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Mobile computing: a scientometric assessment of global publications output

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The paper examines 34641 global publications output on mobile computing research, as covered in Scopus database during 2007-16. The study finds that mobile computing research is growing at 9.35% rate per annum and its citation impact averaged to 3.39 citations per paper. The global share of top 10 most productive countries ranged from 3.29% to 31.06%, with largest global publication share coming from China (31.06%), followed by USA (15.35%), etc. Together, the top 10 most productive countries accounted for 81.24% global publication share during 2007-16. Seven of top 10 countries achieved relative citation index above world average of 1: USA (2.37), U.K. (1.78), Italy (1.72), Canada (1.64), etc. International collaborative publications share of top 10 most productive countries in mobile computing research during 2007-16 varied from 11.55% to 48.16%. Computer Science, among subjects, accounted for the largest publication share (89.55%), followed by engineering (33.58%), social sciences (18.67%), mathematics (8.74%), etc. during 2007-16. The top 20 most productive organizations and authors contributed 14.79% and 1.76% global publication share respectively and accounted for 9.5% and 5.11% global citation share respectively during 2007-16. The top 20 journals accounted for 24.11% share of total journals output of 5673 papers during 2007-16. The top 50 highly cited publications registered citations in the range from 164 to 1235 citations per paper and together these top 50 papers cumulated 16822 citations, with an average of 336.4 citations per paper. These 50 highly cited papers resulted from participation of 184 authors and 103 organizations, and were published in 31 journals, including 4 in *IEEE Transactions on Mobile Computing,* 2 papers each in *Decision Support System, IEEE Communication Magazine, IEEE Pervasive Computing and IEEE Communication Surveys & Tutorials* and 1 paper each in other 26 journals.

Keywords: Mobile computing; Scientometrics; Citation impact

Introduction

Mobile computing utilizes portable computing devices and wireless communication networks for computing and communication[1]. In mobile computing, users can connect their portable computing devices such as laptop, tablet or smart-phone wirelessly to and through the internet from where ever they are to and through a private network. Continuous connectivity from any place of their convenience -- say, business, homes, and hot-spots cyber cafes, available on cell phones – is central to the concept of mobile computing. Mobile computing is all about portable computing devices coupled with wireless access to communication networks; no physical connectivity, only remote or mobile connectivity. It frees users from spatial and temporal constraints of an organization's fixed information system. Recent new technologies and innovations in mobile computing in particular in (i) wireless communication, (ii) client-end mobile devices for interactivity, and (iii) mobile applications have together spurred the mobile revolution and made mobile computing more and more pervasive. Mobile computing is seen as an instance of third wave of computing -- characterized as one person-to-many computers, though not practical in desktop computer environment[2]. Mobile computing platform has in the recent past demonstrated its immense potential to spur the pace of digital economy in India. Given its wide range of applications in almost all sectors of the national economy, mobile computing has truly changed and improved quality of our daily life and has made this world a better place to live in. Currently, R&D work in mobile computing technologies spans a wide range of topics including security issues, powerful wireless communication,

mobile application platform, client-end mobile devices, etc.

This paper seeks to look at global publications output in mobile computing research with a view to understand what are the current global trends in mobile computing research and which countries are providing impetus to growth in mobile computing research output.

Review of literature

There are only a few studies available on broad quantitative analysis of mobile computing research. Among these studies, Anderson[3] selected 102 papers (from 26 journals) on mobile computing between 1999 and 2008 and classified them based on the accentuated factors of mobile computing, research approach (descriptive or prescriptive) and use scenario (B2E/B2B, B2C/C2C, or Technical/Neutral). The results showed that most articles stressed factors such as context awareness (25.4%), interface (21.5%), varying connectivity (13.8%) and hardware capacities (9.8%). The author mentioned the under-researched factors in application dependencies, supporting technologies, task dependencies and time dependencies.

Ladd, Datta, Sarkar, and Yu[4] analyzed mobile computing trends in research and practice between the years 2000–2009 with an inductive categorization of 806 articles in nineteen leading academic, crossover and practitioner outlets. They developed a comprehensive framework that addresses both where mobile computing research has been over the past ten years, but also areas of opportunity for future research.

Fischer and Smolnik[5] provided an overview of existing research on mobile, ubiquitous, and pervasive computing, classify extant literature according to the studies' focus on the impact of mobile computing use on the individual, organization, and society and uncover areas where further research is needed. Chang and Wang[6] performed a co-word analysis for a corpus of 4821 SCI/SSCI indexed papers related to mobility in the Web of Science (WoS) database from 1995 to 2013 and revealed the interplay over time among mobile computing, commerce, and applications. Ailsto and Alahuhta[7] explored whether one can predict the supply and consequently the diffusion of new mobile technology-based innovations by studying the number of publications discussing that technology?

The bibliometric method is used to analyze the research effort put into certain enabling technologies for mobile computing and then their diffusion is estimated by looking at the new products that incorporate these technologies. Barbara[8] indicated that the emergence of powerful portable computers, along with advances in wireless communication technologies, has made mobile computing a reality. Among its applications that are finding their way to the market of mobile computing those that involve data management hold a prominent position. In the past few years, there has been a tremendous surge of research in the area of data management in mobile computing. This research has produced interesting results in areas such as data dissemination over limited bandwidth channels, location-dependent querying of data, and advanced interfaces for mobile computers.

This paper is an effort to survey these techniques and to classify this research in a few broad areas.

Objectives of the study

The main objectives of this study are to study the performance of global mobile computing research during 2007-16, based on publications covered in Scopus database. Specific objectives are:

- To study the growth of world research output and the citation impact of the research output;
- To understand the international collaboration share of top 10 most productive countries;
- To examine global research output by broad subject areas and study their growth and decline;
- To trace the subject trends by identifying significant keywords; (v) to study the publication productivity and citation impact of 20 most productive organizations and authors; and
- To study the characteristics of top 50 highly cited papers

Methodology

The study retrieved and downloaded the publication data of the world in mobile computing

Table 1—World literature on mobile computing research

Publication Period	World		
	TP	TC	CPP
2007	2428	15830	6.52
2008	6130	21649	3.53
2009	4588	20262	4.42
2010	3299	12928	3.92
2011	3094	12916	4.17
2012	2940	11465	3.90
2013	2835	11490	4.05
2014	3022	6406	2.12
2015	3680	3930	1.07
2016	2625	551	0.21
2007-11	19539	83585	4.28
2012-16	15102	33842	2.24
2007-16	34641	117427	3.39

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper

research from the Scopus database (http://www.scopus.com) for 10 years during 2007-16. Keywords, such as "mobile computing'' or ''m-computing'' or ''mcomputing" were used in "keyword" tag and restricting it to the period 2007-16 in "date range tag" was used for searching the global publication data and this becomes the main search string. When the main search string with restricted to individual top 10 most productive country name in "country tag", the publication data on the individual country in mobile computing was obtained. The search string is further restricted to "subject area tag", "country tag", "source title tag", "journal title name" and "affiliation tag", to get information on the distribution of publications by subject, collaborating countries, author-wise, organization-wise and journal-wise, etc. For citation data, citations to publications were also collected from the date of publication till 29 December 2016.

KEY("Mobile computing" or "M-computing" or "Mcomputing") AND PUBYEAR > 2006 AND PUBYEAR < 2017

Analysis

The world has published 34641 publications on mobile computing research in 10 years during 2007-16, which increased from 2428 publications in 2007 to 2625 publications in 2016, registering annual average growth rates of 9.35%. The cumulative growth of world publications on mobile computing research increased from 19539 during 2007-11 to 15102 publications during 2012-16, witnessing a growth rate of -22.71%. The average citation per publication (CPP) registered by global publications on mobile computing research was 3.39 during 2007-16, which decreased from 4.28 during 2007-11 to 2.24 during 2012-16 (Table 1).

Global publication share & citation Impact of Top 10 most productive countries

The global mobile computing output originated in more than 100 countries during 2007-16. Table 2 lists the output of top 10 most productive countries in mobile computing research during 2007-16. The publication share of 10 most productive countries in mobile computing research was 81.24% of the world output during 2007-16, which decreased from 84.04% during 2007-11 to 77.62% during 2012-16. Individually, the global publication share of these 10 countries varied from 3.29% to 31.06% during 2007-16, with highest publication share (31.06%) coming from China, followed by USA (15.35% share), South Korea (5.59%), Germany, U.K., India and Taiwan (from 4.01% to 4.92% share), Japan, Canada and Italy (from 3.29% to 3.71% share)during 2007-16. The global publication share has increased by 6.73% in USA, followed by 5.28% in India, 1.67% in Italy, 1.01% in U.K., South Korea and Canada (0.70% each), 0.52% in Germany, 0.38% in Japan and 0.29% in Taiwan, as against decrease by 23.73% in China from 2007-11 to 2012-16. Seven out of 10 countries have scored relative citation index more than 1: USA (2.37), U.K. (1.78), Italy (1.72), Canada (1.64), Taiwan (1.24), Germany (1.17) and South Korea (1.04) during 2007-16.

International collaboration

The share of international collaborative publications of the top 10 countries varied from 11.55% to 48.16%, with the highest share coming from U.K. (48.16%),followed by Canada (42.42%), USA (32.08%), Italy (31.73%), Germany (31.48%), Japan (24.28%), South Korea (19.57%), Taiwan (13.62%), China (12.32%) and India (11.75%) during 2007-16.

Distribution of research output by sub-fields

The global mobile computing output research during 2007-16 has been published in the context of nine sub-fields (as reflected in Scopus database classification), with highest publications share

Table 2—Publication output and global publication share of top 10 most productive countries in mobile computing during 2007-16

Sl. no.	Name of the country	Number of papers			Share of papers			TC	CPP	ICP	%ICP	RCI
		2007-11	2012-16	2007-16	2007-11	2012-16	2007-16	2007-16				
1	China	8089	2669	10758	41.4	17.67	31.06	14674	1.36	1325	12.32	0.4
2	USA	2426	2892	5318	12.42	19.15	15.35	42670	8.02	1706	32.08	2.37
3	South Korea	1032	905	1937	5.28	5.99	5.59	6834	3.53	379	19.57	1.04
4	Germany	918	788	1706	4.7	5.22	4.92	6775	3.97	537	31.48	1.17
5	U.K.	864	820	1684	4.42	5.43	4.86	10141	6.02	811	48.16	1.78
6	India	493	1178	1671	2.52	7.8	4.82	2990	1.79	193	11.55	0.53
7	Taiwan	758	630	1388	3.88	4.17	4.01	5857	4.22	189	13.62	1.24
8	Japan	692	593	1285	3.54	3.93	3.71	4264	3.32	312	24.28	0.98
9	Canada	647	607	1254	3.31	4.02	3.62	6959	5.55	532	42.42	1.64
10	Italy	501	640	1141	2.56	4.24	3.29	6667	5.84	362	31.73	1.72
	Total	16420	11722	28142	84.03	77.62	81.23	107831	3.83			
	World	19539	15102	34641				117427	3.39			
	Share of 10 Countries in World Total	84.04	77.62	81.24				91.83				

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index

Table 3—Global publications in mobile computing by sub-fields

Sl. no.	Subject*	Number of Papers (TP)			Activity Index		%TP
		2007-11	2012-16	2007-16	2007-11	2012-16	2007-16
1	Computer Science	17821	13201	31022	101.85	97.61	89.55
2	Engineering	8097	3536	11633	123.40	69.72	33.58
3	Social Science	5109	1358	6467	140.06	48.17	18.67
4	Mathematics	1433	1595	3028	83.90	120.83	8.74
5	Medicine	160	432	592	47.92	167.39	1.71
6	Decision Science	215	352	567	67.23	142.40	1.64
7	Business, accounting & management	255	235	490	92.26	110.01	1.41
8	Physics & astronomy	216	273	489	78.31	128.06	1.41
9	Biochemistry, genetics & molecular biology	329	139	468	124.63	68.13	1.35
	World Output	19539	15102	34641			

*There is overlapping of literature under various subjects

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper

(89.55%) coming from computer science, followed by engineering (33.58%), social sciences and mathematics (18.67% and 8.74%), medicine, decision science, business, accounting & management, physics & astronomy and biochemistry, genetics & molecular biology (from 1.35% to 1.71%) during 2007-16. The research activity, as reflected in activity index, has witnessed decrease in computer science (from 101.85 to 97.61), engineering (from 123.40 to 69.72), social science (from 140.06 to 48.17) and biochemistry, genetics & molecular biology (from 124.63 to 68.13), as against increase in mathematics (from 83.90 to 120.83), medicine (from 47.92 to 167.39), decision science (from 67.23 to 142.40), business, accounting & management (from 92.26 to 110.01) and physics & astronomy (from 78.31 to 128.06) from 2007-11 to 2012-16 (Table 3).

Most productive organizations

In global mobile computing research, the productivity of 20 most productive organizations varied from 162 to 812 publications and together contributed 14.79% (5125 publications) publication share and 9.51% (11163) citation share to its

Table 4—Profile of top 20 most productive global organizations in mobile computing research

Sl. no.	Institutions	TP	TC	CPP	HI	ICP	%ICP	RCI
1	Beijing University of Post & Telecommunications, China	812	1055	1.30	14	70	8.62	0.38
2	Wuhan University, China	384	214	0.56	7	32	8.33	0.16
3	Tsinghua University, China	376	1552	4.13	20	105	27.93	1.22
4	Huazhong University of Science & Technology, China	347	703	2.03	11	73	21.04	0.60
5	University of Electronics Science & Technology of China	260	261	1.00	8	28	10.77	0.30
6	Herbin Institute of Technology, China	238	172	0.72	7	24	10.08	0.21
7	Dalian University of Technology, China	222	409	1.84	10	41	18.47	0.54
8	Southeast University, China	218	161	0.74	7	17	7.80	0.22
9	Nokia, Finland	214	1167	5.45	18	138	64.49	1.61
10	Beijing Jiaotong University, China	205	427	2.08	10	40	19.51	0.61
11	Xidian University, China	203	276	1.36	9	47	23.15	0.40
12	Beihang University, China	199	223	1.12	8	24	12.06	0.33
13	Carnegie Mellon University, USA	199	2909	14.62	24	69	34.67	4.31
14	Nanjing University of Posts & Telecommunications, China	190	162	0.85	6	22	11.58	0.25
15	South China University of Science & Technology, China	186	458	2.46	8	23	12.37	0.73
16	Beijing Institute of Technology, China	184	166	0.90	4	10	5.43	0.27
17	Tianjin University, China	180	108	0.60	6	11	6.11	0.18
18	North China Electric Power University, China	174	22	0.13	2	3	1.72	0.04
19	Zhejiang University, China	172	231	1.34	7	29	16.86	0.40
20	Electronics & Telecommunication Research Institute, South Korea	162	487	3.01	11	13	8.02	0.89
	Total of 20 organizations	5125	11163	2.18	9.85	819	15.98	0.68
	Total of India	34641	117427	3.39				
	Share of top 20 organizations in India's total	14.79	9.51					

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index

cumulative publications output during 2007-16. The scientometric profile of these 20 organizations is presented in Table 4. Five organizations have registered higher publications output than the group average of 256.25: Beijing University of Post & Telecommunications, China (812 publications), Wuhan University, China (384 publications), Tsinghua University, China (376 publications), Huazhong University of Science & Technology, China (347 publications) and University of Electronics Science & Technology of China (260 publications) during 2007-16.

Five organizations have registered more than the average citation per publication (2.18) during 2007-16: Carnegie Mellon University, USA (14.62), Nokia, Finland (5.45), Tsinghua University, China (4.13), Electronics & Telecommunication Research Institute, South Korea (3.01) and South China University of Science & Technology, China (2.46).

Eight organizations have registered more than the average h-index (9.85): Carnegie Mellon University, USA (24), Tsinghua University, China (20), Nokia, Finland (18), Beijing University of Post & Telecommunications, China (14), Electronics & Telecommunication Research Institute, South Korea and Huazhong University of Science & Technology, China (11 each), Beijing Jiaotong University, China and Dalian University of Technology, China (10 each) during 2007-16.

Eight organizations have achieved more than the average share of international collaborative publications (15.98%): Nokia, Finland (64.49%), Carnegie Mellon University, USA (34.67%), Tsinghua University, China (27.93%), Xidian University, China(23.15%), Huazhong University of Science & Technology, China (21.04%),Beijing Jiaotong University, China (19.51%),Dalian University of Technology, China (18.47%) and Zhejiang University, China (16.86%) during 2007-16.

Table 5—Top 20 most productive authors in mobile computing research

Sl. no.	Author	Author affiliation	TP	TC	CPP	HI	ICP	%ICP	RCI
1	V.C.M. Leung	University of British Columbia	44	453	10.3	11	32	72.73	3.04
2	J.J.P.C. Rodriques	University of Beira Interior, Portugal	42	262	6.24	9	34	80.95	1.84
3	J. Cao	Hong Kong Polytechnic University, China	37	259	7	8	29	78.38	2.06
4	R. Deters	University of Saskatchewan, Canada	35	113	3.23	5	3	8.57	0.95
5	A. Gani	University of Malaya, Malaysia	34	681	20.03	15	20	58.82	5.91
6	M.Chen	Huazhong University of Science & Technology, China	31	284	9.16	7	26	83.87	2.7
7	T.Kunz	Carleton University, Ottawa, Canada	29	93	3.21	5	2	6.9	0.95
8	A.Schmidt	University of Duisberg, Essen, Germany	29	258	8.9	6	17	58.62	2.62
9	E.N.Huh	Kyung Hee University, S.Korea	28	22	0.79	3	2	7.14	0.23
10	S.W. Loke	La Trobe University, Australia	29	548	18.9	5	8	27.59	5.57
11	L.Shu	Guangdong University of Petroleum Technology, China	28	102	3.64	5	25	89.29	1.07
12	R.Tafazolli	University of Surrey, U.K.	28	54	1.93	4	4	14.29	0.57
13	B.Dheodt	Ghent university College, Belgium	27	268	9.93	8	2	7.41	2.93
14	M.Gerla	University of California Los Angles, USA	27	133	4.93	7	7	25.93	1.45
15	B.Guo	Northwestern Polytechnic University, Xian, China	27	247	9.15	7	19	70.37	2.7
16	M. Satyanarayanan	Carnegie Mellon University, USA	27	1173	43.44	11	12	44.44	12.82
17	Z. Yu	Northwestern Polytechnic University, Xian, China	27	213	7.89	6	18	66.67	2.33
18	Z.Zhong	Beijing Jiaotong University, China	27	157	5.81	6	5	18.52	1.72
19	A.V.Vasilakos	National Technical University of Athens, Greece	26	391	15.04	9	26	100	4.44
20	D.Zhang	Institut Telecom SudParis, France	26	287	11.04	8	23	88.46	3.26
		Total of 20 authors	608	5998	9.87	7.25	314	51.64	2.96
		Total of the World	34641	117427	3.39				
		Share of 20 authors in World output	1.76	5.11					

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index

Five organizations have registered the relative citation index more than average (0.68): Carnegie Mellon University, USA (4.31), Nokia, Finland (1.61), Tsinghua University, China (1.22), Electronics & Telecommunication Research Institute, South Korea (0.89) and South China University of Science & Technology, China (0.73) during 2007-16

Most productive authors

In global mobile computing research, the productivity of 20 most productive authors varied from 26 to 44 publications and together contributed 1.76% (608 publications) publication share and 5.11% (5998) citation share to its cumulative publications output during 2007-16. The scientometric profile of these 20 authors is presented in Table 5.

Six authors have registered higher publications output than the group average of 30.4: V.C.M. Leung (44 publications), J.J.P.C. Rodriques (42 publications), J. Cao (37 publications), R. Deters (35 publications), A. Gani (34 publications) and M.Chen (31 publications) during 2006-15.

Seven authors have registered more than the average citation per publication (9.68) of all authors: M. Satyanarayanan (43.44), A. Gani (20.03), S.W. Loke (15.04), A.V.Vasilakos (15.04), D.Zhang (11.04), V.C.M. Leung (10.30) and B.Dheodt (9.93) during 2007-16.

Eight authors have registered more than the average h-index (7.25) of all authors: A. Gani (15), M. Satyanarayanan and V.C.M. Leung (11 each), A.V.Vasilakos and J.J.P.C. Rodriques (9 each),

D.Zhang, B.Dheodt and J. Cao (8 each) during 2007-16.

Eleven authors have achieved more than the average share of international collaborative publications (51.64%) of all authors: A.V.Vasilakos (100.0%), L.Shu (89.29%), D.Zhang (88.46%), M.Chen (83.87%), J.J.P.C. Rodriques (80.95%), J. Cao (78.38%),V.C.M. Leung (72.73%), B.Guo (70.37%), Z. Yu (66.67%), A. Gani (58.82%) and A.Schmidt (58.62%) during 2007-16.

Six authors registered the relative citation index more than average (2.96) of all authors: M. Satyanarayanan (12.82), A. Gani (5.91), S.W. Loke (5.57), A.V.Vasilakos (4.44), D.Zhang (3.26) and V.C.M. Leung (3.04) during 2007-16.

Preferred journals

The 20 most productive journals in mobile computing research contributed from 41 to 171 papers and together contributed 24.11% share (1368 papers) to the total journal publication output during 2007-16. The publication share of these top 20 most productive journals increased from 22.08% to 25.48% from 2007-11 to 2012-16. The most productive journal (with 171 papers) was *IEEE Pervasive Computing*, followed by *IEEE Transactions on Mobile computing* (132 papers), *Personal and Ubiquitous Computing* (102 papers), *Pervasive and Mobile Computing* (99 papers), etc. during 2007-16 (Table 6).

Significant keywords

Around 41 significant keywords have been identified from the literature, which throws light on the possible trends of research in this field. These keywords are listed in Table 7 in the decreasing order of the frequency of occurrence during 2007-16.

Highly cited papers

There were 50 highly cited papers, which have received citations from 164 to 1235 during 2007-16. These 50 highly cited papers together received 16822 citations, leading to average citation per paper of 336.4 Of the 50 highly cited papers, 10 involve the participation of single organization (non-collaborative) and 40 involved the participation of two or more organizations (of which 20 national collaborative and 20 international collaborative). Among international collaborative papers, the largest participation among 18 countries, was with USA (31 papers), followed by U.K. and Canada (4 papers each), Australia, India and H. Kong (3 papers each), France, Germany, Switzerland, Taiwan and China (2

Table 6—Preferred journals in mobile computing research

Sl. no.	Journal	Number of Papers		
		2007-11	2012-16	2007-16
1	IEEE Pervasive Computing	56	115	171
2	IEEE Transactions on Mobile Computing	53	79	132
3	Personal and Ubiquitous Computing	38	64	102
4	Pervasive and Mobile Computing	22	77	99
5	IEEE Communication Magazine	50	32	82
6	Wireless Personal Communication	37	45	82
7	Telemedicine & E-Health	16	48	64
8	Future Generation Computer Systems	14	45	59
9	Multimedia Tools & Applications	9	48	57
10	Journal of Network & Computer Applications	23	33	56
11	Sensors, Switzerland	0	53	53
12	International Journal of Wireless & Mobile Computing	6	44	50
13	Journal of Supercomputing	10	40	50
14	Mobile Networks & Applications	14	35	49
15	Computer Communication	29	18	47
16	IEEE Transactions on Vehicular Technology	32	14	46
17	International Journal of Mobile Communication	31	15	46
18	IEEE Internet Computing	20	21	41
19	IEEE Transactions on Consumer Electronics	27	14	41
20	Journal of Systems & Software	16	25	41
	Total of 20 Journals	503	865	1368
	Total of World	2278	3395	5673
	Share of 20 journals in World journal output	22.08	25.48	24.11

Table 7—Significant keywords in literature on mobile computing

Sl. no.	Keyword	Frequency	Sl. no.	Keyword	Frequency	Sl. no.	Keyword	Frequency
1	Mobile Computing	21149	17	Sensor Networks	1442	33	Mobile Agents	840
2	Wireless Telecommunication Systems	11029	18	Sensors	1400	34	Cryptography	796
3	Wireless Networks	8910	19	Smart Phones	1383	35	Artificial Intelligence	790
4	Mobile Devices	7229	20	Mobile Cloud Computing	1359	36	Sensor Nodes	788
5	Ubiquitous Computing	5156	21	Telecommunication Networks	1252		Wireless Local Area Networks	728
6	Mobile Telecommunication Systems	3886	22	Human Computer Interactions	1228	37	Computer Networks	654
7	Mobile Applications	2946	23	Computer Simulation	1178	38	Mobile Users	638
8	Cloud Computing	2649	24	Mobile Security	1173	39	Digital Storage	598
9	Cellular Telephone Systems	2398	25	Ad Hoc Networks	1151	40	Multimedia Systems	584
10	Global System for Mobile Communication	2368	26	Mobile Ad Hoc Networks	1051	41	Grid Computing	581
11	Algorithms	2310	27	Internet Protocols	1040			
12	Communication Systems	2162	28	Network Security	936			
13	Wireless Sensor Networks	1774	29	Information Management	918			
14	Distributed Computer Systems	1748	30	Social Networking (Online)	881			
15	Internet	1729	31	Web Service	872			
16	Mobile Phones	1500	32	Authentication	840			

papers each) and Japan, Italy, New Zealand, Finland, Singapore, Portugal and South Korea (1 paper each). Among 50 highly cited papers, 26 appeared as articles, 14 as conference papers, 9 reviews, and 1 short survey. The 50 highly cited papers involved the participation of 184 authors and 103 organizations. These 50 highly cited papers were published in 31 journals, of which 4 papers were published *in IEEE Transactions on Mobile Computing*, 2 papers each in *Decision Support System, IEEE Communication Magazine, IEEE Pervasive Computing* and *IEEE Communication Surveys & Tutorials and* 1 paper each in *Advanced Materials, Biomedical Engineering Online, British Journal of Educational Technology, Computer, Future Generation Computer Systems, IEEE Journal of Biomedical & Health Informatics, IEEE Journal on Selected Areas in Communication, IEEE Signal Processing Magazine, IEEE Transaction on Broadcasting, IEEE Transaction on Intelligent Transport Systems, IEEE Transaction on Magnetics, IEEE Transaction on Pattern Analysis & Machine Intelligence, IEEE Transaction on Robotics, IEEE Transaction on Systems, Man & Cybernetics. Part B, IEEE Wireless Communication, Information & Management, Information Systems Journal, International Journal of Medical Informatics, International Materials Review, Journal of Biomedical Informatics, Journal of Light-wave Technology, Mobile Network & Applications, Pervasive & Mobile Computing, Science, Science of the Total Environment and Wireless Communication & Mobile Computing.*

Conclusion

This study analyzed global publications output in mobile computing research published in 10 years during 2007-16. China, USA, and South Korea have

emerged as world leaders in mobile computing accounting for 52% global share. China tops the list of top 10 most productive countries in the world with 31.06% global share followed by USA (15.35% share), South Korea (5.59%) and others during 2007-16. India is ranked 5th amongst 10 most productive countries in mobile computing research. India's national share of international collaborative papers has been marginal, 11.75% compared to 48.16% by U.K., Canada (42.42%), USA (32.08%), and others. In the list of top 20 most productive organizations in mobile computing in the world, India is nowhere. China has claimed as many as 18 positions in the ranking of top productive organizations in mobile computing between 1-20 spots. Of the top 50 highly cited papers in mobile computing during 2007-16, USA is the highest contributor with 31 highly cited papers, followed by U.K. and Canada (4 papers each), Australia, India and H. Kong (3 papers each), France, Germany, Switzerland, Taiwan and China (2 papers each) and Japan, Italy, New Zealand, Finland, Singapore, Portugal and South Korea (1 paper each). China's contribution to 50 highly cited papers has been marginal, limited to just 2 papers. India contributed just 3 highly cited papers.

This study shows that China's research in mobile computing is though significantly high in terms of quantity of research but it is low in its quality of research. USA tops as the world leader in terms of quality of research in mobile computing even as it ranks 2nd top on quantity of research. Mobile computing research in the world has been found growing rapidly with 9.35% rate. At a time when the number of mobile subscriptions (6.8 billion) is approaching global population figures, with 40% of people in the world already online [9], application usage on mobile devices has exploded. Conclude that given its immense potential for mobile applications in all sectors of national economy, popularity of mobile computing technology is growing fast. It is desirable that nations, in particular India, should encourage and intensify mobile computing research in its component areas such as mobile computing architecture, wireless communication systems, applications, and security with the aim to make mobile computing implementation as an affordable and low cost option.

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