, commerce, and politics (e.g., Ryan, 2010). However, we lack historical work that has treated Web-based innovations' evolutionary path from a communication media perspective using appropriate media theories. In my opinion, we need such work to understand the values inherent in such innovations from a media perspective and a possible path to more accurately predicting future advancements.

Among the impact that Web-based innovations have had on society, how it has transformed the way we communicate and access information seems to stand out. At different stages of the Web's advancement, people have often recognized and adopted inherent innovations as communication media. At such stages, buzzwords have often emerged among innovators, media practitioners, and/or consumers. Notable examples include the terms hypermedia, multimedia, rich media, and social media. Even though many individuals have referred to these terms as buzzwords, they have typically captured Web-based media innovations' salient features in a parsimonious manner. In a way, the terms implicitly characterize media akin to media capacity theories (MCTs) that one can find in academic literature. The implied media characterization positions them as potential reference concepts in the quest to elucidate how Web-based media innovations have evolved. However, using these terms without sufficient academic scrutiny can create vagueness as to what they really mean and how their meanings relate to or differ from media capacity theories already established in the academic literature.

Researchers have used MCT constructs such as media richness and social presence, which have apparent similarity with buzzwords such as rich media and social media, to study Web-based media. However, it remains unclear whether researchers have used these academic terms in the same sense as practitioners have used the buzzwords that they resemble. It also remains unclear whether Web-based media studies anchored on MCT constructs such as media richness and social presence suffer the same criticisms associated with the MCTs themselves due to the latter's perceived weaknesses that led researchers to create successive theories such as channel expansion theory, media expansion theory, media synchronicity theory, media naturalness theory, and media compensation theory. Besides, the many terms that refer to objective media capacity poses a challenge for researchers to identify a concrete theoretical basis for tracing Web-based media's evolutionary path.

In addition to the aforementioned buzzwords and MCTs, some other terms have emerged in reference to the Web that could provide some hints about the nature of Web-based media but that researchers have insufficiently studied in such a media context. For example, Peters (2009) applied the term logistical media to Web-based media as search engine indexes exemplify. However, the concept has not received further significant development. Although the buzzword cloud has not been conventionally used as media qualifier, the services on the Web that gave rise to it constitute yet another phenomenon worth examining in relation to Web-based media capacity studies.

Therefore, in this paper, I examine the congruence and lack thereof between these buzzwords and theories and their aptness and weaknesses as frameworks in order to synthesize more concrete and harmonized basis for objectively characterizing Web-based media. Specifically, I:

1) Critically examine whether one can use existing media capacity theories and media-related buzzwords (such as rich media, multimedia, hypermedia, social media) to characterize Web-based media.

2) Synthesize a theoretical framework to objectively characterize Web-based media.
3) Explore whether one can use the synthesized framework to characterize various innovation milestones in Web history.

This paper proceeds as follows: in Section 2, I critically review existing media capacity theories. In Section 3, I critically review media-related buzzwords. In Section 4, I synthesize a theoretical framework for characterizing media capacity. In Section 5, I use the synthesized framework as a basis for objectively characterizing various innovation milestones in the Web's unique history. Finally, in Section 6, I conclude the paper.

2 A Critique of Media Capacity Theories in the Academic Literature

Academic research on media capacity theories arguably debuted with two main theories: social presence theory (SPT) and media richness theory (MRT). First developed by Short, Williams, and Christie (1976) and Daft and Lengel (1984, 1986), respectively, SPT and MRT have featured in management communication as frameworks for studying how managers make choices. Both theories support a rational manager choice model and embody the notion that characteristics inherent in the media objectively determine media appropriateness. While media richness focuses on a medium's capacity to convey rich information, social presence deals with its capacity to convey the feeling that other persons are present in the communication activity. Both theories consider the medium's richness and the social presence independent of the user and context.

The fact that both theories consider social presence and media richness as communication medium qualities seems to have made them particularly attractive for use as frameworks for Web-based media studies. A search through the literature shows that researchers have used the terms social presence theory and media richness theory in the Web context in at least 620 and 860 peer-reviewed journal papers, respectively. However, not everyone supports the claims about objective capacity that these two theories make, which we discuss in Section 2.1.

2.1 Media Richness and Social Presence Theories in Academic Literature

2.1.1 Media Richness

Although one can consider the way in which people commonly use the buzzword rich media as implying that richness constitutes a quality of media, several researchers dismissed claims to objective richness as MRT posits due to insufficient support for the theory's assumptions (particularly its assumptions about information richness). By information richness, the theory's proponents meant information's ability to change understanding in a given time interval. In other words, they considered communication transactions that can overcome different frames of reference or clarify ambiguous issues in a timely manner rich. Even though some researchers found various degrees of support for MRT (e.g., Burke, Aytes, Chidambaram, & Johnson, 1999; Daft, Lengel, & Trevino, 1987; Lee & Heath, 1999; Lee, Cheung, & Chen, 2007; Timmerman & Madhavapeddi, 2008; Trevino, Lengel, Bodensteiner, Gerloff, & Muir, 1990; Trevino, Lengel, & Daft, 1987), others failed to find support (e.g., Dennis & Kinney, 1998; El-Shinnawy & Markus, 1997, 1998).

The conflicts in results from researches based on MRT led researchers to propose some modifications of the theory over time. For example, Carlson and Zmud (1994) proposed a reformulated model named channel expansion theory (CET) that presents usage experience as a factor that positively impacts media richness perception. In other words, with usage, communication participants will view a given channel (e.g., email) as possessing increasing media richness.

Later, Dennis and Valacich (1999) proposed media synchronicity theory (MST) as an alternative. Unlike CET, MST maintains the richness objectivity that MRT posits. However, for communication effectiveness, MST posits that one should match media capabilities to fundamental communication processes' needs (i.e., conveyance and convergence needs) and not to tasks as MRT proposes. MST also defines five media capabilities (immediacy of feedback, parallelism, symbol variety, reprocessability, and rehearsability) that subsume and extend the original four dimensions in MRT (namely, the support for instant feedback, cues, personal feelings and subtleties conveyance).

Later still, Kock (2004) proposed media naturalness theory (MNT), which simply specifies media similarity to face-to-face communication as capacity criterion, a perspective that Kock (2004) referred to as media naturalness. MNT posits that a given medium's naturalness (i.e., its similarity to face-to-face interaction) better predicts its efficiency as a communication medium. The theory holds that humans naturally have a biological composition for face-to-face communication; therefore, they will likely find other media forms that deviate from face-to-face interaction more arduous to use. However, Kock (2004) suggested that the similarity between the mental schema of two individuals in a communication interaction (i.e., schema alignment) and the degree to which they have developed their schema in regards to using a particular medium for communication counterbalances the congruence between naturalness and efficiency.

In using similarity to face-to-face interaction as benchmark for naturalness, MNT suggests that one could simply replace richness with naturalness as objective criterion for qualifying a given medium. However, drawing on the same natural evolution principle embodied in MNT, Hantula, Kock, D'Arcy, and DeRosa (2011) weakened naturalness as an objective criterion for qualifying a given medium by proposing media compensatory theory (MCT), which highlights adaptation to media. MCT holds that, when humans face media other than face-to-face interaction, they compensate or adapt their behavior to the new media.

Drawing from the above studies, we can see that richness as an objective media property seems to have lost its initial objective meaning. On the contrary, similarity to face-to-face interaction as MNT proposes seems to present a more objective approach to classifying human communication media capacity independent of whether a given medium constitutes the most efficient one or not for meeting a given communication need. Without focusing on MNT's richness criteria, this position does not undermine the notion that humans can adapt to new forms of media other than face-to-face interaction as MCT implies. This position shifts the focus from ability to facilitate understanding to proximity to the face-to-face experience. However, we still need to examine how to determine proximity to face-to-face interaction.

2.1.2 Social Presence

According to how Short et al. (1976) originally posited it, social presence theory (SPT) holds that communications media vary in their degree of social presence (i.e., the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships" (p. 65)) and that these variations play an important role in determining how individuals interact (Short et al., 1976).

SPT has not received criticism in a way that could have led to alternative theory proposals possibly because researchers have not focused so much on testing the assumption that social presence constitutes a medium's quality. However, Oztok, Zingaro, Makos, Brett, and Hewitt (2015) suggested that a new factor that they call social capital moderates social presence. They suggested that social presence relates more to communication between weak ties rather than to communication between strongly tied participants, which does not necessarily change what social presence means as SPT postulates.

Many researchers seem to take for granted that media have differing capacities to support social presence. Furthermore, they have problematically correlated social presence with richness as per MRT. Even though MRT subsumed SPT's assumptions, researchers have often treated SPT separately from MRT. Besides management communication, researchers have applied the theory to various forms of communication research, such as e-learning (Joksimovic, Gaševic, Kovanovic, Riecke, & Hatala, 2015; Kraten, 2015; Wei, Chen, & Kinshuk, 2012; Zhao, Sullivan, & Mellenius, 2014), customer communication (Ji & Hollenbeck, 2015), travel information (Chung, Han, & Koo, 2015), games (McCreery, Vallett, & Clark, 2015), and social e-commerce (Lu, Fan, & Zhou, 2016).

Given that we now widely use the term social media due to the Web's evolution, we also need to further explore social presence's assumptions as a possible approach to tracing how the Web has evolved. I do so in Section 3.

3 A Critical Review of Media-related Buzzwords

Conceptual developments in academic circles notwithstanding, innovators and consumers have perhaps used words such as social, multi, rich, and interactive the most frequently to qualify Web-based media, which one cannot ignore in tracing the Web's evolution as a haven of communications media innovations. In Sections 3.1 to 3.4, I trace each term's origins and compare and contrast their assumptions with the academic theories that I discuss in Section 2 in order to synthesize unified criteria for characterizing Web innovations as media. In addition to these buzzwords that explicitly qualify media, I also briefly analyze the media capacity implications of Web innovations that gave rise to the cloud buzzword in Section 3.5.

3.1 Social Media

Although it remains unclear who first used the term social media, in the public domain, one can trace an early appearance to the domain socialmedia.com, which Tina Sharkey, CEO of Babycenter.com and a former executive at iVillage and AOL, reportedly owned (Bercovici, 2010). Sharkey registered the domain in 1999—earlier than when the term social media entered the mainstream. However, people began to widely use the term only after innovations that power social interactions on the Web emerged. In this light, Kaplan and Haenlein (2010) defined social media in a way that relates it with the so-called Web 2.0. Specifically, they defined social media as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content" (p. 61). Other authors simply refer to social media as a set of tools and applications that enable individuals to interact on the Web (Briscoe, 2010).

Even before the term social media entered the mainstream, some authors (Biocca, Burgoon, Harms, & Stoner, 2001) had suggested that we needed a social presence theory in a technological environment where the Internet and virtual environments become increasing social. When one considers the extent to which the SPT applies to Web innovations, a question concerns at what stage of innovations the Web became social. The Web innovations (such as social network services) that gave rise to the mainstream use of social media debuted in the 2000s decade. However, for the inventor of the World Wide Web, Tim Berners-Lee (2006), the Web has always been social from conception, a position that points to possible gradation of perceived social presence as the Web advanced towards so-called social media. In one sense, this line of thought provides a way to track advances in social presence support from the early Web to the so-called Web 2.0 era when social media became a buzzword. Therefore, I propose that we can arrange the degree to which one perceives communication participants as persons (social presence) in a continuum ranging from an implicit social presence to an explicit social presence (see Figure 1).

Implicit social presence does not expose participants' identity; however, their inputs or actions constitute social cues that others can leverage (e.g., selecting from among top search results on a search engine that leverages others' activities as cues for information relevance). Implicit social presence changes to explicit social presence as it begins to expose participants' identity. In other words, one can more readily answer the question "who's input is this?" as one moves towards the explicit end of the social presence continuum. However, the implicit end must support acknowledgements such as "this is someone's input"; otherwise, one can note social presence to be totally lacking. Explicit social presence could strongly favor relationship building, while both implicit and explicit seem to favor efforts to harness collective intelligence. In this light, one can support Tim Berners-Lee's (2006) argument that the Web has always been social from conception.

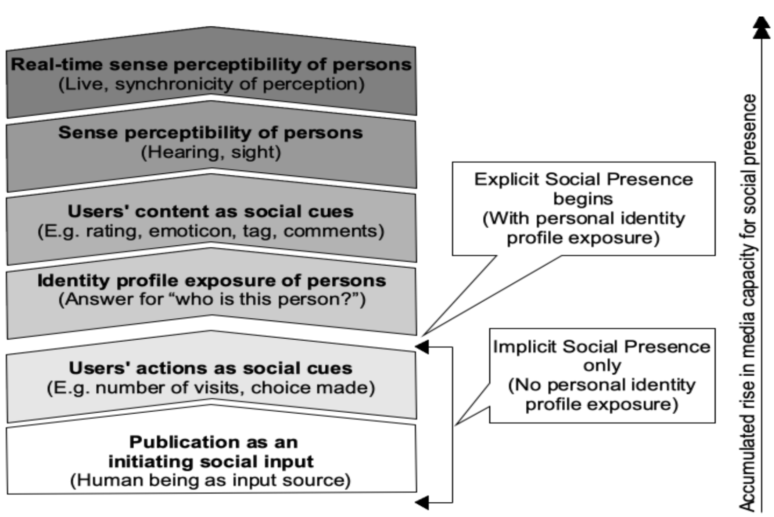

Figure 1. A Schematic View of the Proposed Continuum in Web-based Media Social Presence Capacity

In relation to MCT, this social presence continuum seems to present a pattern that corresponds to proximity in face-to-face interaction as MNT proposes. As one moves up the continuum, the activities become more akin to what can obtain in face-to-face interaction with live synchronicity (as obtainable with live video chats) at the very top. However, SPT does not account for social media's network dimension, which views social relationships in terms of nodes and ties that help delineate how information flows in social networks. One could not conceivably trace the Web's evolution as a communication media platform without referring to advances in such social networks on the Web.

Furthermore, since social network analyses examine human social interactions, they usually study relationship patterns that connect social actors (i.e., the nodes) in a network and their activities (Marcus, Moy, & Coffman, 2007). These analyses draw attention to social networks' logistical media dimension in as much as the networks represent detailed organizations and implementing complex operations involves tracking people and their relationships. This approach could pave the way for studies that examine how Web innovations have advanced based on their effectiveness and efficiency, which researchers have used as concrete measures to examine logistical performance (Fugate, Mentzer, & Stank, 2010).

3.2 Multimedia

Tay Vaughan (1993) seems to have pioneered the use of the term multimedia in reference to media in his book *Multimedia: Making it Work*. In the book's eight edition, he defined multimedia as "a woven combination of digitally manipulated text, photographs, graphic art, sound, animation, and video elements" (Vaughan, 2010, p. 1).

The multimedia principle (Mayer, 2001), which posits message display forms (i.e., multimedia) in combination could facilitate understanding, seems to be in line with the idea embodied in MRT as Daft and Lengel (1984, 1986) proposed it. However, multimedia principle's underlying assumptions do not seem to have any direct equivalent among the richness determinants that MRT posits. While the availability of multiplicity of cues may represent the closest, the multimedia principle specifically focuses on combined message forms as reflected in Mayer's statement that people learn better from words and pictures than from words alone. Thus, the basis for effectiveness that the multimedia principle posits seems to better align with media naturalness, which uses face-to-face interaction as benchmark. The principle posits that different message forms simultaneously fed through different channels (i.e., auditory/verbal and pictorial/visual)—which one can typically obtain in face-to-face communication—facilitate understanding and retention. Once more, media naturalness understood as proximity to face-to-face communication accommodates multimedia as a mark of proximity.

The interactive multimedia concept, which Vaughan (2010) used to refer to a situation in which the end user can "control what and when the elements are delivered" (p. 1), constitutes yet another possible point at which one can compare multimedia and media richness or naturalness. For example, the immediacy with which electronic games provide feedback in a command-response cycle would earn such games an interactive title. So would websites that respond to commands such as drag and drop, hide and reveal, add or edit content, and so on. Even though interactivity can readily occur in a face-to-face communication, interactive multimedia seems to also connote feedback between the medium itself and the person using such medium. Therefore, I would treat interactive multimedia as media that embeds or encodes such interactivity logic.

3.3 Rich Media

One can trace the term rich media's appearance in industry back to its use in online advertisement to qualify interactive advertisement banners (Bruemmer, 1999). Many continue to use it in advertisement circles to refer to content that contain videos (or simply images) that have some form of embedded user interaction—whether multimedia (i.e., combined message forms) or not. For example, Google (n.d.) defines rich media as "a digital advertising term for an ad that includes advanced features like video, audio, or other elements that encourage viewers to interact and engage with the content". Thus, rich media adverts offer ways to involve an audience with them and focus on eliciting a strong user response. Several other online advertisement service providers such as Microsoft, AOL, Mediaplex, MediaMind, and Adform have also used the term rich media in the same manner on their respective websites. Rich media understood in this way shares the interactivity concept with interactive multimedia even though, for rich media, interactivity seems to be specifically geared towards enhancing the user experience.

3.4 Hypermedia

Vaughan (2010) further extended the possibilities of the multimedia landscape by including navigability as a feature that can characterize multimedia implementations. He suggested that, “when you provide a structure of linked elements through which the user can navigate, interactive multimedia becomes hypermedia” (p. 1). Thus, one can use the term hypermedia to refer the Web as a navigable multimedia platform.

Hypermedia has its foundations in the term hypertext, which researchers have acknowledged Theodor Holm Nelson to have coined (Saz, & Marco, 1996; Horn, 1989). Even though Vannevar Bush first proposed the idea in 1935, Theodor Holm Nelson expanded the idea in 1965 prior to the World Wide Web’s creation and defined hypertext as computer-supported non-sequential writing (Horn, 1989, p. 258). He crystallized his vision around a plan (called Xanadu) for a worldwide network intended to serve hundreds of millions of users simultaneously. Acknowledging Nelson’s notion of hypertext as a foundation of his invention, Tim Berners-Lee referred to the World Wide Web as a task that married together hypertext and the Internet (Berners-Lee & Fischetti, 1999, p. 7).

Although researchers have often used hypertext and hypermedia interchangeably, to be strictly accurate, hypermedia includes other forms of media such as images, video, animation and sound, multimedia system characteristics, and text (Dillon & Jobst, 2005; Horn, 1989, p. 18).

Navigability as a feature of hypermedia together with the underlying content organization that such media implies does not seem to have any equivalent among the criteria in the media capacity theories that I discuss in Section 2. How effectively users navigate (e.g., information retrieval), which could to a large extent depend on how organized the target content is, goes beyond MRT’s and other MCTs’ assumptions. According to McAleese (1999, pp. 5-6), users’ freedom to browse, navigate, and take part in a journey or voyage of discovery at will constitutes hypertext’s most distinguishing feature. Such users usually expect rapid access to the information that they require. Advancements in Web-based media also seem to have occurred in this direction as search engine indexes, which constitute a type of logistical media that points the information seeker in the right direction, exemplify.

3.5 Cloud

In the Internet context, innovators have used the term cloud to refer to software-based services that provide tools and infrastructure as on-demand services on the Web. In this section, I do not dwell on the cloud’s intricacies in its present various forms (e.g., software as a service, platform as a service, and infrastructure as a service). Rather, I draw attention to the ability to structure or organize Web content in such a way that one can create functionally differentiated services at a high level. Along with navigability and searchability, this capacity for functional differentiation seems to also indicate that Web-based media contains an organizational or logistical support dimension.

Besides offering the potential to publish documents in different formats, as a software system, the Web has been open to further functional differentiation through programming. As such, one would not find it surprising that the title Web applications emerged at some point to accommodate the application nature of the innovations that drive further advancements. Web applications extend a Web server’s functionality and provide a more interactive experience (Hunter & Crawford, 2001, p. 2). Such applications can be as simple as a keyword search on a document archive or as complex as an electronic storefront.

4 A Synthesis of Criteria for Characterizing Media Capacity

In Sections 2 and 3, I compare and contrast media capacity-related buzzwords, MCTs, and observable Web phenomena such as the cloud. Drawing on these critical analyses, I propose a way to characterize Web-based media in this section.

First, I recommend that one avoid media richness as MRT defines it, as a de facto standard for classifying Web-based media capacity. Researchers have found the richness criteria that MRT specifies to not apply in several contexts, which led to successive modifier theories (i.e., CET, MST, MNT, and MCT). However, such findings do not imply that one should not qualify media as rich but rather that, whenever one does so, one should also specify the criteria for richness.

Second, I propose three complementary dimensions of media capacity characterization: 1) sensibility support, 2) interactivity support, and 3) logistical support. Each dimension could metamorphize into individual theories (e.g., sensibility support theory (SST), interactivity support theory (IST) and logistical support theory (LST)) or one theory (e.g., sensibility interactivity and logistical support theory (SILST)). I present the rationale for each dimension below.

4.1 Sensibility Support

I derive this capacity dimension from the proximity to face-to-face interaction that MNT posits and the social presence continuum that I propose in Section 3.1. I believe that framing embodied media capacity as sensibility support provides a more parsimonious and direct way to relate media to the degree to which it supports various degrees of sense experience on the part of the communicating parties. Borrowing from the Aristotelian philosophy that ranks sight as the most important sense followed by hearing, smell, taste, and touch (Jütte & Lynn, 2005), I consider the degree to which media supports various ramifications of visuals a major factor in capacity determination. Even though Aristotle ranked the other senses lower than sight in importance, digitally encoding information that people can perceive via hearing, smell, taste, and touch usually involves more complexity than via sight. Therefore, I consider support for them as the next level of media capacity beginning with hearing. In summary, the indicators for this dimension include visual, audio, haptic, and multi-sensory support levels. I further define these indicators in Section 4.5.

4.2 Interactivity Support

I consider interactivity support a dimension different from sensibility support because interactivity essentially differs from sensual perception. Shifting focus away from sense perceptibility, the indicators for interactivity support include a user's ability to control the communication outcome, support for multi-directional communication, and synchronicity between communicating parties. As I state in Section 3.2 one can consider interactivity mainly from two dimensions: 1) interaction with the medium itself (e.g., interactive games, adverts) and 2) as a medium for interactivity between communicating parties (e.g., in conversations).

4.3 Logistical Support

Logistical support refers to media's organizational nature, which conceptually differs from sensibility and interactivity. Logistical refers to that aspect of Web-based media that helps one find the information one desires, communicating partners, tools, and so on. Its indicators include Web hypermedia's navigable nature, searchability support (which search engine indexes typically facilitate; user-created metadata that describe other information also plays a role here). The ability to provide functionally differentiated content constitutes yet another indicator in this dimension. To buttress logistical support's importance, John Durham Peters has suggested that the old-new media axis turns around logistics. In his own words:

> *Logistical or organizational media are so fundamental that they are rarely visible. Their job is to organize and orient, to arrange people and property in time and space. They are rarely content-driven, and Marshall McLuhan's slogan that the medium is the message seems particularly applicable to them. They are often abstract data processors. Calendars, clocks, and towers are classic logistical media. So are names, indexes, addresses, maps, tax rolls, logs, accounts, archives, and the census.* (Peters, 2009)

The fact that efficiency in organizational or logistical media arguably represents the biggest strength of one of the biggest Internet service providers, Google, largely supports Peters' position.

4.4 A Further Overview of the Concepts Embodied in the Synthesized Framework

In Figure 2 below, I summarize the concepts in the proposed framework for objectively characterizing Web-based media. While the base concept maintains the overarching focus on media capacity, I present the three complementary dimensions with the respective indicators, which, in principle, constitute measures for the dimensions.

In Figure 2, I deliberately use the title "some indicators" because I do not rule out the possibility of extending the list due to new innovations. For example, the fact that I include neither taste nor smell does not rule out the possibility that science could make it possible to include them at some point.

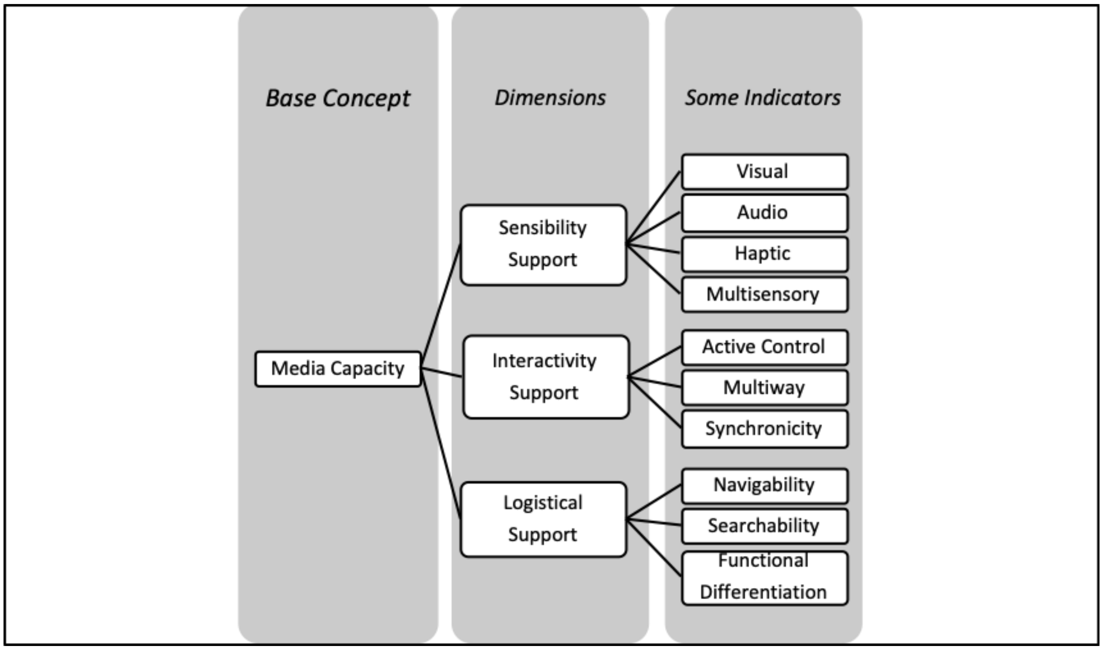

Figure 2. Summary of Framework Concepts

One should also keep in mind that one can treat each indicator in the list as a species that may have one or more subspecies akin to species and breeds in biological classifications. For example, one may further specify visual as visual text, visual image, visual motion graphic, immersive visual, and so on. Likewise, one may further specify multi-way interaction as one-to-one, one-to-many, or many-to-many communication structures. These subspecies provide a more fine-grained way to establish a hierarchy among the indicators in terms of proximity to face-to-face interaction or the complexity involved in their implementation on the Web. I follow this approach in Section 5 where I apply the proposed framework to characterize Web-based media innovations. Meanwhile, at this point, I also note what each indicator represents (for ease of reference, I present the basic definitions in Table 1).

Table 1. Definitions of Indicators for Media Capacity Dimensions

Media capacity dimension	Indicator	Definition
Sensibility support	Visual	Communication content perceptibility to the pictorial/visual channel.
	Audio	Communication content perceptibility to the auditory/verbal channel.
	Haptic	Communication content or medium endowed with touch sensitive feedback.
	Multi-sensory	Communication content that comprises content perceptible to more than one sense.
Interactivity support	Active control	A user’s ability to influence a communication process through relevant input usually in an ongoing manner as long as the communication process remains in force.
	Multi-way	Communication in two or more directions which may occur in the context of one-to-one, one-to-many, or many-to-many communication structures.
	Synchronicity	The speed at which multi-way communication occurs.
Logistical support	Navigability	The efficiency with which a user can locate desired information following a hyperlink structure.
	Searchability	The extent to which a user can successfully find information with efficiency and ease through index search.
	Functional Differentiation	Ability to provide functionally differentiated Web content (e.g., various forms of user profiling, software and infrastructure provisioning as services on the Web).

4.5 Sensibility Support Indicators

4.5.1 Visual

This indicator refers to content that supports a visual sense experience. Such content could range in implementation complexity from basic text to static graphic images to motion text or graphics to multimedia and immersive visual experiences.

4.5.2 Audio

This indicator refers to content that involves sound that people can hear. Although audio content often appears in multi-sensory multimedia alongside visual content, support for audio which can vary in sound quality and encoding efficiency is essentially distinct from visual.

4.5.3 Haptic

This indicator pertains to touch. Powered by suitable haptic technology, haptic communication content recreates touch by applying forces, vibrations, or motions to users (Castillo-García, Muñoz Hernandez, & García Gil, 2017). One can describe such content or medium as haptic-enabled content. Compared to visual and audio content, haptic content seems to involve the most complexity to implement.

4.5.4 Multi-sensory

This indicator falls under the sensibility category because it concerns multiple sense perceptions. One should not confuse this indicator with multimedia as the latter does not necessarily involve more than one sense. Multimedia content can be all visual (e.g., texts and images), whereas multi-sensory content must involve at least two senses. In other words, all multi-sensory content is multimedia, but not all multimedia content is multi-sensory. So, rather than treat multimedia as an indicator distinct from each sense, I use it at the subspecies level for each sensory indicator. For example, I consider combined visual text and visual images as visual multimedia and, hence, categorize it under the visual indicator rather than under the multi-sensory indicator.

4.6 Interactivity Support Indicators

4.6.1 Active Control

By active control, I mean a user's ability to influence a communication process through relevant input in an ongoing manner as long as the communication process remains in force. Liu (2003) defines active control as responsiveness to user input that enables a user to voluntarily participate in and instrumentally influence the communication process. Thus, success in control depends on the content's or medium's responsiveness. The implementation complexity of responsiveness varies with the nature of the medium. For example, an interactive game is more complex than simple user control of what webpage users see through clicks on hyperlinks even though both involve active control.

4.6.2 Multi-way

As the name implies, multi-way refers to support for communication in two or more directions. Such communication may occur in one-to-one, one-to-many or many-to-many communication structures. Each structure in a sense further specifies multi-way interaction's nature and lends itself to establishing an interaction-complexity hierarchy. A multi-way medium may also support these structures in combination.

4.6.3 Synchronicity

The degree to which communicating parties synchronize in a real-time communication process depends on the speed at which the multi-way communication occurs. Thus, speed constitutes a measure of synchronicity. As I indicate in Section 4.2, the communication process may include both person-to-person and person-to-medium communication (e.g., as in an interactive game).

4.7 Logistical Support Indicators

4.7.1 Navigability

This indicator refers to the degree to which a user can follow a hyperlink structure to successfully find information with efficiency and ease (Fang et al., 2012). As long as the medium supports navigability (as with the Web), factors that affect navigation's efficiency and effectiveness will likely relate to concrete design issues. For example, the title one chooses for a hyperlink anchor or how one groups hyperlinks could each play a role in how easily users locate the information they desire via navigation.

4.7.2 Searchability

This indicator refers to the extent to which a user can successfully find information with efficiency and ease through index search. Besides the nature of the index itself, the match algorithm that the search engine uses for search terms plays a major role in such searches' efficiency and effectiveness.

4.7.3 Functional Differentiation

Primarily driven by Web-based media innovations' software-based nature, functional differentiation refers to the ability to provide Web content as specialized content with a concrete functional nature. To illustrate, even though the Web basically began as an information space, innovation has taken it to a level whereby we can leverage the same technology for specialized functions such as profiling users' activity, identity, and relations (e.g., to produce social graphs) and providing software and even infrastructure. Similar to navigability and searchability, these functions' maturity largely depends on how efficiently and effectively they serve their respective purposes.

5 Use of Synthesized Framework to Characterize Web Innovation Milestones

In this Section, to further illustrate how one can use the synthesized framework to classify Web-based media, I present a three-dimensional (3D) typology of Web-based innovations that I anchor to the three synthesized Web-based media capacity dimensions (i.e., sensibility, interactivity, and logistical support) and their indicators. Such typology can help one better explain the underlying media capacity of innovations that fuel observable adoption phenomena, which sometimes lead to new buzzwords. I also present a historical basis for the typology.

To achieve this quasi-historical analysis goal, I needed to consult sources that dated back to the times when successive innovations emerged on the Web. Therefore, I consulted not only relevant academic journals but also publications from innovating individuals, organizations, and news media. I largely referenced relevant news and magazine articles in LexisNexis Academic database as researchers have ranked it high for relevance, precision, and recall (Oulanov & Pajarillo, 2003). I prioritized online articles that the Wayback Machine Web archive (http://www.archive.org) captured as the archive guaranteed I could permanently access them for future reference. Besides, Murphy, Hashim, and O'Connor (2007) have suggested that the archive is valid for studies related to website content, age, smf number of updates (Murphy, Hashim, & O'Connor, 2007).

I analyzed sources from 1989 (i.e., when the Web began) to 2005 (i.e., when the Web 2.0 buzzword became popularized).

5.1 Hierarchy of Indicators

As I conducted my analysis, I created an ordinal hierarchy of indicator subspecies in each media capacity dimension that could apply to Web innovation milestones, which I present in Table 2 below. Although no innovation milestones featured immersive and haptic technology, I include them in the table to illustrate possible extensions as more innovations emerge.

Table 2. Ordinal Hierarchy of Web Innovation Indicators

Media capacity dimension	Ordinal number	Indicator (subspecies)	Indicator (top level)
Sensibility support	1	Visual text	Visual
	2	Combined text and image (multimedia)	Visual
	3	Combined text, image, and motion graphics (multimedia)	Visual
	4	Multimedia with audio content	Multi-sensory
	5	Multimedia with interleaved audio and visual (audiovisual) content	Multi-sensory
	6	Multimedia with haptic content	Multi-sensory
	7	Immersive multi-sensory	Multi-sensory
Interactivity support	1	Clickable links	Active control
	2	User event-driven dynamism	Active control
	3	Chat	Multi-way
	4	Real-time (live) interaction	Synchronicity
Logistical support	1	Information hyperlinking	Navigability
	2	Information categorization	Navigability
	3	Information indexing	Searchability
	4	Profiling users' activity	Functional differentiation
	5	Profiling users' identity	Functional differentiation
	6	Providing software	Functional differentiation
	7	Providing infrastructure	Functional differentiation
	8	Profiling relations between users	Functional differentiation

5.2 3D Typology of Web Innovations

Using the ordinal hierarchy in Table 2, I created a 3D scatter plot to graphically illustrate the level at which various Web innovation milestones exhibited sensibility, interactivity, and logistical support, which the x, y, z coordinates indicate, respectively (see Figure 3). I determined names for the milestones based on their nature. Note that I did not allocate the ordinal numbers arbitrarily but based on the characteristics I perceived the milestones to have.

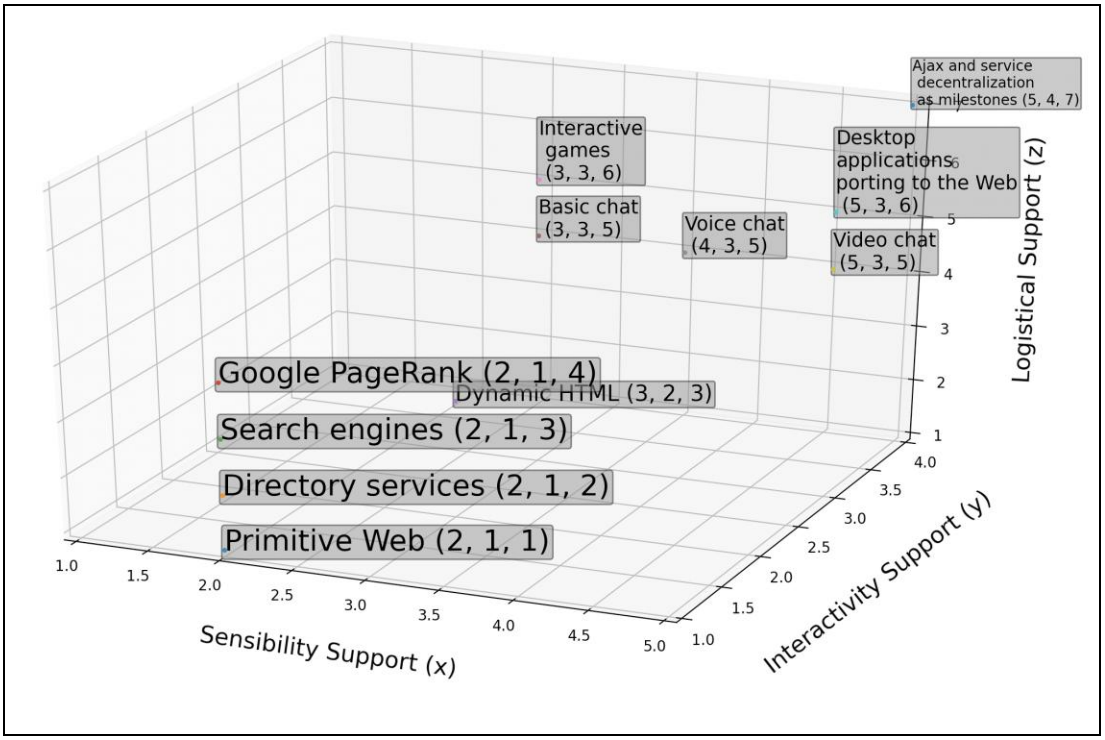

Figure 3. Scatter Plot of 3D Typology of Web Innovation Milestones

I also illustrate the scatter plot in tabular form in Table 3 below.

Table 3. Sensibility, Interactivity and Logistical Support that Each Milestone Exhibited

Innovation milestone	Sensibility support	Interactivity support	Logistical support
Primitive Web	2	1	1
Directory services	2	1	2
Search engines	2	1	3
Google PageRank	2	1	4
Dynamic HTML	3	2	3
Basic chat	3	3	5
Interactive games	3	3	6
Voice chat	4	3	5
Video chat	5	3	5
Desktop applications porting to the Web	5	3	6
Ajax and service decentralization as milestones	5	4	7

5.3 Historical Basis for the Milestones in the Typology

5.3.1 Primitive Web

At its invention, the Web included sensibility, interactivity, and logistical support albeit in a rudimentary way. The Web in 1989 when Sir Tim Berners-Lee invented it essentially comprised (from most to least important) three components: a uniform resource indicator (URI), hypertext transfer protocol (HTTP), and hypertext markup language (HTML) (Berners-Lee & Fischetti, 1999, p. 39). However, the Web supports the three media capacity dimensions primarily due to HTML, the language that documents on the Web use. Essentially, Berners-Lee created the Web as a system of published documents that a Web browser could visualize. HTML includes not only support for visual text in a document's body but also visual images. Thus, I allocated the primitive Web 2 on the sensibility support scale (as in Table 3) since it supported both text and images on the same page. I would have allocated it 3 on the scale if it supported the animated GIF image format. However, although HTML did not necessarily exclude GIF images, which CompuServe invented in 1987, GIF images became viable for online animation only when Netscape created the Netscape Navigator 2.0 browser in 1985 (Eppink, 2014).

The fact that the Web featured clickable hyperlinks on the one hand constitutes basic interactivity through which users could control what webpage they saw next. As such, I allocated the primitive Web 1 on the interactivity support scale. On the other hand, these clickable hyperlinks, which one can implement using the HTML <a> (anchor) tag, give the Web its fundamental hypermedia nature. Thus, I also allocated the primitive Web 1 on the logical support scale. The associated anchor title in a sense constitutes a basic hint that helps users find the information they desire via navigation.

5.4 Directory Services

Before successful search engines emerged, directory services helped users find information on the Web. Search engines actually emerged before directory services did. However, the earlier search engine inventions did not survive. In fact, initial frustrations led many to shift their focus to directory services; hence, I place directory services invention as a milestone before search engines.

Innovators initially faced a challenge in efficiently creating automated search indexes, which led them to create directory services similar to the one that Berners-Lee first created in 1991 (i.e., http://vlib.org/). Such directory services grouped content on the Web according to topics and provided navigation trees along topical lines. Notable among such startups included Galaxy (http://www.galaxy.com) in January, 1994, the Yahoo! Directory (http://dir.yahoo.com) in April, 1994, and the Open Directory Project (http://www.dmoz.org/) in 1998. Indeed, the fact that Yahoo! Celebrated receiving a million hits on a single day after operating for about six months, which translated to almost 100,000 unique visitors (Yahoo! Media Relations, n.d.), reflects the importance of the need to organize information on the Web. To further facilitate data retrieval, Yahoo! later became a searchable directory service.

With respect to categorization using the synthesized framework, I consider directory services invention a climb (single unit) in the logistical support dimension of the Web, as it facilitates navigation. The other dimensions remain unchanged.

5.5 Searchable Web

Even though the directory services that I discuss above helped users find the information they desired, it cost much time and money to manually compile their taxonomies. Eventually, search engine services, which automatically indexed Web content, replaced directory services. Apart from vlib.org, which one can consider more as symbolic for being the first, the other directory service examples that I mention above no longer operate.

Search engines became an indispensable tool for users to find information on the Web even from its early days (Levene, 2010). In fact, people perceived the need for a search engine in the Internet space even before the Web emerged. For instance, in 1990, Alan Emtage, a student at McGill University in Montral, created Archie, a tool for searching file transfer protocol (FTP) files (Sonnenreich & Macinta, 1998). With Archie's growth in popularity, the University of Nevada System Computing Services group developed another search engine named Veronica in 1993 that targeted documents that people published via the Gopher communications protocol.

Matthew Gray seems to have pioneered search engines for the World Wide Web in 1993 in creating the World Wide Web Wanderer, a robot that initially tracked the Web's growth by counting Web servers. Several inventions that both Gray and others developed subsequently appeared that focused on improving this initial invention (Levene, 2010; Sonnenreich & Macinta, 1998; Wall, n.d.). For example, Gray later developed Wandex, the first Web database that captured uniform resource locators (URLs). By December 1993, more robot-powered search engines such as JumpStation, the World Wide Web Worm, the Repository-Based Software Engineering (RBSE) spider, and Excite had surfaced on the Web. Unfortunately, these search algorithms did not adequately analyzes links or cache full page content. As the spiders did not know what they indexed, users could not efficiently use them to find the information they desired.

Search engines obviously needed further development. In this regard, advancements appeared that indexed full text unlike previous search engines that could not do so. The first such full text search engine, WebCrawler (http://www.webcrawler.com/), started in April, 1994. Lycos (http://www.lycos.com/) followed it shortly after in the same year. Next, AltaVista (http://www.altavista.com/) appeared in December, 1995, with the ability to handle millions of hits per day without slowing down. Besides its capacity improvements, AltaVista, a product of Digital Equipment Corporation (DEC), first used natural language queries and Boolean operators such as AND, OR, NOT, IN query strings. In 2003, Overture Services acquired AltaVista (Mack, 2003). Subsequently, in the same year, Yahoo! acquired Overture Services (Pruitt, 2003). From 8 July, 2013, the service redirected to search.yahoo.com (Rossiter, 2013). Inktomi, yet another search engine innovation at the time, started in September, 1995. Unlike the other services, it provided search engine infrastructure rather than a website dedicated to search service. Yahoo! struck a deal to acquire Inktomi in 2002 (Krazit, 2002), which completed in March, 2003 (Business Wire, 2003).

With these innovations, one could finally search the Web. At this point, I allocated it 3 on the logistical support scale. The emergence of Google's PageRank algorithm later in the decade took the Web to another level of search efficiency and effectiveness.

5.6 Google PageRank

The need to organize information about publications in a way that facilitates identification and retrieval eventually led to Web indexing and search engines in the early 1990s. However, before innovators began to leverage users' actions and/or direct inputs (i.e., information space navigators), knowledge about available information seems to have been quite limited. In this context, Google PageRank made a major difference.

While the search engines that I discuss in the sections above represented some advancement in the quest for tools to effectively search for information, they seem to have declined after Google appeared in 1998. Google became quickly known for returning extremely relevant results as *PC Magazine* reported in 1998, Google's foundational year ("Top 100 websites", 1998). By June, 2000, having established an agreement with Yahoo!, Google became the default search engine provider for Yahoo! services. Google's distinctive features become particularly relevant to analyzing search engine features that facilitate information identification and retrieval on the Web.

To quote Google's founders, Larry Page and Sergey Brin:

> *Google search engine has two important features that help it produce high precision results. First, it makes use of the link structure of the Web to calculate a quality ranking for each webpage. This ranking is called PageRank.... Second, Google utilizes link to improve search results.* (Brin & Page, n.d.).

According to Page and Brin, the PageRank algorithm, which leverages the citation graph on the Web, helped to fill a gap in other search engines. Mapping such citation graphs, they could rapidly calculate a webpage's "PageRank", which they defined as a way to objectively measure a webpage's importance that corresponded well with how people subjectively viewed importance. Therefore, they concluded that, due to this correspondence, PageRank constituted an excellent way to prioritize the results of Web keyword searches. I believe that, by leveraging citation (links), PageRank constitutes a significant milestone in harnessing collective intelligence in that it reflects an intellectual judgement about information's nature. A statement from a regional Google lead in an interview that I conducted throws more light on users' importance to the PageRank algorithm:

> *Our search technology incorporates an inherent social component via PageRank. In order to rate relevance, we examine the number of links to a particular website. Links are created for the most part, by people and so we are actually polling people's opinion of the relevance of a site in order to determine its relevance. This "social graph" of a website is implicit. An explicit exploitation of the social graph, seems a natural extension.*

Creating value by leveraging what I refer to as implicit social presence (user-activity profiling without published identity profile) on the Web suggests that PageRank represents a boundary between the old and the new Web in respect to shaping the Web 2.0 experience. At this stage, I allocated the Web 4 on the logistical support scale to reflect user-activity profiling that Google conducted.

5.7 Dynamic HTML

In parallel to advances in information-search and -retrieval systems that culminated in search engines such as Google, the 1990s also witnessed initiatives towards sensibility and interactivity advancements. The improvement in HTML documents' interactivity on the client side (Web browser) in response to user input led to the term dynamic HTML, which I consider another Web milestone.

One can trace early attempts to improve interactivity on the Web to early HTML standard definitions (Berners-Lee & Connolly, 1995) that included the possibility to encode user input as a form data set on a webpage for submission to the Web server. This feature already existed prior to the HTML 2 standard's release in 1995 (Raggett, Lam, Alexander, & Kmiec, 1998). With this feature, a user could use a form dataset with a in-built action URI and HTTP method to access an information service. Dave Raggett, who has edited various books on HTML standards, provides useful historical information (along with several coauthors) to trace further tracing advancements in HTML (see Raggett et al., 1998).

Besides form elements, HTML standard definitions also raised the bar with respect to interactivity by introducing image maps (i.e., document elements that allow users to click different areas in an image to reference different network resources as specified by their URI). By April, 1993, the newly released Mosaic browser could render images and fill-out forms. Emerging browser developments further drove efforts in interactivity by including elements such as ActiveX in Microsoft Windows Explorer, which Microsoft released in 1995. In the same year, Netscape also introduced frames that divided the screen into independent and scrollable areas. Marc Andreesson and Jim Clark created Netscape in 1994. They created and marketed their own browser based on the NCSA mosaic browser (Raggett et al., 1998).

Java's birth and incorporation into the Netscape Navigator browser in 1995 opened up more possibilities for incorporating interactive media into the Web space (Oracle, n.d.). In the same year, Brendan Eich created a scripting language called JavaScript (that began as an innovation called Moncha and then Livescript), which Netscape and Sun Microsystems adopted. Netscape also started to promote JavaScript as a complement to the newly created Java language (Lohr, 1996). One could use JavaScript to embed Java applets in webpages and, thus, boost interactivity. In addition, it could enable one to interactively validate user inputs on the browser before they submitted a form dataset to the service URI on the server side.

JavaScript's increasing use led to the technique known as dynamic HTML, which, according to the World Wide Web Consortium (W3C, 2005), constitutes a term (or buzzword if one prefers) that some vendors used to describe the combination of HTML, stylesheets, and scripts that allow one to animate documents. Macromedia Flash, a product previously known as Future Splash Animator before Macromedia acquired the original innovating company in December, 2006, also boosted interactivity. Prior to Macromedia acquiring the product, it quickly became popular even among bigger software companies such as Microsoft (Waldron, 2000). These innovations (JavaScript and Flash) took the Web to the next interactivity support level (i.e., level *2*).

The Web increased in sensibility support (to level 3) at this stage due to additional innovations that drove motion graphics. Innovative activities that Macromedia performed added more possibilities to the growing interactive Web space. Adobe later acquired Macromedia in 2005 (Flynn, 2005). Besides its innovation that allowed one to play movies on webpages called shockwave, Macromedia released Java applets that helped one add media elements to webpages with little programming knowledge, such as slideshows, icons, animator, banners, bullets, and charts. All these elements boosted the visual multimedia landscape (Internet Software Update, 1996; McIntosh, 1996).

Finally, I allocated the Web 3 on the logistical support scale because dynamic HTML did not require user-activity profiling, unlike PageRank, which earned the Web 4 on the logistical support scale,.

5.8 Basic Chat

In the latter 1990s, efforts emerged to leverage the Web for conversation-type interactions (namely, instant messaging and chat). Resulting software applications that allowed such interactions included Yahoo! Messenger (Slatalla, 1998) and the MSN Messenger Service (Randall, 1999b; Snider, 1999). American Online (AOL) also reportedly launched its newly acquired instant messaging system ICQ (Dennis, 1999b). Yahoo! first launched Messenger on 9 March, 1998, as Yahoo Pager. Prior to this launch, Yahoo already offered what the company referred to as a family of communication services, which included email, chat, message boards, people search, and classifieds (Yahoo!, 1998b). Around this same period, Netscape announced it would deliver a new technology called Gecko that users could download from http://www.mozilla.com. The company designed Gecko to integrate Internet browsing into instant messaging, chat, email, and finance software (Woods, 1998). By 1999, a news reporter could affirm that "chat, in which a number of users communicate in real time, and instant messaging, in which typically two users contact each other directly in real time, have emerged as basic communications tools on the Web" (Festa, 1999b).

The Web firmly became a person-to-person communication platform with these chat features. . Along with this profile capture emerged more personalization features. For example, AOL instant messenger version 2.0 released in the 1999: it let users know when their friends came online (i.e., presence notification) and included some new personalization features such as an enhanced people finder (Balderama, 1999; Derfler & Cohen, 2000; Knowles, 1999).

One could further break down chat to distinguish between support for one-to-one, one-to-many, and many-to-many communication structures if one had data that associated the communication structures with differing innovation milestones. I qualify this milestone as basic chat to distinguish it from later developments that supported voice or video.

Due to the user identity profiling associated with chat, I raised the logistical support level to *5*. This identity profiling of users in my opinion opened a new page in the advancements of social presence of users on the Web, a phenomenon that I refer to as explicit social presence in Section 3.1. I also raise the level of interactivity support one more step to 3 due to chat's the interactive nature.

5.9 Interactive Games

In the late 1990s, people also ported highly interactive content such as games to the Web, a milestone worth paying attention to. Even though I do not distinguish between basic chat and interactive games in in sensibility and interactivity support (see Table 3), I consider it one step higher than chat in logistical support considering the intricacies that one faces in porting games from desktop to the Web.

By December, 1997, a company named Classic Games announced that it had over 60,000 players registered on its game website (http://www.classicgames.com) (Classic Games, 1997). To play the games, users needed a Java-enabled browser. Shortly after, Yahoo! seems to have acquired the company and announced that it had launched Yahoo! Games. The company offered users who signed up five classic board games: Backgammon, Checkers, Chess, Go, and Reversi (Yahoo!, n.d.). At some point in 1998, requests to http://www.classicgames.com redirected to http://www.play.yahoo.com/.

5.10 Voice Chat

In the 1990s, voice chat also emerged. For example, in January, 1996, OnLive Technologies announced OnLive Traveler, a virtual reality modeling language (VRML) browser that allowed multiple participants to communicate via voice in real time in shared 3D virtual worlds. The browser worked as both a standalone application and a Web browser extension (Newsbytes, 1996). OnLive Technologies conceived the product to include client and server software for creating shared voice-enabled 3D communities compatible with the Web. Another company called Quarterdeck that also focused on voice technology developed WebTalk, an innovation that used compression/decompression software (codecs) to allow users to integrate the Web, voice, and text chat, and email using any browser (Aguilar, 1996; Mitchell, 1996). Voice-compression technology's emergence seems to have pushed companies to incorporate voice chat in online messaging services. For example, Prodigy incorporated Voxware's speech-compression technology into its online messaging services (McKenna, 1997). Yahoo! also reportedly added voice to its chat service (Woo, 1999).

In the ordinal scale of my proposed Web media capacity dimensions, voice chat is similar to basic chat except that I raised the bar with respect to sensibility support by one step to level 4 to reflect voice support.

5.11 Video Chat

Video's incorporation into person-to-person conversation (i.e., video chat) seems to have emerged in the 2000s, though many had already anticipated it in the 1990s. For example, in expressing a vision for the future, Kutnick, Senior Vice President at Quarterdeck, said:

> *Down the road we're going to add our collaborative computing module that allows you to share data. I will actually be able to take you somewhere, whether it be on the Web or to a spreadsheet, and talk to you at the same time. The idea is to be able to share data, voice, and eventually, video* (Aguilar, 1996).

Software makers such as Novell, IBM, and its subsidiary Lotus had begun working on this vision in the late 1990s (Randall, 1999a; Wong & Wolverton, 2000). In 2000, Novell had introduced instantme 2.0, a new version of its instant messaging software with support for real-time multimedia communications such as text, audio, and video. It also used encryption and digital certificates for security (Telecomworldwire, 2000).

Video chat further raises the sensibility support level *5*, which reflects video support. Other dimensions remain the same as those obtainable for basic and voice chats.

5.12 Desktop Applications Porting to the Web

In the 1990s, some organizations attempted to migrate traditional desktop applications to Web browsers, which reflects further advancement in the functional differentiation attainable on the Web (which I capture in this paper as level 6 logistical support). Lycos and Neoplanet made one such attempt in a joint project to offer a browser that let users surf the Internet, send instant messages and email, and participate in what they referred to as "virtual communities" (Cheng, 1999; Festa, 1999a). Some analysts suggest that, in providing free emails, scheduling software, address databases, and so on as Web-based solutions, organizations such as Yahoo, Excite, and Lycos pioneered the desktop of the future (Dennis, 1999a; Miles, 1999). However, the widespread porting of traditional desktop tools such as office productivity tools to the Web seems to have required enhanced interactivity. Such interactivity did not emerge until asynchronous JavaScript and XML (Ajax) technologies and further developments in Macromedia Flash paved the way.

5.13 Ajax and Service Decentralization as Milestones

From the historical presentations so far, one may perceive the progress towards the Web 2.0 era as a smooth continuity and not an abrupt jump in technology innovations. To cap this advancement towards Web 2.0 era, in this section, I present two major technological trends towards the latter 1990s that did not become more fully realized until the Web 2.0 era: Ajax and service decentralization (e.g., peer-to-peer communication structures).

Jesse James Garrett coined the acronym Ajax in 2005 (Langley, 2006). Citing Google Suggest (an autocomplete feature at the time) and Google Maps (i.e., maps.google.com) Web applications as examples, Garrett used the acronym in February, 2005, to represent a fundamental shift in what one could achieve on the Web with respect to user experience enhancement (Garrett, 2005). The term quickly became the conventional choice to describe a phenomenon that started developing about eight years earlier and that came to the limelight with the such technologies that Google used (Bisson, 2005; Gomes, 2005; LaMonica, 2005a). With Ajax, interactivity could become more efficient as the need to retrieve more data from the server no longer required users to completely refresh an entire webpage (Bisson, 2005). Thus, Ajax "free[d] Web pages from the clunkiness they suffer by making them more interactive and so more functional" (LaMonica, 2005a). Though one could use some other tools such as Adobe Flash to achieve similar transformation, Ajax laid the groundwork for extensive rich Internet application development (Payne, 2007). The wide preference for Ajax may have related to the fact that its components conformed to open standards.

Rich Internet applications refer to interactive and functionally differentiated Web-based software applications such as office productivity tools. By making webpages more functional, the drive towards porting desktop applications to the Web space became a part of software as a service (SaaS). By 2005, more applications that leveraged Ajax development approach began to emerge. For example, Writely.com users could view and edit Microsoft Word documents using a browser, NumSum.com provided a Web-based spreadsheet, Kiko.com provided a calendar and contact database, Meebo.com provided an interface to four major instant messaging networks, and Zimbra.com provided Web-based groupware (Dornan, 2005). At the time, Richard MacManus (2005) profiled several emerging Web-based office productivity applications, which he referred to as Web 2.0 office. Among these applications included AjaxOffice, Writely, gOffice, and thinkfree. Thus, to borrow from LaMonica (2005b), Ajax seems to have helped transition websites to Web platforms.

The highly functional webpage phenomenon so significantly characterized Web 2.0 applications that usage statistics based on number of pages viewed did not make sense to organizations such as Nielson anymore (Nielson provides Web usage statistics through the domain nielson.com). Rather, what mattered on platforms such as Facebook and Twitter became how long a user remained online and not how many pages the user viewed. By June, 2007, Nielson announced that it would shift to using the total amount of time users spent on the Web rather than how many pages they viewed (based on total minutes and total sessions) to estimate user engagement on the Web in line with the shift towards the so-called rich Internet applications and streaming media (Ross, 2007).

Besides Ajax, some services that encouraged decentralized application architectures emerged that may have also laid foundation for Web 2.0 features, such as peer-to-peer (P2P) file sharing system. I traced the first popular instance back to Napster, a music sharing system that leveraged users' computer systems (Calvi & García Matilla, 2004; Minar & Hedlund, 2001). Shawn Fanning, a 19-year old student at Northeastern University of Boston, developed Napster in January, 1999, to share music files with his university colleagues through the Internet (Calvi & García Matilla, 2004, p. 118). As Minar and Hedlund (2001) succinctly said in reference to Napster: "Machines in the home and on the desktop are connecting to each other directly, forming groups and collaborating to become user-created search engines, virtual supercomputers, and filesystems" (p. 3). Later, Skype, which became among the most reliable messaging platforms in the Web 2.0 era, used the same architecture.

Tracing how such services evolved, Calvi and García Matilla (2004) draw attention to the successive movements towards decentralization. They note that one may consider Napster partially decentralized as Napster itself did not host files for download on its servers—users accessed the files from other users. However, when considering the server architecture, they refer to the first set of P2P exchange systems as centralized in as much as a centralized server housed the information about users and the files they could exchange. In other words, users had to search the Napster central server for the name and location files that users made available to one another. This centralized function also established a connection between users' computers. Albeit only partially decentralized, Napster became an original model for distributing music through the Internet. Napster grew exponentially. By mid-2001, users had reportedly downloaded over 70 million files using Napster (Calvi & García Matilla, 2004, p. 123). As a result, organizations such as the Recording Industry Association of America (RIAA) established a judicial process against Napster in March, 2001, which forced the company to restrict traffic to copyrighted files. Napster's business eventually collapsed.

In parallel to Napster, another system called Gnutella emerged. This system, which a subsidiary of American Online called Nullsoft developed (Calvi & García Matilla, 2004, p. 129), supported file sharing among users without any centralized server. Strictly speaking, Nullsoft designed Gnutella not as a network but as a protocol or method to handle file sharing among peers (i.e., user computer systems) that would guarantee users' and files' anonymity. Anyone could freely download the open source software. It became a model of a truly distributed peer-to-peer network solution with completely independent nodes.

Both Napster and Gnutella seem to have inspired other innovations that leveraged the two architectural styles that they relied on. Calvi and García Matilla (2004) refer specifically to such hybrid networks as decentralized networks in which computers can operate both as servers and as user devices. Kazaa, technology behind the FastTrack network service, constitutes a notable example among such systems.

A company called Sharman Networks designed Kazaa as Napster faced legal challenges. By leveraging Gnutella's distributed nature, Kazaa could avoid the legal battles that Napster faced. In addition to this advantage, Kazaa featured sufficient centralization such that it could manage large volumes of information efficiently. Besides the fact that any computer on the network could act as a server, Kazaa could automatically designate user computers with more resources and speed as "super nodes" or "super users" (super peers) that handled indexation and file search. Due to such scalability, the FastTrack network service based on Kazaa attracted many users.

One can perhaps better appreciate the power and success of the decentralized architecture that Kazaa represented by considering Skype. Developed by the same team that built Kazaa (i.e., three Estonian programmers named Ahti Heinla, Priit Kasesalu, and Jaan Tallinn) in 2003, Skype allowed users to communicate with text, voice, and video (Thomann, 2006). However, the Swedish-born Niklas Zennström and Janus Friis from Denmark founded Skype as a company (Thomann, 2006). Skype used P2P architecture to directly connect two (or more) computers rather than route communication through a central server. In doing so, the program performed better than past alternatives and provided more secure communication (Gough, 2006).

The Extensible Messaging and Presence Protocol (XMPP), a different decentralization architecture, also affected the Web 2.0 area. XMPP used Jabber, an open technology for instant messaging and social presence that Jeremie Miller created in 1998 and the Jabber open source community refined in 1999 and 2000, as its core technology (XMPP Standards Foundation, n.d.-a, n.d.-b). XMPP, an open technology for real-time communication, powered various applications such as instant messaging applications; software that allowed users to chat via text, voice, and/or video; lightweight middleware; collaboration software; software that syndicated content; and software that routed XML data.

Jabber/XMPP's creators conceived the technology to offer transparent compatibility with other real-time messaging services and protocols (Miller, 1999). As such, one could leverage the technology for conversations between users without the need to directly connect to a server or domain. Jabber managed the server-to-server negotiations behind the scenes in a way that users could see. Though Jabber (XMPP) seems to have eroded server and domain boundaries, Miller (2001) asserted it could become the common platform for supporting dynamic and flexible conversations. Thus, unsurprisingly, by 2003, Jabber's surpassed ICQ, the original instant messaging service that gained mass popularity, in user base (XMPP Standards Foundation, 2003). Notably, such technology seems to have laid foundation for a more conversational Web. For example, GoogleTalk used XMPP to support text, voice, and video chat. Cisco Collaboration Services (Cisco Systems, n.d.) also used XMPP in the Web 2.0 era for various purposes. Some social media platforms have also used XMPP, such as Twitter (Stone, 2008) and Facebook (Kaicaid, 2010; Reiss, 2008).

6 Conclusion

In this paper, I examine whether one can use existing media capacity theories and media-related buzzwords (such as rich media, multimedia, hypermedia, social media) to characterize Web innovations as media as a prelude to elucidate a suitable framework to describe the way in which Web-based media innovations have incrementally advanced. I observed a number of inadequacies. Notable among them included 1) inconsistency in the implied meaning of terms such as rich to qualify media across media capacity theories and buzzwords, 2) a mix-up between terms such as rich and interactivity, 3) disputed criteria for the use of social qualifier for Web-based media, and 4) a lack of standardized reference to organizational or logistical media such as indexes as bona-fide qualifiers of Web-based media.

To remedy these inadequacies, I synthesize three complementary media capacity dimensions (i.e., sensibility support, interactivity support, and logistical support), which have the potential to become media capacity theories (e.g., sensibility support theory (SST), interactivity support theory (IST) and logistical support theory (LST)) or one unified theory (e.g., sensibility interactivity and logistical support theory (SILST)).

To further substantiate this critical analysis outcome, I traced how Web innovations have evolved from the Web's inception and describe how one can use these three media capacity dimensions to characterize milestones. I consider only Web 2.0 milestones to avoid excessive paper length. The typology and dimensions I present provide clues as to how one can characterize media innovations in an objective manner. I recommend that researchers conduct further work that uses my categorization to more extensively examine Web 2.0 innovations and beyond as future innovations emerge. Although I focus on the World Wide Web in this paper, one could use my framework to objectively characterize other non-Web electronic media systems' media capacity.

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About the Author

Pius Onobhayedo is a Senior Lecturer at both the School of Media and Communication and the School of Science and Technology of Pan-Atlantic University. He holds a PhD degree in Communication from the University of Navarra, Spain, with a digital media centered research. His thesis focused on the effective use of Web innovations as organizational communications media. Prior to joining Pan-Atlantic University, he was the founding technology lead and Chief Technology Officer of Socketworks and SWglobal, Internet generation software companies. As an academic, he remains a passionate software developer and teaches software development. His research interest aligns with the impact of technological advances (Web, mobile, IoT, AI, blockchain, gamification, etc.) on communication processes and theories, be they business, personal or group communication. Recently, he was a Visiting Scholar to the Business Communication department, Marshall School of Business, University of Southern California, USA, during which he submitted this article for publication.