Webology, Volume 12, Number 2, December, 2015

Mapping a decade of linked data progress through co-word analysis

Massoomeh Niknia

Ph.D. Candidate, Department of Library and Information Science, Kharazmi University. Tehran, Iran; Archivist at IGMC (IRAN GRID Management Co.), Iran. E-mail: niknia (at) igmc.ir

Seyedeh Leili Mirtaheri

Ph.D., Department of Computer Engineering, Faculty of Engineering, Kharazmi University, Iran. E-mail: mirtaheri (at) khu.ac.ir

Received November 29, 2015; Accepted December 26, 2015

Abstract

Linked data describes a method of publishing structured data which it can be interlinked and become more effective through semantic queries. This enables data from different sources to be connected and queried. It builds upon standard web technologies such as HTTP, RDF and URIs. This method helps human readers to share information in a way that can be read automatically by computers. Regarding the importance of Linked data, the main aim of this article is visualizing scientific mapping of linked data to show its progress through one decade. The scientometric study employs hierarchical cluster analysis, strategic diagrams and network analysis to map and visualize the linked data landscape of the "Scopus" publications through the use of co-word analysis. The study quantifies and describes the thematic evolution of the field based on a total of 717 Scopus articles and their associated 19977 keywords published between 1970s and 2014. According to the results the thematic visualization and the clusters show most concepts concentrated around computer related terms, such as big data; cloud computing semantic data; semantic technologies; semantic web; artificial intelligence; computer programming; semantic search, etc. In addition, we found that in recent years after librarians and information scientists doing researches in linked data on the behalf of computer scientist the "user" studies became important.

Keywords

Information clustering; Scientometric; Science maps, Linked data, Co-word analysis

Introduction

Linked data is subject area which Tim Berners-Lee used it for the first time in a design note about the Semantic Web project. The term “Linked Data” is used almost anywhere these days, the term coined by Tim Berners-Lee in 2006 in a design note about the Semantic Web project. it refers to a set of best practices for publishing and interlinking structured data on the Web. The concept is complex; we can summarize it as that set of best practices required for publishing and connecting structured data on the web for use by a machine. It is an expression used to describe a method of exposing, sharing and connecting data via Uniform Resource Identifiers (URIs) on the web (Guerrini & Possemato, 2013). Linked data is necessary for participating in the web of data, but for taking part in the semantic web, putting data on the web and link them is not enough: there are other necessary requirements which, according to Berners-Lee (“Linked data - Design Issues”), are:

1. Using URI for identifying or referring to sources. The URI (Uniform Resource Identifier) is the characters set used to indicate univocally the names of the resources on the web and are expressed in a machine-readable form;

2. Using HTTP URIs, so that the user can look for and locate resources through them (this is called dereferencing)

3. Providing useful information about the resource when we search it with URI, using standards (for example RDF, SPARQL);

4. Including links with other URIs for finding out linked information. (Berners-Lee, 2006).

Now “Linked Data” can be seen in many areas like computer science, engineering, information technology, information science, information systems. It can also be seen in the life sciences where linked data sets such as Health Service, clinical data and patient data are analyzed and used to advance breakthroughs in science in researches. Other area of research where “Linked Data” is of central importance is social sciences among many others.

The leap in computational power enables the collection, storage and analysis of linked data sets and also linked data sets provides social media contexts for posts and describes the relationships between social media users and moreover institutions introducing innovative technological solutions to linked data analytics are flourishing.

In this article, we explore the term “Linked Data” as it emerged from the peer reviewed literature. Peer reviewed articles offer a glimpse into “Linked Data” as a topic of study and the scientific problems methodologies and solutions that researchers are focusing on in relation to it. The purpose of this article, therefore, is to sketch the emergence of “Linked

Data” as a research topic from several points: (1) Timeline, (2) geographic output, (3) disciplinary output, (4) types of published papers, and (5) thematic and conceptual development (6) clustering and science maps. To accomplish this overview we used Scopus.

Related Works

There are many researches about visualization of knowledge and science which conducted in various methods but there was no researches about linked data which visualize this subject area. Co-word analysis have been used in many subject areas, such as knowledge management (Hou et al., 2006), nanotechnology (Kostoff et al. 2006), medical informatics (Wagner & Leydesdorff, 2005) and human genome (Doisneau-Sixou et al., 2003).

Sedighi and Jalallimanesh (2014) provided a visualization overview of the wide distribution of KM publications. The analysis of clusters of the historiographical maps, based on Local Citation Score (LCS) and Global Citation Score (GCS), indicated the most frequent thematic trends. Their co-word occurrence analysis for mapping KM research topics showed that the structure of fundamental subject areas within the field of KM has changed and expanded dynamically during 2004-2010.

Halevi and Moed (2012) explored the term Big Data as it emerged from the peer reviewed literature. The purpose of their article was to sketch the emergence of Big Data as a research topic from several points: timeline, (2) geographic output, (3) disciplinary output, (4) types of published papers, and (5) thematic and conceptual development. To accomplish this overview we used Scopus.

Jalalimanesh (2012) introduced a novel methodology to extract core concepts from text corpus. His methodology is based on text mining and social network analysis. At the text mining phase the keywords are extracted by tokenizing, removing stop-lists and generating N-grams. Network analysis phase includes co-word occurrence extraction, network representation of linked terms and calculating centrality measure. Also he applied his methodology on a text corpus including 650 thesis titles in the domain of Industrial engineering. Interpreting enriched networks was interesting and gave us valuable knowledge about corpus content.

Methods

The term "Linked Data" was searched on Scopus using the index and author keywords fields. No variations of the term were used in order to capture only this specific phrase. It should be noted that there are other phrases such as "LD", “Linked Open Data” or “LOD” that appear throughout the literature and might refer to the same concept as Linked data. However, the aim of this article was to capture the common "Linked Data" phrase itself and examine the ways in which the researchers adapted and embedded it in the mainstream research literature.

The search results were examined manually in order to determine the complete match between the articles' content and the phrase "Linked Data". Special attention was given to articles from the 1970s and 1980s which were retrieved using the above fields.

All retrieved resources (3553) were analyzed using the Scopus analytics tool which enables different aggregated views of the results set based on year, source title, author, affiliation, country, document type and subject area. In addition, a content analysis of the titles and abstracts was performed in order to extract a timeline of themes and concepts within the results set. Within the content analysis results, we found that linked data in "life science" resources, especially older resources which are about linked data indicated to this subject in the different meaning as Tim Berners-Lee introduced in 2006. Most of these resources are about linked data bases especially patients' data in diseases or linked data structure which is a data structure that consists of a set of data records (nodes) linked together and organized by references (links or pointers). So the link between data can also be called a connector. After close evaluation of the results set, 2826 resources were removed from the final results set which left 717 core articles. We examine only articles because they are peer reviewed resources. So our search strategy was: "Linked Data" in Keywords, Title & abstract, from all years to 2014 in Physical sciences and social sciences articles. Then Regarding the importance of linked data area, the main aim of this article is visualizing scientific mapping of linked data to show its progress through the years.

This scientometric study employs hierarchical cluster analysis, strategic diagrams and network analysis to map and visualize the linked data landscape of the Scopus publication through the use of co-word analysis. Co-word analysis is a content analysis technique that uses patterns of co-occurrence of pairs of items (i.e., words or noun phrases) in a corpus of texts to identify the relationships between ideas within the subject areas presented in these texts. Indexes based on the co-occurrence frequency of items, such as an inclusion index and a proximity index, are used to measure the strength of relationships between items. Based on these indexes, items are clustered into groups and displayed in network maps (He, 1999).The study quantifies and describes the thematic evolution of the field based on a total of 717 Scopus articles and their associated 19977 keywords. More significantly, this study identifies the evolution of major themes in the discipline, and highlights individual topics as popular, core, or backbone research topics in Linked Data.

Results

The growth of research articles about "Linked Data" from 2008 to the present can be easily explained as the topic gained much attention over the last few years (see Figure 1).

It is, however, interesting to take a closer look at older instances where the term was used. For example, the first appearance of term "Linked Data" appears in a 1972 article on Computer and Information Science (according to data available in Scopus). The 1972 article discusses the capability of an associative memory to search some useful data bases. The report utilizes a simplified cell and a collection of "assembler language" instructions to show how sets and trees can be searched in the memory. An OR rail and an EXCLUSIVE-OR rail are discussed in relation to their use to search-ordered and unordered sets, strings, and tree data structures. linked data structures are also discussed. This report is oriented toward the software aspects of the associative memory to lead to further research in the design of high-level languages that utilize the capability of the rails.

Other early occurrences of the term are usually related to computer modeling development for linked data sets in areas such as health, geography and engineering.

When segmenting the timeline and examining the subject areas covered in different timeframes, one can see that the early papers are led by computer engineering in health sciences (information processing; Data Collection, Data Processing) but also in areas such as buildings, Mathematical Techniques, Mathematical models. From 2000 onwards, the field is led by computer science followed by engineering and mathematics.

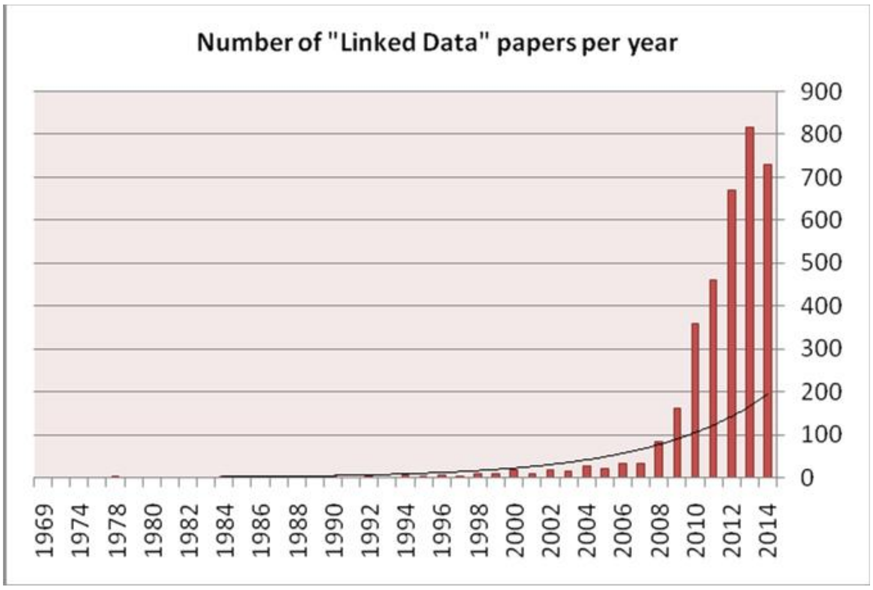

Figure 1. Time line of linked data as a topic of research

Another interesting finding in terms of document types is that conference papers are most frequent followed by articles (see Figures 2 and 3). As we see in the thematic analysis, these conference papers become visible through the abstracts and titles analysis.

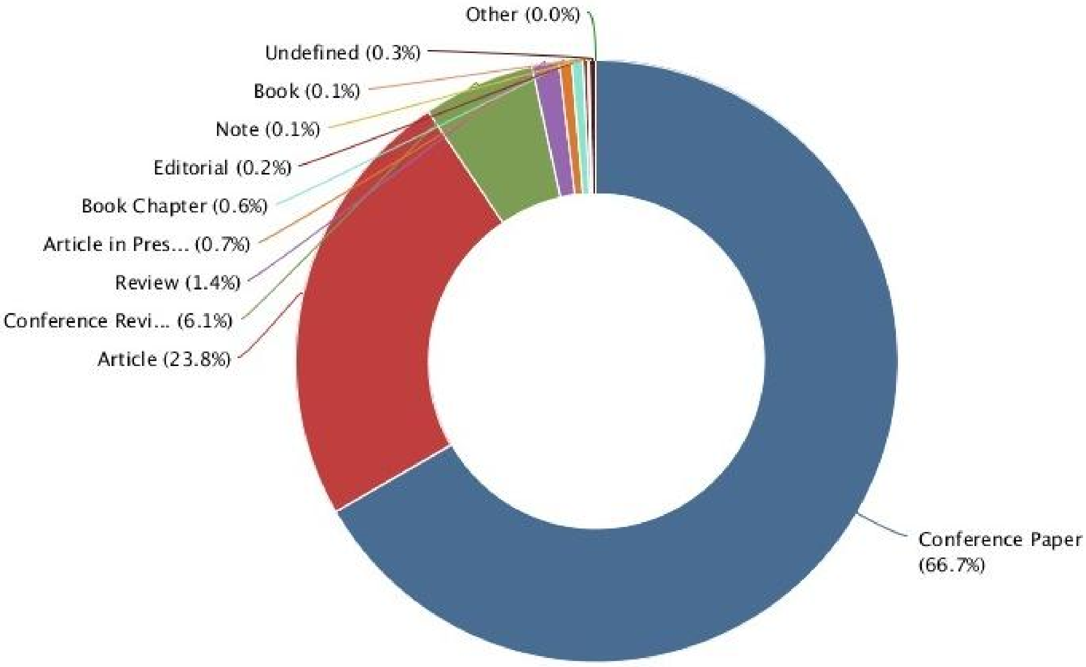

Figure 2. Document types of linked data papers

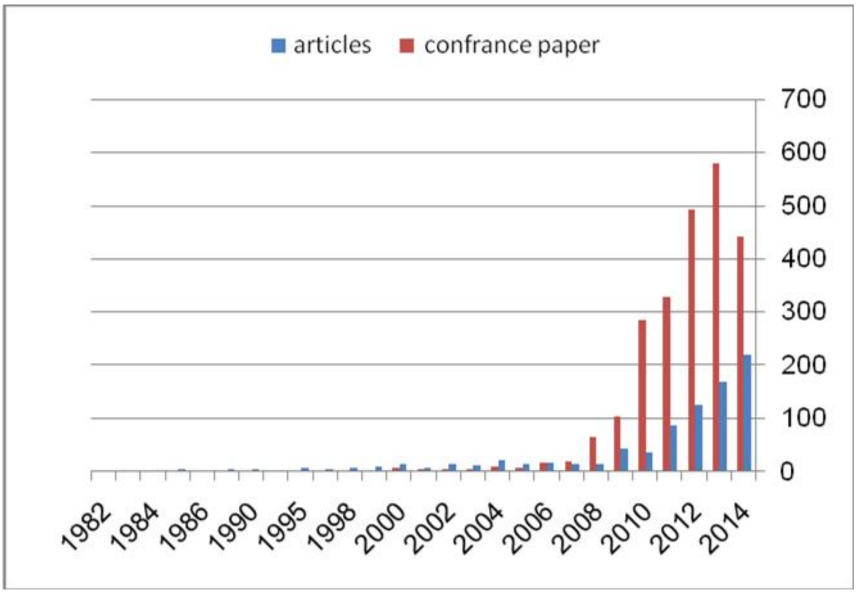

Figure 3. Conference papers and Articles growth over time

The top subject area in this research field is computer science; but one can notice other disciplines that investigate the topic such as mathematics, social sciences and engineering (see Figure 4). Other subject areas that are evident in the results sets but not yet showing significant growth are medicine, biochemistry, decision sciences, business, arts and humanities and environmental sciences.

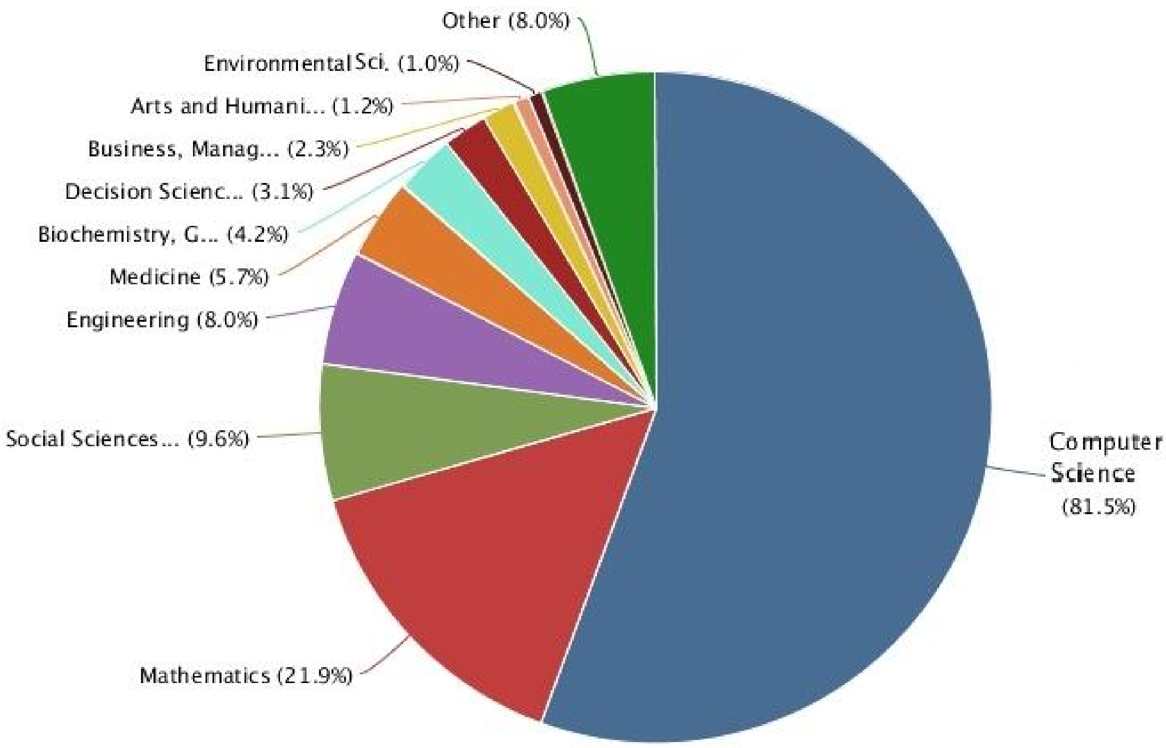

Figure 4. Subject areas researching linked data

Finally, we took a look at the geographical distribution of papers. The USA has published the highest number of papers on "Linked Data" by far, followed by Germany in second place (see Figure 5). In both countries the research on "Linked Data" is concentrated in the areas of computer science and engineering.

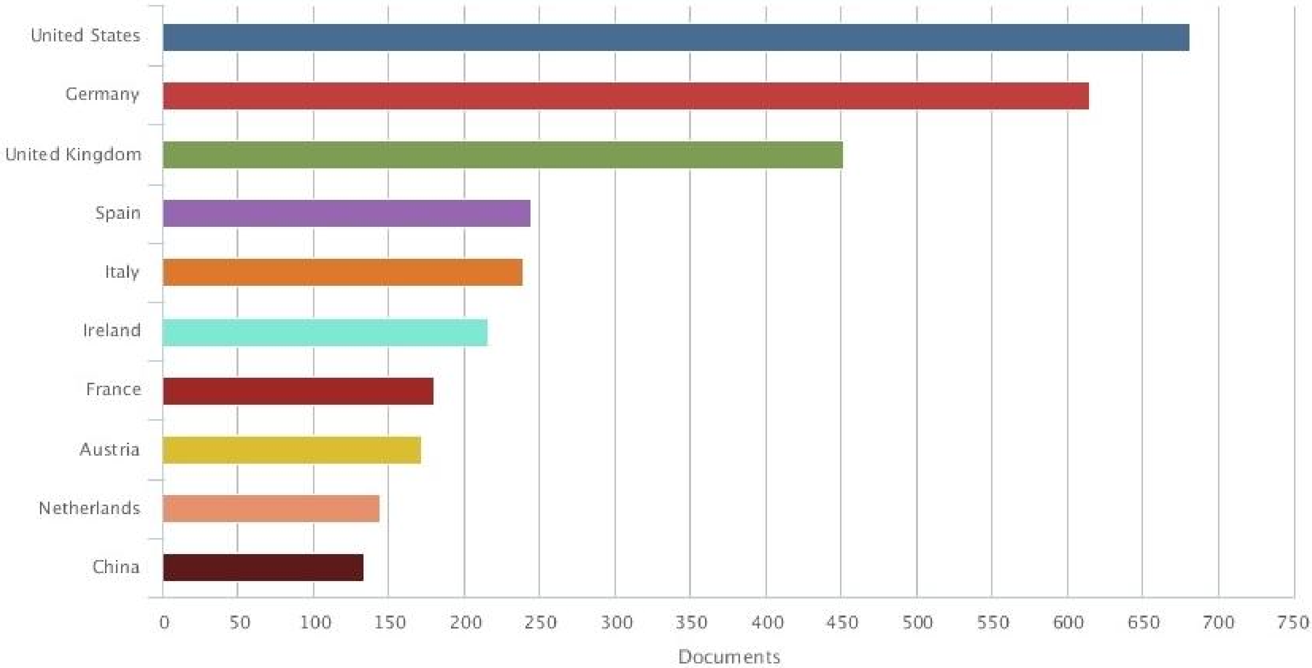

Figure 5. Geographical Distribution of linked data papers

In the USA, these four areas are followed by Computer Science, Mathematics, Social Sciences, Medicine and Biochemistry, Genetics and Molecular Biology, in Germany computer science and Computer Science, Mathematics, Social Sciences are followed by engineering and Business, Management and Accounting. This observation indicates that the USA is strong in research areas such as medical, health and biochemistry while Germany is strong in areas such as engineering and Business, Management and Accounting.

In addition to the overall characteristics of the publications on "Linked Data", we also conducted a thematic contextual analysis of the author keywords and index keywords in order to understand how and in what ways the topics within this field have evolved. In order to accomplish this, the author keywords and index keywords in each article were collected then the texts were then entered into the freely available visualization software WordStat. As we said before, the analysis was conducted on 717 articles and These visualizations were produced by ignoring health and life science resources because with content analysis we found some keywords like: " Birth, Breast, Cancer, Care, Cohort, Disease, Health, Medicare, Morality, Older, Patients, Population, treatment, women" which affect on the produced map, then after producing co-word matrix with WordStat, we used VOSviewer as another free software for producing maps (see Figures 6 and 7).

In WordStat software, we compare TF/IDF (term frequency–inverse document frequency) factor to reflect how important a word is to a document in the collection of linked data articles. The TF/IDF value increases proportionally to the number of times a word appears in the document, but is offset by the frequency of the word in the corpus, which helps to adjust for the fact that some words appear more frequently in general. So the phrase which their TF/IDF value were less than 10.8 removed and 228 phrase were remain to produce map. Nodes (circles) in this map (Figure 6) indicate the phrases. The size of each node is equal to the total weight of nodes that are associated with that node. Whatever one node associated with a higher weight node, the size and density of that node is become higher. Table 1 shows these 6 clusters in their own color.

Figure 7 shows the high density phrases in linked data. By moving from red to blue the density is decreased and the red, orange and yellow clusters made the hot topics in linked data.

Figure 6. Network map in linked data Linked Data – 1970s-2014

Table 1. Subject Clusters in Linked Data

Cluster name	The phrases in the cluster
First Cluster	Age_Factors; Birth_Rate; Birth_Weight; Body_Mass; Bottle_Feeding; Breast_Feeding; Breast_Neoplasms; British_Columbia; Cancer_Registry; Cluster_Analysis; Cohort_Analysis; Cohort_Studies; Comparative_Study; Continental_Ancestry_Group; Controlled_Study; Cost_Of_Illness; Data_Analysis; Data_Collection; Dental_Caries; Diabetes_Mellitus; Ethnic_Groups; Family_Characteristics; Family_Planning; Feeding_Behavior; Health_Care; Health_Care_Cost; Health_Care_Cost; Health_Care_Cost; Health_Care_Surveys; Health_Insurance; Health_Maintenance_Organizations; Health_Service; Health_Services; Health_Services_Research; Health_Status; Health_Survey; Health_Surveys; Home_Care; Infant_Feeding_Practice_Study; Insurance_Claim; International_Classification; Length_Of_Stay; Life_Expectancy; Linear_Regression; Logistic_Models; Logistic_Regression_Analysis; Longitudinal_Studies; Longitudinal_Study; Major_Clinical_Study; Medical_Record; Medical_Record_Linkage; Middle_Aged; Population_Dynamics; Preschool_Child; Proportional_Hazards; Psychological_Aspect; Public_Health; Record_Linkage; Regression_Analysis; Related_Disorders; Respiratory_Tract; Risk_Assessment ; Risk_Factor; Risk_Factors; Sectional_Studies; Sectional_Study; Seer_Program; Sensitivity_And_Specificity; Sex_Difference; Sex_Factors; Social_Class; Social_Security; Socioeconomic_Factors; Socioeconomic_Status; Statistical_Model; Substance_Abuse ; Survival_Rate; Time_Factors; Traffic_Accident; United_States; Utilization_Review; Young_Adult
Second Cluster	Amount_of_information; augmented_reality; big_data; cloud_computing; database_systems; data_handling; data_integration; data_linkage; data_sets; distributed_computer_systems; entity_linking; exploratory_search; feature_selection; geographic_information; geographic_information_systems; heterogeneous_data; Information_filtering; information_management; information_science; information_services; information_technology; instance_matching; internet_of_things; keyword_search; knowledge_base; Knowledge_based_systems; knowledge_basis; knowledge_management; knowledge_representation; learning_systems; life_cycle; linked_data_principles; linked_datum; linked_open_datum; management_system; ontology_matching; public_procurement; quality_of_service; query_execution; query_processing; rdf_data; recommender_systems; relational_database; research_data; semantic_data; semantic_technologies; semantic_web; sensor_data; sensor_networks; sensor_web; social_media; social_networking; social_networks; social_service; sparql_queries; state_of_the_art; structured_data; supply_chains; support_vector_machines; web_application; web_of_datum; world_wide_web

Cluster name	The phrases in the cluster
Third Cluster	Artificial_intelligence; computer_programming; computer_programming_languages; computer_simulation; computer_software; data_acquisition; data_processing; data_sources; data_structure; data_structures; decision_making; decision_support; dynamic_linked_data_structures; Formal_verification; graph_theory; information_integration; information_theory; linked_data_structures; linked_lists; logic_programming; mathematical_models; performance_analysis; problem_solving; programming_language; spatial_data; theorem_proving
Forth Cluster	Bibliographic_Data; Cultural_Heritage; Data_Management; Data_Model; Data_Quality; Data_Reduction; Data_Sharing; Data_Transformation; Digital_Humanities; Digital_Libraries; Dublin_Core; Knowledge_Organization_Systems; Linked_Data; Linked_Open_Data; Open_Data; Open_Government; Resource_Description_Framework; Sparql_Endpoint; Web_Applications; Web_Data; Web_Of_Data
Fifth Cluster	Computational_Linguistics; Information_Extraction; Information_Retrieval; Information_Systems; Multimedia_Systems; Named_Entity; Natural_Language; Natural_Language_Processing; Natural_Language_Processing_Systems; Query_Languages; Question_Answering; Relevance_Feedback; Search_Engines; Semantic_Annotation; Semantic_Annotations; Semantic_Information; Semantic_Search; Structured_Information; United_Kingdom; Web_Resources; Web_Services
Sixth Cluster	Access_control; computational_biology; computer_interface; computer_program; data_mining; data_visualization; drug_discovery; gene_expression; human_computer_interaction; information_processing; information_storage_and_retrieval; management_systems; medical_data; priority_journal; programming_languages; semantic_web_technology; sequence_analysis; user_interfaces;

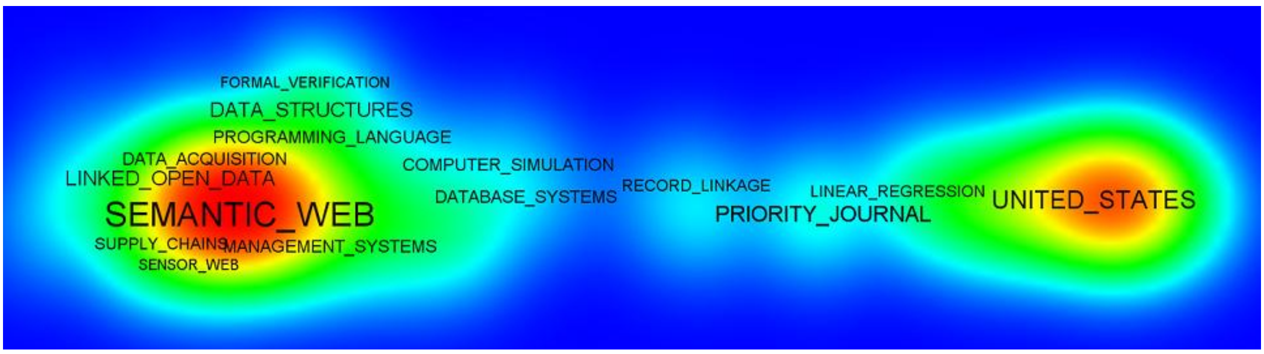

Figure 7. Density map in linked data – 1970s-2014

Table 2. Subject Clusters in Linked Data

Cluster name	The phrases in the cluster
First Cluster	Age_Factors; Birth_Rate; Birth_Weight; Body_Mass; Bottle_Feeding; Breast_Feeding; Breast_Neoplasms; British_Columbia; Cancer_Registry; Cluster_Analysis; Cohort_Analysis; Cohort_Studies; Comparative_Study; Continental_Ancestry_Group; Controlled_Study; Cost_Of_Illness; Data_Analysis; Data_Collection; Dental_Caries; Diabetes_Mellitus; Ethnic_Groups; Family_Characteristics; Family_Planning; Feeding_Behavior; Health_Care; Health_Care_Cost; Health_Care_Cost; Health_Care_Cost; Health_Care_Surveys; Health_Insurance; Health_Maintenance_Organizations; Health_Service; Health_Services; Health_Services_Research; Health_Status; Health_Survey; Health_Surveys; Home_Care; Infant_Feeding_Practice_Study; Insurance_Claim; International_Classification; Length_Of_Stay; Life_Expectancy; Linear_Regression; Logistic_Models; Logistic_Regression_Analysis; Longitudinal_Studies; Longitudinal_Study; Major_Clinical_Study; Medical_Record; Medical_Record_Linkage; Middle_Aged; Population_Dynamics; Preschool_Child; Proportional_Hazards; Psychological_Aspect; Public_Health; Record_Linkage; Regression_Analysis; Related_Disorders; Respiratory_Tract; Risk_Assessment ; Risk_Factor; Risk_Factors; Sectional_Studies; Sectional_Study; Seer_Program; Sensitivity_And_Specificity; Sex_Difference; Sex_Factors; Social_Class; Social_Security; Socioeconomic_Factors; Socioeconomic_Status; Statistical_Model; Substance_Abuse ; Survival_Rate; Time_Factors; Traffic_Accident; United_States; Utilization_Review; Young_Adult
Second Cluster	Amount_of_information; augmented_reality; big_data; cloud_computing; database_systems; data_handling; data_integration; data_linkage; data_sets; distributed_computer_systems; entity_linking; exploratory_search; feature_selection; geographic_information; geographic_information_systems; heterogeneous_data; Information_filtering; information_management; information_science; information_services; information_technology; instance_matching; internet_of_things; keyword_search; knowledge_base; Knowledge_based_systems; knowledge_basis; knowledge_management; knowledge_representation; learning_systems; life_cycle; linked_data_principles; linked_datum; linked_open_datum; management_system; ontology_matching; public_procurement; quality_of_service; query_execution; query_processing; rdf_data; recommender_systems; relational_database; research_data; semantic_data; semantic_technologies; semantic_web; sensor_data; sensor_networks; sensor_web; social_media; social_networking; social_networks; social_service; sparql_queries; state_of_the_art; structured_data; supply_chains; support_vector_machines; web_application; web_of_datum; world_wide_web

Cluster name	The phrases in the cluster
Third Cluster	Artificial_intelligence; computer_programming; computer_programming_languages; computer_simulation; computer_software; data_acquisition; data_processing; data_sources; data_structure; data_structures; decision_making; decision_support; dynamic_linked_data_structures; Formal_verification; graph_theory; information_integration; information_theory; linked_data_structures; linked_lists; logic_programming; mathematical_models; performance_analysis; problem_solving; programming_language; spatial_data; theorem_proving
Forth Cluster	Bibliographic_Data; Cultural_Heritage; Data_Management; Data_Model; Data_Quality; Data_Reduction; Data_Sharing; Data_Transformation; Digital_Humanities; Digital_Libraries; Dublin_Core; Knowledge_Organization_Systems; Linked_Data; Linked_Open_Data; Open_Data; Open_Government; Resource_Description_Framework; Sparql_Endpoint; Web_Applications; Web_Data; Web_Of_Data
Fifth Cluster	Computational_Linguistics; Information_Extraction; Information_Retrieval; Information_Systems; Multimedia_Systems; Named_Entity; Natural_Language; Natural_Language_Processing; Natural_Language_Processing_Systems; Query_Languages; Question_Answering; Relevance_Feedback; Search_Engines; Semantic_Annotation; Semantic_Annotations; Semantic_Information; Semantic_Search; Structured_Information; United_Kingdom; Web_Resources; Web_Services
Sixth Cluster	Access_control; computational_biology; computer_interface; computer_program; data_mining; data_visualization; drug_discovery; gene_expression; human_computer_interaction; information_processing; information_storage_and_retrieval; management_systems; medical_data; priority_journal; programming_languages; semantic_web_technology; sequence_analysis; user_interfaces;

As the thematic visualization and the clusters show most concepts concentrated around computer related terms, such as big data; cloud computing semantic data; semantic technologies; semantic web; Artificial intelligence; computer programming; Semantic Search, etc. but surprisingly we saw although we remove health and life science from the retrieved resources from Scopus those concepts are in the first cluster so we can conclude linked data is one of the important research areas in health and life. Also we found that in recent years after librarians and information scientists doing researches in linked data on the behalf of computer scientist the "user" studies became important. So it should be noted that user studies in linked data concept need more researches. For example enabling a non-technical user with limited knowledge of the data at hand to formulate complex queries and generally to make sense of a dataset or studying on User interface in linked data is interesting.

Conclusions

Our results show that researches on linked data emerged in the 1970s but have seen an explosion of publications since 2008. Although the term is commonly associated with computer science, the data shows that it is applied to many different disciplines including health, engineering, arts and humanities and social sciences. Conferences, especially those sponsored by IEEE and/or ACM, are the leaders in the progression of publications in this area followed by journal articles. Geographically, researches are led by the USA followed by Germany and some European countries.

A closer look at the concepts and themes in the abstracts and titles over time show how this area, which began as a computer and technology focus area with applying this technology to reach to the semantic web but this area not focusing on user experience. Maybe in recent years after solving computing issues the role of user become more important. The concept of linked data as a research topic seems to be growing and it is probable that by the end of 2016 the number of publications will double, if not more, and its analytics and applications will be seen in various disciplines.

This study was conducted using "Scopus.com" in April 2015 and the numbers and percentages presented in this article reflect the indexed publications at the time. These are bound to change as "Scopus.com" is updated daily with new publications, covering articles in press. In addition, the dates and document types presented in this study are direct derivatives of Scopus coverage as far as sources and dates. A similar search on other databases might result in slightly different findings and may vary according to the database coverage.

References

Berners-Lee, T. (2006, July 27). Linked data. Retrieved February 15, 2015, from http://www.w3.org/DesignIssues/LinkedData.html

Doisneau-Sixou, S. F., Sergio, C. M., Carroll, J. S., Hui, R., Musgrove, E. A., Sutherland, R. L. . (2003). Estrogen and antiestrogen regulation of cell cycle progression in breast cancer cells. *Endocrine-Related Cancer*, 10(2), 179-186.

Guerrini, M., & Possemato, T. (2013). Linked data: a new alphabet for the semantic web. *Italian Journal of Library, Archives, and Information Science* (*JLIS.it*), 4(1), article 6305, 67-90. Retrieved February 15, 2015, from http://leo.cineca.it/index.php/jlis/article/view/6305

Halevi, G., & Moed, H. (2012). Big data: Science Metrics and the black box of Science Policy. *Research Trends*, 30 (September), 3-6. Retrieved February 15, 2015, from http://www.researchtrends.com/wp-content/uploads/2012/09/Research_Trends_Issue30.pdf

He, Q. (1999). Knowledge discovery through co-word analysis. *Library Trends*, 48(1), 133–159.

Hou, Hai-yan, Liu, Ze-yuan, Chen, Yue, Jiang, Chun-lin, Yin, Li-chun, Pang, Jie. (2006). Mapping of science studies: The trend of research fronts[J] *Science Research Management*. 27(3): 90-96 Jalalimanesh, A. (2012). Knowledge Discovery in Scientific Databases Using Text Mining and Social Network Analysis. *2012 IEEE Conference on Control, Systems and Industrial Informatics (ICCSII)*, Bandung, Indonesia, September 23-26.

Kostoff, R. N., Stump, J. A., Johnson, D., Murday, J. S., Lau, C. G.Y., Tolles, W. M. (2006). The structure and infrastructure of the global nanotechnology literature. *Journal of Nanoparticle Research*, 8(3-4), 301-321.

Sedighi, M., & Jalalimanesh, A. (2014). Mapping research trends in the field of knowledge management. *Malaysian Journal of Library & Information Science*, 19 (1), 71-85.

Wagner, C., & Leydesdorff, L. (2005). Mapping Global Science using International Co-authorships: A Comparison of 1990 and 2000. *International Journal of Technology and Globalization*, 1(2), 185-208.

Bibliographic information of this paper for citing:

Niknia, Massoomeh, & Mirtaheri, Seyedeh Leili (2015). " Mapping a decade of linked data progress through co-word analysis." *Webology*, 12(2), Article 141. Available at: http://www.webology.org/2015/v12n2/a141.pdf