ASSOCIATION FOR INFORMATION SCIENCE AND TECHNOLOGY.

THE AWARD OF MERIT

DR. PETER INGWERSEN NOMINATION

LIST OF CONTENTS

(One more publication in Additonal information file)

1. **Name, address, and telephone number of nominee: Dr. Peter Ingwersen**

Dr. Peter Ingwersen
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2. **Name, address, and telephone number of nominator: Dr. Virginia Ortiz-Repiso**

Dr. Virginia Ortiz-Repiso

Universidad Carlos III de Madrid
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3. Description of the works for which the nominee is recommended

Universidad Carlos III de Madrid

Department of Library and Information Science

June 28, 2016

Association for Information Science and Technology. The Award of Merit

To: Awards and Honors Committee

It is a genuine pleasure and honor for me to nominate, with great respect, Dr. Peter Ingwersen, in name of ASIS&T European Chapter, for the ASIS&T Award of Merit. The European Chapter is proud to have such an outstanding researcher in its circle.

Dr. Ingwersen has made and he continues to make, remarkable contributions to the field of Library and Information Science. The overarching theme of Dr. Ingwersen's research interlinks the fundamental essence of the disciplinary triangle of information, people, technology and their relationships; and he stands as one of the most widely published and highly cited researchers in the field of Library and Information Science.

Dr. Ingwersen became lecturer at Royal School of Library and Information Science (RSLIS), Denmark in 1973, after his graduation from the School in the same year. He was promoted to Associate Professor at the School in 1984. He obtained his Ph.D. degree in 1991 from the Copenhagen Business School, Faculty of Economics, Institute of Informatics and Management with a doctoral dissertation entitled Intermediary Functions in Information Retrieval Interaction. He has worked with the Information Retrieval Service of the European Space Agency (ESA-IRS) in Frascati, Italy, as a Research Fellow. He has been Visiting Professor at Rutgers University in New Jersey. This experience confirms his foundations are firmly rooted in the information science tradition.

Since 2001 he served as Professor of Information Science at RSLIS; and, in 2010 he became a Professor Emeritus of the University of Copenhagen. He is also Affiliate Professor at Abo Akademi University, Turku, Finland, from 1997 and held a Research

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Chair of Excellence at University Carlos III, Madrid, Spain November 2011-July 2012. He has been awarded the degree Dr. Ph. Honoris Causa in 2010 by the Information Science Faculty of University of Tampere, in 2014 the degree of Dr. Pol. Sc. Honoris Causa by Åbo Akademi University, both in Finland, and in 2015 the degree of Dr. Ph. Honoris Causa by the University Carlos III Madrid, Spain.

His academic merits and distinctions are numerous as shown in the accompanying CV. His publications are many, as well as the citations received for his work. Despite these many accomplishments, I do not wish quantify publications and citations here, but instead I would like to focus on the significant innovations of his career and importance of his contributions to the evolution of LIS.

Dr. Ingwersen's research encompasses two chief domains (1) information retrieval, and (2) bibliometric and especially, webometrics.

Hi is known for development of Cognitive Theory of Information Retrieval, as an attempt to globalize information retrieval through the representation of all components in a holistic approach. Traditional models of information retrieval (Boolean, vector, probabilistic), paid little or no attention to the social context of the tasks of indexing and searching. If we consider information seeking and the ways users use the information retrieval systems, we cannot neglect the social context and thus the cognitive aspects. Dr. Ingwersen made this apparent by leading the way in investigating the cognitive processes of interaction between people and systems. He analyzed the impact of computer technology on the search behavior of individuals, and the application of this approach in the information industry, such as structural representations with different levels of complexity cooperating in a process of interactive communication. Ingwersen emphasizes that these are the binding factors of this theory: the subjective nature that every individual and the context in which it operates; that is, studying their mood, their area of interest, the degree of motivation, and other factors.

Dr. Ingwersen also contributed a global model called poly-representation. This model, based on inferential logic, indicates that the more evidence one has via consultation

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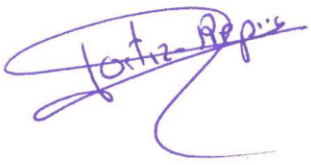
documents and the relationships between them, the more likely that the results will resemble the information needs of the user. This is what Ingwersen called intentional redundancy. In short, he created a theory and a school that many others have followed.

Dr. Ingwersen, with Almid, was the first to analyze in 1997, the web with bibliometric techniques. In this area he is considered the "father of webometrics". Until then the metric studies applied to all internet, resulting in the Cybermetrics. Their quantitative studies focused only on the web, and named the new discipline webometrics. Almind and Ingwersen considered each link as a citation and then found the average volume of links received by each page. In this area, Dr. Ingwersen also designed the so-called Web Indicators for measuring the impact factor, again, a theory and a school followed by many researchers.

Dr. Ingwersen is an internationally recognized scholar in the field of information and library science. He has contributed new theories and research approaches. Given his level of productivity, impact, and contribution to research in library and information science, I hope you will recognize Dr. Ingwersen with the 2016 ASIS&T Award of Merit.

Sincerely,



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Chair-elect ASIS&T European Chapter

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4. Biographical information about the nominee

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September, 2014

PROFESSIONAL PROFILE

Peter Ingwersen, born in 1947, is Professor Emeritus 2010 from University of Copenhagen, the Royal School of Library and Information Science (RSLIS), Denmark, where he served as Professor of Information Science from 2001. He is also Affiliate Professor at Abo Akademi University, Turku, Finland, from 1997 and held a Research Chair of Excellence at University Carlos III, Madrid, Spain November 2011 – July 2012.

He became lecturer at RSLIS in 1973, after graduation from the School in the same year. Associate Professor at the School 1984. He obtained his Ph.D. degree 1991 from Copenhagen Business School, Faculty of Economics, Institute of Informatics and Management with a doctoral dissertation on Intermediary Functions in Information Retrieval Interaction. He has been awarded by the degree Dr. Ph. Honoris Causa in 2010 by the Information Science Faculty of University of Tampere, in 2014 the degree of Dr. Pol. Sc. Honoris Causa by Åbo Akademi University, both in Finland, and in 2015 the degree of Dr. Ph. Honoris Causa by the University Carlos III Madrid, Spain.

Until 1982 he lectured on information storage and retrieval, cataloguing and indexing theory and carried out research on cognitive aspects of information seeking and retrieval. 1982-84 he joined the online service staff of the Information Retrieval Service, the European Space Agency (ESA-IRS), Frascati, Italy, as ESA Research Fellow. His R&D activities were concerned with user-system interface improvements, the development of a new family of online support and retrieval tools, like the Zoom/RANK command facility, as well as systems management.

Back at RSLIS as Associate Professor from 1984, he worked in a new department dealing with information resource management and design of specialized information services and systems for industry and institutions. As the driving force behind the curriculum development of the M.Sc. program in Library and Information Science at RSLIS he was appointed head of this program 1990-93. From July 1993 he became Head of the Department of Information Retrieval Theory, in 1999 merged with the Department of Information Studies. Simultaneously, he was senior researcher at the Centre for Informetric Studies (CIS), RSLIS, 1996-2000. From January 2001 he became Research Professor, and was called as Full professor, specializing in Information Seeking, Interactive Information Retrieval, and Informetrics/Webometrics. Retired from RSLIS in August 2010 as Professor Emeritus.

As expert consultant he has served in the 1990s in several ESPRIT projects on the design of knowledge-based IR interfaces and systems, and participated in the development of the information system of the Danish Parliament. Professor Ingwersen served as EU reviewer on

ESPRIT and Basic Research (LTR) projects (SIMPR; FERMI), and he participated in the three-year ESPRIT Long Term Research consortium (MIRA) developing evaluation methods for interactive multi-media retrieval, sponsored by the EU Commission.

He served as Visiting professor during the Spring-term 1987 at Rutgers University, NJ, USA, invited by the School of Communication, Information and Library Studies. He has been Visiting Scholar at Keio University, Tokyo, Japan, 1996 and at University of Pretoria, Republic of South Africa, 1997, one month respectively. In 1999-2002 he served as Visiting Professor at the Department of Information Studies, Tampere University, Finland, sponsored by the Nordic Research Academy (Norfa), now named NORDFORSK. He was invited as Visiting Scholar by Shanghai Library and China Academy of Science, the Documentation and Information Center, Shanghai in August, 2003 – and again in 2008. He is member of the Advisory Board of the International Collaborative Academy of Library and Information Science (ICALIS), Wuhan University, from 2008.

Since 1980 his lines of research focus on three themes: Interactive Information Retrieval (IIR); Information Science theory; Scientometrics and Webometrics. IIR is his main line of research throughout his career. It concerns studies of the relationships between the searcher of information in context of organizational, social and cultural factors and information (retrieval) systems such as libraries, scientific databases and lately web-based search engines, like Google. The research is based on cognitive approaches to information transfer, interaction and use, including interface issues, and he has developed task-based theories for IIR as well as empirical studies of scientific users' search characteristics, interaction and relevance behavior. Together with Professor Kalervo Järvelin, Tampere University, Finland, he has developed an internationally recognized research framework, including research design examples, for interactive IR and information seeking studies.

With respect to Information Science theory his main focus has been on development of understanding the concepts of 'information' and 'relevance' seen from a user's cognitive perspectives. These analyses bridges over to IIR. In his view Information Science theory also leads to a broader understanding of scientific communication patterns and thus to the third line of research on Scientometrics and Webometrics. This theme deals with the quantitative study of scientific information transfer, e.g. by means of publication patterns, citation analysis or download capture (Scientometrics), or the quantitative study of link structures, impact and graphs on the Web (Webometrics).

Since the mid-1990s his research has concentrated on evaluation of academic research output, by means of scientometric (or bibliometric) analyses of scientific publications, journals and web structures. He is in particular known as the instigator of 'Webometrics' in 1996, signifying the quantitative studies of the WWW (together with the late Thomas Almind) and for investigating the properties of the so-called Web Impact Factor. He has conducted a range of research evaluation studies of various scientific fields as well as countries, most lately impact analyses on Renewable Energy research in EU, Spain and Germany. His is currently engaged in the *SAPIENS* Project concerned with citation impact and altmetric studies of sustainable energy research in collaboration with University Carlos 3, Madrid, and analyses of the effect of national research assessment systems on research publishing patterns and international citation impact (Denmark).

Among his published works are several research monographs on information retrieval interaction and research evaluation, as well as more than 170 peer reviewed journal, conference and book articles on information science, curriculum development, information systems design, informetrics, including research evaluation, Scientometric and Webometric analyses, and, in particular, on integrated cognitive approaches to interactive IR theory. He has contributed articles

on information science and retrieval to the Encyclopedia of Library and Information Science, USA, 1995 and 2010 and the International Encyclopedia of Communication, USA, 2010 and 2013. His first monograph, Information Retrieval Interaction, 1992, has sold more than 2000 copies worldwide and is also published in Japanese translation, 1995, as well as in Korean, 1998 and Persian, 2010. It is available free on the web from 2002, and has been visited almost 20,000 times and cited more than 300 times (Web of Science).

Together with Academy Professor Kalervo Järvelin, Tampere University, Finland, he published in 2005 by Springer his most recent research monograph: *The Turn: Integration of Information Seeking and Retrieval in Context*, which has been translated into Chinese by ISTIC, Beijing, 2007 and Japanese by Maruzen Publishers, 2008. This is cited almost 300 times (Web of Science)

He has been Chair or member of four international university departmental research assessment committees in Republic of South Africa (1996), Spain (2005) and University of Tampere, Department of Information Studies, Finland (2008). Most recently he participated as panel member at the departmental and centre evaluation of CWTS, Leiden University, The Netherlands, 2008. Member of the evaluation panel of candidates for the Spanish CONEX programme, University Carlos 3, Madrid, 2014. Since 1993 he has been member of 19 professorial evaluation committees and official external examiner at 22 doctoral dissertations worldwide.

Since 2000 professor Ingwersen has supervised 10 doctoral theses on interactive IR, Citation-based IR, Webometrics and Small World phenomena, Thesaurus design & use, Collaborative information seeking and Informetric methods applied to thesaurus design as well as on Museum taxonomies for cultural heritage. He has supervised long-term visiting Chinese, Japanese, Spanish and UK post-doctoral and doctoral researchers and visiting professors. From 1998 he has organized several one and two-week international doctoral research courses, on Information Seeking and Retrieval (ISR) and Informetrics, sponsored by the Nordic Academy of Research (NORFA, presently NORDFORSK), and has participated in several Nordic and EU sponsored PhD courses and summer schools (e.g. ESSIR from 1999).

He was member of the Standing Executive Committees of the NORFA-sponsored research network for Information Studies: NORDISNet 1998-2002 with 1.5 Mill. NOK, the ensuing Nordic research school, NORSLIS, 2004-2008, sponsored by NordForsk with 1 Mill NOK/year, and the South African research educational network sponsored by DANIDA 1998-2000 with 2.6 Mill. DKK.

Since 1989 he is member of the ACM-SIGIR international Program Committee, and served as its EU Program Chair 1995 and 2000. As Conference Chairman he organized the 15th ACM-SIGIR Conference on R&D in Information Retrieval, held in Copenhagen, June 1992, and co-chaired the CoLIS 2-4 Conferences on Conceptions of Library and Information Science, held in Copenhagen, 1996, Dubrovnik, Croatia, 1999, and Seattle, USA, 2002. He instigated the Information Interaction in Context (IIiX) symposium series 2006-2014, which is merged from 2016 with the HCI symposiums into the international ACM/SIGIR Conference on Human Interaction and Information Retrieval (CHIIR). He is member of its Steering Committee2016-2017. Co-Chair of the 2013 ICTIR Conference on IR theory in Copenhagen. He was member of the editorial board of Journal of Documentation 1990-2001, and is currently board member of the Journal of American Society of Information Science and Technology (JASIST), Scientometrics, Journal of Informetrics, Information Processing & Management, Chinese Journal of Science & Technology Information, South African Journal of Library and Information Science, and the electronic journal Cybermetrics. He has served the Association for Information Science &

Technology (ASIS&T) as member 2010-2011 and Chair of the selection Committee for the ASIS&T Research Award 2012-2013.

Professor Ingwersen has received several awards and a research medal. He received the Jason Farradane Award, 1993 from the Institute of Information Scientists, UK. In 1994 he received the American Society for Information Science/New Jersey Distinguished Lectureship Award. The Association for Science Studies, Berlin, made him Honorary Member in 2001 and in 2003 he received the distinguished American Society for Information Science & Technology (ASIS&T) Research Award, for his work on the cognitive approach to Information Retrieval. In 2005 he was honored by the Thomson Award of excellence in Denmark, being the most highly internationally cited Danish researcher in the social sciences. That same year he received the prestigious Derek De Solla Price Award, selected by the international peers in Scientometrics and Informetrics. In 2007 ASIS&T awarded him the Outstanding Information Science Teacher Award. In 2009 the Los Angeles Chapter of ASIS&T awarded him with the Contributions to Information Science and Technology Award (CISTA). In 2015 he was honored by the UK e-information Group, receiving the Tony Kent Strix Award in recognition of his major and sustained contributions to the field of information retrieval. Among his invited lectures and key-notes worldwide are the Anne V. Marinelli Lecture Series, Texas Woman's University, 1992 as well as the Lazarow Memorial Lecture twice: 1) The Information School, University of Washington, Seattle, 2002, and 2) University of Tennessee, 2009, sponsored by Thomson Reuters and the Eugene Garfield Foundation. He has given keynotes at several conferences, most recently at the Information Interaction in Context Symposium (IIiX), 2012, Nijmegen, The Netherlands.

He understands, speaks and writes fluently: Danish; English; – and speaks: Italian; French

Peter Ingwersen
Professor Emeritus

Selected publications 1982-2016 – only peer reviewed articles and monographs

Monographs:

Information Retrieval Interaction. Peter Ingwersen. London: Taylor Graham, 1992 (0-947568-54-9) x, 246 p.

The International Visibility of Danish and Scandinavian Research 1988-96: A General Overview of Science & Technology and the Social Sciences by Online Publication Analysis. Peter Ingwersen. Centre for Informetric Studies, the Royal School of Library and Information Science, Copenhagen, 1998. 72p. (ISBN: 87-7415-263-7) (CIS Report 5).

The Turn: Integration of Information Seeking and Retrieval in Context. Ingwersen, P. and Järvelin, K. Dordrecht: Springer, 2005: 460 p. – Translated and published into Chinese (2007) and Japanese (2008).

Scientometric Indicators and Webometrics - and the Polyrepresentation Principle in Information Retrieval. Ingwersen, P. Bangalore: Ess Ess Publications, New Delhi, India, 2012. 100 p. 978-81-7000-657-2 (Sarada Ranganathan Endowment Lectures; 28).

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Online citation analysis: a methodological approach. Finn Hjortgaard Christensen and Peter Ingwersen. *Scientometrics*, vol.37(1), 1996, pp. 39-62.

Data set isolation for bibliometric online analyses of research publications: fundamental methodological issues. Peter Ingwersen and Finn Hjortgaard Christensen. *Journal of American Society for Information Science,* vol. 48(3) 1997, 205-217.

The development of a method for the evaluation of interactive information retrieval systems. Pia Borlund and Peter Ingwersen. *Journal of Documentation*, vol. 53(3), 1997, pp. 225-250.

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The Calculation of Web Impact Factors. Peter Ingwersen. *Journal of Documentation*, 1998, 54(2): 236-243.

Online indicators of Danish Biomedical Publication Behaviour 1988-96: International visibility, impact, and co-operation in a Scandinavian and World context. Peter Ingwersen. *Research Evaluation*,8(1), 1999, 39-45.

Publication behaviour and international impact: Scandinavian clinical and social medicine 1988-96. Peter Ingwersen and Irene Wormell. *Scientometrics*, 1999, 46(3), 487-499.

A user-oriented interface for generalized informetric analysis based on applying advanced data modeling techniques. Kalervo Järvelin, Peter Ingwersen & Timo Niemi. *Journal of Documentation,* 2000, 56(3): 250-278.

Cognitive Information Retrieval. Peter Ingwersen. *Annual Review of Information Science & Technology (ARIST),* vol. 34, 1999. Published for American Society for Information Science and Technology (ASIST) by Information Today, Medford, NJ, 2001, 3-52.

Dimensions of relevance. Erica Cosijn & Peter Ingwersen. *Information Processing & Management.* 2000, 36, 533-550.

The international visibility and citation impact of the social sciences in the Scandinavian countries: the decay of a myth. Peter Ingwersen. *Scientometrics*, 2000, 49(1), 39-61.

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Data Fusion According to the Principle of Polyrepresentation. Peter Ingwersen, Berit Lund & Birger Larsen. *Journal of American Society for Information Science and Technology* (JASIST), 2009, 60(4): 646-654.

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Production, consumption and research on solar energy: The Spanish and German case. Elias Sanz-Casado; Maria Luisa Lascurain-Sánchez; Antonio Eleazar Serrano-Lopez; Birger Larsen; & Peter Ingwersen. *Renewable Energy*, Vol. 68, 2014, pp. 733-744. http://dx.doi.org/10.1016/j.renene.2014.03.013

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Taking scholarly books into account. Current developments in five European countries. Gimenez-Toledo, Elea; Manana-Rodrıguez, Jorge; Engels, Tim C. E.; Ingwersen, Peter; Polonen, Janne; Sivertsen, Gunnar; Verleysen, Frederik T.; Zuccala, Alesia Ann. In: *Scientometrics*, online 15-02-2016, 15 p.; DOI 10.1007/s11192-016-1886-5.

Dr. Rousseau

To whom it concerns,

Dr. Peter Ingwersen HAS made noteworthy contributions (plural!) to the field of information science, by the expression of new ideas, the development of better techniques for IR and generally performing outstanding services to the profession of information science.

I will not go over all his publications and rewards, including honorary professorships (doctor honoris causa) but like to point out that he is one of the few colleagues active in and bridging the unfortunate divide between Information Retrieval, citation analysis and research evaluation.

Moreover, and most importantly he is an avid searcher for scientific truth, whatever the standing of possible opponents.

Peter Ingwersen and I have been co-authors, co-members of doctoral juries and co-attendants of many conferences. It was always an enriching experience.

Hence, it is my great pleasure to support my colleague Dr. Peter Ingwersen for the ASIS&T Award of Merit.

Dr. Ronald Rousseau
KU Leuven, Belgium
June 16, 2016

Dr. Greenberg

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June 22, 2015

Dear ASIST Award of Merit Jury,

I am extremely pleased to write a letter supporting Dr. Peter Ingwersen's nomination for the ASIST Award of Merit. I have known of Dr. Ingwersen's research since the early 1990's when working on my master's degree in information and library science. Dr. Ingwersen's name and his scholarship in information retrieval was prominent at this time, and his work has remained at the forefront of information and library science over the last near 30 years. In 2012, I also had the honor of sharing an office with Dr. Ingwersen at the University of Carlos III-Madrid, where we were both in residence as Chairs of Excellence. Here, I had to opportunity to learn, first-hand, more about his research, including new directions in bibliometrics.

In the area of research, Dr. Ingwersen stands as one of the most accomplished and prolific scholars in the field of information and library science, with his contributions in the area of cognitive theory of information retrieval, bibliometrics, and webometrics. His scholarship appears chiefly in top tier journals. Moreover, he has had a global impact via his original contributions that have shaped specific tracks and panels at leading research conferences.

As an educator and teacher he has been a truly positive force at his home institution, and internationally, at schools such as Rutgers University (United States), Tampere University (Finland), Keio University (Japan) and University of Carlos III-Madrid (Spain). He has engaged in curriculum development and actively mentored young, developing researchers. On this latter point, I'd like to share that in Madrid, I observed, with sheer the delight, his reaching out to quite a few doctoral students, asking them about their research, and offering feedback and guidance. Dr. Ingwersen has boundless energy, and he is a committed teacher, providing mentorship in research in a truly dedicated way.

Finally, in the area of service, Dr. Ingwersen is on the editorial board of a number of top tier journals. He is committed to a number of professional communities in information retrieval and bibliometrics. He has offered his services as a consultant and subject matter expert to government and industry, and he has been very generous with his time and his knowledge.

Dr. Ingwersen is a remarkable scholar, educator and member of the field of information and library science. It is an honor for me to support his nomination for the ASIST Award of Merit. I'd like to also add that as ASIST becomes a more global organization, and hosts a conference in Copenhagen, I can think of no other scholar that is most deserving of this esteemed award. Thank you to the committee for taking the time to read my letter, and to the leadership in nominating Dr. Ingwersen for the ASIST Award of Merit.

Sincerely

Alice B. Kroeger, Professor, Director of the Metadata Research Center
College of Computing & Informatics, Drexel University

Dr. Connaway

28 June 2016

Association for Information Science and Technology
The Award of Merit
Awards and Honors Committee

Dear ASIS&T Award of Merit Jury:

I am writing a letter of support for Dr. Peter Ingwersen's nomination for the 2016 ASIS&T Award of Merit. Dr. Ingwersen is a legend in the library and information science (LIS) research areas of cognitive theory of information retrieval, bibliometrics, and webometrics. His research has appeared in the most prestigious scholarly journals and has influenced conference themes and numerous research, including theses and dissertations.

Peter also has been recognized internationally as an educator. He has been invited to work with university faculty in numerous institutions. As a visiting faculty member he has engaged with students and offered direction, advice, and feedback on their research. When I was the Chair of Excellence at the Universidad Carlos III de Madrid (UC3M) in 2014 I worked with a doctoral student, who had worked with Dr. Ingwersen when he was at UC3M in 2012. He continued to work with her for three years and was an active member of her doctoral committee. The influence of his work was evident in the student's doctoral research since she used Dr. Ingwersen's cognitive theory of information retrieval for the theoretical framework for her research.

When I was a Visiting Scholar at the Royal School of Library and Information Science in Copenhagen, Denmark in 2014 Peter made time to meet and work with me even though he was emeritus faculty at the time. Such examples exemplify the passion and enthusiasm that Dr. Ingwersen portrays for the future of LIS research, researchers, and professionals.

Peter also has served on the editorial boards of some of the top-ranked journals in the LIS field. His contributions are evident in the quality of the research that was published in these journals when he served on these boards.

It is with great enthusiasm and respect that I nominate Peter Ingwersen for the 2016 ASIS&T Award of Merit. His contributions as a scholar, educator, and mentor warrant this nomination. Since the ASIS&T Annual Meeting is in Copenhagen, Denmark, the city where Dr. Ingwersen was a longstanding and renowned member of the faculty of the Royal School of Denmark, it is fitting that this honor be bestowed upon him.

Sincerely,

Lynn Silipigni Connaway

Lynn Silipigni Connaway, PhD
Senior Research Scientist
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Dr. Borlund

UNIVERSITY OF COPENHAGEN
FACULTY OF HUMANITIES

To:
Dr.Virginia Ortiz-Repiso Jimenez

Letter of Support of Professor Emeritus Peter Ingwersen for the 2016 ASIS&T Award of Merit

27 JUNE 2016

ROYAL SCHOOL OF LIBRARY AND INFORMATION SCIENCE / IVA

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With this letter I support the nomination of Professor Emeritus Peter Ingwersen for the 2016 ASIS&T Award of Merit. For decades Professor Ingwersen has been the leading proponent of the cognitive viewpoint information retrieval (IR), and has as such contributed significantly to the development and maturing of the research area of interactive IR and its theoretical foundation. His proposal of the 'principle of poly-representation' is such an example. The research community's recognition of Professor Ingwersen and the significance of his research is seen in the shift in IR towards a user-oriented perspective and a more system-user holistic understanding of IR, which has strengthen the research area and bridged the areas of IR and Information Seeking Behaviour. Building on his IR knowledge, he has also been able to make considerably contributions to the research areas of scientometrics and bibliometrics, and he has coined the term 'webometics' together with a former student of his. Professor Ingwersen possesses distinct and remarkable qualities worth awarding, in that, he is brilliant at identifying research problems and hence foresees new research trends due to his natural curiosity extraordinaire interdisciplinary overview of existing research. Students of his (myself included) have over the years benefitted greatly from these talents and so has the research community. The recognition of Professor Ingwersen is also seen by the numerous awards he has received during his long career, e.g., ASIS&T LA Chapter CISTA Award Medal (2009); AIST&T Outstanding Teacher Award (2007); Derek de Solla Price Medal (2005); Thomson Award of Research Excellence (2005); ASIS6T Research Award (2003); ASIS New Jersey Chapter Distinguish Lectureship Award (1994); Jason Farradane Award (1993). Professor Ingwersen has dedicated his entire work-life to IR, his students, and the research community, and has made a difference, which we should honour! For these reasons, I support the nomination of Professor Emeritus Peter Ingwersen for the 2016 ASIS&T Award of Merit.

Yours sincerely,

Pia Borlund

Pia Borlund, Professor (wso), PhD

Dr. Järverling

UNIVERSITY OF TAMPERE

School of Information Sciences

Letter 1 (1)

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June 23rd, 2016

Jury of the 2016 ASIST Award of Merit
Awards & Honors Committee
Association for Information Science and Technology

Ref.

Re: 2016 ASIST Award of Merit nomination support letter – Prof. Peter Ingwersen

Dear Jury and Awards & Honors Committee --

It is my great pleasure to support the nomination of Dr. Peter Ingwersen, Professor Emeritus at The Royal School of Library and Information Science, the University of Copenhagen, Denmark, for the 2016 ASIST Award of Merit.

Dr. Ingwersen has been, over decades, a leading figure in the research of interactive information retrieval (IIR), scientometrics and informetrics with both theoretical and empirical contributions of great significance in all these areas. His contributions have been recognized through great many citations and prestigious awards as detailed in the nomination package, and a devastating list of lecture invitations and positions of trust such as to journal editorial boards and chair roles of leading Information Science conferences. In addition, Dr. Ingwersen has been an esteemed teacher and mentor all over the world.

On a more personal note, Dr. Ingwersen has been a warm, idea-rich, encouraging, entertaining and demanding colleague. This is not my sole opinion but something I hear from many of his colleagues and former students and mentees.

In the light of his excellent and broad-reaching merits and great impact I consider Professor Peter Ingwersen an excellent candidate for the 2016 ASIST Award of Merit.

Sincerely yours,

Kalervo Järvelin, Professor,
Recipient of ASIST Research Award 2012

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11. A copy of one significant publications

Toward a Basic Framework for Webometrics

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In this article, we define webometrics within the framework of informetric studies and bibliometrics, as belonging to library and information science, and as associated with cybermetrics as a generic subfield. We develop a consistent and detailed link typology and terminology and make explicit the distinction among different Web node levels when using the proposed conceptual framework. As a consequence, we propose a novel diagram notation to fully appreciate and investigate link structures between Web nodes in webometric analyses. We warn against taking the analogy between citation analyses and link analyses too far.

Introduction

Library and information science (LIS) and related fields in the sociology of science and science and technology studies have developed a range of theories and methodologies—now including webometrics—concerning quantitative aspects of how different types of information are generated, organized, disseminated and used by different users in different contexts. Historically, this development arose during the first half of the twentieth century from statistical studies of bibliographies and scientific journals (Hertzel, 1987). These early studies revealed bibliometric power laws like *Lotka's law* on productivity distribution among scientists (Lotka, 1926); *Bradford's law* on the scattering of literature on a particular topic over different journals (Bradford, 1934); and *Zipf's law* of word frequencies in texts (Zipf, 1949). Similar power-law distributions have been identified on the Web, for example, the distribution of TLDs (top level domains) on a given topic (Rousseau, 1997) or inlinks per Web site (Adamic & Huberman, 2000, 2001; Albert, Jeong, & Barabási, 1999).

Decisive for the development of bibliometrics and scientometrics was the arrival of citation indexes of scientific literature introduced by Garfield (1955) that enabled analyses of citation networks in science (e.g., Price, 1965). Access to online citation databases catalyzed a wide range of citation studies, especially mapping scientific domains, including growth, diffusion, specialization, collaboration, impact, and obsolescence of literature and concepts. For extensive coverage, see the ARIST chapters by White and McCain (1989) and Borgman and Furner (2002).

The breakthrough of online citation analysis parallels the later avalanche of webometric studies enabled by access to large-scale Web data. In particular, the apparent yet ambiguous resemblance between citation networks and the hypertextual interdocument structures of the Web triggered much interest from the mid-1990s (e.g., Almind & Ingwersen, 1997; Bossy, 1995; Downie, 1996; Ingwersen, 1998; Kuster, 1996; Larson, 1996; McKiernan, 1996; Moulthrop & Kaplan, 1995; Pitkow & Pirolli, 1997; Rousseau, 1997; Spertus, 1997).

Furthermore, the central bibliometric measures of cocitation (Small, 1973) and bibliographic coupling (Kessler, 1963) have been applied to studies of Web clustering, Web growth, and Web searching (e.g., Ding, Zha, He, Husbands, & Simon, 2001; Efe et al., 2000; Larson, 1996; Menczer, 2002; Pitkow & Pirolli, 1997; Weiss et al., 1996).

Since its advent, the Web has been widely used in both formal and informal scholarly communication and collaboration (e.g., Cronin, Snyder, Rosenbaum, Martinson, & Callahan, 1998; Harter & Ford, 2000; Hurd, 2000; Thelwall & Wilkinson, 2003; Wilkinson, Harries, Thelwall, & Price, 2003; Zhang, 2001). Webometrics thus offers potentials for tracking aspects of scientific endeavor traditionally more hidden from bibliometric or scientometric studies, such as the use of research results in teaching and by the general public (Björneborn & Ingwersen, 2001; Cronin, 2001; Thelwall & Wilkinson, 2003; Thelwall, Vaughan, & Björneborn, forthcoming) or the actual use of scientific Web pages.

A range of new terms for the emerging research field were rapidly proposed from the mid-1990s, for example, *netometrics* (Bossy, 1995); *webometry* (Abraham, 1996); *internetometrics* (Almind & Ingwersen, 1996); *webometrics* (Almind & Ingwersen, 1997); *cybermetrics* (journal started 1997 by Isidro Aguillo)[1]; *Web bibliometry* (Chakrabarti, Joshi, Punera, & Pennock, 2002). This and similar more

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[1]http://www.cindoc.csic.es/cybermetrics/

specific conceptual diversity and development often made (and make) it difficult to understand what actually is analyzed in the contributions. The transformation over a year from internetometrics to webometrics by the same authors, Almind and Ingwersen (1996, 1997), is typical of the conceptual confusion.

Tomas C. Almind wanted, originally, to investigate both the communicative and networking aspects of the Internet *and* to analyze the typology, contents, and characteristics of the national Web pages, as in traditional bibliometric publication analyses. But it was unclear where the Internet stopped and the Web started; hence the broad notion of internetometrics in the original CIS Report (1996)[2]. However, because Almind was very careful to distinguish between communication processes and contents, he and Ingwersen decided that the publication analysis-like study published in 1997 were entirely concerned with Web page types and properties—not with communication on the Internet; hence the conception of webometrics in the title of that classic article.

As a consequence of this conceptual variety, the present paper proposes a consistent framework and terminology with which to deal with matters of webometrics. The paper is organized the following way. First, we set webometrics and associated metrics into the LIS framework of informetrics. This is followed by an introduction of basic link terminology and fundamental Web node diagram configurations. The subsequent section is devoted to advanced link terminology and Web node diagrams. The paper ends with a brief discussion section and conclusions.

Webometrics, Bibliometrics, and Informetrics

Being a global document network initially developed for scholarly use (Berners-Lee & Cailliau, 1990) and now inhabited by a diversity of users, the Web constitutes an obvious research field for bibliometrics, scientometrics and informetrics.

Webometrics and cybermetrics are currently the two most widely adopted terms in library and information science for this emerging research field. They are generically related, see Figure 1, but often used as synonyms. In continuation of the Almind case above, the present paper proposes a differentiated terminology distinguishing between studies of the Web and studies of *all* Internet applications. In this framework, webometrics is defined as:

> The study of the quantitative aspects of the construction and use of information resources, structures and technologies on the Web drawing on bibliometric and informetric approaches. (Björneborn, 2004)

This definition thus covers quantitative aspects of both the construction side and the usage side of the Web embracing four main areas of present webometric research: (1) Web page content analysis; (2) Web link structure analysis; (3) Web usage analysis (including log files of users' searching and browsing behavior); (4) Web technology analysis (including search engine performance). This includes hybrid forms, for example, Pirolli, Pitkow, and Rao (1996) who explored Web analysis techniques for automatic categorization utilizing link graph topology, text content and metadata similarity, as well as usage data. Further, all four main research areas include longitudinal studies of changes on the dynamic Web of, for example, page contents, link structures and usage patterns. So-called Web archaeology (Björneborn & Ingwersen, 2001) could in this webometric context be important for recovering historical Web developments, for example, by means of the Internet Archive (www.archive.org).

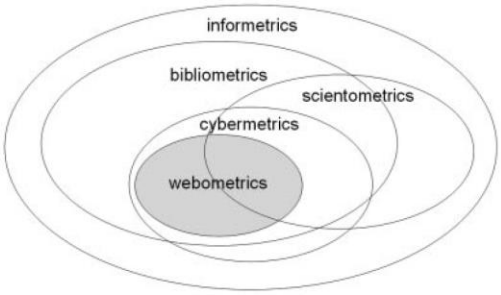

FIG. 1. Relationships between the LIS fields of infor-/biblio-/sciento-/cyber-/webo-/metrics. Sizes of the overlapping ellipses are made for sake of clarity only.

The above definition places webometrics as a LIS specific term in line with bibliometrics and informetrics (also cf., e.g., Cronin, 2001; Björneborn & Ingwersen, 2001). This domain lineage is stressed by the formulation "drawing on bibliometric and informetric approaches" because "drawing on" denotes a heritage without limiting further methodological developments of Web-specific approaches, including the incorporation of approaches of Web studies in computer science, social network analysis, hypertext research, media studies, and so forth.

In the present framework, *cybermetrics* is proposed as a generic term for:

> The study of the quantitative aspects of the construction and use of information resources, structures and technologies on the *whole* Internet drawing on bibliometric and informetric approaches. (Björneborn, 2004)

Cybermetrics thus encompasses statistical studies of discussion groups, mailing lists, and other computer-mediated communication on the Internet (e.g., Bar-Ilan, 1997; Hernández-Borges, Pareras, & Jiménez, 1997; Herring, 2002; Matzat, 1998) *including* the Web. Besides covering all computer-mediated communication using Internet applications, this definition of cybermetrics also covers quantitative measures of the Internet backbone technology, topology, and traffic (cf. Molyneux & Williams, 1999). The breadth

[2]Published by the now closed Centre for Informetric Studies (CIS) at the Royal School of Library and Information Science, Denmark.

of coverage of cybermetrics and webometrics implies large overlaps with proliferating computer-science-based approaches in analyses of Web contents, link structures, Web usage, and Web technologies. A range of such approaches has emerged since the mid-1990s with names like *cyber geography* and *cyber cartography* (e.g., Dodge, 1999; Dodge & Kitchin, 2001, 2002; Girardin, 1995, 1996)[3], *Web ecology* (e.g., Pitkow, 1997; Chi et al., 1998; Huberman, 2001), *Web mining* (e.g., Etzioni, 1996; Cooley, Mobasher, & Srivastava, 1997; Kosala & Blockeel, 2000), *Web graph analysis* (e.g., Broder et al., 2000; Clever Project, 1999; Kleinberg, Kumar, Raghavan, Rajagopalan, & Tomkins, 1999), *Web dynamics* (e.g., Levene & Poulovassilis, 2001), and *Web intelligence* (e.g., Yao, Zhong, Liu, & Ohsuga, 2001).

The raison d'être for using the term *webometrics* in this context could be to denote a close lineage to bibliometrics and informetrics and stress a LIS perspective on Web studies as noted previously. In this context, the earlier mentioned term *Web bibliometry* used by Chakrabarti et al. (2002) is especially interesting because computer scientists thus recognize the heritage in bibliometric research to be drawn on in Web studies. Other computer science approaches to link structure analysis also pay tribute to inspiration from citation studies, for example, Albert and Barabási (2002), Chakrabarti et al. (1999), Efe et al. (2000), Kleinberg (1999), Kosala and Blockeel (2000), Pitkow and Pirolli (1997), Vázquez (2001).

There are different conceptions of informetrics, bibliometrics, and scientometrics. Figure 1 shows the field of informetrics embracing the overlapping fields of bibliometrics and scientometrics following widely adopted definitions by, for example, Brookes (1990), Egghe and Rousseau (1990), and Tague-Sutcliffe (1992). According to Tague-Sutcliffe (1992, p. 1), *informetrics* is "the study of the quantitative aspects of information in any form, not just records or bibliographies, and in any social group, not just scientists." Furthermore, *bibliometrics* is defined as "the study of the quantitative aspects of the production, dissemination and use of recorded information" and *scientometrics* as "the study of the quantitative aspects of science as a discipline or economic activity" (ibid.). In the figure, politico-economical aspects of scientometrics are covered by the part of the scientometric ellipse lying outside the bibliometric one.

The diagram in Figure 1 further shows the field of webometrics entirely encompassed by bibliometrics, because Web documents, whether text or multimedia, are *recorded* information (cf. Tague-Sutcliffe's abovementioned definition of bibliometrics) stored on Web servers. This recording may be temporary only, just as not all paper documents are properly archived. Webometrics is partially covered by scientometrics, as many scholarly activities today are Web-based, while other such activities are even beyond bibliometrics, i.e., nonrecorded, like person-to-person conversation. Furthermore, webometrics is totally included within the field of cybermetrics as defined previously.

[3]Cf. http://www.cybergeography.org/

In the diagram in Figure 1, the field of cybermetrics exceeds the boundaries of bibliometrics, because some activities in cyberspace normally are not recorded but rather communicated synchronously, as in chat rooms. Cybermetric studies of such activities still fit in the generic field of informetrics as the study of the quantitative aspects of information "in any form" and "in any social group" as stated above by Tague-Sutcliffe (1992).

Naturally, the inclusion of webometrics expands the field of bibliometrics, as webometrics inevitably will contribute with further methodological developments of Web-specific approaches. As ideas rooted in bibliometrics, scientometrics, and informetrics contributed to the emergence of webometrics, ideas in webometrics might now contribute to the development of these embracing fields.

Terminology and Web Node Diagrams

The following three subsections deal with terminological issues and forms of diagrams for conceptualizing and illustrating Web structures at different levels of analysis in a consistent way.

Basic Link Terminology

The initial exploratory phases of an emerging field like webometrics inevitably lead to a variety in the terminology used. For example, a link received by a Web node (the network term *node* here denotes a unit of analysis like a Web page, directory, or Web site but could also be an entire top-level domain of a country) has been named, for example, *incoming link, inbound link, inward link, back link,* and *sitation;* the latter term (McKiernan, 1996; Rousseau, 1997) has clear connotations to bibliometric citation analysis. An example of a more problematic terminology is the two opposite meanings of an *external link:* either as a link pointing out of a Web site or a link pointing into a site.

Figure 2 illustrates an attempt to create a consistent basic webometric terminology for link relations between Web nodes (Björneborn, 2004). The figure reflects that the Web may be viewed as a so-called directed graph, using a graph-theoretic term (e.g., Broder et al., 2000; Kleinberg et al., 1999). In such a Web graph, Web nodes are connected by

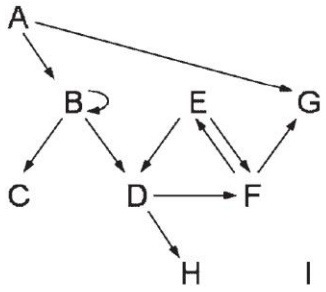

FIG. 2. Basic link relations (Björneborn, 2004). The letters may represent different Web node levels, e.g., Web pages, Web directories, Web sites, or top-level domains of countries or generic sectors. See legend in Table 1.

directed links. In this context, it should be noted that graph theoretic approaches have been used in bibliometrics and scientometrics since the 1960s for analyzing citation networks and other information networks (e.g., Egghe & Rousseau, 1990; Furner, Ellis, & Willett, 1996; Garner, 1967; Hummon & Doreian, 1989; Nance, Korfhage, & Bhat, 1972). Social network analysis (e.g., Scott, 2000; Wasserman & Faust, 1994) makes extensive use of graph theoretical approaches. A review article by Park and Thelwall (2003) compared information science approaches to studying the Web to those from social network analysis. It was found that information science tended to emphasize data validation and the study of methodological issues, whereas social network analysis suggested how its existing theory could transfer to the Web. Otte and Rousseau (2002) give an excellent overview of applications and potentials of social network analysis in the information sciences with regard to studies of, for example, citation and cocitation networks, collaboration structures and other forms of social interaction networks, including the Internet. In a forthcoming ARIST chapter on webometrics by Thelwall, Vaughan, and Björneborn, applications of graph theory and social network analysis in webometrics are further discussed. The proposed basic link terminology in Table 1 has origins in graph theory, social network analysis and bibliometrics.

The terms *outlink* and *inlink* are commonly used in computer-science Web studies (e.g., Broder et al., 2000; Chen, Newman, Newman, & Rada, 1998; Pirolli et al., 1996). The term *outlink* implies that a directed link and its two adjacent nodes are viewed from the source node providing the link, analogous with the use of the term *reference* in bibliometrics. A corresponding analogy exists between *inlink* and *citation* with the target node as the spectator's perspective; compare to Figure 3 (Björneborn, 2004). A link crossing a Web site border, like link *e* in Figure 4, is thus called a *site outlink* or a *site inlink* depending on the perspective of the spectator. Similar considerations of consistent terminology have been put forward in bibliometrics by, for example, Price (1970) who emphasized a conceptual difference

TABLE 1. Basic link terminology (Björneborn, 2004) for link relations in Fig. 2.

- B has an *inlink* from A; B is *inlinked;* A is *inlinking;* A is an *in-neighbor* of B.
- B has an *outlink* to C; B is *outlinking;* C is *outlinked;* C is an *out-neighbor* of B.
- B has a *self-link;* B is *self-linking*.
- A has no inlinks; A is *nonlinked*.
- C has no outlinks; C is *nonlinking*.
- I has neither in- nor outlinks; I is *isolated*.
- E and F have *reciprocal links;* E and F are *reciprocally* linked.
- D, E, and F all have in- or outlinks connecting each other; they are *triadically interlinked*.
- A has a *transversal* outlink to G: functioning as a shortcut.
- H is *reachable* from A by a directed *link path*.
- C and D are *colinked* by B; C and D have *co-inlinks*.
- B and E are *colinking* to D; B and E have *co-outlinks*.
- Co-inlinks and co-outlinks are both cases of *colinks*.

FIG. 3. Different link terminology for the same link depending on the spectator's perspective as denoted by the eyes (Björneborn, 2004).

between the reference and citation, which matches the difference between outlink and inlink just described.

The terms *out-neighbor* and *in-neighbor* in the proposed terminology are also used in graph-theoretic Web research (e.g., Chakrabarti et al., 2002). On the Web, *self-links* are used for a wider range of purposes than self-citations in scientific literature. This reflects a special case of the general difference between outlinks/inlinks and references/citations. Page self-links point from one section to another within the same page. Site self-links (also known as internal links) are typically navigational pointers from one page to another within the same Web site.

Because of its dynamic and distributed nature, the Web often demonstrates Web pages reciprocally linking to each other—a case not normally possible in the traditional print-based citation world. *Reciprocal links,* such as those between nodes E and F in Figure 2, is a widespread existing Web term for mutual inlinks and outlinks between two Web nodes. This reciprocity is not necessarily completely symmetrical as there may be more links in one direction between two Web nodes. Sometimes, reciprocal links may be deliberately agreed by two Web site creators for attempting to obtain higher ranking in search engines employing inlink counts in ranking algorithms as in Google (Brin & Page, 1998; also cf. Walker, 2002).

In Figure 2, the *triadically linked* nodes D, E, and F correspond to the social network analytic term *triadic closure* (e.g., Skvoretz & Fararo, 1989), for example, used to denote the probability that nodes D and F are transitively connected if there are already links between D and E, and between E and F. In social networks, such simple *triadic structures* or *triads* are the building blocks of larger social structures

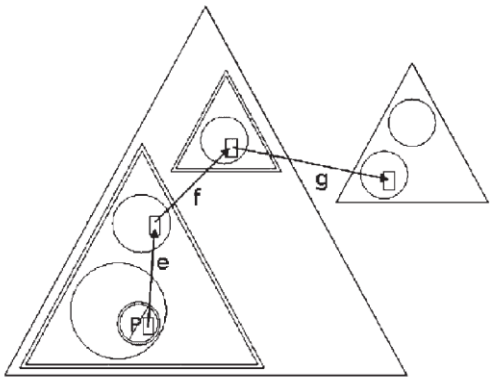

FIG. 4. Simplified Web node diagram illustrating basic Web node levels (Björneborn, 2004).

(e.g., Scott, 2000; Wasserman & Faust, 1994). Milo et al. (2002) use the term *motif* for similar simple triadic building blocks of complex networks in general, for example, in biochemistry, neurobiology, ecology, and engineering.

Most links on the Web connect Web pages containing cognate topics (Davison, 2000). However, some links in a Web node neighborhood may break such typical linkage patterns and connect dissimilar topical domains. Such (loosely defined) *transversal* links (Björneborn, 2001, 2004; Björneborn & Ingwersen, 2001) function as cross-topic shortcuts and may affect so-called small-world phenomena on the Web. Small-world phenomena are concerned with short distances along interconnection paths between nodes in a network graph. For example, short distances between two arbitrary persons through intermediate chains of acquaintances of acquaintances as studied in social network analysis (e.g., Milgram, 1967; Kochen 1989; Pool & Kochen, 1978/1979), and popularized by the notion of "six degrees of separation." Watts and Strogatz (1998) introduced a small-world network model characterized by highly clustered nodes as in regular graphs, yet with short characteristic path lengths between pairs of nodes as in random graphs. In their seminal paper, Watts and Strogatz (1998) showed that a very small percentage of long-range connections is sufficient in a small-world network to function as shortcuts connecting distant nodes of the network.

The concepts of *reachability* and link *paths* as illustrated in Figure 2 are both used in graph theory (e.g., Gross & Yellen, 1999), for example, when describing small-world properties as outlined previously.

The two *colinked* Web nodes C and D in Figure 2 with *co-inlinks* from the same source node are analogous to the bibliometric concept of *cocitation* (Small, 1973). Correspondingly, the two *colinking* nodes B and E having *co-outlinks* to the same target node are analogous to a *bibliographic coupling* (Kessler, 1963). *Colinks* is proposed as a generic term covering both concepts of co-inlinks and co-outlinks. The underlying assumption for the use of both the bibliometric and webometric concepts is that two documents (or two authors/link creators) are more similar, i.e., more semantically related, the higher the frequency of shared outlinks (references) or shared inlinks (citations).

Basic Web Node Terminology and Diagrams

In webometric studies, it may be useful to visualize relations between different units of analysis, for example, in the so-called Alternative Document Model (Thelwall, 2002; Thelwall & Harries, 2003). Figure 4 shows a diagram illustrating some basic building blocks in a consistent Web node framework (Björneborn, 2004). In the diagram, four basic Web node levels are denoted with simple geometrical figures: *quadrangles* (Web pages), *diagonal lines* (Web directories), *circles* (Web sites), and *triangles* (country or generic top level domains, TLDs). Sublevels within each of the four basic node levels are denoted with additional borderlines in the corresponding geometrical figure. For example, a triangle with a

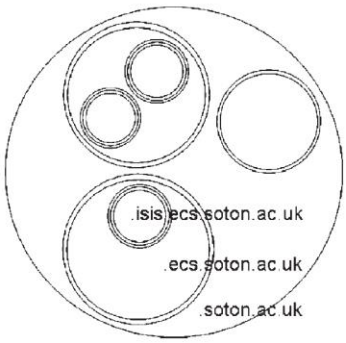

FIG. 5. Simplified Web node diagram of a Web site containing subsites and sub-subsites.

double borderline denotes a generic second level domain (SLD), also known as a sub-TLD, assigned by many countries to educational, commercial, governmental, and other sectors of society, for example, .ac.uk, .co.uk, .ac.jp, .edu.au.

The simplistic Web node diagram in Figure 4 shows a page *P* located in a directory of a subsite in a sub-TLD. The page has a site outlink *e* to a page at a site in the same sub-TLD. The outlinked page in turn is outlinking to a page at a site in another sub-TLD in the same country. The link path *e-f-g* ends at a page at a site in another TLD.

Zooming in on a single Web site, this may comprise several subunits in the shape of subsites, sub-subsites, and so forth, as indicated by hierarchically derivative domain names. For example, as shown in Figure 5, the sub-subsite of The Image, Speech and Intelligent Systems Research Group (isis.ecs.soton.ac.uk) is located within the Department of Electronics and Computer Science (ecs.soton.ac.uk), one of many subsites at the University of Southampton, United Kingdom (soton.ac.uk). Subsites and sub-subsites are denoted as circles with double and triple borderlines, respectively. Subordinate sublevels would logically be denoted with additional number of borderlines. For sake of simplicity, the diagram does not reflect actual numbers and sizes of elements.

Although some Web sites subdivide into derivative domain names, as shown previously, other Web sites locate the same type of subunits into folder directories in their Web site file hierarchy. Obviously, such diverse allocation and naming practices complicate comparability in webometric studies. In Figures 6A and 6B, one or more diagonal lines (resembling URL slashes and reflecting the number of directory levels

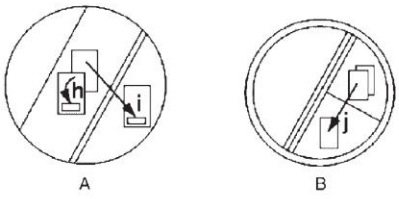

FIG. 6. Simplified Web node diagrams of a Web site and a subsite with links between different directory levels including page subelements.

below the URL root level) denote directories, subdirectories, and so forth.

Web pages may also consist of subelements such as text sections, frames, and so forth. Additional bands illustrate such page subelements as in the targets of the page self-link *h* and the page outlink *i* from the two sibling Web pages in the same directory in Figure 6A. More numerous and complex linkages within a site or subsite, and so forth, can be illustrated by combinations of elements in Figures 6A and 6B, showing links between pages located either at different directory levels (Figure 6A) or in sibling directories at the same level (Figure 6B) in the Web site file hierarchies.

Naturally, any diagrammatic representation of large-scale hypertext structures will get too tangled to be of any practical use or to be interpreted in any quantitative way. However, the proposed Web node diagrams with their simple and intuitive geometrical figures are intended to be used to emphasize and illustrate qualitative differences between investigated Web node levels in a webometric study. Figure 7 shows an example of such a Web node diagram used to illustrate included and excluded Web nodes and links in a connectivity analysis of the UK academic Web space (Björneborn, 2004). Moreover, the diagrams can illustrate actual structural aspects of limited subgraphs of an investigated Web space. Figure 8 gives an example of how the Web node diagrams were used in the above study more specifically concerned with what types of links, pages, and sites function as small-world connectors across dissimilar topical domains in an academic Web space (Björneborn, 2004).

Advanced Link Terminology and Diagrams

The Web can be studied at different granularities employing what here will be called *micro, meso,* and *macro* level perspectives (Björneborn, 2004). Micro level webometrics consists of studies of the construction and use of Web pages, Web directories, and small sub-subsites, and so forth, for example, constituting individual Web territories. Meso level webometrics is correspondingly concerned with quantitative aspects of larger subsites and sites, and macro level webometrics comprises studies of clusters of many sites, or focuses on sub-TLDs or TLDs. Several webometric studies, including classic ones by Larson (1996) and Almind and Ingwersen (1997), have used meso level approaches concerned with site-to-site interconnectivity as well as macro level TLD-to-TLD analysis, primarily applying page level link counts. However, to extract useful information, links may also be aggregated on different node levels as in the earlier mentioned Alternative Document Model (Thelwall, 2002; Thelwall & Harries, 2003).

An adequate terminology for aggregated link relations should capture both the link level under investigation and the reach of each link. Such a terminology should reflect at least three elements: (1) the investigated link level, (2) the highest-level Web node border crossed by the link, and (3) the spectator's perspective (cf. Figure 3). For sake of simplicity, the perspective from the outlinking nodes is chosen in the following examples showing higher and higher link aggregations.

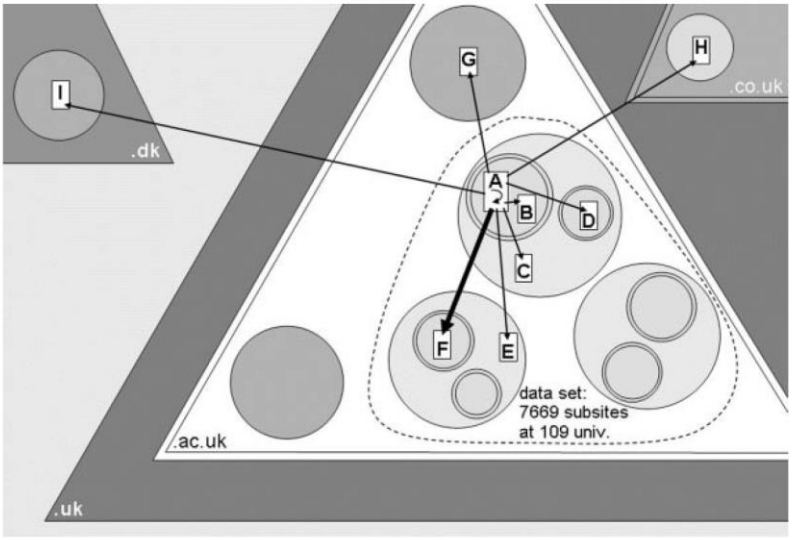

FIG. 7. Example of Web node diagram illustrating qualitative differences between links and Web node levels in a webometric study. The figure illustrates included and excluded Web nodes and links in an analysis of small-world link structures across the UK academic Web space (Björneborn, 2004). The bold link AF symbolizes all included 207,865 page level links between 7,669 subsites at 109 different UK universities in the analysis. All other links were excluded: AA (page self-links); AB (subsite self-links); AC and AD (site self-links); AE (site outlinks to university main sites); AG (site outlinks to ac.uk sites outside data set); AH (sub-TLD outlinks, i.e., links to other UK sub-TLD); and AI (TLD outlinks, i.e., links to other TLD).

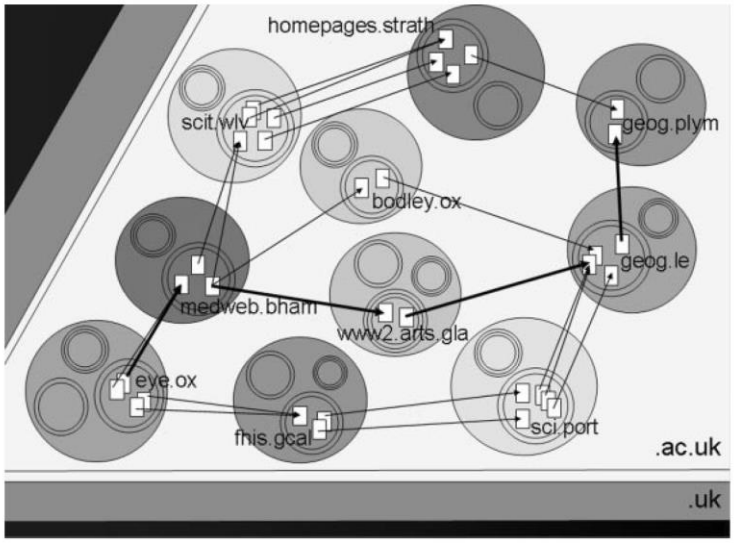

FIG. 8. Example of Web node diagram showing a limited subgraph. It contains an excerpt of shortest link paths (path length 4) between a subsite on eye research (www.eye.ox.ac.uk) and a subsite in geography (www.geog.plym.ac.uk) to identify pages and sites that provide transversal (cross-topic) links across dissimilar topical domains in the UK academic Web space (Björneborn, 2004). Bold links show one example of a shortest link path between the two mentioned subsites. Only links connecting subsites at different UK universities were considered (cf. Figure 7). See Appendix for affiliations.

Figure 9 below shows 14 *page level links* including a page level subsite outlink, k_p (also being a page level site self-link). The subscript in k_p denotes page level. If a webometric study comprises just one level of links, the terminology can be simplified to cover merely the link reach. In such a case, l_p is a site outlink, m_p a sub-TLD outlink, and n_p a TLD outlink.

For sake of simplicity, directory and subsite level links will not be treated here. However, the terminology for these levels would parallel the other levels included.

Figure 10 illustrates 11 site level links. For example, o_s is a site level site outlink aggregating three page level links from Figure 9. Site self-links are denoted with curved arrows.

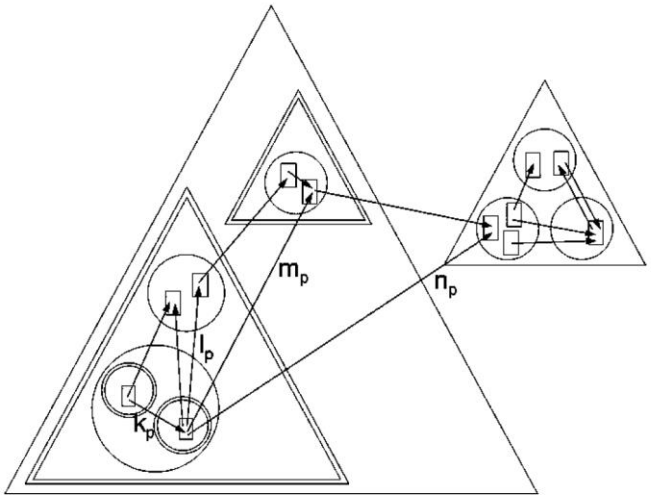

FIG. 9. Web node diagram with page level links (Björneborn, 2004).

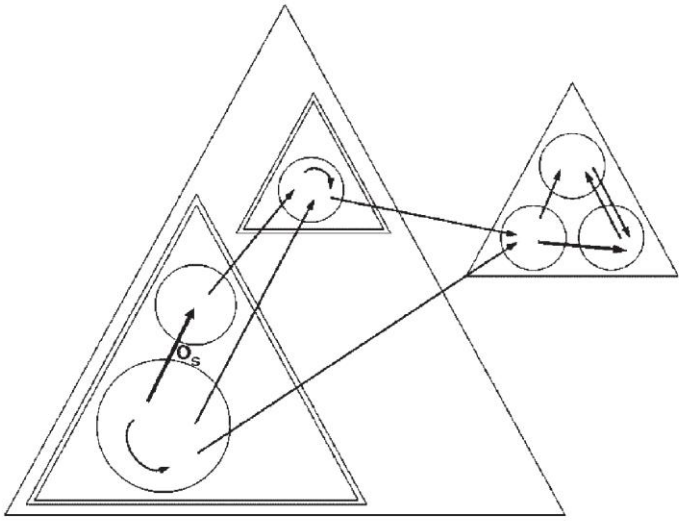

FIG. 10. Web node diagram with site level links.

In this context, it should be noted that a site level link always connects a source site with a target site. Correspondingly, a page level link always connects a source page with a target page; compare to Figures 8 and 9. This point is necessary to make, because a target URL for a Web page may deceivingly look like an URL for a Web site. It is thus common Web practice to stem the target URL of top entry pages of a Web site. For example, instead of writing the full URL www.db.dk/default.htm in a target link pointing to the top entry page of the Royal School of Library and Information Science, it is more convenient to stem the URL to www.db.dk because Web servers automatically look for default pages for stemmed URLs. However, this stemmed URL still denotes a Web page and not a Web site.

This line of higher and higher link aggregations ends with sub-TLD level links as shown in Figure 11 and TLD level links in Figure 12. Terminology for these levels parallel the other levels included.

Discussion and Conclusion

We have demonstrated the relationships between the various metrics associated with library and information science in the framework of its established subfield informetrics. Most basically, we refer webometrics as belonging to cybermetrics and covered by an expanded concept of bibliometrics. We believe that a general consensus exists as to this framework within library and information science.

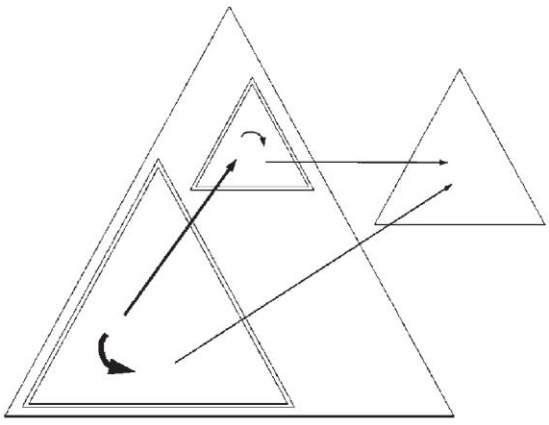

FIG. 11. Web node diagram with sub-TLD level links.

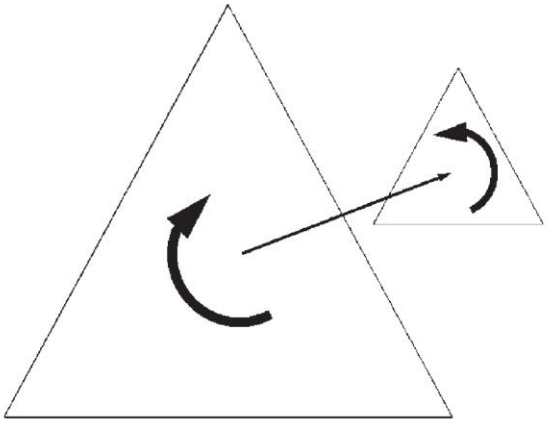

FIG. 12. Web node diagram with TLD level links.

The proposals concerning the basic link terminology are consistent with the increasingly common notation of the most used concepts in the field of webometrics, such as inlink or outlink. However, other notations are obviously required for the additional possible forms of hypertextual associations between Web nodes, for example, reciprocal or transversal links. However, the term *sitation,* introduced by McKiernan (1996) and Rousseau (1997), is not seen as a convenient notation for (in)links. *Sitation* suffers from the same conceptual problem as the term *citation*—namely, that it can be interpreted as synonymous with outlink, i.e., an outgoing reference to other work. Moreover, during oral presentations the distinction between the words *citations* and *sitations* is far from obvious and requires context to be fully understood.

From our perspective, two dimensions of the link terminology are particularly important. First, an analogy exists between references or citations and outlinks or inlinks. Likewise, traditional cocitation or bibliographic coupling is technically similar to colinked or colinking Web nodes, respectively. Nevertheless, it *is* only an analogy, as also stressed by, for example, Björneborn and Ingwersen (2001), Egghe (2000), Meyer (2000), Prime, Bassecoulard, and Zitt (2002), and van Raan (2001). The reasons for giving scholarly references to other scientific work are not fully understood and are different from providing outlinks in the dynamic Web environment (cf. Kim, 2000; Thelwall, 2003; Wilkinson et al., 2003). In many cases, for example, navigational reasons prevail. Operationally, however, one may calculate, analyze, or map the manifestations of such activities. Hence, analogous to citation analyses one must take care when making interpretations of link analyses on different Web spaces.

Second, it is important to be aware of what is measured or counted. For example, there is a rather large difference between counting the *real* number of inlinks to a Web site or page and counting the number of in-neighbors in the shape of Web pages (or sites) inlinking at least once to some Web node. This difference is often overlooked in both calculus and applying terminology. Again, we observe an analogy to citation analysis, when numbers of citations—not only the number of citing articles—are counted. The intellectual and conceptual confusion increases, however, in particular for newcomers in the informetric subfields, when one considers that it is exactly the number of cociting articles, not the actual citations, that commonly are applied to calculating the strength of cocitation.

The distinction among Web node levels, its terminological impact, and the proposal of a consistent diagram notation is necessary for the topology of the Web to be understood and investigated. For example, this distinction is useful when analyzing and illustrating different aggregated Web node levels—nested as Chinese boxes within boxes—as shown in Figures 9–12. There exists a constant possibility of loosing the point of perspective in such analysis, in particular if terminological rigor is lacking.

In conclusion, it should be emphasized that the outlined webometric framework as well as the terminology and diagram notation proposals are seen as conceptual foundations and building blocks by which future discoveries and perspectives of the Web and webometrics hopefully will thrive.

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Appendix

Figure A1 shows a so-called path net consisting of all shortest link paths (path length 4) between two subsites, www.eye.ox.ac.uk and www.geog.plym.ac.uk, in a study of small-world link structures across the UK academic Web space (Björneborn, 2004). Only links connecting subsites at different UK universities were considered in the study. ID numbers refer to 7669 investigated subsites. Counts of page level links between subsites are shown. White nodes denote subsites included in the path net excerpt shown in Figure 8. The affiliations of the subsites in the path net are listed in Table A1.

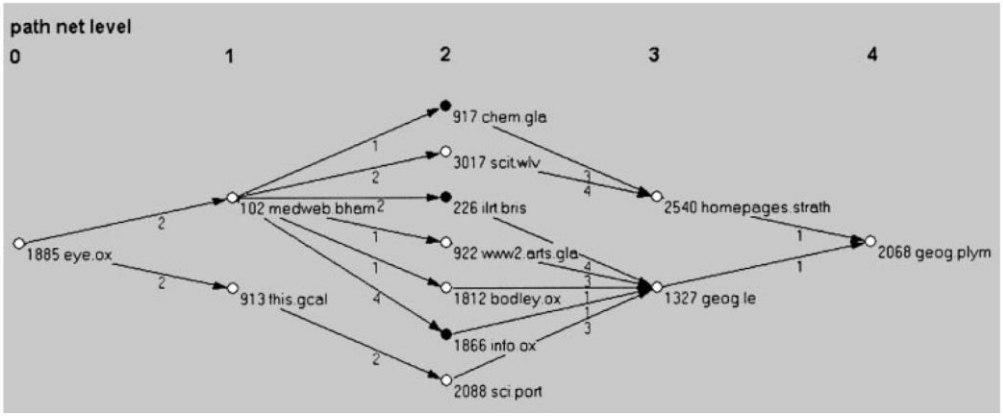

FIG. A1. Path net consisting of all shortest link paths between two subsites.

TABLE A1. The affiliations of the subsites in the path net.

Path net level	Id	Short domain name	Affiliation
0	1885	eye.ox.ac.uk	Dept of Ophthalmology, Univ. of Oxford
1	102	medweb.bham.ac.uk	School of Medicine, Univ. of Birmingham
1	913	fhis.gcal.ac.uk	Faculty of Health, Glasgow Caledonian University
2	226	ilrt.bris.ac.uk	Institute for Learning and Research Technology, Univ. of Bristol
2	917	chem.gla.ac.uk	Dept of Chemistry, Univ. of Glasgow
2	922	www2.arts.gla.ac.uk	Faculty of Arts, Univ. of Glasgow
2	1812	bodley.ox.ac.uk	Bodleian Library, Univ. of Oxford
2	1866	info.ox.ac.uk	Official Oxford University web pages
2	2088	sci.port.ac.uk	Faculty of Science, Univ. of Portsmouth
2	3017	scit.wlv.ac.uk	School of Computing and Information Technology, Univ. of Wolverhampton
3	1327	geog.le.ac.uk	Dept of Geography, Univ. of Leicester
3	2540	homepages.strath.ac.uk	Personal web pages, Univ. of Strathclyde
4	2068	geog.plym.ac.uk	Dept of Geographical Sciences, Univ. of Plymouth