imagining Library 4.0: Creating a Model for Future Libraries

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Abstract

Purpose: The purpose of this paper is to suggest a Library 4.0 model based on the concepts of Library 4.0 discussed in the literature as the future of library service. The concepts and model of Library 4.0 can be adapted to fit every different kind of library.

Design/Methodology/Approach: For this purpose, first, major reference databases (e.g., Google Scholar, EbscoHost, LISA, etc.) were examined for literature that discusses Web 4.0 and Library 4.0. Second, examples of information technology environments as well as studies and news articles related to information technology were comprehensively collected and analyzed by focusing on those which may influence libraries. Third, examples of cutting-edge information technology applied in libraries were examined and analyzed. Other examples were found of cutting-edge information technologies that have not yet been used in libraries but would be applicable to the next-generation library. Fourth, this study developed a model for next-generation library service provided by Library 4.0 and representative keywords explaining Library 4.0.

Findings: First, opinions of scholars tracking the rise of Web 4.0 vary widely, but Web 4.0 features commonly suggested by previous researchers are: reading, writing, and executing simultaneously, intelligence-based agents, connected web, ubiquitous web, intelligence connections, and intelligence-based web. Secondly, this study determined the features of Library 4.0 as: intelligence-based, massive data, augmented reality, context aware, cutting-edge displays, and infinite creative space. Third, in this context, the keywords that best explain Library 4.0 are: Intelligent, Makerspace, Context-Aware Technology, Open Source, Big Data, Cloud Service, Augmented Reality, State-of-the-art Display, and Librarian 4.0.

Originality/Value: Discussions about Web 4.0 have begun, but little has been written about Library 4.0. This study is significant for deriving keywords for Library 4.0 and presenting the development direction of Library 4.0. In the future, research on Library 4.0 can actively proceed from this starting point.

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Introduction

The LIS field has seen discussions of Library 3.0 for the past 10 years. The development stages of various library iterations have been continually researched by scholars and analyzed by field librarians as new digital technologies allow for large-scale changes in a short amount of time. Libraries, by nature, are very similar to living organisms in that they are influenced by external pressures to constantly evolve, including in this case, changing information technology environments and a greater reliance on web-based services.

The age is fast approaching when technology and humanity will merge and become one (Rohrbeck, Battistella, & Huizingh, 2012). Passive entertainment such as television in its current form represents the 1.0 age, while Web 2.0 represents an age of content created by users, such as blogs and podcasts (Kirschner & Muller, 1987). Web 3.0, then, is the ongoing era of users jumping into media, using virtual worlds and becoming more active. In the future, Web 4.0 will be when humans are upgraded with technological extensions, always connected to the internet (“always-on”) (Farber, 2007). That era has already started for the younger generations alive today, who already communicate with the web in the same way that they would talk to their friends (Kirschner & Muller, 1987). The online space and the physical space are not as differentiated for them as for generations past.

Web 3.0 represents data and analysis filtered through artificial intelligence, while Web 4.0 technology will become one with users’ lives (Callari, 2009). Codin (2007) lists three conditions for constructing Web 4.0: ubiquity, identity, and connection. “Ubiquity” refers to the lines between offline and online life becoming blurred, with users connected to Web 4.0 at any time and place. “Identity” means specific protocols will exist to determine efficiently who the users are, what they are doing, and what kinds of things they need. “Connection” means a continuously connected network of users. Codin predicts that, once Web 4.0 is constructed, unwanted information like spam emails will disappear and only information needed by users will be provided because, unlike versions of the web in the past where users wander from place to place in a sea of information when searching, Web 4.0 will only provide information suitable for users by integrating all the
known data about their identity. For example, customers passing by a particular store will be identified, and personalized advertising messages for each person will display for them as they pass.

Library 3.0 or 4.0 will not only reflect the changing nature of the web as described above, but it will also feature new attributes based on the uniqueness of libraries. Noh (2010) said Library 3.0 will combine the concepts of a social semantic digital library, linked library, and mobile library, while Kruk, Decker, et al. (2007), Kruk, Woroniecki, Gzella, Dabrowski, & McDaniel (2007) and Aloaibi (2010) emphasize the social semantic library as a 3.0 library. In light of the services presently provided by libraries, we are already living in the era of Library 3.0, and it seems appropriate to begin a discussion of Library 4.0.

While substantial time has passed since the discussion of Web 4.0 started, it is difficult to find studies suggesting models for Web 4.0 and predicting its features. However, considering the discussions of Web 4.0 made by researchers, some concepts have already been introduced to libraries, beginning to constitute Library 4.0, and other concepts are still being actively discussed in advance of being applied to libraries. However, these discussions are fragmentary and not embracing Library 4.0 as a whole. Therefore it is necessary at this time to start a discussion on Library 4.0 to predict the direction of and strategies for development of future libraries so that future librarians can play a leading role in responding to the era of Web 4.0.

Technology keeps making great leaps forward, meaning that today most people have access to devices that were only the stuff of science fiction in the films of ten to thirty years ago. It is imperative that library development stays abreast of these fast-moving trends. Accordingly, this paper suggests a Library 4.0 model based on the concepts of Library 4.0 discussed in the literature and the aspects that have already been applied in some contexts. The concepts and model of Library 4.0 can be adapted to fit every different kind of library.

RELATED WORKS ON LIBRARY 4.0

Many scholars have suggested developmental directions for future libraries. In particular, when a new concept or technology appears and massively influences society at that specific point in time, researchers present forecasts for how it will influence libraries and how libraries will develop thereafter. In this study for suggesting a library model, the first step was naturally an attempt to analyze all of the available research. However, it was discovered that there are few studies available specifically on the topic of Library 4.0. Thus, considering that Library 4.0 is a form of next-generation digital library, this study focuses on examining the papers suggesting models of next-generation digital libraries.

First, there are studies classifying and examining the features of digital libraries from their first generation to the present and suggesting development directions for the next-generation libraries. Greenstein and Thorin (2002) focused on the experiences of premier research libraries in the USA and comprehensively discussed the essential challenges faced by digital libraries as well as how cultural, legal, and financial support would influence the history and development directions of digital libraries in the future.

Almost 5 years before Greenstein, Mukaiyama (1997) argued that digital libraries will hold a central place in the 21st century and technologies making up the next-generation digital libraries will be three-system architecture (integrated messaging system, electronic agents, multimedia database, and application system), individual technologies (digitized literature, smart search engines, SDI agents, concept-based search, hypermedia search, and concept-based video search using 3D visualization), and integration technology (for instance, content recording structures). These technologies have already been applied to libraries.

Kroski (2009) listed the defining features of present-iteration digital libraries as mobile (new services and basic technologies, mobile content and new transmission formats, and mobile apps), social (social and library websites, attractive user experience, and cooperation with community businesses), and open (open source applications and open content). Kroski also predicted that essential areas of next-generation digital libraries would be the semantic web, grouping, cloud computing, life streaming (online recording of daily life by collecting blog comments or online photos and directly shooting videos), and filtering. Therefore, the elements Kroski forecasted for next-generation digital libraries (NGDLs) roughly match those ascribed to Web 4.0 to some degree.

Breeding (2011) argued that plans in preparation for future libraries are essential for fully utilizing new technologies as soon as possible to avoid obsolescence. As he pointed out, up to now, changes in libraries have been in terms of formats (digitalization and adoption of various multimedia) and affluent convergence (lack of boundaries between equipment and content formats). RFID systems, which presently allow automatic and simple handling of physical materials, may lose their value. However, he was not able to forecast which technology would play a significant role in the library's future.

Piper (2013), in his paper regarding the future digital nature of libraries, referred to a project conducted by Hathitrust (hathitrust.org) and DPLA (Digital Public Library of America) as a model which may become a guideline for constructing massive libraries in the next 15 years. The project will be conducted based on a shared system, metadata, and digitalized contents. The project is very similar to Google's digital books endeavor (GoogleBooks) except without the commercialization aspect. The process is the same: 1) providing search tools for the virtual catalogs available, 2) expanding the scope for all books written in all languages, and 3) user-based systems for helping users find new books. Cooperation between organizations on such a massive scale has not been possible before.

McGettigan (2013) introduced examples of construction of NGDLs and information services, hybrid libraries combining traditional libraries and virtual ones providing virtual reference service, personalized OPACs, 24-h service, and downloadable media. The revolutionary service spirit of next-generation digital libraries is based around the ideals of space for free community networking, technological resources provided free of charge, connections with the local economy, a sense of belonging to community, and promoting a high level of trust in the local community. Other such efforts have been made by public libraries, notably the Chattanooga Public Library and the Willingboro Public Library.

The ALA has provided examples of applying cutting-edge technologies to library services since 2009, and in 2013 evaluated the most innovative ones among them as mobile internet, cloud sourcing, open source development, and cost effective online education (ALA, 2013a, 2013b, 2013c). The ALA also selected five outstanding cases of institutions applying these revolutionary technologies to libraries. Among those cases, Corcoran Library (Boston College High School Library in Massachusetts) allowed all students to access the library's online resources through their mobile sites and developed applications which become optimized for mobile search. The library announced that it will develop archives and a virtual reality tour available through QR code (ALA, 2013a, 2013b, 2013c). In 2014, excellent examples selected by the ALA were: 1) “Creative Solution”, a digital sign board system, 2) “Me Card Technology” which allows users to access all the libraries connected through one card, 3) a system under which the users and the department of archives can upload open stories of new library construction through photo and video streams, and 4) simple video creation systems (ALA, 2014).

In addition, there are many studies discussing innovative changes in the contents of books in NGDLs. Among them, Crane et al. (2006) conducted research modeling of NGDLs and discussed groundbreaking changes in the content of books. The limit of NGDLs, he concluded, is based on existing print versions. He also described necessary features of future digital collections as: sophisticated screen design, voluntary learning, and real-time community participation. He asserted that,
based on books having those features, customized services and per-
sonalized services will become available. After analyzing the previous re-
search, it is apparent that the keywords and concepts which should be
included in Library 4.0 are semantic web, cloud computing, life string
(Kroski, 2009), virtual reality of the open source library (ALA, 2014),
and virtual library (Chow et al., 2010).
In this section, the literature of Library 4.0 based on Web 4.0 was
examined. The concepts and development process of Web 4.0 and
Library 4.0 will be discussed further in later sections.

RESEARCH PROCESS AND METHOD

RESEARCH METHOD

The aim of this paper is to discuss possible development directions
for Library 4.0, using the research content that follows (Fig. 1).
First, all literature available on major reference databases
(e.g. Google Scholar, EbscoHost, LISA, Korean databases, etc.) that
discusses Web 4.0 and Library 4.0 was collected. The keywords used
for searching were Web 1.0, Web 2.0, Web 3.0, Web 4.0, Library 1.0
through Library 4.0, NGDLs (next generation digital library), and
many individual kinds of cutting-edge technologies. Literature was
then categorized by each web or Library iteration number, and by
cutting-edge technologies.
Second, examples of information technology environments as
well as studies and news articles related to information technology
were collected and analyzed by focusing on those which may influence
libraries.
Third, cutting-edge information technology applied to libraries were
examined and analyzed. Also, some cutting-edge information technolo-
gies which have not yet been used in libraries but would be applicable to
the next-generation library were discovered.
Fourth, this paper developed a model for next-generation library
service consisting of Library 4.0 and representative keywords explaining
Library 4.0 (Fig. 5).

RESEARCH QUESTIONS

This paper intends to analyze trends of information technology as
well as their social and cultural environments, comprehensively analyze
research papers discussing Web 4.0 or Library 4.0, and forecast the
future design of Library 4.0. A secondary goal is to identify keywords
explaining Library 4.0 and the services it will provide. The research
questions raised by this process are as follows:
RQ 1: How advanced are current discussions of Web 4.0?
RQ 2: What do researchers suggest will be key features of Web 4.0?
RQ 3: What will be major keywords explaining Library 4.0?

DEVELOPMENT OF WEB 4.0 MODEL

DEVELOPMENT OF WEB 4.0

According to Berners-Lee (2006), Web 1.0, as the first generation
of the internet, was not just read-only content but also a recognition
system. Web 1.0 started as a sort of information space informing people
of data for business with very limited interactions between users and
almost no content creation. Information search and information
consumption were the main activities available at that time.
Hassanzadeh and Keyvanpour (2011) said that Web 3.0, or the sem-
antic web, reduces the amount of time and decision-making required
from users with machine-readable content that allows the system to do
most of the work. Web 3.0 includes two platforms: a semantic techno-
logical environment and a social computing environment. The semantic
web represents open standards, and social computing allows coopera-
tion between human users and machines so that massive social com-
munities can be effectively organized (Norasak, 2008). Web 4.0 will be
a “read, write, execute, and concur web” where intelligent interaction
is available. Web 4.0 will be a more symbiotic web where human
users and machines have more personal interactions.
Fowler and Rodd (2013) said that “ultra-intelligent electronic
agents” will be the defining feature of Web 4.0, and they also summa-
rized characteristics of Web 1.0 through Web 2.0 and insisted that the

Fig. 1. Research method and process.
development between generations has come faster and faster, with each generation having a shorter lifespan. In other words, one of the most prominent features of Web 1.0 were search engines, such as Yahoo in the early 1990s. Web 2.0’s defining characteristic was social media, such as Wikipedia, a cooperation project, and SNS (social networking sites) such as Facebook and Twitter. Web 3.0 is most commonly known for the “3D Web” based on fast computer processing and the rapid development of network and storage (Burrus, 2013).

Burrus (2013) argued that super-smart electronic agents embedded with small cameras can identify the user and may be able to manage all aspects of daily life for the user from the moment of waking up in the morning, just like a secretary or friend. However, just as we cannot predict the exact concepts for next-generation smart phones until they are developed and unveiled, so too is it impossible to know the exact image of Web 4.0, as it will look in the future. He also added that, just as we predict wearable smart phone technology may become popular soon, Web 4.0 is expected to have a similar performance capacity. Burrus also summarized succinctly that Web 1.0 was for search, Web 2.0 was for social media, Web 3.0 is for the 3D Web, and Web 4.0 will open the era of smart agents.

Kang and Yong (2007) wrote that Web 1.0 brought about the concept of information connection, while Web 2.0 is characterized by the concept of allowing creation, storage, evaluation, and sharing of information through users’ active participation. Web 3.0, the semantic web, is a web where data and knowledge are connected based on intrinsic meanings rather than just links of information, and Web 4.0 will represent an upgraded, higher level intelligence on the part of technology, and a ubiquitous web based on a web operation system under which everything is connected, such as an “Internet of Things”.

Chauhan (2009) said that Web 4.0 will have a structure which not only includes all services and functions, but is supported by artificial intelligence, i.e., the web will be able to analyze information, discuss with other people interested in the same areas, and create new ideas or theories. Web 4.0 will be able to let researchers know information suitable to their research and discussions carried out through the internet or mobile devices even when they are in a different place.

Skryabina (2010) compared the features of Web 1.0 through Web 4.0: Web 1.0 represents an era of availability of information delivery. Web 2.0 represents an era allowing interaction between users. Web 3.0 is the era when direct cooperation is available for a new start. Web 4.0 represents a generation-changing concept to make society a better place through innovation.

Aghaei, Nemmatbakhsh, and Farsanini (2012) discussed the development of Web 1.0 through Web 4.0, and they defined them as follows: Web 1.0 as a web of information connection, Web 2.0 as a web connecting people, Web 3.0 as a web connecting knowledge, and Web 4.0 as a web connecting intelligence.

Patel (2013) introduced and compared the features of each generation of Web 1.0 through Web 5.0 and tried to analytically suggest development directions for the web. He suggested a classification of web generations: Web 1.0 as an awareness web exclusively for reading; Web 2.0 as human-centered participation web for reading and writing; Web 3.0 as a knowledge connection web for reading, writing, and executing; Web 4.0 as an ultra smart electronic agent for reading, writing, and executing; and Web 5.0 as a web appealing to feelings and emotions.

Sharma (2012) described Web 1.0 as a one-dimensional web; Web 2.0 as a social web; Web 3.0 as a semantic web; and Web 4.0 as an intelligent web. From the point of view of data volume and search ability, he explained the webs as described in the following diagram. As we see in Fig. 2, while the data volume rapidly increased until Web 2.0, afterward it began to decrease. Search support functions developed from keyword search to tagging, natural language search, semantic search, and inference; inference search became available when the world entered into the era of Web 4.0.

Web 4.0, as described from the results of the research mentioned above, is: reading, writing, and simultaneous execution (Aghaei et al., 2012; Patel, 2013), ultra-intelligent electronic agents (Fowler & Rodd, 2013), an Internet of Things (Kang & Yong, 2007), an intelligent web (Chauhan, 2009; Sharma, 2012), and an intelligent connection web (Aghaei et al., 2012). Based on the various research (Patel, 2013), the development of web versions can be organized and characterized as in Table 1.

The next chapter will conduct a comprehensive analysis of these discussions and suggest a model for Web 4.0.

WEB 4.0 MODEL

As is shown above, many researchers have begun a discussion of Web 4.0, but its exact definition has not yet been decided. However, based on the views of scholars, various keywords and features are usually agreed upon. For example, Godin (2007) suggested three conditions for Web 4.0: first, “ubiquity,” meaning ubiquitous computing connecting with Web 4.0 at any time and place; second, “identity,”
meaning personalized services to be provided by identifying the context of users; and, third, “connection,” meaning consistent connection with other users. He referred to Apple’s iPhone as a service model similar to Web 4.0.

In addition, major keywords shown to be related to Web 4.0 in the terminology cloud are Convergence, Remixability, Standardization, Participation, Usability, Economy, and Design. However, we also can see that the concepts for Web 1.0 through Web 3.0 like Semantic, Open APIs, AJAX, CSS, RSS, and Social Software also appear (Fig. 3).

As described above, representative features of Web 4.0 are referred to as a symbiosis web, reading, writing, and executing simultaneously, web OS, middleware, and a massive web allowing intelligence interaction just like a human brain. While a clear definition of Web 4.0 has not yet been agreed upon by researchers, we can see that it will be a web using artificial intelligence. In this chapter, I would like to examine essential concepts of Web 4.0.

**SYMBIOTIC WEB**

Notwithstanding an accurate definition, many people refer to Web 4.0 as a symbiotic web, due to the interaction between human users and machine components as resembling a symbiotic relationship. Web 4.0 technology will have a stronger interface than our current user-controlled models so that the machine becomes able to make decisions and properly execute them based on the content it reads itself (Hemnath, 2010). Patel (2013) also discussed the likelihood of Web 4.0 involving sophisticated user interfaces for human–technology interactions to become more symbiotic. Aghaei et al. (2012), too, wrote about Web 4.0 as a symbiotic web where humans and machines can cooperate and interact with each other.

**WEB OS**

One of the early mentions of the concept of Web 4.0 appeared in the international symposium of “Semantic Technology” held in San Jose, California in May 2007. At this symposium, Web 4.0 was defined as an upgraded to a higher state of intelligence and a ubiquitous system based on a web operation system under which everything is connected, dubbed an “Internet of Things” (Kang & Yong, 2007).

**READING, WRITING, AND EXECUTING SIMULTANEOUSLY**

Marcus (2008) said Web 4.0, with the ability to read, write, and execute simultaneously, will provide global transparency, governance

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**Table 1**

<table>
<thead>
<tr>
<th>Web 1.0</th>
<th>Web 2.0</th>
<th>Web 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>2006</td>
<td>2016</td>
</tr>
<tr>
<td>The web</td>
<td>The social web</td>
<td>The semantic web</td>
</tr>
<tr>
<td>Tim Berners Lee</td>
<td>Tim O’Reilly</td>
<td>Sir Tim Berners Lee</td>
</tr>
<tr>
<td>Read only web</td>
<td>Read and write web</td>
<td>Read, write and execute web</td>
</tr>
<tr>
<td>Information sharing</td>
<td>Interaction</td>
<td>Immersion</td>
</tr>
<tr>
<td>Millions of users</td>
<td>Billions of users</td>
<td>Trillions of users</td>
</tr>
<tr>
<td>Echo system</td>
<td>Participation</td>
<td>Understanding self</td>
</tr>
<tr>
<td>Connect information</td>
<td>Connect people</td>
<td>Connect knowledge</td>
</tr>
<tr>
<td>Brain and eyes (= information)</td>
<td>Brain, eyes, ears, voice, and heart (= passion)</td>
<td>Brain, eyes, ears, voice, heart, arms, and legs (= freedom)</td>
</tr>
<tr>
<td>The hypertext/CGI web, (the basic)</td>
<td>The community web (for people: apps/sites)</td>
<td>The semantic web (for machines)</td>
</tr>
<tr>
<td>Pushed web, text/graphics based flash</td>
<td>Two-way web pages, wikis, videos, pod casts, shading, personal publishing, 2D portals</td>
<td>3D portals, avatar representation, interoperable profits, multi-user virtual environment (MUVEs), integrated games, education and business, all media flows in and out of virtual web worlds</td>
</tr>
<tr>
<td>Companies publish content that people consume (e.g. CNN)</td>
<td>People publish content that other people can consume, companies build platforms that let people publish content for other people (e.g. Flickr, YouTube, AdSense, Wikipedia, Blogger, MySpace, RSS, Digg)</td>
<td>People build applications that people can interact with, companies build platforms that let people publish services by leveraging the associations between people or special content (e.g. Facebook, Google Maps, My Yahoo!)</td>
</tr>
<tr>
<td>Search engines retrieve macro contents. Search is very fast but many times results are inaccurate or overwhelming</td>
<td>Search engines retrieve tags with macro contents. (Furl even retrieves tags with macro contents). The process of tagging is manual, tedious, and covers negligible percents of the <a href="http://WWW">WWW</a>. Web 2.0 tags everything: pictures, links, events, news, blogs, audio, video, and so on. Google Base even retrieves micro content texts.</td>
<td>Search engines will retrieve micro content texts which were tagged automatically. This implies translating billions of Web 1.0 macro contents into micro contents. The result could be more precise search because tagging can solve part of the ambiguity that homonyms and synonyms introduce into the process of search.</td>
</tr>
<tr>
<td>Static content, one way publishing of content without any real interaction between readers or publishers or each other</td>
<td>2 way communication through social networking, blogging, wikis, tagging, user generated content, and video.</td>
<td>Undefined. Ai and the web learning what you want and delivering you a personalized web experience.</td>
</tr>
<tr>
<td>The web in the beginning when it was first developing</td>
<td>New advances that allow a much more sophisticated user interaction with web pages — citizen journalism, social networks and Wikis</td>
<td>Thought to be the future — where the web is more interactive with users, leading to a kind of artificial intelligence</td>
</tr>
<tr>
<td>Personal web sites</td>
<td>Blogs</td>
<td>Semantic blogs: SemiBlog, Hasystack, Semblog, Structured Blogging</td>
</tr>
<tr>
<td>Content management system</td>
<td>Wikis, Wikipedia</td>
<td>Semantic wikis: Semantic MediaWiki, SemperWiki, Platypus, dSpace, Rhizome</td>
</tr>
<tr>
<td>AltaVista, Google</td>
<td>Google personalized, DumpFind, Hakia</td>
<td>Semantic search: SWSE, Swoogle, Intellidimension</td>
</tr>
<tr>
<td>Citeseer, Project Gutenberg</td>
<td>Google Scholar, Book Search</td>
<td>Semantic digital libraries: JeromDI, BRICKS, Longwell</td>
</tr>
<tr>
<td>Message boards</td>
<td>Community portals</td>
<td>Semantic forums and community portals: SIOC, OpenLink DataSpaces</td>
</tr>
<tr>
<td>Buddy Lists, Address book</td>
<td>Online social networks</td>
<td>Semantic social networks: FOAF, PeopleAggregator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Semantic social information spaces: Nepomuk, Gnowsis</td>
</tr>
</tbody>
</table>

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![Fig. 3. Web 4.0 keywords](resource: http://www.brainiac.in).
structure, distribution, participation, and cooperation to major aspects of society such as industry, politics, and local communities in online networks to maximize participation. In other words, Web 4.0 will ensure global transparency through users’ simultaneous participation online.

**MASSIVE WEB**

Web 4.0 has also been described as a kind of middleware functioning between software and operating systems (Callari, 2009) and a massive web of highly intelligent interactions much like a human brain (Farber, 2007).

**INTELLIGENT WEB**

Many scholars explain Web 4.0 as a kind of intelligent web. Sharma (2012) wrote that Web 4.0 is an intelligent web, able to make inference searches, i.e., Web 4.0 uses artificial intelligence to make a decision, using inference and searched content. This decision will be made based on the system learning over time how we live and what we want. Patel (2013) also defined Web 4.0 as an ultra intelligent electronic agent, symbiotic, ubiquitous, and, in particular, a machine which will be developed up to the level of a human brain, with advanced nanotechnology and human interaction interfaces. Accordingly, the machine in the era of Web 4.0 will be so smart that it will be able read the web content, make and execute decisions on websites, and have a more or less order-oriented interface (Jenkins, 2011).

Fowler and Rodd (2013) and Burrus (2013) agreed that “ultra-intelligent electronic agents” were key features of Web 4.0, where the web itself will analyze information, discuss it with interested people, and create new ideas or theories. In this way, Web 4.0 will be able to provide information suitable to ongoing research or discussions to researchers through internet or mobile devices even though they are in different places (Chauhan, 2009).

**LIBRARY 4.0 MODEL**

**DEVELOPMENT OF LIBRARY VERSIONS**

Library 1.0 is associated with Web 1.0 in the same way Library 2.0, 3.0, and 4.0 are linked to their corresponding versions of the web. A huge body of research discusses library versions in the field of Library and Information Science. The term “Library 1.0” began to be used for comparison when the term “Library 2.0” was introduced by Michel Casey.

Library 2.0 refers to the application of Web 2.0 tools to library services. Library 2.0 is generally perceived as the application of the interactive, collaborative, and multimedia web-based technologies to library services and collections (Maness, 2006). Farkas (2005) explains that Library 2.0 is about allowing user participation through writing reviews and tagging in the catalog and making users’ voices heard through blogs and wikis. She insisted that the Library 2.0 makes the library human, ubiquitous, and user-centered. Library 2.0 is a transition within the library world in which programs and services are delivered to the users through new and innovative methods (Cho, 2012; Sanzo, 2008). Cho (2012) said that the principles of Library 2.0 are “entirely” user-centered and that they facilitate seamless collaboration between the users themselves to create community content using new communication technologies.

The Library 2.0 is the library which is everywhere (Casey, 2007; Chad & Miller, 2005; Stephens, 2005). The library has no barriers, information resources managed by Library 2.0 are readily available, and barriers to use them are minimized (Chad & Miller, 2005; Stephens, 2007). Library 2.0 invites and facilitates the culture of participation (wikis, blogs, RSS and social bookmarking systems facilitate), drawing on the perspectives and contributions of staff, technology partners, and the wider user community (Miller, 2006; Chad & Miller, 2005; Miller, 2005; Stephens, 2007). Library 2.0 uses flexible best of breed systems, requires a new relationship between libraries and a wide range of partners in which all parties together push the limits of what is possible while ensuring that core services continue to operate reliably (Chad & Miller, 2005; Crawford, 2006).

Belling et al. (2011) explain that the term Library 3.0 refers to the use of emerging technologies such as the semantic web, cloud computing, mobile devices and established tools like federated search systems, to facilitate the development, organization and sharing of user-generated content through seamless collaboration between users, experts and librarians. Kwan, Stilwell, and Underwood (2013) defined Library 3.0 as intelligent, organized, a federated network of information pathways, apomediated, and “my library”.

It is generally accepted that Library 1.0 represents the conservative traditional library in which the users are passive. Library 2.0 represents a major departure from the conservative library service model and emphasizes the participation of the users to the extent that the librarians are eclipsed. Library 3.0 seems to be a hybrid between the 1.0 and 2.0 models and reasserts the librarians in the information value chain as mediators. The following Table 2 is a comparison of the library versions derived through the analysis of concept definitions and research papers on Library 1.0, Library 2.0, and Library 3.0.

**EXAMPLES OF APPLYING CUTTING-EDGE TECHNOLOGIES TO LIBRARIES**

This paper is likely to become the starting point for discussions of Library 4.0. As seen in previous research, many scholars have discussed the development stages of libraries. In other words, in the initial stage, researchers focused on organizing the contents of libraries to be more next-generation oriented, while later research focused on designing futuristic digital libraries connecting with external trends such as Twitter and Facebook. In particular, discussions of Library 3.0 seem to focus on the semantic concept. Oh and Won (2007) defined a digital library as a SSDL (Social Semantic Digital Library), which consists of an ontological system and actively supports the participation and cooperation of users while possessing the essential requirements and architecture models required for the digital library. They divided those requirements into functional requirements and structural requirements. Functional ones include providing significance-based services, providing various points of entry, support of group intelligent activities, and efficient management of information resources. Structural requirements are modularity, significance-based networking, and protection of resources and copyrights. Alotaibi (2010) analyzed the development stages of libraries, discussed the concept of the social semantic digital library, and researched the integrity of social and collective aspects of libraries. Kruk and others conducted studies on SSDL and tried to identify the true nature of SSDL (Kruk, Decker, et al., 2007; Kruk, Woroniecki, et al., 2007). In this study, the researchers analyzed how the semantic web and social networking technologies can support the improvement of digital library services. In addition, through suggesting SSDL structure, Kruk et al. tried to describe various services based on those technologies. Discussing the concept and true nature of Web 3.0, Noh (2010) wrote that the discussions of those concepts have been conducted by a number of scholars and on-site experts in recent years, who analyzed various discussions of Library 3.0, and organized the various proposed concepts for it. Based on these, she suggested models of Library 3.0 services, and the key concepts are: 1) a social semantic digital library where “genuine knowledge sharing and cooperation” is available thanks to the application of semantic web technology, which makes machine data processing and social networking services available to electronic libraries, 2) linked libraries where the library resources become linked data and connect with other libraries all around the world, and 3) ubiquitous mobile libraries with RFID and mobile technology.

However, Library 4.0 must include not only software-based approaches but also technological environment development such as makerspace, Google Glass, context aware technology, digitalization of contents, big data, cloud computing, and augmented reality.
### Table 2

<table>
<thead>
<tr>
<th>Library versions</th>
<th>Library 1.0</th>
<th>Library 2.0</th>
<th>Library 3.0</th>
<th>Library 4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related technologies</td>
<td>Personalized, customized</td>
<td>Bi-directional, public</td>
<td>Semantic technology, artificial intelligence, context-awareness, cloud computing</td>
<td>Intelligent library</td>
</tr>
<tr>
<td>Interaction</td>
<td>Information consumption</td>
<td>Reproduction through user participation</td>
<td>Information sharing and openness</td>
<td>Participation, sharing, and openness</td>
</tr>
<tr>
<td>Knowledge, Providing information</td>
<td>Library-centric production</td>
<td>Library-centric production</td>
<td>Library-centric production</td>
<td>Library-centric production</td>
</tr>
<tr>
<td>Information users</td>
<td>Read, write</td>
<td>Read, write</td>
<td>Read, write, execute</td>
<td>Read, write, execute</td>
</tr>
<tr>
<td>Keywords</td>
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<td>MARCXML, MODS, MARC</td>
<td>MARCXML, MODS, MARC</td>
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<tr>
<td>Corresponding terminal</td>
<td>PC, Mobile</td>
<td>PC, Mobile</td>
<td>PC, Mobile</td>
<td>PC, Mobile</td>
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<tr>
<td>Knowledge structure</td>
<td>Metadata</td>
<td>Metadata</td>
<td>Metadata</td>
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<tr>
<td>Related technologies</td>
<td>Semantic web, metadata, and ontologies</td>
<td>Semantic web, metadata, and ontologies</td>
<td>Semantic web, metadata, and ontologies</td>
<td>Semantic web, metadata, and ontologies</td>
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<tr>
<td>Interaction</td>
<td>Machine meets user needs</td>
<td>Machine meets user needs</td>
<td>Machine meets user needs</td>
<td>Machine meets user needs</td>
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<tr>
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<td></td>
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<td>Interaction</td>
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<td>Knowledge, Providing information</td>
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<td>Information users</td>
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<td>Related technologies</td>
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### Concepts and Keywords of Library 4.0

Chauhan (2009) wrote that the web itself is a kind of library, and it can be classified into different parts based on function: the “learning web” and the “Spamming or Trashing web.” The learning web is a “massive open virtual library” while the “Spamming or Trashing web” includes entertainment. Libraries will be able to survive only by cooperating with various professional academic networks in the era of Web 4.0. He also said that the form of that cooperation will become Library 4.0, and it will be constructed in a virtual library environment where all the services are provided in virtual space.

While I attempted to complete a broad search across the literature, information on Library 4.0 was scarce except for those studies described above. However, Library 4.0, as an organic system, must have features closely influenced by changes in the external environment and has almost every feature of Web 4.0. Physical libraries will accept the features of Library 4.0 for its spatial changes. Of course, the concepts of Library 3.0—social semantic digital library, linked library, and ubiquitous mobile library—will be included in Library 4.0 as well.

In this context, based on analysis of the information environment and information technology, analysis of previous research and examples, and the development directions of next-generation digital libraries as well as analysis of the social and cultural environment, I would like to suggest the concepts and keywords of Library 4.0.

### Intelligent Library

From the discussions of Web 4.0, many scholars agree that Library 4.0, as a future library, will become an intelligent library where not only inference and research are available, but the system will analyze information by itself and discuss findings with users like a colleague (Chauhan, 2009; Jenkins, 2011; Aghaei et al., 2012; Sharma, 2012; Fowler & Rodd, 2013).

In other words, we can assume that Library 4.0 will bear many similarities to Web 4.0 and incorporate many of the same concepts and technologies. Through that logic, we can imagine an environment that fuses platforms, services, and large amounts of content (massive web), a library that allows librarians, users, and machines to coexist (symbiotic web), technology that allows humans and machines to read, write, execute, and concur at the same time (read–write–execution–concurrency web), and a library that thinks, makes decisions, and provides library services using reasoning (intelligent library).

Kwanya et al. (2013) concluded that Library 2.0 pushed the role of the librarian into the background with advances in the search capabilities of technology. They emerge more significant, however, in Library 3.0 where they act as “apomediaries,” helping users locate, access, and use the most accurate and reliable information in different formats from many sources. They also point out that Library 3.0 addresses some of the issues of the reliability of user-created content in Library 2.0 by providing more tools and content to organize the often-chaotic information environment Library 2.0 created. Library 3.0, they ultimately argue, is intelligent and personalizable to a point where it is almost a living organism, sustained by the engagement of users, librarians, and experts.

### Massive Data Library

The amount of data and services to be managed by future libraries will be massive enough to transform them into Massive Data Libraries. The concepts and services of big data, cloud service, and open source contents appeared thanks to the scale of accumulated data, expansion of services, and increased availability due to the open-source format.

Big data is a massively sized data set which cannot be collected, stored, managed, or analyzed by ordinary database software devices because it stretches those devices beyond the limits of their abilities (Manyika et al., 2011). Big data is cost saving and improves decision-making by enhancing insight through massive volume, speed, and innovative information processing (Lehong & Laney, 2013). These big data...
systems may be utilized for improving the information services of libraries, i.e., analysis results of big data can be utilized for planning information service suitable for users, and, based on that result, information resources for each topic, user, and issue may be developed and customized (Lee, 2013).

Big data, just like the semantic web and linked data, show human interaction, communication flow, and relationships among data. While Big data is frequently discussed with the concept of cloud computing, it must be considered separately as a massive collection of data available to users whenever they need it through an internet connection and an internet-based computer network. On the other hand, cloud computing is required technology to make Big data available and involves lending cyber-storage space so that users can easily access information technology resources such as servers, storage, applications, and software which exist in shared pools by using the internet at the moment of such a need through various client devices. Although they are linked, it is important to understand and differentiate the concepts of big data and cloud computing (Choi & Woo, 2012).

Many methods allow cloud computing to be applied to library services: integrated management of library resources in web-based distributed surroundings, remote access to resources and services, resource sharing among libraries, construction of comprehensive service systems, and cooperation among libraries (Kim, 2012). In addition, the concept of cloud computing is applicable to a cloud collection where digital conservation and conservation of physical, printed copies can play a complementary role. This framework creates new value by jointly preserving and utilizing books, which are preserved through both digital and physical forms (Cho, 2012).

Meanwhile, in their research on modeling the next-generation digital library (NGDLs), Crane et al. (2006) described innovative changes on the part of book content and gave an example of open source environment through real-time community participation and distribution contribution. In the massive web, the users create and share knowledge as group intelligence and will expand open source contents. Users reading digital books do not simply receive searched data in the form of PDFs but begin to use all the available data through dynamic connection. The following are features of books in a NGDLs:

♦ Both certain data and its related data are shown on the screen, and these data are created by users or professionals who are connected dynamically in real-time.
♦ Users' individual needs are automatically analyzed, and digital books will be ceaselessly organized to fit those needs.
♦ Classification and data mining, mechanical learning, significant connection between concepts and the literature, and multi-language services (automatic translation) will be automated
♦ Higher quality of book construction, classification, comments, and connections with related papers will be maintained by user participation.
♦ NGDLs will provide personalized and user-oriented services, much more than current iterations.

Digital books are dynamic and connections among concepts and to other works will be perfect through automation or group intelligence. These processes will be carried out with the aim to satisfy the personal demands of users.

AUGMENTED REALITY LIBRARY

Augmented reality is a technology that shows virtual elements overlaid atop real world displays (Azuma et al., 2001). It is also known as Mixed Reality (MR) because it shows real-world elements combined with virtual ones for supplementary information. The system is available for real-time interactions in 3D spaces so that limitless information can be brought into reality and utilized at the desired time and place (Dunston, 2008). Augmented reality technology is roughly classified into location-based augmented reality, for marking information where the user is looking using directions created by other users, image recognition augmented reality for adjusting available content based on visual cues, including camera position, and image tracking augmented reality, which tracks camera location for each frame and then shows suitable content for that frame (Hah, Kim, & Kim, 2011).

Hah et al. (2011) applied augmented reality technology in suggesting a system where the information and location of books users are seeking in the library are indicated when they search the catalog and then guides the user to that location. This method for realizing a technology and design using augmented reality for greater user convenience may be applied more extensively in the library, perhaps used for providing: book information and evaluation information of augmented reality to real books, augmented reality information to the building or other features of the library, and augmented reality information to the interior facilities of library.

CONTEXT AWARE LIBRARY

The next generation of digital library embraces the notion of the ubiquitous library, and context-awareness is one of the emerging technologies necessary for its implementation. Context-aware computing technology is a system designed to search and provide the services that users require in their current situation by analyzing and identifying the available contextual information (the current situation of the user) such as the user’s current location, time, people and devices in the vicinity, and the user’s behavior and inputted data (Noh, 2013).

A service that is context aware uses certain conditions such as the location and environment of users to better respond to user needs. The system combines user-entered information as well as situational data to provide users suitable results. Context aware services have been classified into security service, convenience service, environmental comfort service, entertainment service, information service, and community service (Song, Cho, & Cho, 2008).

Context aware services applicable to libraries are book status information (book location checks and guidance service using augmented reality technology, checks and guidance service for books being moved or returned), book content information, My Library management service, library internal information, providing and lending electronic books, and connection with relevant agencies (Lee, 2013). Noh (2013) wrote, in an example of an application of context aware technology to the library, that the library may recognize the user and provide customized service to both new users and existing users.

In addition, it can provide information suitable to the circumstances of users, context aware reference and book lending service, and identify the user in an emergency by recognizing their behavior, route, and temperature. Besides this, as an environmental comfort service, temperature, humidity, and lighting can be adjusted for different users, books, and equipment (Song et al., 2008; Noh, 2010). However, it seems that there have not been adequate research on context aware services available in the library, and it is necessary to conduct more study into applying context aware systems to libraries before a broadly applicable system and guidelines thereof can be put in place.

CUTTING-EDGE RECOGNITION CAPABILITY

Library 4.0 will make it possible to realize a cutting-edge display environment equipped with recognition capability. The technologies and products making that environment possible have already been launched, and applying them well to the developing NGDLs will be the key to success. Representative models of this cutting-edge display equipment are Google Glass, HUD, Flexible Display, and Transparent Display.

Google Glass is a kind of wearable computer equipped with Head Mounted Display (HMD), which is under development as an R&D project titled “Project Glass” and will make it easy to realize a ubiquitous digital environment (Furlan, 2013). Google Glass can use many other Google applications including Google Now, Google Map, Google Plus,
Google Glass can presently display functions including showing information in a hands-free form, interaction through voice command in natural language, video recording, picture taking, video calls, image search, translation, directional guidance, message sending, weather search, and providing flight information. These functions are only the beginning and can be extended, strengthened, and enhanced as much as is desired.

The ALA, in its “2014 ALA Midwinter Meeting (http://exhibitors.ala.org/)”, displayed Google Glass and discussed its applicability to the library (ALA, 2013a, 2013b, 2013c). Once a user wearing Google Glass enters a library, the library may display only books of interest to the user on the library wall. The user will not have to look around at all the books in the library, and, if he or she says the title of a book, summary information of that book will be provided. If desired, the library can automatically lend those books in both online and offline formats. The library can also provide immediate translations for search services and metadata through the Glass format. The guide to the library will be taken charge of by Google Glass, even to the physical space, and it will be a great advance in services for the disabled because a sound guide, book reading, and reference services will all be available.

Despite this possible vision of the future, researchers and librarians still have plenty of work to do before it can become a reality. For instance, library applications and content must be developed specifically for use with devices like Google Glass.

Meanwhile, display environments providing information are rapidly changing and the types of information provided by libraries vary (Ohe, Kume, Demachi, Taguchi, & Ichimura, 1999). Information suitable to the needs of users must be provided through the device and in the form desired by the users. Displays presently available or at a stage of commercialization to be applicable to the library in the near future are HUD, Flexible Display, and Transparent Display (Fig. 4).

HUD (Head-Up Display) is a device which allows the pilot of an airplane to accurately view information from instruments and CRT within his or her view, designed to display operating information on the windshield glass of an automobile or airplane (Newman, 1995). At present, it is used for reducing automobile accidents. Flexible Display is a paper-like display known for realizing the same picture quality even if it is folded or bent (Kirschner & Muller, 1987). This technology will replace existing screens on laptops, PC monitors, and televisions, and is expected to be embraced by the electronics market thanks to the reduction in screen size and volume it represents. Transparent Display is a collective name for a display that is completely see-through when turned off, and remains partially transparent when turned on. This technology, which combines augmented reality and touch screens, has many everyday applications, including living room windows or indoor and outdoor advertisements and PSAs. The future library will construct display environments using the technology described above.

**INFINITE CREATIVE SPACE**

Combining infinite creative space with library services is an innovative idea which will have a positive impact on the lives of library users. Infinite creative space in libraries will allow users to see the world differently and give them an opportunity to explore or imagine new possibilities for a future they will create.

The concept of infinite creative space is meant to facilitate the creation of something using technology, but does not include only STEM activities. The space is intended to draw creative people, and the infinite creative space movement centered in libraries helps to teach users to think creatively and explore solutions. It is a space where people gather and create new things with certain technologies.

The internet age has made users aware of the many different ways to acquire knowledge besides physical books, and therefore librarians have reached for new identities within their core mission of information community helpers. Infinite creative space (or makerspace) is a natural extension of that identity. Camoprodon, Bigazzi, Pineda, Tham, and Mattia (2013) expressed the key concepts surrounding the “Coworking and Makerspaces” movement with “community” as the most important, followed by open, sharing, collaboration, startups, network, makers, and entrepreneurship.

Noh (2014) comprehensively examined domestic and foreign examples of infinite creative space construction with previous research and drew up 12 total concepts for the roles of the space: 1) social communication, 2) learning, 3) sharing creative resources, 4) exploring interested topics, 5) job search and assistance for business startups,
6) finding and cultivating authors, 7) self-publication, 8) idea incubation, 9) cooperative creation, 10) experiencing and utilizing new equipment, 11) storytelling, and 12) expert mentoring and consulting. Because the space has so many varied uses, many potential programs and events covering a wide range of topics could be held there.

**KEY CONCEPTS OF LIBRARY 4.0**

In conclusion, based on the analysis conducted by this research team on the research on each development stage of the web including Web 4.0, NGDLs, other various papers regarding Library 3.0 and 4.0, and the result of reviewing technologies applicable to the library, the generation development process of Library 4.0 is shown in Fig. 5.

As shown in the following picture, the era of Library 4.0 is likely to be realized beginning in 2015, and the essential keywords and concepts of Library 4.0 will be Intelligent Library, Makerspace, Context-Aware Technology, Open Source, Big Data, Cloud Service, Augmented Reality, and State-of-the-art Display. Moreover, the role of librarians will be very significant in making all of these concepts applicable to the library; training the Librarian 4.0 must be a top priority.

**DISCUSSION AND FUTURE STUDIES**

**DISCUSSION**

This paper, in order to create a model of Library 4.0 as a NGDLs, the literature and newspaper articles related to information technologies and examples of their application in the library have been collected and analyzed. This chapter concentrates on discussing the research questions raised in the course of conducting that research.

First, opinions of scholars tracking the rise of Web 4.0 vary widely, but Web 4.0 features commonly suggested by previous researchers are: reading, writing, and executing simultaneously, intelligence-based agents, connected web, ubiquitous web, intelligence connections, and intelligence-based web. In the terminology cloud regarding Web 4.0, the terms Convergence, Remixability, Standardization, Participation, and Usability are the most prominent. Summarizing the opinions of various scholars, this study defined Web 4.0 as a symbiotic web, a semantic web (connecting web), a web that reads, writes, and executes simultaneously, a massive web, and an intelligence-based web.

Second, the features of Library 4.0 most often suggested by previous research were examined, and it seems that few scholars have tackled this concept in the past. Thus, a broader scope for research collection was defined to forecast a model for a NGDLs and conduct a comprehensive analysis on the concept of Web 4.0. As a result, the features of Library 4.0 were determined as: intelligence-based, massive data, augmented reality, context aware, cutting-edge displays, and infinite creative space.

Third, in this context, the keywords that best explain Library 4.0 are: Intelligent, Makerspace, Context-Aware Technology, Open Source, Big Data, Cloud Service, Augmented Reality, State-of-the-art Display, and Librarian 4.0.

This study presented the development of Library 4.0 and its keywords for the first time in the LIS field as shown in Fig. 5. Because of this groundbreaking model, this paper has great significance to future research on this topic.

**SUGGESTIONS FOR FUTURE STUDIES**

This paper discusses Library 4.0, although, unfortunately, there were almost no previous studies devoted to the topic. Discussions of Web 4.0, however, are a current topic of research popular among information scientists and internet users alike. Therefore, it is an appropriate time to begin the discussion of Library 4.0 and preparing for future libraries shaped by future technologies.

This study aims to suggest a model of Library 4.0 by reviewing the findings of leading researchers who discuss Web 4.0 and next generation digital libraries, since the available information on how Web 4.0 will form Library 4.0 is so far lacking.

This study could not provide a very wide range of applications to Library 4.0. It also does not specify recommendations for the application direction. This lack is because there are not enough resources related to the concept and discussion of Library 4.0. Therefore, this study focuses on proposing concepts and keywords. However, research in case studies and specific recommendations for the direction of Library 4.0 must be conducted. Future studies must also concentrate on detailed ways to
CONCLUSION

Even in 2013, Patel had already begun writing about ideas for Web 4.0. As we enter into the era of Web 4.0 and various new features begin to appear, it is still difficult to clearly define the more distant Web 5.0, but he referred to it as a distributed “Symbionet” web and predicted that we would be able to surf by ourselves in 3D virtual worlds of Symbionet. He said Web 5.0 will connect people through Smart Communicators, expressing them as avatars. Users will interact with content that satisfies their feelings and needs, and avatar facial expressions will change in real time through neural technology.

Because library development is so tied to technological developments, it is important to begin a discussion of Library 4.0 as Web 4.0 begins to take shape in reality—and Web 5.0 in the imagination. This paper discusses the development direction of Library 4.0 based on the changes in cutting-edge information technologies and user demands for the library. Keywords for describing Library 4.0 will be Intelligent, Makerspace, Context-Aware Technology, Open Source, Big Data, Cloud Service, Augmented Reality, State-of-the-art Display, and Librarian 4.0. Future studies will need to discuss in more detail how each technology must be applied to the library to best serve users and communities.

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