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**World Mobile Research: A Scientometric Assessment
of Research Publications Output during 2007-16**

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Abstract

The paper examines 140375 global publications on world mobile research, as covered in Scopus database during 2007-16. The field of world mobile research witnessed an annual average growth rate of 1.68%. The top 20 most productive countries individually contributed global share from 1.14% to 20.52%, with largest global publication share coming from China (20.52%), followed by USA (17.09%), etc. Together, the top 20 most productive countries accounted for 95.05% of global publication output during 2007-16. The international collaborative publications share of top 20 most productive countries varied from 6.30% to 47.88% in world mobile research during 2007-16. Computer science, among broad subjects, contributed the largest publication share of 67.69%, followed by engineering (42.65%), social sciences (13.80%), mathematics (8.59%), medicine (5.47%), physics & astronomy (3.26%), business, accounting & management (2.86%), biochemistry, genetics & molecular biology (2.24%), materials science (2.22%) and decision science (1.51%) during 2007-16. The top 20 most productive organizations and authors together contributed 13.14% and 1.35% share of global publication output during 2007-16. Among the total research output of 45213 papers in journal medium, 19.36% share appeared in top 20 journals during 2007-16. Of the total global mobile research output, 503 registered as highly cited papers, with 100 to 100+ citations per paper, averaging to 180.04 citations per paper.

Keywords: Mobile Research, Global Publications, Sub-fields, Scientometrics, Bibliometrics

1. Introduction

Mobile networks, technologies, hardware and applications etc. which make up the mobile world are rapidly impacting most aspects of our lives, transforming the world and revolutionizing how we live, interact, work and play. The face of communication is fast changing, and so is the face of computing. Mobile device penetration has been rapid and monumental. *“There are almost as many cell-phone subscriptions (6.8 billion) as there are people on this earth (seven billion)—and it took a little more than 20 years for that to happen”*. Continuous technological advancements in the mobile world and its component fields have influenced modern world business practices, transformed the economic

landscape and generated massive improvements in numerous business domains. From business to entertainment, it is difficult to imagine living without mobile networks and technologies.

Mobile world of networks, technologies, hardware and applications reflect the emerging symbiosis of portable computers and wireless networks, addressing the convergence of mobility, computing and information organization, access and management. Given their ever-growing impact across industrial, commercial, and domestic settings, mobile networks, technologies, hardware and applications are the topics of vital research and discussion in mobile world.

A number of studies in mobile world literature are already in place but topics covered in such studies are mainly micro-level ones such as -- mobile devices, system platform, mobile applications, mobile communication technologies, mobile computing, or mobile cloud computing. However, macro-level studies claiming to provide a comprehensive overview of mobile networks, technologies, hardware and applications with a holistic approach are still a gap. As research pursuits in the major components of mobile world – including networks, technologies, hardware and applications -- are maturing and have since reached well beyond the development stage, it is important that a study is undertaken that seeks to map world mobile research with a holistic approach and describes the direction of current and past research pursuits.

1.1. Literature Review

Up till now, no study has been reported at the national and international level on quantitative analysis of overall mobile research output during the last two decades. However, few quantitative studies based on publication output were reported in the subfields of mobile research, namely in area of mobile technology [2], mobile computing [3-4], mobile commerce [4-6], mobile applications [4], mobile learning [7-9] and mobile payments [10], etc. Since there was no overall mobile and its related study available at global level, the authors therefore decided to undertake the present study.

2. Objectives

The main objectives of present study are to study the performance of global mobile research during 2007-16, based on publications covered in Scopus database. In particular, the study focuses on the following objectives: (i) To study the growth of world research output and global publication share of top 20 most productive countries; (ii) To study the international collaboration share of top 20 most productive countries; (iii) to study the distribution of global research output by broad subject areas and by sub-fields and study their growth and decline; (iv) To study the publication productivity and citation impact of 25 and 20 most productive organizations and authors; (v) To study the medium of communication and (vi) to study the characteristics of top 503 high cited papers

3. Methodology

The study retrieved and downloaded the publication data of world's mobile research from the Scopus database (<http://www.scopus.com>) for 10 years during 2007-16. A keywords, such as "mobile*" were used in "keyword" tag and "source title" tags and then restricting it to the period 2007-16 in "date

range tag” was used for searching the global publication data and this become the main search string. When the main search string with restricted to individual country name in “country tag”, the publication data on individual top 20 most productive countries one by one in mobile research was obtained. The global search string is further restricted to “subject area tag”, “country tag”, “source title tag”, “journal title name” and “affiliation tag”, to get information on 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 date of publication till 15 February 2017. For sub-fields, individual sub strings were framed to get information on each sub-field.

SRCTITLE(Mobile)OR TITLE(Mobile) AND PUBYEAR > 2006 AND PUBYEAR < 2017

4. Analysis

4.1 Publications Distribution

The global research output in the field of mobile research studies cumulated to a total of 140375 publications in 10 years covering the period 2007-16. The annual output in this field increased from 12707 in 2007 to 14538 publications in 2016, registering 1.68% world average growth per annum. The five-yearly global research output in this field increased from 67887 in 2007-11 to 72488 publications in 2012-16, witnessing 6.78% quinquennial world average growth (Table 1).

Table 1. Global Research Output in Mobile Research, 2007-16

Year	Papers
2007	12707
2008	14055
2009	13438
2010	14137
2011	13550
2012	13938
2013	14733
2014	14008
2015	15271
2016	14538
Annual Growth	1.68%
2007-11	67887
2012-16	72488
Quinquennial Growth	6.78%
2007-16	140375

Of the total global publications output in mobile research, 63.32% (88889) appeared as conference papers, 29.35% (41205) as articles, 2.74% (3847) as book chapters, 1.15% (1608) as editorial, 1.01% (1416) as reviews, 0.71% (1002) articles in press (1002) and the rest as notes (659), conference reviews (643), letters (333), short surveys (304), books (285), erratum (173), business articles (18) and abstract reports (3) during 2007-16. The distribution of the total global publications output by language was also

skewed, with 96.74% share (135797) appeared in English, 2.13% (2992) in Chinese, 0.48% (677) in German, 0.30% (416) in French, 0.26% (368) in Spanish, 0.16% (222) in Japanese, 0.13% each (186 and 184) in Korean and Portuguese, 0.09% (133) in Russian, 0.07% (102) in Turkish and the rest in 24 other languages

4.2. Top 20 Most Productive Countries

The global research output in mobile research originated from over 150 countries, with top 20 countries accounting for the bulk of the global output 95.05% during 2007-16 (Table 2). The spectrum of global publication share of these 20 most productive countries varied relatively from 1.14% to 20.52%, with China accounting for the highest global share (20.52%), followed by USA (17.109%), South Korea (6.11%), Germany and U.K. (5.78% and 5.49% respectively), Japan, India and Taiwan (from 4.03% to 4.89% respectively), France, Canada and Italy (from 3.17% to 3.86% respectively), Spain, Australia and Finland (from 2.18 to 2.92% respectively), Malaysia, Greece, Sweden, Singapore, Brazil and Hong Kong (from 1.14 to 1.48% respectively) during 2007-116. The global publication share of India increased by 3.18%, followed by USA (3.02%), Malaysia (0.78%), Spain (0.70%), Brazil (0.48%), Italy (0.44%), Australia (0.34%), Singapore (0.23%), Canada (0.19%), U.K. (0.15%), Sweden (0.11%) and Hong Kong (0.07%), as against decrease by 7.58% in China, followed by Finland (0.58%), Japan (0.35%), Taiwan (0.31%), Germany (0.14%), Greece (0.06%), France (0.04%) from 2007-11 to 2012-16.

Table 2. Publication Output and Global Publication Share of Top 20 Most Productive Countries in Mobile Research during 2007-16

S.No	Country Name	Number of Papers			Share of Papers			ICP	%ICP
		2007-11	2012-16	2007-16	2007-11	2012-16	2007-16		
1	China	16584	12217	28801	24.43	16.85	20.52	1815	6.30
2	USA	10548	13454	24002	15.54	18.56	17.10	8024	33.43
3	South Korea	4146	4424	8570	6.11	6.10	6.11	1672	19.51
4	Germany	3976	4144	8120	5.86	5.72	5.78	2678	32.98
5	U.K.	3677	4035	7712	5.42	5.57	5.49	3387	43.92
6	Japan	3442	3423	6865	5.07	4.72	4.89	1545	22.51
7	India	2067	4515	6582	3.04	6.23	4.69	897	13.63
8	Taiwan	2845	2810	5655	4.19	3.88	4.03	792	14.01
9	France	2634	2787	5421	3.88	3.84	3.86	2477	45.69
10	Canada	2492	2801	5293	3.67	3.86	3.77	2426	45.83
11	Italy	1995	2451	4446	2.94	3.38	3.17	1663	37.40
12	Spain	1736	2364	4100	2.56	3.26	2.92	1615	39.39
13	Australia	1668	2029	3697	2.46	2.80	2.63	1421	38.44
14	Finland	1687	1379	3066	2.49	1.90	2.18	1162	37.90
15	Malaysia	730	1344	2074	1.08	1.85	1.48	517	24.93
16	Greece	1019	1042	2061	1.50	1.44	1.47	759	36.83
17	Sweden	896	1036	1932	1.32	1.43	1.38	925	47.88
18	Singapore	766	986	1752	1.13	1.36	1.25	830	47.37
19	Brazil	644	1037	1681	0.95	1.43	1.20	445	26.47

20	H. Kong	751	851	1602	1.11	1.17	1.14	585	36.52
	Total	64303	69129	133432		95.37			
	World	67887	72488	140375					
		94.72	95.37	95.05					

4.3 International Collaboration

International collaboration in mobile research studies is very common amongst top 20 most productive countries, except for China, contributing between 24.93% and 47.88% of their national share as international collaborative publications. China contributed 6.33% national share as international collaborative publications. Sweden tops the list of top 20 most productive countries with its highest national share (47.88%) as international collaborative publications, followed by Singapore (47.37%), Canada (45.83%), France (45.69%), U.K. (43.92%), Spain (39.39%), Australia (38.44%), Finland (37.9%), Italy (37.4%), Greece (36.83%), H. Kong (36.52%), USA (33.43%), Germany (32.98%), Brazil (26.47%), Malaysia (24.93%), Japan (22.51%), South Korea (19.51%), Taiwan (14.01%), India (13.63%) and China (6.30%) during 2007-16.

4.4 Subject-Wise Distribution of Research Output

The global research studies in mobile research cuts across several disciplines (as reflected in Scopus database classification) including computer science accounting for the highest publications share (67.69%), followed by engineering (42.65%), social sciences (13.80%), mathematics (8.59%), medicine (5.47%), physics & astronomy (3.26%), business, accounting & management (2.86%), biochemistry, genetics & molecular biology (2.24%), materials science (2.22%) and decision science (1.51%) during 2007-16.

Table 3. Subject-Wise Break-up of Global Publications on Mobile Research during 2007-16

S.No	Subjects*	Number of Papers (TP)			Activity Index		%TP
		2007-11	2012-16	2007-16	2007-11	2012-16	
1	Computer Science	47524	47489	95013	103.43	96.79	67.69
2	Engineering	32072	27791	59863	110.78	89.90	42.65
3	Social Sciences	11856	7511	19367	126.58	75.10	13.80
4	Mathematics	5172	6893	12065	88.64	110.64	8.59
5	Medicine	2532	5149	7681	68.16	129.82	5.47
6	Physics & Astronomy	1682	2893	4575	76.02	122.46	3.26
7	Business, Accounting & Management	1905	2112	4017	98.06	101.82	2.86
8	Biochemistry, Genetics & Molecular Biology	1516	1622	3138	99.90	100.10	2.24
9	Materials Science	1349	1765	3114	89.58	109.76	2.22
10	Decision Science	939	1186	2125	91.37	108.08	1.51
	World Total	67887	72488	140375			

• There was overlapping of research output under various subjects

The research activity, as reflected in activity index, has witnessed increase in mathematics (from 88.64 to 110.64), medicine (from 68.16 to 129.82), physics & astronomy (from 76.02 to 122.46), business, accounting & management (from 98.06 to 101.82), biochemistry, genetics & molecular biology (from 99.90 to 100.10), materials science (from 89.58 to 109.76) and decision science (from 91.37 to 108.08), as against decrease in computer science (from 103.43 to 96.79), engineering (from 110.78 to 89.90) and social sciences (from 126.58 to 75.10) from 2007-11 to 2012-16 (Table 3).

4.5 Global Mobile Research Studies by Broad Sub-Fields

Distribution of global research output by sub-fields characterizing mobile research studies revealed that mobile networks accounted for the largest share 30.32%, followed by mobile telecommunication networks (21.76%), mobile computing (16.77%), mobile communications (15.99%), mobile applications (13.69%), mobile robots (10.27%), mobile technology (9.39%), mobile learning (5.10%), etc. during 2007-16. Looking at the trends of research in these sub-fields, largest increase of 4.37% was observed in mobile applications, followed by mobile cloud computing (2.47%), mobile learning (2.33%), mobile security (0.57%), mobile games (0.27%), mobile banking (0.16%), mobile payments (0.15%) and mobile marketing (0.07%), as against decrease by 13.80% in mobile networks, followed by mobile telecommunication networks (13.66%), mobile computing (7.32%), mobile communications (4.15%), mobile technology (1.12%), mobile standards (0.73%), mobile commerce (0.39%), Mobile ad hoc networks and mobile robots (0.15% each), mobile hardware (0.09%) and mobile photography (0.06%) from 2007-11 to 2012-16 (Table 4).

Table 4. Global Mobile Research Publications by Sub-Fields during 2007-16

S.No	Sub-Fields*	Number of Papers			Share of Papers		
		2007-11	2012-16	2007-16	2007-11	2012-16	2007-16
1	Mobile Networks	25423	17143	42566	37.45	23.65	30.32
2	Mobile Telecommunication Networks	19561	10982	30543	28.81	15.15	21.76
3	Mobile Computing	13952	9595	23547	20.55	13.24	16.77
4	Mobile Communications	12306	10134	22440	18.13	13.98	15.99
5	Mobile Applications	7763	11459	19222	11.44	15.81	13.69
6	Mobile Robots	7028	7392	14420	10.35	10.20	10.27
7	Mobile Technology	6768	6413	13181	9.97	8.85	9.39
8	Mobile Learning	2647	4516	7163	3.90	6.23	5.10
9	Mobile Security	3319	3959	7278	4.89	5.46	5.18
10	Mobile Standards	1662	1247	2909	2.45	1.72	2.07
11	Mobile Commerce	1443	1260	2703	2.13	1.74	1.93
12	Mobile Cloud Computing	233	2041	2274	0.34	2.82	1.62
13	Mobile Hardware	1061	1066	2127	1.56	1.47	1.52

14	Mobile Games	939	1198	2137	1.38	1.65	1.52
15	Mobile Marketing	419	496	915	0.62	0.68	0.65
16	Mobile Payments	341	473	814	0.50	0.65	0.58
17	Mobile Ad Hoc Networks	343	259	602	0.51	0.36	0.43
18	Mobile Banking	168	294	462	0.25	0.41	0.33
19	Mobile Photography	150	119	269	0.22	0.16	0.19
	World Total	67887	72488	140375			
*There is overlapping of research under these sub-fields							

4.6 Significant Keywords

Around 49 significant keywords were identified from the literature highlighting broad trends in mobile research. These keywords are listed in Table 5 in the decreasing order of their occurrence during 2007-16.

Table 5. List of Significant Keywords appearing in Global Mobile Research Literature during 2007-16

S.No	Name of Keyword	Frequency	S.No	Name of Keyword	Frequency
1	Wireless Networks	17981	26	Mobile Agents	2469
2	Mobile Devices	17927	27	Artificial Intelligence	2234
3	Wireless Telecommunication Systems	17242	28	Mobile Learning	2227
4	Mobile Computing	16495	29	Standards	2161
5	Mobile Telecommunication Systems	14452	30	E-Learning	1941
6	Mobile Robots	10619	31	Social Networking Online	1854
7	Mobile Phones	7733	32	Education	1774
8	Ad-Hoc Networks	6997	33	Mobile Nodes	1628
9	Wireless Sensor Networks	6445	34	Mobile Technology	1615
10	Mobile Ad Hoc Networks	6398	35	Mobile Antennas	1601
11	Telecommunication Networks	5718	36	Mobile Users	1586
12	Computer Simulation	5530	37	Learning Systems	1516
13	Mobile Applications	5417	38	Mobile Security	1444
14	Sensors	5174	39	Behavioral Research	1443
15	Robots	5010	40	Virtual Reality	1433
16	Internet	4968	41	Computer Networks	1427
17	Sensor Networks	4586	42	Commerce	1425
18	Robotics	4299	43	Mobile Environment	1340
19	Ubiquitous Computing	3949	44	Electronic Commerce	1310
20	Radio Communication	3500	45	Intelligent Systems	1258
21	Internet Protocols	3385	46	Mobile Networks	1215
22	Human Computer Interactions	3360	47	Mobile Cloud Computing	1192
23	Global System of Mobile Communications	3121	48	Mobile Platforms	1170
24	Smart Phones	3052	49	Embedded Systems	1121
25	Mobile Communications	2792			

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4.7 Top 25 Organizations in Mobile Applications Research

The productivity of top 25 most productive organizations in global mobile research varied from 491 to 2204 publications cumulated in 10 years. Together they accounted for 13.14% (18445 publications) global share during 2007-16. The scientometric profile of these 25 organizations is presented in Table 6.

Nine amongst 25 organizations registered productivity above the group average of 737.8 publications per organization: Beijing University of Posts & Telecommunications, China (2204 publications), Tsinghua University, China (1084 publications), Nokia Corporation, Finland (1006 publications), Huazhong University of Science & Technology, China (875 publications), Wuhan University, China (850 publications), Harbin Institute of Technology, China (809 publications), Korea Advanced Institute of Science & Technology, S. Korea (791 publications), Shanghai Jiaotong University, China (772 publications) and Aalto University, Finland (772 publications) during 2007-16

Fourteen amongst 25 organizations registered citation impact above group average of 4.13 citations per publication (4.13): Carnegie Mellon University, USA (11.65), National University of Singapore (7.26), Aalto University, Finland (7.17), Nanyang Technological University, Singapore (7.01), National Chiao Tung University, Taiwan (6.52), Yonsei University, S. Korea (6.28), Korea Advanced Institute of Science & Technology, S. Korea (5.47), Nokia Corporation, Finland (5.37), Samsung Electronics Co Ltd, S.Korea (5.13), Korea University, S. Korea (5.01), National Taiwan University (4.94), Tsinghua University, China (4.76), Shanghai Jiaotong University, China (4.65) and Huazhong University of Science & Technology, China (4.52) during 2007-16.

Fourteen amongst 25 organizations registered h-index above the group average (24.44): Carnegie Mellon University, USA (36), Tsinghua University, China (34), National Chiao Tung University, Taiwan and Korea Advanced Institute of Science & Technology, S. Korea (32 each), National University of Singapore and Nokia Corporation, Finland (31 each), Shanghai Jiaotong University, China (30), Aalto University, Finland, Nanyang Technological University, Singapore and Huazhong University of Science & Technology, China (29 each), Yonsei University, S. Korea (28), Korea University, S. Korea, National Taiwan University and Beijing University of Posts & Telecommunications, China (25 each) during 2007-16.

Ten amongst 25 organizations accounted for international collaborative publications share above the group average (23.69%): Nokia Corporation, Finland (61.63%), Nanyang Technological University, Singapore (42.27%), National University of Singapore (40.33%), Aalto University, Finland (34.72%), Carnegie Mellon University, USA (34.00%), Tsinghua University, China (33.76%), Zhejiang University, China (31.93%), Shanghai Jiaotong University, China (29.02%), Huazhong University of Science & Technology, China (25.60%) and Xidian University, China (24.35%) during 2007-16.

Table 6. Scientometric Profile of Top 25 Most Productive Global Organizations in Mobile Research during 2007-16

S.No	Name of the Organization	TP	TC	CPP	HI	ICP	%ICP
1	Beijing University of Posts & Telecommunications, China	2204	3738	1.70	25	264	11.98
2	Tsinghua University, China	1084	5164	4.76	34	366	33.76
3	Nokia Corporation, Finland	1006	5407	5.37	31	620	61.63
4	Huazhong University of Science & Technology, China	875	3958	4.52	29	224	25.60
5	Wuhan University, China	850	1666	1.96	23	119	14.00
6	Harbin Institute of Technology, China	809	1424	1.76	15	136	16.81
7	Korea Advanced Institute of Science & Technology, S. Korea	791	4326	5.47	32	154	19.47
8	Shanghai Jiaotong University, China	772	3586	4.65	30	224	29.02
9	Aalto University, Finland	772	5536	7.17	29	268	34.72
10	Electronics & Telecommunications Research Institute, S. Korea	699	1769	2.53	17	78	11.16
11	Zhejiang University, China	689	2600	3.77	24	220	31.93
12	Southeast University, China	650	1271	1.96	16	98	15.08
13	National Chiao Tung University, Taiwan	627	4087	6.52	32	80	12.76
14	Beihang University, China	618	1496	2.42	15	105	16.99
15	University of Electronics Science & Technology of China	615	1666	2.71	19	110	17.89
16	Xidian University, China	575	1224	2.13	17	140	24.35
17	Korea University, S. Korea	563	2819	5.01	25	110	19.54
18	Beijing Jiotong University, China	560	1439	2.57	16	127	22.68
19	National Taiwan University	552	2729	4.94	25	71	12.86
20	Carnegie Mellon University, USA	547	6370	11.65	36	186	34.00
21	Samsung Electronics Co Ltd, S.Korea	532	2729	5.13	23	108	20.30
22	Beijing Institute of Technology, China	530	666	1.26	10	69	13.02
23	Yonsei University, S. Korea	523	3283	6.28	28	78	14.91
24	Nanyang Technological University, Singapore	511	3581	7.01	29	216	42.27
25	National University of Singapore	491	3564	7.26	31	198	40.33
	Total of 25 organizations	18445	76098	4.13	24.44	4369	23.69
	Total of the world	140375					
	Share of 25 organizations in world output	13.14					
TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers							

4.8 Top 20 Most Productive Authors in Mobile Research

The productivity of top 20 most productive authors in global mobile applications research varied from 77 to 130 publications cumulated in 10 years. Together they accounted for 1.35% (1889 publications) global publications share during 2007-16. The scientometric profile of these top 20 authors is presented in Table 7.

Nine amongst 20 top authors registered productivity above the group average of 94.45 publications per author: L.Barolli (130 papers), V.C.M.Leung (120 papers), A.Boukerche and M.Gerla (113 papers each), J.Wu (108 papers), R. Tafazolli (101 papers), S.K.Das (100 papers), T.Hara (97 papers) and K.L.Wong (96 papers) during 2007-16.

Six amongst top 20 authors registered citation impact above the group average of 8.73 citations per publication (8.73): K.L.Wong (26.66), M.Chen (20.00), S.K.Das (17.24), X.Shen (16.84), V.C.M.Leung (12.40) and M.Conti (11.69) during 2007-16.

Nine amongst top 20 authors registered h-index above the group the average (13.3): K.L.Wong (30), X.Shen (20), S.K.Das (19), V.C.M.Leung (17), M.Conti (16), M.Gerla and J.Wu (16 each), M.Chen (14) and A.Boukerche (14) during 2007-16.

Nine amongst top 20 authors registered international collaborative publications share above the group average (48.33%): X.Shen (97.47%), M.Chen (88.46%), J.Cao (84.44%), J.J.Rodrigues (81.52%), I.You (81.01%), L.Barolli (80.0%), M.S.Alouini (70.59%), V.C.M.Leung (66.67%) and S.K.Das (58.0%) during 2007-16.

Table 7. Top 20 Most Productive Global Authors in Mobile Research, 2007-16

S.No	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP
1	L.Barolli	Fukoka Institute of Technology, Japan	130	383	2.95	11	104	80.00
2	V.C.M.Leung	University of British Columbia, Canada	120	1488	12.40	17	80	66.67
3	A.Boukerche	University of Ottawa, Canada	113	706	6.25	14	52	46.02
4	M.Gerla	University of California, Los Angeles, USA.	113	939	8.31	16	48	42.48
5	J.Wu	Florida Atlantic University, USA	108	873	8.08	16	39	36.11
6	R. Tafazolli	University of Surrey, U.K.	101	464	4.59	8	23	22.77
7	S.K.Das	University of Texas at Arlington, USA	100	1724	17.24	19	58	58.00
8	T.Hara	Osaka University, Japan	97	374	3.86	9	23	23.71
9	K.L.Wong	National Sun Yat-Sun University, Taiwan	96	2559	26.66	30	0	0.00
10	J.J.Rodrigues	University of Beira Interior, Portugal	92	570	6.20	13	75	81.52
11	J.Cao	Hong Kong Polytechnic University	90	731	8.12	13	76	84.44
12	M.Conti	IIT-CNR, Pisa, Italy	87	1017	11.69	16	19	21.84
13	M.S.Alouini	King Abdullah University of Science & Technology, Saudi	85	161	1.89	7	60	70.59

		Arabia						
14	S.Nishio	Osaka University, Japan	84	272	3.24	8	9	10.71
15	W.Wang	Zhejiang University, China	82	329	4.01	8	8	9.76
16	X.Shen	University of Waterloo, Canada	79	1330	16.84	20	77	97.47
17	I.You	Korea Bible University, S.Korea	79	177	2.24	7	64	81.01
18	M.Chen	Huazhong University of Science & Technology, China	78	1560	20.00	14	69	88.46
19	S.H.Kim	Chungam National University, South Korea	78	194	2.49	8	12	15.38
20	P.Mohapatra	University of California, Davis, USA	77	632	8.21	12	17	22.08
	Total of 20 authors		1889	16483	8.73	13.3	913	48.33
	Total of the world		140375					
	Share of 20 authors in world output		1.35					
TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers								

4.9 Medium of Communication

The top 20 most productive journals in global mobile research accounted for 19.36% global journals output share (8755 papers), reporting 175 to 1610 papers per journal during 2007-16. The five-yearly publication share of these top 20 most productive journals jumped from 18.12% to 20.12% during the quinquennial period from 2007-11 to 2012-16. The top most productive journal (with 1610 papers) was *IEEE Transactions on Mobile Computing*, followed by *Wireless Communications & Mobile Computing* (1331 papers), *Mobile Networks & Applications* (758 papers), *Pervasive and Mobile Computing* (726 papers), etc. during 2007-16 (Table 8).

Table 8. List of Top 20 Most Productive Journals in Global Mobile Research during 2007-16

S.No	Name of the Journal	Number of Papers		
		2007-11	2012-16	2007-16
1	IEEE Transactions on Mobile Computing	603	1007	1610
2	Wireless Communications & Mobile Computing	568	763	1331
3	Mobile Networks & Applications	288	470	758
4	Pervasive & Mobile Computing	229	497	726
5	Mobile Information Systems	60	435	495
6	International Journal of Wireless & Mobile computing	107	352	459
7	International Journal of Interactive Mobile Computing	8	405	413
8	International Journal of Mobile Communication	195	168	363
9	Wireless Personal Communication	94	235	329
10	International Journal of Applied Engineering Research	0	260	260

11	Microwave & Optical Technology Letters	151	95	246	
12	IEEE Transactions on Vehicular Technology	131	109	240	
13	IEICE Transactions on Communications	139	70	209	
14	International Journal of Mobile Learning & Organizations	118	91	209	
15	International Journal of Distributed Sensor Networks	10	188	198	
16	IEEE Communication Magazine	85	106	191	
17	PLOS One	20	165	185	
18	IEEE Transactions on Consumer Electronics	126	53	179	
19	Computer Communication	102	77	179	
20	Journal of Wireless Mobile Networks Ubiquitous Computing & Dependable Applications	51	124	175	
	Total of 20 journals	3085	5670	8755	
	Total of the journal world output	17030	28183	45213	
	Share of 20 Journals in journal global output	18.12	20.12	19.36	

4.10 Highly Cited Papers

From out of a total of 140375 papers on mobile research, 503 (0.36%) received 100 to 100 + citations per paper in 10 years covering the period 2007-16. These 503 highly cited papers together cumulated 90755 citations, with an average of 180.04 citations per paper. Amongst 503 highly cited papers, 373 were in 100-199 citation range, 82 papers in 200-299 citation range, 24 papers in 300-399 citation range, 30 in 400-599 citation range and the rest of 5 papers in 700-1000 citation range. These 503 highly cited papers originated from more than 70 countries. The USA accounted for the highest number of papers (241), followed by U.K. (63 papers), Taiwan (32 papers), Australia (31 papers), China and Germany (30 papers each), Canada (29 papers), South Korea (27 papers), France and Italy (21 papers each), Hong Kong and Switzerland (17 papers each), Singapore (15 papers), Japan (13 papers), Netherlands (12 papers), India, Finland and Spain (10 papers each), etc.

Top 18 organizations which contributed 503 highly cited papers include: University of Southern California, USA made the largest contribution of 14 papers, followed by Carnegie Mellon University, USA (11 papers), MIT, USA, University of Cambridge, U.K. and Eidgenossische Technische Hochschule, Switzerland (9 papers each), Microsoft Research, USA, Purdue University, USA and University of Toronto, Canada (7 papers each), University of Waterloo, Canada, Microsoft Research, India, Tsinghua University, China, Huazhong University of Science & Technology, China, City University of Hong Kong, University of Sydney, Australia, Northwestern University, USA, National Chiao Tung University, Taiwan, National Taiwan University of Science & Technology, Taiwan, Intel Corporation, USA (6 papers each), etc.

Top 16 authors which contributed to these 503 highly cited papers include: S.K.Das of University of Texas at Arlington, USA made the largest contribution of 5 papers, followed by P.Hui (University of Cambridge, U.K.) and M.Conti (IIT-CNR, Pisa, Italy)(4 papers each), K.K.Chintalapudi (Microsoft Research, India), T.Spyropoulos (INRIA Sophia Antipolis, France), R.Buyya (University of Melbourne, Australia), E.Hossain (University of Manitoba, Canada), J.Urry (Lancaster University, Canada), M.M.Zavalanos and

G.J. Pappas (University of Pennsylvania, USA), N.Mallat (Helsinki School of Economics, Finland), Y.S.Tseng (National Chiao Tung University, Taiwan) and K.L.Wong (National Sun Yat-Sun University, Taiwan), S.J.Lippart (MIT,USA), B. Krishnamachari(University of Southern California, USA) and J.A.Landey (University of Washington, USA)(3 papers each), etc

These 503 highly cited papers were published in 182 journals, with largest number appearing in *IEEE Transactions on Mobile Computing* (65 papers), followed by *IEEE Communication Magazine* (20 papers), *IEEE Communication Survey & Tutorials* (12 papers), *Computers & Education* (10 papers), *Mobile Networks and Applications* (9 papers), *Computers in Human Behavior* and *IEEE Transactions on Robotics* (8 papers each), *Science* (7 papers), etc.

5. Summary and Conclusion

The study provides quantitative and qualitative description of the world mobile research output covering publications in the 10-years period during 2007-16. The world output data on mobile research which cumulated to a total of 140375 publications during 2007-16, was sourced from Scopus database. The annual output in the field registered 1.68% growth during 2007-16, increasing from 12707 in 2007 to 14538 publications in 2016. Contrary to the ongoing publication trends in scholarly communication, journal medium is no longer the publication mode in field of world mobile research; it has been pushed down to the 2nd spot. Instead, the conference proceedings has overtaken its place, and has since become the new publication mode, accounting for the largest 57.99% global publications share, and journals as the second largest medium with 32.21% share.

China is the world leader in world mobile research accounting for the largest 20.52% global share, followed by the USA (17.09%). The next top eight countries leading the world in mobile research are: South Korea, Germany, the U.K., Japan, India, Taiwan, France, and Canada contributed to global output between 3.77% and 6.11% during 2007-16. The world share of top 10 countries in the world mobile research was 76.24%, and of top 20 countries it was 95.05%, their national share involving international collaborative publications varied widely from 6.30% (China) to 47.88% (Sweden) during 2007-16.

Out of the several component fields that make up the mobile world, mobile networks has been found to be the most sought research field, accounting for the largest publication share 30.32%, followed by mobile telecommunication networks (21.76%), mobile computing (16.77%), mobile communications (15.99%), mobile applications (13.69%), mobile robots (10.27%), mobile technology (9.39%), mobile learning (5.10%), etc. during 2007-16. The quinquennial world publications output across sub-fields which make up mobile world was dynamic. The global publications output published during two successive quinquennial periods from 2007-11 to 2012-16 registered an increase in select subject sub-fields: mobile applications, mobile cloud computing, mobile learning, mobile security, mobile games, mobile banking, mobile payments and mobile marketing. In certain other select sub-fields, the global publications output registered a decline during the corresponding periods. These sub-fields are: mobile networks, mobile telecommunication networks, mobile computing, mobile communications, mobile

technology, mobile standards, mobile commerce, mobile ad hoc networks, mobile robots, mobile hardware and mobile photography.

World mobile research studies are multidisciplinary in nature cutting across several disciplines -- computer science (67.69%), engineering (42.65%), social sciences (13.80%), mathematics (8.59%), medicine (5.47%), physics & astronomy (3.26%), business, accounting & management (2.86%), biochemistry, genetics & molecular biology (2.24%), materials science (2.22%) and decision science (1.51%) during 2007-16. The research activity in these disciplines was dynamic, registering an increase in its index from 91.37 to 108.08 points (world average activity in a discipline is 100 points) involving 9-disciplines: mathematics, medicine, physics & astronomy, business, accounting & management, biochemistry, genetics & molecular biology, materials science and decision science. The research activity index in three other disciplines registered a decline: computer science, engineering and social sciences. The research activity index was measured using discipline-wise publications data across two successive quinquennial periods 2007-11 and 2012-16.

The top 25 productive organizations in the mobile world research accounted for 13.14% global publication share during 2007-16 with an average productivity of 737.8 papers per organization. Their performance on other metrics was: citation impact of 4.13 citations per paper, h-index 24.44, and 23.68% national share as international collaborative papers.

The top 20 most productive authors accounted for 1.35% global publication share during 2007-16 with an average productivity of 94.95 papers per author, citation impact of 8.73 citations per paper, h-index 13.30), and 8.33% national share as international collaborative papers.

The top 20 most productive journals in the world mobile research accounted for 19.36% share of global output in journals during 2007-16. *IEEE Transactions on Mobile Computing* was the most sought after journal for publishing mobile research (1610 papers), followed by *Wireless Communications & Mobile Computing* (1331 papers), *Mobile Networks & Applications* (758 papers), *Pervasive and Mobile Computing* (726 papers), etc. during 2007-16

Amongst the total output of 45213 journal papers in world mobile research, only 503 (1.11%) papers were considered as highly cited papers cumulating 100 to 100+ citations per paper in 10 years during 2007-16. These 503 highly cited papers accounted for a total of 90755 citations, with an average of 180.04 citations per paper. Bulk of the highly cited papers (373 papers) cumulated 100 to 199 citations, 82 papers cumulated 200-299 citations, 24 cumulated 300-399 citations, 30 cumulated 400-599 citations and the rest 5 papers cumulated 700-1000 citations. More than 70 countries participated in publishing these 503 highly cited papers, with the largest number of highly cited papers (241) coming from USA, followed by U.K. (63 papers), Taiwan (32 papers), Australia (31 papers), China and Germany (30 papers each), Canada (29 papers), South Korea (27 papers), France and Italy (21 papers each), Hong Kong and Switzerland (17 papers each), etc.

Conclude that there was a wide scope for different countries to make investments in R&D by prioritizing their research efforts in various sub-fields which are largely of commercial importance and also by

devoting more qualified manpower in this area and encouraging wider international collaboration to achieve more productivity and raise the quality and impact of their research efforts.

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