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Semantic Web: A Quantitative Analysis of World Publications Output (2001-2010)

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ABSTRACT

This study analyses the world research output on Semantic Web during 2001-2010, using Scopus database. It describes the overall growth pattern, publications share and citation impact of different countries. It analyses the characteristics of most productive institutions, authors and highly-cited papers. The patterns of research communication in most productive journals are also indicated.

Keywords: Semantic Web, World publication output, scholarly information

1. INTRODUCTION

The scholarly information arena offers researchers an ever-increasing array of resources, including library's catalogues, databases, full-text resources, digital repositories and Web pages. For accessing these resources, it is necessary to have knowledge of the various resources, their access mechanisms and the query interface they provide. It even requires a manual comparison between the results returned from several resources and does not enable the user to move from one resource to another for further discovery and navigation[1]. Significant efforts are under way to address these issues, not just for scholarly information but also for all Web-accessible data. The increasing interest in Web information retrieval led to the Semantic Web initiative. The term Semantic Web was coined by Tim Berners-Lee[2], the inventor of the World Wide Web and Director of the World Wide Web Consortium, which oversees the development of proposed Semantic Web standards.

The Semantic Web is a "web of data" that enables machines to understand the semantics, or meaning, of information on the World Wide Web[2]. It extends the network of hyperlinked human-readable web pages by inserting machine-readable semantic annotations or metadata or about pages and how they are related to each other, enabling automated agents to access the Web more intelligently and perform tasks on behalf of the users. "The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation according to Berners-Lee, *et al.*"[2]

The Semantic Web vision involves the sharing and processing of data by automated tools as well as by people. The central idea of the Semantic Web is to extend the current human readable web by encoding the semantics of web-resources in a machine interpretable form, and then automatically integrating data from different sources for performing actions on behalf of the user and to search for information based on its meaning rather than its syntactic form. It provides a common framework that allows data to be shared and reused across applications, enterprise and community boundaries. This vision requires new and advanced methods, models, tools and systems for services related to creation, access, retrieval, integration and filtering of web-based contents.

The Semantic Web is similar to tagging systems the individual use in blogs to help search engine to find topics and pull them up. Blog tagging, however, is decided by individual tagger. Similar meta-tagging systems are used to identify web pages to search engines. Meta-tags for

web pages in fact are descriptors of the entire page or even the entire site. Tags, however, may not describe the discrete data on the page. Other tagging systems are based on extensible mark-up language (XML), from which web formatting code (HTML) is derived. XML tagging systems define at the beginning of a document what the tags will mean within the document. One can tag words, phrases and data for formatting and data search purposes. XML provides an elemental syntax for content structure within documents, yet associates no semantics with the meaning of the content contained within[3-4].

Several formats have been designed for Semantic Web to meet this goal, among which the Resource Description Framework (W3C, 1999) from the W3C and Topic Maps (ISO, 1999) from the International Standardisation Organisation aim at describing resources and establish relationships among them. Resource Description Framework (RDF) starts with self-description of data that other tagging systems use, but RDF names each item and relationship between items in a way that allows computers and software to exchange them automatically.

It works best when groups agree to common schemes. However, groups can be of any size, which means that tagging is decentralized and does not require agreement across user groups. RDF uses a triple descriptor—a noun, verb and object, generally called a Universal Resource Identifier (URI). RDF can be enriched with a RDF Schema (RDFS) which expresses class hierarchies and typing constraints, e.g. to specify that a given relation type can connect only specific classes. The semantic tagging provided by RDF and Topic Maps may be extended by references to external knowledge coming from controlled vocabularies, taxonomies and ontologies[3-4].

An ontology is an abstract model which represents a common and shared understanding of a domain[5]. Ontologies generally consist of a list of interrelated terms and inference rules and can be exchanged between users and applications. They may be defined in a formal way, from natural language to description logics. The Web Ontology Language (OWL) belongs to the latter category. OWL is built upon RDF and RDFS and extends them to express class properties. OWL establishes the relationship of concepts within the data sets, which allows this relationship to be translated across other databases. Web ontology language that can formally describe the semantics of classes in the domains of interest and the semantics of properties (or attributes) is used in Web documents. Ontologies provide richer integration and interoperability of data and permit the development of applications that search across diverse communities or merge information from them. Ontologies are like a library classification, which have to be structured so that they are recognizable in the RDF. Metadata and ontologies are complementary and constitute the Semantic Web's building blocks. They avoid meaning ambiguities and provide more precise answers. In addition to a better accuracy of query results, another goal of the Semantic Web is to describe the semantic relationships between these answers.

2. OBJECTIVES

The main objective of this study is to analyze the research performance in Semantic Web, as reflected in its publications output during 2001-2010. In particular, the study focuses on the following objectives: (i) To study the research output, its growth, and global publications share and impact of various significant countries, (ii) To study the publications productivity and impact of leading institutions and authors, (iii) To study the characteristics of highly cited papers and (iv) To study the patterns of research communication in most productive journals.

3. METHODOLOGY AND SOURCE OF DATA

This study is based on the publications data in Semantic Web retrieved from the Scopus Citation database for the 10 years (2001-2010). The search strategy/keyword used to retrieve the data on Semantic Web is as follows:

(((TITLE-ABS-KEY("semantic Web") OR TITLE-ABS-KEY("web of data")) AND PUBYEAR AFT 2000 AND PUBYEAR BEF 2011))

The search using the above keywords becomes finally our main string. For citations data, three years, two year and one year citations window has been used for computing average citations per paper for Semantic Web research publications during 2000-2007, 2008 and 2009. For analysing institutional, authors and journals output, the separate search strategies for generating institutional, author and journal outputs were developed, which later combined with the main string to generate the desired output. For generating high-cited papers, the main string is first run. Then, the tag "citation to" is ticked, which rearranges the entire output in the decreasing order of citations received by each paper with most high-cited papers at the top. Then the high-cited papers are marked and downloaded for analyses.

4. ANALYSES AND RESULTS

4.1 Overall Publications Output and Impact

There were 11846 papers published world over on Web Semantics during the last ten years, from 2001 to 2010. These papers have grown at an annual average growth rate of 75.90 per cent. In terms of cumulative output, the research output on Web Semantics has

increased from 2279 papers in 2001-05 to 9567 papers in 2006-2010, showing a growth rate of 319.79 per cent (Table 1). On further breaking the research output by source, 5736 papers appeared in conference proceeding, 3198 in book series, 2851 in journals, 56 in trade publications and 5 as books. On analysing the citation impact (as measured on a three year citation window) of overall publication output, it was found that over the years the citation impact has come down. It is not consistent, because the field is still developing and yet to mature. The average citation impact of all papers during 2001-2010 was only 1.87 (Table 1).

Table 1. Research output and impact of research on Web Semantics: 2001-2110

Period	TP	TC	ACPP
2001	35	1017	29.06
2002	108	703	6.51
2003	337	1411	4.19
2004	759	2467	3.25
2005	1040	2764	2.66
2006	1340	3486	2.60
2007	1784	4928	2.76
2008	1970	3664	1.88
2009	1958	1661	0.85
2010	2515	66	0.03
Total	**11846**	**22167**	**1.87**

TP = Total papers; TC = Total citations; ACPP = Average citation per paper

4.2 Contributions and Impact of Different Countries

On measuring the contribution of various countries, it was found that China contributed the largest share of papers (16.53 per cent share) during 2001-2010 on Web Semantics, followed by United States, Germany and United Kingdom (from 9.01 per cent to 12.15 per cent share), Italy and Spain (from 5.08 per cent to 5.99 per cent share), South Korea, Netherlands, Japan, India, Brazil and Taiwan (from 1.04 per cent to 2.56 per cent share) and Belgium, Switzerland and Singapore (from 0.77 per cent to 0.97 per cent share). These 15 countries together contributed 8749 papers, accounting for 73.86 per cent share in world publications output during the same period. In terms of citation impact, the largest (4.08) was received by United States for its all publications during 2001-2010, followed by Netherlands, U.K and Singapore (from 3.07 to 3.27), Germany, Italy and Belgium (from 2.04 to 2.62), Taiwan, Spain, Switzerland, Japan and South Korea (from 1.11 to 1.89) and India, China and Brazil (from 0.78 to 0.85) (Table 2).

Table 2. Contribution and citation impact of Different countries on Semantic Web: 2001-2010

Country	TP	TC	ACPP
China	1958	1613	0.82
USA	1439	5878	4.08
Germany	1335	3503	2.62
U.K.	1067	3321	3.11
Italy	710	1657	2.33
Spain	602	1040	1.73
South Korea	303	335	1.11
Netherlands	291	951	3.27
Japan	236	316	1.34
India	224	191	0.85
Brazil	142	111	0.78
Taiwan	123	232	1.89
Belgium	115	235	2.04
Switzerland	113	152	1.35
Singapore	91	279	3.07
Total	**8749**	**19814**	**2.26**
World Total	**11846**		
Share of 15 countries in world output	**73.86**		

4.3 Institutional Contributions and Impact

The top 15 most productive institutions involved in Semantic Web research have published 75 and more papers each during 2001-2010. Of these 15 authors, 5 are from China, 3 from U.K., 2 each from Germany and Austria and 1 each from Ireland, Spain and Netherlands. The publications profile of these 15 institutions along with their research output, citations received and h-index values are presented in Table 3. These 15 institutions involved in Semantic Web research together have contributed 16.28 per cent share (1929 papers) in the cumulative world publications output, with an average of 128.6 papers per institution. Only 9 institutions have registered higher publications share than the group average. These are Digital Enterprise Research Institute, Ireland with 204 papers, followed by University of Southampton, U.K (196 papers), Universität Karlsruhe, Germany (167 papers), Open University, U.K (159 papers), University of Manchester, U.K (149 papers), Wuhan University, China (130 papers), Zhejiang University, China (128 papers), Vrije Universiteit, Netherlands (128 papers) and University of Innsbruck, Austria (121 papers).

The average citation per paper registered by the total papers of these 15 institutions on Semantic Web was 3.18. Only 6 institutions have registered comparative higher citation impact than the group average. The highest impact of 6.91 citations per paper was scored by the University of Manchester, U.K., followed by Vrije

Table 3. Contribution and citation Impact of top 15 institutions on semantic web: 2001-2010

Name of the Institution	TP	TC	ACPP	H-Index
Digital Enterprise Research Institute, National University of Ireland, Galway, Ireland	204	705	3.46	16
University of Southampton, U.K.	196	843	4.30	17
Universität Karlsruhe, Karlsruhe, Germany	167	839	5.02	19
Open University, Knowledge Media Institute, Milton Keynes, U.K.	159	424	2.67	12
University of Manchester, Manchester, U.K.	149	1029	6.91	20
Wuhan University, Wuhan, China	130	71	0.55	3
Zhejiang University, China	128	143	1.12	8
Vrije Universiteit Amsterdam, Netherlands	128	645	5.04	16
University of Innsbruck, Austria	121	337	2.79	12
Technische Universitat Wien (Vienna Institute of Technology), Austria	104	266	2.56	11
Universidad Politecnica de Madrid, Spain	95	152	1.60	6
Tsinghua University, China	95	116	1.22	11
Southeast University, Nanjing, China	90	138	1.53	7
Shanghai Jiaotong University, China	88	188	2.14	7
Deutsches Forschungszentrum für Künstliche Intelligenz, Kaiserslautern, Germany	75	241	3.21	7
Total	**1929**	**6137**	**3.18**	**11.47**
Total World Output	**11846**			
Share of 15 Top Institutions in World Output	**16.28**			

Universiteit, Netherlands (5.04 citations per paper), Universität Karlsruhe, Germany (5.02 citations per paper), University of Southampton, U.K. (4.30 citations per paper), Digital Enterprise Research Institute, Ireland (3.46 citations per paper) and Deutsches Forschungszentrum für Künstliche Intelligenz, Kaiserslautern, Germany (3.21) (Table 3). The average h-index value of these 15 Indian most productive institutions was 11.47 during 2001-2010. The seven institutions have scored higher h-index value than group's average of 11.47. The highest h-index value (20) was achieved by University of Manchester, U.K, followed by University of Karlsruhe, Germany (19), University of Southampton, U.K (17), Digital Enterprise Research Institute, Ireland and Vrije Universiteit, Netherlands (16 each) and Open University, U.K and University of Innsbruck, Austria (12 each) (Table 3).

4.4 Authors' Contributions and Impact

Based on the publication data, 15 authors have been identified as prolific authors who have published more than 32 papers on Semantic Web research. Of these 15 authors, 3 each are from U.K. and Austria, 2 from China and 1 each is from Greece, Spain, USA, Germany, Canada, Ireland and Italy. These 15 authors together contributed 629 papers with an average of 41.93 papers per author and account for 5.31 per cent share in the world cumulative publications output during 2001-2010. Five authors have published higher number of papers than the group's average. These are Enrico Motta with 74 papers, followed by John Domingue (55 papers), Dieter Fensel (52 papers), Grigoris E. Antoniou (48 papers) and Ian Horrocks (44 papers).

Considering the quality/impact of papers, these productive authors have received a total of 2782 citations for 192 papers with an average of 4.42 citations per paper. Six authors have registered higher citation impact than the group's average citation impact of all authors (4.42). These are Ian Horrocks with 13.82 citations per paper, followed by Tim W. Finin (6.87 citations per paper), Thomas Lukasiewicz (6.63 citations per paper), Steffen Staab (5.97 citations per paper), G Stefan Decker (5.94 citations per paper) and Dieter Fensel (4.92 citations per paper).

Measuring the performance of these authors on the basis of h-index, eight authors have achieved the higher h-index value than the group's average of 7.05. These authors are Ian Horrocks with h-index of 16, followed by Dieter Fensel and Tim W. Finin (13 each), Steffen Staab (10), John Domingue and Stefan Decker (9 each) and Thomas Lukasiewicz (8) (Table 4).

Table 4. Contribution and citation impact of top 15 authors on semantic web: 2001-2010

Name of author	Author affiliation	TP	TC	ACPP	H-Index
Enrico Motta	Open University, Milton Keyes, U.K.	74	272	3.68	10
John Domingue	Technische Universität Wien, Institut für Informationssysteme, Austria	55	154	2.80	9
Dieter Fensel	University of Innsbruck, Semantic Technology Institute (STI) Innsbruck, Austria	52	256	4.92	13
Grigoris E. Antoniou	Institute of Computer Science, Greece	48	122	2.54	7
Ian Horrocks	Oxford University, Computing Laboratory, U.K.	44	608	13.82	16
Asunción Gómez-Pérez	Universidad Politécnica de Madrid, Ontology Engineering Group, Spain	40	108	2.70	5
Tim W. Finin	University of Maryland, USA	39	268	6.87	13
Steffen Staab	University of Koblenz, Information Systems and Semantic Web Research Group, Germany	39	233	5.97	10
Jeff Z. Pan	University of Aberdeen, Dept. of Computing Science. U.K.	37	108	2.92	7
Dragan Gasevic	Athabasca University, School of Computing and Information Systems, Canada	35	88	2.51	6
Zhaohui hui Wu	Zhejiang University, School of Computer Science, China	35	63	1.80	5
Huajun J. Chen	Zhejiang University, School of Computer Science, China	33	43	1.30	4
Stefan Decker	Digital Enterprise Research Institute, National University of Ireland	33	196	5.94	9
Nicola Fanizzi	Università Degli Studi di Bari Aldo Moro, Dipartimento di Informatica. Italy	33	51	1.55	5
Thomas Lukasiewicz	Institut für Informationssysteme, Computing Laboratory, Austria	32	212	6.63	8
	Total	**629**	**2782**	**4.42**	**7.05**
	World output	**11846**			
	Share of 15 authors in world output	**5.31**			

4.5 Role of Keywords

Keywords are also important indicators which throw light on thought content of the subject field. By analysing the keywords one gets an idea about different terminologies used by authors and indexers and also about the direction in which the subject is evolving. Table 5 gives the list of high frequency keywords appearing on the Web Semantics literature during 2001-2010.

The most prominent keywords are Semantic Web, Semantics, Ontology, World Wide Web, Web Services and Information Theory, with their share in total publications output varying from 15.65 per cent to 84.73 per cent. The second category of important keywords is Information Retrieval, Information Services, Metadata, Multi Agent System, Knowledge Based Systems and Internet, with publication share varying from 6.09 per cent to 9.62 per cent. In the third category of importance of keywords include Query Languages, Linguistics, XML, Search Engines, Artificial Intelligence, Database Systems, Knowledge Representation, Information Systems, Websites, User Interfaces, Computer Software, Semantic Web Technology, Computer Programming Languages and Electronic Commerce, with contribution varying from 3.29 per cent to 5.93 per cent during 2001-2010 (Table 5).

4.6 Media and Channels of Communication

Scientists communicated their research results through variety of document types. Conference papers were the most predominant channel of communication where more than 70 per cent of the publications were published, followed by articles (23.54), reviews (1.89 per cent) and editorials (0.54 per cent). Among the journal articles, the most productive 30 journals publishing literature on Semantic Web are listed in Table 6. Together these 30 journals contributed 1123 papers during 2001-2010, constituting 39.39 per cent share in total journal world output. The most productive journal publishing papers in this area is Communications in Computer and Information Science with 132 papers and 4.63 per cent share, followed by Web Semantics (102 papers, 3.58 per centshare), IEEE Intelligent Systems (78 papers, 2.74 per cent share), etc. (Table 6).

Table 5. List of important keywords appearing in literature on web semantics: 2001-2010

Keywords	Frequency	Keywords	Frequency
Semantic Web	10037	Linguistics	629
Semantics	7051	XML	627
Ontology	5103	Search Engines	567
World Wide Web	3272	Artificial Intelligence	556
Web Services	2130	Database Systems	541
Information Theory	1854	Knowledge Representation	541
Information Retrieval	1140	Information Systems	516
Information Services	904	Websites	443
Metadata	894	User Interfaces	442
Multi Agent System	808	Computer software	434
Knowledge-Based Systems	761	Semantic Web Technology	431
Internet	722	Computer Programming Languages	427
Query Languages	703	Electronic Commerce	390

4.7 High Cited Papers

Of the 11846 papers published on Semantic Web during 2001-2010, only 3132 papers (26.44 per cent) have received 1 or more citations. Of the 3132 cited papers, 30 papers have received 100 or more citations since their inception, 78 papers citations in the range of 50-99, 162 papers citations in range of 25-49 and 2862 papers citations in the range of 1-25.

Of the 108 high cited papers receiving citations 50 and above, 88 appeared in journals as articles (63), reviews (13) and notes (2) and 20 as conference papers. The 88 papers are published in 43 journals. The highest number of papers (16) are published in Web Semantics, followed by 8 papers each in IEEE Internet Computing and IEEE Intelligent Systems, 7 papers in IEEE Intelligent Systems and Their Applications, 4 papers in IEEE Transactions on Knowledge and Data Engineering, 3 papers in VLDB Journal, SIGMOD Journal and Lecture Notes in Computer Science (Including subseries Lecture Notes in Artificial Engineering and Lecture Notes in Bioinformatics), 2 papers in Data and Knowledge Engineering and 1 paper each in 34 other journals.

Of the 108 high cited papers, only 35 involve international collaboration (27 bilateral and 8 multilateral) . Among these 108 high cited papers, USA has appeared in 59 papers, followed by Germany and UK (19 papers each), Canada and Netherlands (5 papers each), China and Spain (4 papers each), Italy, Singapore, France, Austria, Ireland and Sweden (2 papers each) and Finland, Japan, Taiwan, Portugal, Vietnam, India, Greece, South Korea, Norway, Australia and Brazil (1 paper each). A list of top 20 high cited papers is given in Table 7.

5. SUMMARY AND RESULTS

In all 11846 papers were published the world over on Web Semantics during the last ten years from 2001 to 2010, witnessing an annual average growth rate of 75.90 per cent. The average citation impact of all papers on Web Semantics during 2001-2010 was 1.87. China tops the list among the 15 leading countries contributing to research on Web Semantics during 2001-2010, with 16.53 per cent world publications share, followed by United States, Germany and United Kingdom, Italy and Spain (from 5.08 per cent to 12.15 per cent share), South Korea, Netherlands, Japan, India, Brazil and Taiwan (from 1.04 per cent to 2.56 per cent share) and Belgium, Switzerland and Singapore (from 0.77 per cent to 0.97 per cent share). These 15 countries together have contributed 8749 papers, accounting for 73.86 per cent share in world output during the same period. United States registered the largest citation impact of 4.08 for all its publications during 2001-2010, followed by Netherlands, UK and Singapore, Germany, Italy and Belgium (from 2.04 to 3.27) and Taiwan, Spain, Switzerland, Japan and South Korea, India, China and Brazil (from 0.78 to 1.89).

The most prominent keywords noticed in Web Semantics literature during 2001-2010, include Semantic Web, Semantics, Ontology, World Wide Web, Web Services and Information Theory, with their share in total publications output varying from 15.65 per cent to 84.73 per cent and Information Retrieval, Information

Table 6. Media of communication of journal publicationson web semantics: 2001-2010

Name of the Journal	No. of papers	% Share in total Journal output
Communications in Computer and Information Science	132	4.63
Web Semantics	102	3.58
IEEE Intelligent Systems	78	2.74
Studies in Computational Intelligence	61	2.14
IEEE Internet Computing	53	1.86
Expert Systems with Applications	47	1.65
Semantic Web & Information Systems	43	1.51
Lecture Notes in Business Information Processing	43	1.51
IEEE Transactions on Knowledge and Data Engineering	35	1.23
Journal of Computational Information Systems	35	1.23
Journal of Web Semantics	35	1.23
BMC Bioinformatics	33	1.16
Journal of Universal Computer Science	32	1.12
International Journal of Metadata Semantics and Ontologies	31	1.09
Journal of Southeast University, English Edition	27	0.95
Knowledge Based Systems	27	0.95
Data and Knowledge Engineering	26	0.91
Jisuanji Jichong Zhizao Xitong Computer Integrated Manufacturing Systems, CIMS	26	0.91
Frontier in Artificial Intelligence & Applications	25	0.88
Jisuanji Yanjiu Yu Fazhan Computer Research & Development	25	0.88
Jisuanji Gongcheng Computer Engineering	24	0.84
SIGMOD Record	23	0.81
Briefings in Bioinformatics	22	0.77
Journal of Biomedical Informatics	22	0.77
Electronic Notes in Theoretical Computer Science	21	0.74
Ruan Jian Xue Bao Journal of Software	21	0.74
Wseas Transaction on Information Science & Applications	19	0.67
Jisuanji Xue Bao Chinese Journal of Computers	19	0.67
Studies in Health Technology and Informatics	18	0.63
IEEE Intelligent Systems & their Applications	18	0.63
Total	**1123**	**39.39**
Total world output in Journals	**2851**	
Share of 30 Journals in world Journal output	**39.39**	

Services, Metadata, Multi Agent System, Knowledge Based Systems and Internet, with their share in publications varying from 6.09 per cent to 9.62 per cent. The 15 most productive institutions involved in Semantic Web research (publishing 75 and more papers each during 2001-2010) have together contributed 1929 papers, accounting for 16.28 per cent share in the cumulative world publications output, with an average output of 128.6 papers per institution.

The top 15 most productive authors on Semantic Web (publishing 32 or more papers) have together contributed 629 papers, accounting for 5.31 per cent share in the world cumulative publications output during 2001-2010 and with an average of 41.93 papers per author. The most productive 30 journals publishes on Semantic Web have together contributed 1123 papers during 2001-2010, constituting 39.39 per cent share in total journal world publications output.

Among the 11846 papers published on Semantic Web during 2001 to 2010, only 26.44 per cent (3132 papers) have received 1 or more citations. Of these papers, 30 papers have received 100 or more citations since their inception, 78 papers citations in the range of 50-99, 162 papers citations in range of 25-49 and 2862 papers citations in the range of 1-25. Of the 108 highly cited papers (receiving 50 or more citations), only 35

Table 7. List of top 20 highly cited papers on web semantics: 2001-2010

Authors name	Title (document type)	Source	No.of citations
Berners-Lee, T.; Hendler J. & Lassila, O.	The semantic web (Note)	*Scientific American*, 2001, **284**(5), 34-43.	3132
McIlraith S.A.,; Son, T.C. & Zeng, H.	Semantic web services (Article)	*IEEE Intelligent Systems and their Applications*, 2001, **16**(2), 46-53.	609
Horrocks, I.; Patel-Schneider, P.F. & Van Harmelen, F.	From SHIQ and RDF to OWL: The making of a Web Ontology Language (Article)	*Web Semantics,* 2003, **1**(1), 7-26.	409
Kalfoglou, Y.; Schorlemmer, M. &	Ontology mapping: The state of the art (Article)	*Knowledge Engineering Review*, 2003, **18**(1), 1-31.	352
Hendler, J.	Agents and the semantic web (Article)	*IEEE Intelligent Systems and their Applications*, 2001, **16**(2), 30-37.	351
Maedche, A. & Staab, S.	Ontology learning for the semantic web (Article)	*IEEE Intelligent Systems and their Applications*, 2001, **16**(2), 72-79.	329
Noy, N.F.; Sintek, M.; Decker, S., *et al.*	Creating semantic web contents with protÃ©gÃ©-2000 (Article)	*IEEE Intelligent Systems and their Applications*, 2001, **16**(2), 60-71.	304
Milanovic, N. & Malek, M.	Current solutions for Web service composition (Article)	*IEEE Internet Computing*, 2004, **8**(6), 51-59.	275
Shadbolt; N.; Hall; W. & Berners-Lee, T.	The semantic web revisited (Review)	*IEEE Intelligent Systems*, 2006, **21**(3), 96-101.	244
Sycara, K.; Paolucci, M.; Ankolekar, A., *et al.*	Automated discovery, interaction and composition of Semantic Web services (Article)	*Web Semantics*, 2003, **1**(1), 27-46.	239
Medjahed, B.; Bouguettaya, A. & Elmagarmid, A.K.	Composing web services on the Semantic Web	*VLDB Journal*, 2003, **12**(4), 333-51.	231
Fensel, D.; Van Harmelen, F., *et al.*	OIL: An ontology infrastructure for the semantic web (Article)	*IEEE Intelligent Systems and their Applications*, 2001, **16**(2), 38-45.	197
Narayanan, S. & McIlraith S.A.	Simulation, verification and automated composition of web services (Conference Paper)	*Proceedings of the 11th International Conference on World Wide Web*, WWW '02, 2002, 77-88.	196
Doan, A.; Madhavan, J.; Domingos, P., *et al.*	Learning to map between ontologies on the semantic web (Conference Paper)	Proceedings of the 11th International Conference on World Wide Web, WWW-02, 2002, 662-673	195
Cardoso J., Sheth A.	Semantic E-workflow composition (Article)	*Journal of Intelligent Information Systems*, 2003, **21**(3), 191-225.	154
Doan, A.H.; Madhavan, J.; Dhamankar, R., *et al.*	Learning to match ontologies on the Semantic Web (Article)	*VLDB Journal,* 2003, **12**(4), 303-19.	152
Alani, H.; Kim, S.; Millard, D.E.; Weal, M.J., *et al.*	Automatic ontology-based knowledge extraction from web documents (Article)	*IEEE Intelligent Systems*, 2003, **18**(1), 14-21.	140
Verma, K.; Sivashanmugam, K.; Sheth, A., *et al.*	METEOR-S WSDI: A scalable P2P infrastructure of registries for semantic publication and discovery of web services (Article)	*Information Technology and Management,* 2005, **6**(1), 17-39.	138
Guo Y.; Pan Z. & Heflin J.	LUBM: A benchmark for OWL knowledge base systems (Conference Paper)	*Web Semantics,* 2005, **3**, 158-82.	128
Boulos M.N.K.; Wheelert S.	The emerging Web 2.0 social software: An eanbling suite of sociable technologies in health and health care education (Article)	*Health Information and* Libraries Journal, 2007, **24**(1), 2-23.	124

involve international collaboration (27 bilateral and 8 multilateral). Among these high cited papers, USA has appeared in 59 papers, followed by Germany and UK (19 papers each), Canada and Netherlands (5 papers each), China and Spain (4 papers each), Italy, Singapore, France, Austria, Ireland and Sweden (2 papers each), etc.

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