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# Recent Development in Information Science: Implications for Information Systems Research

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## ABSTRACT

Over past several decades, the management information systems (MIS) community has adopted theories, methodologies, philosophical bases, and assumptions from sister disciplines. This paper reports the changing nature of information science (IS) towards multi-disciplinarity and its development over the past decade. It also examines the contribution of informetrics to MIS research in delineating the intellectual structure of information systems, comparing cumulative research traditions, demonstrating theoretical differences between competing approaches, tracing a paradigm shift. Development in IS provides MIS researchers with ample opportunities for cross-disciplinary research, new research tools, new theories to understand information systems phenomena, etc.

### Keywords

information science, informetrics, cross-disciplinary research.

## INTRODUCTION

Over the past several decades, the management information systems (MIS) community has accepted good ideas and adopted theories, methodologies, philosophical bases and assumptions from reference disciplines to solidify its domain and demarcate its reference disciplines. Many theories and ideas originated from cognitive science, psychology, management science, systems science, communication science, organizational science, social psychology, communication science, and computer science have positively contributed to the various information systems research subspecialties of information systems.

Information science is a sister discipline that focuses on the different aspects of information in organizations. Extant literature suggests that MIS research has influenced information science (IS) research stronger than IS did on MIS and the shared impact of MIS and IS is growing increasingly. Computer science, artificial intelligence, information retrieval, interdisciplinary applications, and statistical methods are the fields that were supported by MIS and IS simultaneously (Sugimoto et al., 2008). MIS and IS share a great deal of common areas of interests and potentially exciting cross-disciplinary research opportunities in advancing both fields and those fields impacted by cross-fertilization of MIS and IS.

This paper aims to report the changing nature of IS towards multi-disciplinarity and its development over the past decade. It also examines the contribution of informetrics to MIS research in delineating the intellectual structure of information systems, comparing cumulative research traditions, demonstrating theoretical differences between competing approaches and tracing a paradigm shift. With information science's expansion of cybermetrics/webometrics, MIS and information science are in a new era in which they can cooperate to produce synergistic outcomes. These developments in information science provide MIS researchers with ample opportunities for cross-disciplinary research, new research tools, new theories to understand information systems phenomena, etc.

## CHANGING NATURE OF INFORMATION SCIENCE

IS is an interdisciplinary field of study that deals with storing, processing, distributing, communicating, and using information in an organization. Concepts, theories, and methods are from such varied disciplines as library science, computer science and engineering, linguistics, statistics, management science, and psychology. In its early stages in the 1960s,

information science was concerned primarily with managing documents. American Document Institute had been the premier society for information professionals since 1937. The institute changed its name to the American Society for Information Science and Technology (ASIS&T) in 1970. This name change implies that before 1970s, information science was primarily concerned with information retrieval system design and evaluation, indexing systems and techniques and evaluation, search strategy and evaluation, interface design, information seeking and behavior, use of information, scientific and scholarly communication, bibliometric law and analysis, and information policy. The term "information science" is often used interchangeably with "library and information science (LIS)", which aims to study the design, development, and evaluation of the information retrieval system, process, and technologies and scholarly communication (Bates, 1999).

During the 1990s, the core of information science centered around the design and evaluation of document retrieval systems and the interconnectedness of scholarly literature and diffusion of ideas through the analysis of cocitation, bibliographic coupling, and citation analysis (White and McCain, 1998). Recent research (Chua and Yang, 2008) revealed that from 1998 to 2007 the nature of IS research is shifting towards multi-disciplinarity in terms of author's collaboration trends, top key words and subdisciplines, and authors' affiliations. This study shows that the proportion of top authors published in a top IS journal from the core information science discipline has noticeably declined from 61% to 47.7%, when comparing the two periods of 1988-1997 and 1998-2007. This decline of the core IS authors also indicates the increasing number and proportion of authors in other disciplines including MIS and computer science. Besides document and information retrieval, the measurement of research productivity and mapping the intellectual structure of academic disciplines remain as core subspecialties in information science over the past two decades. However, new subspecialties emerged to join the top key words in IS research. They are information architecture, information seeking, knowledge management, data mining, fuzzy retrieval systems, World Wide Web, visualization, user behavior, electronic journals, and digital libraries. The following section overviews the development in information science over the past decade.

## DEVELOPMENTS IN INFORMATION SCIENCE OVER THE PAST DECADE

The emergence of the Internet and WWW forced information scientists to redefine the boundaries of information science and the perimeters around the field. Figure 1 does not include all of the exhaustive subspecialties of information science, but highlights several core areas of information science. The center of the figure includes three core areas of study within the inscribed circle: information retrieval, document management, and bibliometrics. The figure also depicts 5 subspecialties of information science that have evolved during the past decade. The development of the Internet has expanded the scope of bibliometrics into electronic communication media. These new areas are often called webometrics and cybermetrics. Figure 2 shows the relationships among many subfields of informetrics. Informetrics is a broader term that encompasses the electronic communication of media including the Internet and World Wide Web, books, and journals.

### Informetrics

The terms bibliometrics, librametry scientometrics, and informetrics are frequently used interchangeably. Even in the late 1980's, all these terms were not clearly distinguishable each other. Until recently, the chaotic state of terminologies has persisted. The conceptual and terminological confusion of the emerging phenomena seem to be settling down. According to Wormell (Wormell, 1998, p. 258), the individual identities of the subfields "bibliometrics", "informetrics", "scientometrics" and "technometrics" were unfortunately not very clear. However, there seems to be a growing acceptance of the term "informetrics" as "a scientific discipline including all the statistical and mathematical aspects connected with library, documentation and information problems with strong links to the theoretical aspects of information retrieval." To distinguish the differences among the many different terminologies, Tague-Sutcliffe (1992, p.1) defined informetrics as the study of the quantitative aspects of "information in any form, not just records or bibliographies, and in any social group, not just scientists."

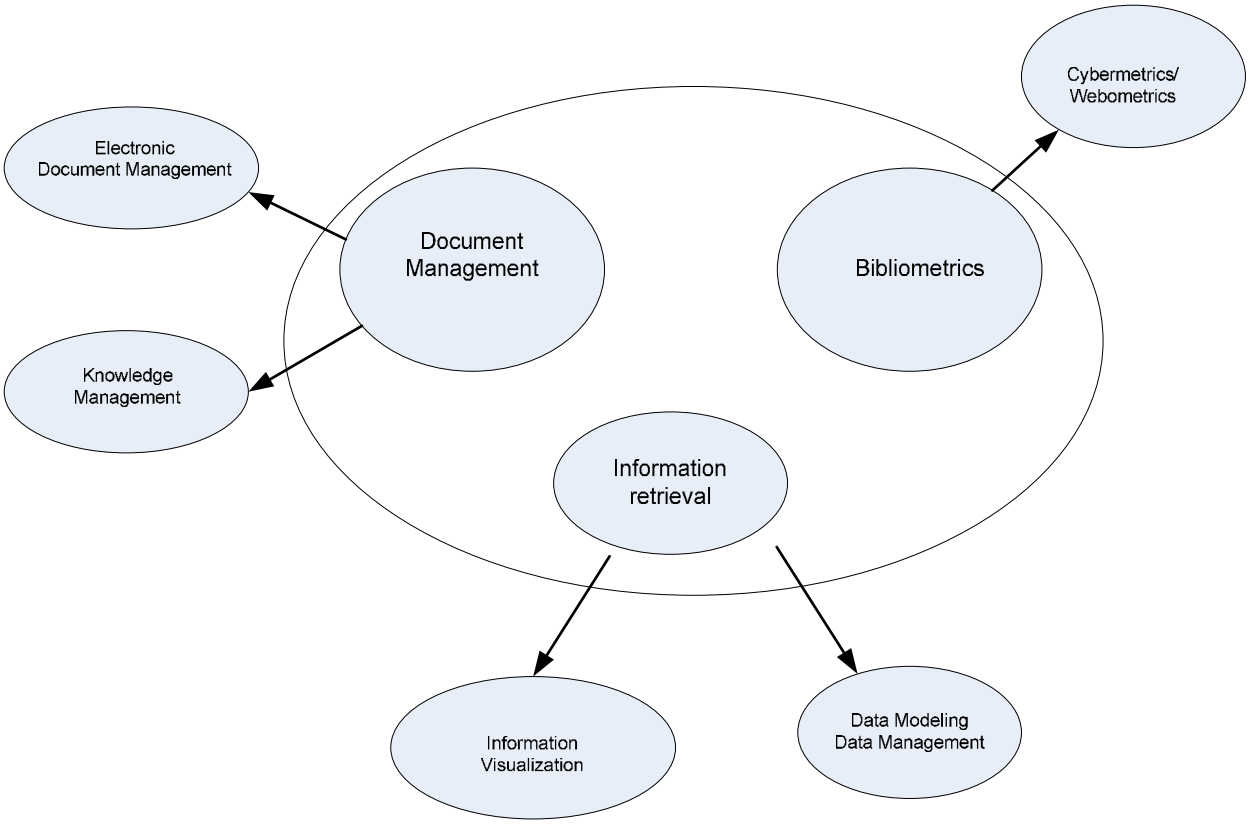


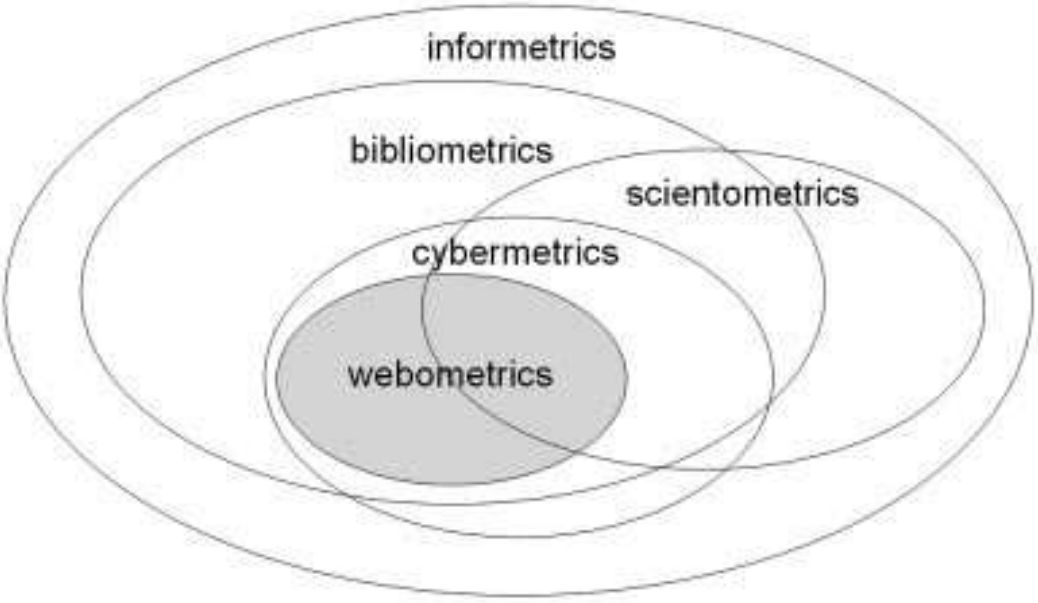

**Figure 1. Information Science Map**

### Bibliometrics/ Scientometrics

The basic units of bibliometric studies are authors and documents (journal articles, conference proceedings and books). The trends and patterns of scientific communications can be detected by analyzing (quantitatively as well as qualitatively) the aggregated periodical data. The study areas of bibliometrics and libarametry include bibliometric distribution, citation analysis, library use studies, etc. One of the sub areas in bibliometric research is distribution. The study of bibliometric distribution has led to the important laws in bibliometrics such as Lotka's law of scientific productivity, Bradford's law of scatter, and Zipf's law of word occurrence. Scientometrics is the application of quantitative tools to the study of scientific communications (Leydesdorff, 2001), as opposed to the more broadly defined term bibliometrics as "the production, dissemination and use of recorded information" (Tague-Sutcliffe, 1992).

### Cybermetrics

Since the late 1990's, a new subset of informetrics called webometrics/cybermetrics, has become part of the mainstream library and information science research area. A basic framework for webomatrics (figure 2) provides a broad picture of relationships among informetrics, bibliometrics, cybermetrics, webometrics, and scientometrics (Björneborn and Ingwersen, 2004). Cybermetrics is proposed as a generic term for the quantitative study of all internet applications. This includes *the construction and use of information resources, structures, and technologies on the whole Internet drawing on bibliometric and informetric approaches (Björneborn, 2004).* The coverage of cybermetrics includes webometrics, statistical study of the computer-mediated communication on the Internet (Herring, 2002) such as discussion groups, mailing lists, Usenet newsgroup, etc., and quantitative measure and analysis of the Internet backbone technology, topology, and traffic (Molyneux and Williams, 1999).




Source: Björneborn & Ingwersen (2004, p. 1217).

**Figure 2. Relationships among many subfields of informetrics**

Due to the inseparable relationships between modern organizations and the Internet, computer-mediated communication (CMC) research on the Internet has already permeated in a wide range of academic fields including information science. Web users' online information systems behavior has been a popular research topic in MIS and information science. Topics include the determinants of uninhibited behavior (flaming) in CMC (Kayany, 1998), evaluating the quality of learning in computer supported co-operative learning (Newman et al., 1997), predicting student achievement in e-learning courses(Lykourentzou et al., 2009), measuring acceptance of computer-mediated communication systems (Hiltz and Johnson, 1989), analysis of sociointerpersonal communication patterns among discourse participants in CMC (Park, 2008), and the Internet as a resource for political information and communication (Robbin and Buente, 2008)

### Webometrics

Webometrics is proposed as a generic term for the quantitative study of the World Wide Web phenomena such as the construction and use of information resources, structures, and technologies on the Web drawing on bibliometric and informetric approaches (Björneborn, 2004). Especially, the hyper-link is the core of Webometrics. The coverage of webometrics includes the analyses of link structure, page content, usage (log file), and technology. Web mining analyzes World Wide Web documents and multimedia to discover intelligence. It consists of mining web structure, web usage, and web contents. Often, Webometrics and Web mining are used interchangeably. Therefore, the details of web mining are to be discussed in the data management section. Zuccala (2007) introduced a web intelligence tool, LexURL, for gathering and analyzing links to digital libraries. The web intelligence tool can be used to analyze web server log files and web contents.

### Data Modeling and Data Management

The core subject of data management in both information science and MIS is concerned with the design, development, query, and maintenance of databases in organizations. A striking difference is on the area of mining of web structure, web usage and web-contents. MIS data management has not paid much attention on the web mining. Especially, web structure mining (web colink analysis) is excluded in this section due to the relatively low applicability in business organizations. Readers are referred to Zuccala (2006) to understand some differences between author cocitation analysis (ACA) and web colink analysis (WCA).

*Web usage (log file) analysis/Web usage mining* (Etzioni, 1996, Cooley et al., 1997) refers to the mining of web log and usage. Web logs are files that contain all of the information about the visitors' activities such as IP address, authentication, date, time, GTM zone, request method, page name, HTTP version, status of the page retrieving process, and number of bytes transferred, etc. Web mining aims to find new growth opportunities by restructuring organizations' websites so that clients can access the desired pages efficiently and improve navigation (Pabarskaite and Raudys, 2007). Besides, Web graph analysis (Broader et al., 2000, Thelwall and Wilkinson, 2003) studies the web as a mathematical graph. Web pages are considered to be nodes connected by arcs (hyperlinks). Web topology is also an important subject of this field including visualizing link structures. Web graph analysis is also concerned with the development and use of visualization tools and systems to analyze clickstreams, which are visitors' paths through a Web site. An interactive visualization system is developed to help users interpret and explore the clickstream data of online stores. This system visualizes the effectiveness of Web merchandising and provides functionalities for zooming, filtering, color-coding, dynamic querying and data sampling (Lee et al., 2001).

*Web page content analysis/Web content mining* is the process of extracting concepts (semantic meaning) from the contents of Web pages by applying information retrieval techniques to unstructured (text), semi-structured (HTML, XML), and structured (database) Web pages (Scime, 2004). Search engines are responsible for extracting semantic meaning from the contents of Web pages. It is necessary for search engines to understand the elements of Web pages (text, data, and embedded HTML and XML codes) to extract semantic meaning. HTML is a page description language that specifies where and how (the size, shape, etc) the data, text, multimedia should be placed on a Web page document. On the other hand, XML make it possible for Web browsers and application programs to manipulate and interpret the meaning by tagging selected elements of documents content. Researchers in computer science and information science developed approaches to extract the conceptual structure of a Web page by analyzing HTML tags and HTML tree structure (Han and Elmasri, 2004). They also developed approaches to improve Web browser's automatic understanding of the page content by adding semantic information to XML attributes (Kotb et al., 2004). The added semantic information allows Web browsers to understand the page's semantic dependencies, evaluate and check page consistency.

### Information Visualization

Information visualization research in information science was initiated by author cocitation analysis (ACA) researchers to visualize the relationship among authors, documents, and fields, using a large variety of statistical tools. These tools included dendrograms, two-dimensional and three dimensional maps derived from multidimensional scaling (MDS), factor loading plots, clustering, Kohonen self-organizing maps, geographic style maps.

Now there are new visualization tools such as pathfinder networks (PFNET), AuthorLink, and VxInsight. ACA researchers have developed visualization tools such as AuthorLink (Lin et al., 2003). Some ACA researchers applied visualization tools developed in other disciplines to ACA analyses, including Pathfinder Networks (White, 2003) and VxInsight (Boyack et al., 2002). PFNETs can be produced with software such as KNOT (The Knowledge Network Organizing Tool (KNOT) Software by Interlink at http://interlinkinc.net/index.html and Pajek. The KNOT software uses the Pathfinder network generation algorithm (Schvaneveldt, 1990). Pajek (*Slovenian word for spider*) is software for large network analysis, which is free for non-commercial use at http://vlado.fmf.uni-lk.si/pub/networks/pajeck/. AuthorLink is a web-based prototype system for author searching and a visualization tool. It is a system that enhances author searching in a bibliographic database created by the Institute for Scientific Information (Lin et al., 2003).

Another application area of information visualization is research on knowledge visualization. It has been multi-disciplinary endeavors from multiple disciplines such as bibliometrics, scientometrics, data mining, knowledge discovery, etc. VxInsight® is a knowledge and domain visualization tool for technology planning (Beck et al., 1999), domain analyses for competitive intelligence (Boyack et al., 2002), and knowledge mining (Davidson et al., 1998). It was developed by Sandia National Laboratories for presenting information as a landscape. The distinguishing feature of VxInsight® is its ability to mine and visualize the competitive nature of information for science and technology management.

A generic knowledge visualization approach was developed to extend traditional ACA, using a 3D knowledge Landscape (Chen and Paul, 2001). This approach replaces multi-dimensional scaling (MDS) with the Pathfinder network scaling technique and visualizes the intellectual grouping of authors produced by factor analysis. A new methodology is proposed to generate scientograms of major scientific domains on the basis of cocitation of Institute of Scientific Information categories (Moya-Anegón et al., 2007).

### Knowledge Management

A series of Critical Delphi study results (Zins, 2006) concluded that information science explores the various perspectives of data, information, knowledge, and messages phenomena in computer based as well as other technologies, in human society and living and physical worlds. Consequently, it was suggested that the name of the field be changed from "information science" to "knowledge science." Knowledge management is positioned at the core of the information science field map.

Knowledge management systems consist of several subsystems that acquire, store, disseminate, and apply knowledge. A key issue of knowledge manage research is organizational memory. Organizational memory (OM) is defined in many ways. For example, OM is "the amount of a firm's stored knowledge and familiarity or information about a particular phenomenon"(Hanvanich et al., 2006) OM is "corporate knowledge that represents prior experiences and is saved and shared by users"(Nilakanta et al., 2006). Many agree with the notion of stored knowledge. However, they may not agree on exactly what to store in the repository --. stored records of corporate manuals, databases, filing systems, and tacit knowledge (Nonaka and Takeuchi, 1995), or technical, functional, and social aspects of the work, the worker, and the workplace (Argote et al., 2003) or stored information from an organization's history (Walsh and Ungson, 1991). Researchers in computer science, information systems, information science jointly have carried out a wide range of research on this topic such as ontology-based evaluation of organizational memory (Weinberger et al., 2008), Knowledge sharing in online environment (Hew and Hara, 2007).

### Electronic Document Management

Electronic document management (EDM) is concerned with the management of creating, storing, organizing, transmitting, retrieving, manipulating, updating and disposing electronic documents. The documents consist of texts, photos, video clips, spreadsheet data, voice annotation, etc.(Sprague, 1995). EDM systems are based on the client server architecture.

Research on EDM systems deals with a wide range of issues in the management of electronic documents. They include creating electronic documents and converting paper documents into electronic documents, organizing, tracking, and retrieving e-documents through indexing of metadata (document identifiers, document keywords, document contents, date of document created or updated). The other research areas include securing electronic documents from unauthorized users and managing the access to document based on the security levels. Electronic documents are created and managed either jointly or individually. The documents may need to be forwarded to other individuals or departments for further processing via the workflow management module. The workflow management has become an important research area in electronic document management.

## DISCUSSION AND CONCLUSION

This paper overviewed new developments in information science. In the late 1990's, the Internet and WWW let the information science redefine its cores and boundaries to include five more research subspecialties as shown in figure 1. They are cybermetrics/webometrics, data modeling and data management, information visualization, knowledge management, and electronic document management, in addition to bibliometrics, information retrieval, and document management.

Informetrics is a research methodology that transcends the individual field of inquiry. Despite its usefulness and capabilities that reveal a larger vista hidden in the bibliographic databases, ACA has not been a popular research tool in some academic disciplines including the MIS area. Considering the limited exposure of this research methodology to the MIS area, this paper provided an introduction to bibliometrics that may be useful for MIS research. ACA is the principal bibliometric tool to establish *relationships* among authors in an academic field. Therefore it can identify subspecialties of a field and how closely each subgroup is related to each of the other subgroups. By establishing relationships among authors, ACA provides a basis of revealing the intellectual structure of literature and defining the principal subject (major area of subspecialties in an academic discipline and their contributing disciplines) through the empirical consensus of numerous authors in an academic discipline (Eom, 2009). An earlier contribution of informetrics to MIS research has been primarily providing a quantitative research tool for delineating the intellectual structure of MIS (Culnan, 1986, Culnan, 1987), decision support systems (Eom, 2007) , knowledge management (Ponzi, 2003), comparing cumulative research traditions(Eom, 2007), demonstrating theoretical differences between competing approaches (Sircar et al., 2001) , and tracing a paradigm shift in the DSS area over time (Eom, 2007).

With information science's expansion of new domain of research areas into several subspecialties as described in the recent development section above, researchers in MIS and information science are in a new era in which they can cooperate to

produce synergistic outcomes. These developments in information science provide MIS researchers with ample opportunities for cross-disciplinary research, new research tools, new theories to understand information systems phenomena, etc. With the increasing trend of web-based information systems such as web-based database applications, business intelligence research is just one area for researchers where both areas can be beneficial. As introduced**,** Web usage (log file) analysis **(**Web usage mining**)** is now an important IS research area, especially with the expanded research area of Webometrics. E-business web sites' server creates Web logs that contain all information about visitors' activities. The Web logs can be analyzed to create new opportunities for selling more. The interactive visualization tool (Lee et al., 2001), for example, can help e-business users analyze clickstream data of online stores to develop e-commerce strategies to increase sales.

Electronic document management and knowledge management: managing semi-structured knowledge in enterprise-wide knowledge management systems is the sub-area that can be most beneficial from electronic document management research in information science. Semi-structured knowledge systems, a.k.a., digital asset management systems, are concerned with the knowledge obtained from digital assets including multi-media files (video, audio, digital pictures, etc.) and un-structured and semi-structured documents (memos, brochures, invoices, e-mails, voice mails, etc.).

Data modeling and data management: Designing, implementing, and querying databases have been fundamental subjects of data management in MIS, IS, and computer science. Development and management of web-based database management have become an indispensable area in those academic disciplines. MIS researchers can borrow many research findings by researchers in information science and computer science in data management. In this paper, we introduced small examples from information science and computer science that may be useful for MIS researchers. For example, the semantic web allows computers to perform the tedious work involved in finding, sharing and combining information on the web. There are query languages that facilitate navigation in unknown structures of databases with the implicit assumption that the user knows how data are semantically associated each other. Research in computer science formulated expressive and declarative query language for discovering semantic associations among unknown entities or entities that are only known by some of their characteristics (Niemi and Jämsen, 2007a) and demonstrated the usage of the query language and discuss its new applications (Niemi and Jämsen, 2007b).

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