

Convergence of Technology: Implications for Library and Information Science and Services

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Abstract. Technology is converging in various ways: different types of technology are integrated on devices, in software and apps, in information systems, and certainly in library and information science/services. Technology from different disciplines are also converging to address complex problems, and to produce new products and services. The paper suggests three implications of technology convergence for LIS services and profession: adopt and integrate different technologies in various LIS services; extend LIS technologies to other technology areas; and explore convergence of LIS with IT, educational technology/e-learning, and instruction of academic and writing skills. LIS professionals are bravely exploiting technology convergence, but more systematic and principled approaches and deeper understanding is needed. The paper suggests that a useful perspective is that all these technologies are developed by humans, and meant to help humans in some way. The paper derives three principles from this, and discusses some approaches to exploiting technology convergence to support user tasks, needs and behavior, and to developing innovative methods of knowledge organization and management, and information transfer to integrate with other technology areas, and thus participate in technology convergence.

WHAT IS TECHNOLOGY CONVERGENCE?

Convergence of technology reflects a dominant trend in industry, in products and services, in research and education, and more broadly in our daily life. It certainly reflects developments in library and information science/services (LIS). It is also a strategy that is consciously adopted by public and private-sector organizations to address difficult problems, or to develop innovative products and services.

One definition of technology convergence is “the combination of two or more different technologies in a single device” ([igi-global.com/dictionary](https://www.igi-global.com/dictionary/)¹). Certainly, many different types of technology are combined:

- on devices—for example, smart phones, tablets, smart TVs, smartwatches
- in software and apps—for example, Web browsers, phone apps
- in information systems—for example, Web portals, information retrieval systems, online database systems.

The information and communication technologies coming together on devices, software and information systems include:

- different file formats—for example, html, docx, jpeg, mpeg, avi
- different physical storage media—for example, harddisk, flash drive, the cloud, and
- different telecommunication media—for example, wifi, landline, and optical cable
- different types of computer programs and applications

Cloud computing technology supports the syncing of files on different locations across storage and telecommunications media, as well as the running of applications across these locations and media.

¹ <https://www.igi-global.com/dictionary/technology-convergence/29500>

However, technology convergence is more than juxtaposing multiple technologies in one device or application. Bainbridge and Roco (2016) characterized *convergence* as “a deep integration of knowledge, tools, and all relevant areas of human activity to allow society to answer new questions, to create new competencies and technologies, and overall to change the respective physical or social ecosystems.” In other words, *technology convergence* implies that multiple technologies are integrated/merged/blended into a unified whole that is more than the sum of the parts—to address a problem or to serve a function. Jeong and Lee (2015) noted that convergence can involve previously distinct knowledge, technology, product, or industry domains. They distinguished between three types of convergence:

1. *science convergence* that merges different scientific disciplines
2. *technology convergence* that merges technologies of different application areas
3. *industry convergence* that merges companies with different technologies and in different application areas.

Lee et al. (2016) gave some examples of the convergence of technology industries, including the smartphone industry which integrates cell phones, computer, software, etc., and the smart car industry which integrates automobile, electronics, software, etc. Industry analysts have predicted that the convergence of Big Data, IoT (Internet of Things), AI, visualization, brain computing interface, and virtual reality will produce the next generation of applications (“Convergence of Big Data ...”, 2017). Other analysts have identified *smart homes* as a complex application area requiring the convergence many emerging technologies: voice activation, smart sensors, robotics, wearables, wireless charging, smart sensors, wireless communication and IoT (“Technology convergence enabling homes of the future”, 2018).

Converged technologies in an application area can evolve into a new technology and field of study. Bainbridge and Roco (2016) pointed out that nanotechnology “came into being through convergence of chemistry, physics, engineering, and many other disciplines, notably biology and materials in which proteins and crystals are nanoscale structures, computer science in which the smallest components of electronic circuits approach the nanoscale, and mathematics ... Engineering, through its major components of mechanical, chemical, biomedical and electrical engineering, played a central role, not only applying nanoscience developments to technologies, but also energizing and coordinating the collaborative efforts across disciplines.”

Technology convergence in products and services is enabled by pervasive telecommunication and Internet services that are globally linked, miniaturization of devices and ubiquitous computing, and fueled by globalization, consumerization of technology, and people’s hunger for social communication and networking, for information, and for prompt and effective services regardless of location, time and communication channels.

IMPLICATIONS FOR LIS

What are the implications of technology convergence for library and information services, for the library and information profession, and for library and information science? I define *technology* broadly as a body of knowledge that has been systematized in a coherent way to provide a service or to serve a function. So, “high tech” can be integrated with LIS technologies and services. Let us review the main functional areas and expertise of the LIS profession:

1. Information/knowledge organization
2. Information/reference service
3. Library service to specific communities
4. Library and collection management
5. Library system, including digital library and information portals
6. Archives and heritage management.

Each LIS professional probably specializes in one or two of these areas. The obvious implications of technology convergence are the need to:

1. Adopt, adapt and integrate different technologies in the various LIS functions and areas of expertise, and in this way embrace technology convergence in LIS
2. Extend LIS technologies to other technology areas, and thus participate in technology convergence initiatives in industry and society
3. Explore convergence of the LIS field with IT, educational technology and e-learning, and teaching of soft skills (including academic, research and writing skills).

These are difficult undertakings: LIS professionals are bravely exploiting technology convergence, but perhaps reactively and in piecemeal and superficial ways. Systematic and principled approaches (including theories and strategies) and deeper understanding are needed to guide these undertakings. I suggest that a useful perspective or way of looking at the situation is that all these technologies are developed by humans, and meant to help humans in some way. Furthermore, all the technologies involve information/knowledge in some way. These perspectives imply the following principles:

1. The underlying principles of all technologies are understandable by humans (including LIS professionals) at some level of abstraction. The basic idea for any technology is fairly simple, even if the mathematics is complex! However, the idea underlying a technology may involve a different way of thinking, which may need some mental effort for LIS professionals to grasp and be comfortable with.
2. All technologies are oriented towards engaging with humans at some stage, and often to supporting some human task. LIS professionals can focus on strengthening this link between technology and human (including human tasks, needs and behavior), and on developing new links or applications that may not have been obvious or originally intended by the inventors of the technology.
3. Whenever information/knowledge is involved, the following LIS processes are likely to be needed: information/knowledge organization and management, and information transfer to users (including mediation by LIS professionals and interface design).

In short, to exploit the convergence of technology, content and media, LIS professionals need to make the mental effort to understand the principles and way of thinking underlying different technologies, develop innovative ways of combining different types of technology to support user tasks, needs and behavior, and develop innovative methods of knowledge organization/management, and information transfer to integrate with other technology areas, and thus participate in technology convergence.

There are, however, a few challenges facing the LIS community:

- The current mindset and way of thinking of LIS professionals, including their perspective of library/information service and how they are supposed to help users. LIS professionals tend to be library-oriented in focusing on helping users to use library resources and to provide packaged information services. While strengthening their role as mediator, LIS professionals should view themselves also as collaborator, information resource, and expert on LIS technologies to support the technology convergence efforts of their users.
- The lack of depth in our understanding of users—their tasks, needs and behavior. In a university library, for example, it is not enough to understand the sources of information that researchers use or prefer. LIS professionals need to be scholars and researchers to some extent, in order to understand how researchers use information and how LIS technologies can support research.
- The lack of depth in our understanding of information/knowledge and its use in the users' domain (disciplinary area). There is too much focus on the containers of information (i.e. documents).
- The lack of depth in our understanding of technologies, especially in how they make use of information to engage with or help users. There is too much focus on current library technologies.

In the rest of the paper, I propose a new direction and mission for university library services that leverages the convergence of technology to better support research and education. I then suggest possible roles that LIS professionals can take in technology convergence.

A NEW DIRECTION FOR UNIVERSITY LIBRARY SERVICES

I propose this mission for university library services: *linking data, ideas, people and tools to support learning and co-creation of knowledge.*

Linking together data/ideas to create new knowledge

Ideas in research papers can be linked and combined to form new knowledge. New LIS technologies incorporating knowledge organization and text mining (especially text summarization) are needed to perform information integration and synthesis. Research data in the university's data repository can also be linked and integrated to create new knowledge. This requires data analytics and data visualization tools, supported by knowledge organization technology. Librarians thus need to become knowledgeable in e-science, e-social science and digital humanities research.

Andreas Degkwitz (2015), Chief Librarian of the Humboldt University of Berlin, noted in his paper at the IFLA World Library and Information Congress 2014 that librarians have to support data driven research by building networks of data and texts:

Considering the change of paradigm from texts towards data we are in the situation to redesign our [library] tasks in depth and to align them to the digital paradigm of data driven research. ... We have to prepare the materials for further use cases and to provide the necessary requirements to link, to process and to share all of it. We have to cooperate with each other and with the researchers to manage these new challenges ... As a result we have to build up networked collections of data and texts as WEB-based hubs or platforms for all the materials our researchers create and publish. (p. 5)

Futurist Thomas Frey (2014) presented this vision of libraries supporting networks of ideas:

I proposed a rather unusual mission for libraries, that of becoming "liquid networks" for our ideas. ... Whenever a great idea forms in our head, we look for a place to put it. Is it something useful, that we can turn into a product, add to a document, tell to our friends, include in a presentation, or attach with magnets to the front of our refrigerator? Every social network, discussion forum, or live webcast has become a cosmic breeding ground for "liquid networks" and how ideas often have sex with other ideas. So it's analogous to thought-blocks giving birth to other thought-blocks. ... how can one idea be coupled to another and used as a building block for something bigger? That's where liquid networks come into play. Using libraries as a focal point for idea sharing is something new, and creating an environment for clustering great epiphanies ... We've never really had the benefit of tapping into an idea archive in the past, so this will be uncharted territory ... It will also be a breeding ground for sparking new epiphanies. Every new business that gets launched happens as a result of an epiphany. ... it's in our best interest to create new epiphanies faster, better, and cheaper than ever before. And libraries can become the catalysts for these liquid networks of the future.

Linking people to data and ideas

It is no longer just about linking users to books, journals and journal articles, but more so about linking users to their content, i.e. to research results, methods and ideas. University libraries are embracing the new service of research data management—managing the data behind research results and journal article

content. But they have to go on to help researchers to find useful research data to reuse, to mine and to integrate with the researchers' own research data—to create new knowledge. Different types of apps are needed to link users to useful data and ideas, and librarians need to be knowledgeable about them.

In addition, librarians need a deeper understanding of research and of how researchers use information and data to create new knowledge. Librarians are already knowledgeable about *information seeking* and *searching* behavior. However, the area of *information use and reuse*, especially *information integration* in the context of knowledge creation and technology convergence, is hardly researched. In short, university librarians need to become competent researchers themselves to be able to help university researchers and faculty—else the university library will be taken over by Google and Google Scholar. Other librarians who are more technology-oriented need to design better system interfaces to link users to data and ideas.

Linking people to people

Researchers can be linked to other researchers in different ways and for different reasons. Librarians have long been involved with citation analysis, bibliometrics, and more recently altmetrics. These are based on citation links between researchers and, in the case of altmetrics, exposure and social engagement links. Social network analysis technology can be used to analyze networks of researchers. The library can also offer social media platforms to host research clusters, and thus support social networking among researchers.

Links between researchers can also be identified as a side-effect of linking ideas found in research papers. This will identify researchers performing related or complementary research. Many online databases (e.g., PubMed.gov²) already display a list of “similar articles” to the article displayed, as well as a list of articles that have cited the displayed article.

Linking people to apps

Librarians need to go beyond EndNote to curate apps that are useful for various learning and research purposes. To offer advice to researchers on the use of the apps, librarians need to be conversant with their use but also understand how technology can support research data collection, data preparation, data visualization, and data analysis.

Support for learning

Librarians now provide information literacy and scholarly communication instruction to students, including on online searching and citation formatting. This can be expanded to academic and research skills instruction, including information use and integration in academic report writing and literature review writing.

In addition to academic skills instruction, the technologies mentioned earlier for linking data and ideas, and for linking people to ideas can be adapted for individual exploratory learning using library resources. In addition, social media technology can be incorporated to support peer-learning.

POSSIBLE ROLES OF LIS PROFESSIONALS IN TECHNOLOGY CONVERGENCE

LIS professionals should participate in technology convergence initiatives. Otherwise, professionals from IT and management sectors will move in to fill the void. It is easier for university librarians to participate in technology convergence in science and technology, as they are already supporting researchers in

² <https://www.ncbi.nlm.nih.gov/pubmed/>

various ways. Public librarians can, however, support technology convergence in the areas of education and life-long learning, social services, heritage and the arts. Two areas where LIS professionals can contribute in technology convergence initiatives are in information/knowledge organization and in user services.

In the area of information/knowledge organization, development of taxonomies and ontologies are important in many smart technologies. For example, ontologies are being developed to support IoT (Internet of Things) applications (Bajaj et al., 2017). Indeed, a proposal for a IoT-Lite Ontology³ is being reviewed by the World Wide Web Consortium. Lefkowitz (2018) pointed out that although machine-learning and deep-learning are currently the dominant approach in AI, the symbolic approach to AI based on semantic reasoning using an ontology is needed for “tasks that require explicit reasoning using knowledge about the problem domain and often, about the world in general (i.e., ‘common sense’).” I predict that ontology and knowledge-based AI will become important in the future. I am organizing a Workshop on Ontology & Rich Semantics⁴ in Singapore on 26 November 2018 to explore the application of ontology in digital humanities and in intelligent applications with research data/text.

In the area of user services, LIS professionals can deepen their understanding of user tasks, user needs and user information behavior in general, so that they can help to design apps and services that support users in accomplishing tasks. I suggest that a deeper understanding of user cognitive and thinking processes, and developing methods for studying them (e.g., using eye-tracker machines and electroencephalogram (EEG)) will be useful in developing effective user interfaces.

In some universities, the library and IT department have been placed in the same organizational unit presumably to foster a convergence of library and IT functions and services in supporting research and learning (Joint, 2011). University librarians should also explore convergence of library services with educational technology and e-learning departments, and academic writing departments, and perhaps even with disciplinary departments. There is no reason why librarians should not teach and provide professional support in the areas of data management and analytics, text mining, user information behavior, and interface design.

CONCLUSION

Technology convergence carries important implications and presents significant challenges for library and information services, for the profession, and for the LIS field. It also offers opportunities for LIS professionals to play important roles and contribute to scientific, technological, industry, educational and social innovations that convergence brings.

However, for LIS professionals to thrive in an era of convergence requires a new mindset with a focus on data and ideas rather than on documents, and on helping users to learn and accomplish tasks rather than on just finding relevant documents. It also requires mental flexibility to learn different ways of thinking underlying different technologies in order to integrate them in LIS services. A deeper understanding of LIS technologies (e.g., ontology) as well as of human information behavior and cognitive information processing are needed to apply them in technology convergence initiatives in other disciplines. All these carry implications for LIS education: LIS schools need to educate a new breed of LIS professionals to thrive in an era of technology, media and content convergence.

³ <https://www.w3.org/Submission/2015/SUBM-iot-lite-20151126/>

⁴ <https://blogs.ntu.edu.sg/chriskhoo/ontology-rich-semantics/>

REFERENCES

- Bainbridge, W.S., & Roco, M.C. (2016). Science and technology convergence: With emphasis for nanotechnology-inspired convergence. *Journal of Nanoparticle Research*, 18, 211. doi:10.1007/s11051-016-3520-0
- Bajaj, G., Agarwal, R., Singh, P., Georgantas, N., & Issarny, V. (under review). A study of existing ontologies in the IoT-domain. Retrieved from <https://hal.inria.fr/hal-01556256/document>
- Convergence of Big Data, IoT and AI to drive next generation applications: New growth opportunities in visualization technology and brain computing interface emerge from Big Data progress, finds Frost & Sullivan's TechVision team. (2017, September 5). *PR Newswire*.
- Degkwitz, A. (2014). "Yes, we can", if we take over future tasks! Paper presented at *IFLA WLIC 2014, Session 208 - Knowledge in the Digital Age - Libraries and librarians are managing the digital transformation - Knowledge Management*. Retrieved from: <http://library.ifla.org/875/1/208-degkwitz-en.pdf> (Also published in L. Bultrini, S. McCallum, W. Newman, & J. Sempere (Eds.), *Knowledge management in libraries and organizations* (IFLA Publications 173, pp. 55-64). Berlin: De Gruyter Saur.)
- Frey, T. (2014, August 12). Liquid networks: A breeding ground for ideas (blog post). *Futurist Speaker*. Retrieved from <https://www.futuristspeaker.com/business-trends/the-future-library-a-liquid-network-for-ideas/>
- Jeong, S., & Lee, S. (2015). What drives technology convergence? Exploring the influence of technological and resource allocation contexts. *Journal of Engineering and Technology Management*, 36, 78-96. doi:10.1016/j.jengtecman.2015.05.004
- Lee, H., Kim, N., Kwak, K., Kim, W., Soh, H., & Park, K. (2016). Diffusion patterns in convergence among high-technology industries: A co-occurrence-based analysis of newspaper article data. *Sustainability*, 8(10), 1029. doi:10.3390/su8101029
- Lefkowitz, L. (2018, January 29). Semantic reasoning: The (almost) forgotten half of AI. *aiweek.io*. Retrieved from <http://aiweek.io/consumer-ai/semantic-reasoning-the-almost-forgotten-half-of-ai/>
- Joint, N. (2011). New perspectives on the convergence of academic libraries and campus information technology departments. *Library Review*, 60(8), 637-644. doi:10.1108/00242531111166674
- Technology convergence enabling homes of the future*. (2018). Available from: Report Buyer (<https://www.reportbuyer.com/product/5474806>).