A Novel Ontology based Framework for Trend Detection from Research Paper Titles

Swaraj K P , Dr. Manjula D, Adhithyan V, Hemnath K B, Manish Kumar L

Abstract—Classification of research papers based on topics like Data Mining, Software Engineering, and Networks etc. is generally done manually. Nowadays Researchers are particularly interested in knowing trending subtopics and keywords under their area of interest and the relevant research articles published in those areas. In this article, a fast novel approach is proposed to find trending topics and subtopics from large cluster of research paper titles for the past n years. Also, an effective method is presented to retrieve paper titles based on a topic or subtopic from trending topics. Finally a ranking algorithm is suggested based on which the resultant paper titles are ranked before being displayed. In this study, titles of papers for last 3 years from DBLP computer science dataset were extracted and stored in a database. Even though, articles from only last 3 years were considered, this system can be easily scaled to accommodate any size and time period. Experiment studies revealed that the proposed trend detection framework is accurate, efficient and scalable.

Index Terms— DBLP, Hadoop, Map Reduce, Ontology, Owl, Sparql, Trend detection, Topic detection

1 INTRODUCTION

From its initial stages itself, the domain of Computer Science has been extremely wide and consistently evolving contributing much to the industry and societal advancement. This undeniable fact is emphasized by a countless numbers of technological advancements and plethora of exploratory papers which are published consistently scattering over wide range of established and emerging topics in the field of Computer Science and Engineering. Worldwide, numerous research articles are published every year covering wide span of topics in this relevant domain. Currently, there is no well-known system to detect trending topics from research paper titles and also to retrieve important research paper titles from a trending sub topic.

DBLP is a bibliographic dataset in xml format, hosted at University of Trier, in Germany, which provides metadata about computer science publications. It is now used by many computer scientists for getting an idea about the titles and authors in computer science domain and also for research purpose [6].This dataset has meta data of more than 2.5 million articles and spans a wide range of computer science topics such as Artificial Intelligence, Databases, Data Mining, Cloud computing, Information Extraction and so forth, which can be further classified into several sub-topics, sub-sub-topics and so on. The xml Meta data is a treasure of rich information and has been enticing considerable research interest from researchers for the last couple of years. Careful excavation of this pertinent dataset divulges certain extremely interesting statistics. For example, analysis of dataset for a particular time interval, say most recent 6 months reveals that; there will be set of certain hot topics which will have more academic and research interest than other topics. Such novel topics can be generally termed as trending hot topics. The major drawback of this dataset is that it doesn't provide mapping of article titles to various topics in computer science discipline and is not up to date. Hence it is very laborious and time consuming to manually find topics of article titles and performing topic based trends. Needless to say that, accuracy of clustering based hot topic detection will be very low. The novel framework proposed in this article employs computer science domain ontology to classify research paper titles in dynamically updated bibliographic dataset into respective topics which greatly enhances the accuracy and efficiency. ACM CCS Domain ontology which is well-known domain ontology has been used as an information model encompassing various hierarchical relationships between topics in computer science domain for this mapping.

Multiple advantages acquired by Ontology based detection of such hot topics in a temporal manner from dynamic bibliographic datasets can be. a) It provides consistent insights in identifying trending hot topics at a particular time period efficiently and quickly. b) It is possible to identify different dynamic emerging and bursty topic trends on a temporal basis c) Domain ontology is always supported with a helper ontology with established and emerging terms for accurate detection of topic keywords. d) It is possible to recommend article titles to readers.

Map Reduce is a software framework to quickly process big unstructured data in parallel across a distributed

- *Swaraj K P is currently pursuing Ph.D. as a research scholar in computer science and engineering at Anna University, Tamil Nadu, India. E-mail: swarajkp@cs.annauniv.edu*
- *D Manjula is currently working as Professor in computer science and engineering at Anna University, India. E-mail: manju@annauniv.edu*
- *Adhithyan V Hemnath K B and Manish Kumar L are pursuing bachelor of engineering in computer science and engineering at Anna University.*

cluster of commodity computer systems. Because of its huge popularity, Map reduce libraries have been made available for different platforms .The open source implementation is part of Apache Hadoop framework. The proposed framework utilizes hadoop architecture and map-reduce algorithms to greatly enhance the speed while detecting hot topics, keywords and article suggestions.

The rest of the paper is organized as follows. Section 2 highlights the related works. Section 3 describes in detail on the novel framework used for the detection of hot topics based on domain ontology and map reduce based cloud computing technique. Section 4 analyses the experimental results and discusses the performance measures and Section 5 concludes with future research directions.

2 RELATED WORK

Closed frequent keyword set [2] is generally used to detect topics rather than maximal frequent keyword-set. Most of the semantic information is lost when maximal frequent keyword set is used.

Clustering documents based on frequent itemsets [3] has been studied in the algorithms FTC and HFTC [4] and the Apriori-based algorithm [5]. Both of these works consider the documents as bags of words and then find frequent itemsets. The major lacuna of bag of words techniques or vector space model is that the relative ordering of terms are not maintained. Hence the semantic information present in the document is lost. In this proposed framework, phrases from the titles of the research papers are extracted first and frequent substrings are derived as frequent keyword-sets, maintaining the underlying semantics.

3 PROPOSED SYSTEM

The steps for proposed framework are listed below.

1. First extract titles of research paper from DBLP dataset using a DOM parser
2. Store it in a file.
3. Extract phrases and keywords from titles using map reduce[1] and without map reduce.
4. A part of ACM classification ontology 2012 (topic-subtopic relation) is created using Protégé software and stored in owl format.
5. After keyword extraction, frequent keyword set is formed and stored in database on a temporal basis.
6. Also the frequent keywords are mapped with titles [1].
7. The frequent keyword set is then mapped with ACM classification ontology to find keyword's relevant topic and subtopic, based on which trending topics are displayed.
8. sparql query with apache-jena api is used in java to map titles to topics.
9. A novel method is provided to retrieve titles under a topic or subtopics which are ranked based on a custom algorithm that identifies frequencies of frequent keywords from a title and uses that statistics for ranking.

The build system has following features:

1. A method to find trending subtopics under a broader topic.
2. Retrieval of research paper titles under a topic or a subtopic of a year (user must specify the year) and results are ranked based on custom ranking algorithm.
3. A user interface to list trending topics.

The proposed system has the following phases:

1. Pre-processing-This phase includes title extraction, phrase detection, keyword formation, frequent keyword identification using map-reduce and without map-reduce from xml dataset, mapping of frequent keywords to ontology and frequent keyword to title relation.
2. Trend detection and research paper title retrieval.

3.1 Title Extraction

DBLP dataset is a computer science Bibliography which contains the metadata of over 2.8 million publications written by many authors in several thousands of journals or conferences. DBLP dataset is an xml file which contains all bibliographic records. From DBLP dataset, DOM parser was used to extract titles and year. The extracted titles and year will be indexed and stored in file. Also, the DBLP dataset was processed using map-reduce framework for improving performance metrics.

3.1.1 Title Extraction – Map Reduce

Map-reduce framework processes large dataset in an efficient manner. Mapper function will take the input file and produces output as a set of titles based on year. Mapper function output is sorted. Map function will allocate the number of map tasks based on the number of input paths to the map function.

XML Configuration

1. *Specify Input format class*
2. *Define start tag and end tag to be parsed*
3. *Specify Input path and output path*
4. *Specify all required class*

Algorithm1-Title Extraction using Map Reduce

Input to Map Function: DBLP dataset

```
1)  Create a Java DOM  XML parser
2)  Get elements by tag name
3)  For each node:
        i)  retrieve Titles based on the year
```

Algorithm 2-Phrase Extraction using Map Reduce

Input to Map Function: Extracted Titles and Stop words

```
Declare hash map<string, integer>
Declare string temp, phrase
Read stop words and store it in hash map
for each titles:
      Iterate until a space
      Store iterated word in temp
        check whether temp is in   hash map
      if temp is in hash map
          eliminate temp
            store phrase
      else
       phrase += temp
       temp = ""
```

Algorithm3-Keyword set Formation using Map Reduce
Input to Map Function: Extracted Phrases

```
Declare string keyword
for each phrases:
            separate phrases by space
          for each word:
                keyword = word
               store keyword
```

3.2 Phrase detection and Keyword formation

From each title, phrases are found out. A phrase can be defined as a substring present between two stop words. We used around 114 Standard English stop words. A keyword is a substring of phrase so that, underlying semantics is maintained. The keywords both 1-gram and bi-gram extracted will be associated with title in file. Similar to that of Title Extraction, Map-reduce is used to extract phrases and keywords from titles extracted.

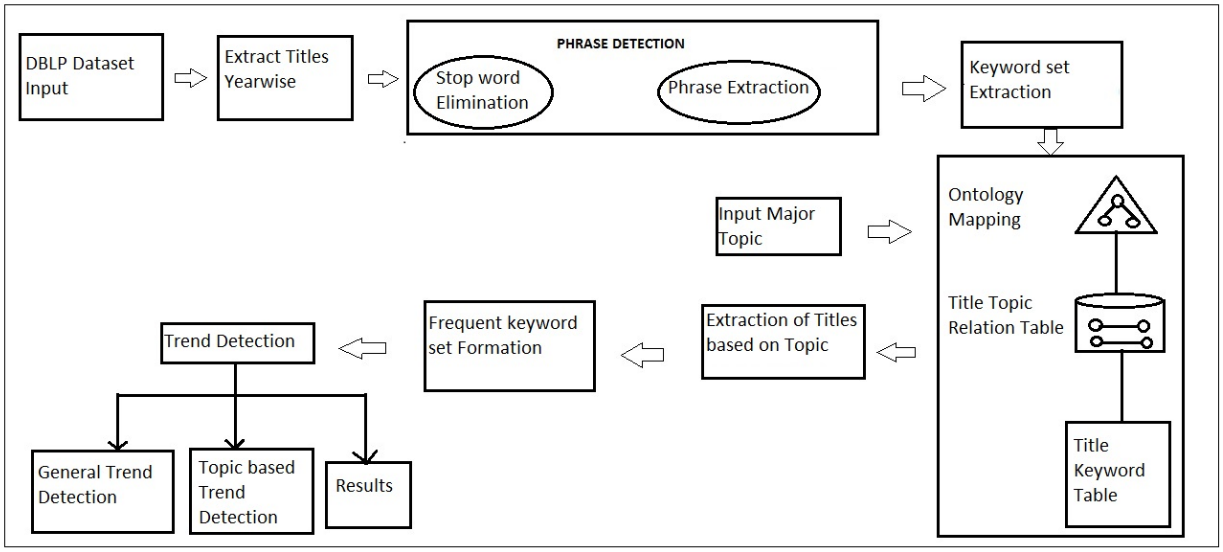


Fig. 1. Architecture of the proposed Trend Detection System

Example:

Title: DDBJ new system and service refactoring.
Year: 2012
Phrases: DDBJ new system, service refactoring
Keywords (one gram): DDBJ, new, system, service, refactoring
Keywords (two gram): DDBJ new, new system, system service, system refactoring.

Thus each keyword extracted will have potential to identify a topic or subtopic.

3.3 Frequent Keyword identification

Algorithm 4: Frequent keyword set formation

Input: Keywords (one gram or two gram)

```
Declare hash map <string, int>
for each keyword:
    if hashmap.get(keyword) = not found
        hashmap.put(keyword,1)
    else
        frequency = hash map.get(keyword)
        hashmap.put(keyword,frequency + 1)
```

The closed frequent keywords have the potential to identify the trending topics.

The keywords from titles stored in file are used to form frequent keyword sets. Thus, the frequent keywords identified both one gram and two gram will be stored in database.

3.4 Keyword to ontology mapping

Using apache jena api with java, sparql query can be used to query ontology owl file.A sparql query is used to obtain the classification hierarchy and the result is stored in database After storing of ontology, frequent keywords are mapped with topic and subtopics of ontology based on corresponding keywords from ontology.

3.5 Frequent keyword, titles mapping

Frequent keywords are then mapped with titles which contain the frequent keyword (Algorithm 5). In this study we have considered keywords with frequency of 20 or greater to be potential trends.

Algorithm 5:Frequent keyword (both one gram and two g ram) to paper mapping

```
map = all frequent keywords from database

for each title in database:
        keywords[ ] = get corresponding keyword
                      of title
        index = index no of title from database

 for each keyword:
         if keyword found in map
          append(keyword, title)
```

This mapping will help in retrieval of paper titles based on a keyword, topic or subtopic. So the pre-processing helps to populate the backend, so that trends and paper retrieval can be easily done.

3.6 Trend detection and titles retrieval

Researchers are always on the lookout for finding trending topics and titles from their domain of interest. It is extremely cumbersome to manually sort and find the trends even if hot words are detected. Hence trend detection of titles is a must based on hot keywords. There are many existing methods for detecting trend. In this framework Trend detection is found by statistical frequency based methods. Based on the frequency, hot topics are found out. This part is designed to have a UI (User Interface) that list the trends and also list the papers based on input topic obtained from user.1 gram 2 gram trends of keywords are provided from a domain and article titles are displayed based on these. Also, there is an option to display the trending subtopics belonging to a broader topic. The titles retrieved based on the hot keywords must be arranged using some ranking methods to effectively list the retrieved titles. Hence the titles retrieved are ranked based on the following algorithm (Algorithm 6) before being displayed.

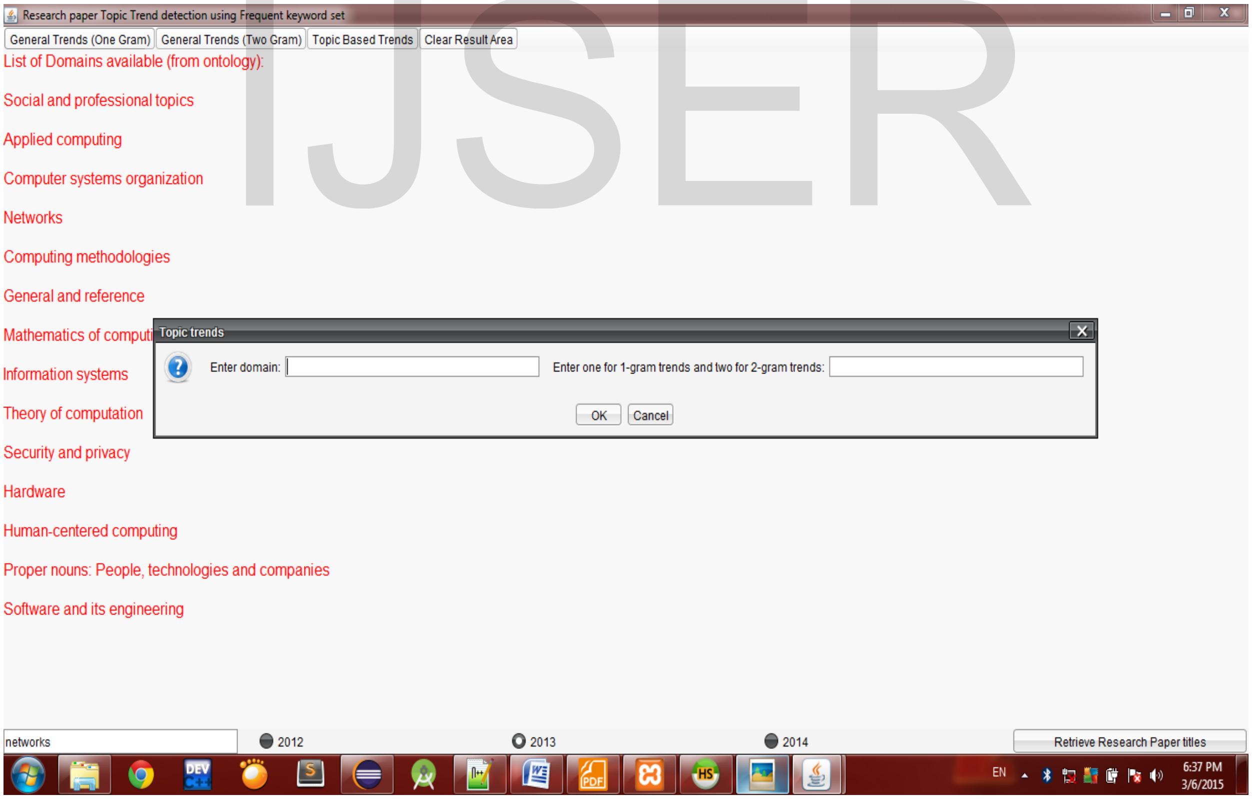
Algorithm 6:Title ranking
Input: Topic, keyword or subtopic

```
papers[]={obtain indexes of paper mapped with keyword}
result<string,int>

for each index in paper:
        title = getTitle(index) from database(db)
      keyword = getKeyWord(index) from db
      frequency = 0

  for each keyword :
      frequency += get frequency of current
                    keyword count from db
     result.put(title,frequency)
sort result based on frequency in descending order
```

Thus the ranking algorithm uses the closed frequent keyword set to rank the paper.

TABLE 1. General Trends

General Trends(One gram)-past 3 years	**General Trends(Two gram)-past 3 years**
Wireless (2271) *	Wireless sensor (739)*
Networks (2163)*	Cognitive radio (499)*


Research paper Topic Trend detection using Frequent keyword set
General Trends (One Gram)
General Trends (Two Gram)
Topic Based Trends
Clear Result Area
Topic trends
OK
Cancel
2012
2013
2014
Retrieve Research Paper titles
EN
6:37 PM
3/6/2015

List of Domains available (from ontology):

Social and professional topics

Applied computing

Computer systems organization

Networks

Computing methodologies

General and reference

Mathematics of computi

Information systems

Theory of computation

Security and privacy

Hardware

Human-centered computing

Proper nouns: People, technologies and companies

Software and its engineering

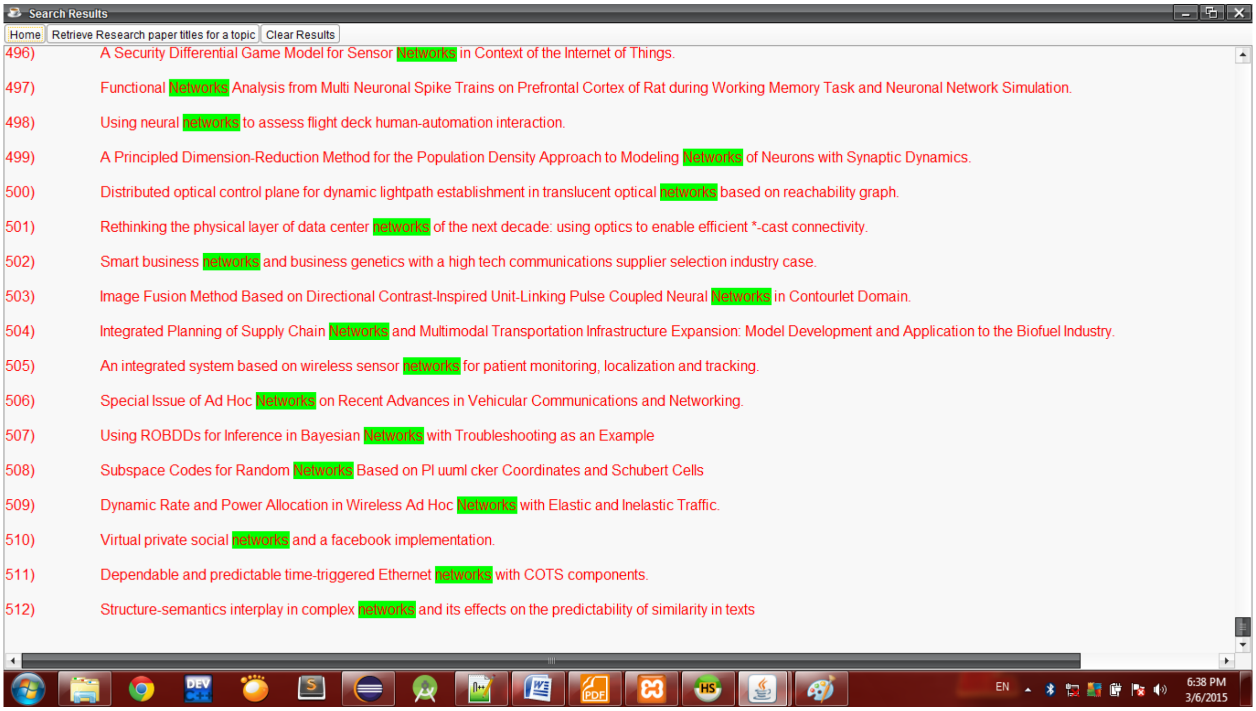
Enter domain:

Enter one for 1-gram trends and two for 2-gram trends:

networks

Fig. 2. Top trending topics based on analysis of 2013 papers

**-indicates the keyword frequency in dataset considered*



496) A Security Differential Game Model for Sensor Networks in Context of the Internet of Things.

497) Functional Networks Analysis from Multi Neuronal Spike Trains on Prefrontal Cortex of Rat during Working Memory Task and Neuronal Network Simulation.

498) Using neural networks to assess flight deck human-automation interaction.

499) A Principled Dimension-Reduction Method for the Population Density Approach to Modeling Networks of Neurons with Synaptic Dynamics.

500) Distributed optical control plane for dynamic lightpath establishment in translucent optical networks based on reachability graph.

501) Rethinking the physical layer of data center networks of the next decade: using optics to enable efficient *-cast connectivity.

502) Smart business networks and business genetics with a high tech communications supplier selection industry case.

503) Image Fusion Method Based on Directional Contrast-Inspired Unit-Linking Pulse Coupled Neural Networks in Contourlet Domain.

504) Integrated Planning of Supply Chain Networks and Multimodal Transportation Infrastructure Expansion: Model Development and Application to the Biofuel Industry.

505) An integrated system based on wireless sensor networks for patient monitoring, localization and tracking.

506) Special Issue of Ad Hoc Networks on Recent Advances in Vehicular Communications and Networking.

507) Using ROBDDs for Inference in Bayesian Networks with Troubleshooting as an Example

508) Subspace Codes for Random Networks Based on Pl uuml cker Coordinates and Schubert Cells

509) Dynamic Rate and Power Allocation in Wireless Ad Hoc Networks with Elastic and Inelastic Traffic.

510) Virtual private social networks and a facebook implementation.

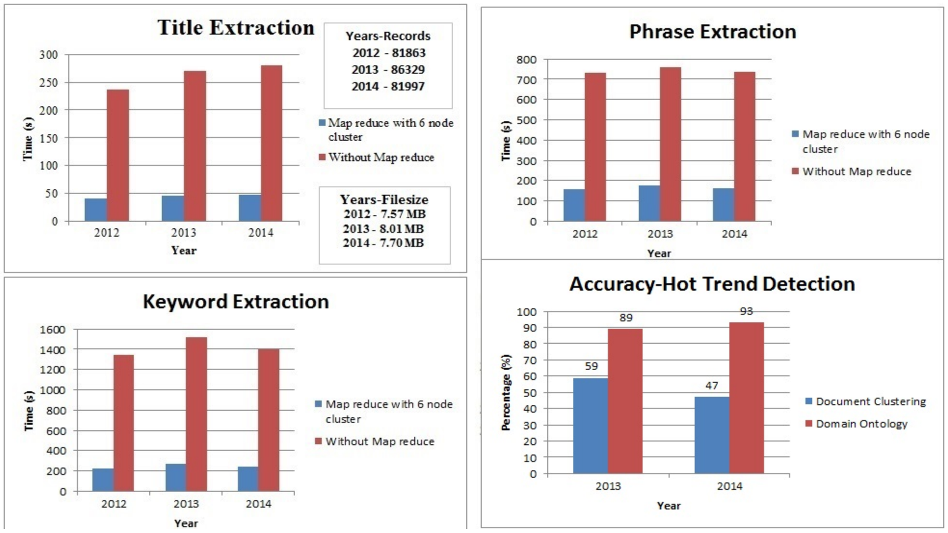
511) Dependable and predictable time-triggered Ethernet networks with COTS components.

512) Structure-semantics interplay in complex networks and its effects on the predictability of similarity in texts

Fig. 3. Search result for papers published under domain 'networks' for year 2013

4 PERFORMANCE

In the pre-processing stage we have used 6 node hadoop cluster and map reduce algorithms along with normal java based approach up to keyword formation for calculating and comparing performance metrics.



Hadoop Cluster Configurations

Master: Name node,Secondary Name node,Job Tracker
System:intel core-i7 2.3 Ghz processor,8GB ram,1TB harddisk

Slaves (6): Data Node,Task Tracker
System:intel core-i7 2.3 Ghz processor,8GB ram,1TB harddisk

Fig .4. Year wise Comparative Performance during title extraction, phrase and keyword extraction

With and without map reduce

Relative ordering is not maintained in the map-reduce output, since the output gets sorted. So map-reduce can be used in situations where relative ordering is not required. Since relative ordering plays a major role in our approach, we opted for normal approach.

We used cox-stuart trend analysis method to find out the accuracy of trends. We obtained a value of 0.125, the value is greater than 0.05 (we chose a significance level of 95%). Therefore there is no significant trend. If value is less than 0.05 we accept the hypothesis as significant trend.

5 CONCLUSIONS

In this work we focused on a novel ontology based approach to quickly identify all the hot topics at a particular time interval by mapping article titles to topics from big xml bibliographic data set. We pre-processed the titles from DBLP dataset using hadoop map reduce and converted it into keywords which are then used to form frequent keyword sets. Subsequently it is used to find trending topics. ACM classification ontology helps to accurately match a title with a topic. Frequent keyword sets help in ranking of research paper titles. This framework aids budding researchers in quickly finding trending topics, subtopics and retrieve paper titles under their area of interest with high precision. As a future work trend detection based on hadoop based multi document summarisation and ontology is planned.

REFERENCES

[1]. Kumar Shubankar, AdityaPratap Singh, Vikram Pudi ,"A Frequent Keyword-Set based Algorithm for Topic Modeling and Clustering of Research Papers," IEEE ICDM ,2013.

[2]. N. Pasquier, Y. Bastide, R. Taoull, and L. Lakhal, "Efficient Mining of Association Rules using Closed Itemset Lattices," Information Systems, 1999.

[3]. R. Agarwal, and R. Srikant, "Fast Algorithms for Mining Association Rules," Proceedings of the 20th VLDB Conference, 1994.

[4]. F. Beil, M. Ester, and X. Xu, "Frequent Term-based Text Clustering," Proceeding of the 8th International Conference on Knowledge Discovery and Data Mining (KDD), 2002.

[5] S. M. Krishna, and S. D. Bhavani, "An Efficient Approach for Text Clustering based on Frequent Itemsets," European Journal of Scientific Research, 2010.

[6] Ley M.: The DBLP Computer Science Bibliography :Evolution, Research issues, Perspectives. Proceedings of the 9th International Symposium on String Processing and Information Retrieval, Springer-Verlag London, UK, (2002)

Swaraj K P is a research scholar in the Department of Computer Science and Engineering at Anna University, Chennai. He is the corresponding author of this paper. He can be contacted at swarajkp@cs.annauniv.edu

Dr. Manjula, D. is working as Head and Professor in the Department of Computer Science and Engineering at Anna University, Chennai.

Hemnath K B, Manish Kumar L, Adhithyan V are final year students pursuing B.E