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Topic Maps : A Bibliometric Study

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Abstract

Topic Maps is an international standard (ISO/IEC 13250) to describe and encode knowledge structures and associating them with relevant information resources. This thesis seeks to investigate what has been written about Topic Maps from year 2000 to 2011, as well as finding out the research and publication trend in Topic Maps. This study was based on quantitative methodology, which was bibliometric analysis. The data was collected from Scopus and Web of Knowledge databases. Search keywords used are “topic map”, “topic maps” and “ISO/IEC 13250”. A total of 356 publications (265 conference papers, 91 journal articles) from 2001 to 2011 taken into data analysis. The findings revealed that Topic Maps researchers had a preference to present their findings in conference rather than in journal. The authorship pattern was more towards coauthorship. Most researchers were coauthored locally, as international collaboration was very low. Computer science and library and information science related journals were the favourite publishing venue. Majority of the conferences were computer science and education related. The focus of the topic maps was on data integration and interoperability (2001-2004), information theory (2005 – 2008), knowledge and intelligent based system (2009 – 2011). Also, there were five themes identified, namely content management, repository, ontology, information architecture, retrieval and navigation, and semantic web. The future research areas will possibly be collaborative e-learning system, knowledge visualization system, visualization construction, semantic metadata creation from a relational database, knowledge navigation and retrieval improvement, intelligent topic map, distributed knowledge management based on extended topic maps, knowledge service system, knowledge representation modeling, and multi granularity and multi-level knowledge.

Keywords: topic maps, bibliometric

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CHAPTER 1: INTRODUCTION

1.1. Introduction

This introductory chapter outlines the rational for this thesis. It introduces the thesis with the motivation of the research, statement of problem, aims and objectives and finally research questions. The motivation is the curiosity of knowing the research topics of Topic Maps. This leads to the statement of the problem. The statement of problem describes how this thesis would benefit and be a guide for future research on Topic Maps. Lastly, aims and objectives, also research question present the importance of the study.

In this thesis, the phrase “Topic Maps” as a capitalized proper noun is used referring to the name of ISO/IEC 13250. Whereas, “topic map” a common noun of the singular form of “topic maps” is referring to set of topics and associations.

1.2. Motivation

My interest in Topic Maps originated from the course Digital Documents in Masters in Digital Library Learning programme which held in University College of Oslo and Akershus. Before the course, I have not been exposed to knowledge representation tool such as Topic Maps. Seeing the basic functionality of Topic Maps in the field of library and information science, I began to express interest to discover the research and publication of Topic Maps in various domains.

Topic Maps is designed and developed to handle the construction of indexes, glossaries, thesauri, and tables of contents (Park & Hunting, 2002). Topic map has been existed way back 20 years ago since 1991. The Davenport Group started the work of topic maps, due to customer pressure, where they insisted the vendors to improve subject term consistency in their document system and published books. The major problem mentioned was how to provide master indexes for the documentation system. In other words, it was the back-of-book indexes. Initially, the problem was solved with SOFABED (Standard Open Formal Architecture for Browsable Electronic Documentary). However, in 1992, a new group HyTime was established. It provided SGML (Standard Generalized Markup Language) with multimedia and hyperlinking features. HyTime elaborated SOFABED model into HyTM (HyTime Topic Maps). Then, it was taken to another paradigm to the Web as XTM (XML Topic Maps) by Steven Newcomb. Eventually, Topic Maps specification was published as ISO/IEC 13250:2000 (Park & Hunting, 2002).

As mentioned that Topic Maps was developed to handle indexes; nevertheless, it has been applied beyond other domain, such as Information architecture and web publishing and to enabling more structured and semantic information retrieval on the web (Estrada, 2009). In other words, Topic Maps provides a basis for the Semantic Web. When mentioning about Semantic Web, there is another similar technology that provides the foundation for Semantic Web, and the technology is RDF (Resource Description Framework). RDF is a model developed by World Wide Web Consortium (W3C). RDF is a technology representing Information about resources in WWW, and W3C is leading the Semantic Web aiming to make the current web from unstructured documents into a "web of data" using RDF (Presutti, Garshol, Vitali, & Gessa, 2005). Topic Maps and RDF were developed in parallel during the late 1990's each by separate institutions, but in term of their purpose, they appeared to be different. Topic Maps for human reading, and RDF for machine processing. However, research has it that both turned out to have many similarities. Obviously, the RDF seems to be the leading champion in Semantic Web as compared to Topic Maps because of RDF was developed within W3C, which is more incline and favourable to the web as compared to ISO. Major academic experts in knowledge representation field pointed out the weakness of conceptual or formal foundation as a critical flaw of TM (KTweb, 2003). Despite this, various institutions are still currently making research about Topic Maps. This indicated that Topic Maps provides an open field for various research subjects. I believe many research groups are curious about literature review of Topic Maps. Therefore, I studied about scientific literatures written on Topic Maps, which appears in journals and conference proceedings. There is a literature review study on Topic Maps by Estrada (2009). However, it was more confined to the library and information science. Hence, this thesis is not merely a literature review, but it uses bibliometric methods to discover focus of the research on Topic Maps.

1.3. Statement of Problem

The research problem for this thesis is to study what have been written about Topic Maps in scientific journals and conference proceedings during the time frame of 2000 – 2011. This time frame was selected because Topic Maps was published in ISO standard in 2000. Therefore, it is interesting to find out the research and publication trend in Topic Maps as there is no study conducted on this matter. This can be a guide and understanding for future research on Topic Maps. Also, it could help to stimulate and benefit the research about Topic Maps in the future.

1.4. Aims and Objectives

This thesis seeks to investigate what has been written about Topic Maps during the period from year 2000 – 2011. In other word, this research aims to find out any open field for various research subjects. Below are the specific objectives of this study:

- To identify the publication trend of Topic Maps whether the publication is concentrated on certain years.
- To study the directions and focuses of Topic Maps research.
- To identify researchers, journals, conference proceedings and countries which have been concentrated on Topic Maps research.
- To discover future research area of Topic Maps.

1.5. Research Questions

Research questions are formulated from the statement of the problem presented earlier. Lukkari (2011) carried out bibliometric study on Working Capital Management divided the research questions into three groups, which are external, internal and future research areas. Therefore, the research questions in this thesis are grouped into three categories, which are external and internal attributes of publications and future research areas.

External attributes of the publications

1. How publications are placed in time?
2. How publications are concentrated to specific researchers, journals, conference proceedings, and country?

Internal attributions of the publications

3. Which publications about Topic Maps are the most cited?
4. What has been studied about Topic Maps?

Future

5. What are the future research areas?

1.6. Limitation and Scope

The following limitation and scope was applied to this study:

- Only peer-reviewed journal articles and conference papers were covered.
- Literatures from year 2000 onwards were taken into consideration.

1.7. Outline of Thesis

There are five chapters in this thesis.

Chapter One of this thesis provides a rationale for the research project by providing some background information, motivation of doing such research, and discussion of research problem. The research questions are stated together with the aims and objectives as well as limitation and scope.

Chapter Two reviews on the literature which informed of this thesis. It defines the studied topic Topic Maps and presents different findings and perspectives to TM from recent scientific literature.

Chapter Three outlines the methodology used in this thesis and provides justification for that choice. Data source, data collection and analysis, are examined.

Chapter Four consists of data analysis. Analysis of the literature and a discussion of the findings in relation to the literature discussed in Chapter Two.

Chapter Five presents conclusion and discussion about the findings of this study and offer suggestions for further research.

CHAPTER 2 : LITERATURE REVIEW

2.1. Introduction

This chapter aims to review the literatures which are related to Topic Maps. Literatures on Topic Maps will be reviewed on a general level and its usage, application and functionality.

2.2. Topic Maps

Topic Maps is an international standard (ISO/IEC 13250) to describe and encode knowledge structures and to associate them with relevant information resources (Pepper, 2000, 2002). It is an advanced technique of indexing, linking and addressing knowledge representation (Garshol & Moore, 2008). Topic Maps started from the merging of electronic indexes where it solves the information management problems involved in creating, maintaining and processing indexes for complex documentation (Garshol, 2004; Pepper, 1999, 2000). Topic mapping is found traditionally in back-of-book indexes, glossaries and thesauri (Pepper, 2002). Therefore, it is very close to subject-based classification technique(Pepper, 2000). Topic maps are subject-centric (Pepper, 2002). Through its emphasis on the centrality of subjects, rather than documents or applications, it presents a new way of using computers to manage information and knowledge, dubbed subject-centric computing (Pepper & Moore, 2010).

Topic Maps is published as ISO/IEC 13250 in 2000 (Garshol, 2002). This standard is known as HyTM (short for HyTime Topic Maps), which defines the basic model with SGML-based syntax. When HyTM was established, there were three known issues with the syntax. The issues were (1) HyTM is not an XML syntax, (2) it is not a complete Document Type Definition (DTD), and (3) it did not use URIs for external references (Biezunski, Newcomb, & Bryan, 2006). With these issues, it was clear that something more web-optimized was needed. Therefore, TopicMaps.Org was formed in ad-hoc to create a new XML and URIs based topic map syntax (Biezunski et al., 2006; Garshol, 2002). Then in 2001, XML Topic Maps (XTM) 1.0 specification was published and accepted into the second edition of ISO 13250. XTM become the main topic map syntax in many topic map tools; HyTM syntax, on the other hand, is rarely used (Garshol, 2002). This had brought TopicMaps.Org and the ISO topic map committee came into an agreement on a division of labour, where ISO would focus on core standards development, meanwhile TopicMaps.Org would focus on the user community issues. Later ISO approved two new standards, namely, TMQL (Topic Map Query Language) and TMCL (Topic Map

Constraint Language), and the topic map data model was being reformulated was being reformulated (Pepper & Garshol, 2002). TMQL is a query language for topic maps. It helps and simplifies information extraction (Biezunski et al., 2006). The creation of the query language provides a possible approach to interoperability between any two technologies, in other words, integration at the query level (Garshol, 2003). As for TMCL, it is a schema or constraint language for topic maps. Schemas can be written to give constrains what is allowed to say in the topic maps (Biezunski et al., 2006), so that it can ensure greater consistency and more predictable results for both users and applications (Pepper & Moore, 2010). As for TopicMaps.Org, they became a member section of OASIS[1] and decided to start promoting the published subjects concept (Garshol, 2002).

Topic maps is organized around topics, and each topic is used to represent some real-world thing (Garshol & Moore, 2008; Pepper, 2000). In other words, the central of topic maps are topics which represent about the things the topic maps is. The basic concept of topic map is topics, associations and occurrences. Topic is subjects of discourse; association is relationship between the subjects; and occurrence, is connection between the subjects and information resources (Garshol, 2002).

Pepper (1999, 2000) mentioned that topic maps enabled to encompass all navigation aids and retrieval, such as multi-document indexes, glossaries, cross reference and thesauri. Then in 2002, Pepper & Garshol (2002) said that a Topic Map is functionally equivalent to these navigation aids and retrieval. However, the selling point always brought up in Topic Maps has been placed at the centrality of Topic Maps, which is the concept of the subject, is being applied. It focuses more on how to **name** and how to **identify** subject. According to Grønmo (2003), there are not any other knowledge representation puts this much focus on these two as much as Topic Maps. Pepper (2002), who compared RDF and Topic Maps, mentioned that the prominent knowledge representation RDF is focused on resources where information resources are attached with metadata structure, whereas, Topic Maps focus on the "aboutness" of information in a subject, by applying proper naming and identifying subject.

2.2.1. Topic Maps Concept

A topic map is essentially an SGML or XML documents used for representing topics, occurrences of topics, and associations between topics. The key concepts are the topic (and topic type), the topic occurrence (and occurrence role), and the topic association (and association type) (Pepper, 1999,

[1] **OASIS** (Organization for the Advancement of Structured Information Standards) is a not-for-profit consortium that drives the development, convergence and adoption of open standards for the global information society.

2007). To be easily remembered the key concept, acronym "TAO" is the short for Topics, Association and Occurrences. Other concepts like scope, public subject and facets, are an extension of topic map model which provide more expressions (Pepper & Moore, 2001; Pepper, 2000).

Topic

A topic can be any "thing", such as, a person, an entity, a concept, regardless of its existence and characteristics (Pepper, 1999, 2000).

Occurrences

A topic may be related to one or more information resources, and vice versa. These resources are called occurrences of the topic. Occurrences perform the similar function like the page numbers in a back-of-book index (Garshol, 2004; Pepper, 2000). The resources for occurrences are either: resource reference (a URI - Uniform resource identifier) or resource data (expressing a piece of information about a subject) (Pepper & Moore, 2001).

Association

An association defines as a relationship between one or more topics. The topics are members of that association (Pepper & Moore, 2001) and they has corresponding association role played in that association (Pepper, 1999).

2.2.2. Building Topic Maps

Topic Maps is represented in many ways, in files, inside databases, as internal data structures in running programs, and in the human mind. All these different ways have the similar representation of abstract structure, in the form of a data model (Garshol & Moore, 2008).

There are several different approaches to build Topic Maps. There are three main approaches to build Topic Maps (Garshol, 2002):

- Manually by humans authoring the topic maps. The advantage is producing high quality and rich topic maps. Disadvantage will be the expensive cost of human labour.
- Automatically generate Topic Maps from existing source data which is well-structured and has clearly defined semantics and metadata (Pepper & Garshol, 2002). However,

unstructured source data can be made structured via various natural-language processing tools (Garshol, 2002; Pepper & Garshol, 2002). Nevertheless, the task is more complex because rarely the output result is usable without any quality assurance done by a human (Pepper & Garshol, 2002).

- 100% automatically produce the Topic Maps from structured source data like XML, RDBMS, LDAP servers and more specialized applications. This is because data originating from relational databases is marked up using SGML or XML, along with metadata which is rich and consistent (Pepper & Garshol, 2002). It defines interchange syntaxes based on SGML or XML (Pepper, 1999). Topic Maps Engine appears in every topic map application. It is equivalent to an RDBMS database engine. It functions to import and export XTM, store update, and query topic maps. Any storage and updates will be taken care by the engine (Garshol, 2002).

Other than the above approaches, the creation of Topic Maps could be based on these three types: System Topic Map, Semantic Topic Map, and User-Defined Topic Map (Ahmed, 2000):

- System Topic Map: It combines several similar type of repositories into a virtual repository with seamless browsing. It acts as an application that could talk and merge the output of multiple system topic map engines
- Semantic Topic Map: The meaning from the content of the repository is extracted and be used to generate semantic topic map. It represents the connections of that meaning as a Topic Map.
- User defined Topic Map: It gives users to create their own perspectives on a set of data. Eventually, it can be applied in 3 areas, namely, Individual workspaces, shared workspaces and knowledge management.

2.3. Topic Maps Application

Ever since Topic Maps has become ISO standard, it is used in a variety of fields and purposes. Topic Maps have several classic functions: Classifying and organizing, querying (adding semantic precision), navigating (semantically and multiview point), filtering and segmentizing (capturing context), visualizing and merging (ISO/IEC JTC1/SC34/WG3, 2008). Garshol (2004) explained that Topic Maps facilitates many tools such as programming APIs (Application programming interface), query languages, schema languages, portal integration, graphic vizualization, content management,natural language querying, workflow and so on.

Topic Maps have been used for many different purposes in industry, public sector, and academia (ISO/IEC JTC1/SC34/WG3, 2008). In Europe, public sector used Topic Maps in pharmaceuticals, automobiles, publishing and more (Newcomb & Biezunski, 2003). Estrada (2009) mentioned there was a widespread of Topic Maps usage in Germany and Norway where there were numerous large and small scale projects using Topic Maps.

The application of Topic Maps includes the following:

- Semantic indexing (ISO/IEC JTC1/SC34/WG3, 2008), such as Metadata management (Garshol, 2007);
- Semantic portals (Garshol, 2007);
- Knowledge management (ISO/IEC JTC1/SC34/WG3, 2008; Pepper & Moore, 2010); Extension of knowledge management involves areas like Businesss process management, Product configuration, Business rules management, IT asset management, Manufacturing asset management, and Intelligence gathering and analysis (ISO/IEC JTC1/SC34/WG3, 2008; Garshol, 2007).
- Specialized knowledge based systems (Pepper & Moore, 2010; Wrightson, 2001a);
- E-learning(ISO/IEC JTC1/SC34/WG3, 2008; Pepper & Moore, 2010; Garshol, 2007);
- Enterprise information integration (Pepper & Moore, 2010; Wrightson, 2001a; ISO/IEC JTC1/SC34/WG3, 2008 ; Garshol, 2007);
- Digital library (Pepper & Moore, 2010; Wrightson, 2001a);
- Business process information flows and modelling (Garshol, 2007 ; Pepper & Moore, 2010; Wrightson, 2001a).
- Content management system (Pepper & Moore, 2010; Wrightson, 2001a), for example, document management systems and technical documentation systems;
- Information system (Pepper & Moore, 2010; Wrightson, 2001a), for example, Enterprise Resource Management systems, Product data systems (engineering data, CAD/CAM);
- Websites, portals (Pepper & Moore, 2010), catalogues, site indexes (Garshol, 2002), intranets, extranets, existing portal resources (Pepper & Moore, 2010; Wrightson, 2001a), and web publishing (Pepper & Moore, 2010; Wrightson, 2001a).

2.3.1. Knowledge Management

Topic maps is an enabling technology for knowledge management (Pepper, 2000). Since topic maps is known for representing knowledge about the things it describes, it is used as knowledge management tools (Garshol, 2002) where complex knowledge structures are encoded and linked them to related information assets. In an organization, the corporate memory (roles, products, procedures) is the knowledge structure and they are linked to different documentation using Topic Maps (Pepper, 2000) and Topic Maps has the capability to capture and manage human knowledge expressed by employees. This knowledge is eventually to be shared and reused across departments, organizations and systems. This is possible because of the merging of information is based on international standard possessed by Topic Maps (ISO/IEC JTC1/SC34/WG3, 2008; Pepper & Moore, 2010). Topic maps is expanded to other areas of Knowledge management such as Business process management, Product configuration, Business rules management, IT asset management, Manufacturing asset management, and Intelligence gathering and analysis (ISO/IEC JTC1/SC34/WG3, 2008).

Topic Maps are seen as a Knowledge Representation tool (Wrightson, 2001b). It integrates knowledge representation and inference tools, such as case based reasoning and expert systems (Wrightson, 2001a). The characteristics of Topic Maps for knowledge representation are (Wrightson, 2001b):

- An associative network between resources could be established. Each resource represents concept.
- Resources are being organized in a knowledge space where topics are linked to the resources in a structured way.
- A unifying conceptual framework is used for interrelating different sets of information resources.

2.3.2. Digital Library

Topic Maps has progressed into digital libraries. Digital library fundamentally is digital content that is organized along with bibliographic principles. Traditional digital libraries are governed and organized by bibliographic principles, however, Topic Maps is seen to be useful to attuned to the needs of digital information and also supporting bibliographic principles and practices, making the digital

library semantic in a way (Pepper & Moore, 2010). The New Zealand Electronic Text Centre[2] used Topic Maps for managing digital content on documentary heritage materials. Estrada (2009) mentioned that one significant application of Topic Maps to digital libraries is in facilitatinsg the navigation of TEI (Text Encoding Initiative) encoded full-text collections.

2.3.3. Visualization and Navigation

Visualization is a technique for the enhancement of the users' perception of the structure in large information spaces and for a location to provide navigation facilities (Le Grand & De Paris, 2000). Data visualization techniques are gradually becoming prominent. Hence, Topic Maps graphic user interface is becoming easier to be built for data visualization purpose (Ahmed, 2000). There are several Topic Maps engines provide visualization of Topic Maps. One example is provided by Ontopia Navigator (Le Grand & De Paris, 2000).

Topic Maps adapted a few visualization techniques. Topic Maps can be seen as network of topics. Graphs and trees are seen to be suitable in the representation of global structure of the Topic Maps (Le Grand & De Paris, 2000). Graph visualization displays the Topic Maps as a set of interconnected nodes (Ahmed, 2000). However, the downside of this is the representation may become cluttered rapidly as the number of topics and associations increases. Therefore, it is not suitable for topic maps containing millions of topics and associations (Le Grand & De Paris, 2000).

Topic Maps has been represented as maps. It is to enhance navigation in complex information systems, especially for website. It illustrates the relative importance of each web page according to the size of the corresponding zone on the map. The zone sizes are used to represent topics and associations instead of web pages. Self-organizing map (SOM) algorithm of Kohenen is used to organize automatically the documents into a two-dimensional grid so that related documents can appear in the same zone or close to each other (Le Grand & De Paris, 2000).

Topic Maps is used as a visual data mining tool in virtual worlds and multidimensional representation. With the visualization in 3-dimensional, users could interactively explore data and in a faster pace to discover some meaningful patterns, trends and relationship in data mining (Le Grand & De Paris, 2000).

[2] http://www.nzetc.org/

2.3.4. Integration

Topic Maps provides a meta-model for integrating information and enabling subject-based merging (Pepper & Moore, 2010). Information from different sources can be combined and they are integrated into a single complete topic maps (Garshol, 2004). Information is usually dispersed in several systems. To fasten and easy merging or integration of information, topic maps acts as a middleware for transferring data between systems (Pepper & Moore, 2010). Costly migration, integration and re-engineering of existing content will be avoided when applying topic maps (ISO/IEC JTC1/SC34/WG3, 2008; Pepper & Moore, 2010).

Integration can be done via mappings technique. Topic maps has two approaches to applying mappings between models: Static mappings and Dynamic mappings. Static mapping are about conversions or exports: the step is straightforward as a set of data in the source model is brought to produce a complete mapping in the target model, whether in serialized or in persistent storage. Dynamic mappings are complicated. An API is needed where data from the source model are made dynamically to be stored in the target model. Each updates to the source data is instantly reflected through the mapping interface (L. M Garshol, 2001).

2.3.5. Semantic Indexing

The volume of information is exploding and overloading at an exponential rate, the same goes to the search engine results. However, Topic Maps is used for semantic indexing. Semantic indexing is a technique useful for searching and organizing large data collections, particularly unstructured data. Therefore, Topic Maps provides subject-based organization, associative model (intuitive navigation) and structured queries (add power to full-text search) (ISO/IEC JTC1/SC34/WG3, 2008). Instead of returning documents, a Topic Maps based system can return the topics that best match and extra information. This feature provides a starting point for going into the topic map and browsing around to find the answer to the specific question (Garshol, 2004). The semantic indexing applies to taxonomy management, metadata management and semantic portals (ISO/IEC JTC1/SC34/WG3, 2008).

2.3.6. E-learning

The core of e-learning is knowledge. This is somehow related to knowledge management where knowledge is also largely involved (ISO/IEC JTC1/SC34/WG3, 2008). Topic maps is related in e-

learning because of its strengths as a content management technology (Pepper & Moore, 2010). In the learning environment, Topic Maps is a model that captures knowledge acquisition, which is what the student has learned. It structures e-learning systems, organizes school and university curricula and enables the merging of Topic Maps built for such resources (ISO/IEC JTC1/SC34/WG3, 2008). In Norway, school students are encouraged to create their topic maps to record what they have learned. The National School Curriculum has its definitive expression in topic map (Pepper & Moore, 2010).

2.3.7. Content management

Topic Maps is used to organize content in content management systems. Traditional content management only has simple folder hierarchies and property value metadata. However, Topic Maps driven content management could integrate information from diverse sources, in a way could function like an expert system (Garshol, 2002). Topic Maps model with metadata representation and cross-linked structure of content, could increase findability and easy browsing in a system's content (Garshol, 2002, 2007; Ahmed, 2000). Other than that, integration of separate content management system could be done by Integrated Topic Management System (ITMS). Topic Maps takes the process of merging information from disparate sources and also with content management system content. Eventually, information can be integrated easily and reuse again (Garshol, 2007).

CHAPTER 3 : METHODOLOGY

3.1. Introduction

This study is quantitative methodology. Quantitative methodology was selected because bibliometric analysis was applied to this research. Bibliometrics were firstly introduced by Pritchard. It was the usage of mathematical, in particularly, statistical methods to books and other media of communication (Sun, Wang, & Ho, 2012). Citation and content analysis are found to be the commonly used bibliometric methods. Bibliometrics have wide applications in various areas to elevate research performance or assess the research trends by investigating the publication characteristics, such as sources, authorship, geographical origins, subject and citations. Bibliometric methods have been used to measure scientific progress in many disciplines of science and engineering and are a common research instrument for systematic analysis. The concept of "evaluative bibliometrics" was first proposed, and many scientists have tried to evaluate the research trend in the publication outputs of countries, research institutions, journals and subject category, citation analysis and the peak year citation per publication (Fu, Ho, Sui, & Li, 2010; Rosas, Kagan, Schouten, Slack, & Trochim, 2011).

3.2. Bibliometric

Bibliometrics was established as the result of bibliographies statistical studies (Egghe & Rousseau, 1990). The term "Bibliometrics" was first proposed by Alan Pritchard. It is to update scientific bibliographies. He analyzed literatures in order to discover the patterns of authorship, and the historical development of subject fields, publication and use (Sun et al., 2012). In a simple way, bibliometrics is a study of relationship of numbers and patterns in bibliographic data and use (Kumara, Prakasan, Mohan, Kademani, & Kumar, 2009). The basic definition of bibliometrics then means both statistical and mathematical methods applied to books and other materials, for example journals (Egghe & Rousseau, 1990). Bibliographic studies include relationships among a number of papers, growth of literature and patterns of library and database usage. In today's context, bibliometrics is a technique for production measurement and the dissemination of different schools of human and scientific knowledge (Archambault & Gagné, 2004). Microsoft Encarta (2006) defines bibliometrics studies as information scientists analyse many and various phenomena that affect any aspect of information (Kumara et al., 2009). The evaluation of scientific work is among the key driving forces behind scientific advancements (Rosas et al., 2011).

The purpose of using bibliometric could be a common research instrument for systematic analysis (Fu et al., 2010; Mao, Wang, & Ho, 2010) to analyze certain quality of a research and performance of a knowledge field (Lundberg, 2006), by giving a comprehensive picture of the scientific production of a field, regardless of subjectivity in peer review and expert judgments (Chen & Guan, 2011). Bibliometric has become a tool for monitor research evaluation and management such as research funding allocation, academic promotion and recruitment (Chen & Guan, 2011; Della Mea, 2011; Kumara et al., 2009). In addition, bibliometric forecasts important emerging research hot topics in technological domains (Chen & Guan, 2011).

3.2.1. Distribution of publication

The study of publication output in a field can be a reliable indicator of research work's status in that field (Kumara et al., 2009). Analysis of the number of publications is the most basic bibliometric indicators. The study was done by Della Mea (2011) showed that the distribution of papers in time by year and it gave a variation of result about research. Li, Zhang, Wang, & Ho (2009) mentioned that the gradual increases in the number of outputs revealed stable growth and communication in research. Nevertheless, (Thornley, McLoughlin, Johnson, & Smeaton, 2011) argued that it is difficult to get comprehensive and accurate data on publication numbers and even more difficult to get such data on how often these publications have been cited. This could be a disadvantage and limitation of bibliometric study.

Fu et al. (2010) conducted a study on bibliometric analysis of solid waste research to evaluate the current trends, and the authors analyzed the publication document type aspect. Document types are taken into consideration because in most bibliometric studies only certain document types are included, and each different document types convey relevant scientific information (Rehn & Kronman, 2008).

Also, Fu et al. (2010) had done an exponential model to describe the relationship between the annual number of articles and the year published. This regression analysis method could estimate the growth rate for annual articles and the trendline. Trendline is most reliable if suitable trendline is applied, such as linear, logarithmic, polynomial, power, or exponential.

3.2.2. Authorship

The study of authorship pattern in publication is an attractive part of bibliometric study. The counting of the number of the contributing author offers some indication to the degree of collaboration between authors, at least two people by engaging their efforts in mind and body. This is particularly common in the field of sciences as compare to humanities (Pradhan, Panda, & Chandrakar, 2011).

Kumara et al. (2009) who analyzed physics and engineering literatures by identifying prolific authors in the field. Most productive author with the number of publications more than 5 were observed. Identifying prolific contributor could tell who is the key player in certain research field.

Della Mea (2011) studied the coauthorship and collaboration trend of Telepathology literatures. This was to find out the involvement of coauthors in dissemination activity. The analysis of coauthorship patterns is frequently used in bibliometric study as a mean for understanding collaboration (Rosas et al., 2011).

Moppett & Hardman (2011) screened out authors with identical names and initials by checking the author's institutional and departmental affiliation. Furthermore, checking the first author and reconfirm with the second author technique was used. Rehn & Kronman (2008) mentioned that misspellings of author's name may lead to incorrect number of citations and publications. However, this type of error is common and negligible.

3.2.3. Country

From the analysis of the author's affiliation, the country of the author could be identified provided the address is available. Ugolini et al. (2010) used the first author's country to identify the country of origin of the article. Nevertheless, there will be a misleading for a study that based on the first author country affiliation only because it will dilute the weight of international collaborative studies.

This could be overcame with the criteria made by Fu et al. (2010); Sun et al. (2012). The contribution of different countries were determined by the location of the affiliation of at least one author of the published papers. Those articles that were coauthored by researchers from more than one country were assigned as "Internationally collaborative publication". This is to show the pattern of international collaboration to reveal information on the intensity and breadth of collaboration

between researchers of different countries (Chuang, Chuang, Ho, & Ho, 2011). “Independent publication” was assigned to articles written by the researchers from the same country. “First author publication” was assigned to article by the only first author’s country affiliation. “Publication of the country of corresponding author” was assigned to articles where corresponding author’s country affiliation is identified. Finding out internationally collaborative articles could suggest whether a community of research is more internationally connected or not (Liu, Zhang, & Hong, 2011). Della Mea (2011) reminded about the limitation of identifying the country of affiliation due to some papers did not report affiliation and did not have country address.

3.2.4. Hosting journal and conference proceedings

An analysis of hosting journal and conference title can provide a perspective of the publication pattern in a certain field (Franceschet, 2010; Rehn & Kronman, 2008). Della Mea (2011) indicated that by examining the hosting journal for the articles, the result could show that the subjects focus of a disciplinary area. There is also a debate concerning the role of conferences in computer science field where computer scientist publish more in conference proceedings than in journals. However, the impact of publishing in a journal is higher than the impact of conference papers (Franceschet, 2010). Within the discipline of Computer Science, one of the main issues has been proper recognition of the importance of conferences versus journal publications, where journal publications are easily evaluated through impact factors and the like, whereas the impact of publications in conferences is less easily measured (Thornley et al., 2011). Therefore, identifying the type of journals and conference proceedings could measure the impact of Topic Maps.

3.2.5. Citation analysis

Citations in papers are used to establish linkages with other papers. Citation is used widely in bibliometric study as a study reference to and from documents (Jan, 2009). The citation analysis of bibliographic records with a reference list could supply two main aspects of bibliometric study. Firstly, the possibility to find publications in the same area by identifying the literatures that cite (refer to) or are cited by the literatures in the bibliographic records. Secondly, is the assessment of bibliometric quality. In other words, it is reasonable to assume that most citations are a positive sign that citing author finds something useful in the material he cites (Rehn & Kronman, 2008).

Chen & Guan (2011) used citation analysis to detect influential publications which act as intellectual turning points of nanobiopharm-research evolution during the given 18-year period. During the last 16 years, Li et al. (2009) identified the most cited papers in their study. These most cited papers were able to recognize the research hotspot.

3.2.6. Content analysis

Content analysis of publications can be statistically based on keywords and title words. Keywords and title words of publications convey the thought contents of the papers precisely and to identify the direction of knowledge will grow (Kumara et al., 2009). Fu et al. (2010) mentioned that keywords show research emphasis. Statistical analysis of keywords can be used to identify directions in science, and has proved to be valuable in investigating the development of science and programmes. The high title words and keywords frequency shows what are all the aspect that have been studied (Kumara et al., 2009). The content analysis could be divided into title words analysis, author's keywords analysis, index keywords analysis, title and abstract analysis, and co-words mapping analysis.

Title words analysis is feasible for content analysis as the title of an article calls for much deliberation from authors and can provide valuable information of the whole paper to readers, helping them to find the information (Fu et al., 2010; Sun et al., 2012). The title of an article includes reasonably details of the articles' subject that the author would like to communicate most to the readers (Li et al., 2009; Mao et al., 2010). However, the downside of this analysis is when the title is segmented into single words, it breaks the integrity of phrase in title (Mao et al., 2010).

Author keywords analysis could offer the information of research trend that is concerned by researchers. Authors assign keywords that reveal the internal structure of an author's reasoning. (Sun et al., 2012). Therefore, they provide a reasonably detailed picture of the article's theme (Fu et al., 2010). The downside of this analysis is the lack of standardization among keywords assigned by authors, for example, spelling variations, abbreviations and synonymous terms (Li et al., 2009). However, different from title word analysis, in author keywords analysis, the intact words were preserved that the authors want to convey (Mao et al., 2010).

Index keywords are database supplied extra search terms picked up from articles' titles cited by authors in their footnotes and bibliographies (Mao et al., 2010) and is usually more concerned about

novel research directions than the mature direction in the field (Li et al., 2009). Index keyword analysis could explain the article's content with greater understanding and variety (Fu et al., 2010), in other words, it could provide a reasonably comprehensive overview of research trends (Liu et al., 2011).

Chen & Guan (2011) looked into content analysis in another direction where co-word analysis mapping was involved. Co-word analysis is a bibliometric technique to find out research topics based on the keyword usage pattern in publications, such as keywords or term extracted from title, abstract or document's body, which has been largely and successfully used for dynamic evolution of science. It is a content analysis technique where mapping is carried out effectively to associate the strength between keywords in text data. Science mapping, on the other hand, is for building bibliometric maps that explain the way of scientific domains, specific disciplines or research fields are structured conceptually, intellectually and socially (Cobo, Lopez Herrera, Herrera-Viedma, & Herrera, 2011). The title and abstract word analysis could be added for mapping and to make inferences of the scientific literature or to identify the subjective focus and emphasis specified by authors (Sun et al., 2012). There are several softwares capable of mapping. They are Bibexcel, CiteSpace II, CoPalRed, IN-SPIRE, Leydesdorff's Software, Network Workbench Tool, Sci2 Tool, VantagePoint, and VOSViewer. VOSViewer is selected for this study because it can be used to construct and visualize bibliometric maps of any kind of co-occurence data. Also, it is based on mapping technique that constructs a similarity matrix from a co-occurrence matrix using association strength (Cobo et al., 2011).

3.3. Data Collection Techniques

3.3.1. Data source

The data was collected from two scientific databases, namely Scopus and Web of Knowledge. Web of Knowledge and Scopus were selected because of both are scientific databases where scientific publications were indexed there. As Web of Knowledge and Scopus are competitors, hence both might have distinct records. Therefore, both databases were selected for data collection. Both databases have the bibliographic export functionality which saves a lot of time and less manual work could be avoided.

3.3.2. Search Strategy

Keyword or term is essential for retrieving relevant records for this study. Therefore, below were the keywords or terms which had been used in Web of Knowledge and Scopus for retrieving records for data analysis.

Search keywords/terms used: “Topic Map”, “Topic Maps”, “ISO/IEC 13250”.

Collected data

Using the keywords/terms for search strategy, below were the results retrieved:

1. ISI Web of Knowledge database : 91 records
2. Scopus : 385 records

Data Cleaning:

Initial data cleaning was done in Microsoft Excel. Data cleaning was based on the research purpose and questions. Data cleaning involved duplications, document types, publication year, and relevant topic.

Duplication:

Both databases records were merged into single Microsoft Excel spreadsheet. Each duplication of same records was removed. Same records here mean records with matching title and author.

Document types:

Scopus and Web of Knowledge indicated each bibliographic record with document types. Besides duplications, conference review, editorial, note, review, short survey, book review, and news item were removed. This is because the focus of this study is to find out what research or study had been done on Topic Maps.

Relevant topic:

After checking each title and abstract of the record, it was found 10 records which were not related to Topic Maps. Subject related to geography maps and RDF.

Publication year:

Records from publication year 2000-2011 were considered. Topic maps became ISO standard since 2000. Publications in 2012 were not included because the data in this study was collected in March 2012 and it was still early for 2012.

Summary:

Finally, a total of 356 clean records are used for analysis.

Record type	Total records
Scopus	385
Web of Knowledge	91
Total (a)	**476**
Deleted record	
Duplication	80
Irrelevant document type	26
Irrelevant topic	10
Outside publication year range	4
Total deleted (b)	**120**
Clean records (a - b)	**356**

3.4. Data analysis

Questions	Type of analysis	Data field source	Data analysis	Software
1. How publications are placed in time?	Trend analysis	Document type; Publication year;	1. Distribution of publication per year 2. Distribution of publication cumulative per year 3. Distribution of publication type per year 4. Regression analysis (trendline)	Excel
2. How publications are concentrated to specific researchers, journals, conference proceedings, country or affiliations	Trend analysis	Author's name; Source title; Country; Affiliation; Publication year;	5. Top productive author 6. Single authored and collaborative publication per year 7. Distribution number of publication per number of author 8. Top journal title published 9. Distribution of journal subject category 10. Top conference title published 11. Distribution of conference subject category 12. Distribution of publication by country	Excel

3. Which publications about Topic Maps are the most cited?	Citation analysis	Cited by; References;	13. Top cited publications and references 14. Top cited journals	Excel
4. What has been studied about Topic Maps?	Content analysis	Title; Author's Keyword; Index keyword; Abstract;	15. Title word count 16. Author's keyword count 17. Index keyword count 18. Bibliometric mapping of title and abstract using co-word analysis	Excel VOSViewer
5. What are the future research areas?	Content analysis	Title; Author's Keyword; Index keyword; Abstract;	19. Analysis based on the result in research question 4	

CHAPTER 4: DATA ANALYSIS

4.1. Introduction

This chapter presents the bibliometric analysis of data obtained which was the 356 publications from year 2000 – 2011. The data analysis is divided into 5 sections and each section will report based on the research questions of this study:

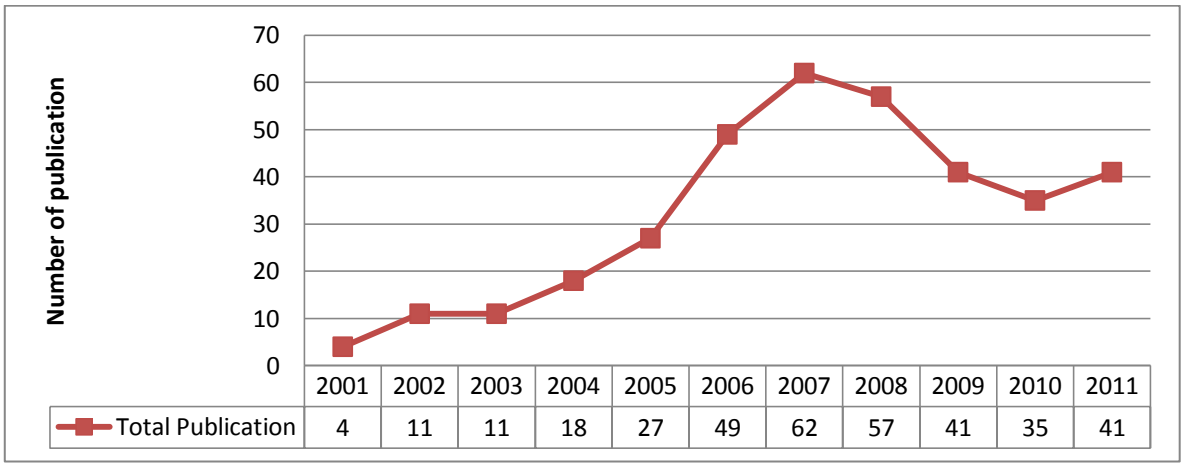
1. How publications are placed in time?
2. How publications are concentrated to specific researchers, journals, conference proceedings, and country?
3. Which publications about Topic Maps are the most cited?
4. What has been studied about Topic Maps?
5. What are the future research areas?

4.2. Question 1: How publications are placed in time?

4.2.1. Distribution of publication per year

There is a total number of 356 publications produced from 2001 to 2011. In figure 4.1, it had the most publication of 62 in 2007. There was a growing increase of publications between 2003 and 2007, with 2005-2006 having the largest increase of 22 publications. However, after 2007, as seen from the figure, the publications dropped tremendously until year 2010. Nevertheless, the publications remained fairly consistent from 2009 to 2011.

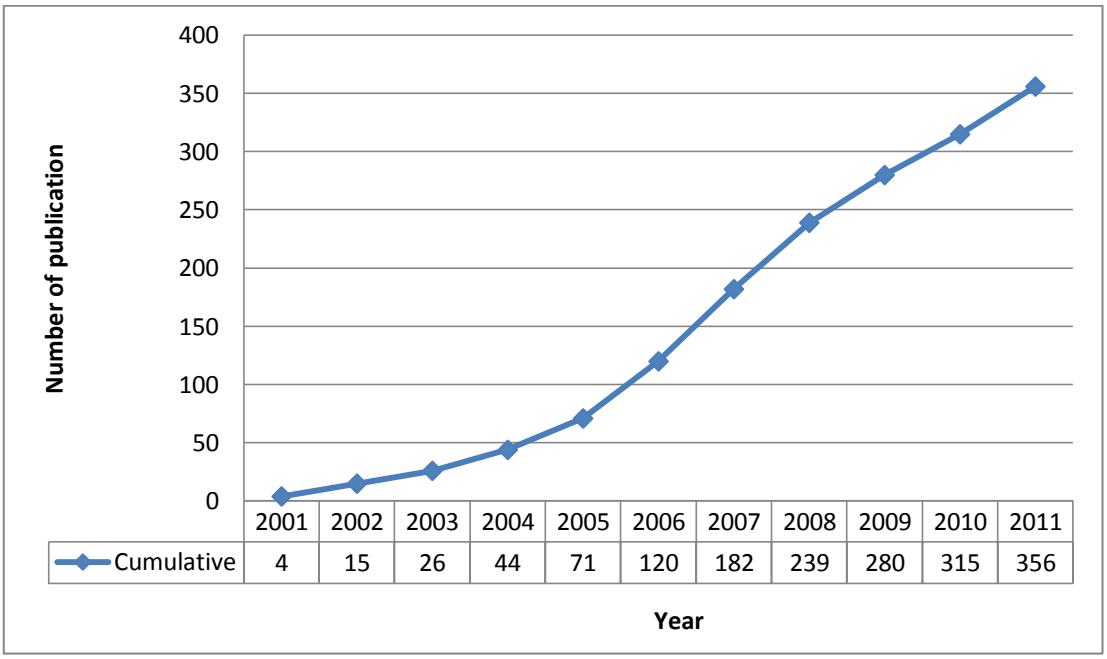
Figure 4. 1 Distribution of publication per year



4.2.2. Distribution of publication cumulative per year

Figure 4.2 shows the distribution of publication cumulative per year. As can be seen from the figure, the publications can be divided into 3 phases. From 2001 to 2005, the publications seemed to be slow and low. However, from 2005 onwards to 2008, topic maps publications started picking up tremendously. Finally, from 2008 to 2011, the publications started to slow down, because the number of publications between 2008 and 2011 dropped (figure 4.1).

Figure 4. 2 Distribution of publication cumulative per year



4.2.3. Distribution of publication type per year

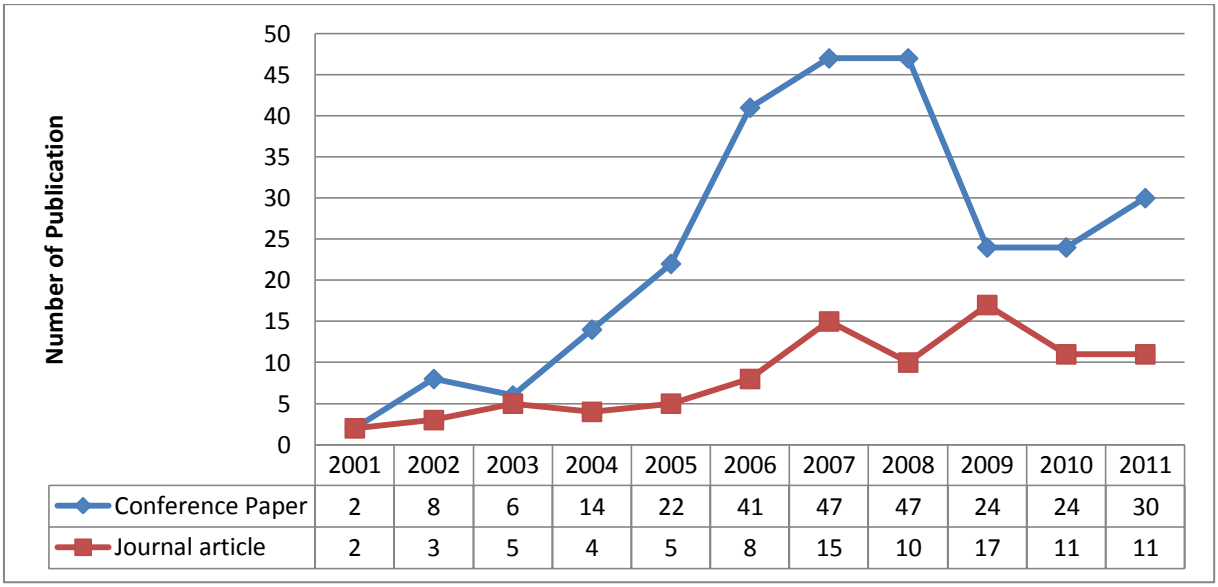
A total of 265 conferences papers and 91 journal articles about Topic maps was considered for the data analysis. It shows that Topic Maps literatures were mostly presented in conference papers. In figure 4.3, the number of conference paper increased from year 2003, and it remained steady from 2006 to 2008. There was a sudden decrease of conference paper from 2009 onwards. The reason of this sudden drop was discussed in section 4.3.6 (top conference title published). As for the journal articles, the publications remained consistent.

Conference proceedings and journals are two different venues for researchers to publish their research findings. According to Thornley et al. (2011), within the discipline of computer science subject, publication in conferences have a more proper recognition of importance rather than in a journal, in other words, conferences are used as the main publication venue in computer science field (Fortnow, 2009). This is because conference publication has been the dominant publication venue in computing research since early 1980s (Vardi, 2009). Fosmire (2001) mentioned the conference proceedings serve as a medium for rapid dissemination of information and transmit idea for research, and it is particularly common and make sense for young discipline (Fortnow, 2009). Conferences are preferred due to the opportunity to describe the research before peers at a public presentation (Patterson, Snyder, & Ullman, 1999). According to Vardi (2009), some expectation that conference papers will be followed up by journal papers, but in reality, only a small portion of conference papers are followed up by journal papers.

Franceschet (2010) discussed the role of conferences in the subject of computer science, the author strongly believed researchers should be publishing in a journal to achieve impact instead of in conference proceeding because the effort of the researchers will be rewarded with a higher impact. Fortnow (2009) promoted that it is “time for computer science to grow up” and to establish the maturity of the field by publishing papers properly and adapting to the appropriate conference and journal model that has worked well for all other academic fields. Topic Maps researchers should take their publication venue into consideration in order to bring Topic Maps into more impactful and significant level. This is important so that Topic Maps researchers will not be “driving on the wrong side of the publication road”, said Vardi (2009).

Comparing the number of journal articles and conference papers, it shows that conference papers had a higher number of papers than journals articles. According to Huang (2008), a high number of conference papers reveal a technology is in the initial stage, which is not reaching the technology maturity yet. On the other hands, if the number of journal articles is higher than conference papers, it means that the technology is reaching maturity. From the result, it shows Topic Maps has not reached the maturity stage because the number of journal articles was still low.

Figure 4. 3 Distribution of publication type per year

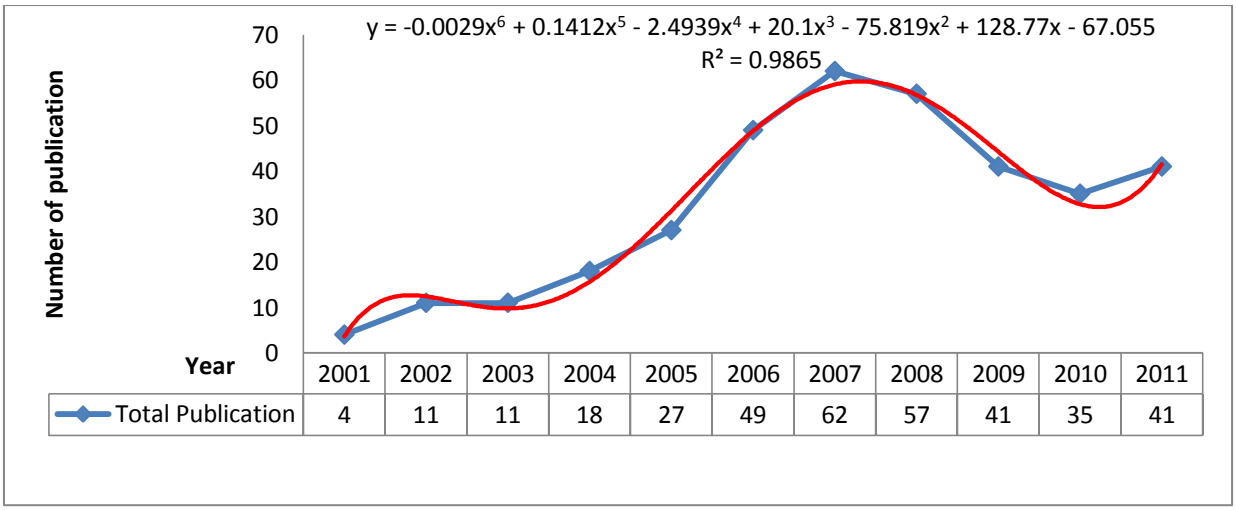


	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Conference Paper	2	8	6	14	22	41	47	47	24	24	30
Journal article	2	3	5	4	5	8	15	10	17	11	11

4.2.4. Regression analysis (trendline)

Trendline is used to graphically display trends in data and analyze problems of prediction. Regression analysis is one of trendline analysis. Regression lines are used to depict the relationship between the independent (x) and dependent (y) variable in the graph. In figure 4.4, we can see the relationship between independent variable – year and dependent variable – number of publications. As can be seen from the graph, the data show fluctuation. Therefore, a polynomial trendline, which is a curve line, is applied in this graph. A trendline is most accurate when the R-squared value is at or near to 1. Here, the R-squared value is 0,9865. Therefore, the equation can be used to predict future number of publications in Topic Maps. It is predicted to have around 55 publications for 2012.

Figure 4. 4 Regression analysis of publication



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total Publication	4	11	11	18	27	49	62	57	41	35	41

4.3. Question 2: How publications are concentrated to specific authors, journals, conference proceedings, and country

4.3.1. Top productive author

There were 629 authors that contributed to the 356 publications in this study. Table 4.1 shows top productive authors, who had been identified by counting the number of publications contributed by the authors.

The most productive author is Lu H (Lu Huimin 鲁慧民)[3], with 16 publications. She was a PhD student based in School of Electronic and Information engineering, Xi'an Jiaotong University, Xi'an China. She engages in knowledge management and knowledge integration. She focuses on intelligent Topic Maps, knowledge navigation and knowledge service.

This is followed by Dicheva D (Darina Dicheva)[4], a professor of computer science based in the department of computer science, Winston-Salem State University, USA. Her areas of interest are knowledge networks and management, web information management, adaptive information retrieval and filtering, user modeling, application of artificial intelligence in education and teaching programming to novices. In the Topic Maps research, her area would be in e-learning, ontology, information extraction, information retrieval, visualization and graphic interface.

In the third rank is by Dichev C (Christo Dichev)[5], with 12 publications. He is an associate professor in the department of computer science, Winston Salem State University, USA. He is in the same department and university like Dicheva D, whom he had coauthored several articles. His area of interest covers semantic web, topic maps, reasoning systems, information retrieval, web mining and information extraction, distributed AI, logic programming and OO extensions and AI languages. His research area in Topic Maps is comparable with Dicheva D, such as e-learning, graphical interface, and ontology.

[3] http://stads.wanfangdata.com.cn/zz/FlAuthor.aspx?peopleName=%E9%B2%81%E6%85%A7%E6%B0%91&peopleOrg=&SimilarOrg=0&isJump=3
[4] http://myweb.wssu.edu/dichevad/newpage/research.html
[5] http://myweb.wssu.edu/dichevc/

Sharing the same number of publication as Dichev C, is Feng B (Feng Boqin 冯博琴)[6]. He is a professor and PhD supervisor in Xi'an Jiaotong Univeristy. He research interests include computer network and distributed computing. Most likely that Feng B was the PhD supervisor of Lu H., since they had coauthored several articles. Therefore, the author's Topic Maps research interest is similar with Lu H., mostly engages in knowledge management and artificial intelligent, such as knowledge integration, knowledge navigation, knowledge service, knowledge visualization, ontology merging, intelligent topic map and extended topic map.

Author Garshol L.M (Lars Marius Garshol)[7] is worth to be mentioned here because he is among the few authors from outside the academic sector. The author published various kinds of articles and presentations and developed semantic technology softwares.

Table 4. 1 Top productive author

Author Name	Number of publication
Lu H.	16
Dicheva D.	13
Dichev C.	12
Feng B.	12
Andres F.	9
Li G.	8
Stanescu L.	8
Burdescu D.	7
Garshol L.M.	7
Hatzigaidas A.	6
Chen I.-X.	5
Dudeck J.	5
Kim K.	5
Lee J.Y.	5
Mihai G.	5
Naito M.	5
Ouziri M.	5
Papastergiou A.	5
Schweiger R.	5
Tryfon G.	5
Yang C.-Z.	5

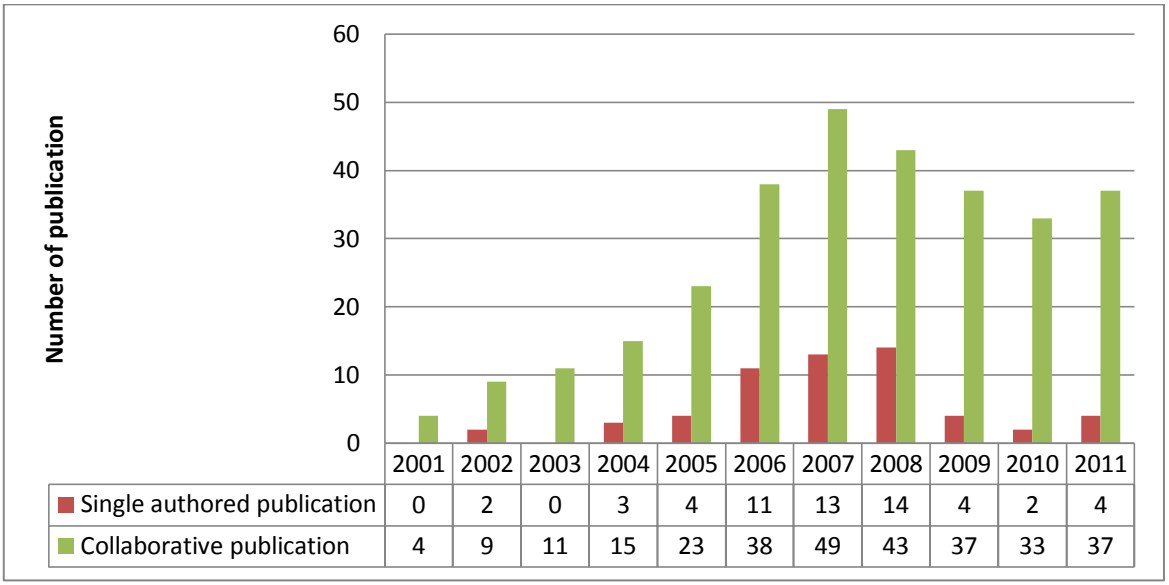
[6] http://stads.wanfangdata.com.cn/zz/FlAuthor.aspx?peopleName=%E5%86%AF%E5%8D%9A%E7%90%B4&peopleOrg=&SimilarOrg=&isJump=3

[7] http://scholar.google.com/citations?hl=en&user=ivhRw7EAAAAJ&view_op=list_works&pagesize=100. Also, http://www.garshol.priv.no/

4.3.2. Single authored and collaborative publication per year

The authorship and collaboration pattern was towards coauthored publications. This has been the case since 2001. There was a total of 299 (84%) coauthored publications and 57 (16%) single-authored publications. Figure 4.5 depicts the year wise trend of single authored and coauthored publication in the field. The single authored publications had peak period between 2006 and 2008. However, it shows a decrease between 2009 and 2011. Coauthored publications increased by year, and they remained high each year. This indicated that more authors preferred collaborative effort in publication. This fitted into the multiple authored norm of the physical or experimental sciences publication where it is common to spot high proportion of coauthored publication as part of physical sciences publication characteristic. Authorship patterns in Information Systems (IS) publications showed the similar result to this study where coauthored publications were obvious in IS field (Cunningham & Dillon, 1996).

Figure 4. 5 Trend of Articles Productivity in 1985-2007



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Single authored publication	0	2	0	3	4	11	13	14	4	2	4
Collaborative publication	4	9	11	15	23	38	49	43	37	33	37

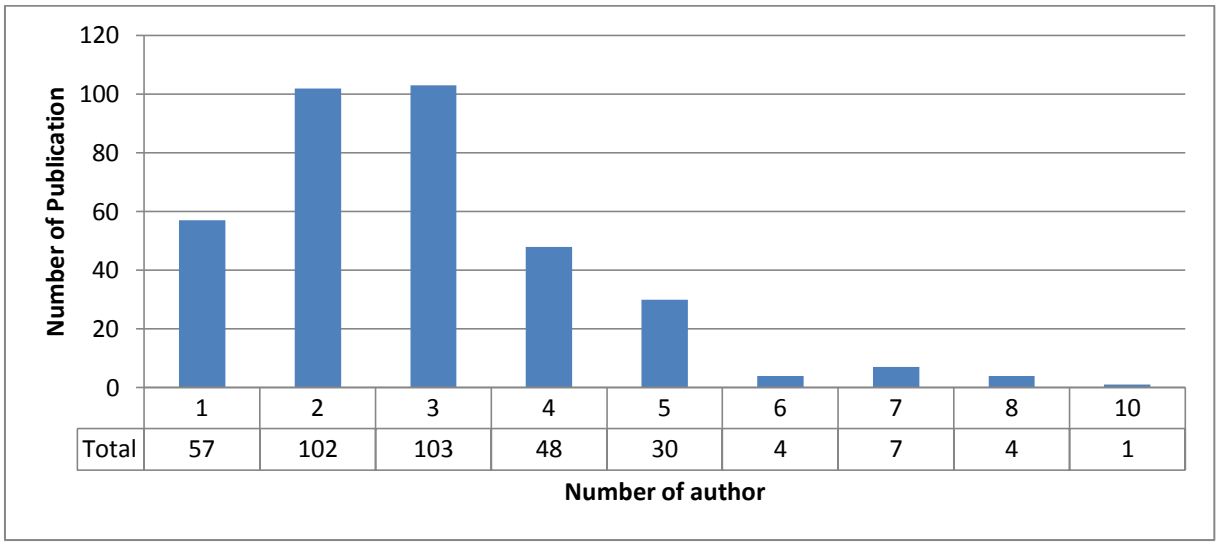
4.3.3. Distribution number of publication per number of author

Figure 4.6 shows the coauthorship pattern. 57 out of 356 publications were single authored. The majority of the papers was coauthored with two or three authors. The maximum number of authors for a single paper was ten, but it was only one publication[8]. The average number of authors per

[8] Chau, M., Chen, H., Qin, J., Zhou, Y., Sung, W.-K., Chen, Y., Qin, Y., et al. (2002). NanoPort: a web portal for nanoscale science and technology. *Proceedings of the 2nd ACM/IEEE-CS joint conference on Digital libraries*, JCDL '02 (pp. 373–373). New York, NY, USA: ACM. doi:10.1145/544220.544320

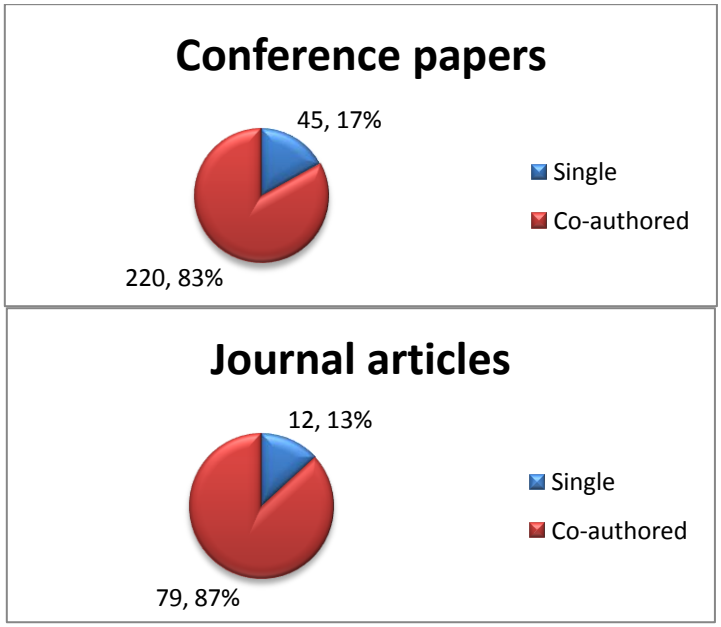
article was 1.76. It shows that the size of the research team for Topic Maps was relatively small, even though the rate of coauthorship was high. Franceschet (2010) conducted study on collaboration in computer science mentioned it is typical to see a collaboration of two or three authors in computer science.

Figure 4. 6 Distribution number of publication per number of author



There are many reasons for coauthorship. In Figure 4.7, we could see that coauthored conference papers (220 papers out of 256, 83%) and journal articles (79 articles out of 100, 87%). It shows that coauthorship pattern is independent of publication type. It was being mentioned by Franceschet (2010) that conference papers had more coauthorship. This is because coauthorship is needed when there are stringent deadlines for the production of a paper, usually imposed by the computer science conferences. Other than that, Cunningham & Dillon (1996) explained that technical sciences is based on complex, expensive instruments or equipment, therefore it is a norm for coauthorship.

Figure 4. 7 Distribution number of publication per number of author based on publication type



4.3.4. Top journal title published

There were 91 journal articles taken for analysis, and 67 journal titles were identified. In table 4.2, the top journal titles were WSEAS Transactions on Information Science and Applications (5 articles), Journal of Universal Computer Science (4 articles), and IEICE Transactions on Information and Systems (3 articles), Information Technology Journal, Journal of Information Science (3 articles) and Studies in Computational Intelligence (3 articles each). It appears that Topic Maps research was published in certain subject specific journals. They were published mostly in computer science, library and information science and engineering journals. Other disciplines found were medicine and education.

Also, in Table 4.2, it shows that authors published articles in WSEAS Transactions on Information Science and Applications published papers in 2005 (1 article), 2007 (3 articles) and 2009 (1 article). As for Journal of Universal Computer Science, the publication was not consistent. However, the Journal of Information and Computational Science has two articles recently in 2010 and 2011. Nevertheless, it is impossible to determine the publishing consistency of this journal and the number of articles was too small to make prediction. Generally, from the result, it indicated that there were no particular journal titles that Topic Maps researcher targeted for publishing. The number of articles published in each journal was too small and it was difficult to make a conclusion of which journal title would be the favourite publishing venue for the researchers.

Table 4. 2 Top journal title published

Journal Title	Year	Subject	Number of Article
WSEAS Transactions on Information Science and Applications	2005,2007,2009	Computer Science	5
Journal of Universal Computer Science	2002,2003,2009	Computer Science	4
IEICE Transactions on Information and Systems	2006,2008,2010	Computer Science	3
Information Technology Journal	2009,2010	Computer Science	3
Journal of Information Science	2004,2006,2007	Library and Information Science	3
Studies in Computational Intelligence	2007,2009	Computer Science	3
Expert Systems with Applications	2008,2011	Computer Science	2
Hsi-An Chiao Tung Ta Hsueh/Journal of Xi'an Jiaotong University	2010,2011	Engineering	2
Informatics for Health and Social Care	2008	Medicine	2
International Journal of Advanced Manufacturing Technology	2007	Engineering	2
International Journal of Metadata, Semantics and Ontologies	2009,2010	Library and Information Science	2
Journal of Educational Media and Library Science	2006,2008	Education	2
Journal of Information and Computational Science	2010,2011	Engineering	2
Journal of Software	2009,2011	Computer Science	2
Journal of the American Society for Information Science and Technology	2004,2008	Library and Information Science	2

Note: The remaining journals provided one paper each. See complete listing in Appendix 1.

4.3.5. Distribution of journal subject category

Figure 4.8 shows the distribution of journal subject category. The subject and focus of the each journal were identified. It was not a surprise that majority of the journals are within computer science subject (30 journal titles), library and information science (12 journal titles) and engineering (8 titles), because Topic Maps received much influence from the computer science (possibly engineering – computer related) and information science discipline. However, it was found interesting to discover other subjects such as agricultural and biological sciences (1 journal title), Business, management and accounting (4 journal titles), material science (1 journal title), medicine (6 journal titles), decision science (1 journal title), education (3 journal titles) and communication (1 journal title), had articles regarding Topic Maps.

Figure 4. 8 Publishing journal subject area

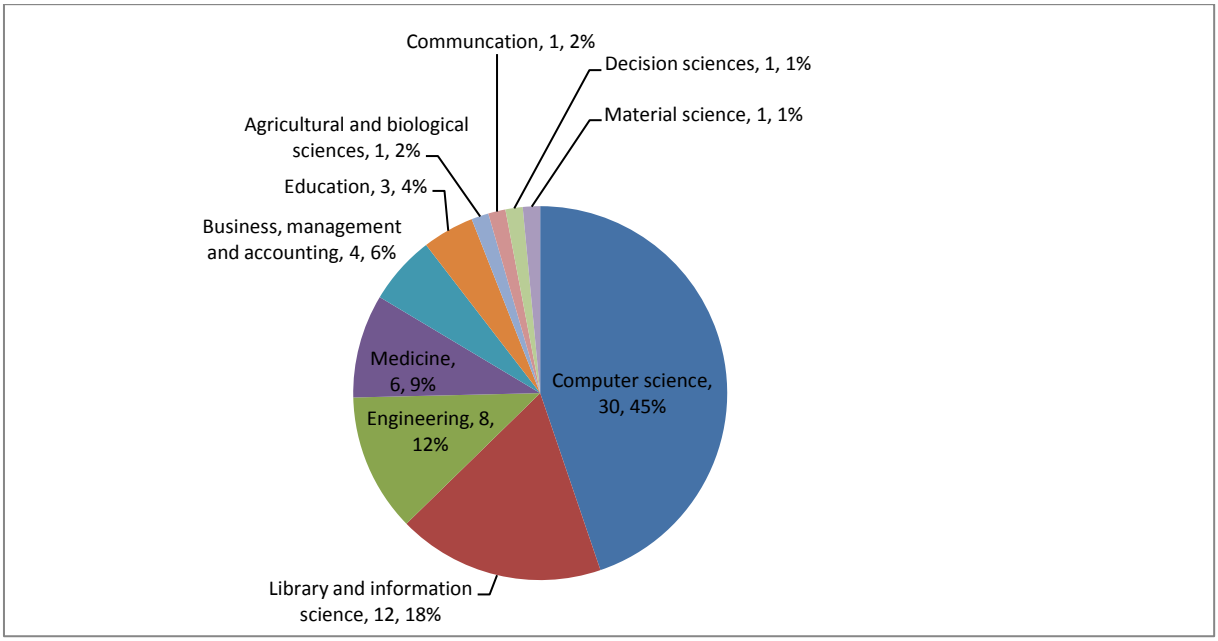


Table 4. 3 Distribution of publishing journal per year

Journal subject	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Computer science	2	1	2	1	3	2	4	2	12	5	6	40
Library & information sc.			2	2		2	3	2	1	2	2	16
Engineering							1	1	2	3	2	9
Medicine			1		2		1	1	1			6
Business, mgmt & acct.				1		1	1	1				4
Education						2	2	1				5
Agriculture & bio. sc.											1	1
Communication								1				1
Decision sciences						1						1
Material science		1										1
Grand Total	**2**	**2**	**6**	**5**	**5**	**8**	**13**	**9**	**16**	**10**	**11**	**84**

Table 4.3 shows that computer science related journals have been actively publishing Topic Maps related articles every year. Library and information science related journals appeared to publish articles starting from 2003 to 2011 yearly, except for 2005. Engineering came in rather late in 2007, after that it had become consistent until 2011. The trend of authors, who published articles in library and information science and engineering related journal, could be regarded as consistent and regular. Medicine was another interesting subject. It started as early as in 2003, and it continued in 2005, 2007, 2008 and 2009. After 2009, there were no more articles published in medical related journal. This might indicate there was no continuation of Topic Maps research in medical field. This

phenomena happened to business, management and accounting related journal, where it was started in 2004 and stopped publication after 2008. Agriculture and biological science might be the emerging subject in Topic Maps, however, it is still too early to forecast the potential of Topic Maps to be applied in agriculture area.

In table 4.3, computer science related journal was the favourite publishing venue. Nevertheless, Library and information science (LIS) related journals also played the essential role of disseminating the Topic Maps knowledge in 2003, 2004, 2006 to 2011. According to Estrada (2009), Topic Maps was being introduced to LIS community in 2003 by Steve Newcomb and Michel Biezunski at the series of conferences "Luminary Lectures at Your Library" organized by The Library of Congress. Other than that, Topic Maps was being introduced at LITA 2006 (Library and Information Technology Association) forum where Steve Newcomb and Patrick Durusau presented what Topic Maps was in relation to the vision of subject-centric computing. These conferences were possible booster for applying Topic Maps in LIS field, for example, in e-learning, classification, metadata, subject gateway, memory/knowledge organization, retrieval, integrated library system and infometrics.

Table 4. 4 Topic Maps related articles in LIS journals

Article Title	Year	Journal Title
Gestion des ressources pédagogiques d'une e-formation	2003	Document Numerique
How can classificatory structures be used to improve science education?	2003	Library Resources and Technical Services
Metadata-based modeling of information resources on the web	2004	Journal of the American Society for Information Science and Technology
Metadata? Thesauri? Taxonomies? Topic maps! Making sense of it all	2004	Journal of Information Science
Constructing Web subject gateways using Dublin Core, RDF and Topic Maps	2006	Information Research
Representing organizational memory for computer-aided utilization	2006	Journal of Information Science
Schema and constraints-based matching and merging of Topic Maps	2007	Information Processing and Management
The editor of conceptual maps, DigiDocMap	2007	INVESTIGACION BIBLIOTECOLOGIA
A multi-layer metadata schema for digital folklore collections	2007	Journal of Information Science
Information organization and retrieval using a topic maps-based ontology: Results of a task-based evaluation	2008	Journal of the American Society for Information Science and Technology
Topic maps and the ILS: An undelivered promise	2008	Library Hi Tech
Towards a novel content organisation in agriculture using semantic technologies: A study with topic maps as a tool	2009	International Journal of Metadata, Semantics and Ontologies
SPARQL queries to RDFS views of Topic Maps	2010	International Journal of Metadata, Semantics and Ontologies
An investigation of research on evolution of altruism using informetric methods and the growing hierarchical self-organizing map	2010	Malaysian Journal of Library and Information Science
Topic maps from a knowledge organization perspective	2011	Knowledge Organization
Research on the semantic-based co-word analysis	2011	Scientometrics

Another favourite venue for authors to publish their research was in medical/healthcare informatics related journals. In total, there were 7 medical related journal titles, which published 8 articles in 2003 (2 articles), 2005 (2 articles), 2007 (1 article), 2008 (2 articles) and 2009 (1 article). In table 4.5, Topic Maps started to be applied in medical field in terms of clinical data / medical records organization, information and support system, social networks and informatics.

Table 4. 5 Topic Maps related articles in medical journals

Article Title	Year	Journal Title
Linking clinical data using XML topic maps	2003	Artificial Intelligence in Medicine
Transparent ICD and DRG coding using information technology: Linking and associating information sources with the eXtensible markup language	2003	Journal of the American Medical Informatics Association
Implementing health care systems using XML standards	2005	International Journal of Medical Informatics
Development of a XML-based electronic drug information system with topic maps [Entwicklung eines XML-basierten elektronischen arzneimittel-informations- systems mit topic-maps]	2005	Krankenhauspharmazie
The Topic Maps and their connection with social networks [Los Topic Maps y su relaciÃ³n con las redes sociales]	2007	ACIMED
Domed: Semantic data integration and navigation in Web-based medical records	2008	Informatics for Health and Social Care
A web-based melanoma image diagnosis support system using topic map and AJAX technologies	2008	Informatics for Health and Social Care
Mapping the domain of medical informatics	2009	Methods of Information in Medicine

4.3.6. Top conference title published

There was a total of 265 conference papers taken into analysis of obtaining the conference titles where these papers were presented. 150 unique conferences were identified. There were 9 conference papers with unknown conference titles. Table 4.6 shows the top conference title (by proceeding and year) with the number of conference paper presented. **Topic Map Research and Applications (TMRA)** conference was the leading conference for Topic Maps. TMRA was an annual series of international conferences dedicated to Topic Maps in science and industry. The first conference of TMRA was held in 2005 and subsequently in 2006 and 2007. Each year, at least 20 papers were being presented, in total, 62 conference papers were presented. In fact, TMRA was held every year until 2010. Unfortunately, conference proceedings of TMRA 2008, 2009 and 2010 were not being indexed neither in Web of Knowledge nor SCOPUS databases. This was because these proceedings were published in LIV series by the University of Leipzig. Therefore, these three years of

TMRA conference papers' bibliographic data were not being capture in this study. This was a limitation of this study.

There was a big difference in terms of the number of conference papers between **TMRA** (62 papers) and **Annual ACM Southeast Conference, ACMSE** (5 papers) and **IEEE International Conference on Advanced Learning Technologies, ICALT** (5 papers) where both ACMSE and ICALT were placed second of having Topic Maps related papers. This showed that TMRA played a major role in showcasing any Topic Maps research activities.

Most of the focus of the conferences was found to be computer science related, for example, semantic web, artificial intelligence, enterprise information system, information technology, web engineering/intelligence, intelligence system/computing, database and expert system, and information networking. Also, information science conferences on information and knowledge management, and document engineering were the target of the authors for presenting their research on Topic maps in these fields.

Two digital library conferences hosted a total of 5 conference papers. They were **ACM/IEEE-CS Joint Conference on Digital Libraries** (in 2002, 2005 and 2011) and **International Conference on Asian Digital Libraries ICADL** (in 2004 and 2006). Topic Maps based digital library has future potential for further research.

Table 4. 6 Top conference title published

Conference Title	Subject	Total Conference Paper
International Conference on Topic Maps Research and Applications, TMRA	Topic maps	62
1st International Workshop on Topic Map Research and Applications, TMRA 2005		22
2nd International Conference on Topic Maps Research and Applications, TMRA 2006		20
3rd International Conference on Topic Maps Research and Applications, TMRA 2007		20
Annual ACM Southeast Conference, ACMSE	Computer science	5
45th Annual ACM Southeast Conference, ACMSE 2007		5
IEEE International Conference on Advanced Learning Technologies, ICALT	Education	5
5th IEEE International Conference on Advanced Learning Technologies, ICALT 2005		4
7th IEEE International Conference on Advanced Learning Technologies, ICALT 2007		1
International Conference on Enterprise Information Systems, ICEIS	Information System	4
6th International Conference on Enterprise Information Systems, ICEIS 2004		2
7th International Conference on Enterprise Information Systems, ICEIS 2005		1
8th International Conference on Enterprise Information Systems, ICEIS 2006		1
International Semantic Web Conference, ISWC	Semantic web	4
1st International Semantic Web Conference (ISWC)		3
2nd International Semantic Web Conference (ISWC)		1
ACM/IEEE-CS Joint Conference on Digital Libraries	Digital library	3
Proceedings of the Second ACM/IEEE-CS Joint Conference on Digital Libraries, 2002		1
5th ACM/IEEE Joint Conference on Digital Libraries - Digital Libraries: Cyberinfrastructure for Research and Education, 2005		1
11th Annual International ACM/IEEE Joint Conference on Digital Libraries, JCDL'11		1
International Conference on Database and Expert Systems Applications, DEXA	Computer science	3
12th International Conference on Database and Expert Systems Applications, DEXA 2001		1
19th International Conference on Database and Expert Systems Applications, DEXA 2008		1
20th International Conference on Database and Expert Systems Applications, DEXA 2009		1
International Conference on Applications of Natural Language to Information Systems, NLDB	Computer science	3
9th International Conference on Applications of Natural Language to Information Systems, NLDB 2004		1
12th International Conference on Applications of Natural Language to Information Systems, NLDB 2007		1
14th International Conference on Applications of Natural Language to Information Systems, NLDB 2009		1
Hawaii International Conference on System Sciences	Information system	3
38th Annual Hawaii International Conference on System Sciences		1
40th Annual Hawaii International Conference on System Sciences 2007		1
44th Annual Hawaii International Conference on System Sciences, HICSS-44 2010		1

Note: The remaining conferences provided one or two papers. See complete listing in Appendix 2.

4.3.7. Distribution of conference subject category

In figure 4.9, there was a total of 150 unique conference had papers presented about Topic Maps. The subject and focus of the each conference was identified. It was not a surprise that majority of the conferences was computer science related (79). This was followed by education (12), knowledge management (8), information science (7), engineering (7), and business, management and accounting (7). There were many disciplines that appeared once or twice, for example, agriculture,

archive, communication, control theory, environment science, ergonomics, mathematics, military, mobile technology, nanotechnology, and geoscience. These subject areas might either be emerging subjects or just once-off subjects for Topic Maps.

Figure 4. 9 Conference subject area

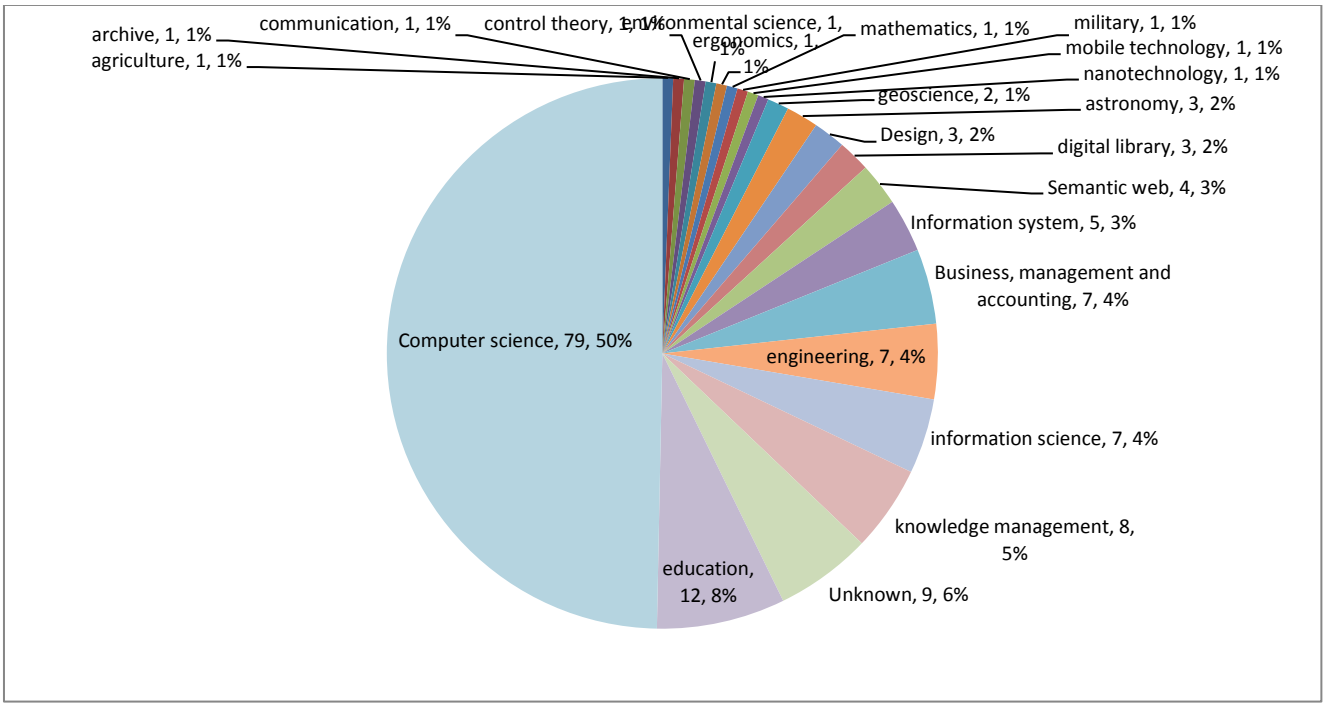


Table 4.7 shows the distribution of conferences subject category from 2001 to 2011. In 2001, papers were presented in conference related to astronomy, computer science (database and expert system). Surprisingly, astronomy adopted Topic Maps in early years. In 2002, astronomy conference remained active and made a come-back in 2010. This indicated that Topic Maps was applied in space applications. New categories such as military, digital library and semantic web emerged in 2002. In 2003, we could see that education and knowledge management related conferences had taken in Topic Maps papers. Conferences on digital library and knowledge management were seen to be appearing on and off from 2002 to 2011. Education related conferences were showing big interest in Topic Maps papers. It showed that Topic Maps played a significant role in education and learning technology.

Other non-computer science and information technology disciplines started to recognize the importance of Topic Maps. Other disciplines having adopted Topic Maps were in agriculture, astronomy, design, education, environmental science, ergonomics, geoscience, management, engineering, mathematics, military, and nanotechnology. Having different disciplines could courage coauthorship between researchers in Topic Maps and other fields.

Table 4. 7 Distribution of conference subject per year

Conference subject	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Computer science	1	1	2	10	9	8	15	12	14	5	16	93
education			1		1	2	1	2	1	2	3	13
knowledge management			1		1			2	2	3	1	10
information science					1	3	1	1	1	2	1	10
Information system				1	3	2	1		1		1	9
Business, management and accounting				1			2	1		3	1	8
engineering			1					1		4	1	7
Semantic web		1	1			2	1	1		1		7
digital library		1		1	1	1		1			1	6
Design								1	1	1		3
astronomy	1	1								1		3
geoscience					1						1	2
agriculture											1	1
archive								1				1
communication									1			1
control theory								1				1
environmental science									1			1
ergonomics											1	1
mathematics											1	1
military		1										1
mobile technology							1					1
nanotechnology										1		1
Grand Total	2	5	6	13	17	18	22	24	22	23	29	181

4.3.8. Distribution of publication by country

Table 4.8 shows the distribution of publication by country. Data on the country distribution of publications were based on the affiliation information of authors. Out of these 41 countries, 22 were from Europe, 11 were from Asia, 4 were from North and South America, 3 were from Africa and 1 was from Oceania. The productivity ranking of countries was led by China, which was responsible for the most single country articles (57) and first-author country articles (57). Germany published the second highest number of articles (54), followed by USA (51), South Korea (32), France (26), Taiwan (24), Norway (17), UK (13), Japan (13) and Romania (11).

Nevertheless, it is not surprising to obtain China as the leading country for producing Topic Maps related research due to its high population of people. However, having a comparison between countries with ratio total number of articles per country population, it was found the result changed where top five productive countries were Norway ranked the first, followed by Austria, Taiwan, Germany and South Korea.

Table 4. 8 Distribution of publication by country

TP total articles; SP single country articles; CP internationally collaborative articles; FA articles with first author country; RP articles with corresponding author; % share in articles; R rank

Country	TP	TP % (R)	SP	SP % (R)	CP	CP % (R)	FA	FA % (R)	RP	RP % (R)
China	57	13,97 (1)	55	17,57 (1)	2	2,13 (11)	57	16,01 (1)	0	0 (20)
Germany	54	13,24 (2)	43	13,74 (2)	11	11,7 (2)	50	14,04 (2)	4	7,69 (5)
USA	51	12,5 (3)	37	11,82 (3)	14	14,89 (1)	42	11,8 (3)	9	17,31 (1)
South Korea	32	7,84 (4)	29	9,27 (4)	3	3,19 (8)	30	8,43 (4)	2	3,85 (7)
France	26	6,37 (5)	16	5,11 (7)	10	10,64 (3)	21	5,9 (6)	5	9,62 (4)
Taiwan	24	5,88 (6)	23	7,35 (5)	1	1,06 (17)	24	6,74 (5)	0	0 (20)
Norway	17	4,17 (7)	17	5,43 (6)	0	0 (31)	17	4,78 (7)	0	0 (20)
UK	14	3,43 (8)	6	1,92 (14)	8	8,51 (4)	7	1,97 (13)	7	13,46 (2)
Japan	13	3,19 (8)	7	2,24 (11)	6	6,38 (5)	7	1,97 (13)	6	11,54 (3)
Romania	11	2,7 (10)	11	3,51 (8)	0	0 (31)	11	3,09 (8)	0	0 (20)
Austria	9	2,21 (11)	9	2,88 (9)	0	0 (31)	9	2,53 (9)	0	0 (20)
Canada	9	2,21 (11)	8	2,56 (10)	1	1,06 (17)	9	2,53 (9)	0	0 (20)
Czech	8	1,96 (13)	7	2,24 (11)	1	1,06 (17)	8	2,25 (11)	0	0 (20)
Greece	8	1,96 (13)	7	2,24 (11)	1	1,06 (17)	8	2,25 (11)	0	0 (20)
Italy	7	1,72 (15)	4	1,28 (16)	3	3,19 (8)	5	1,4 (16)	2	3,85 (7)
Netherlands	7	1,72 (16)	2	0,64 (19)	5	5,32 (6)	4	1,12 (18)	3	5,77 (6)
Spain	7	1,72 (16)	6	1,92 (14)	1	1,06 (17)	6	1,69 (15)	1	1,92 (12)
Australia	5	1,23 (18)	3	0,96 (18)	2	2,13 (11)	4	1,12 (18)	1	1,92 (12)
India	5	1,23 (18)	4	1,28 (16)	1	1,06 (17)	4	1,12 (18)	1	1,92 (12)
Thailand	5	1,23 (18)	0	0 (34)	5	5,32 (6)	5	1,4 (16)	0	0 (20)

Tunisia	5	1,23 (18)	2	0,64 (19)	3	3,19 (8)	3	0,84 (21)	2	3,85 (7)
Belgium	4	0,98 (22)	2	0,64 (19)	2	2,13 (11)	3	0,84 (21)	1	1,92 (12)
Brazil	3	0,74 (23)	1	0,32 (25)	2	2,13 (11)	3	0,84 (21)	0	0 (20)
Denmark	3	0,74 (23)	1	0,32 (25)	2	2,13 (11)	1	0,28 (27)	2	3,85 (7)
Portugal	3	0,74 (23)	1	0,32 (25)	2	2,13 (11)	1	0,28 (27)	2	3,85 (7)
Iran	2	0,49 (26)	1	0,32 (25)	1	1,06 (17)	1	0,28 (27)	1	1,92 (12)
Ireland	2	0,49 (26)	2	0,64 (19)	0	0 (31)	2	0,56 (24)	0	0 (20)
Poland	2	0,49 (26)	2	0,64 (19)	0	0 (31)	2	0,56 (24)	0	0 (20)
Russia	2	0,49 (26)	2	0,64 (19)	0	0 (31)	2	0,56 (24)	0	0 (20)
Switzerland	2	0,49 (26)	0	0 (34)	1	1,06 (17)	1	0,28 (27)	1	1,92 (12)
Algeria	1	0,25 (31)	0	0 (34)	1	1,06 (17)	1	0,28 (27)	0	0 (20)
Bulgaria	1	0,25 (31)	0	0 (34)	1	1,06 (17)	0	0 (40)	1	1,92 (12)
Cuba	1	0,25 (31)	1	0,32 (25)	0	0 (31)	1	0,28 (27)	0	0 (20)
Finland	1	0,25 (31)	0	0 (34)	1	1,06 (17)	0	0 (40)	1	1,92 (12)
Hong Kong	1	0,25 (31)	0	0 (34)	1	1,06 (17)	1	0,28 (27)	0	0 (20)
Malaysia	1	0,25 (31)	1	0,32 (25)	0	0 (31)	1	0,28 (27)	0	0 (20)
Oman	1	0,25 (31)	0	0 (34)	1	1,06 (17)	1	0,28 (27)	0	0 (20)
Slovenia	1	0,25 (31)	1	0,32 (25)	0	0 (31)	1	0,28 (27)	0	0 (20)
South Africa	1	0,25 (31)	1	0,32 (25)	0	0 (31)	1	0,28 (27)	0	0 (20)
Sweden	1	0,25 (31)	1	0,32 (25)	0	0 (31)	1	0,28 (27)	0	0 (20)
Turkey	1	0,25 (31)	0	0 (34)	1	1,06 (17)	1	0,28 (27)	0	0 (20)

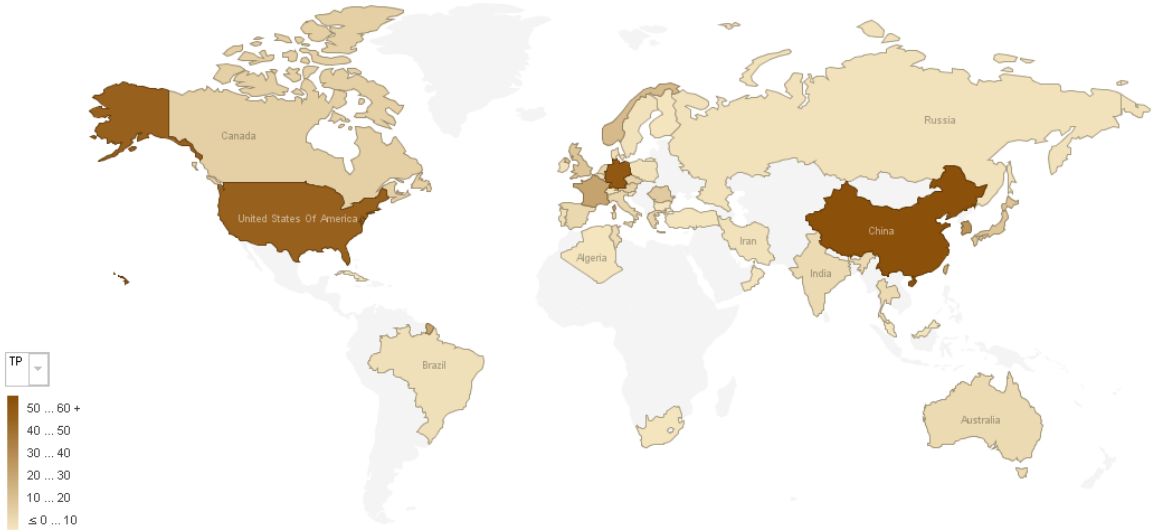
Total articles (TP)

As consistent with other bibliometric analysis, economic developments were correlated with the academic outputs (Liu et al., 2011). These countries in figure 4.10 (China, Germany, USA, South Korea, France, Taiwan, Norway, UK and Japan) were categorized as industrialized countries and major developing countries. The reason that China ranked first here was because China is the emerging nation in research. China has become the fifth leading nation in terms of its share of the world's scientific publications in 2006. In 2011, it was reported that there was an increase in spending by the Chinese government on research and development in supporting the development of China as a global power in science and technology. In addition, with the unlimited pool of highly skilled human resources, the continuation of growth could be expected in the future (Sigma Scan 2.0, 2011; Zhou & Leydesdorff, 2006). One possible reason behind the rise in China's output may be that China also started publishing in the English language, as it is known that English language dominates in academic publishing and in conferences (Traynor, 2011).

Germany, South Korea, Norway and Japan appeared to be among the top due to the countries actively involved in Topic maps research and conferences[9]. Also, these countries were the steering of Topic Maps related research. For example:

- Topic Maps Research and Applications (TMRA) conferences were organized annually in Germany (2005-2010).
- International Topic Maps Users Conferences were held annually in Norway (2007-2010).

Figure 4. 10 Country distribution of publication based on total articles



Internationally collaborative articles (CP)

In terms of international collaboration, USA was placed the first with 14 articles. Therefore, we could say that USA collaborated strongly with other nations. This is followed by Germany (11), France (10), UK (8), Japan (6), Thailand (5) and Netherlands (5). The degree of international collaboration in Topic Maps was low and was not internationally connected. China was placed at 11th spot with only 2 articles. The comparison of country distribution of publication between single country and internationally collaborative article can be seen in figure 4.11 and 4.12. Locations, cultural relations and language are determinants of research collaborations. Perhaps the different working culture could be the reason of turning down international collaboration. Also, possible reason that China had a low collaboration rate was due to the increase funding of research and development in China (Zhou & Leydesdorff, 2006), it was possible that China did not look outside China for source of funding and collaboration partners. According to Chuang et al. (2011), it is possible that the source of funding may also affect the choice of collaboration partnership.

[9] http://www.topicmapslab.de/events?locale=en&page=2

From figure 4.6, the number coauthorship publications was high for Topic Maps publications. However, the international collaboration was low as seen in table 4.8. This shows that most authors preferred to coauthor their work locally instead of collaborating with authors from other countries. Nevertheless, team of researchers should understand that local collaborations might not bring much impact. This is because according to Liu et al. (2011) and Zhu & Willett (2011), international collaboration in a publication is often beneficial in terms of drawing more citations than those produced by individual countries.

Figure 4. 11 Country distribution of publication based on single country articles

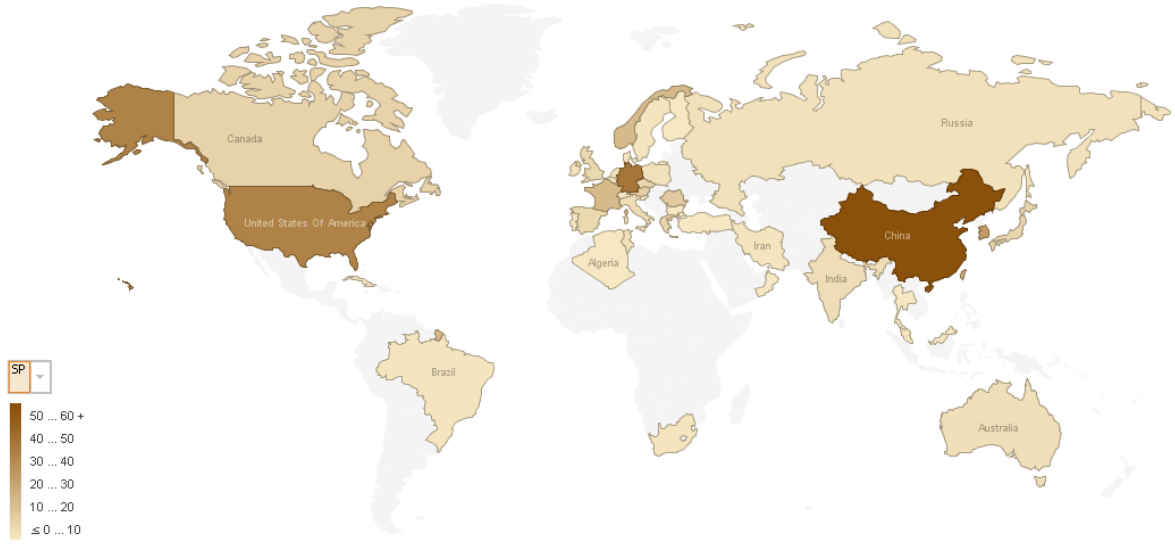
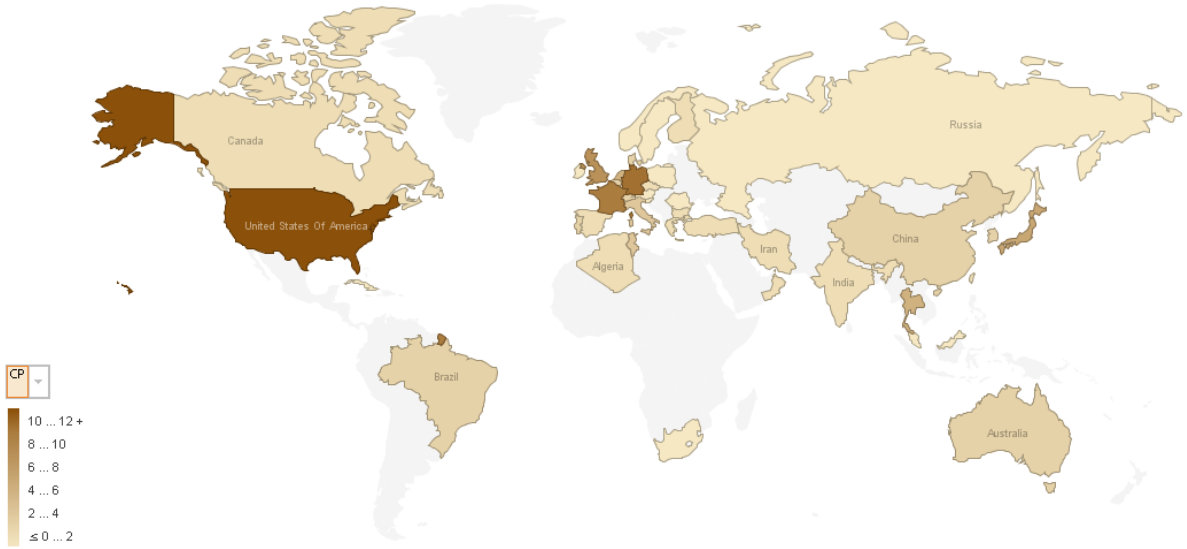


Figure 4. 12 Country distribution of publication based on internationally collaborative articles



4.4. Question 3: Which Topic Maps publications are the most cited?

4.4.1. Top cited publications and references

Out of these 356 publications in our study, 11 publications were highly cited with more than 10 times (Table 4.9). From the title list, it showed that Topic Maps had spread some impact on disciplines such as biomedical, healthcare and education.

Top productive authors in table 4.1 did not appear in the top cited publications list in table 4.9, except Dicheva, D and Dichev, C. This could mean that these two authors were purely active in producing Topic Maps related works.

Table 4. 9 Top cited publications

Authors	Title	Year	Cited by
De Bruijn B., Martin J.	Getting to the (c)ore of knowledge: Mining biomedical literature	2002	42
Dicheva D., Dichev C.	TM4L: Creating and browsing educational topic maps	2006	35
Garshol L.M.	Metadata? Thesauri? Taxonomies? Topic maps! Making sense of it all	2004	33
Sintek M., Decker S.	TRIPLE - A query, inference, and transformation language for the Semantic Web	2002	33
Chau M., Huang Z., Qin J., Zhou Y., Chen H.	Building a scientific knowledge web portal: The NanoPort experience	2006	22
Kim J.-M., Shin H., Kim H.-J.	Schema and constraints-based matching and merging of Topic Maps	2007	17
Schweiger R., Hoelzer S., Rudolf D., Rieger J., Dudeck J.	Linking clinical data using XML topic maps	2003	15
Dicheva D., Dichev C.	Authoring educational topic maps: Can we make it easier?	2005	15
Dicheva D., Dichev C., Wang D.	Visualizing topic maps for e-Learning	2005	14
Liu D.-R., Ke C.-K., Lee J.-Y., Lee C.-F.	Knowledge maps for composite e-services: A mining-based system platform coupling with recommendations	2008	10
Amati G., Carpineto C., Romano G.	Query difficulty, robustness, and selective application of query expansion	2004	10

The 356 publications' references were analysed for citation analysis. There was a total of 5749 references. Table 4.10 shows the top most cited references by these 356 publications. There was a mixture of website, standard, article, conference paper, journal article and book. These references could be possibly the main/classic references for future researchers who want to carry out topic maps research. Most of the references were concerning about Topic Maps standards, such as "Topic Maps Data Model", "ISO/IEC 13250:2000 Topic Maps: Information Technology Document Description and Processing Languages", "Guide to the topic map standards", "Topic Map Constraint Language (TMCL) Requirements and Use Cases", and "Topic maps reference model". Prominent authors could be seen here as well. Authors such as Pepper, S., Moore, G., Garshol, L.M., Biezunski, M., Bryan, M., Newcomb, S., Ahmed, K., and Barta, R. were important authors for early development of Topic Maps. This table shows that standard documents were cited mostly by Topic Maps researchers in order to obtain basic concept of topic maps. There were three titles where RDF could be found. This might be

the researchers were comparing the Topic Maps with RDF technology or the possibility switching between these two technologies.

Table 4. 10 Top cited references

Authors	Title	Year	Citations
Pepper, S., Moore, G.	XML Topic Maps (XTM) 1.0	2001	89
Pepper, S.	The TAO of Topic Maps - Finding the Way in the Age of Info Glut	2000	64
Garshol, L.M., Moore, G.	Topic Maps - Data Model	2003	46
Biezunski, M., Bryan, M., & Newcomb, S.	ISO/IEC 13250:2000 Topic Maps: Information Technology Document Description and Processing Languages		30
Park, J., Hunting, S.	XML Topic Maps: Creating and Using Topic Maps for the Web	2002	30
Berners-Lee, T., Hendler, J., Lassila, O.	The Semantic Web	2001	25
Garshol, L.M.	Metadata? Thesauri? Taxonomies? Topic Maps! Making Sense of It All	2004	25
Dicheva, D., Dichev, C.	TM4L: Creating and Browsing Educational Topic Maps	2006	21
Garshol, L.M.	Living with topic map and RDF : Topic maps, RDF, DAML, OIL, OWL, TMCL	2003	18
Garshol, L.M.	Tolog - A Topic Map Query Language	2001	17
Biezunski, M., Newcomb, S., Bryan, M.	Guide to the topic map standards	2002	17
Moore, G., Nishikawa, M., Bogachev, D.	Topic Map Constraint Language (TMCL) Requirements and Use Cases	2004	16
Rath, H. H	The Topic Maps Handbook	2003	16
Kim, J.M., Shin, H., Kim, H.J.	Schema and constraints-based matching and merging of topic maps	2007	15
Grand, B.L., Soto, M.	Visualisation of the semantic web: Topic maps visualisation	2002	14
Ahmed, K.	TMShare - Topic Map Fragment Exchange in a Peer-To-Peer Application	2003	12
Lacher, M.S., Decker, S.	On the Integration of Topic Maps and RDF Data	2001	12
Ahmed, K.	Topic Map design patterns for information architecture	2003	11
Barta, R.	TMIP - A RESTful Topic Maps Interaction Protocol	2005	11
Garshol, L.M.	What Are Topic Maps	2002	11
Garshol, L.M.	TMRAP - Topic maps remote access protocol	2006	11
Maicher, L., Witschel, H.F.	Merging of distributed topic maps based on the Subject Identity Measure (SIM)	2004	11
Durusau, P., Newcomb, S., Barta, R.	Topic maps reference model		10
Moore, G.	RDF and Topic Maps - An exercise in convergence	2001	10

As a comparison between table 4.9 and 4.10, there were two articles that appeared in both tables. They were “Metadata? Thesauri? Taxonomies? Topic Maps! Making Sense of It All” by Garshol, L.M. and “TM4L: Creating and Browsing Educational Topic Maps” by Dicheva, D., Dichev, C. It showed that these two articles have high quality and can be regarded as classics. Also, the highly cited article by Dicheva, D., Dichev, C. could be the result of frequent self-citations. Self-citation is useful for orientating the reader about the author’s prior work and to provide background information (Sammarco, 2008). At the same time, authors who publish more have wider opportunities to cite their previous work (Fowler & Aksnes, 2007). This could be the reason Dicheva D. and Dichev C. were top productive authors in this study. The top cited references in table 4.10 is not listed in table 4.9 because these titles “XML Topic Maps (XTM) 1.0” by Pepper, S., Moore, G., “The TAO of Topic Maps - Finding the Way in the Age of Info Glut” by Pepper, S. and “Topic Maps - Data Model” by Garshol,

L.M., Moore, G., were Topic Maps specification documents, ISO/IEC standard article and web articles. Therefore, they were not included in the publication of this study.

4.4.2. Top Cited journals

Table 4.11 shows the top cited reference journals for 356 publications. Communication of ACM came up as the top journal with 53 citations, followed by Lecture Notes in Computer Science (LNCS) with 44 citations, Information Processing and Management (35 citations) and IEEE Intelligent Systems with 32 citations. By looking at the journal titles, computer science related journals were used extensively in Topic Maps research. Also, some science disciplines with computer science application were used, for example, British Journal of Educational Technology and Bioinformatics. Future researchers of Topic Maps should consider finding information and references in these journals.

Comparing table 4.11 and 4.2, there were only four journal titles that matched. This means that the journal that the researchers referred to had no influence over the decision of which journal they targeted for publishing.

Table 4. 11 Top cited journals

Journal Title	Subject	Citations
Communication of the ACM	Computer science	53
Lecture Notes in Computer Science (LNCS)	Computer science	44
Information Processing and Management	Library and information science	35
IEEE Intelligent Systems	Computer science	32
Journal of the American Society for Information Science and Technology	Library and information science	31
Expert Systems with Applications	Computer science	28
Scientific American	Multidisciplinary	22
British Journal of Educational Technology	Education	21
Journal of Information Science	Library and information science	21
Markup Languages: Theory & Practice	Computer science	19
Decision Support Systems	Business, Management and Accounting	17
IEEE Transactions on Knowledge and Data Engineering	Computer science	15
Journal of the American Society for Information Science	Library and information science	13
Lecture Notes in Artificial Intelligence (LNAI)	Computer science	13
D-Lib Magazine	Library and information science	12
ACM Computing Surveys	Computer science	11
IEEE Internet Computing	Computer science	11
Scientometrics	Library and information science	11
Bioinformatics	Biology	10
Engineering Journal of Wuhan University	Engineering	10
International Journal of Medical Informatics	Medicine	10
Journal of the China Society for Scientific and Technical Information	Information science	10

4.5. Question 4: What has been studied about Topic Maps?

4.5.1. Title word count

In title analysis, search words, stopwords, prepositions and other meaningless words were excluded. After eliminating these words, a total of 818 keywords were identified. Top 15 title words from year 2001 – 2011, year 2001- 2004, year 2005-2008 and year 2009 - 2011 were taken into analysis and can be seen in table 4.12.

In year 2001 to 2011, ***knowledge***, ***semantic***, ***using***, ***web***, and ***system*** were the top title words used. Overall, the focus of topic maps research could be ***knowledge management***, ***information management***, ***semantic web***, ***ontology***, ***information system***, ***model***, ***e-learning***, ***resources*** and ***data organization***. The words ***environment*** and ***approach*** were possibly explaining the platform and method of using Topic Maps. Taking the word ***using***, it indicated the practical technique was important in Topic Maps research.

In year 2001 to 2004, the focus could be on ***knowledge representation***, ***data integration***, ***XML***, ***data mining***, and ***query***. Probably it was a stage where ***XML*** was the language used for Topic Maps and ***data integration*** was important element for consideration when implementing topic maps in current system.

In year 2005 to 2008, it is possible that ***knowledge*** and ***information management*** becoming prominent, together with semantic web. ***Education*** related subject, such as ***e-learning***, ***education***, and ***learning*** started to bloom. ***Retrieval*** was considered important functionality for Topic Maps. ***Ontology*** was used frequently only in this period.

From 2009 to 2011, Topic Maps research could be seen to be more ***knowledge***-based, ***semantic***, and ***intelligent***. ***Model*** and ***modeling*** could indicate that different models were ***construct***ed. ***Extended*** could be the ***Extended*** Topic Maps (ETM), the extension of conventional topic map in structure. Also, ***collaborative*** in ***knowledge*** and ***learning*** could be the focus of the topic maps research.

In summary based on title keyword count, Topic Maps was tightly associated with ***knowledge***. The idea of ***semantic*** came during the period of 2005 – 2011, before that period ***semantic*** was not much being mentioned. ***Web*** was frequently mentioned from 2001 – 2008, then ***system*** started to have an impact. This could show that authors treated ***web*** and ***system*** as the same object, or more maybe

Topic Maps being applied more in later years in other application systems, besides ***web***. ***Ontology*** was popular in during 2005 – 2008 only. ***Management*** came in from 2005 – 2011, and this might be the starting point for ***knowledge management***. ***E-learning*** and ***learning*** became prominent starting from 2005. ***Learning*** might start to be ***collaborative*** during 2009 – 2011. Topic Maps might start to get involved being ***intelligent*** from 2009, and in the same period of time, ***model*** and ***modeling*** bloomed. This indicated creating new model was important to have an ***intelligent*** system.

Table 4. 12 Title word count by year

Year 2001 – 2011 (356)	
Title	**Count**
Knowledge	80
Semantic	42
Using	42
Web	39
system	38
Information	33
management	31
approach	21
model	20
Data	19
Ontology	18
service	17
E-learning	16
environment	16
learning	16
resource	16

Year 2001 – 2004 (44)	
Title	**Count**
Knowledge	9
Using	7
Information	6
Web	6
XML	6
mining	4
resource	4
approach	3
Data	3
Integration	3
Query	3
representation	3
service	3
system	3
Application	2
Building	2

Year 2005 – 2008 (195)	
Title	**Count**
Knowledge	28
Semantic	28
Web	27
Using	25
Information	19
management	19
system	16
Ontology	13
environment	12
learning	10
approach	9
Distributed	9
education	9
E-learning	9
retrieval	9
Application	8

Year 2009 – 2011 (117)	
Title	**Count**
Knowledge	43
system	19
Semantic	12
Intelligent	11
model	11
management	10
Using	10
approach	9
Data	8
Information	8
resource	8
Modeling	7
Collaborative	6
construct	6
Extended	6
learning	6

4.5.2. Author's keyword count

In the author's keyword analysis shown in table 4.13, the highest frequency of author 's keyword was ***Ontology*** (25 times). This is followed by ***Semantic Web*** (24), ***Knowledge management*** (15), ***information retrieval*** (12), ***e-learning*** (11) and ***XML*** (10). There were focuses on ***knowledge navigation***, ***representation***, ***organization*** and ***service***. ***Intelligent topic map***, ***RDF***, ***thesauri*** and ***visualization*** emerged to be important. Finally, ***XML Topic Maps*** were being mentioned too, probably it was used for web-based topic maps.

In year 2001 – 2004, ***knowledge management*** became the focus (6 times), followed by ***ontology*** (4), ***XML*** (4), ***semantic web*** (3). In year 2005 – 2008, ***semantic web*** became prominent, followed by ***ontology*** (9), ***information retrieval*** (6), ***visualization*** (6) and ***e-learning*** (5). Finally, in year 2009 –

2011, ***Ontology*** came as the main focus (12), with ***intelligent topic maps*** (9), ***knowledge management*** (7), ***knowledge navigation*** (7), ***semantic web*** (6) and ***thesauri*** (6).

In summary, ***ontology*** and ***semantic web*** were the frequently used keywords since beginning from 2001-2011. ***E-learning*** began to catch the attention of the researchers during the period of 2005 – 2011. ***XML*** was popular only in the beginning of the year. ***Information retrieval*** seemed to be important throughout the years. Many keywords in 2001-2004 were data related, such as ***corpora***, ***large datasets***, and ***metadata***. This could be research related to ***data integration*** topic. Perhaps ***data integration*** was the focus in 2001-2004. ***Text mining*** was only found in 2001-2004. In 2005-2008, focus of Topic Map research was more on ***information retrieval***, ***visualization*** and ***navigation***, most probably the Topic Maps was establishing itself in ***information architecture*** during this period of the year. Finally, in year 2009-2011, Topic Maps seemed to be extended in providing ***intelligent*** and ***knowledge-based systems*** or ***services***. Nevertheless, the count of the keywords were too small for making a summary of trend. Fu et al. (2010) mentioned that the large number of once-only author keywords in the results which probably indicated a lack of continuity in research and a wide disparity in research focuses. In another point of view, this showed that the mainstream research was considered focusing on a small and scattered field.

Table 4. 13 Author's keyword count by year

Year 2001 - 2011	
Keyword	**Count**
Ontology	25
Semantic web	24
Knowledge management	15
Information retrieval	12
E-learning	11
XML	10
Intelligent topic map	9
Knowledge navigation	9
Knowledge representation	8
RDF	8
Thesauri	8
Visualization	8
XML Topic Maps	7
Knowledge Organization	5
Knowledge service	5

Year 2001 - 2004	
Keyword	**Count**
Knowledge management	6
Ontology	4
XML	4
Semantic web	3
Corpora	2
Information retrieval	2
Knowledge Organization	2
Knowledge representation	2
Large Datasets	2
Metadata	2
Semantic Nets	2
Semantic relationships	2
Text mining	2
Virtual Observatory	2
Centering Model	1

Year 2005 - 2008	
Keyword	**Count**
Semantic web	15
Ontology	9
Information retrieval	6
Visualization	6
E-learning	5
RDF	4
Retrieval	4
TM schema	4
Web service	4
Description logics	3
Knowledge representation	3
Navigation	3
Organisational memory	3
Self-organizing map	3
XML	3

Year 2009 - 2011	
Keyword	**Count**
Ontology	12
Intelligent topic map	9
Knowledge management	7
Knowledge navigation	7
Semantic web	6
Thesauri	6
E-learning	5
XML Topic Maps	5
Information retrieval	4
Knowledge service	4
Relational database	4
Clustering	3
Component	3
Distributed knowledge management	3
Extended topic map	3

4.5.3. Index keyword count

There was a total of 42 articles without index keyword. Table 4.14 shows the ranking of index keywords. ***Semantics*** had the highest count with 109. This is followed by ***ontology*** (68), ***semantic web*** (51), ***information retrieval*** (41), ***metadata*** (36). The unexpected and uncommon keyword was ***optical projectors*** (36).

In year 2001 -2004, ***semantics*** was placed first (12), then ***world wide web*** (10), ***XML*** (10), ***artificial intelligence*** (6). In year 2005 – 2008, the keyword ***semantics*** remained as top keyword (64), followed

by ***ontology*** (36), ***optical projectors*** (36), ***semantic web*** (32) and ***information theory*** (31). In year 2009 – 2011, ***semantics*** continued remained as top keyword (33). ***Ontology*** also remained in second spot (28), followed by ***knowledge management*** (18) and ***semantic web*** (16). The reason of having keyword ***optical projectors*** in 36 articles was a mystery due to the author had check through each title of the publication and could not figure out the relationship between ***optical projectors*** and topic maps to publication title.

In summary, ***semantics***, ***ontology***, ***metadata***, ***knowledge representation*** and ***information retrieval*** were among the frequently appeared keywords throughout the years. ***XML*** was frequently mentioned in 2001-2004. In 2005 – 2008, ***information theory*** appeared to be high in the index keyword count. ***Mathematical models*** could possibly relate to ***information theory***. ***E-learning*** started to be highly used in this period of year. In 2001-2004, the focus seemed to be in ***interoperability*** of ***metadata*** and ***database system***. In 2005 – 2008, the focus should be on ***information theory*** where the effective communication of information is important which resulted in ***retrieval*** and ***navigation*** related topic such as, ***information retrieval***, ***ontology***, ***query languages***, ***data structures*** and ***knowledge representation***. In 2009 – 2011, ***knowledge management*** appeared to be high in count. The focus here seemed to be creating ***knowledge-based systems*** such as ***knowledge management*** using ***multi-granularity*** and ***multi-level*** kind of techniques or model to achieve it.

Table 4. 14 Index keyword count by year

Year 2001 - 2011	
Keyword	Count
Semantics	109
Ontology	68
Semantic Web	51
Information retrieval	41
Metadata	36
Optical projectors	36
World Wide Web	36
Information theory	34
Knowledge representation	33
Query languages	32
Knowledge management	30
Internet	29
Knowledge based systems	29
E-learning	25
XML	25

Year 2001 - 2004	
Keyword	Count
Semantics	12
World Wide Web	10
XML	10
artificial intelligence	6
Computer Science, Theory & Methods	6
Information retrieval	6
Knowledge representation	5
Metadata	5
Database systems	4
Internet	4
Ontology	4
Search engines	4
Data mining	3
human	3
Interoperability	3

Year 2005 - 2008	
Keyword	Count
Semantics	64
Ontology	36
Optical projectors	36
Semantic Web	32
Information theory	31
Query languages	22
Information retrieval	21
World Wide Web	21
Mathematical models	19
Metadata	19
Internet	17
E-learning	16
Knowledge based systems	16
Data structures	15
Knowledge representation	15

Year 2009 - 2011	
Keyword	Count
Semantics	33
Ontology	28
Knowledge management	18
Semantic Web	16
Information retrieval	14
Knowledge representation	13
Metadata	12
Visualization	12
Navigation	11
Knowledge based systems	10
Multi-granularity	10
Multi-level	10
Information science	9
Information technology	9
Knowledge navigation	9

4.5.4. Summary based on title words, author's keywords and index keywords

Below is the summary of the result based on the title words, author's keywords and index keywords.

Year 2001 – 2004: The focus was on ***data integration*** and ***interoperability*** which involved ***corpora***, ***large datasets***, ***metadata***, and ***database system***. ***Data*** and ***text mining*** was a phase used which came before ***data integration*** process.

Year 2005 – 2008: the focus should be on ***information theory*** where the effective communication of information was important. ***Mathematical models*** were the basis for ***information theory***. ***Information communication*** was highly related to ***information architecture***, ***retrieval*** and ***navigation***

related topic such as, ***information retrieval***, ***ontology***, ***query languages***, ***data structures***, ***visualization*** and ***knowledge representation***. Besides that, ***e-learning*** was the focus as well. Probably, the ***information architecture***, ***retrieval*** and ***navigation*** were being applied the most in ***e-learning*** and ***education*** settings.

Year 2009 – 2011: The focus was more towards creating ***knowledge*** and ***intelligent based system*** and ***services***. This could be possible with the creation of ***multi-granularity*** and ***multi-level*** models. Therefore, ***intelligent topic map*** and ***extended topic map*** were created to support the function of ***knowledge and intelligent based system*** and ***service***.

4.5.5. Bibliometric mapping of title and abstract using co-word analysis

In this section, bibliometric map was created using co-word analysis. This is a content analysis technique that is effective in mapping the strength of association between information items in textual data.

A co-word map was created based on the title and abstract of 356 publications. The title and abstract were used for analysis in VOSviewer[10], a bibliometric mapping software. Terms with a minimum occurences of 10 were selected, and out of the 5543 terms, 133 met the threshold. For each of the 133 terms, a relevance score was calculated. Based on this score, 66 most relevant terms were selected.

The map is shown in figure 4.13. Colours indicate the density of terms, ranging from blue (lowest density) to red (highest density). Prominent terms include content and concept. Based on the red colour density, there were five groups of themes being identified in table 4.15.

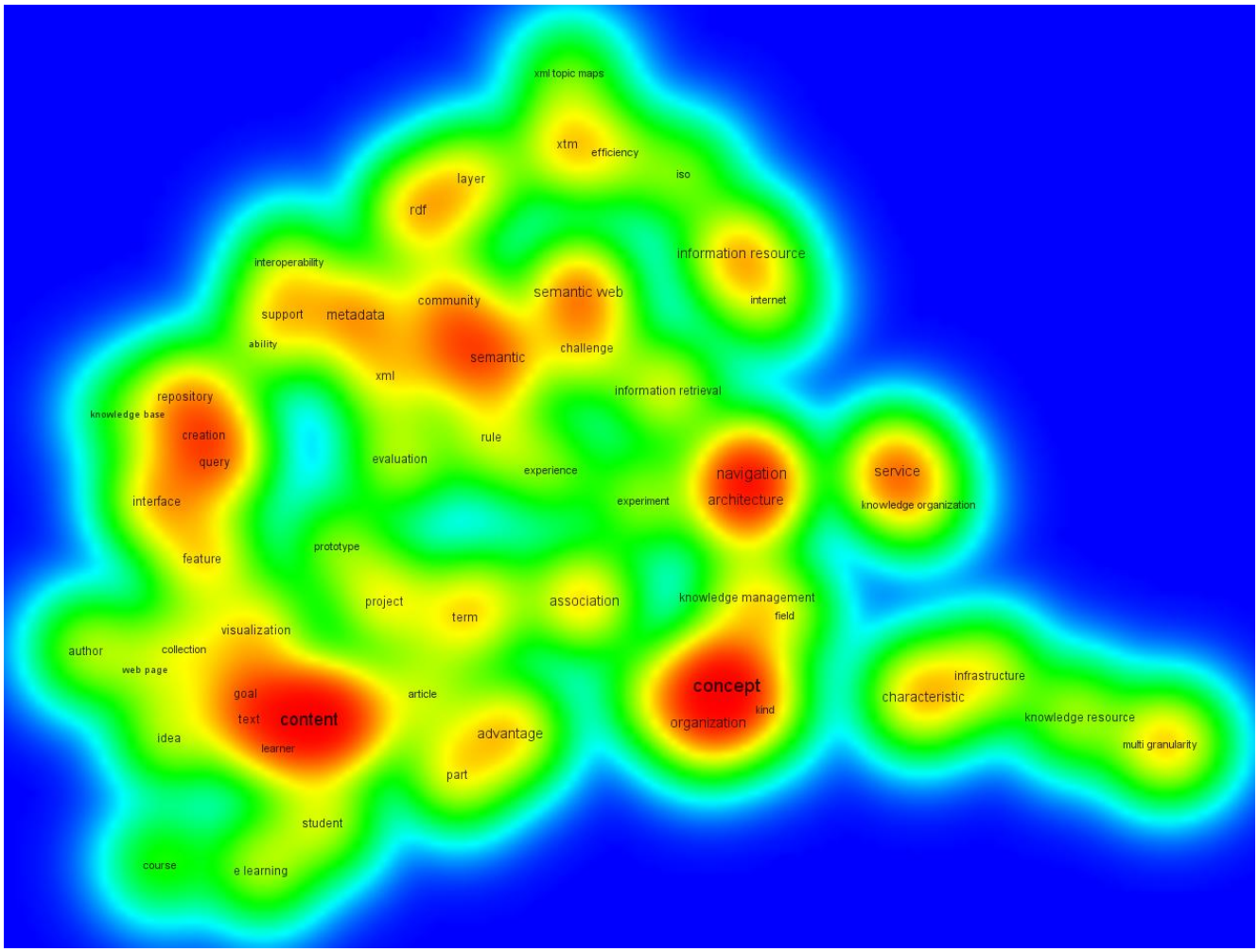
Table 4. 15 Density of Terms (Themes identified)

Terms	Theme
Content, goal, text, learner, collection, student, visualization	Content management
Creation, query, repository, knowledge base, interface	Repository
Concept, organization, kind	Ontology
Navigation, architecture	Information architecture
Semantic, community, semantic web, challenge, metadata, support, interoperability	Semantic web

[10] http://www.vosviewer.com/

There were five focus areas which were content management, repository, ontology, information architecture and semantic web. ***Content management*** here was related to the management of learner's content and collection which most likely was applied in e-learning environment. In this environment, it seemed like visualization was emphasized. As seen in figure 4.13, ***repository*** was closely related to ***content management*** focus area. The important feature of a repository was based on the creation of the query, and its interface and being knowledge based. ***Ontology*** talked about the organization of knowledge as a set of concepts within certain fields and its kind. Ontology seemed to be used in the area of knowledge management. Another focus was ***information architecture***, where the central focus was on navigation and architecture. Lastly, the focus on ***semantic web*** might be semantic related issues from community of user and challenges they faced. Most likely the issues faced were about metadata, support and interoperability.

Figure 4. 13 Bibliometric mapping of title and abstract (density view)



4.6. Question 5: What are the future research areas?

Table 4. 16 Top title, author and index keywords in year 2009 - 2011

Year 2009 - 2011		Year 2009 - 2011		Year 2009 - 2011	
Title word	**Count**	**Author keyword**	**Count**	**Index keyword**	**Count**
Knowledge	43	Ontology	12	Semantics	33
system	19	Intelligent topic map	9	Ontology	28
Semantic	12	Knowledge management	7	Knowledge management	18
Intelligent	11	Knowledge navigation	7	Semantic Web	16
model	11	Semantic web	6	Information retrieval	14
management	10	Thesauri	6	Knowledge representation	13
Using	10	E-learning	5	Metadata	12
approach	9	XML Topic Maps	5	Visualization	12
Data	8	Information retrieval	4	Navigation	11
Information	8	Knowledge service	4	Knowledge based systems	10
resource	8	Relational database	4	Multi-granularity	10
Modeling	7	Clustering	3	Multi-level	10
Collaborative	6	Component	3	Information science	9
construct	6	Distributed knowledge management	3	Information technology	9
Extended	6	Extended topic map	3	Knowledge navigation	9

Table 4.16 shows the top title, author and index keywords for year 2009 to 2011. The recent 3 years of keyword results were used for the purpose of identifying future research areas for Topic Maps. Based on the keywords listed in Table 4.16, keywords were grouped according to themes (table 4.15). These keywords are useful for providing direction and current trend of Topic Maps research.

Table 4. 17 Possible future research areas

Themes	Keywords	Possible future research areas
Content management and repository	System, management, collaborative, construct, e-learning, visualization, knowledge-based system	Collaborative e-learning system Knowledge visualization system Construct visualization
Semantic web	Semantic, semantic web, relational database, metadata	Creating semantic metadata from relational database
Retrieval and navigation	Resource, data, information, knowledge navigation, XML topic maps, information retrieval, navigation	Improving knowledge navigation and retrieval
Ontology	Knowledge, intelligent, model, modeling, intelligent topic map, knowledge management, thesauri, knowledge service, component, clustering, distributed knowledge management, extended topic maps, knowledge representation, multi granularity, multi-level	Intelligent topic maps Distributed knowledge management based on extended topic maps Knowledge service system Knowledge representation modeling Multi granularity and multi-level knowledge system

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1. Conclusion

How publications are placed in time?

There is a total of 356 publications produced from year 2001 to 2011. It had the most publication of 62 in 2007. However, the number of publication seemed to be decrease over the years after 2007. It is predicted that there will be 55 publications for 2012 based on regression analysis. There were more conference papers (265) produced than journal articles (91). It shows that Topic Maps researchers had a preference to present their research finding in conference rather than in journal. This publishing trend is similar with computer science researchers'.

How publications are concentrated to specific researchers, journals, conference proceedings, and country?

The most productive authors were Lu Huimin (16), Dicheva, Darina (13), Dichev, Christo (12), and Feng, Boqin (12). Majority of the authors were found to be academicians and from universities. The authorship pattern was more towards coauthorship than single author. There were a total of 299 (84%) publications by multi-authors and 57 (16%) single authored publications. Most of the coauthorship publications consisted of two (102 publications) and three (103 publications) coauthors. The highest coauthorship was 10 authors with only 1 paper. Therefore, it would be common to see a collaboration of two or three authors in Topic Maps publications. Another reason of having many multi-authored publications here was because most of the publications were conference papers, and conference paper is common to have coauthorship.

The top journal titles publishing Topic Maps related articles were WSEAS Transactions on Information Science and Applications (5), and Journal of Universal Computer Science (4). From the low count of publications for each journal titles, it indicated that there was no any particular journal that Topic Maps researchers targeted for publishing. Nevertheless, it was found attractive to identify the subject category of the journal titles. There was a total of 67 journal titles published Topic Maps related articles. Most of the journal titles were of computer science related (30), library and information science (12), engineering (8) and medicine (6). Besides, there were others appealing disciplines found, such as business, management and accounting, education, agriculture, communication, decision sciences and material science.

There was a total of 265 conference papers taken into the analysis of obtaining the conference titles where these papers were presented. There were 150 unique conference titles identified. Topic Map Research and Application (TMRA) conference was the leading conference for Topic Maps with 62 papers. Followed by Annual ACM Southeast Conference, ACMSE (5 papers) and IEEE International Conference on Advanced Learning Technologies, ICALT (5 papers). In term of the subject distribution of the conference, majority of the conferences were computer science related (79), followed by education (12), knowledge management (8), information science (7), engineering (7), business, management and accounting (7). Other than that, there were agriculture, archive, communication, control theory, environment science, ergonomics, mathematics, military, mobile technology, nanotechnology, and geoscience.

Bibliographic data on the country distribution of publications were based on the affiliation information of the authors. There were 41 countries identified, Europe (22), Asia (11), North and South America (4) and Africa (10) and Oceania (1). China was the leading country in articles productivity (57), followed by Germany (54), USA (51), South Korea (32), France (26), Taiwan (24), Norway (17), UK (13) and Japan (13). However, in term of internationally collaborative articles, China was placed at 11th spot with only 2 articles. USA was placed the first with 14 articles, then Germany (11), France (10), UK (8) and Japan (6). The number of the international collaboration was quite low, even though the number of coauthorship was high. This indicated that most researchers were coauthored locally.

Which publications about Topic Maps are the most cited?

The top cited publications in this study were "Getting to the (c)ore of knowledge: mining biomedical literature" by De Bruijn B. and Martin J with 42 citations. Followed by "TM4L: Creating and browsing educational topic maps" by Dicheva D., Dichev C. (35 times), "Metadata? Thesauri? Taxonomies? Topic maps! Making sense of it all" by Garshol L.M. (33 times) and "TRIPLE - A query, inference, and transformation language for the Semantic Web" by Sintek M., Decker S. (33 times).

On the top cited references, the following was cited most in Topic Maps related literatures. "XML Topic Maps (XTM) 1.0" by Pepper S. and Moore G (89 citations). Secondly, "The TAO of Topic Maps – Finding the way in the age of info glut" by Pepper S (64 times), "ISO/IEC 13250:2000 Topic Maps: information technology document description and processing languages" by Biezunski M, Bryan M, and Newcomb S. These can be classified as the classic literatures for Topic Maps. Most of the references were Topic Maps standard documents.

There were two articles that appeared as most cited by and cited, which were “Metadata? Thesauri? Taxonomies? Topic Maps! Making Sense of It All” by Garshol, L.M. and “TM4L: Creating and Browsing Educational Topic Maps” by Dicheva, D., Dichev, C. It might indicate the researchers viewed these two articles as more quality and reliable.

Most Topic Maps researchers referred to computer science journals. The top cited journals were Communication of ACM with 53 citations, followed by Lecture Notes in Computer Science (LNCS) with 44 citations, Information Processing and Management (35 citations) and IEEE Intelligent Systems with 32 citations. This could help future Topic Maps researchers to find resources in these journals.

What has been studied about Topic Maps?

Based on the title word, author’s keywords and index keywords, the focus of the Topic Maps changed along the period. From 2001 to 2004, the focus was on data integration and interoperability. In 2005 – 2008, the focus shifted to information theory where effective communication of information, such as information architecture, retrieval and navigation was emphasized. Finally, from 2009 to 2011, the focus was more towards creating knowledge and intelligent based system and services.

With the bibliometric mapping of title and abstract using co-word analysis, there were five themes identified for Topic Maps. They were content management, repository, ontology, information architecture, retrieval and navigation, and semantic web.

What are the future research areas?

Based on the recent three years of keywords result, the future research areas will possibly be collaborative e-learning system, knowledge visualization system, visualization construction, semantic metadata creation from a relational database, knowledge navigation and retrieval improvement, intelligent topic map, distributed knowledge management based on extended topic maps, knowledge service system, knowledge representation modeling, and multi granularity and multi-level knowledge.

In conclusion, Topic Maps could still be relevant as a technology for the semantic web in coming years. However, the usage of Topic Maps is predicted to be low after having analyzed the result from this study. The reason is Topic Maps is viewed as immature 10-years-old technology. In additional,

other similar technology such as RDF could have done semantic web much better than Topic Maps, which leads to the preference of RDF. Lastly, the absence of Topic Maps specific conference and journal is the key factor of the low research activities on Topic Maps.

5.2. Discussion

From the result, the peak year for Topic Maps was in 2007. TMRA conferences were held every year until 2010. Unfortunately, conference proceedings of TMRA 2008, 2009 and 2010 were not being indexed neither in Web of Knowledge nor SCOPUS databases. This was because these proceedings were published in LIV series by the University of Leipzig. Therefore, these three years of TMRA conference papers' bibliographic data were not being capture in this study. This was a limitation of this study. If the conference papers for TMRA 2008, 2009 and 2010 were included in this study, the peak period of Topic Maps would be from 2007 to 2009. This period of years could be the golden age for Topic Maps where there were research, application and publication being produced.

The publication of Topic Maps literatures will still be continued on, and researchers will still write and publish papers on Topic Maps. The question is the number of Topic Maps papers which will be published. Topic Maps researchers have the strong inclination of presenting papers in conferences, just as other computer scientists who favour publishing in conference rather than journal. This trend will not be changed in few years time. As for conference papers related to Topic Maps, the trend will probably decrease. Many leading Topic Maps conferences have been discontinued, for example, Topic Maps Research and Applications (TMRA) which started in 2005 and ended in year 2010. It is succeeded by the International ICST conference on No SQL Databases and Social Applications in year 2012. Other Topic Maps conference such as International Topic Maps User Conference were held annually in Norway from 2007 and ended in 2010. Both of these conferences were subject specific conference on Topic Maps and they are important conferences for promoting and pushing the usage of Topic Maps technology. However, both conferences ended in the same year in 2010. The reason for this incident of discontinuation could not be found, most likely the community started to show lack of interest. Without these Topic Maps specific conferences, it is predicted that there will be a drop in Topic Maps research, especially in conference proceedings. With the low number of conference papers, it will affect the number of journal articles, as mentioned by Vardi (2009), only a small portion of conference papers is followed by journal articles. Looking at the result of this study, it is predicted that the number of journal articles will be slightly consistent and most likely it will not exceed 20 articles per year, which is quite low. All these incidences indicate that Topic Maps might have not reached technology maturity stage, but has lost its importance and significant now or

future. Perhaps Topic Maps has less commercial value for semantic web technology where most would prefer RDF. This can be a further research topic.

However, from the study result, it is difficult to identify a dedicated journal which Topic Maps researchers preferred to have their papers being published. It will be beneficial if a dedicated Topic Maps journal being established which will help to boost up the Topic Maps research and theory regardless of the discipline of researchers in, be it computer science, library and information science, medicine or education. This could create an avenue for Topic Maps researchers to have a targeted journal for publishing their work. Also, another benefit could be that with the increasing number in journal articles could place Topic Maps close to technology maturity.

In term of authorship, Topic Maps research depends a lot on academician in universities. There were not many authors from companies and commercial industries published papers in journals. These authors might prefer presenting their study in conferences, and there are small chances of these conference papers to be followed up by publishing in a journal. This is because most of the authors from companies or commercial industries do not need to achieve key performance indicators in research work like the academicians do. The authorship pattern in Topic Maps is more toward coauthorship than single author. This is because of most publications are conference papers, and coauthorship is common for this reason (Franceschet, 2010). It seems like the more technical is a research work, the more collaborations it will have. It is wise to have a coauthorship work if the research work is too technical and has tight deadline for submitting the conference paper.

Topic Maps article published in library and information science journal in 2003. Estrada (2009) mentioned that Topic Maps was introduced to LIS community in 2003 at the series of conference. However, in this study result, there was digital library conference (Second ACM/IEEE-CS Joint Conference on Digital Libraries) held in 2002 and there was one Topic Maps related paper presented, which showed that Topic Maps was possible being introduced to LIS community as early as 2002. Perhaps Estrada (2009) did not mention about this conference because it might be considered as a conference for computer scientists rather than librarians, which was more technical and not suitable for general librarians.

The application of Topic Maps in the manufacturing sector was started in a university in Korea. There were two journal articles [11] [12] published by them in 2007. After that, in 2008, there was a conference

[11] Lee, J., & Kim, K. (2007). A distributed product development architecture for engineering collaborations across ubiquitous virtual enterprises. The International Journal of Advanced Manufacturing Technology, 33(1), 59–70. doi:10.1007/s00170-006-0443-4

[12] Chae, H., Kim, K., Choi, Y., Kim, C.-H., & Lee, J. Y. (2006). A view-based approach to modeling product semantics in design chains. The International Journal of Advanced Manufacturing Technology, 32(9-10), 863–876. doi:10.1007/s00170-006-0419-4

paper[13] presented by a group of researchers from the non-academic institution in Korea. It shows that the journal articles brought an impact in the manufacturing sector. As for the medical industry, there were several Topic Maps related articles published as early as 2003. It was found that mostly were journal articles. This shows that researchers in the medical field prefer to publish in journal articles. Conferences might not be a popular avenue for them to showcase their research. However, the last Topic Maps related article in the medical field was published in 2009, and in total there were only 6 articles. This might indicate that Topic Maps was no longer useful in this field, and with only 6 articles, the potential of having Topic Maps to be applied in the medical field is low.

It is intriguing to look at the distribution of Topic Maps publication by country. There was a significant influence of Topic Maps in East Asian countries, such as China, South Korea, Taiwan and Japan. The highlight and booster for Topic Maps research in East Asia would probably be the AToMS (Asian Topic Maps Summit)[14] 2007 held in Kyoto Japan. But there were two downfalls being identified for this conference, first, AToMS was held once only. Second, conference proceeding was not produced. This could indicate that AToMS was just a short term promotion of Topic Maps in Asia. If not, Topic Maps research could have been a massive hit in East Asia.

In Europe, Germany, France, Norway and UK have a large share of Topic Maps research. Germany and Norway are the main leading actor for Topic Maps research. It is because Germany was the TMRA conference host country annually. Norway also hosted several Topic Maps conference and there is a company called Ontopia with a suite of topic map solutions and business partner with companies in USA, Japan, South Korea, Germany and UK. This might be the reason that Topic Maps have influence in Japan and South Korea. With AToMS 2007 conference, Topic Maps influence could possibly spread to China. Based on the result of this study, China had only 8 publications from 2002-2007, and after 2007, the number of publication raised to 57. Nevertheless, Topic Maps is only well-known in Norway among Northern European countries. Denmark, Sweden and Finland did not show many publications about Topic Maps. This might show that Topic Maps is not an attractive technology to these countries.

Referring to top cited references of 356 publications, standard documents from ISO website were cited the most. Among the top references, there were three titles found with the word RDF within the title. There are a few possibilities that these references were used. It could be the researchers

[13] Jung, E.-H., Cho, K.-M., Song, K.-H., Nam, S.-H., & Lee, S.-W. (2008). Methodology of Topic Maps creation and Semantic Web for technological information search regarding injection-mold based on Collaboration Hub. Smart Manufacturing Application, 2008. ICSMA 2008. International Conference on (pp. 78 –83). doi:10.1109/ICSMA.2008.4505617

[14] http://www.knowledge-synergy.com/news/atoms2007-en.html

were comparing the Topic Maps with RDF technology. Also, it could be about data integration or dealing with interoperability between these two technologies.

From 2001 to 2004, Topic Maps focused on data integration and interoperability. In order for Topic maps to establish itself in the early stage, the basic element like data should first be dealt with. The ability of a technology to integrate data and interoperability issues are a serious concern for using a new technology. It was desirable that Topic Maps could provide solutions.

From 2005 to 2008, Topic Maps shifted the focus on "information theory" for effective communication of information. This might indicate that Topic Maps succeeded in dealing with data integration and interoperability issue, and therefore, Topic Maps could establish itself in information architecture, retrieval and navigation. E-learning was the application area identified. Education application was targeted most likely because it was easier to implement and it had less risk involved. Also, since most of the Topic Maps researchers were academicians, e-learning was an area which the researchers found familiar with and could help or improve with the university's teaching and learning method.

From 2009 to 2010, Topic Maps had grown to be more knowledge and intelligent based. Topic Maps was being extended, and element of "intelligence" was created. This was to support the reasoning of knowledge and intelligent system, therefore, Topic Maps needed to acquire artificial intelligent and reasoning features so that it is comparable with other latest technologies and keep up with the latest development. The researchers created new names such as "intelligent topic map" and "extended topic map". This could be seen as to promote Topic Maps and perhaps created some rebranding to make Topic Maps up-to-date and fresh.

Hence, the possible future research areas on Topic Maps should be something new, fresh, innovative and could replace old techniques and technologies. There will be a wide range of research possibility if Topic Maps goes into knowledge and intelligent based, bridging the gap closer between Topic Maps and Semantic Web. Therefore, reasoning is an important element to be considered if to connect it with semantic web and artificial intelligent. Another possible research area that Topic Maps could venture into is mobile or business applications. Mobile application could have more commercial value as compare to education such as e-learning. This could boost up the value of Topic Maps.

In summary, Topic Maps could still "survive" or in use for coming more years. However, the usage of Topic Maps might foresee to be low after having analyzed the result from this study. This might be because Topic Maps is still an immature technology or Topic Maps is started losing out to other

similar technology such as RDF. From the academic point of view, the absence of Topic Maps specific conference and journal could bring down the study on Topic Maps tremendously.

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Appendixes

Appendix 1: List of journal title with one article (total: 52)

1. ACIMED
2. Advances in Electrical and Computer Engineering
3. Applied Intelligence
4. Artificial Intelligence in Medicine
5. British Journal of Educational Technology
6. Campus-Wide Information Systems
7. Computer
8. Computer Standards and Interfaces
9. Computer-Aided Design and Applications
10. Dalian Ligong Daxue Xuebao/Journal of Dalian University of Technology
11. Decision Support Systems
12. Document Numerique
13. Dongnan Daxue Xuebao (Ziran Kexue Ban)/Journal of Southeast University (Natural Science Edition)
14. Earth Science Informatics
15. Future Generation Computer Systems
16. IEEE Multimedia
17. IFIP International Federation for Information Processing
18. Informatica (Ljubljana)
19. Information and Software Technology
20. Information Processing and Management
21. Information Research
22. International Journal of Advanced Media and Communication
23. International Journal of Digital Content Technology and its Applications
24. International Journal of High Performance Computing and Networking
25. International Journal of Knowledge Management
26. International Journal of Medical Informatics
27. International Journal of Web and Grid Services
28. Internet Research
29. INVESTIGACION BIBLIOTECOLOGIA
30. Journal of Computational Information Systems
31. Journal of Computer Assisted Learning
32. Journal of Computing in Civil Engineering
33. Journal of E-Learning and Knowledge Society
34. Journal of Intelligent Information Systems
35. Journal of Interactive Learning Research
36. Journal of Internet Technology
37. Journal of Research and Practice in Information Technology
38. Journal of the American Medical Informatics Association
39. Journal of the Chinese Society of Mechanical Engineers, Transactions of the Chinese Institute of Engineers, Series C/Chung-Kuo Chi Hsueh Kung Ch'eng Hsuebo Pao
40. Journal of Web Semantics
41. Knowledge Organization
42. Krankenhauspharmazie
43. Library Hi Tech
44. Library Resources and Technical Services
45. Malaysian Journal of Library and Information Science
46. Methods of Information in Medicine
47. Multimedia Tools and Applications
48. Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering
49. Scientometrics
50. Signal Processing: Image Communication
51. Wirtschaftsinformatik
52. Zhongnan Gongye Daxue Xuebao/Journal of Central South University of Technology

Appendix 2: List of conference with one or two papers

Conference with one paper (Total: 118)

1. ACM International Conference on Design of Communication, SIGDOC 2008
2. ACM International Conference on Information and Knowledge Management, CIKM 2009
3. Annual Meeting of the American-Society-for-Information-Science-and-Technology
4. Annual SIGCSE Conference on Innovation and Technology in Computer Science Education
5. Archiving 2008
6. ASEE Annual Conference and Exposition
7. Astronomical Data Analysis
8. Bangalore Annual Compute Conference, COMPUTE'09
9. Chinese Control Conference, CCC
10. Conference on Technologies and Applications of Artificial Intelligence, TAAI 2010
11. Data Warehousing and Knowledge Discovery, Dawak 2003
12. EUC 2005 Workshops: UISW, NCUS, SecUbiq, USN, and TAUES
13. European Conference on Cognitive Ergonomics, ECCE 2011
14. European Conference on IR Research (ECIR)
15. European Conference on Research and Advanced Technology for Digital Libraries, ECDL 2008
16. European Conference on Technology Enhanced Learning, EC-TEL 2008
17. IASTED International Conference on Internet and Multimedia Systems and Applications, IMSA 2005
18. IEEE Congress on Evolutionary Computation, CEC 2008
19. IEEE International Computer Software and Applications Conference, COMPSAC 2009
20. IEEE International Conference on Communications Technology and Applications, IEEE ICCTA2009
21. IEEE International Conference on Computer Systems and Applications, 2006
22. IEEE International Conference on e-Science, e-Science 2009
23. IEEE International Conference on Information Reuse and Integration, IRI - 2005
24. IEEE International Conference on Intelligent Computing and Intelligent Systems, ICIS 2009
25. IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, IDAACS'2011
26. IEEE International Conference on Internet Multimedia Services Architecture and Applications, IMSAA 2009
27. IEEE International Conference on Management of Innovation and Technology, ICMIT2010
28. IEEE International Conference on Network Infrastructure and Digital Content, IC-NIDC 2010
29. IEEE International Enterprise Distributed Object Computing Conference Workshops, EDOCW2006
30. IEEE International Geoscience and Remote Sensing Symposium, IGARSS 2005
31. IEEE International Symposium on Applied Computational Intelligence and Informatics, SACI 2011
32. IEEE Joint Conference on E-Commerce Technology and the 5th Enterprise Computing, E-Commerce and E-Services, CEC 2008 and EEE 2008
33. IEEE Network Operations and Management Symposium Workshops - NOMS 08
34. IEEE Symposium on Computers and Communications, ISCC 2010
35. IEEE Systems Readines Technology Conference -(AUTOTESTCON 2002)
36. IEEE Workshop on Computational Intelligence for Visual Intelligence, CIVI 2009
37. IEEE/ACIS International Conference on Computer and Information Science, ICIS 2006. In conjunction with 1st IEEE/ACIS International Workshop on Component-Based Software Engineering, Software Architecture and Reuse, COMSAR 2006
38. IEEE/IFIP Network Operations and Management Symposium, NOMS 2010
39. IET International Conference on Frontier Computing. Theory, Technologies and Applications
40. IFIP International Conference on Computer and Computing Technologies in Agriculture and the 4th Symposium on Development of Rural Information, CCTA 2010
41. IITA International Conference on Nanotechnology and Computer Engineering, CNCE 2010
42. Innovations in Information Technology, IIT
43. Int. Conf. on Applied, Numerical and Computational Mathematics, ICANCM'11, Int. Conf. on Computers, Digital Communications and Computing, ICDCC'11, Int. Conference on Applied Social Science, Social Economy and Digital Convergence, IC-ASSSE-DC'11
44. International ACM Workshop on Traceability of Emerging Forms of Software Engineering, TEFSE 2005, Held in Conjunction with the 20th IEEE/ACM International Conference on Automated Software Engineering, ASE 2005
45. International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems, AH 2006
46. International Conference on Advanced Computer Science and Information Technology, AST 2011
47. International Conference on Advanced Learning Technologies, ICALT 2006
48. International Conference on Advances in Computer Science, Environment, Ecoinformatics, and Education, CSEE 2011
49. International Conference on Advances in Product Development and Reliability, PDR'2010
50. International Conference on Autonomous Infrastructure, Management and Security, AIMS 2009
51. International Conference on Complex, Intelligent and Software Intensive Systems, CISIS 2011
52. International Conference on Computational Intelligence and Software Engineering, CiSE 2009
53. International Conference on Computational Intelligence for Modelling, Control and Automation, Jointly with IAWTIC 2006: International Conference on Intelligent Agents Web Technologies and International Commerce
54. International Conference on Computational Science and Its Applications - ICCSA 2005
55. International Conference on Computational Science, ICCS 2007
56. International Conference on Computer Distributed Control and Intelligent Environmental Monitoring, CDCIEM 2011
57. International Conference on Computer Research and Development, ICCRD 2011
58. International Conference on Computer, Mechatronics, Control and Electronic Engineering, CMCE 2010
59. International Conference on Computers and Advanced Technology in Education
60. International Conference on Computing, CIC 2006
61. International Conference on Computing, Information and Control, ICCIC 2011

62. International Conference on Convergent Information Technology, ICCIT 07
63. International Conference on Digital Information and Communication Technology and Its Applications, DICTAP 2011
64. International Conference on Education and Management Technology, ICEMT 2010
65. International Conference on Education Technology and Computer, ICETC 2010
66. International Conference on Electric and Electronics, EEIC 2011
67. International Conference on Electrical and Control Engineering, ICECE 2010
68. International Conference on Environmental Science and Information Application Technology, ESIAT 2009
69. International Conference on Extending Database Technology
70. International Conference on Future Information Technology, FutureTech 2011
71. International Conference on Fuzzy Systems and Knowledge Discovery, FSKD 2010
72. International Conference on Grid and Cooperative Computing, GCC 2008
73. International Conference on Hybrid Learning and Education, ICHL 2009
74. International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems, IEA/AIE 2006
75. International Conference on Information Integration and Web-based Applications and Services, iiWAS 2008
76. International Conference on Information Sciences and Interaction Sciences, ICIS 2010
77. International Conference on Information Technology and Applications, ICITA 2005
78. International Conference on Information Technology Based Higher Education and Training, ITHET 2004
79. International Conference on Information Technology: New Generations, ITNG 2011
80. International Conference on Intelligent Computation Technology and Automation, ICICTA 2011
81. International Conference on Intelligent Systems Design and Applications, ISDA 2008
82. International Conference on Knowledge Engineering and Ontology Development, KEOD 2010
83. International Conference on Knowledge Management and Knowledge Technologies, i-KNOW 2011
84. International Conference on Management and Service Science, MASS 2011
85. International Conference on Management Science and Engineering, ICMSE'06
86. International Conference on Mechanic Automation and Control Engineering, MACE2010
87. International Conference on Metadata and Semantic Research, MTSR 2010
88. International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, UBICOMM 2007
89. International Conference on Model and Data Engineering, MEDI 2011
90. International Conference on Programming Languages and Compilers, PLC'05
91. International Conference on Promotion and Innovation with New Technologies in Engineering Education, FINTDI 2011
92. International Conference on Service Systems and Service Management
93. International Conference on Smart Manufacturing Application, ICSMA 2008
94. International Conference on Smart Materials and Intelligent Systems 2010, SMIS 2010
95. International Conference on Software Engineering and Applications
96. International Conference on Software Engineering Research and Applications, SERA 2004
97. International Conference on Technologies for E-Learning and Digital Entertainment, Edutainment 2006
98. International Conference on Technology for Education, T4E 2011
99. International Conference on User Modeling, Adaptation and Personalization, UMAP 2010
100. International Florida Artificial Intelligence Research Society, FLAIRS - 24
101. International Forum on Information Technology and Applications, IFITA 2009
102. International Geoscience and Remote Sensing Symposium, IGARSS 2011
103. International IEEE Conference Intelligent Systems, IS 2008
104. International Symposium on Intelligent Systems and Informatics, SISY 2011
105. International Workshop on Data Engineering for Wireless and Mobile Access, MobiDE 2003
106. International Workshop on Database and Expert Systems Applications
107. International Workshop on Databases in Networked Information Systems, DNIS 2007
108. International Workshop on Web Information and Data Management, held in conjunction with the ACM 15th Conference on Information and Knowledge Management, CIKM 2006
109. Joint Conference on Information Sciences, JCIS 2006
110. OTM Workshops 2004
111. Pacific Asia Conference on Knowledge Discovery and Data Mining, PAKDD 2008
112. TUG 2004
113. Virtual Observatories
114. VLDB Workshop on Ontologies-Based Databases and Information Systems, ODBIS 2006 - 32nd International Conference on Very Large Data Bases
115. Workshop on Blended Learning, WBL 2008
116. Workshop on Intelligent Information Technology Application, IITA 2007
117. WSEAS Int.Conf. on DATA NETWORKS, COMMUNICATIONS and COMPUTERS
118. WSEAS International Conference on Applied Computer Science, ACS '09

Conference with two papers (Total: 23)

1. AAAI Workshop
2. ACM Symposium on Document Engineering
3. IEEE International Symposium on IT in Medicine and Education, ITME
4. IEEE Workshop on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, IDAACS
5. IEEE/WIC/ACM International Conference on Web Intelligence
6. IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology
7. International Astronautical Congress 2010, IAC 2010
8. International Conference on Advanced Information Networking and Applications
9. International Conference on Asian Digital Libraries ICADL
10. International Conference on Computer Science and Software Engineering, CSSE 2008
11. International Conference on Computer Supported Cooperative Work in Design, CSCWD 2009
12. International Conference on Conceptual Structures, ICCS
13. International Conference on Convergence and Hybrid Information Technology
14. International Conference on Digital Information Management, ICDIM
15. International Conference on Information and Knowledge Engineering
16. International Conference on Information Science and Applications, ICISA 2011
17. International Conference on Information Science and Engineering, ICISE
18. International Conference on Intelligent Computing, ICIC
19. International Conference on Knowledge-Based and Intelligent Information and Engineering Systems, KES
20. International Conference on Web Engineering
21. International Symposium on Knowledge Acquisition and Modeling, KAM
22. International Symposium on Methodologies for Intelligent Systems
23. International Workshop on Principles and Practice of Semantic Web Reasoning, PPSWR 2006