A conceptual model for Socio-Pragmatic Web based on activity theory

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Abstract: How is the future of the Web, as one of the most influential inventions of the twentieth century? Today, there are great conceptual gaps between the Web 2.0 (Social Web), Web 3.0 (Semantic Web), and Web 4.0 (Pragmatic Web) generations. Every generation of Web is merely an independent conceptual branch of Web and the future Web needs to benefit from the combination of concepts from each generation. This paper has three distinct contributions to make for paving the way for the future Web. First, we tried to extract all main concepts of today’s Web, and propose them as the principles for the future Web, which we name the Socio-Pragmatic Web (SPWeb). Then, we use the Activity Theory (AT) as a transdisciplinary theory for human social behavior to provide a conceptual model for SPWeb. Our conceptual model offers generic Knowledge-Embodied Agents (KEA) in three different abstraction levels as the building blocks of SPWeb. As different KEA types, Web Service-KEA, Artificial Intelligent-KEA, and Cognitive-KEA have different levels of capabilities. For each KEA type, we propose different elements and technologies of today’s Web as the candidates for their development to prove the feasibility of these KEAs. Finally, we will show that the Concept Realization and Weaving Functions of the KEA models altogether can generate a powerful future web, as it satisfies SPWeb’s principles.

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PUBLIC INTEREST STATEMENT

What is the future of the Internet, Web and social networks? How would it transform the everyday life of individuals and societies? This paper is not a story telling, or even a future study about the next generation of the Web; but rather, it is a first step towards architecting the future of Web. The paper summarizes the main features of current Web generations, and shows the need for a unifying theory to capture all those features. So, it proposes a conceptual model for the next generation Web, according to a theory for human social behavior called Cultural-Historical Activity Theory (CHAT). Then, it describes the main technology candidates to develop that architecture in three development levels.
1. Introduction
Initially, Web was a response to the diversity and distribution of content types and channels of communication (T. J. Berners-Lee, 1989). Different network applications such as email systems, news forums, file systems, information search and access and so on, were acting as separate communication channels. In addition, each application had its proprietary content types and file formats, which cannot be used in other applications directly.

So, the main feature of Web was unifying and integrate different and diverse content types (text, picture, video, etc.) and communication channels (email, forums, news channels, etc.) of those days (T. J. Berners-Lee, 1989). This integrating and unifying nature of Web, inspired application developers to use it as a development platform. This way, Web was gradually transformed into an interactive media, business and social environment, as well as a knowledge platform (Aghaei et al., 2012). These approaches and usages of Web were not a planned and even imagined perspective for its initial development. But, they were a natural consequence of the above-mentioned feature.

Nowadays, we face a similar situation of diversity and divergence in a different way, due to diverse practices of development on Web. The original Web (Web 1.0) more powerfully continues its life as a technical unifying development environment. On the other hand Facebook, Twitter, Wikipedia and many other applications are developed on Web and successfully made new social communication environments (Fuchs, 2017). However, there are several challenges to integrate these environments, they share common features that are conceptualized as a new generation, “Web 2.0,” or Social Web (O’reilly, 2005).

Concurrently, there is a different branch of efforts and practices to link and relate every piece of content to the others according to their meanings. Google, Microsoft, Apple, Facebook and many other technology firms developed their own solutions that may eventually share in some technologies (T. Berners-Lee et al., 2001). This branch of efforts conceptualized as a different generation, “Web 3.0” or “Semantic Web” (Hendler, 2009). Similarly another term coined as “Web 4.0” or “Pragmatic Web” to describe a narrow yet another branch of efforts to use the power of robots, Bots and Artificial Intelligent Agents in Web (De Moor, 2005).

Thus, these generations of Web have not been generations after generations; but rather, each generation represented a different type of developments in web space, which presently exist in the ICT environment.

Many scholars expressed the need to converge these different practical and theoretical efforts on Web (Patel, 2013). Some of them emphasized on the necessity of a unifying theoretical (or even philosophical) approach for this convergence (Fuchs, 2017). This paper is an effort to address such a need, referring to a theory of social behavior with about one century of history as Cultural-Historical Activity Theory (CHAT) or briefly Activity Theory (AT) (Engeström & Gläveanu, 2012). The paper is based upon AT for an advanced and comprehensive specification of knowledge in the context of human social activity, according to AT. It proposes Socio-Pragmatic Web (SPWeb) as a unifying conceptual model for the future of web.

For this purpose, in section two we study the main features of the original Web (Web 1.0), Social Web (Web 2.0 or Social Media), Semantic Web (Web 3.0 or Knowledge Web) and Pragmatic Web.
(Web 4.0) according to their history and main theories. Thus, we are going to derive the main features of these generations as the requirements of the future web and the principles of SPWeb.

In section three, we offer the concept of a Knowledge-Embodied Agent, KEA as the main building block of SPWeb derived from the notions of subject, object, and activity structure of AT. Therefore, we need to introduce AT and some of its main concepts and principles according to the third (current) generation of AT. Two main features of KEA are Concept Realization and Weaving Function that are introduced. These features originated in the concepts of object realization and object formation in an Activity System (AS) that we will describe briefly. Doing so, we construct the conceptual model of SPWeb based on KEA and its main functions using the two above-mentioned concepts.

This way, SPWeb is born through integration of separate and diverse principles available in different generations of web. It was mentioned that none of today developments of web were imaged or planned at the beginning and at that time, web was merely the result of integration of different available achievements in ICT until then. It seems that through integration of diverse principles and concepts in current web generations, the new web would be the platform for many achievements and developments which are not imaginable yet. In the present article, just primary examples of the achievements for actualization of such an integration are considered.

2. Principles of current Web generations
Different generations of Web are practical, still wise responses to the problems and capacities of Information Technology. Therefore, they obey clear rationales, while there are several discussions and debates about their exact definitions and descriptions (Borsetti Gregorio Vidotti et al., 2019). Below we briefly introduce the main concepts of each Web generation according to the literature. The future web needs to include these concepts altogether. Therefore, we consider them as the main principles of the next Web generation.

2.1. Original Web (Web 1.0)
The first official specification of Web was a project proposal by Tim Berners-Lee to The European Organization for Nuclear Research, known as CERN (T. J. Berners-Lee, 1989). Although he never counted Web as his property in the form of copyright or similar ways (Berners-Lee & Fischetti, 2001), almost everyone considers him as the father of Web (Consortium, 2019). He reviewed the efforts in making web, several times in different writings and speeches (T. Berners-Lee, 2019). First, he described his solution as a future-proof system that facilitates access to any data format in any access platform as below (T. J. Berners-Lee, 1989, p. 19):

At this stage, we will be looking for a systems which are future-proof:

- Portable, or supported on many platforms,
- Extendible to new data formats.

After that, he briefly called all his efforts in creating web as a marriage between Hypertext and the Internet in the form of Uniform Resource Indicator (Berners-Lee & Fischetti, 2001). URI is an addressing schema that can address every resource type, from a file (with text, image, voice or movie, etc. content), a person (email address), an internet forum or even a running computer program (e.g., a database query; T. Berners-Lee et al., 1998, 2005).

URI along with Hypertext Markup Language (HTML) empowered Web to gather diverse data types in a single page (Berners-Lee & Connolly, 1995; T. J. Berners-Lee, 1989; Yashin & Mezianaya, 2019). Nowadays, with HTML, it is trivial to view a web page on your desktop or mobile interface that contains Texts, Images, Voices, and Animations and so on (Consortium, 2018). Every piece of them can reside on web servers other than the website that contains the main page. In other words, the content of every single web page can be distributed over the Internet. These basic features generates
WWW as a distributed network of diverse contents. Along with all the evolutions in WWW, URI and HTML remained innate features of every web developments until now (Frain, 2020).

Here, we do not focus on technical aspects, because they are evolving continuously. Instead, we pursue the conceptual aspect behind this diversity and multiplicity that sheds light on all inventions in WWW. All of them have original concepts of diversity and distributed nature of data (as web contents) in their definitions and implementation, in some ways. Therefore, we can derive two principles from Web 1.0 objects and features as below:

**Principle 1:** Diversity of Web contents in data level.

**Principle 2:** Distributed contents of Web again as data.

### 2.2. Social Web (Web 2.0)

Unlike Web 1.0 which had a distinguished inventor and roughly birthday, Web 2.0 was born gradually as a result of different experiences (Allen (2017)). In about 1.5 decade of the first Web generation, different new features generated; such as private and public messaging, chat groups, discussion forums, news channels, Blogs, peer to peer file sharing, user generated encyclopedias, and so on (Shuen, 2018). The main common feature of these web sites was “user participation” that Kali et al. (2019) called “networking people.” However, several different points of views have been studied and discussed about Web 2.0 such as its technical aspects, its application domains, its social impacts as a media or a new living space, and even its philosophical foundations (Allen, 2017; Anderson, 2016; Fuchs et al., 2010; Wilson et al., 2011).

#### 2.2.1. Technological stance

The first official conceptualization for these features was made by O'Reilly in an international workshop (O'reilly, 2005). He first introduced the technologies emerged on the web that shape the Web 2.0 space, such as blogs, BitTorrent, Flicker, Wikipedia, and so on. Then, he emphasized on common features of these web sites from a technical point of view, and derived five principles as of “the Web as a platform,” “harnessing collective intelligence,” “Data is the next Intel inside,” “end of software release cycle,” and “lightweight programming models” (O'reilly, 2005). Technical point of view is very popular in Web 2.0 studies and makes a broad infrastructure for its development (T. Berners-Lee & Fischetti, 2001; Golbeck, 2013; O'Reilly & Battelle, 2009; Porter, 2008; Shuen, 2018).

In a detailed analysis, Anderson (2016) uses an iceberg metaphor with three levels of Services, Ideas, and Technologies/Standards to describe Web 2.0. He continues the conceptualization of O'reilly and summarizes the ideas behind Web 2.0 as “User-generated Content,” “Harnessing the power of crowd,” “Architecture of Participation,” “Openness,” “Data on an epic scale,” “The Network Effect and Web Topology.”

To derive abstract concepts from these conceptualizations, we keep in mind that technology is not the sole viewpoint toward the Web 2.0. So, we will consider other points of view and then conclude their common concepts.

The Figure 1 shows these concepts and separates their technical aspects from their abstract ideas.

#### 2.2.2. Application domains

Several other scholars emphasized on different application domains of Web 2.0 and studied its usages and the evolutions in its application domains (Autio et al., 2018; Martínez-López et al., 2016; Porter, 2008). To bring only some examples, Sandars and Schrotter (2007), Lee (2010) and many others proposed Web 2.0’s effects on education and learning domain. It is one of the most popular application domains of Web 2.0 so far. Constantinides and Fountain (2008) and Martínez-López et al. (2016)
discussed Web 2.0 concepts and feature in business, marketing and branding domain. Also, Web 2.0 raised wave of new applications in healthcare (Garmann-Johnsen et al., 2018). E-government is another domain of applications for Web 2.0 through democratization and citizens participations (Nam, 2020). Fuchs (2017) and (Allen, 2017) and many others studied social web as a media, although they have some critical stands in the role of Web 2.0 in this domain.

2.2.3. Social and philosophical aspects
As an emerging phenomena, Web 2.0 has its own impact on shaping social relationships. O'Reilly and Battelle (2009) considered it as a source of social concepts such as Openness and Transparency. This social impact goes beyond some ideas and shapes new social styles in problem solving, design and manufacturing and investment. Buzzwords such as Crowdsourcing (Schenk & Guittard, 2011), Participatory Design and Production (Chitanana, 2020), Crowdfunding (Parhankangas et al., 2019), and so on, found their position in social relationships.

Fuchs et al. (2010) bring more philosophical aspects of cognition and communications and cooperation to establish a theoretical foundation for such evolutions. However, there are many debates on the lack of a comprehensive theory behind the development of Web in general and especially Web 2.0 (Allen, 2017). We will return to this aspect in section three and introduce a powerful foundation as the theory behind Web developments in human society.

Almost all the above viewpoints agree in the point that Web 2.0 is a continuous evolution of Web 1.0. As for Web 1.0, we pursue only the main abstract concepts behind all of the above aspects. Therefore, Web 2.0 continues to have Principles 1 and 2, besides that it crosses the border of data and covers processed data as information or even knowledge. As a derived conclusion, we add three new principles as the main concepts of Web 2.0 that are:

**Principle 3**: Social or community-based contribution to content provision.

**Principle 4**: Content has a continuous spectrum of data, information, and knowledge.
Principle 5: Web as a platform for social and technical developments.

2.3. Semantic and Pragmatic Web (Web 3.0, 4.0)
Semantic Web that later called Web 3.0 is a series of parallel efforts and practices made on Web to make the content more meaningful and comprehensible to machines or shared meaning (T. Berners-Lee et al., 2001). Most of these efforts have technological natures such as using XML, RDF, OWL, and Ontologies to represent a content as a piece of knowledge that has relations to other pieces (Alor-Hernández et al., 2019).

However, the most abstract concept and idea behind these technological developments is knowledge representation. As a result, the main responsibility of semantic web reduced to forming knowledge and its processing (Borsetti Gregorio Vidotti et al., 2019). However, these processes can be named as meaning processes. Therefore, several other aspects for the meaning of content have been left outside the mainstream semantic efforts (Borsetti Gregorio Vidotti et al., 2019). For example, how a piece of knowledge has different meanings in different knowledge domains, results in important concepts as context, situations, and usage of that piece of knowledge.

These concepts bring a new approach to the Web development as the content in use or Pragmatic Web (Li et al., 2018; De Moor, 2005). This way, we can consider Pragmatic Web as if it maintains the main idea or concept of Semantic Web in a broader view.

This common concept between the two generations of Web is the true knowledge or the knowledge in use. It pushes forward the definition of content spectrum in Principle 4’ (revised), to embrace knowledge in use or knowledge in context. The new definition for that principle is as follows:

Principle 4’ (revised): Content has a continuous spectrum from data to the knowledge in use or practicable knowledge for machine or human.

Furthermore, this continuous spectrum should be considered contiguous. In other words, it is important that every piece of content should be a part of the context and therefore it should have tight relations to other pieces according to its meaning and usage (Schneider et al., 2013). Accordingly, the fifth principle changes to form a new definition for the platform as follows:

Principle 5’ (revised): Web as a platform for [social and technical] context developments.

According to the above discussions, Table 1 summarizes five principles found in the four generations of Web.

3. Socio-Pragmatics Web; a perspective
Combining the five principles can sketch a new perspective for the future Web that we name it Socio-Pragmatic Web. Therefore, the future Web will have all the substantial principles and basic concepts of its predecessors.

3.1. SPWeb a definition
As an integral definition, SPWeb can be specified as follows:

SPWeb is a socially generated domain-inclusive platform of knowledge as being practiced, comprised of human individuals and artificial agents.

The above definition is totally derived from combining the five above principles. From the end, SPWeb should contain artificial agents as well as human individuals for the principles 3 and 5. The content of SPWeb covers all levels of content from data, information, knowledge and the knowledge of their usages according to principles 4 and 5. According to principle 3, this content is
Table 1. Five principles of four Web generations

|                | P1-Diversity | P2- Distributed | P3- Social Contribution | P4'- knowledge in Use | P5'- Context Development Platform |
|----------------|--------------|------------------|-------------------------|------------------------|-----------------------------------|
| Web 1.0        | Diverse data types: Text, Image, video, etc. | A Page with items in different addresses | -                       | -                      | -                                 |
| Web 2.0        | Web 1.0 + beyond Data (Information and Knowledge) | Web 1.0 + different producers of content | A community produces a piece of content as well as consuming it (Blogs, Wikis, etc.) | -                      | A platform for Software, Content, Business, and even social movements, development |
| Web 3.0        | As in Web 2.0 | Every piece of content as a combination of other distributed contents | -                       | Different levels of semantic relations between contents | A platform for software and content development |
| Web 4.0        | Web 1.0 + Content from a variety of usage domains | Web 3.0 | -                       | Content as knowledge in practice | Web 3.0 |

As a result of collaborative work of all individuals in the web, no matter artificial or human. The content of SPWeb is not specific to a certain knowledge or usage domain or in a special form and limiting form of access to satisfy Principle 1. Finally, everyone may have the authority over every part of SPWeb’s content; however, no one owns all the pieces of a content to provide it in SPWeb (Principle 2). This means that a community collaborate on generating the knowledge contained in the SPWeb.

3.2. SPWeb lifestyle

Indeed, such a new Web makes a new lifestyle! In this new world, everyone is empowered to provide any live content he/she wishes. Content has a spread-spectrum ranging from a simple tiny data to a complicated inference over a large set of knowledge rules. Simple data might include examples such as the temperature of my location, heavy traffic in the street I am driving, or that we have just ran out of salt in the kitchen. Inferences over a large set of knowledge rules are powerful knowledge statements such as a medical diagnosis made by a practitioner after reviewing the patient records, a legal consultancy made by a lawyer, or approval of building permission in the municipality.

All these contents are direct or indirect results of a human practice and can be regarded as a part of a larger social activity. Also, all of them are provided in a process beginning from Web and ending into it. SPWeb provides all individuals with such a toolset to introduce their possible practices, and search through it to find the provided practices. Everyone (with required profession) can compose an appropriate set of these practices and make a social process to accomplish a large and complicated activity. The critical feature of SPWeb is its ability to evaluate every piece of provided content and every planned compositions, with the appropriate knowledge in SPWeb.

The above specification introduces this new lifestyle very briefly. However, it seems enough to help us imagine it as a lifestyle of creativity and innovation, through social participation of knowledgeable individuals. Bringing more examples from these SPWeb-based practices and activities, provides a clearer picture of the lifestyle in SPWeb. Therefore, section 4 has different examples
along with every component in the conceptual model of SPWeb. The rest of lifestyle picture is left to the readers’ imagination.

3.3. Theoretical requirements of SPWeb

Developing such a web requires answering fundamental questions about main concepts contributed in its definition. They are questions about knowledge, society and their relations to human behavior. Questions about knowledge are such as: What is knowledge? Is there a uniform classification of knowledge for different domains? How knowledge can be produced and used? (Anderson, 2016) What is the relationship between natural language and jargons and their contribution to development of a society? Etc. Such questions have a vast variety of discussions in epistemology and philosophies of science and learning. In addition, there are more debates on the concept of society: What is a society? How is it formed? How people relate or collaborate with each other in a society? Etc. These questions have deep roots in sociology and economy and their philosophical basis, as well (Autio et al., 2018; Fuchs et al., 2010).

Finally, combination of the two concepts of knowledge and society in practice relates them to other important issues such as situation, context, culture, and history that affect social behavior of humans. This leads us to pursue a theoretical foundation with standpoints in these issues while it is derived from realities and practices in the above fields. In the next section, we briefly introduce AT as such a theoretical foundation and try to develop a conceptual model for SPWeb based on it.

4. AT as a theoretical foundation of SPWeb

Activity Theory (AT) is a social behavior theory with about a century of powerful conceptualizations about human activity in the society (Kaptelinin et al., 1995). In this section, we do not want and cannot bring a complete description for AT; but, we will introduce most important and useful concepts of AT as AT Principles (ATP)s to develop a model for SPWeb. Therefore, the concepts of tool-mediation, object-orientation, object formation, and activity hierarchy will be discussed along with the network of activities.

4.1. ATP1: Activity as a whole unit

In three generations of AT, Vygotsky, Leontief, and Engestrom articulated their distinct definitions for activity (Engestrom, 1999). However, in all the three definitions activity remains a relatively independent and integrated whole. Vygotsky defined activity as a subject’s action to obtain an object by mediation of a tool, as depicted in Figure 2 (left). Leontief brought forward the social and collaborative nature of activity, introducing the notion of Activity System (AS) as depicted in Figure 2 (right). He defined activity as collective tool-mediated efforts of subjects in a community according to some rules with a division of labor toward a shared object (Leontiev, 1974).

![Figure 2. Structure and elements of an Activity System according to: Left: First Generation; Right: Second Generation of AT.](https://doi.org/10.1080/2331186X.2020.1797979)
In this structure, outcome is the external result of performing the activity as the evidence to its fulfillment. Engestrom developed the definition to a network of relatively independent activities with a partially shared object, as depicted in Figure 3 (Engestrom, 1987). We will use all the three notions of activity to develop our conceptual model.

4.2. ATP2: Mediation by knowledge packages

Mediation is originally the main idea of Vygotsky's articulation for AT as its first generation in 1920s. He specifies an activity as an effort of a subject (individual) to obtain an object (motive, goal) with the mediation of a tool. As a mediator, tool directs the subject to the proper interaction with its object. Tools are created and transformed during the development of the activity itself; and they carry with them a particular culture as the historical evidence of their development (Vygotsky, 1978). As Nardi discussed in (Nardi, 1996), AT considers every tool having an external (objective) representation along with an internal (mental) representation simultaneously.

Mediation appears in the interrelation of every two elements of activity system. Rules (or social rules) are norms, standards, or laws that mediate the relations between a subject and its community. Division of labor mediates between the community of activity and their shared object. Therefore, AS has three mediating elements; so, it is called a multimediator (Bødker & Andersen, 2005).

As said before, a tool or generally a mediator carries with itself the history and the culture of its usage in activity. In other words, the use of a mediator is an accumulation and transmission of social knowledge (Engestrom, 1987). From epistemic point of view as in (Engeström, 1990, 2007), each mediator works in different knowledge levels, as depicted in Figure 4. Briefly, an activity system is a conglomerate of different knowledge types or epistemic models for realizing a concept. These knowledge types include:

- Episodic knowledge as answers to “what” questions (What, Who, When, Where, and so on).

- Procedural knowledge as answers to “how” questions.

- Semantic knowledge as answers to “why” questions.

- Higher-level semantics or pragmatic knowledge as answer to “where-to” questions.
The first three epistemic model types are well-known models in epistemology and model theory (Wartofsky, 1979). However, the last type originates in the notion of object of activity in the activity theory. “Where-to” refers to a motive or high-level object of an activity that is the main reason of forming the activity system, while it may have no explicit or direct cause and effect relation to its elements.

4.3. ATP3: Hierarchy of activity

From a different point of view, an activity has a hierarchical structure with three levels of activity, action and operation; as in Figure 5, the first level of hierarchy is activity toward a motive. Motive is a top-level object that is not subordinate to any other object. This means that a subject can instantiate different sublevel objects to realize the top-level object or motive of activity. Subject consciously relates all subordinate objects directly to the motive (Bertelsen & Bødker, 2003).

Actions are in the second level that are goal directed processes, and altogether fulfill an object of activity. Subject of activity breaks object/activity down to a series of goals/actions consciously or with a motive in mind, but performs the actions only concerning their goals. Therefore, different series of goals/actions can fulfill the same object of activity. On the other hand, different actions can fulfill the same goal and a goal itself can have sub goals. In the third level, conditions guide the operations in an automatic or unconscious manner. An action consists of a series of operations and different series of operations can fulfill the same action. Again, the subject has some level of consciousness in breaking down an action to a series of operations. However, it performs the operations only according to the conditions, omitting the goal of action.

As shown in Figure 5, every level of the hierarchy can be transformed to its adjacent levels. As the activity loses its conscious level toward automation, moves downward to action and operation. This occurs, for example, when the subject has no need to be aware of the motive of activity or the goal of an action because of some enactments through repeating the activity or action in the same situation. In the opposite, as subject needs to be aware of the goal of its action or the motive of its activity, operation or action moves upward through increasing the subject's consciousness level. This may occur when for example, an error takes place in performing an operation or in achieving the goal of an action.
4.4. **ATP4: Object-formation and construction**

Object directs human activity, so, an activity is the way an object of a human is realized; and an activity is the result of the interaction between a subject and its object. The object itself is a result of all the mental features of a subject such as motive, emotions, knowledge, experiences, and so on, that cause a subject to participate in an activity (Engeström et al., 1999). This way, the object of activity distinguishes it from other activities in a social setting. In other words, object of activity is not a personal idea, but it has a collective (shared) nature and activity is an interrelation between its subject, object, and the community.

According to AT, object is not an objective goal or anything in the environment that can be reached or possessed. The object of activity has a dual nature; it is both a projection of human mind onto the objective world and a projection of the world onto human mind (Engeström et al., 1999). The object is a transitional being and a horizon, that by taking every step, brings a new look on the object to take the next step. Engestrom specifies this transition as object formation, and shows it in an extended experience in a clinical process (Engeström, 1990). As he conceptualizes in a medical cure activity system, object formation itself produces a series of objects as its outcomes. However, every produced object through object formation (such as patient expectations, physician impression, meaningful pattern of disease, treatment plan, and altering to health state) has another activity system to realize that object.

In a separate study Kaptelinin and Nardi (2006) bring a clearer and more distinct specification for object formation in two phases. They specify two activity systems for object formation as object
construction and object instantiation activity systems. In the first AS, an object (or a series of objects) is constructed to satisfy the top-level motives of an activity. Then, the second AS forms the settings to find an instance of the constructed object to obtain the instantiated object. In the case they studied, a large pharmaceutical company needs to specify the target type of genes or disease as the new long-term research program, in the first AS. Then, the second AS is the research activity to study the selected genes to develop a new medicine for the market.

5. SPWeb conceptual model
The mentioned AT principles inspire in developing the future web as a web of activities, i.e. SPWeb. Indeed, the conceptual model of SPWeb is based on the third generation of AT. Therefore, we will only show how the current technologies of web, along with some future developments, can represent AT principles and concepts. Inspiring from the concept of activity as a whole, we will introduce the building block of SPWeb as a knowledge-embodied agent, KEA. We will show that all KEAs comply with a higher-level epistemic structure. However, there are three distinct KEA types based on the capability level they need. Then, we will show how a society of such agents resembles a Socio-Pragmatic Web.

To adhere to the conceptual level, we do not go further to the details of KEA’s implementations. Rather, we will show that KEAs are feasible and introduce the candidate technologies for each KEA type. In addition, we will mention some simple and realizable examples for each type of KEA.

5.1. KEA, as the building block of SPWeb
To describe KEA according to AT principles, we synthesize different subsets of ATPs and deduce each feature from every subset, as represented in Figure 6.

**KEA-Feature 1**—Autonomy in realizing a concept: KEA is an integrated knowledge unit comprised of different knowledge packages that realizes a concept.

From ATP1, AT emphasizes on the activity as a whole unit of human behavior. Some parts of ATP4 specify the whole activity as an equivalent or a realization for its object, i.e. a concept to be realized. ATP2 argues about the elements of activity as knowledge packages with a specific role in the activity. These three ATPs enable deduction of the first KEA feature.

**KEA-Feature 2**—An Epistemic tools constellation: KEA is analogous to an Activity System (AS), therefore it should have all AS mediators as knowledge elements. According to ATP2 and ATP4, KEA should represent at least three types of knowledge of a concept realization, ontological, procedural and causal knowledge. A KEA can have all the four types of knowledge by representing a final cause or abstract meaning in use, as well.

**KEA-Feature 3**—KEA is socially constructible entity vs. designed entity: KEA formation is not a top-down design process, but it is a consciously bottom-up while top-down construction in its society.
According to ATP3, human activity has a hierarchy based on activity/motive, action/goal, and operation/condition reciprocal movement. Also, from ATP4, motive/object of an activity system can declare a hierarchy of objects along with their own activity systems to be realized, in order to realize the main motive/object of the first activity system. Such an interwoven relations of motives/objects/goal/conditions eliminates the possibilities of a predesign hierarchy of systems. This requires different types of conscious decisions in both orders, downward and upward, as Engestrom emphasizes in Engestrom (2007, p. 13):

Bødker and Andersen (2005) Design Paradox: The epistemic levels depicted in Figure 1 [Figure 4 in this paper] are but a preliminary attempt to create a framework for critical reflection and epistemically conscious design of technologies for learning—something called “leveled design.” Paradoxically, such a design approach may lead to conscious decisions not to predesign all the epistemic levels of an emerging instrumentality: that is, to the conscious reservation of open spaces for emerging designs and reconfigurations from below. (p. 394)

KEAs are the building blocks or nodes in our conceptual model for SPWeb. So, in this section, we will show the structure of these building blocks. SPWeb consists of three basic KEA types: Web Services-KEAs (at system level), Artificial Intelligent-KEAs (as artificial knowledge workers), and finally Cognitive-KEAs as SPWeb Weavers. It will be shown that vertical and horizontal weaving function of Cognitive-KEAs construct SPWeb in a pragmatic and social manner respectively.

5.2. Web service (or system) KEA, WS-KEA
KEA at the system level represents the operation level of activity where conditions direct all the behaviors of the agent. In this level, KEA needs two types of knowledge (“what” and “how”) and translates them to a system’s behavior. As a building block of SPWeb, the nearest candidate to such a system behavior is a Web Service. A general web service, as it specified in Service Oriented Model (SOM) of W3C (World Wide Web Consortium), has a structure as in Figure 7.

As it is mentioned in W3C document, SOM is the most complex model in web usage (Ferris, 2004).

The Service Oriented Model is the most complex of all the models in the architecture. However, it too revolves around a few key ideas. A service is realized by an agent and used by another agent. Services are mediated by means of the messages exchanged between requester agents and provider agents.

Here, we do not go to more details of this equivalence; but, Table 2 very briefly specifies the W3C’s definition of SOM elements and their equivalent types of knowledge in KEA.
| SOM elements        | Definitions                                                                 | Type of KEA or knowledge | WS-KEA | KEA | What | How | WHY |
|---------------------|------------------------------------------------------------------------------|--------------------------|--------|-----|------|-----|-----|
| Provider Agent      | An agent is a program, responsible for service provision. It corresponds to the notion of software agent in [Web Arch] | ✓                        |        |     |      |     |     |
| Requester Agent     | An agent may request a service                                               | ✓                        |        |     |      |     |     |
| Owner Agent         | An owner that is a person or organization                                      | ✓                        |        |     |      |     | ✓   |
| Resource            | It is a thing to be used by a service based on a policy                       | ✓                        |        |     |      |     |     |
| Goal State          | A goal state is a state of some service or resource that is desirable ...     | ✓                        |        |     |      |     |     |
| Policy              | A policy is a constraint on the behavior of agents or people or organizations | ✓ ✓ ✓                   |        |     |      |     |     |
| Service Task-       | Any action that may be performed by an agent, e.g., sending or receiving a message or changing to another observable state. | ✓ ✓ ✓                   |        |     |      |     |     |
| Service Role-Actions|                                                                                |                          |        |     |      |     |     |

(Continued)
| Type of KEA or knowledge | KEA | SOM elements | Definitions |
|--------------------------|-----|--------------|-------------|
| WS-KEA                   |     | SOM          | A choreography defines the sequence and conditions in order to achieve a goal state. |
|                         |     | SOM          | The set of behavior expected when interacting with the service. |
| Choreography             |     | SOM          | A choreography defines the sequence and conditions in order to achieve a goal state. |
| Semantics                |     | SOM          | The set of behavior expected when interacting with the service. |

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The conceptual model of KEA is able to represent this very complex model as it is shown in Table 2. Direct contributors to the service (its provider and consumer) are WS-KEAs. The owner of the service is a higher-level KEA that specifies the policies over its services. Policy itself, along with two other SOM elements, i.e. Service Task-Actions, and Choreography, contains knowledge about “how” the service works.

Although, SOM includes the policy enforcement on the service or resource, but policy making and deciding on it belong to another model (Policy Model) that concentrates on the concepts of security and quality of service. In other words, the question, about “Why” some policy should be applied to a service, is out of the service model scope.

Two other elements of SOM as resource and goal state are, in some way, the input and output of the service and contain “what” type of knowledge for KEA. Finally, semantics element, as it is defined, contains knowledge type of “how” for the KEA to operate the service. Figure 8 sketches an equivalent conceptual model for SOM in the notions of WS-KEA conceptual model. All that differentiates WS-KEA from other KEA types is that its elements have fixed design and configurations.

The only flexible (configurable) element of SOM is policy that is established by the service owner. Therefore, the very simple while complete model of WS-KEA can be concluded as in the right-hand Figure 8. In the simple model, a WS-KEA is an agent who realizes the concept of service goal according to the established policy by its owner and provides it to every consumer.

5.2.1. Examples of WS-KEA
1. There are several concepts in medical domain that can be realized with WS-KEAs. Medical diagnostic tools such as “body thermometer,” “blood glucose meter,” “electrocardiography (ECG),” and several other medical test, imaging and scanning tools, all can be presented as WS-KEAs. Nowadays, such services are not imaginative and some of them are even commercial products.

2. All automobile controls such as accelerator, brake, and clutch pedals, and steering wheel can be provided as WS-KEAs. Again, such services have been gone much farther than technical feasibility and there are some commercial developments for them.

3. In crisis management domain, there are different sensors and actuators to be implemented as network reachable services, i.e. WS-KEA.

Several conceptualizations in the “Internet of Things” can meet the expectations of WS-KEA implementations.
5.3. Artificial intelligence KEAs, AI-KEA, as knowledge workers

Artificial Intelligence Agents especially as specified in terms of cognitive agents have rich inference powers on their environment, tasks and goals. These agents can be designed to perform complex tasks in order to achieve a desired goal in different conditions. This is somehow as described in the action level of activity, in which the subject pursues its desired goal consciously in different conditions.

Unlike a web service, which is specified officially by W3C, there is no official standard or model for intelligent agents. Nevertheless, there are common aspects in the most famous definitions brought for an Intelligent Agent. Wooldridge and Jennings (1995) bring a simple definition for an intelligent agent and repeat it in (Wooldridge, 2009, p. 15) as:

An agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives.

Padgham and Winikoff (2005), in their definition, emphasize on acting upon a goal according to the situation (conditions) in the environment. However, they mention the social nature of agent as its interaction with other agents.

Russell et al. (2010, p. 59) define an intelligent agent in their academic textbook for Artificial Intelligence (that is mentioned as the definition for intelligent agent in Wikipedia) as follows:

An agent is something that perceives and acts in an environment. The agent function for an agent specifies the action taken by the agent in response to any percept sequence.

The most important issues in the above definition are perceiving the environment and acting upon it. However, the main question is about the proper action for an agent according to the perceived environment. They mention it as what actually [the agent] wants in the environment or simply its goal in the environment.

As a general rule, it is better to design performance measures according to what one actually wants in the environment, rather than according to how one thinks the agent should behave. (Russell et al., 2010, p. 37)

However, there is a distance between the abstract or mathematical specification of the goal in the environment and the actual or implemented functionality of agent toward it.

It is important to keep these two ideas distinct. The agent function is an abstract mathematical description; the agent program is a concrete implementation, running within some physical system. (Russell et al., 2010, p. 35)

The main differences between a web service and an intelligent agent come from the nature and properties of their environments. Russell and Norvig mention different properties for the environments such as Fully observable vs. partially observable; Single agent vs. multiagent; Deterministic vs. stochastic; Episodic vs. sequential; Discrete vs. continuous; Known vs. unknown (Russell et al., 2010). In other words, a fully observable, single player, deterministic, episodic, discrete and known environment enables a service to be defined, developed, and provided with desired output in the specified conditions. As the environment moves toward a partially observable; multi player, stochastic, sequential, continuous, and unknown environment, the consciousness of the agent should be leveraged to make proper inferences and decisions about its actions.

In contrast with the environment, the agent itself has fully observable, single player, deterministic, episodic, discrete, and known behavior. So, the agent loses its control on the desired results in the environment and focuses only on its tasks with its sensors and actuators. Unlike web services, intelligent agents only set their behavior for the probability to achieve their goal, and there is no
guarantee on the generated output of the agent’s tasks in its environment. The more the knowledge and learning an agent has from its environment, the higher the probability to gain its goal.

Now, we can model an Artificial Intelligent-KEA as in Figure 9. It processes the sensed situation with respect to its desired goals in the environment and makes a decision about how to operate the actuators it owns. As in Figure 9, all the sensors and actuators of the AI-KEA are WS-KEAs (concept realizers); so, the AI-KEA works with two sets of realized concepts, sensed concepts form the environment and applicable concepts to it. All an AI-KEA should do is to relate these two sets of concepts according to its goal in the environment. This conceptual relation is another set of concepts as “how” artifacts that relate the sensed concepts to the applied concepts.

The main difference between WS-KEA and AI-KEA is the capability to decide about how to make this relation. This is the point that the third artifact type, “why” artifact, take the role. In other words, as it is shown in Figure 9, the sensed concepts along with the goal concepts in the environment determine the “why” artifact to be used. The “why” artifact in its turn deliberates the “how” artifact to be applied on the actuator concepts of the AI-KEA.

As in Figure 9, all the sensors and actuators of the AI-KEA are WS-KEAs, and its knowledge about environment’s behavior makes the relation between the sensor and actuator WS-KEAs’ behaviors. According to ATP3, as the automation level of the subject’s actions promotes, the goal-directed behavior is transformed into automated and conditional operations. Therefore, as AI-KEA’s knowledge about the environment’s behavior is promoted, the agent’s behavior moves toward a WS-KEA, and vice versa.

On a more abstract level, an AI-KEA can realize a concept in different ways (How concepts) with two sets of sense and act concepts (What concepts) according to a logic (Why concept) as shown in the right hand side of Figure 9.

5.3.1. Examples of AI-KEA
1. Diagnosis of a special disease, e.g. high blood sugar may have several procedures through different instruments. An AI-KEA with some of these instruments that knows how to use them in order to identify the disease is an example. Therefore, it realizes the concept of, e.g. “High blood sugar diagnosis”.

2. Stopping an automobile or reducing its speed may occur in several ways through multiple instruments (e.g., breaks, hand break, slowing down the gear, etc.). An AI-KEA may have the knowledge to use all or some of these instruments and realize the concept of “Stopping an automobile”.

Figure 9. Left: Conceptual model for an Artificial Intelligence-Knowledge Embodied Agent, AI-KEA; Right: Simple model of AI-KEA.
3. Finding a living human in a crisis environment may have several ways through different instruments. An AI-KEA equipped with such methods and tools can realize the concept of “finding a living human”.

5.4. Cognitive KEA, C-KEA as SPWeb weaver
In this level, every KEA needs to have two critical features. First, it should have an internal motive or high-level object as the starting point of an activity system. The second feature is the required knowledge of forming the activity system and its elements. At the first look, the second feature seems to be accessible for an AI-KEA, since it can contain every piece of knowledge. However, as Engestrom (2014) specifies an interrelated and evolving network of activities, such pieces of knowledge are too diverse in different knowledge domains and too evolving to be represented with a simple AI-KEA. However, the first feature of having motive, essentially is as far from the landscape of an AI-KEA as there are few intelligent agents to have motives even in Sci-Fi movies. Therefore, we agree that only human agents can take the role of Cognitive KEAs, at least in the accessible future.

Now, the most important problem is how to define these agents to prevent chaos or their very unpredictable behavior. Based on the mentioned ATP2 and ATP4, we define the object formation functions of this agent as Web Weaving (vertically and horizontally) to address this problem. However, these functions are not all the possible functionalities of a C-KEA, but they seem adequate to develop a conceptual model of the future web.

5.5. Vertical Web weaving (Object instantiation)
According to ATP1, every motive can act as a high-level object for an activity system. At the simplest form, a C-KEA should transform the object of activity (its motive) to a set of well-defined goals for AI-KEAs and develop the appropriate activity with the required elements. This brings down the activity to goal-directed actions, so we name it “vertical weaving.” Generally, based on ATP3, every high-level object (motive) can be transformed into a sublevel object that in turn can be transformed into another sublevel object. Finally, every object should be transformed to a set of goals for AI-KEAs. Every object in this hierarchy should be realized by an activity system with a C-KEA that can be the same C-KEA of the higher-level activity system or a new one.

According to ATP4, forming a sublevel object or even instantiating it with a set of goals is performed in an activity system. Therefore, a C-KEA uses a set of mediating artifacts as tools, rules and division of labor to form a sublevel object. According to ATP2, each mediating artifact is a piece of knowledge that the C-KEA should be proficient in it. However, these pieces of knowledge may be as explicit as to be represented by an AI-KEA. Figure 10 sketches a conceptual model for object instantiation.

Professional knowledge in every specific domain has such knowledge elements that take the role of a specialized language or jargon for that knowledge domain. This is where we address the shared knowledge platform or the common language between different C-KEAs that somehow prevents chaos and makes their behaviors merely predictable. These AI-KEAs (shared pieces of knowledge) reinforce and govern the way every C-KEA forms a sublevel object, while allowing it to apply its personal manner.

5.6. Examples of object instantiation
1. For a doctor to diagnose the state of a patient (the motive) there are several methods, such as getting the patient history, making simple experiments (such as body temperature, blood pressure, etc.) and so on. According to the initial symptoms and evidences (conceptual tools), the division of labor in a clinical setting, and the treatment rules and protocols, he would decide to apply one of the diagnosing tools (sublevel object/goal) or their combination.

2. To drive (motive) in a road, even on a straight path (governing rule), the driver should make several decisions about increasing or decreasing its car speed, to overtake other cars (sublevel
objects/goals), and so on, according to the observed and anticipated behavior of other drivers (division of labor).

3. To save people caught up in a crisis (motive) according to the type of disaster and priorities in that crisis type (rules) and his role in managing the crisis (division of labor) one should decide on what to do from different possible actions, i.e. “finding living humans,” “make alert notifications,” “help injured persons,” and so on (sublevel objects/goals).

5.7. Object construction (Horizontal Web weaving)
Not all motives or high-level objects can be directly transformed into a series of sublevel objects. Indeed, most of the objects are partially shared objects in a community of activity. Again, transforming a motive to a set of same level and complementary objects becomes possible through developing the appropriate activity system as depicted in Figure 11. This type of C-KEA functionality is more complex than the previous one. It usually not only consists of different professions but also requires knowledge and conceptual tools in the general domain of planning and management.

In other words, this type of weaving is only the function of some C-KEAs with high profession in their own domain along with planning and management capabilities, as well as powerful motives and deep insights. Moreover, as in vertical weaving, the explicit knowledge pieces in both the main profession and discipline of planning and management can be represented by appropriate AI-KEAs. Again, these AI-KEAs reinforce and govern the way a C-KEA constructs complementary sublevel objects. Operational research methods, strategic planning concepts and tools, and negotiation techniques and skills are some examples of the appropriate disciplines to support this function.

5.8. Examples of object construction
1. Performing diagnosis tasks may require the doctor to deliberate several sublevel objects, such as professional experiments and different medical imaging. Such tasks urge other clinical personnel to participate in realizing some of the objects.

2. The driver of a car with an object “to go to a destination” needs to break that into several sublevel objects (e.g., checking the traffics, choosing the path, driving in a highway, overtaking a car, driving in a busy street, encountering an accident and altering the path, etc.). All of these
sublevel objects may require other drivers to participate in realizing that object. For example, overtaking a car requires the other driver to acquire awareness, getting off the path, probably slowing down, etc.)

3. Managing a crisis as a motive requires different sublevel objects to be deliberated for realization. For example, it requires saving humans, controlling the source of disaster, preventing the crisis to spread, and so on. All of these objects require other members of the team to participate in realizing the object by realizing some other sublevel objects.

6. KEA-Weaved SPWeb and future Web principles
We developed a conceptual model for a Socio-Pragmatic Web based on the principles and concepts of Activity Theory. Now, it is time to inspect the model according to the future web principles concluded in Table 1 and show if the model satisfies the concluded principles. Table 3 summarizes the results of this inspection. In the Table 3, all the three levels of SPWeb satisfy all the five principles of the future web.

In other words, SPWeb in three layers is inherently diverse, distributed, socially contributed, knowledge-foundation for practice, and a development platform for the context in its broader meaning.

7. Conclusion and further works
This paper provides a conceptual model for the future Web (that we call it Socio-Pragmatic Web or SPWeb). World Wide Web as a unifying environment for the diverse and distributed content types in the Internet continued its way to Web 2.0 or Social Web with the notion of social contribution in content provision. Web 3.0 or Semantic Web on the other hand is an effort to link different contents based on their meanings and continued with Web 4.0 or Pragmatic Web to promote this meaning to the usage level. In this paper, we studied the development path and derived five common principles for the future Web as diversity, distribution, social contribution, knowledge in use, and context development platform.

Satisfying these principles needs a powerful theoretical basis that covers all the concepts of Web generations. Therefore, we introduced and used Cultural Historical Activity Theory (CHAT) as a theoretical basis. Human activity as a whole unit, mediation as knowledge packages, activity hierarchy, and object formation are briefly introduced from the AT literature. These principles provide the required basis to develop a conceptual model for the SPWeb. SPWeb
Table 3. SPWeb compliance with the derived principles of the future web

|                | P1-Diversity                                                                 | P2- Distributed                              | P3- Social Contribution                      | P4- knowledge in Use                       | P5- Context Development Platform          |
|----------------|------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------|--------------------------------------------|------------------------------------------|
| WS-KEA         | Every device in every usage domain can be a WS-KEA                         | Several devices spread over the globe, can contribute in realizing a single concept | Humans as service owners can contribute in the way a service is provided by setting the policy for a single WS-KEA | Every WS-KEA is a knowledge package that realizes a concept to be used by other Web participants | Every single WS-KEA represents a tiny part of the context and they altogether develop the lower layer of context |
| AI-KEA         | Diverse plans for every AI-KEA to realize a concept                        | Every element of an AI-KEA model can be resided everywhere in the web | Human agents (C-KEAs) set the goals for an AI-KEA | AI-KEAs can be the richest packages of explicit knowledge that works | The more AI-KEAs to realize new concepts, the broader and deeper the context to be developed |
| C-KEA          | As much as several billions of unique users (as humans)                   | Nobody owns all the human knowledge while everybody can add a piece to it | Every activity in SPWeb is inherently community-based and a social phenomenon | Every single piece of knowledge in the C-KEA level is used in an activity and cannot be found outside it. | The highest level of context (human level, or society) can be developed through horizontal and vertical weaving |

A conceptual model is constructed by knowledge entities in different levels of consciousness from humans down to machines. Therefore, the conceptual model has a main building block as Knowledge-Embodied Agent, KEA in three different types.

The first KEA type is WS-KEA that contains all the required knowledge to provide a web service in the machine level. Regarding the Service Oriented Model, provided by W3C, we showed that proposed conceptual model for WS-KAE covers all the elements and relations in the SOM. The second type of KEA as AI-KEA is introduced and its conceptual model is proposed. IA-KEA uses WS-KEAs to interact with its environment and it has the ability to tune their behavior. However, AI-KEA needs a higher-level KEA to define its goal to be pursued in the environment. The third type as C-KEA is a professional human that can use AI-KEAs to realize his or her motive.

C-KEA has two main capabilities, object instantiation and object construction. In object instantiation, C-KEA develops a series of goals/AI-KEA as the equivalent to his or her object. In object construction, C-KEA uses AI-KEAs to develop a network of sublevel objects to be realized by other C-KEAs. Object instantiation and construction resembles vertical and horizontal weaving functions for the web, respectively.

Finally, it is shown that SPWeb conceptual model takes the role of an overall vision for the future web as it satisfies its requirements. The next steps to developing such a web is to provide methodologies for the development of three KEA types as well as to candidate or develop the required technologies for their implementations. The other important aspect of SPWeb development is the required methodology for knowledge extraction and representation for the three KEA types. In addition, the first and vague format of their knowledge according to the web services and intelligent agents' specifications has been introduced and discussed.
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