Retrospective, Relevance, and Trends of Software Agents, Environments and Applications School (WESAAC)

Enyo Gonçalves[1,4], Mariela Cortés[2], Marcos de Oliveira[1], Nécio Veras[3], Mário Falcão[2], Jaelson Castro[4]

[1] Universidade Federal do Ceará

[2] Universidade Estadual do Ceará

[3] Instituto Federal de Educação, Ciência e Tecnologia do Ceará

[4] Universidade Federal de Pernambuco

enyo@ufc.br, mariela@larces.uece.br, marcos.oliveira@ufc.br, necio.veras@ifce.br, mariofalcao.es@gmail.com, jbc@cin.ufpe.br

Abstract. *Multi-Agent Systems (MAS) software has been increasing dramatically in last years. In this context, the Software Agents, Environments and Applications School (WESAAC) is a Brazilian event of MAS which is in its tenth edition. When studying a research area, it is important to identify the most active groups, topics, the research trends and so forth. This study aims to investigate how the WESAAC is evolving, by analyzing the papers published in its 9 editions. We adopted a research strategy that combines scoping study and systematic review good practices. We identify the most active institutions and authors, the main topics discussed, the types of the contributions, the conferences and journals that have most referenced WESAAC papers, the publications with the greatest impact, and the trends in MAS. We found 116 papers over the 9 WESAAC editions, which were analyzed and discussed.*

1. INTRODUCTION

Nowadays, agent technology has been widely applied to solve a vast set of problems. Russell and Norvig [9] define an agent as an entity that can perceive its environment through sensors and act in the environment through actuators. According to Wooldridge [10], agents are complex entities with behavioural properties, such as (i) autonomy (i.e., they are able to execute without interacting with humans), (ii) social ability (i.e., they are able to interact by sending and receiving messages and not by explicit task invocation, (iii) Reactivity (i.e. The capacity of perceiving the environment and respond to its changes) and (iv) Proactiveness (i.e. a goal-directed behavior). Multi-Agent Systems (MAS) is the sub area of artificial intelligence that investigates the behavior of a set of autonomous agents, aiming to solve a problem that is beyond the capacity of a single agent [8]. The agent-oriented development paradigm requires adequate techniques to explore its benefits and features in order to support the construction and maintenance of this type of software [11].

In this context, the Software Agents, Environments and Applications School (WESAAC) provides a forum for researchers, practitioners and educators to present and

discuss the most recent innovations, trends, experiences and concerns in the field of software agents. The overall goal of the WESAAC is to provide an opportunity for researchers and students (both under-graduate and graduate) to discuss their goals, methods, and results of their research. The School aims to provide students with useful guidance on various aspects of the research from established researchers and the other student attendees. It also helps participants to establish a research and social network of their peers.

Motivated by the celebration of 10th edition of the WESAAC, this work aims to analyze the 116 full papers published in the WESAAC throughout its 9 previous editions. This review aims to identify the most active institutions and authors, the main topics discussed, the types of the contributions, the conferences and journals that have most referenced WESAAC papers, the most addressed topics, the publications with the greatest impact, and the trends in MAS.

The information provided in this paper may be useful in different contexts. For example, a newcomer (eg. new research student) will be able to identify main groups, main researchers and the work already developed. Moreover, topics that have not deserved much attention by the WESAAC may be identified and become the subject of new research projects. This kind of information will also be useful for setting up possible collaborative networks.

This paper is structured as follows. In Section 2, it is described the retrospective of the event. The research method is described in Section 3. In Section 4, it is presented the review results. In Section 5, it is discussed some threats to validity. Some related works are presented in Section 6. Finally, the conclusion and future works are presented in Section 7.

2. Retrospective of the Event

WESAAC provides a forum for researchers and a school for students. Initially called "Workshop - School of Agent Systems for Collaborative Environments" and then from the fourth edition, following suggestions from the participants of the first three editions, the event's scope was expanded without losing its trademark (acronym), and the interest that involved originally the researchers. In the fifth edition, the national scope of the event was maintained and strengthened, with the participation of prominent researchers from the MAS field, several institutions from Brazil, such as USP, IME / RJ, UFRGS, FURG, UFSC, UCPEL, UTFPR, and abroad, notably the University of Bologna (Italy), who presented lectures and led workshops on their research topics.

The first edition of WESSAC occurred in 2007 in the city of Pelotas- RS, at the Catholic University of Pelotas (UCPel), and it was coordinated by prof. Dr. Carlos Antonio da Rocha Costa. His second edition was in 2008 in the city of Santa Cruz do Sul-RS, at the University of Santa Cruz do Sul (UNISC), and it was coordinated by Prof. Dra. Rejane Frozza. The third edition happened in 2009 in the city of Caxias do Sul-RS, at the University of Caxias do Sul (UCS), under the coordination of prof. João Luis Tavares da Silva. The fourth edition took place in 2010 in the city of Rio Grande-RS, at the Federal University of Rio Grande (FURG), under the overall coordination of Prof. Dra. Diana Frances Adamatti. The fifth edition took place in 2011, in Curitiba-PR, at the Federal Technological University of Paraná (UTFPR), under the overall coordination of prof. Dr. Gustavo Alberto Giménez Lugo.

The sixth edition took place in 2012 in the city of Florianópolis-SC, at the Federal University of Santa Catarina (UFSC), under the coordination of prof. Dr. Jomi Fred Hübner. The seventh edition happened in the city of São Paulo-SP at the University of São Paulo (USP) in 2013, under coordination of Prof. Anarosa Alves Franco Brandão. The eighth edition occurred in Porto Alegre-RS at Pontifical Catholic University of Rio Grande do Sul (PUCRS) in 2014, under the organization of Prof. Rafael Bordini. The ninth and last edition took place in the city of Niterói-RJ in 2015, under the coordination of Prof. Viviane Torres da Silva [2].

All the proceedings and links to the home pages of WESAAC editions, and the results of this research are available in a web page created to this paper in: http://200.129.25.54/professor/necio/wesaac2016/site/#/.

3. RESEARCH METHOD

The experimental software engineering community has proposed reliable processes, guidelines and templates for conducting Systematic Literature Reviews (SLR) [6]. In this paper, we adopted the research strategy described in [4]; hence, we conducted a *scoping study* in order to "map out" the WESAAC previous editions.

While a systematic review is a means of identifying, evaluating and interpreting the available research findings related to a research question, topic area, or phenomenon [6], a scoping study is rather focused on examining the extent, range and nature of research activity, providing an overview in a specific area [4].

The set of steps applied in our paper were: (i) Protocol definition; ii) Research Questions definition; (iii) Conduction of Search; (iv) Data Extraction and Mapping; and (v) Data Analysis and Synthesis. These steps combine scoping study and systematic review good practices, such as protocol definition, to take advantage of both methodologies. The protocol has been designed and executed by four researchers with broad familiarity with MAS and one additional researcher that revised this protocol.

3.1. Research questions

The research questions that we intend to answer in this scoping study are:

RQ1 What are the main authors and institutions that published in WESAAC?

RQ2: What is the main language used in the papers?

RQ3. What are the main topics discussed in WESAAC?

RQ4. What are the types of the contributions?

RQ5. What is the impact of the publications of WESAAC in community?

RQ6. What are the trends in MAS?

3.2. Search Strategy, Data Sources and Study Selection

A manual search was conducted by four of the authors in all WESAAC proceedings in order to collect the studies, by examining the studies title and abstract. The following inclusion and exclusion criteria were used:

- Inclusion Criteria: All research papers published in the WESAAC;
- Exclusion Criteria: Short papers published in WESAAC.

The inclusion and exclusion criteria over the last 9 editions of WESAAC proceedings resulted in 116 studies to be further analyzed and classified.

3.3. Data extraction and synthesis

After the search and the selection processes, we performed a data extraction process by analyzing the 116 selected papers. In order to guide this data extraction, we used a predefined extraction form containing the following fields:

> *Identifier, Publication Year, Title, Language, Institution, Authors, Topic discussed, Type of contribution (model, tool, process, approach, method, etc.) and Number of citations by type (conference, journal, book, dissertation, thesis, other).*

This form enabled us to record full details of the papers under review and to be specific about how each of them addressed our research questions. The selection process and the data extraction were performed using a spreadsheet tool. In the next section, we present the results obtained in this scoping study.

4. Results

In this section, each research question is answered by analyzing different point of views, highlighting evidence gathered from the data extraction process.

RQ1. What are the main authors and institutions that published in WESAAC?

In these 9 editions, the WESAAC had the participation of 45 institutions and 230 authors.

From a total of 230 authors who published a paper on WESAAC editions, Antônio Carlos da Rocha Costa from Universidade Federal do Rio Grande do Sul (UFRGS)/Universidade Federal do Rio Grande (FURG) is leading the list with 18 published papers, followed by Graçaliz Pereira Dimuro (16) from Universidade Federal do Rio Grande (FURG) and Diana Francisca Adamatti (9) from Universidade Federal do Rio Grande (FURG). The list with the top four WESAAC authors is shown in Table 1. It is important to mention that the data shows the number of times in which an author is authoring or coauthoring an article.

Table 1. Top 14 Authors.

Author	Institution	#papers
Antônio Carlos da Rocha Costa	Universidade Federal do Rio Grande do Sul (UFRGS)/Universidade Federal do Rio Grande (FURG)	18
Graçaliz Pereira Dimuro	Universidade Federal do Rio Grande (FURG)	16
Diana Francisca Adamatti	Universidade Federal do Rio Grande (FURG)	9
Rejane Frozza	Universidade de Santa Cruz do Sul (UNISC)	8
Jomi Fred Hubner	Universidade Federal de Santa Catarina (UFSC)	5
Andrea Aparecida Konzen	Universidade de Santa Cruz do Sul (UNISC)	4
Cesar Augusto Tacla	Universidade Tecnológica Federal do Paraná (UTFPR)	4
Diego Rodrigues Pereira	Universidade Federal do Rio Grande do Sul (UFRGS)	4
Esteban de Manuel Jerez	Universidad de Sevilla	4
Jaime Simão Sichman	Universidade de São Paulo (USP)	4

Mariela Inés Cortés	Universidade Estadual do Ceará (UECE)	4
Saulo Popov Zambiasi	Universidade do Sul de Santa Catarina (UNISUL)	4
Viviane Torres da Silva	Universidade Federal Fluminense (UFF)/ IBM Research	4

As it has already been mentioned, 45 institutions have had at least one publication at WESAAC. See in Table 2 the 6 institutions with the most number of publications.

Table 2. Number of papers of the top 6 (six) institutions.

Institution	# papers
Universidade Católica de Pelotas (UCEPEL)	22
Universidade Federal do Rio Grande (FURG)	16
Universidade Federal de Santa Catarina (UFSC)	11
Universidade Federal do Rio Grande do Sul (UFRGS)	11
Universidade de Santa Cruz do Sul (UNISC)	8
Pontifícia Universidade Católica do Rio Grande do Sul (PUC-RS)	7

Despite all the universities listed in Table 2 are in the southern region, we can mention that the Universidade de São Paulo (7th place), University of Sevilla (9th place), State University of Ceará (12th place) and Federal Fluminense University (13th place). This shows that despite the hegemony of the Southern Brazilian universities, there is the participation of other regions of the country, and foreign universities as well. WESAAC started in south of Brazil and researchers of these region were involved in most of event editions, therefore it is natural that researchers and universities of the region are well classified.

After the identification of the most active authors and institutions, a verification of the most discussed topics was performed.

RQ2: What is the main language used in the papers?

We also investigated the language in which the papers were written and we identified the percentage of articles written in English and Portuguese. 94 papers (81%) were write in Portuguese and 22 papers (19%) were write in English.

RQ3. What are the main topics discussed in WESAAC?

All papers were analyzed in order to evaluate MAS topics that they have addressed. The list of discussed topics were based on the call for papers of previous editions of the WESAAC. Each paper was classified in one the topics.

The main topics defined according to the papers are shown in Table 3. “Applications of agents and multi-agent systems” is the main discussed topic (36.20%; 42 papers), followed by “agent-based software development” (16.37%; 19 papers). “Social simulations and agent-based simulation” follows closely with 14.65% (17 papers).

RQ4. What are the types of the contributions?

The purpose of this research question was to identify the contributions types of the WESAAC papers. We tried to list the types according to the classification presented in the

papers. Note that, similarly to other research questions, this question also allows a study to be included in only one category. The results of this question are presented in Table 4.

Table 3. The discussed topics in WESAAC.

Topic	#papers	%
applications of agents and multi-agent systems	42	36,2069
agent-based software development (programming languages, platforms, tools, methodologies)	19	16,37931
social simulations and agent-based simulation	17	14,65517
cooperation/coordination (negotiation, argumentation, reputation)	11	9,482759
agent organizations, societal issues, normative systems	9	7,758621
agent architectures and theories (BDI, belief revision, automated reasoning)	8	6,896552
agent communication	4	3,448276
(formal) specification and verification of multi-agent systems	4	3,448276

The predominant contribution that we identified was “Architecture/Framework” (18.96%; 22 studies), followed by “A multiagent System implementation” (18.10%; 21 studies), and “Tool” (15.51%; 18 studies).

Table 4. Types of contributions of WESAAC papers.

Type of Contribution	#papers	%
Architecture/Framework	22	18,96552
A multiagent System implementation	21	18,10345
Tool	18	15,51724
AI model/Formal model/Mathematical model/Ontology	16	13,7931
Simulation	8	6,896552
A multiagent Tecnique	5	4,310345
AI Technique implementation	5	4,310345
Algorithm	5	4,310345
Methodology	5	4,310345
Evaluation	5	4,310345
Multiagent System modeling	3	2,586207
Programming Language	2	1,724138
Discussion or Review	1	0,862069

The topic “AI model/Formal model/Mathematical model/Ontology” is proposed by more than 13,79% of the papers. The “Simulation” topic is proposed by more than 6,89% of the papers.

We also investigated if the contributions were empirically validated. Figure 1 shows that “simulation” is the main type of validation (19,82%, 23 papers), followed by “illustration” (14.65%, 17 papers). The validation “Experiment” was performed by

13.79% (16 papers), "comparison" was conducted by 8,62% (10 papers). 0.86% (1 paper) performed "survey". Some papers did not present any kind of validation (27,58%, 32 papers).

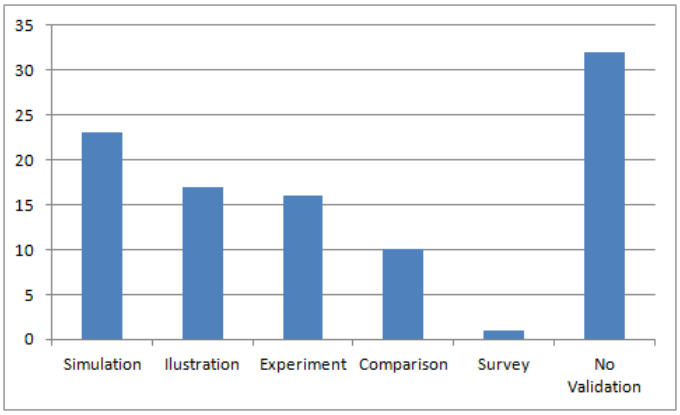

Figure 1. Empirical studies.

Q5. What are the publications of WESAAC community with the greatest impact?

The papers of the 9 WESAAC editions were cited, until 29th February 2016, 55 times by many publication types. The top 5 most cited papers are listed in Table 5. These papers represent the papers from the WESAAC that had the greatest research impact, considering citation count.

Table 5. TOP 5 WESAAC most cited papers.

Paper	Authors	Year	Citations
Agentes tutor e companheiro em um ambiente educacional baseado em estilos cognitivos	Rejane Frozza, Andréa Konzen, Alessandra Mainieri, Jacques Schreiber, Kurt Molz, Jorge Tautz, Ricardo Pedó, Jonas Dresch	2007	6
Modelando a Organização Social de um SMA para Simulacão dos Processos de Produção e Gestão Social de um Ecossistema Urbano: o caso da Horta San Jerónimo da cidade de Sevilla, Espanha	Flávia C. P. Santos, Glenda Dimuro, Thiago F. Rodrigues, Diana F. Adamati1,Graçaliz P. Dimuro, Antônio C. R. Costa, Esteban de Manuel Jerez	2012	5
Simulação Multiagente de uma Abordagem Evolutiva e Espacial para o Jogo do Ultimato	Luís Felipe K. Macedo, Murian dos Ribeiro, Stephanie L. Brião, Celso N. da Fonseca, Marilton S. de Aguiar, Graçaliz P. Dimuro	2012	4
Fred – um agente pedagógico mediador na construção do conhecimento	Julio Cezar Souza de Mello, Rejane Frozza	2007	4
Uma Arquitetura de Referência para Softwares Assistentes Pessoais Baseada em Agentes e SOA	Saulo Popov Zambiasi, Ricardo J. Rabelo	2011	4

The most referred paper is "*Agentes tutor e companheiro em um ambiente educacional baseado em estilos cognitivos",* published in 2007. It was cited 6 times and authored by Rejane Frozza, Andréa Konzen, Alessandra G. Mainieri, Jacques Schreiber, Kurt Molz, Jorge Tautz, Ricardo Pedó, Jonas Dresch.

The topics of the most cited papers are in accordance with the main topics discussed in WESAAC (RQ3). The second address the topic “agent organisations, societal issues, normative systems”. The first in third place papers, from 2012, is from “social simulations and agent-based simulation”. Finally, the other papers tied in third place cover “applications of agents and multi-agent systems” and “agent architectures and theories (BDI, belief revision, automated reasoning)”.

The first place paper addresses the “A multiagent System implementation”, the second is related to “Multiagent System modeling”, the first paper listed in thrid place papers covers “Simulation, Tool and Architecture/Framework”.

Regarding empirical studies, “illustration” was used to validate the paper in first place and the second place. The third place papers used “comparison”, not presented a validation and “simulation”, respectively.

RQ5. What is the impact of the WESAAC publications in community?

A deep investigation over the WESAAC papers shows the numbers of WESAAC referred papers over the years. This investigation was conducted by analyzing manually all citations of each 116 papers through Google Scholar.

Regarding the publication venues of the papers that cites WESAAC papers, we found the following distribution (see Figure 2): 51% in conferences (28 studies, which 9 studies in international conferences and 5 studies in WESAAC editions); 5% in journals (3 studies, which 2 studies in international conferences); 2% in Phd Thesis (1 study), 29% in Master Thesis (16 studies, which 1 international citation) and 13% (7 studies) in others types of documents (technical reports, presentations, etc.).

We also analyzed which conferences have most referenced WESAAC papers. Regarding conference papers, Table 6 shows the conferences that most cite WESAAC papers respectively.

Table 6. TOP 5 conferences.

Conference	#citations
Software Agents, Environments and Applications School (WESAAC)	5
Brazilian Workshop on Social Simulation	4
Latin American Informatics Conference (CLEI)	2

Based on these results, it is possible to see that the papers are serving as good sources to define and evolve the already proposed techniques, methods, processes and so on. However the references from WESAAC papers itself is considered low and could be encouraged in upcoming call for papers. Low amount of citations in journal papers and international conferences should be mentioned, probably it is related to few articles written in English (22 papers). Extended version of the best papers could be published in a journal, as other events been done, and this could encourage more authors to submit. Of the 55 citations, 15 are held by foreign researchers and 62 by researchers not published in WESAAC.

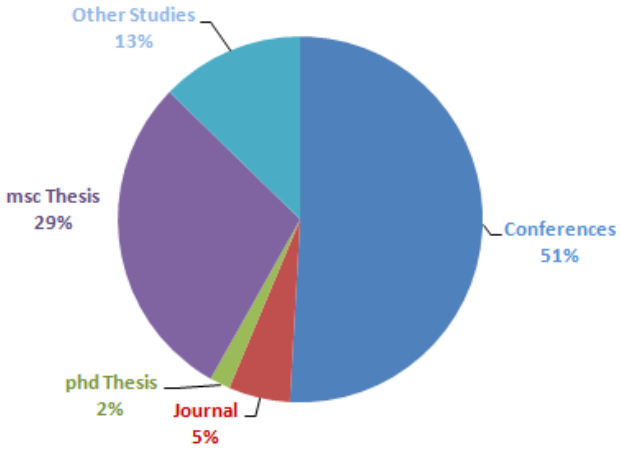

Figure 2. Publication venues of WESAAC papers.

RQ6. What are the trends in MAS?

The purpose of this question is to investigate the trends in MAS in relation to the topics addressed by the WESAAC papers and other papers of the MAS area. In this case we consider the main topics defined according to the papers showned in Table 3, i.e., the top 5 topics along the nine editions, and some papers related to our results.

Figure 3 shows the number of publications per topic/year. According to this figure, it is possible to observe an increase in the following topics: agent software development and agent organizations. On the other hand, we have observed a decrease in the number of papers of the following topics: agent applications and social simulation. The cooperation/coordination topic remained without great variations.

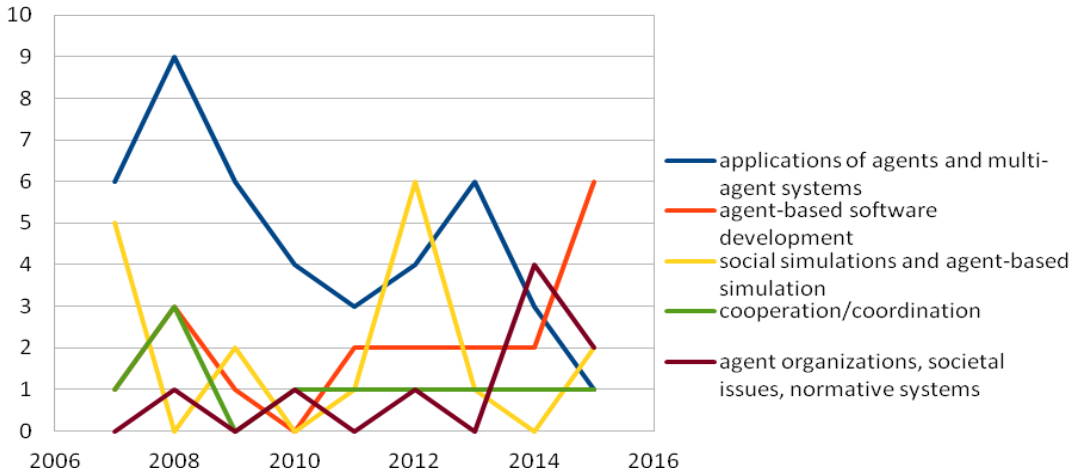

Figure 3. Number of WESAAC publications per topic/year

Figure 4 shows the number of publications per contribution/year, where we can note that all contributions have variations across the editions. According to this figure, it is possible to observe an increase in the last edition from the following contributions: “A Multiagent system implementation” and “Simulation”. On the other hand, it has been observed a decrease in the number of papers related to “Architecture/framework”. The “Tool” contribution has a variation and it was not proposed in last two editions of

WESAAC. The “AI model/Formal model/Mathematical model/Ontology” contribution remained without great variations.

The top of “Tool” contribution was in 2012 and “architecture/framework” was in 2010, with 5 papers each one. The top of “A Multiagent System implementation” was in 2008 with 6 papers. The top of “Simulation” was in 2012 and “AI model/Formal model/Mathematical model/Ontology” was in 2013 with 3 papers each one.

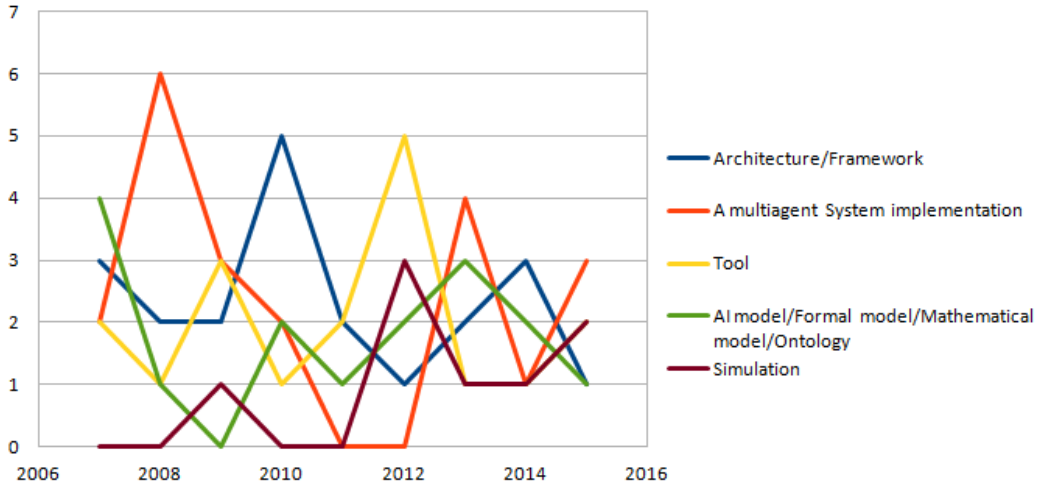

Figure 4. Number of WESAAC publications per contribution/year

Since 2005 specific technical challenges of agent-based computing are discussed: Trust and reputation, Virtual organization formation and management, Resource allocation and coordination, Negotiation, Emergence in large-scale agent systems, Learning and optimization theory, Methodologies, Provenance, Service architecture and composition, and Semantic integration [14].

In that roadmap the authors built fifteen recommendations about challenges appointed and some can found in the history of WESAAC such as: “Creation of tools, techniques and methodologies to support agent systems developers”, “Develop techniques for expressing and reasoning about trust and reputation, on both individual and social level, to enable interaction in dynamic and open environments”, and “Integrate agent components and features to enable the different theories, technologies and infrastructures to come together coherently”.

In other hand, recommendations such as “Develop a range of new techniques for learning and optimization in dynamic and unstable multi-agent environments, together with evaluation methods” and “Establish appropriate trade-offs between adaptability and predictability so that agents can exhibit behaviour, emergent or otherwise, that can be supported by tools and property verification.” are not exploited by authors in any paper.

According to [12], Agent Oriented Software Engineering can be divided in the following themes: Agent Programming Languages, Agent Oriented Frameworks, Agent Oriented Architectures, Agent Oriented Methodologies (Modeling Techniques) and Agent Communication (Content Languages, Interaction Mechanisms). The research community in the last almost 20 years, has explored these themes and the Applications built using technologies that come from them.

In [13], is made a report on the outcomes of the discussions of several researchers in the field, from universities and industry. They were from distinct areas and were engaged on work related with the following subjects: avionics and defence, smart cities, transportation, logistics, workflow management, decision support, healthcare, personal assistants, real-time control systems, power engineering, information integration, and virtual environments. They have concentrated the discussion in the following themes: Integration of MAS with other systems and technologies, and validation of MAS; Coordination and Organization; Tool, Languages and Technologies; and Component Oriented Agent Design.

In those surveys [13], the major concern was to drive efforts from the research community to find out why agent technologies were not embraced yet by the industry, and what is necessary to make that happen. They have pointed out some strategies to that end, such as: concentrate on making better tools and not only building new ones; create ways to validate and test MAS for safety, security, scalability, quality, maintainability, performance and interoperability, for example; componentize agent technology to better integrate it with other types of systems, concentrate on the scalability of the organizations and the runtime environments to support that. There is a concern as well to measure how the Agent Oriented techniques compare against each other, and with other technologies.

5. THREATS TO VALIDITY

There are some threats to the validity of our study, which we briefly describe along with the mitigation strategy for them.

In order to analyze the top authors, institutions, and countries, the number of papers for each one was considered. During this process, no distinction was made regarding the co-authoring of studies. The main author receives the same score as co-authors. We also have to consider that authors change of intuitions and countries. As the analysis of the citations of each 116 papers was performed manually, we considered it as an error prone activity. In order to mitigate this issue, some classifications were double checked.

Finally, we could have explored a broader set of data in order to investigate other aspects of the papers included in the review. Moreover, it is possible that some kind of inaccuracy or misclassification may have occurred in the data extraction performed in this scoping study.

6. RELATED WORKS

The analysis of how the Software engineering (SE) area as well as the Requirements Engineering is evolving has been the topic of some studies [3][4][5]. A scoping study was conducted by [3] in which the authors analyzed 512 papers of the 24 editions of Brazilian Symposium on Software Engineering (SBES), and understanding which is the impact of international research in this event. Their findings suggest that greater attention should be given to the SE area, with the aim to attract research from industry with real data, and also international collaboration.

The celebration of 25th anniversary of the SBES, as well as the realization of the Requirements Engineering Conference in Brazil for the first time, motivated [4] to conduct a mapping study aiming to have a closer look at the local RE community. Their

results showed that the Brazilian researchers have been extensively publishing at SBES and WER. Moreover, their findings reveal the better empirical validation maybe required.

A revision of 258 papers published at WER was performed by [5]. Their results are in a certain way similar as ours: Brazil is one of the countries with the most number of published papers in RE. Moreover, Universidade Federal de Pernambuco (UFPE) is one of the most active institution as far as publications at WER is concerned.

7. CONCLUSIONS AND FUTURE WORKS

In order to understand how the MAS community evolves, this study presented some findings resulted from a scoping study considering the 9 previous editions of WESAAC. In this sense, we identified the most active countries, institutions and authors, the main topics discussed, the types of the contributions, the conferences and journals that have most referenced WESAAC papers, the publications with the greatest impact, and trends in MAS.

Future works include an analysis to discuss about the schools (e.g. for their suitability, themes, repetition, impact on participants' dissertations/thesis or papers). An interview with experts in the area can be also a good way to understand the conference trends along the years [4].

ACKNOWLEDGMENTS

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