

SCIENTOMETRIC DEPENDENCIES IN THE FIELD OF INTELLIGENT PERSONAL ASSISTANTS

Acad. Ivan Popchev

Bulgarian Academy of Sciences

Angel Ivanov

Burgas Free University

Abstract: *An autonomous component – Intelligent Personal Assistant is being developed which utilizes reactive, interactive and proactive behavior. This component will be developed as a genetic agent with BDI (Belief-Desire-Intention) Architecture.*

The goal of the present study is to find the scientometric dependencies concerning the research in the field of Intelligent Personal Assistants during the past 12 years as a part of the whole research and development process.

Key words: *scientometric dependencies, intelligent personal assistant*

I. Introduction

The collaboration between the team of FMII by the University of Plovdiv and the Modelling Laboratory Team of the Bourgas Free University on the next stage of development of the DeLC incorporates a transformation of the educational cluster MyDeLC into a context-dependent environment providing electronic services and electronic learning content corresponding to the requirements of the eLearning teaching model.

As a part of this environment an autonomous component – *Intelligent Personal Assistant* is being developed which utilizes reactive, interactive and proactive behavior. This component will be developed as a genetic agent with BDI (Belief-Desire-Intention) architecture.

The goal of the present study is to find the scientometric dependencies concerning the research in the field of *Intelligent Personal Assistants* during the past 12 years as a part of the whole research and development process.

II. Resources used

The following online resources were used to obtain information:

1. **Research Gate** – www.researchgate.net – One of the largest scientific networks to connect researchers to share and access scientific output, knowledge, and expertise.

2. **Science Direct** – sciencedirect.com - A leading full-text scientific database offering journal articles and book chapters from nearly 3 800 journals and 35 000 e-books.

3. **IEEE Xplore Digital Library** – ieeexplore.ieee.org – a powerful resource for discovery of and access to scientific and technical content published by the IEEE (Institute of Electrical and Electronics Engineers) and its publishing partners.

4. **Google Scholar** – scholar.google.com – Accesses not only pure scientific information but also other related publications so it is used as a marker for the worldwide interest in the field of study.

III. Criteria

These sources were chosen among the others available on the Internet using the following criteria:

1. Number of members;
2. Number of scientific publications;
3. Accessibility;
4. Popularity among the scientific community;
5. Reliable search engines;
6. Representation of information.

IV. Keywords

The chosen keywords for the research were selected by using the relevance to the scientific field:

1. „*Intelligent Personal Assistant*” – the main research subject
2. „*Belief-Desire-Intention*” or *BDI* – the software model to be used for the logical reasoning of the component
3. „*Intelligent agent*” – The software concept to be used for development of the component
4. „*Agent oriented programming*” – the programming paradigm to be used for development of the component
5. „*JADE*” – „Java Engine Development Framework” – the environment which will be used
6. „*Multi Agent System*” – the software technology to be used for development of the component
7. „*eLearning*” – the model which holds the standards for interoperability with the environment
8. „*Internet of things*” – the environment the component will be part of
9. „*Semantic web*” – the environment the component will be part of
10. „*Artificial Intelligence*” – the global scientific field

V. Results

The combined results from all of the sources.

1. Research Gate Keyword Search Results by October 30 2016

Table No 1

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
„Intelligent Personal Assistant”	3	1	1	2	4	8	4	1	1	2	3	3	2
„Belief-Desire-Intention” or BDI	53	62	66	55	45	72	66	42	36	26	30	23	26
„Intelligent agent”	52	62	70	62	56	102	90	76	63	56	62	54	49
„Agent oriented programming”	22	28	37	19	15	24	21	18	16	14	12	12	17

„Java Agent Development Framework” or „JADE”	6	19	25	19	18	23	22	18	23	24	24	26	16
„Multi Agent System”	1040	1210	1360	1430	1520	1790	1400	1390	1080	854	942	511	492
„eLearning”	364	429	528	568	797	801	730	712	787	684	868	1210	983
„Internet of things”	20	26	58	59	134	168	269	426	603	753	1180	2510	2960
„Semantic web”	1320	1650	1970	2000	2620	2780	2490	2310	1950	1510	1740	1450	1140
„Artificial Intelligence”	6840	8170	8450	9321	10803	12204	10749	10900	10358	8812	13223	11800	12501

2. Science Direct Keyword Search Results by October 30 2016

Table No 2

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
„Intelligent Personal Assistant”	0	1	0	1	0	0	0	0	1	3	5	10	10
„Belief-Desire-Intention” or BDI	6	15	12	20	15	14	21	28	24	32	35	38	35
„Intelligent agent” or „Intelligent agents”	199	292	277	308	287	264	241	299	352	337	351	381	403
„Agent oriented programming”	4	11	10	12	6	8	5	14	4	9	11	20	9
„Java Agent Development Framework” or „JADE”	0	13	14	12	15	23	12	24	26	26	33	38	30
„Multi Agent System” or „Multi Agent Systems”	179	356	395	375	457	468	491	639	673	881	954	1090	1148
„eLearning”	180	331	373	486	595	643	870	894	1165	1034	1097	1532	1071
„Internet of things”	0	4	5	9	11	15	42	125	175	286	527	981	1764
„Semantic web”	149	208	339	298	391	399	457	540	652	613	624	732	625
„Artificial Intelligence”	1464	2096	2456	2522	2740	2884	2617	3220	3427	3647	3853	4484	4589

3. IEEE Xplore Digital Library Keyword Search Results by October 30 2016

Table No 3

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
„Intelligent Personal Assistant„	1	0	0	0	0	1	0	0	2	0	2	1	1
„Belief-Desire-Intention” or BDI	4	13	14	10	16	13	11	11	9	17	10	12	3
„Intelligent agent” or „Intelligent agents”	466	567	691	675	950	1011	646	459	383	347	282	321	27
„Agent oriented programming”	7	9	1	4	5	5	2	4	0	3	4	8	2
„Java Agent Development Framework” or „JADE”	2	12	7	6	16	10	11	6	9	16	11	5	6
„Multi Agent System” or „Multi Agent Systems”	142	203	255	244	434	442	479	389	393	399	391	384	242
„eLearning”	16	23	47	26	50	51	85	117	175	170	168	141	25
„Internet of things”	0	1	5	6	20	34	246	612	678	1174	1883	3284	2572
„Semantic web”	321	510	549	700	993	943	926	645	631	439	434	458	240
„Artificial Intelligence”	3487	4283	4509	5708	6914	8254	8342	9263	8331	7618	8294	9559	4356

4. Google Scholar Keyword Search Results by October 30 2016

Table No 4

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
„Intelligent Personal Assistant”	29	13	35	42	23	31	35	33	62	152	144	156	117
„Belief-Desire-Intention” or BDI	392	515	479	505	562	588	617	619	627	565	597	539	374
„Intelligent agent” or „Intelligent agents”	1350	1480	1490	1420	1540	1490	1490	1440	1460	1440	1240	1250	738
„Agent oriented programming”	317	335	355	350	344	370	300	352	346	314	291	330	202
„Java Agent Development Framework” or „JADE”	245	407	484	515	591	548	531	542	560	535	489	407	287
„Multi Agent System” or „Multi Agent Systems”	4130	4840	5130	4700	6020	6600	6580	6680	7050	7260	6960	6720	6600
„eLearning”	8890	8970	9510	10200	10900	13600	12500	12000	16700	17400	13400	15900	7250

„Internet of things”	417	571	828	1050	1580	2120	3820	7290	11600	14600	19800	26100	59400
„Semantic web”	9110	12200	14700	16000	18600	19900	20300	20100	22400	21400	20200	18700	12700
„Artificial Intelligence”	74500	84500	90800	101000	98000	101000	95900	120000	98900	83800	71700	54000	94100

VI. Analysis

Analyzed data by keywords represented by tables and graphics. The large number of results found using Google Scholar is caused by the fact that this search engine utilizes not only pure scientific resources but also others related. It represents mostly the worldwide interest into this field. The results spread is following the overall trend but as the numbers are significantly higher than the rest they are intentionally removed from the graphics in order to better visualize the data using a proper scale.

1. Intelligent Personal Assistant

Table No 5

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Reseach Gate	3	1	1	2	4	8	4	1	1	2	3	3	2
Science Direct	0	1	0	1	0	0	0	0	1	3	5	10	10
IEEE Xplore	1	0	0	0	0	1	0	0	2	0	2	1	1
Google Scholar	29	13	35	42	23	31	35	33	62	152	144	156	117

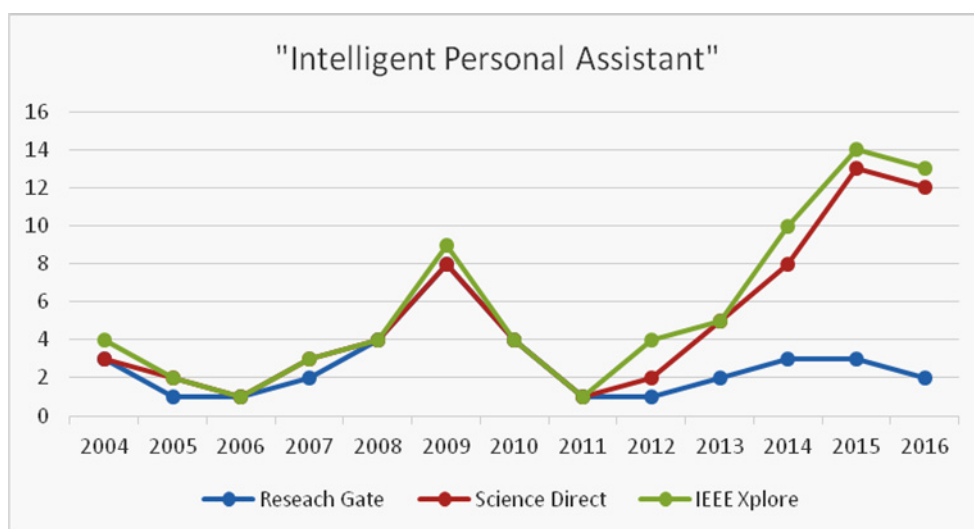


Fig 1

The number of scientific publications concerning „Intelligent Personal Assistant” even though lower in the beginning of the related period of time is growing during the last years but is still low compared to other fields of research like „Artificial Intelligence”. A significant raise is observed during the past two years considering the fact that the results from 2016 are missing two months.

2. „Belief-Desire-Intention” or BDI

Table No 6

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Research Gate	53	62	66	55	45	72	66	42	36	26	30	23	26
Science Direct	6	15	12	20	15	14	21	28	24	32	35	38	35
IEEE Xplore	4	13	14	10	16	13	11	11	9	17	10	12	3
Google Scholar	392	515	479	505	562	588	617	619	627	565	597	539	374

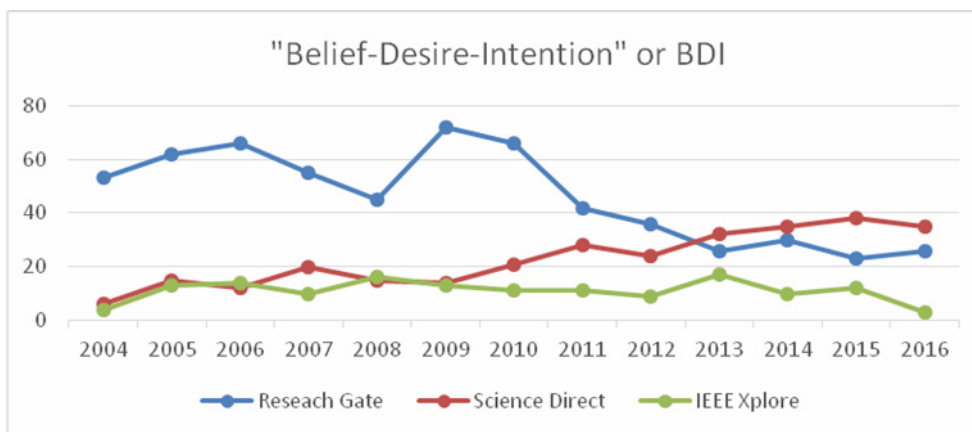


Fig 2

The „Belief-Desire-Intention” or BDI software model is already a well-known concept so it is more popular than „Intelligent Personal Assistant”.

3. „Intelligent Agent”

Table No 7

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Research Gate	52	62	70	62	56	102	90	76	63	56	62	54	49
Science Direct	199	292	277	308	287	264	241	299	352	337	351	381	403
IEEE Xplore	466	567	691	675	950	1011	646	459	383	347	282	321	27
Google Scholar	1350	1480	1490	1420	1540	1490	1490	1440	1460	1440	1240	1250	738

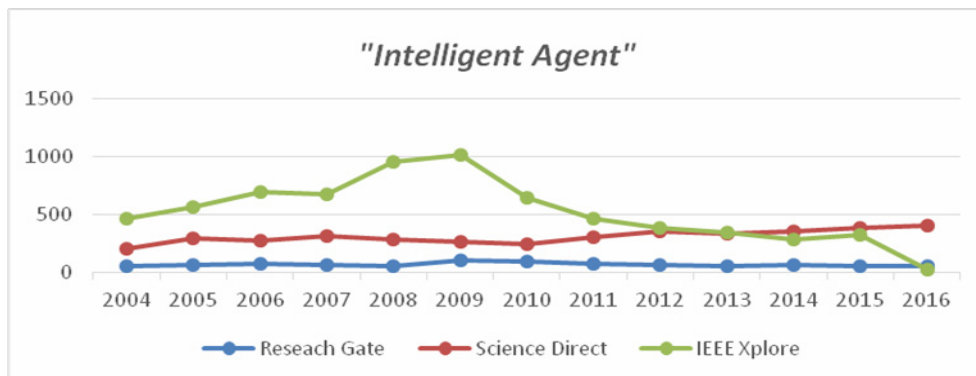


Fig 3

The number of publications where the term „Intelligent agent” is mentioned is maintaining high values for the research period. From 2004 to 2013 most results are present from IEEE Xplore compared to Research Gate and Science Direct.

4. „Agent oriented programming”

Table No 8

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Research Gate	22	28	37	19	15	24	21	18	16	14	12	12	17
Science Direct	4	11	10	12	6	8	5	14	4	9	11	20	9
IEEE Xplore	7	9	1	4	5	5	2	4	0	3	4	8	2
Google Scholar	317	335	355	350	344	370	300	352	346	314	291	330	202

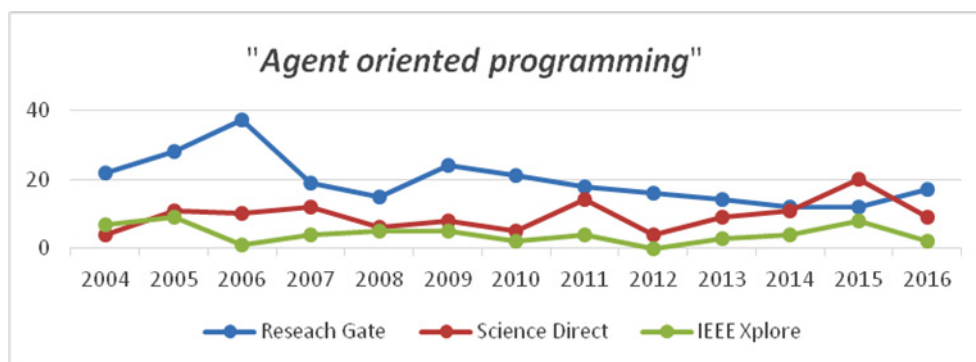


Fig 4

From 2004 to 2014 most results are present from Research Gate compared to Science Direct and IEEE Xplore which follow almost the same trend. There is a peak in 2006 in the number of results from Research Gate – 37 while the peaks for Science Direct and IEEE Xplore are in 2011 – 14 and 4 and in 2015 – 20 and 8 correspondingly.

5. „JADE” or „Java Engine Development Framework”

Table No 9

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Reseach Gate	6	19	25	19	18	23	22	18	23	24	24	26	16
Science Direct	0	13	14	12	15	23	12	24	26	26	33	38	30
IEEE Xplore	2	12	7	6	16	10	11	6	9	16	11	5	6
Google Scholar	245	407	484	515	591	548	531	542	560	535	489	407	287

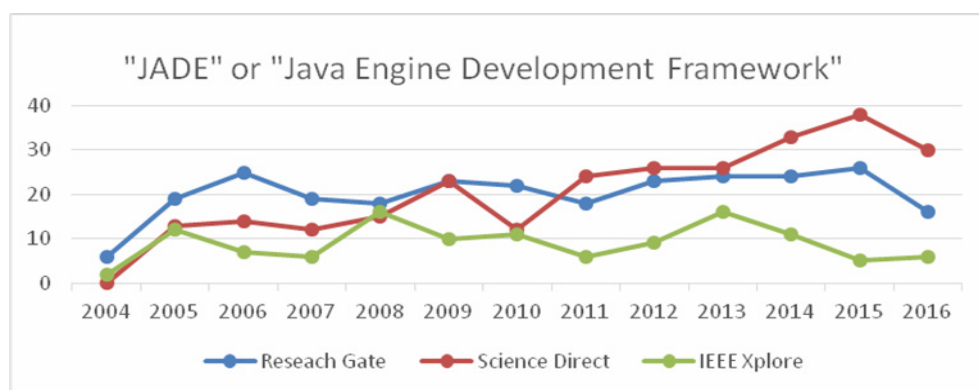


Fig 5

The number of results for „JADE” or „Java Engine Development Framework” follows a similar trend for the researched period except for 2015 where it is getting higher for Research Gate and Science Direct and Lower for IEEE Xplore and Google Scholar.

6. „Multi Agent System” or „Multi Agent Systems”

Table No 10

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Reseach Gate	1040	1210	1360	1430	1520	1790	1400	1390	1080	854	942	511	492
Science Direct	179	356	395	375	457	468	491	639	673	881	954	1090	1148
IEEE Xplore	142	203	255	244	434	442	479	389	393	399	391	384	242
Google Scholar	4130	4840	5130	4700	6020	6600	6580	6680	7050	7260	6960	6720	6600

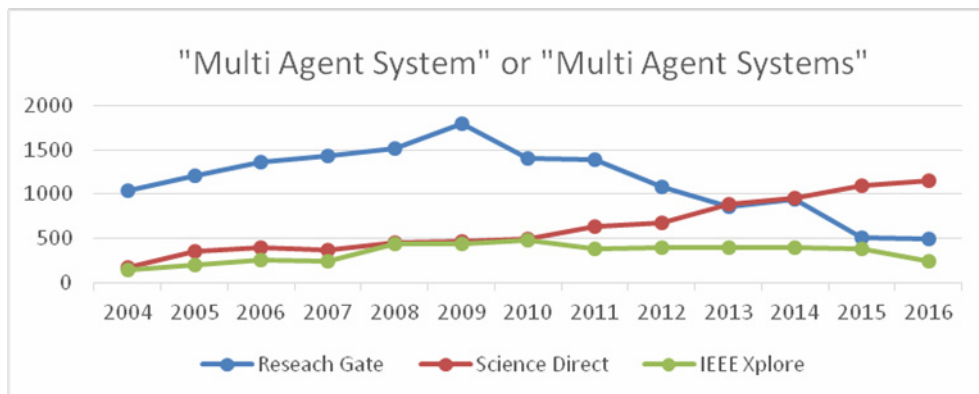


Fig 6

7. „eLearning”

Table No 11

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Research Gate	364	429	528	568	797	801	730	712	787	684	868	1210	983
Science Direct	180	331	373	486	595	643	870	894	1165	1034	1097	1532	1071
IEEE Xplore	16	23	47	26	50	51	85	117	175	170	168	141	25
Google Scholar	8890	8970	9510	10200	10900	13600	12500	12000	16700	17400	13400	15900	7250

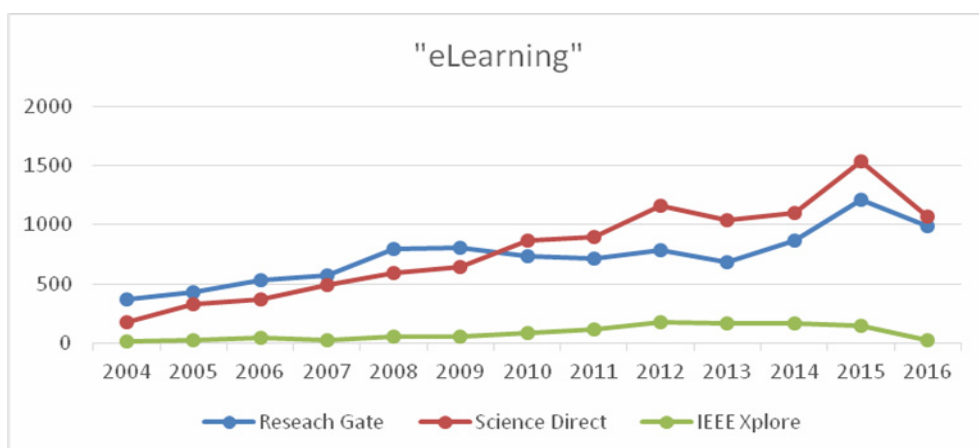


Fig 7

8. „Internet of things”

Table No 12

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Reseach Gate	20	26	58	59	134	168	269	426	603	753	1180	2510	2960
Science Direct	0	4	5	9	11	15	42	125	175	286	527	981	1764
IEEE Xplore	0	1	5	6	20	34	246	612	678	1174	1883	3284	2572
Google Scholar	417	571	828	1050	1580	2120	3820	7290	11600	14600	19800	26100	59400

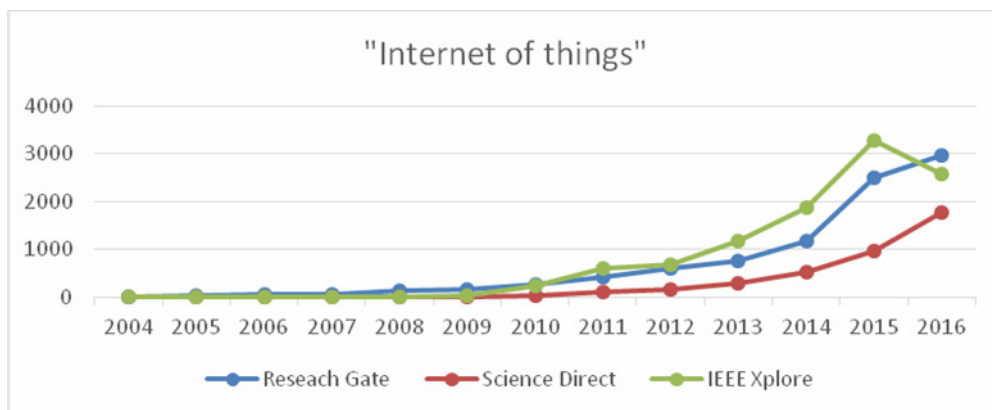


Fig 8

9. „Semantic Web”

Table No 12

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Reseach Gate	1320	1650	1970	2000	2620	2780	2490	2310	1950	1510	1740	1450	1140
Science Direct	149	208	339	298	391	399	457	540	652	613	624	732	625
IEEE Xplore	321	510	549	700	993	943	926	645	631	439	434	458	240
Google Scholar	9110	12200	14700	16000	18600	19900	20300	20100	22400	21400	20200	18700	12700

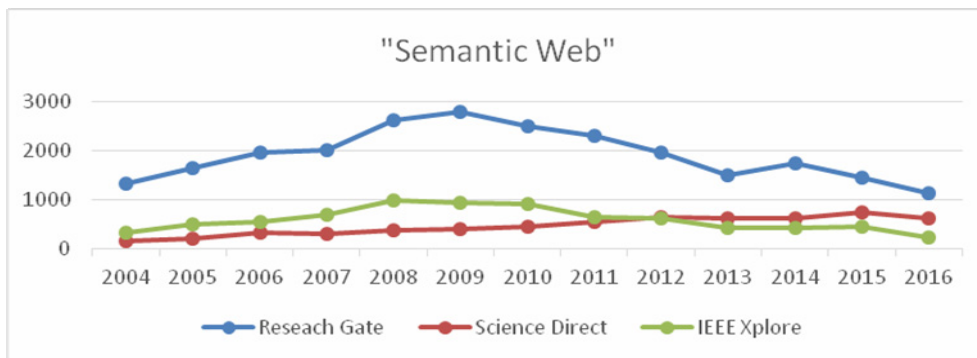


Fig 9

10. „Artificial Intelligence”

Table No 12

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Research Gate	6840	8170	8450	9321	10803	12204	10749	10900	10358	8812	13223	11800	12501
Science Direct	1464	2096	2456	2522	2740	2884	2617	3220	3427	3647	3853	4484	4589
IEEE Xplore	3487	4283	4509	5708	6914	8254	8342	9263	8331	7618	8294	9559	4356
Google Scholar	74500	84500	90800	101000	98000	101000	95900	120000	98900	83800	71700	54000	94100

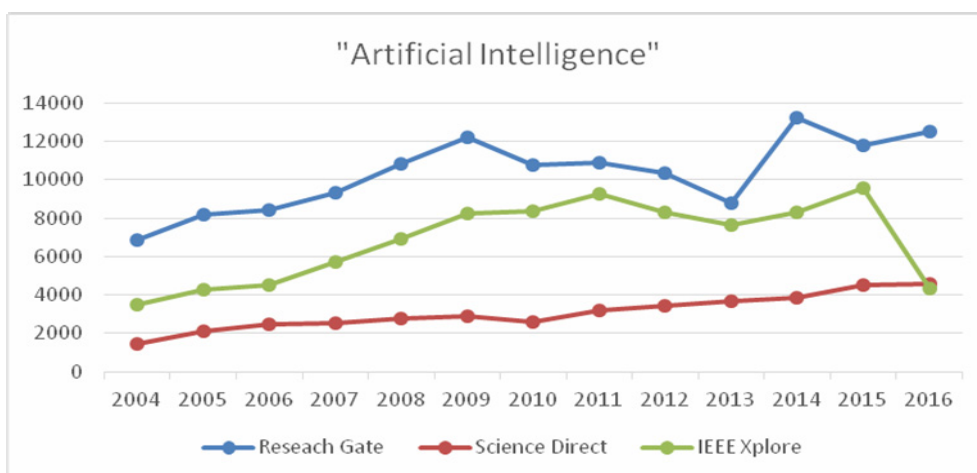


Fig 10

The number of results for the keywords „Multi Agent System”, „eLearning”, „Internet of things” and „Semantic web” is significantly higher than the rest as they represent much larger scientific areas than the rest of the terms included in this research. The highest level of growth can be observed for „Internet of things”.

The keyword representing the global scientific field of research – „Artificial Intelligence” produces the highest number of results and a stable growth can be observed from the collected data.

VII. Conclusion

The results of the study show that while the interest in the field of researching Intelligent Personal Assistants is growing during the past 12 years and more rapidly for the past 5 years there is still a comparatively low number of scientific publications in this area.

The tendency concerning the other related fields of study as *Belief-Desire-Intention (BDI)*, *eLearning*, *Multi Agent Systems*, *Internet of things* and *Semantic web* follows the same pattern.

The number of publications concerning the global field of research – „Artificial Intelligence” also increases at a higher rate.

References

1. Дойчев Е., Среда за електронни образователни услуги, Дисертация, Пловдивски университет „П. Хилендарски”, 2013.
2. С. Стоянов, Д. Орозова, И. Попчев, Виртуалното Образователно Пространство – настояще и бъдеще, Юбилейна научна конференция с международна участие „Новата идея в образованието“, БСУ 2016.
3. Попчев И., М.Георгиева, Наукометричен анализ в областта на BigData, Научна конференция с международно участие „Хоризонти в развитието на човешките ресурси и знанието, БСУ, 2015, стр. 469 – 476.
4. С. Стоянов, CS588: Софтуерни агенти, Лекции, Пловдивски университет „П. Хилендарски”, 2013.
5. Rao, A. S. & Georgeff, M. P. (1995), BDI-agents: from theory to practice, in ‘Proceedings of the First Intl. Conference on Multiagent Systems’, San Francisco
6. JADE – jade.tilab.com
7. JADEX – www.activecomponents.org
8. Research Gate – www.researchgate.net
9. Science Direct – www.sciencedirect.com
10. Google Scholar – scholar.google.com
11. IEEE Xplore Digital Library – ieeexplore.ieee.org