

## Evolution of Decision Support Systems Research Field in Numbers

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*The scientific production in a certain field shows, in great extent, the research interests in that field. Decision Support Systems are a particular class of information systems which are gaining more popularity in various domains. In order to identify the evolution in time of the publications number, authors, subjects, publications in the Decision Support Systems (DSS) field, and therefore the scientific world interest for this field, in November 2010 there have been organized a series of queries on three major international scientific databases: ScienceDirect, IEEE Xplore Digital Library and ACM Digital Library. The results presented in this paper shows that, even the decision support systems research field started in 1960s, the interests for this type of systems grew exponentially with each year in the last decades.*

**Keywords:** DSS, Numbers, Research, Materials

### 1 Introduction

The literature review is a basic activity within the scientific process of publishing academic research articles. The computer-assisted research profiling enriches the traditional literature reviews. The research profiling proposed in different papers [1][2][3][4] uses data mining tools (eg. VantagePoint) designed for structured science and technology information resources, such as the ISI Web of Science, INSPEC or ABI/INFORM ProQuest. But many international scientific databases offers a wide range of information (authors, publications, subjects, etc.), based on results of the searched performed, which are, usually, quite comprehensive to gain a “big picture” perspective on the research activity of that field. This method substantially minimize the data processing time.

The aim of this paper is to analyse different numbers of the research production in the decision support system research field recorded in three international scientific databases - ScienceDirect, IEEE Xplore Digital Library and ACM Digital Library, in order to identify the evolution in time of the DSS research field, major research trends (research topics), the most important DSS publications, the most prolific DSS papers authors and so on.

### 2 DSS – Numbers

Over the years, the concerns in the *Decision Support Systems* (DSS) area have diversified and the development of the web technologies has radically transformed the designed, development, implementation and deployment of DSS [5][6].

The initial concept of *decision support system*, even it was launched before PCs existed, was focused on the use of interactive computing in semi structured decision making [7]. It evolved from the *Decision Management System* concept introduced by Michael Scot Morton. In 1980, Sprague noted that the initial definition of DSS – *computer-based interactive systems that help decision makers to use data and models to solve unstructured problems*, was too restrictive, therefore this definition was extended to include any system involved in the decision making process. This broader DSS definition gave the opportunity to hide under the DSS umbrella of “all information systems that are used by managers or business professionals and don’t fall into some other category” [7].

Due to different perspectives and extremely various dimensions of the decision making support, DSS research field evolved in different directions. This diversity created, during the years, confusions related to the “theoretical basis, architectural form, support

mechanisms, design and development strategies, evaluation approaches, and managerial and organizational aspects of decision making support systems” [8]. This research field was perceived and presented by different researchers from various perspectives, starting from the advantages that DSS offers [9].

The DSS evolution can be divided in four generations: the first generation included data-centred DSS, the second generation of DSS was focused on providing better user-interface, the third generation was focusing on models and the last generation is related to web-based DSS [10].

In the following, there is presented a set of numerical data related to the DSS materials published since the beginning of the DSS research, the most prolific authors in this field, the publications with the biggest number of DSS materials and topics/subjects/keywords of the DSS materials.

### 2.1 Method

The aim of the study, conducted in November 2010, and presented in this paper was to identify the DSS research evolution during the years, by analysing the numbers of the DSS published materials and a series of related data. The method applied involved several queries on three international research databases: ScienceDirect, IEEE Xplore Digital Library and ACM Digital Library. The wide number of records and the scientific centred characteristic of these databases was the reason to decide to use it for this study.

The DSS-related search words used to obtain a wide perspective on the DSS research field are: “decision support system”, “decision system”, “decision tool”, “decision making system” and the plural of these words. These concepts are the most common concepts used by researchers to refer this type of systems.

There have been searched all the materials (articles, books, reports, etc.) that included at least one of the above concepts in title, abstract or keywords.

The information about the authors of the DSS materials published in IEEE Xplore Digital Library and ACM Digital Library, presented

in Table 2, as all the other information presented in this paper, are based on the information provided by the databases as results refinement criteria. In ScienceDirect the authors information was obtained by analysing the results with a word occurrences counting tool.

### 2.2 Results

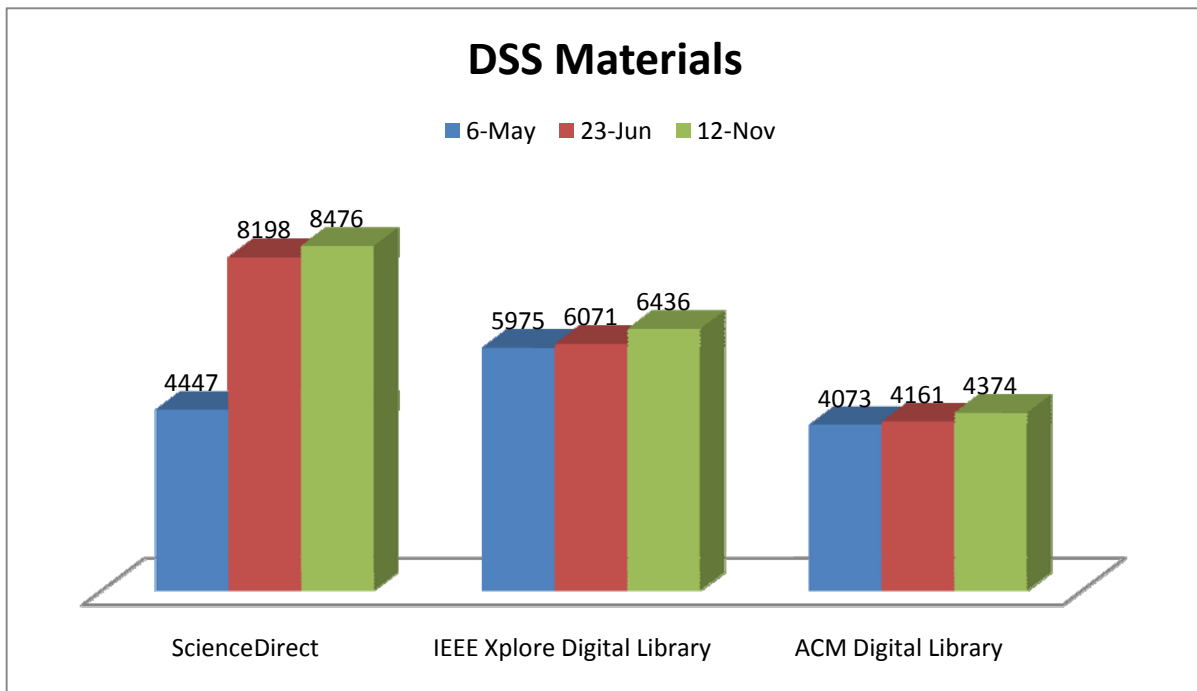
At 12<sup>th</sup> of November 2010, there were reported 8476 materials about decision support system in ScienceDirect, 6436 in IEEE Xplore Digital Library and 4374 in ACM Digital Library (Table 1).

**Table 1.** Numbers of DSS materials indexed in international databases (12.11.2010)

Database	Materials Number
ScienceDirect	8476
IEEE Xplore Digital Library	6436
ACM Digital Library	4374

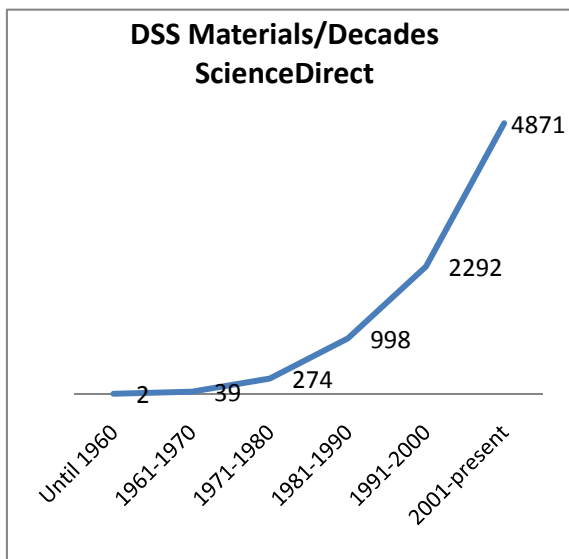
Comparing to a similar search made on 6<sup>th</sup> of May and 23<sup>rd</sup> of June 2010 [11], it can be noted that: 1) in Science Direct the number of the DSS materials increased with **3,39%** in 12<sup>th</sup> November compared to 23<sup>rd</sup> of June and with **84,35%** in 23<sup>rd</sup> of June compared to 6<sup>th</sup> of May 2010; 2) in IEEE Xplore Digital Library the increasing was of **6,01%** and **1,61%**, in 12<sup>th</sup> November compared to 23<sup>rd</sup> of June, respectively in 23<sup>rd</sup> of June compared to 6<sup>th</sup> of May; 3) in ACM Digital Library the number of the DSS materials was higher with **5,12%** in 12<sup>th</sup> November compared to 23<sup>rd</sup> of June, and with **2,16%** in 23<sup>rd</sup> of June compared to 6<sup>th</sup> of May 2010 (Fig. 1).

From the total number of DSS materials from ScienceDirect, on 12<sup>th</sup> of November, 8299 were journal articles, 301 books and 90 reference work. IEEE Xplore Digital Library database included, at the same date, 5751 conference articles, 649 journal articles, 31 early access materials and 5 books. In ACM Digital Library, on 12<sup>th</sup> of November, 1970 DSS materials were periodical articles, 1754 articles published in conferences proceedings, 272 thesis, 228 books and 25 technical reports.



**Fig. 1.** Numbers of DSS materials in ScienceDirect, IEEE and ACM on 6<sup>th</sup> of May, 23<sup>rd</sup> of June and 12<sup>th</sup> of November 2010

The DSS published materials evolution per decades shows an exponential increasing interest for this type of systems. Figures 2, 3 and 4 presents the evolution of DSS materials per decades in ScienceDirect, IEEE Xplore Digital Library and ACM Digital Library.



**Fig. 2.** Evolution of DSS Materials Number per decades (ScienceDirect)

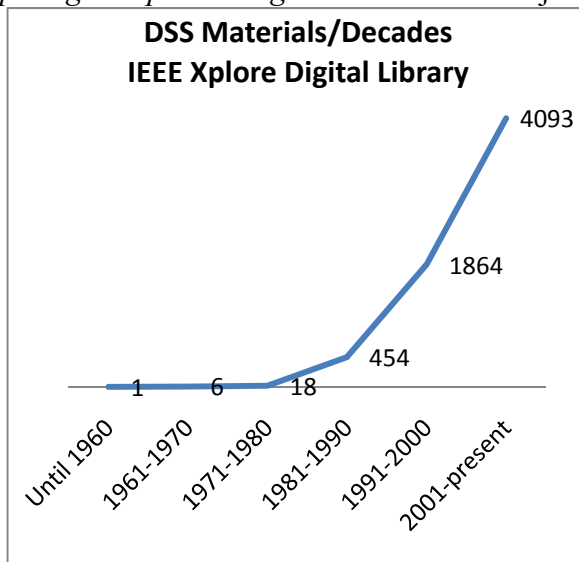
The top 15 of the topics of the DSS-related materials from ScienceDirect include decision support (428 materials), support system

(273), expert system (232), information system (190), health care (96), neural network (90), supply chain (81), manufacturing system (80), software (65), GIS (64), artificial intelligence (55), decision maker (50), operational research (45), fuzzy set (42) and water resource (38). This list of topics emphasis research interest on specific DSS methods, techniques and technologies but also several main application areas: health, manufacturing and environment.

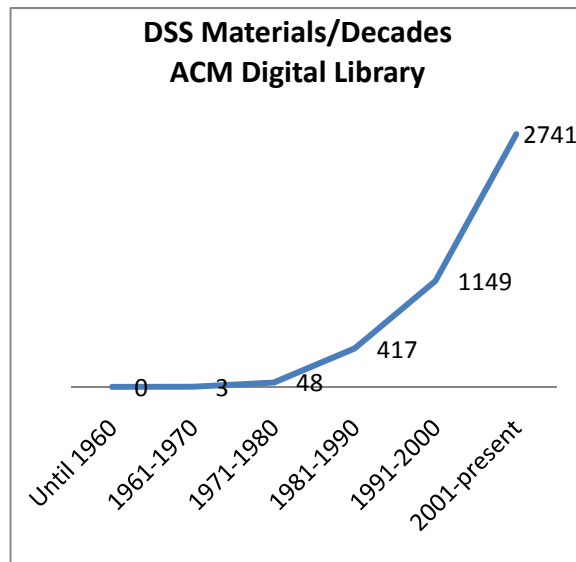
The IEEE Xplore Digital Library frames the scientific production in wider areas. The top 15 subjects of the DSS production in IEEE are: computing & processing (5180 materials), communication, networking & broadcasting (2729), signal processing & analysis (1964), components, circuits, devices & systems (1481), robotics & control systems (1461), bioengineering (968), power, energy, & industry applications (950), general topics for engineers (math, science & engineering) (751), engineered materials, dielectrics & plasmas (734), fields, waves & electromagnetics (565), engineering profession (529), aerospace (508), photonics & electro-optics (481), geoscience (336) and transportation (306). This list of topics suggests other DSS

implementation areas: power, energy and industry applications, aerospace, geoscience and transportation. It must be noted that the main subject of the DSS materials was *computing and processing* and the second subject

*communication, networking and broadcasting*, showing therefore the increased interest and development on the fourth generation of DSS: web-based DSS.



**Fig. 3.** Evolution of DSS Materials Number per decades (IEEE Xplore Digital Library)



**Fig. 4.** Evolution of DSS Materials Number per decades (ACM Digital Library)

Unlike the ScienceDirect and IEEE Xplore Digital Library, that offers a list of subjects/topics of the materials which contains the searched words, ACM Digital Library provides a list of discovered words which can be used to refine the search. The first 15 discovered words on DSS materials are: decision support (2927), decision support systems (2804), systems (788), DSS (638), decision making (563), decision – making (466), evaluation (459), complexity (416), rules (393), area (372), practice (359), cost (339), information system (338), strategies (321) and identifiability (316).

Until 1980, there were only a few published papers about decision support systems which were related to information systems, evaluation, cost, planning systems, strategic planning or support systems (Table 2.). According to Power [12], “beginning in about 1980 many activities associated with building and studying DSS occurred in universities and organizations that resulted in expanding the scope of DSS applications”. Therefore, the DSS applications expanded beyond the initial business and management domain. The pa-

pers published in ‘80s were starting to present more about expert systems, manufacturing systems or communication and networking (Table 2). The communication-driven DSS have their origins during this period. The major applications for DSS “emphasized manipulating quantitative models, accessing and analyzing large data bases and supporting group decision making” [12].

In ‘90s the DSS research was focused on decision support, support systems, experts systems, neural networks and on a particular type of DSS: group decision support systems (GDSS) [13] (Table 2). The web technologies development provided the opportunities for extending the capabilities and deployment of decision support systems, especially communication-driven and group DSS.

In the last decade the DSS research interest was focused on web-based DSS, and the published materials on DSS were presenting more specific DSS implementation than general DSS. In Table 2 there can be identified research topics as supply chains, health care robotics and control systems.

In 2005, Arnott and Pervan [14] noted that to

the DSS 2004 conference (IFIP Working Group 8.3 Conference), from the total of 86 research papers, 30 were about personal DSS, 9 about GDSS, 6 about executive information systems (EIS) (includes business intelligence), 4 about data warehouse, 10 were related to Intelligent DSS, 11 to knowledge management – based DSS, 6 to negotiation support systems and 6 to many DSS types. Arnott and Pervan also showed, by analysing 1020 articles published in the 14 most known DSS journals, that from 1990 to

2003 the DSS research was mainly focused in four areas: personal DSS (35,3%), group support systems (29,2%), intelligent DSS (14,4%) and large data centred systems (EIS) (7,3%). They noted that the decision support focus of the papers they analysed was “reasonably spread” across information technology (23,8%), system development (22,3%), the decision-making process (19%) and the impact of the systems on the organization (16,9%).

**Table 2.** Numbers of DSS materials published in each decade, presented per author and topic/subject/discovered terms (12.11.2010)

Years	Authors			Topic/Subject/Discovered terms		
	ScienceDirect	IEEE	ACM	ScienceDirect	IEEE	ACM
<b>Until 1970</b>	Kaufmann, F. (1) Kleiter, G.D. (1) Kelly, J.A. (1) Gustafson, D.H. (1) Wood, R.C. (1) Myers, J.H. (1) Rhind, R. (1) Kissler, K.H. (1) Kose, R. (1) Trinks, U. (1)	Fischler, M. (1) Schwartz, L. (1) McConnell, J.W. (1) Mattson, R. (1) Firschein, O. (1) Healy, L. (1) Belis, M. (1) Meadows, R.A. (1) Filipowsky, R. (1) Abramson, N. (1) Warfield, J. N. (1)	Warfield, J. N. (1) Kavanagh, T. F. (1) Beged Dov, A. G. (1) Carmichael, C. D. (1) Mitchell, I. E. (1) Ferguson, S. T. (1) Struble, W. H. (1)	Analog computer (2) Information system (2) Spark chamber (2) System approach (2) Markov chain (1)	Components, Circuits, Devices & Systems (4) Communication, Networking & Broadcasting (3) Computing & Processing (Hardware/Software) (3) Signal Processing & Analysis (3) Robotics & Control Systems (2)	information system (2) evaluation (1) performability (1) addition (1) cost (1)
<b>1971-1980</b>	King, W.R. (4) Gordon, L.A. (3) Sage, A.P. (3) Dobrov, G.M. (3) Cole, J.D. (3) Hoffman, K.C. (2) Axelrod C.W. (2) Cohen, C.N. (2) Conn, D. (2) Warner, H.R., (2)	Donovan, J.J. (1) Lee, M.J. (1) Ben-Bassat, M. (1) Thomas, J. (1) Studer, R. (1) Ernst, R.L. (1) Powell, R.E. (1) Poor, H. (1) Jacqby, H.D. (1) Rouse, William B. (1)	McLeod, R. (3) Whinston, A.B. (2) Keen, P. G. W. (2) Donovan, J. J. (2) Carlson, E.D. (2) Edelman, F. (2) Davis, R. (1) Studer, R. (1) Misra, J. (1) Madnick, S.E. (1)	Information system (17) Decision support (4) Planning system (4) Strategic decision (4) Support system (4)	Computing & Processing (Hardware/Software) (11) Engineered Materials, Dielectrics & Plasmas (6) Components, Circuits, Devices & Systems (5) Signal Processing & Analysis (5) Communication, Networking & Broadcasting (4)	decision support (27) decision support system (27) DSS (11) addition (9) cost (9)
<b>1981-1990</b>	Kersten, G.E. (6) Pedrycz W. (5) Kacprzyk, J. (5) Jarke, M. (5) Suh, N.P. (4) Whinstone, A.B. (4) Gupta, Y.P. (3) Moore, J.C. (3) Telem, M. (3) Jelassi, M.T. (3)	Nunamaker, J.F., Jr. (9) Chong, C.-Y. (9) Tse, E. (8) Mori, S. (8) Mori, S. (6) Chang, K.-C. (6) Athans, M. (6) Vogel, D.R. (5) Manheim, M.L. (4) Chong, C.-Y. (4)	Kacprzyk, J. (2) Gray, P. (2) Vogel, D.R. (2) Inmon, W.H. (2) Konsynski, B.R. (2) Kersten, G.E. (2) Applegate, L.M. (2) Raman, K. S. (2) Cundiff, W. E. (2) Weber, E. S. (2)	Expert system (85) Decision support (59) Support system (59) Information system (39) Manufacturing system (20)	Computing & Processing (Hardware/Software) (344) Signal Processing & Analysis (212) Communication, Networking & Broadcasting (194) Components, Circuits, Devices & Systems (130) Robotics & Control Systems (113)	decision support (310) decision support system (306) DSS (30) systems (25) area (23)
<b>1991-</b>	Hasman, A. (6) Eom, S.B. (5)	Kokol, P. (12) McDonald, J.R.	Aiken, M. (13) Turban, E. (4)	Decision support (164)	Computing & Processing (Hard-	decision support (826)

Years	Authors			Topic/Subject/Discovered terms		
	ScienceDirect	IEEE	ACM	ScienceDirect	IEEE	ACM
2000	Visser, M.C. (5)	(10)	Wierenga, B. (4)	Support system (137)	(Hardware/Software) (1,452)	decision support system (806)
	Vallega, A. (5)	Tuominen, M. (9)	Fox, J. (3)	Expert system (111)	Communication, Networking & Broadcasting (688)	DSS (123)
	Wei, K.K. (5)	Hiltz, S.R. (9)	Bhargava, H.K. (3)	Information system (87)	Signal Processing & Analysis (620)	Systems (110)
	Karacapilidis, N. (5)	Hipel, K.W. (8)	Chan, C.-Y. (3)	Neural network (54)	Robotics & Control Systems (412)	group decision support systems (107)
	Forgionne, G.A. (5)	Nunamaker, J.F., Jr. (7)	Kauffman, R.J. (2)		Components, Circuits, Devices & Systems (378)	
	Dijkhuizen, A.A. (5)	Briggs, R.O. (7)	Papadias, D. (2)		Computing & Processing (Hardware/Software) (3,407)	decision support (1,754)
	Whinstone, A.B. (4)	Baba, N. (7)	Ma, J. (2)		Communication, Networking & Broadcasting (1,868)	decision support system (1,655)
	Larsen, E.R. (4)	Kilgour, D.M. (7)	Ranganathan, N. (2)		Signal Processing & Analysis (1,152)	Systems (643)
					Components, Circuits, Devices & Systems (985)	DSS (472)
					Robotics & Control Systems (951)	decision making (431)
2001-present	Patel, V.L. (14)	Frize, M. (13)	Lu, J. (9)	Decision support (178)		
	Puigjaner, L. (10)	Smirnov, A. (9)	Zhang, G. (9)	Supply chain (77)		
	Ubeyli, E.D. (10)	Pashkin, M. (9)	Kacprzyk, J. (7)	Support system (73)		
	Tzeng, G.H. (9)	Levashova, T. (9)	Raś, Z.W. (7)	Information system (45)		
	Khan, F.I. (7)	Vale, Z.A. (8)	Arús, C. (7)	Health care (44)		
	Ma, J. (6)	Ramos, C. (6)	Revetria, R. (6)			
	Jimenez, A. (6)	Lewis, P. (6)	Vellido, A. (6)			
	Espuna, A. (6)	Nikraves, M. (6)	Romero, E. (5)			
	Herrera-Viedma, E. (5)	Najarian, K. (6)	Psarras, J. (5)			
	Ruan, D. (5)	Premchaiswadi, W. (6)	Barkhi, R. (5)			

In the last ten years, the DSS research production kept the ascendant trend (Figure 5). There were recorded only insignificant decreases of the DSS research production from one year to another: in ScienceDirect, in 2002 compared to 2001, and 2008 compared to 2007; in IEEE Xplore Digital Library, in

2005 compared to 2004. The results for 2010 are not relevant considering that the publication indexing rate may vary and probably it is not up to the publication rate, and therefore these numbers do not show a clear vision of the DSS research published materials.

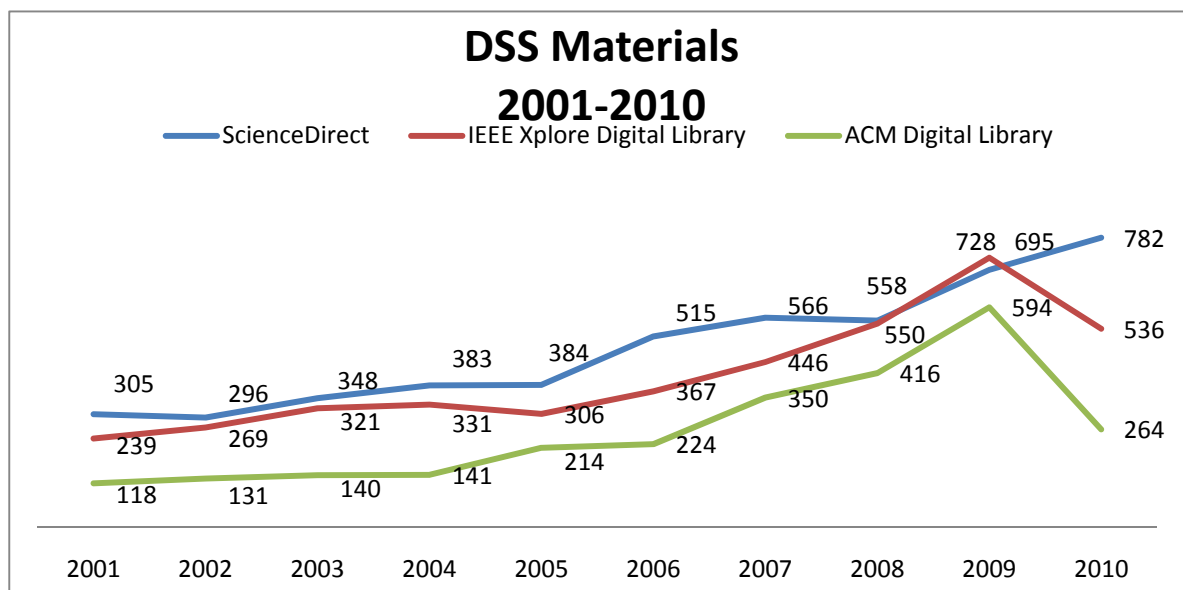


Fig. 5. DSS Research production in the last 10 years

Table 3 presents the first ten publications (journals/books) that contain DSS research papers. The journal with the widest number of articles indexed by one of the database selected (ACM Digital Library), is the *Decision Support System* journal with 593 articles. ScienceDirect includes only 302 DSS articles of this journal (second place).

The next journal, with 353 articles, is *European Journal of Operational Research*. On

the third place is *Expert Systems with Applications* (294 articles) followed by *Fuzzy Sets and Systems* and *Information & Management* with the same number of articles, 132. Not far, there are *International Journal of Production Economics* (119 articles), *Agricultural Systems* (115 articles) and *Computers & Industrial Engineering* (106 articles).

**Table 3.** The first 10 publications which includes DSS materials (12.11.2010)

ScienceDirect		IEEE Xplore Digital Library		ACM Digital Library	
Journal/Book title	No.	Journal/Book title	No.	Journal/Book title	No.
<b>European Journal of Operational Research</b>	353	IEEE Transactions on Systems, Man and Cybernetics	61	Decision Support Systems	593
<b>Decision Support Systems</b>	302	IEEE Transactions on Information Technology in Biomedicine	52	Expert Systems with Applications: An International Journal	140
<b>Expert Systems with Applications</b>	294	Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences, 1991.	49	Information and Management	97
<b>Fuzzy Sets and Systems</b>	132	Proceedings of the Twenty-Third Annual Hawaii International Conference on System Sciences, 1990.	48	Interfaces	70
<b>Information &amp; Management</b>	132	HICSS-32. Proceedings of the 32nd Annual Hawaii International Conference on System Sciences, 1999.	47	ACM SIGMIS Database	36
<b>International Journal of Production Economics</b>	119	Vol.III: Decision Support and Knowledge Based Systems Track, Proceedings of the Twenty-Second Annual Hawaii International Conference on System Sciences, 1989.	45	Computers and Electronics in Agriculture	36
<b>Agricultural Systems</b>	115	IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans	42	Journal of Medical Systems	29
<b>Computers &amp; Industrial Engineering</b>	106	IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews	39	Computers and Operations Research	28
<b>Social Science &amp; Medicine</b>	85	IEEE International Conference on Systems, Man, and Cybernetics, 1997. 'Computational Cybernetics and Simulation, 1997	38	Proceedings of the 28th Hawaii International Conference on System Sciences	26
<b>Omega</b>	82	Vol.III. Decision Support and Knowledge Based Systems Track, Proceedings of the Twenty-First Annual Hawaii International Conference on System Sciences, 1988.	37	Management Science	22

Among the journals, the DSS top 10 publications lists include also the proceedings of two conferences: *International Conference on Systems, Man, and Cybernetics*, 1997 and *Annual Hawaii International Conference on System Sciences*, editions 21 (in 1998), 22 (in 1989), 23 (in 1990), 24 (in 1991), 28 (in 1995) and 32 (1999).

### 3 Conclusions

The DSS systems have constantly evolved from stand-alone systems installed on one workstation to complex systems which runs

on multiple computers in a networked structure, locally, at the beginning, and then worldwide. In the same time, many organizational decisions switched from individual decisions to small groups decisions and later to complex decisions of large groups of different individuals, often placed in geographically distributed locations [15] [16].

A computer-assisted research profiling of the DSS field enriches the traditional literature reviews and provide a "big picture" perspective on the research activity on DSS.

The results presented in this paper show the

increasing interest on the research area of decision support systems, the research interests over the years and the research trends on the last decade, the publications (journals and conferences) which gather most of the DSS research papers and the authors with the widest number of DSS published works, per decades.

There have been selected for study three international scientific databases in order to obtain a more accurate perspective on the DSS research field.

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