A Literature Survey on Information Logistics*

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Abstract. The notion of *information logistics* (IL) has been introduced as a new information management paradigm. Goal is to enable the effective and efficient delivery of needed information in the right format, granularity and quality, at the right place, at the right point in time to the right actors. IL has received much attention in recent years, both from researchers and practitioners. In order to better understand the state-of-the-art and current research trends in the research field of IL, this paper presents a comprehensive IL literature survey. In total, we identified 53 scientific articles discussing IL concepts and approaches. These articles were systematically analyzed and finally classified in ten research clusters. Based on these clusters, a more comprehensive understanding of past, current, and future IL developments becomes possible.

Key words: information logistics, literature survey

1 Introduction

Today's information and communication technologies (ICT) enable the access to information from any location and at any time. At the same time, users are confronted with a continuously increasing information overload [1] making it difficult for them to identify, handle, and apply information.

In order to cope with this challenge, the idea of *information logistics* (IL) has been introduced. Goal is to enable the effective and efficient delivery of needed information in the right format, granularity and quality, at the right place, at the right point in time to the right actors. To achieve this goal, basic principles from many research areas such as material logistics and lean management have been both adopted and adapted. Generally, IL is independent on the use of ICT, but ICT, of course, can be seen as an IL-enabler [2].

In this paper, we present a comprehensive literature survey on the state-of-the-art in the research field of IL. The main objective of our survey is to better understand past, current, and future developments in IL. More precisely, our research questions are: What is the state-of-the-art and what are current research

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trends in the research field of IL? To answer these questions, we analyzed 53 IL-related articles and classified them in ten research clusters.

The remainder of this paper is organized as follows. Section 2 describes the research methodology underlying our survey. Section 3 presents main results of the survey. Section 4 discusses our results. Section 5 summarizes related work and Section 6 concludes the paper with a summary.

2 Research Methodology

In order to ensure the validity of our literature survey, we used survey protocol documents as proposed in the literature survey guide by Okoli and Schabram [3]. Our survey comprises four consecutive steps (cf. Fig. 1): (1) search, (2) selection, (3) analysis, and (4) classification.

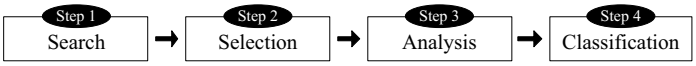

Fig. 1. Steps of our literature survey.

Step 1: First, a profound web-based search was conducted to identify potentially relevant IL articles. We considered an article as being relevant based upon two selection criteria: (1) an article contains the term "information logistics" in its title and (2) the article has to be written in English. Specifically, we used Google Scholar, SpringerLink, the Association for Computing Machinery (ACM) Digital Library, the Institute of Electrical and Electronics Engineers (IEEE) Xplore Digital Library, ScienceDirect, and Microsoft Academic Search (AS). We considered articles from books, journals, and both conference and workshop proceedings. We also took into account reports, editorials, and PhD theses. Other kinds of articles such as commercial white papers were not considered.

Step 2: In the second step, we reassessed the number of articles identified in Step 1. In particular, we removed both irrelevant articles (e.g., an article with the title "Information, Logistics and Retailing Services") and duplicate ones (of course, some articles have been found by several search engines). Then, we identified and selected analyzable articles. We considered an article as analyzable if the article's full text was available. Finally, we enriched all remaining articles with metadata such as citation count, type of publication, and year of publication. This allowed for a more in-depth analysis (cf. Step 3) and also supported the subsequent clustering of the articles (cf. Step 4). In total, we had a list of 63 relevant articles potentially being relevant at the end of Step 2.

Step 3: In the third step, we performed an in-depth content analysis of the 63 articles. Therefore, all 63 articles were reviewed by at least two researchers according to the procedures suggested in [3]. Among other things, a separate review was created for each article. Note that based on the reviews ten articles

were excluded from the survey due to quality issues or other reasons. For example, some articles did not meet our content requirements, consisted only of a few sentences or were literature surveys similar to our one.

Step 4: Based on the remaining 53 articles, the generated meta data, and the created reviews, we then performed the clustering in the last step. Thereby, for example, we also took into account topic, author and institutional relationships. Finally, we organized 53 articles in ten research clusters.

Note that our literature survey has several limitations. First, we only considered articles with "information logistics" in their title. This limitation was made due to the large amount of search engine hits we obtained when we considered papers with the term "information logistics" in their full text. Second, only articles in English were considered.

3 The Survey

This section summarizes the main results of our survey. Section 3.1 discusses the data collection for our literature survey. Section 3.2 presents the ten identified IL research clusters (C1 to C10).

3.1 Data Collection

Altogether, our initial web-based search resulted in 282 hits, i.e., 282 articles potentially being relevant for our survey. Google Scholar delivered the most hits (139 hits), followed by Microsoft AS (94 hits), and the IEEE Xplore Digital Library (20 hits). Less results have been identified based on the ACM Digital Library (13 hits), SpringerLink (13 hits), and ScienceDirect (3 hits). Table 1 summarizes the raw results collected during Step 1.

Table 1. Raw results.

	total hits (Step 1)	**irrelevant hits** (Step 2)	**relevant hits** (Step 2)
Google Scholar	139	62	77
SpringerLink	13	1	12
ACM Library	13	0	13
IEEE Library	20	9	11
ScienceDirect	3	0	3
Microsoft AS	94	53	41
total hits	**282**	**125**	**157**

In Step 2, we identified articles which did not meet our selection criteria (cf. Section 2). As a result of this, we excluded 125 articles from the study, i.e., 157

articles remained, implying an aggregated precision across all search engines of 55.67 %. Out of these 157 articles we then removed duplicate articles and also excluded articles we could not analyze due to a missing full text. At the end of this step, 63 articles were selected for further in-depth analysis.

Before starting our analysis (i.e., Step 3), each of the 63 articles was assigned with additional metadata (cf. Section 2). Among other things, the year of publication was documented. This enabled us, for example, to look for time-based trends and developments. Figure 2 shows, for example, that the number of IL-related articles has significantly increased in recent years.

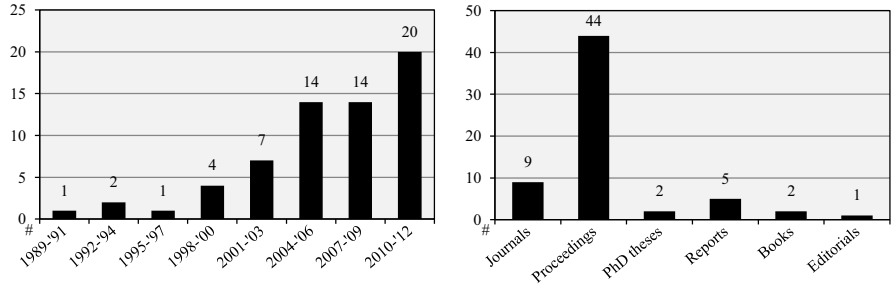

Fig. 2. Publication date and type of analyzed articles.

Figure 2 also illustrates the type of the considered IL articles. Most IL articles (44 ones) stem from workshop or conference proceedings, followed by journals (9 articles), reports (5 articles), PhD theses (2 articles), articles in books (2 articles), and editorials (1 article).

Figure 3 illustrates the citation count of the articles. Most articles (21 ones) are not cited. 14 articles have 1-2 citations, 10 articles have 11-20 citations, 7 articles have 3-5 citations, and another 7 articles have 6-10 citations. The most three cited articles are [4], [5], and [6] (according to Google Scholar).

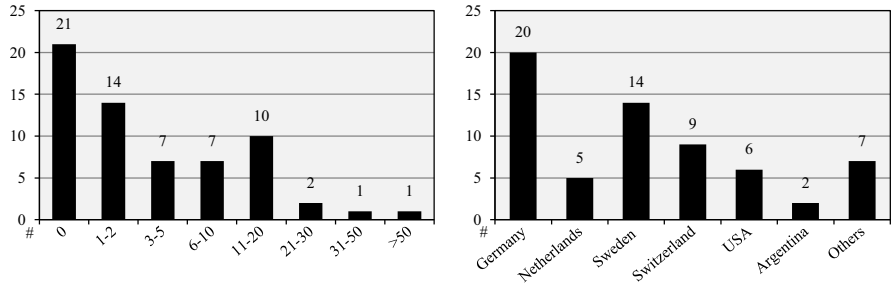

Fig. 3. Citation counts and countries of origin.

Figure 3 also illustrates the country of origin of the articles. Most articles (20 ones) stem from Germany, followed by Sweden (14 articles), Switzerland (9 articles), USA (6 articles), and The Netherlands (5 articles).

In Step 3, the 63 articles were carefully reviewed by at least two reviewers. For each article, a review containing a short summary, the full abstract, and key words was created. As aforementioned, we excluded ten further articles from the survey as a result of the reviews due to quality issues or other reasons. Thus, 53 articles were finally included in the literature survey.

3.2 Research Clusters

This section describes the ten IL research clusters (cf. Fig. 4) we identified based on our literature survey. Table 2 additionally shows the most cited paper for each cluster. Table 3 summarizes the main characteristics of each cluster.

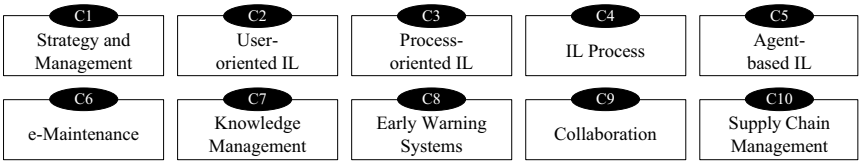

Fig. 4. Identified research clusters.

Cluster 1 (C1): Strategy and Management. Most articles from this cluster stem from the Management Institute of the University of St. Gallen (Switzerland). All articles belonging to this cluster concern strategy and management issues related to IL, in particular the transformation of enterprises into IL organizations. [7], for example, discusses the state of IL strategy. The main finding is that IL strategy depends on company size and structure. In addition, [8] investigates critical success factors for IL strategies. Examples of identified success factors include comprehensiveness, flexibility, support, communication, IT strategy orientation, business/IT partnership, and project collaboration. Special focus of [9] are IL management tasks enabling the use of IL concepts within an organization. [10] discusses general and thus very broad IL management challenges. More specific conceptual models to better understand IL requirements in enterprises are presented in [11] and [12]. A case study assessing the IL landscape of a global automotive company is presented in [13]. Another empirical study assessing benefits, design factors, and realization approaches in IL is presented in [5]. Finally, [14] presents a case study on the design and implementation of IL in the healthcare domain.

Cluster 2 (C2): User-oriented IL. The articles in this cluster address the challenges in user-oriented IL. In [15], the author discusses challenges and solutions for user-oriented information supply in IL. According to [6], IL can be understood as an approach enabling just-in-time delivery of information to

users. Corresponding examples are given in the fields of wearable computing [16], weather forecast [17], and the healthcare domain [18]. [19] argues that the success of information supply depends on successful user adoption and powerful frontend technologies. Therefore, in [19], a Twitter-like frontend for IL is presented. Moreover, [20] presents intelligent IL services and also discusses integration challenges. In [21], an industrial case study on these IL services is presented. A similar, but more technical perspective on integration challenges in IL is addressed in [22].

Besides, context-awareness adopts a key role in user-oriented IL. [23], for example, presents a study on context-based models for IL. Context definitions and representations from different viewpoints (e.g., information demand analysis, decision support) are presented [24]. A reference architecture for context-awareness in IL applications is presented in [2]. Another context framework for IL also considering various situation) is presented by [4]. This framework has been tested in [25] using an automotive prototype to demonstrate its general applicability.

Cluster 3 (C3): Process-oriented IL. This cluster deals with the alignment of process-related information (e.g., working instructions, best practices etc.) with knowledge-intensive business processes so that decision-makers and knowledge-workers can perform their tasks in the best possible way [26]. Specifically, process-oriented IL enables process-oriented and context-aware delivery of relevant information to knowledge-workers. For this task a semantic information network is used, which integrates process objects, information objects, as well as their relationships. In [27], quality dimensions of process-related information (e.g., completeness, punctuality etc.) are investigated in order to determine the relevance of information along business processes. In [28], an ontology-based context framework for process-oriented IL is proposed. This framework aims at the context-aware delivery of process-related information to process participants.

Cluster 4 (C4): IL Process. This cluster is mainly addressed by the Jönköping Business School in Sweden. In [29], IL is introduced as an approach (or process) transforming a given input (e.g., a project description, lessons learned) into some form of output (e.g., a best practice document). Goal is to transform fragmented information into usable information for the receiver. An IL transformation comprises three phases: information supply, information production, and information distribution. In order to realize this IL approach, [30] suggests an agent-based IL approach (i.e., the combination of multi-agent systems and IL). In [31], the notion of IL and basic ingredients of the IL process are discussed. Finally, in [32], the authors present a visual knowledge modeling approach of an IL process as defined in [31].

Cluster 5 (C5): Agent-based IL. This cluster concerns agent-based IL. In this context, an agent is a piece of software that acts for a user when searching for needed information. [33], for example, argues that a multi-agent IL approach, providing techniques for autonomous, situated, social, and pro-active information services, is a well-suited approach for realizing IL. A different perspective is adopted in [34]. The authors discuss the use of adaptive multi-agents approaches. [35] presents an agent-based IL architecture for process management, i.e., to sup-

port processes which rely on informational inputs and produce information as an output. Finally, [36] presents an agent-based IL approach for monitoring and coordination of processes.

Cluster 6 (C6): e-Maintenance. The articles in this cluster concern IL in the context of e-Maintenance. One central maintenance problem is to manage system complexity. Some experiences from the aerospace domain are described in [37]. Specific e-Maintenance IL solutions are discussed in [38]. Moreover, [39] proposes a framework for IL-driven e-Maintenance. In [40], maintenance and ICT are merged from an IL perspective. The role of IL and data warehousing in maintenance management is addressed in [41].

Cluster 7 (C7): Knowledge Management. The articles in this cluster deal with knowledge processing in and through IL. [42] and [43], for example, discuss an IL approach for knowledge processing. The presented knowledge processing approach aims at increasing the daily performance of knowledge-workers in enterprises. [44] proposes IL for conceptual correspondence monitoring. Finally, [45] and [46] address the enabling role of IL approaches in knowledge management. They conclude that an IL approach significantly improves a knowledge-worker's daily performance.

Cluster 8 (C8): Early Warning Systems. This cluster is mainly addressed by the German Research Centre for Geosciences. [47] and [48] apply the concept of IL to hazard monitoring and early warning systems. Goal is to enable the generation of user-tailored warning messages considering user needs with respect to content, location, or individual requirements. In addition, filter mechanisms to avoid information overload in emergency situations are presented.

Cluster 9 (C9): Collaboration. This cluster discusses the importance of IL to support collaboration in enterprises. In [49] and [50], IL is defined as the maintenance, tracking, monitor, and enactment of information flows within collaborative environments. [51] argues, in addition, that an IL approach is necessary to cope with the complexity of information flows. [52] analyzes the information flow between participants of collaborative processes.

Cluster 10 (C10): Supply Chain Management. This cluster deals with IL approaches supporting Supply Chain Management. [53], for example, proposes the design of an ontology to support IL supply chains. This ontology is described in more detail in [54]. Besides, [55] proposes a supply chain strategy to increase supply chain integration through organizational learning regarding IL activities.

Table 2. Most cited article in each cluster.

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
Article	[5]	[4]	[28]	[30]	[34]	[37]	[46]	[47]	[50]	[54]
Date of Article	2008	2004	2012	2008	2001	2009	2009	2011	2000	2005
Citation Count	27	56	3	11	13	25	6	7	12	1
Type	Proc.	Proc.	Proc.	Proc.	Proc.	Jour.	Repo.	Proc.	Proc.	Jour.

Table 3. Articles in the research clusters.

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
Date of First Article	1993	1999	2011	2003	2000	2009	2008	2011	2000	2005
Date of Latest Article	2012	2012	2012	2008	2007	2010	2011	2012	2004	2006
Trend in Cluster	↗	↗	↗	↓	↓	→	↗	→	↓	↓
Foundation in Cluster	↑	↑	↘	↗	↗	↑	→	→	↗	↘
Articles in Cluster	↗	↑	→	→	→	↗	↗	↘	→	→
1989-'91	-	-	-	-	-	-	-	-	-	-
1992-'94	1	-	-	-	-	-	-	-	-	-
1995-'97	-	-	-	-	-	-	-	-	-	-
1998-'00	-	1	-	-	1	-	-	-	2	-
2001-'03	-	4	-	1	1	-	-	-	1	-
2004-'06	-	5	-	1	1	-	-	-	1	3
2007-'09	5	1	-	2	1	3	2	-	-	-
2010-'12	3	3	3	-	-	2	3	2	-	-
total	**9**	**14**	**3**	**4**	**4**	**5**	**5**	**2**	**4**	**3**

4 Discussion

The number of IL-related articles, both from researchers and practitioners, has significantly increased in recent years. Consider, for example, the last three years: 20 new articles have been published since 2010. This makes it worthwhile to conduct a survey. As can be seen, we were able to identify a large number of IL methods, concepts, and approaches for our literature survey. The main problem: The broad field of IL makes the comparison of methods, concepts, and approaches a challenge. In fact, the term "information logistics" is the only commonality between many IL articles [56].

Reason is that IL addresses and recombines a large number of well-known research areas, e.g., material logistics [6], process management [26], information management [9], ubiquitous computing [2], or semantic technologies [15]. Additionally, ideas from business intelligence, location-based services, or enterprise content management are picked up as well.

We classified articles along ten research clusters in our study. However, there do exist overlaps between these clusters (also meaning that several of the identified IL articles could be assigned to more than one cluster). For example, both C2 (i.e., user-oriented IL) and C3 (i.e., process-oriented IL) focus on the delivery of needed information to users. However, while C2 concerns respective requirements and solutions for human users [6], C3 focuses on the support of both

business processes and process participants (as articles assigned to C2 neglect business processes and process orientation). Still, topics are similar in C2 and C3. As another example for overlapping clusters consider C4 (i.e., IL processes) and C5 (i.e., agent-based IL). In order to establish IL processes, [30] (assigned to C4) suggests to use an agent-based IL approach, like the one introduced in [36] (assigned to C5). Also consider C3 and C5. In [35], an agent-based IL architecture for process management is given. This work, however, could be also assigned to C3. In addition, C7 (i.e., knowledge management) and C10 (i.e., supply chain management) do also overlap. For example, both [42] (from C7) and [53] (from C10) discuss ontologies in the context of IL. Finally, IL-based early warning systems [48] in C8 (i.e., early warning systems) adopt approaches we assigned to C2 (e.g., the weather forecast prototype [17]).

5 Related Work

There already exist surveys dealing with IL. However, these surveys either address specific IL application domains or do only include articles published until 2009. More specifically, Haftor [57] conducts a first study on IL definitions and proposes a novel notion of IL. Similar to our survey (cf. Table 4), in turn, is the second study conducted by Haftor et al. [56]. However, this survey does only include IL articles which have been published until 2009. As there have been many IL publications since 2009, our survey represents the most current study. In addition, unlike the study of Haftor et al. [56], we discuss overlaps between research clusters and also discuss time-based trends in IL, types of articles, number of citations, and the country of origin of articles.

Table 4. Differences between [56] and our literature survey.

	Haftor et al. [56]	**Our literature survey**
Period investigated	until 2009	until 2012
Languages of Articles	English, German, Swedish	English
Number of Articles	71	63
Number of Articles in English	$\sim$ 35	63
Strengths of Clusters	■	□
Limitations of Clusters	■	□
Time-based Trends in IL	□	■
Types of Articles	□	■
Citation Counts of Articles	□	■
Country of Origin of Articles	□	■

□ = no ■ = yes

6 Summary

This paper summarizes the results of a profound literature survey in the field of IL. The main objective of our survey is to better understand past, current, and future developments in IL. In total, we included 53 articles in the survey. These 53 articles have been classified into ten research clusters.

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