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A Social Network System for Analyzing Publication Activities of Researchers

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A Social Network System for Analyzing Publication Activities of Researchers

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Abstract: Social networks play an increasingly important role in knowledge management, information retrieval, and collaboration. In order to leverage the full potential of social networks, social networks need to be supported through technical systems. Within this paper, we introduce such a technical system. It is called AcaSoNet. It is a system for identifying and managing social networks of researchers. In particular, AcaSoNet employs a combination of techniques to extract co-author relationships between researchers and to detect groups of persons with similar interest. Past systems have used either search engines to extract information about social networks from the Web (Web mining) or have required people's effort to enter their relationships to others into the system (as being done by most social network services). AcaSoNet, instead, uses a combination of these two types, thereby achieving data reliability and scalability. It extracts and collects data of researchers from the Web but allows researchers to modify the data. In the current version, our system can identify the social network based on publication lists and evaluate the publication activities of users within an academic community.

Keywords: Social network systems, academic community, co-author relationship, publication analysis, productivity analysis, knowledge sharing, knowledge transfer, Web mining, performance analysis, and social network analysis.

JEL Classification Numbers: C43, C88, D83, L86

1. Introduction

The first social networking Website, Classmates, appeared in 1995. But only in 2003, the Web has become a space for the majority of users to socialize. That year has seen the rapid emergence of a new breed of Web sites, collectively referred to as Social Networking Systems (SNS) [14]. Friendster was the pioneer, while Facebook, Orkut, Yahoo, Google and Microsoft started similar services. They brought structure into the process of personal information sharing and online socialization. However, all these systems are not used in professional environments. It is not possible to use these systems for collaboration activities, which require the sharing of information in a more sophisticated manner.

Currently, there is no social-network-based system that provides services for the academic community. The social network used for such a system could be based on the collaboration activities (e.g., co-authorship) of researchers. The services could comprise the search for researchers, the recommendations of scholarly articles (based on the authority of the information creator), the automatic building of research communities, the posting of papers to a group of researchers, and the productivity assessment of a researcher and academic community. In particular, many of these services would require the analysis of the social network of co-authorships. In literature, only a few prototypal systems for finding researchers with similar interest have been developed so far [4] [11] [13] [14] [15].

To make the first step towards a sophisticated social-network-based system for researchers and academic communities, we develop AcaSoNet. AcaSoNet provides basic services that enable researchers to analyze their research performance with respect to the number of publications and the collaboration activities.

The challenge that social network systems for academic communities face is the lack of data about scholars, which can be accessed easily. Therefore, the development of the social network system also requires the introduction of a method for collecting data about scholars. Our method is a combination of Web mining techniques for extracting scholarly articles from the Web and manual verification of the mined data by the scholar. The system allows the scholar (user) to modify, delete, and update any data mined. This method guarantees that we only work with user-verified data. Based on this data, AcaSoNet identifies the relationships of researchers within the academic community and evaluates the researcher's performance with respect to the number of publications and the number of co-authorships. In particular, AcaSoNet generates a performance report about the researcher's publication and collaboration activities.

The remainder of this paper is organized as follows: Section 2 gives a brief introduction of social networks and social network analysis. Section 3 discusses existing social network systems in science, their advantages, and their shortcomings. AcaSoNet is introduced in Section 4. This section includes a description of the challenges, design decisions, and the user interface. Section 5 concludes the paper with a brief evaluation.

2. Social Network Analysis and its Application in Research

Social networks operate on many levels, from families up to the level of nations, and play a critical role in determining the way problems are solved, organizations are run, and the degree to which individuals succeed in achieving their goals. The benefits of the analysis of those social networks are that it can help people to share professional knowledge in a simple way and to evaluate the performance of individuals, groups, or the entire network. For example, with respect to the performance evaluation, the social network of a researcher can be considered an indication of his collaboration activity within a research community [1] [2].

For the analysis, each social network is represented as a graph, which is constructed of nodes and links. Nodes, which denote individuals, organizations, or information, are linked, if one or more specific types of relationships (e.g. financial exchange, friends, trade, and Web links) exist between them. For example, if nodes represent people, a link between two nodes means that two people know each other in some way.

To understand social networks and the impact of certain nodes within the network, the location of nodes (actors) in the network can be evaluated. A social network can be investigated in order to detect collision of interest [4], calculate a person's trustworthiness [7] [8], and to predict referrals between people. For example, if a user explicitly declares friendship to some people, the user will most probably introduce those friends to each other [13]. Furthermore, by determining the node in the center of a social network, social networks can be used to identify experts and authorities on a specific topic [13] [14] [17].

In general, social network analysis (SNA) comprises the measuring of relationships and flows between nodes of a social network. It provides both a visual and a mathematical analysis of human-influenced relationships. Therefore, a social environment can be expressed as a pattern in relationships among interacting actors [19].

In traditional scientometrics literature, social networks in science are investigated by collecting data manually through interviews or questionnaires. Sometimes, the data of those social networks is also obtained through the analysis of co-authored papers and co-citations in scientific publications [5] [10]. A few scientific works have also been performed using data obtained from the Web. The results suggest that real-world networks of academic research communities are closely reflected on the Web [9].

3. Social Network Systems in Science

Beside the approaches for analyzing social networks of researchers, a few social network systems (SNS) have also been developed. These systems not only collect and analyze data but also require active participation of researchers. A few of those systems even provide some basic, Web-based support for collaboration activities. Table 1 gives an overview about those systems [4] [11] [13] [14] [15]. The shortcomings and challenges of those systems face are:

Restricted Use of Collected Social Network Information. A lot of information collected within a SNS is controlled by SNS owners. For example, although FOAF profiles can be

created by users, they can only be posted on the SNS Web site, on which it has been created, and linked to other users of the same SNS. Sharing of profiles across domain boundaries is not allowed in many cases. Sometimes, the export of FOAF profiles in machine readable format is not possible, even though one of the purposes of SNS is information sharing [6] [16].

Table 1. Existing social network systems for the academic community.

Project (Reference)	Focus of the Project	Methodology Applied for Data Collection
Referral Web (Kautz et al. 1997 [11])	Collects information about the social network of researchers.	After giving the names of researchers as input, names of other researchers are extracted from the Web by searching for the co-occurrence of researcher names on Web pages, using queries against existing search engines.
(Miki et al. 2005 [15])	Measures the value of researchers and their works in the community.	The SNS conducts a bibliographical citation analysis of data found on the Web.
Flink (Mika 2005 [14])	Extracts, aggregates, and visualizes online social networks of communities of researchers.	This SNS employs a co-occurrence analysis of researchers by using queries against existing search engines. Information sources are Web pages, emails, publication archives, and FOAF profiles.
(Aleman-Meza et al. 2006 [4])	Detects conflicts of interests among potential reviewers and authors of scientific papers.	It integrates actors and relationships from two different social network databases, namely from a FOAF social network and the co-authorship network of the DBLP bibliography.
POLYPHONET (Matsuo et al. 2006 [13])	Web-based system for identifying researchers with similar interest at a conference.	It uses search engines, especially Google, to find information about co-occurrences of researchers.

Difficulty in Finding Up-to-Date Social Network Information. In order to find social network information on the Web, most of the above-mentioned SNS use Web mining techniques. However, the likelihood of finding valuable information is very low due to the sheer size of the Web. Since many Web sites are created every day, it becomes difficult for crawlers to find up-to-date information.

Large Number of Queries against Search Engines. Using search engines for detecting the relationships between users requires a huge amount of queries. In the above-mentioned SNS, the detection of relationships of 500 people would require more than 124000 queries [13]. This clearly shows that the method is not scalable

4. Concept of AcaSoNet

AcaSoNet is a Web-based, social network system for the academic community. It extracts social network information about researchers from the Web and provides services that leverage the social network information. Currently, AcaSoNet facilitates the execution of performance measures, the management of citations, and the management of publication lists. In the long run, it is planned to extend AcaSoNet by collaboration services. In particular, it is planned to support search for researchers and scholarly articles, as well as the dissemination of research-related information within a social network of a researcher.

4.1. Design Principles

For obtaining social network information, two different approaches are used by existing social network systems: First, users of a SNS state their relations to others by filling out questionnaires or FOAF profiles, linking them to other members of the SNS. Second, social network systems automatically detect relationships through mining of databases. They can mine various sources of information such as e-mail archives, schedules, and the Web [3] [15] [18]. They also analyze keyword co-occurrences within these databases [11] [13] [14].

Since both types of existing data collection methods have their limitations (as explained in the previous section), we propose a method, which is a combination of these two types. In a first step, users provide their exact names and, then, the system queries search engines to find the user's publications on the Web. In a subsequent step, the user can modify and validate the obtained data to make sure that the data stored in the system is correct. Finally, AcaSoNet builds the social network of the user and integrates it into the existing social network of all researchers.

This method produces a precise data set and avoids inconsistent data (i.e. no ambiguity of data). Consequently, the data about users is reliable, while keeping the overhead for the user low. Our approach also reduces the number of queries to a search engine significantly, since it only requires queries for finding information about a person but does not require search engine queries for extracting relationships between users. For example, for extracting co-author relationships, our system does not query search engines. Instead, it asks users to validate the co-author relationships found on the user's publication list. For example, in order to identify co-authors of user A, the list of papers of user A is analyzed. If a co-author B has been found, the system searches for user B within AcaSoNet. If it finds a match, the system will check whether a paper of this co-author has the same title. If the check is positive, B has been identified as the correct co-author of A, and a link between researchers A and B is set. If user B has no account with AcaSoNet, a new account is created. Because of this method, our approach is scalable with the number of users registered with AcaSoNet. In addition to this automatic matching support, each user has the chance to check and modify those links anytime.

Another design principle is that researchers have full control about their social network information. All social network information and the user profile are machine readable and can be exported to other systems anytime. It allows users to use the information for other

purposes then the one mentioned here. This means that the effort of researchers put into building up their profile is not wasted, reducing the cost for signing up with AcaSoNet.

4.2. Architecture

The design of the AcaSoNet architecture follows a service-oriented architecture (SOA), using Web services. Since Web services comprise a concept for achieving machine-to-machine interaction over a network and can be executed on remote systems, it allows AcaSoNet to use external services (e.g., a Web search service, the MyTiesTo service), add easily new services, and to make its own services available for external use. Currently, the only services integrated are the *Portal*, the *MyTiesTo Service* and the *Publication Activity Analyzer* (Figure 1).

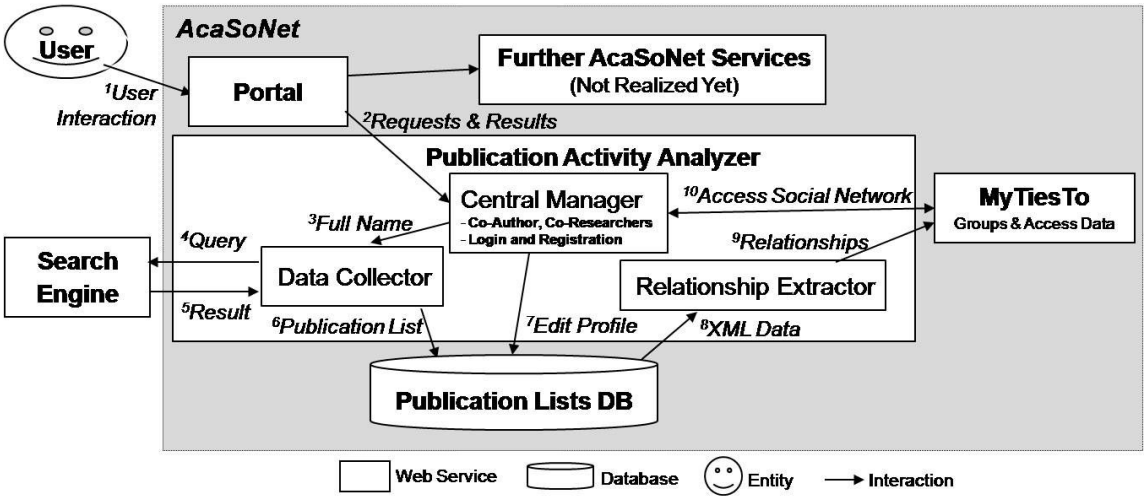


Figure 1. The AcaSoNet Web service architecture and the interactions between its components.

The *Publication Activity Analyzer*, as one service of AcaSoNet, comprises three components (Figure 1): *Central Manager*, *Data Collector*, and *Relationship Extractor*. The *Central Manager* provides the basic interfaces to external services and coordinates the workflow of the Publication Activity Analyzer. It interacts with the user via the portal (step 1 of Figure 1). In particular, it handles user requests such as requests for viewing co-author information or for performing analyses of the users' performance (step 2). Currently, the Central Manager can calculate different research productivity indexes (e.g., h-Index, g-Index, RP-Index [2]), the number of collaborations, the collaboration index for researchers (RC-Index) [1], as well as the Co-Author Collaboration Value (which is defined as the total number of collaborations between researchers multiplied by the co-author's productivity index [1]).

In order to update the user profile, the Data Collector (Figure 1) takes the user's full name as input (step 3 in Figure 1) and generates a query (step 4) that is sent to a Search

Engine service. After obtaining the result from the search engine (step 5), the Data Collector parses the results to build the user's publication list, which is stored in the Publication List DB database (step 6). Since users keep control about their data, users can modify the publication list via the Central Manager (step 7 in Figure 1) and the Portal (step 1). Users can also download their profile data anytime. The Relationship Extractor takes the publication list in XML format from the database (step 8) and extracts the co-author relationships of the user. These relationships are stored using the MyTiesTo service (step 9). The Central Manager accesses these relationships (i.e. the social network information) for analyzing the user's performance and presenting it to the user (step 10).

MyTiesTo, another service of AcaSoNet, manages relationships of social networks. It provides an open architecture that allows storing any kind of social network information. In particular, it stores information about entities of the social network as well as the social relationships between entities. Other services can also use MyTiesTo for storing social network information. These social networks can be independent to the social network that the Publication Activity Planner entered. In addition to this, other research-related services (e.g., collaboration support services, chat applications, file exchange services) can make use of the stored social network information for their own services.

4.3. Database Schema

The type of data needed by the Publication Activity Analyzer can be divided into two groups: The first group comprises relationship information (e.g., information about group memberships and communities), which is provided by the MyTiesTo service. The second group comprises information about publications, which are stored in the Publication List DB database. Figure 2 shows the relationships of the three major tables of the database schema: *Publications* table, *Users* table, and *Publication_User* table.

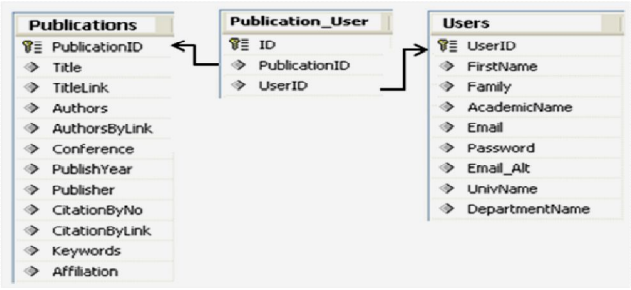


Figure 2. Database schema of the Publication List DB database.

The Publications table stores the information about publications (e.g., journal articles) such as the paper title, the names of authors, the name of the conference or journal, at which the paper had been accepted, and the publication year. The Users table stores the information about a researcher using AcaSoNet. This information includes the user's affiliation, contact information, and name. It is mainly used for identifying the AcaSoNet user. The *Publication_User* table stores relationships between entries in the two previously mentioned tables. It relates a unique *PublicationID* of a Publications table record to a

unique *UserID* of a Users table record. Because of this design, information about authors of a paper, papers of an author, or about co-authors can be extracted through simple queries.

4.4. Publication Data Collection Method

Publication data is extracted from the Web by using Google Scholar, a dedicated search engine for scholars. Google Scholar considers a large variety of publication types (e.g., proceedings of national and international conferences, journals, books, and presentations), which can be found in freely accessible databases. Thus, it finds more publications and citations per researcher than other services [12].

In order to query Google Scholar (step 3 in Figure 3), the Publication Activity Analyzer (i.e. the *Making Query* module) generates a default query (step 2), which is defined as "paper author:name-family". The term *paper* specifies that only papers (not any other type of data like citations or books) should be retrieved. The term *name* represents the author's given name and the term *family* represents the author's surname. Author names and Author family names are retrieved from the Publication List DB database (step 1).

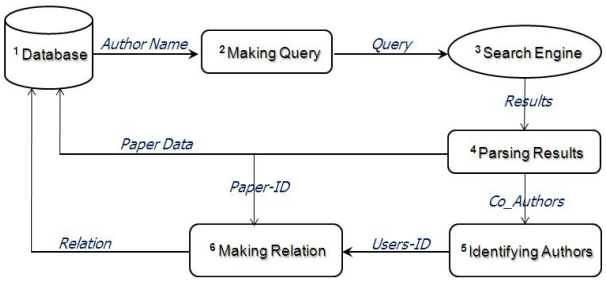


Figure 3. Publication data collection method of the Publication Activity Analyzer.

The search query results are passed to the *Parsing Results* module (step 4 in Figure 3), which parses them and extracts data (e.g. paper title, author names, publication year) about each publication found. The information about papers is stored in the database. The author names of each publication are sent to the *Identifying Authors* module (step 5) in order to identify co-authors within AcaSoNet. The relationships between the publication and each author are formulated by the *Making Relation* module (step 6) and, then, stored using the MyTiesTo service.

4.5. Further AcaSoNet Services

Currently, AcaSoNet provides only two services (i.e. the Publication Activity Analyzer and MyTiesTo). However, it is envisioned to extend AcaSoNet by offering the following services: *Scholars Search Engine*, *Group Management*, and *Co-Researcher Finder*. The Scholars Search Engine service searches for universities, research institutes, scholars, and experts in a specific research area. The Group Management service allows creating communities of users to which information can easily be distributed. The Co-Researcher

Finder service automatically creates groups of researchers based on their research areas. It notifies those groups, if research-relevant data is added or a new researcher joins.

4.6. User Interface

AcaSoNet allows any user (i.e. even a user, who is not registered with AcaSoNet) to access publicly available data. However, if users decide to register, they can, after logging into the system with their login name and password, access more information. Figure 4 shows the Web site that users see after logging in. The Web site shows a user's publication list, which can be edited. Furthermore, at the top-left side of the Web site, index values (e.g., h-Index, g-Index) and statistics about the user's publications are presented. At the top-right side, a link to the user profile and a link to the list of all co-authors are given. Besides, the user can search for publications to be added to the current list of his publications.

Pub-No	Cit-SUM	Cit-AVG	h-index	g-index	Rp'-index	Rp-index
52	1423	27.36	17	37	10	10.99

Verified Publication List

Welcome Peter Brusilovsky
(Peter Brusilovsky, P. Brusilovsky)
Edit Profile Information

Add Paper | Search for more Publications | List of Co-Authors

		Index	Title	Authors	Year	Citation	Conference
Edit	delete	1	Adaptive hypermedia.	P. Brusilovsky,	2001	316	User Modeling and User Adapted Interaction, Ten Year Anniversary Issue (Alfred Kobsa, ed.) 11 (1/2), 87-110 [PDF].
Edit	delete	2	ELM-ART: An adaptive versatile system for Web-based instruction	G Weber,P. Brusilovsky,	2001	193	InternationalJournal of Artificial Intelligence in Education 12(4), 351-384
Edit	delete	3	Course sequencing techniques for large-scale web-based education	P. Brusilovsky,J. Vassileva,	2003	96	International Journal of Continuing EngineeringEducation and Lifelong Learning 13 (1-2)
Edit	delete	4	From adaptive hypermedia to THE adaptive Web	P Brusilovsky,M. T. Maybury,	2002	81	Communications of the ACM 45 (5), Special Issue on the Adaptive Web, 31-33. [ACM DL]
Edit	delete	5	Adaptive Systems for Web-Based Education	P. Brusilovsky,N. Henze,E. Millan,	2002	79	International Journal of Artificial Intelligence

Figure 4. Screenshot of the Verified Publication List Web page, which the user sees after logging in.

Figure 5 depicts the Web page for searching the Web for publications to be included in the user's publication list. The default query, which is shown initially, can be modified. Any new publication can be added to the list by simply selecting it and pressing the "Add Selected to Verified List" button. The user can also mark query results (i.e. publications) for indicating that those results should not be shown in the future. This is useful in order to avoid seeing publications, which do not belong to the user, every time a new query is submitted. It reduces the sorting overhead for the user. For this, the user has simply to click on the "Never Show in Future" button.

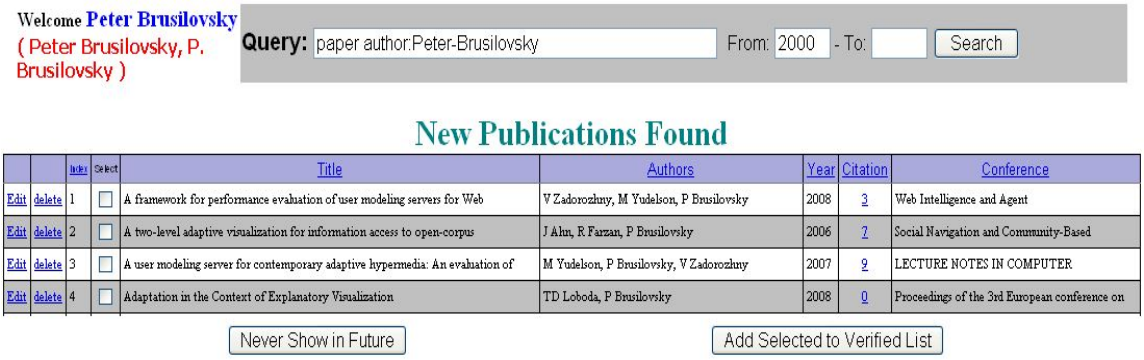


Figure 5. Screenshot of the New Publication Found Web page.

By clicking on the name of a user, the Web site with the user profile comes up. It consists of the contact information, the password, the current affiliation, and the previous affiliations. This information is editable, if the profile belongs to the logged in user.

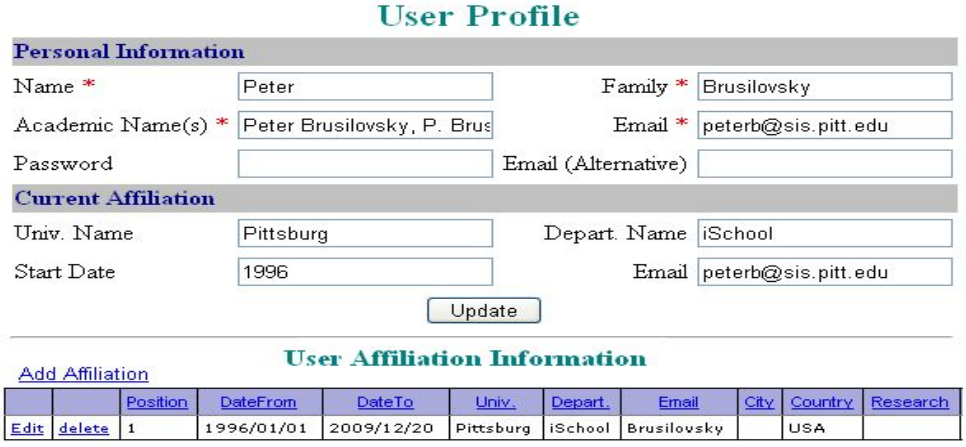
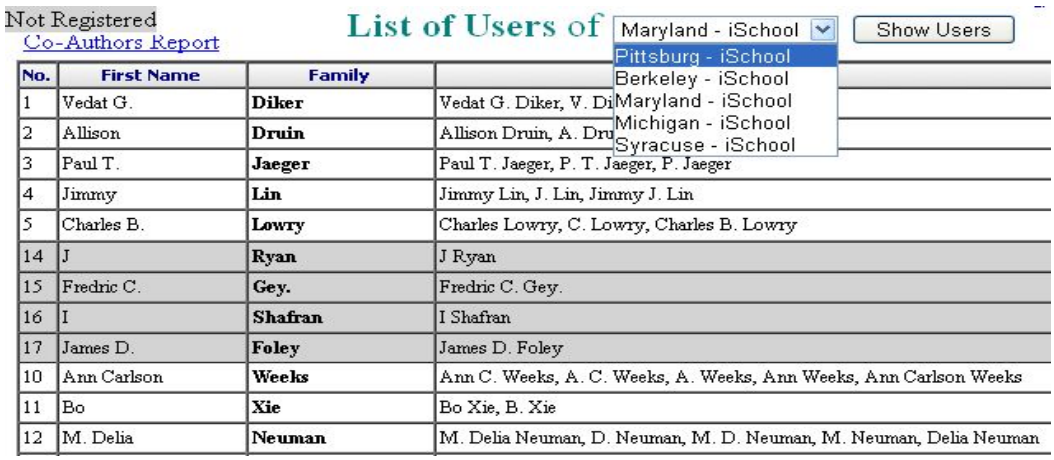


Figure 6. Screenshot of the User Profile Web page

By clicking on the affiliation of a user (e.g., Pittsburg in Figure 6), the research community of the user comes up. Figure 7 shows the list of researchers that have the same affiliation as the user. The researchers of this research community are either already registered with AcaSoNet (light background) or have received an automatically created account. Note, AcaSoNet creates an account, if a user has not registered yet but is a co-author of a registered user. Unregistered users are shown with a dark gray background.


Not Registered
Co-Authors Report

List of Users of Maryland - iSchool Show Users

Pittsburg - iSchool
Berkeley - iSchool
Maryland - iSchool
Michigan - iSchool
Syracuse - iSchool

No.	First Name	Family	
1	Vedat G.	**Diker**	Vedat G. Diker, V. Di
2	Allison	**Druin**	Allison Druin, A. Dru
3	Paul T.	**Jaeger**	Paul T. Jaeger, P. T. Jaeger, P. Jaeger
4	Jimmy	**Lin**	Jimmy Lin, J. Lin, Jimmy J. Lin
5	Charles B.	**Lowry**	Charles Lowry, C. Lowry, Charles B. Lowry
14	J	**Ryan**	J Ryan
15	Fredric C.	**Gey.**	Fredric C. Gey.
16	I	**Shafran**	I Shafran
17	James D.	**Foley**	James D. Foley
10	Ann Carlson	**Weeks**	Ann C. Weeks, A. C. Weeks, A. Weeks, Ann Weeks, Ann Carlson Weeks
11	Bo	**Xie**	Bo Xie, B. Xie
12	M. Delia	**Neuman**	M. Delia Neuman, D. Neuman, M. D. Neuman, M. Neuman, Delia Neuman

Figure 7. Screenshot of the Users with the Same Affiliation Web page.

Finally, the user can get some summary statistics about his/her collaboration activities with other researchers, if the user follows the link "List of Co-Authors" shown on the screenshot of Fig.4. The corresponding Web site not only presents the summary statistics but also the list of co-authors, the total number of publications with each co-author, and some collaboration index values (Figure 8). By clicking on the total number of publications with a co-author ("No. co-Papers" in Figure 8), the joined publications are listed in detail.


Welcome Hassan Karimi
(Hassan Karimi, H.A. Karimi,...)

List of Co-Authors & No. of Publications

CoAuthor-No	Collaboration-No	RC-index	rkta-index
17	26	4	4.84

No.	First Name	Family	Academic Name	No. co-Papers	RKCa-index	CCV-index
1	Xiong	Liu	X. Liu, Xiong Liu,	3	1.8	5.4
2	A.	Hammad	A. Hammad	3	1.99	5.97
3	Shuo	Liu	S. Liu, Shuo Liu,	3	0	0
4	L. W.	Yang	L. W. Yang	2	1.8	3.6
5	I.	Bahar	I. Bahar	2	1.8	3.6
6	J.	Peng	J. Peng	2	0	0
7	C. J.	Jursa	C. J. Jursa	1	1.8	1.8
8	M.	Holliman	M. Holliman	1	1.8	1.8

Figure 8. Screenshot of the *List of Co-Authors* Web page.

In the future, we plan to extend the analysis of the collaboration activities of a user and community. For example, we plan to visualize the collaboration network, its structure, and the position of the user within. Currently, however, AcaSoNet can only provide an initial report about the co-authorship network of a user. As shown in Figure 9, the report gives only an overview about the co-authorship network of a research community in matrix format.

List of All Authors and their Co-Authors & No. of Publications from Maryland - iSchool Show Report

	V. Diker	A. Druin	P. Jaeger	J. Lin	C. Lowry	A. MacLeod	D. Oard	J. Preece	D. Soergel	A. Weeks	B. Xie	M. Neuman	M. White	# of Publications	# of Co-Authors	# of Collaborations
V. Diker	5	-	-	-	-	-	-	-	-	-	-	-	-	5	0	0
A. Druin	-	31	-	-	-	-	-	3	-	4	-	-	-	38	2	7
P. Jaeger	-	-	14	-	-	-	-	-	-	-	-	-	-	14	0	0
J. Lin	-	-	-	37	-	-	2	-	1	-	-	-	-	40	2	3
C. Lowry	-	-	-	-	9	-	-	-	-	-	-	-	-	9	0	0
A. MacLeod	-	-	-	-	-	2	-	-	-	-	-	-	-	2	0	0
D. Oard	-	-	-	2	-	-	61	-	8	-	-	-	-	71	2	10
J. Preece	-	3	-	-	-	-	-	23	-	-	-	-	-	26	1	3
D. Soergel	-	-	-	1	-	-	8	-	21	-	-	-	-	30	2	9
A. Weeks	-	4	-	-	-	-	-	-	-	3	-	-	-	7	1	4
B. Xie	-	-	-	-	-	-	-	-	-	-	15	-	-	15	0	0
M. Neuman	-	-	-	-	-	-	-	-	-	-	-	8	-	8	0	0
M. White	-	-	-	-	-	-	-	-	-	-	-	-	8	8	0	0

Figure 9. Report about the collaboration (i.e. co-authorship) network of a research community.

In detail, the left hand side of the Figure 9 shows the number of joint publications between each pair of authors. The main diagonal depicts the number of single-author publications. The last three columns on the right hand side of the figure show the total number of papers, which the author published, the total number of different co-authors of the author, and the number of collaborations of the author, which is defined as the sum of joint publications of a user with each co-author.

5. Conclusion and Future Work

Within this paper, we presented AcaSoNet, a social network system for researchers with the goal of applying social network systems in a professional environment. With the help of this system, scholars gain benefit by being able to analyze their research performance with respect to the number of publications and different indexes (e.g., h-Index).

The system design of AcaSoNet finds a compromise between data reliability and scalability by combining Web mining techniques for extracting publication data with verification of the obtained publication data through the user. Since the system design is based on Web service technology, it can use external services for searching (e.g., Google Scholar) and can offer services (e.g., MyTiesTo) for providing social network information of authors. Within this paper, we also presented the user interface of AcaSoNet.

In the future, we plan to extend AcaSoNet by services for recommending publications and for automatic research group clustering based on publication lists of scholars.

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