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COMPUTATIONAL GRIDS: CHALLENGES AND NEW TRENDS

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ABSTRACT: This paper presents a literature review on computational grids, analyzing their use by various organizations and companies. It aims to identify the main challenges found in their usage, its trends and application. This computing model, although not new, has a considerable amount of users that operate in several areas. As a model that allows the use of heterogeneous computing environments, computational grids have many issues to consider for their use. This decentralized processing also allows their use to be adapted and improved by newer technologies. The findings of this study may provide insights for researchers and users on architecture improvements and computational grids usage possibilities.

I. INTRODUCTION

The Internet growth, powerful computers availability, high-speed computer networks just as the low cost of components raw materials, is changing the way that scientists and engineers do computing and also the way society in general manages information and services [23]. In 90's, inspired by the availability of long-range high-speed computers and challenged by the computational new applications networks requirements, researchers began to imagine a computing infrastructure that could provide access to on-demand computing and enable resource sharing, as in processing and storage cycles, in a secure and adaptable way, between dynamic individuals groups and institutions [17]. Considering the available technology and resource needs required by new applications, Ian Foster and Karl Kesselman conceptualized a computational model for sharing resources and coordinated problem solving in dynamic virtual organizations and multi-institutional [1, 2]. In this new model, it is possible to access computational resources, according to the work need to be performed by interconnected computers by a network likes it as can be seen in [1], [2], [6], [9] [10], [11], [12], [15], [16], [17], [18], [20], [23], [24], [25], [26] and [27]. What makes this archetype even more attractive is the possibility of common computers with different operating systems and resources, be able to donate processing cycles or storage space when they are idle [1], [2], [6], [11], [12], [15], [24], [25]. This paradigm is known as Grid Computing. The following figure illustrate this idea:

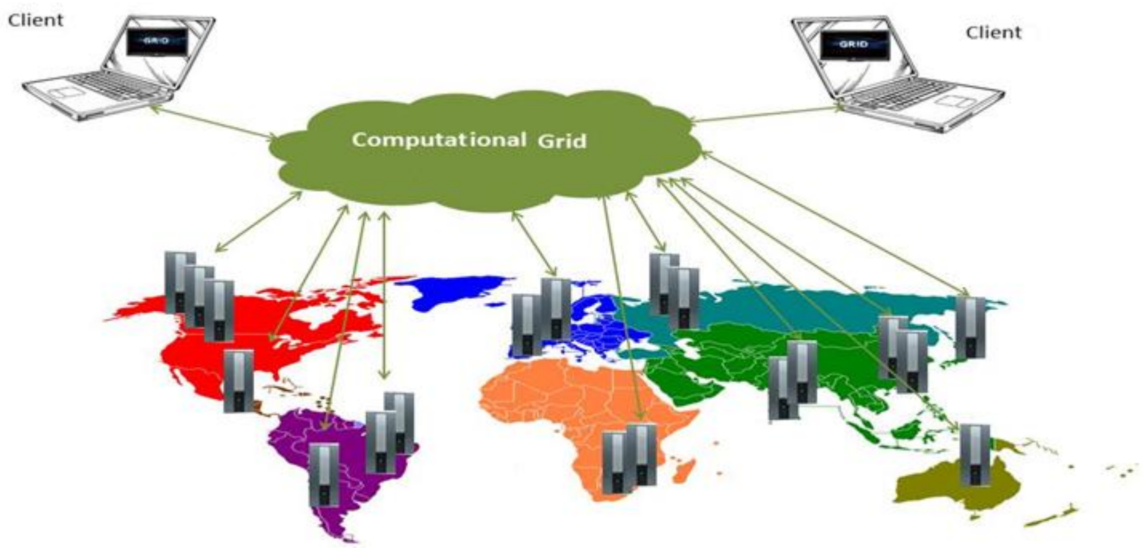


Figure 1 - Computational grid model

According to Ian Foster, computational grids are support systems to run parallel applications that engage heterogeneous distributed resources, offering consistent and affordable access to resources, regardless their physical location [3]. It is understood as parallel application the form of computing where various calculations are performed simultaneously [4] and distributed systems as a set of independent computers that appears to its users as a single coherent system [5]. Brian Chee and Curtis Franklin, say that a grid by nature is composed by loosely linked computers (not sharing memory with each other), and geographically dispersed and heterogeneous [6]. Although commonly considered heterogeneous, it is a possibility and not an obligation for grids, Brian Chee and Curtis Franklin ensure that the heterogeneous nature of many grids improves both its performance and its robustness [6].

In addition to the above features, and still according to Ian Foster and Karl Kesselman in [1,2], a knitted computing system must also have the following features: 1) resources coordination that are not subject to a central body (due to each institution can implement its own policy in its local resources, without interfering directly in the policies access policies to other participating institutions); 2) interfaces use and standardized protocols and be opened; 3) services that can provide non-trivial features (it allows your resources can be used in a coordinated manner to provide different service quality levels, and non-trivial computational power, providing the idea that the combined system is greater than the parties sum). These characteristics, according to [7] and [8]; we can still add: 4) significant maintenance costs, operation and updating are distributed in a more effectively way between partners that shaped the grid; 5) grid computing systems can contribute to the computer creation systems without critical points to failure, that is due to the high redundancy which normally sets these environments; 6) grid computing using more effectively the available computational resources, allowing them to be relocated between grid participants. It is worth mentioning that the resources available to the grid are only used when the computer is idle. [22]

An important concept, when it comes to computational grids, is the virtual organization (Virtual Organization - VO). A virtual organization is an entity that shares its resources in accordance with a policy for a grid [10]. Virtual organizations may represent groups that wish to make use of the grid, groups that provide resources to grid or groups of both: users and licensors [11]. Participants who wish to use the computational grid resources need to be registered in virtual organizations such as universities and research centers, among others [15]. People belonging to a virtual organization have rights of accessing resources provided by the grid, such as computing servers, storage in databases, special networking equipment such as telescopes, sensors and others [5]. When addressed the terms users and licensors, it is good to say that there isn´t a very clear distinction between them. That is, in computational grids the consumer / provider relationship is not well define [11].

II.AN ARCHITECTURE GRID

To define an architecture for a grid it has the aim to create a standard that enables the interaction between different virtual organizations. According to Marcos Pitanga, the objective to define an architecture for a grid is to identify requirements for generic components classes [3]. That is a grid architecture aims to promote the interaction of heterogeneous computing resources under a single architecture. Therefor, it is clear that the software developed for an objective grid provide access to resources from different administrative domains, allowing access only to users and applications that are part of a virtual organization [12].

Kesselman and Cols propose an architecture for grids divided into four layers, named [12]: 1) factory; 2) resources and connectivity; 3) collective services; and 4) user applications, see table 1.

Layer	Defenition
Factory	It deals with several features that form a grid.
Resources and conectivety	It deals with the access safety to resources assigned to the grid.
Collective services	It deals with monitoring and the grid diagnosis.
User applications	It has a set of tools and applications that let you make use of the grid.

Table 1 - A grid architecture, adapted from [12]

The factory layer is an interface for local resources control to be shared in the grid. This layer aims to implement mechanisms that allow the state discovery and the resources control of a grid [13]. It is interesting that in each device mechanisms are needed to initiate, monitor and control the processes execution [3].

The features layer and connectivity takes care of the network communication between different computers and grid resources. In this layer, there are protocols authentication, which provides secure verifying identity means of both users and resources [14]. After this stage, communication protocols are used for computers that contribute in a grid recognize relevant messages in the grid context and ignore any other message coming online, that is, allows resources to communicate with each other, enabling data exchange [28]. It is worth mentioning that this layer protocols need to ensure that the requested operations are in accordance to the policy for the resource [10]. The authors [3] and [14] add that the protocols of this layer are based on the plant layer functions to access and control local resources.

The protocols services layer deal with resources in a global way in order to treat selection conditions, allocation, security, policy and resource accounting [12]. In this layer are used SDKs (Software Development Kits) and APIs (Application Programming Interface) specific for ease middleware programming [15]. Among the layer services, stand out the [3.14]: 1) directory services, which allows to discover the shared resources existence; 2) allocation and scheduling services, that allow participants of a virtual organization to book one or more resources to a specific proposal); and 3) monitoring and diagnostic services, monitoring resources to detect possible failures, overloads or attacks.

At the application layer are included user applications of virtual organizations [12]. There are specific APIs and SDKs for this [10] layer. In this layer the software that will run on the grid will be developed. And for the development of such software is not necessary to know the grid details, as this is already addressed in the other layers [15]. However, such software makes other layers use services [14]. The following image seeks to bring an overview of the grid architecture.

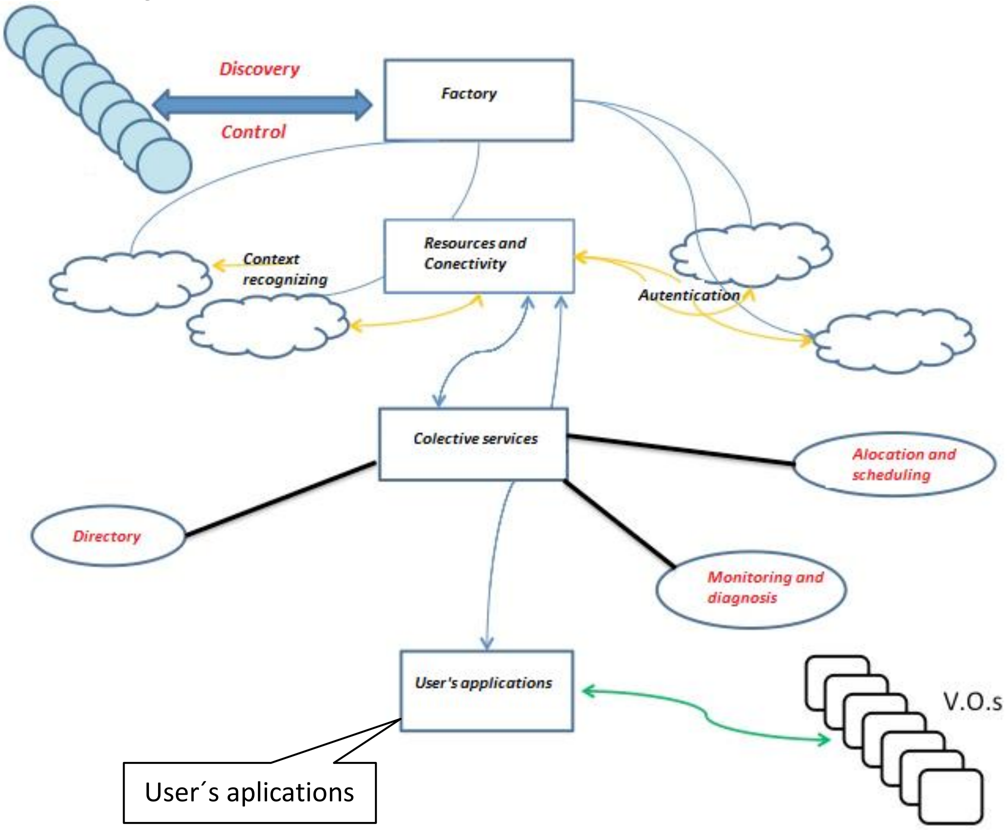


Figure 2 - A grid architecture

III.MIDDLEWARE

As a computational grid is, generally, composed by machines with different characteristics, its management is a complex task. To run a job on a computational grid is necessary, for example, establish the machines identify profile, identify the assigned resources, assess the work needs in question, divide the job, divide the work according to the number of nodes and their available resources and send files for processing. For application developers not have to worry about a huge amount of detail that involve such actions, computational grids have a software layer that aims to hide the complexity of this uneven environment. Several protocols and functions must exist in this software layer with the purpose of providing support for heterogeneous grid elements, allowing adaptation to different operating systems, file systems and communication protocols used [16]. The middleware is the main element of any computational grid, with a layer of software that acts in the collective layers services and resources and connectivity [28]. It is the result of the protocol union, services, APIs and SDKs [15]. Using a computational grid for the most different purposes is only possible by the middleware layer hides the hardware complexity and communication that exists in a grid.
Among the main projects that develop middleware for grids, the following stand out:

Name	Descrition	Highlights	Website
Globus	Toolkit with open source that facilitates the construction of computational grids and grid-based application, in addition to corporate, institutional and geographic boundaries without sacrificing local autonomy.	Project conducted by "Globus Alliance" which includes among others the Argonne National Laboratory and the Institute of Information Sciences	http://www.globus.org
UNICORE	Grid computing Java-based environment that provides a continuous and secure access to distributed resources.	Project funded by the German ministry for education and research, with cooperation between companies as ZAM and Deutcher, among others.	http://www.unicore.eu
BOINC	It is an open source platform used in scientific projects related to the areas of astrophysics, chemistry, molecular biology, medicine, climatology, using personal computers.	Developed by the Berkeley University intended to be compatible with researches like SETI, to seek extraterrestrial intelligence.	http://boinc.berkeley.edu
Condor (HTCondor)	It specializes in performing tasks involving compute-intensive or HTC (High Throughput Computing), which is available a large power tolerant processing fault, for long periods (weeks, months).	Developed at the University of Wisconsin-Madison initially to assess the benefits of intensive computing in campus research.	http://research.cs.wisc.edu/htcondor/

Table 2 - Main middleware projects

For information on other middleware and grid computing projects, there is a good relationship [29].

IV.METHODS REVIEW

This paper sets out six steps to execute a literature review, based on the recommendations, adapted by us, from the Cochrane Handbook publication (Clarke, 2001). The drafting process of this literature review involved 6 steps (research project, studies selection, critical studies evaluation, data collection, grouping and obtained data presentation, results interpretation, updating and improvement) all were guided to achieve the objectives initially proposed in the literature review project.

Step 1: Project Design Literature Review

This literature review project begins with a question to be answered. According to (Clarke, 2001), the question is essential to determine the revised structure. All the literature review steps - research project, studies selection, critical studies evaluation, data collection, grouping and obtained data presentation, results interpretation, updating and improvement - are guided by the research question.

In our literature review project, the following questions were defined:

- What are the challenges faced by grid computing users?
- What are the tendencies regarding the computational grids use?

In this work, the challenges are being treated as obstacles or difficulties in the use or development for computational grids. Tendencies should be understood as new possibilities of use or improvements to be applied in this computational model.

After the formulation of the research problem questions, it was designed a literature review project. In the project are described all materials and steps necessary to perform a literature review. The project design ensures proper planning and organized for all tasks and steps to be performed.

Step 2: Studies search

This is the next step after the literature review project design. In this step, it was identified all studies that could potentially be included in the review in accordance with the criteria established in the literature project review and that will be discussed in the third step.

The studies selection was performed in the databases listed below:

1. ACM Digital Library (http://portal.acm.org);
2. ScienceDirect Elsevier (http://www.elsevier.com);
3. IEEE Xplore (http://ieeexplore.ieee.org/Xplore/home.jsp);
4. Emerald (http://www.emeraldinsight.com/search.htm);

5. Google Scholar (http://scholar.google.com.br);
6. Microsoft Academic (http://academic.research.microsoft.com);
7. Wiley InterScience (http://www.interscience.wiley.com).
8. ISI Web of Science (http://www.isiknowledge.com)

To search for the studies defined the following keywords. It was initially envisaged the possibility of such change into high appearance of cases studies number that are not related to the research topic, or if one of these keywords does not allow us to locate relevant works related to the research subject. The key words used were:

1. *grid computing AND resource management;*
2. *grid computing AND techniques;*
3. *grid computing AND implementation;*
4. *grid computing AND archtecture.*

Two members of the research group, in this present work, carried out the search and studies selection. By reading the title and abstract of them, it was held the first selection of scientific articles within the databases considering the reported research topic.

Step 3: Studies critical evaluation

The studies found during the search in the databases were classified into some categories.

- **Identified studies:** Studies that can potentially be included in the review. Identified by searching in the databases using the key words combined as described in Step 2.
- **Not selected studies:** They represent the identified studies that clearly do not meet the inclusion criteria defined in the literature review project. They were excluded after reading its title and/or abstract for not having relation with the theme proposed for this work.
- **Seleted Studies:** Represent the identified studies that apparently meet the inclusion criteria defined in the literature review project. They were selected after reading its title and its abstract for having relation with the theme proposed for the work. The number sum of selected studies with the non-selected study is the number of studies identified.
- **Excluded Studies:** It is the group formed by selected studies whose analysis after reading it fully indicates that they have no connection with the subject or have little technical quality;
- **Included Studies:** Studies that were used in fact in the literature review. They met all the inclusion criteria set out in the review, and are considered relevant to the research in the scope area of the literature review project.

The classification criteria for the selection of the studies were:

Inclusion Criteria:

- have regard to the theme;
- English Language;
- publications in magazines, conferences, symposium, workshops, periodic and others scientific events;
- Studies that had their publication greater than or equal to the year 2005.

Exclusion Criteria:

- Not have regards to the theme;
- Existing duplicate items in different versions. It will be included the most complete version of the study.

Note: This research considered, during the evaluation, that the included studies had to meet all the criteria for inclusion and could not meet any of the exclusion criteria.

Figure 2 below shows the study phases selection process and the publications number identified in each phase.

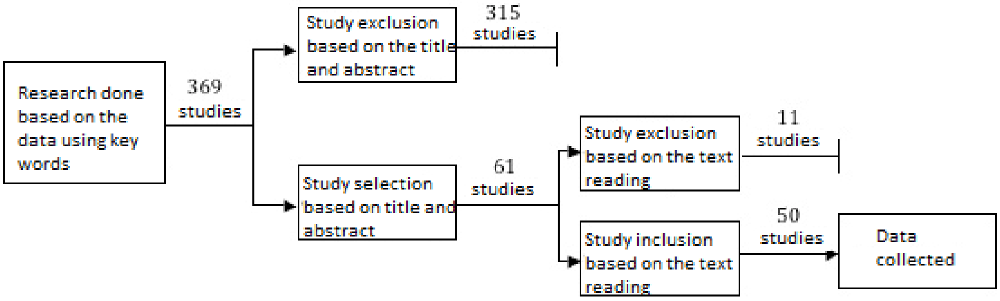


Figure 3 – Studies selection process phases

Step 4: Data collection

At this stage it was placed a set of information from the included studies reading and analysis. The collected datas were considered important for us both to respond to the questions posed in the review project and to give us an idea of the art state research in the studied field. While reading the studies, several consensus meetings were held to discuss data collection important aspects. Reading allowed the extraction of various data that were grouped structured and unstructured, in text and tables with various information about the study in question, it was considered by us as relevant to the literature review process. The table below shows the quantitative relationship, all articles analyzed for database in this study and how they were classified.

	ACM Digital Library	Science Direct - Elseivier	IEEE Xplode	Emerald	Google Scholar	Microsoft Academic	ISI Web of Science	Wiley InterScience	**Total**
Identified	41	2	102	4	101	33	115	39	437
Not Selected	39	0	97	0	91	25	112	5	369
Selected	2	2	5	4	10	8	3	34	68
Excluded	0	1	1	1	2	2	1	4	12
Included	2	1	4	3	8	6	2	30	56

Table 1 - Works analyzed by database

Step 5: Grouping and obtained data presentation

The data extraction process searches to know, to understand and to relate the information and everything that is relevant to achieve the results defined by the literature review project objective.

The included studies were analyzed in qualitative and quantitative terms, in order to obtain data that could satisfactorily answer the questions that motivated this literature review. Data were obtained from studies using a variety of research methodologies, and thus combine information coming from studies case, experiments and literature reviews, all in the computational grids area.

The data obtained from these studies were then classified and grouped as to generate graphs and tables with the purpose of facilitating the interpretation results.

The data were grouped in five different modes:

a) studies description: where each item was converted to a short text form focusing on their most relevant information;

b) studies per year: the works were grouped considering their publication year;

c) research topics: the included works were grouped in research topics, defined by us.

d) research methods: it was taken into consideration, for analyses, the method used in the research.

e) middleware: o middleware used in the computational grids also was an evaluation criteria.

The data collection was carried out according to the variables defined in table 4.

Data extraction	**Descrition**
Studies identification	Unic identification for each study
Data base	Data base where the study was published
Author	Study author(s)
Year	Publication year
Country	Author(s) country
University	Author(s) university(ies)
Citations	Citation quantities for each study
Publication	Journal, Conferency or Workshop
Research Method	Case study, literature review or experiment

Study Focus	Concepts, objectives, methodology and results
Middleware	Middleware cited or used in the study
Subject matter	One of the subjects listed in table 5

Table 4 - Data collected in the selected works

Primary studies were grouped according to the research methods presented in table 5. Table 6 there are the articles listed by topics classification.

Research Method	Descrition
Study case	It is an empirical research that investigates a contemporary phenomenon within its real context. A project, an activity or assignment is monitored according to a specific methodology applied. The results are derived from design measures [30,31].
Literature review	It was developed trying to explain a problem through theories published in books or works of the same gender [30,32].
Experimental research	In this type of research the researcher analyzes the problem, build their hypotheses and works by manipulating the possible factors, variables, which refer to the observed phenomenon [31,32].

Table 5 - Research methods used in the selected articles

Index	Topic
1	Grid Architecture
2	Resource managing
3	Grid overview
4	Security in computational grids

Table 6 - Computational grids topics

Step 6: Results interpretation

The grouping and data presentation from the primary studies were fundamental for the results interpretation.

In this step, we tried to determine relevant evidence on the studies investigated for their importance to the challenges and trends found in the grid-computing model.

Initially, the data was classified and subsequently grouped in the sense that we could extract what were the factors (challenges and tendencies) related to computational grids. From that point, we had other types of information that allowed us to try to answer which of these factors would have greater importance in the improvement or the use of computational grids. In addition, other types of data were collected and grouped; it brought us the base that we consider relevant for understanding the art state of this issue today.

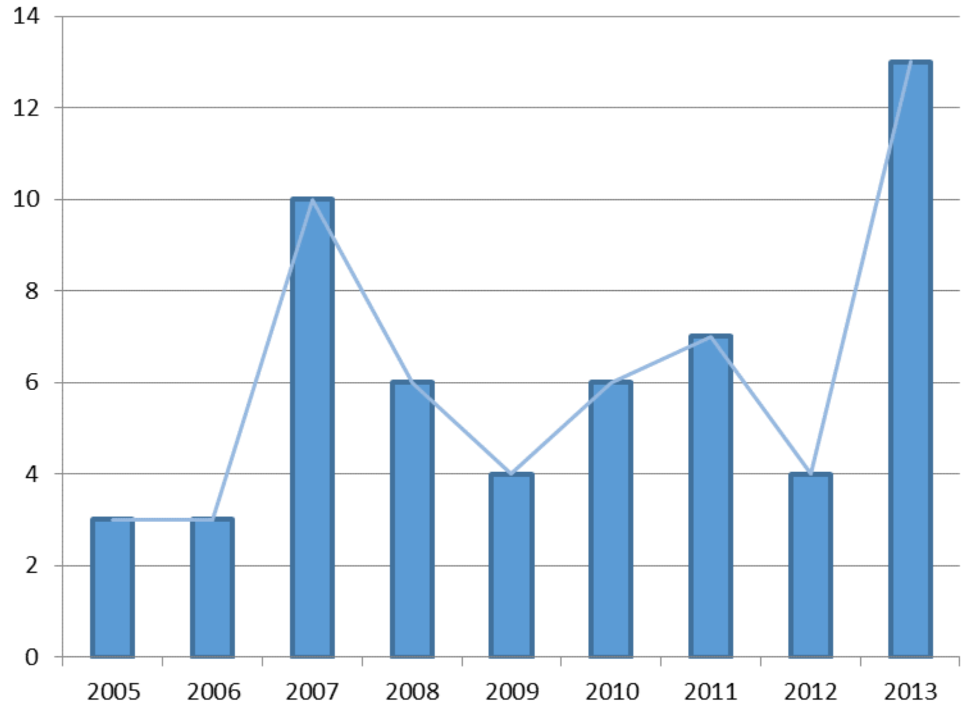
V.RESULTS

This section is responsible for presenting the statistical data analysis results set of the primary studies. Next, in Table 7 shows the relationship for all studies database reviewed in this review.

Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent
Journal	1	0	3	3	1	4	6	4	11	33	59%
Conference	2	3	6	3	3	2	1	0	2	22	39%
Workshop	0	0	1	0	0	0	0	0	0	1	2%

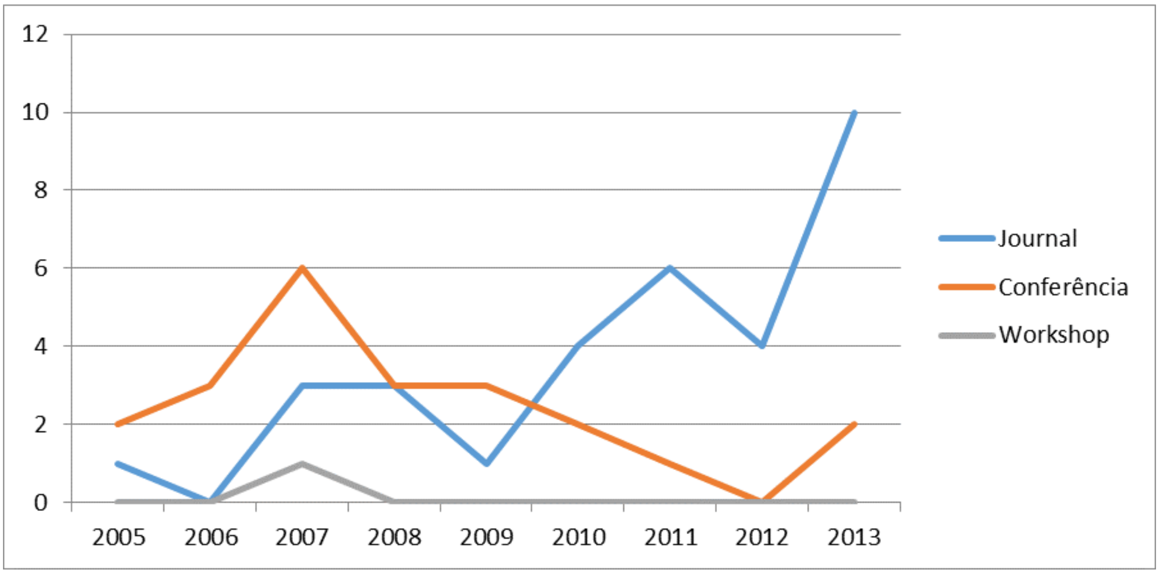
Table 7 – Research activity by year and publication type

The following chart shows the primary studies number included in this review, considering their publication year.



Graph 3 - Publications distribution by year

In Graph 4, the counting of publications year is also being presented. Furthermore, the table provides the number of items that each type of publication (Journal Conference and Workshop) is associated per year.



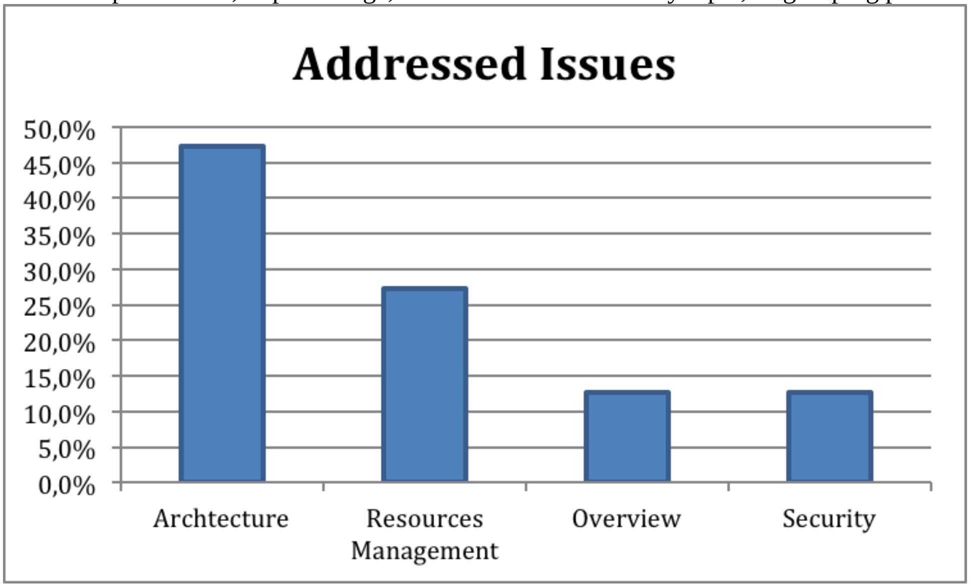
Graph 4 – Research activity per year and publication type

Table 8 presents the results on the selected articles research approaches.

Research Methods	Frequency	Percentual
Case studies	36	64,29%
Experiments	9	16,07%
Literature Review	11	19,64%

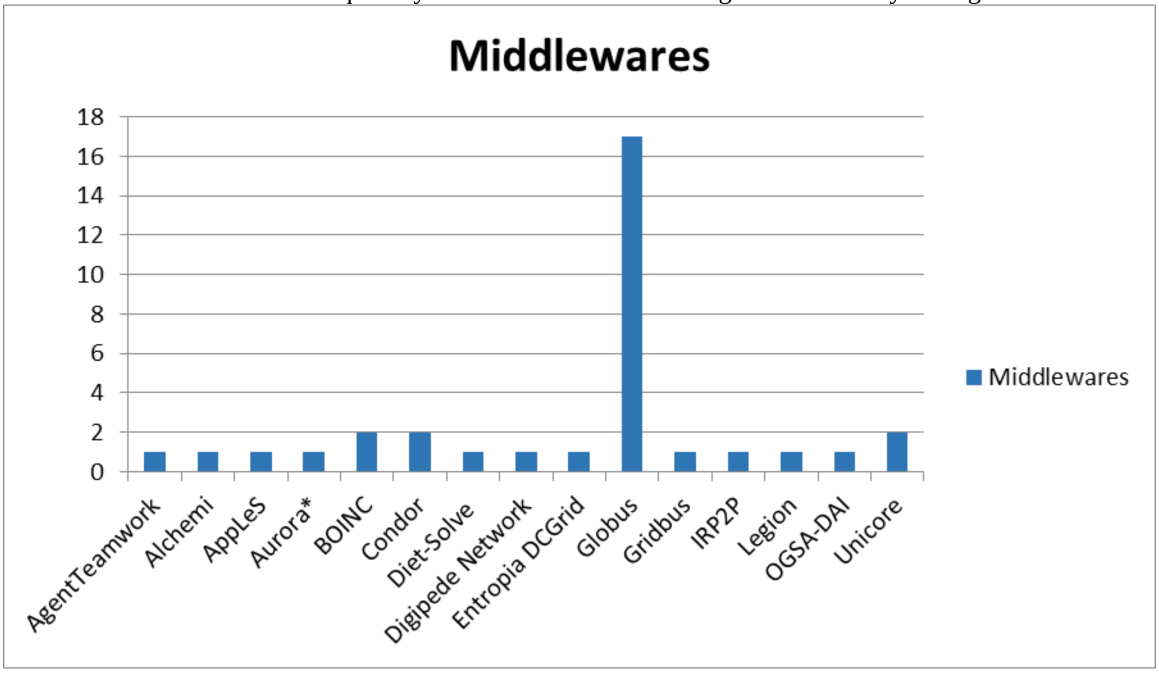
Table 8 – Research Methods

Graph 5 shows, in percentage, the articles distribution by topic, as grouping performed.

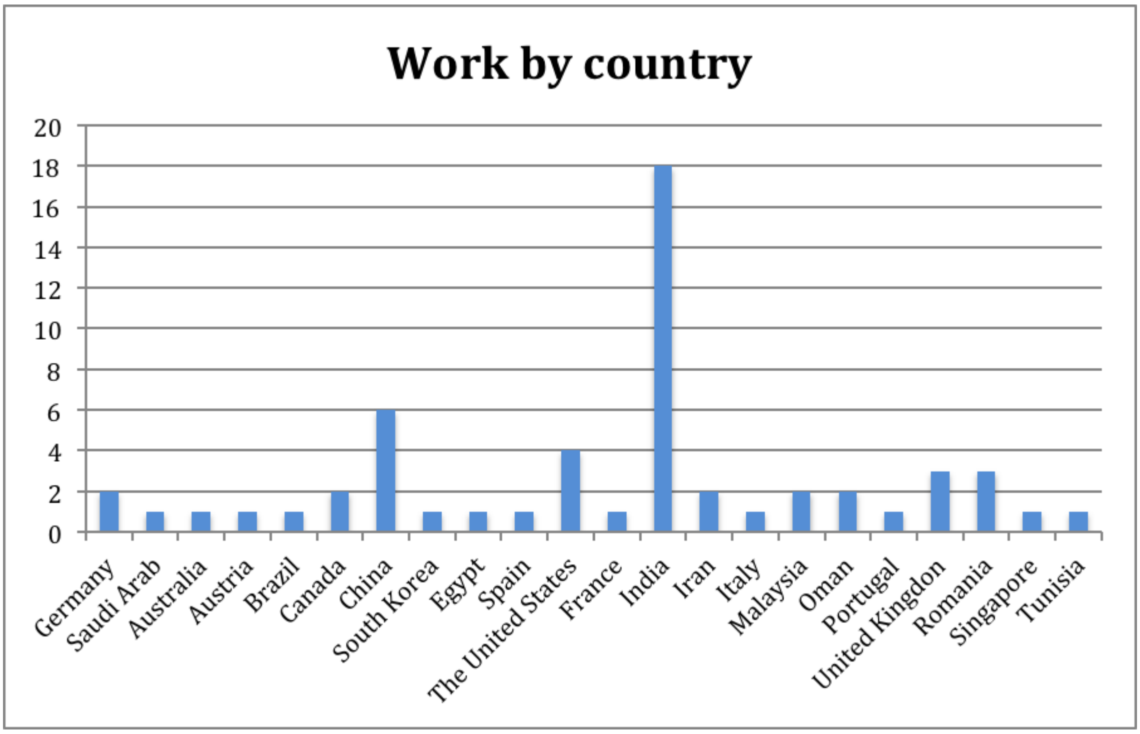


Graph 5 – Issues addressed in papers

Graph 6 shows the middleware that were identified in the primary work and the amount of articles making use of them. In the Chart 7 shows the quantity of works selected according to their country of origin.

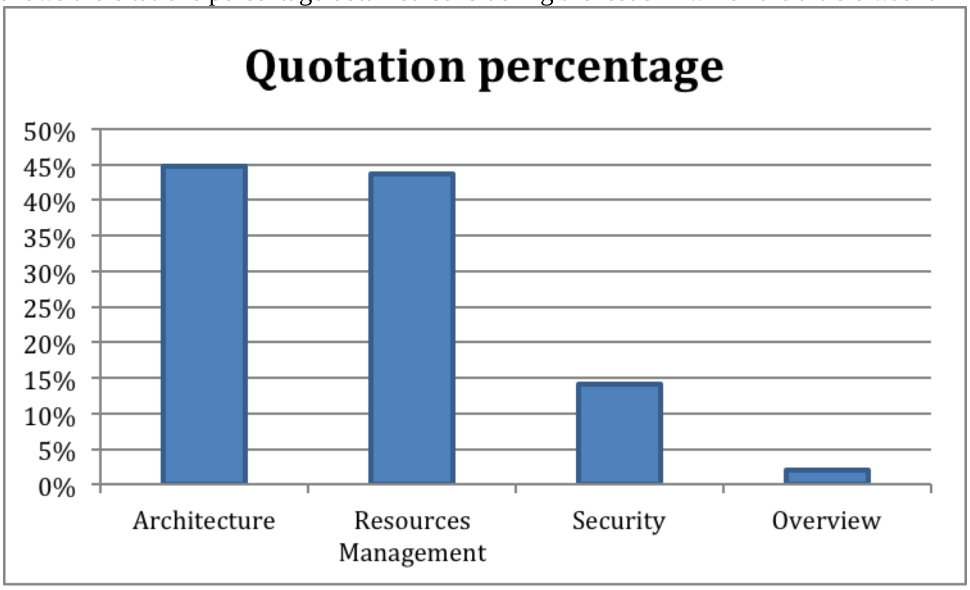


Graph 6 - Middleware addressed in articles.



Graph 7 – Geographical publications distribution by country.

In graph 8 shows the citations percentage obtained considering the issue in which the article was ranked.



Graph 8 - Quotes percentage by subject matter.

VI.**DISCUTION**

This section provides our results discussion and makes a research questions review specified in Review Methods session.

The results presented in graph 3 clearly suggest that interest in grid computing is still significant. In this work, it is evident in the column that identifies the 2013 year of the articles, which had the largest number of selected primary studies.

Regarding the results shown in graph 4, it is evident that most of the articles were published in journals. The rest of the articles had mostly been published in conferences. Interestingly, in the early years, there was a considerable amount of publications in Conferences and Workshops; and that these publications were gradually replaced by publications in journals. This observation makes clear the fact that this field of research has gone from a stage when it was new to a more mature development stage. It also makes clear that currently this field is no longer focus its main interest in Conferences and Workshops.

From the analysis in table 8, it is possible to see that the vast majority of the work (64.29%) used as a research method, the case study. From these case studies, the vast majority (36.11%) present proposals for more efficient discovery and monitoring of the resources for a grid [E4, E5, E8, E10, E20, E22, E28, E32, E45, E46, E56, E47]. Other studies deal with issues such as the integration of computational clouds and mobile grids [E13, E21], or security in computational grids [E42, E29]. This way, analyzing everything stated above, it is possible to see that there are still many improvements that can be implemented in computational grids and there are many efforts.

6.1. Grid Architecture

In graph 5, it appears that the architecture of grids was the most discussed subject in the selected articles. These works, almost entirely, brought proposals for improvements to the computational grids on issues like grid of use for solving complex problems, enabling new devices to provide resources to the grid or even proposals for improvements to specific parts of the grid architecture.

In [E01] the authors apply optimization techniques in Aurora middleware to reduce the overhead in the computing environment. In the study [E02] an architecture of a resource manager for QoS treatment is presented. In Article [E03] the authors present the art state open standards for services in grids and deal with their limitations. Article [E6] proposes a multi-agent based peer-to-peer networks in grids, in order to solve issues related to conventional grid architecture: limitation on system modeling as the dynamics and resources range. The development of an oriented grid on duty to support the implementation of high-performance computing applications, in particular the simulation of dynamic large-scale systems is presented in [E7].

Yet, the study [E8] presents a service discovery scheme and a resource allocation strategy aiming at making more dynamic the service provider. In [E13] is made a proposal of using EUCALYPTUS cloud computing platform as computational resources on demand to the DIET-Solve middleware. IN [E18] the authors propose improvements to the Globus middleware in order to increase the throughput in the grid when subjected to bioinformatics applications. The author of the article [E19] classifies it as an advanced tutorial that instigates two key areas (grid computing and simulation interoperability) that affect the way the modeling and simulation projects that are being developed and implemented. In the study [20], the authors propose an integrated framework for resource management for a bio-grid. The result of this work shows that the grid performance efficiency increases as the problem size grows. In such cases, the proposed resource management framework can help this application to achieve better performance.

The [E21] authors believe that there is a relationship between the solutions provided by the grids and the development of systems for mobile computing scenarios. For this, they proposed a middleware to integrate mobile computing with the grid. Article [E22] behind an interesting proposal to allow interaction with a job running without restarting it. To support this several techniques and interactivity are exploited. The Scale-Changing Technique algorithm (for modeling electromagnetic networks) is used as a model for the development of the article proposed in [E23] and that will be applied in computational grids. Article [E24], the authors highlight two peer-to-peer approaches to data sharing that can be adapted for volunteer computing platforms: bittorrent is the most complex, yet the hierarchical peer-to-peer approach is more secure and customizable. Then, it is explored how they can be applied in the community "Desktop Grid" with a particular emphasis on BOINC project.

In [E25] the authors propose a new architecture for computational grid that allows users with limited resources make any use of computers using hardware / software resources shared. To that end, taking into account the hardware and software requirements as well as quality of service requirements. It is also proposed an algorithm for load balancing and allocation of adaptive tasks. The architecture of a grid and cloud computing are compared in [E35], then similarities and differences are presented. In the study [E37] the authors deal with the embedded information technology in vehicles and how to create a computational grid with such resources.

Use the grid to increase the performance of a web sought was the author's objective in [E40]. The work [E43] compares the performance of an atmospheric data analysis model when subjected to a cluster and a computational grid. In the study [E47] is described in detail and deployed middleware Agent Team Works. By using this software the authors came to the conclusion that to be a more accurate monitoring is necessary to prioritize some over others resources. Article [E48] proposes the use of Haddoop in computational grid to develop a smart marketing model. Benefits of grid usage, its use possibilities and advancement in various scenarios are approached in [E50].

6.2. Managing resources

The second most discussed subject in the articles, still analyzing the graph 5, was the resources management in grids. In [E05], the authors design and implement a system to monitor basic information of each node, like state of the network, computing state of a cluster, number of nodes and on line status and more using Globus tooltik, NWS, and Condor LSF (Load Sharing Facility). In [E10] the authors designed and implemented a job-scheduling model using genetic algorithm and resource management, using weights to consider different types of tasks. In [E27] are presented data replication techniques applied in computational grids.

A resource management model with QoS requirements for grid is presented in [E28]. The [E30] authors describe several techniques used for job scheduling in grids. The [E31] authors propose a QoS monitor for a grid. Article [E32] proposes an architecture where the central star node is both bookie tasks and supplier capabilities. For this, the authors propose an algorithm. In [E33] it is presented a proposal for the integration of parallel applications that present non-functional requirements with a grid architecture. Another proposed resource management with QoS it is presented in [E36]. The use of meta-heuristics to classify the available resources to be allocated in a grid, thereby reducing its running time, are covered in [E39]. A proposed neural network use to classify and estimate the resources of a grid usage time and thus decrease its computational cost is presented in [E45].

In [E46] the authors compare two techniques used for resource management (task farm and paralel date) also defines the parameters to be used in these techniques. Instead of using scheduling based on lines, [E53] uses a more advanced method that is a programming-based approach, allowing advanced booking capabilities, dynamic re-mapping work on the most appropriate resources and optimization schedule based on methods optimization. In [E56] is made a proposal for a dynamic allocation algorithm resources aiming mainly to avoid lack of funds to be booked.

What was revealed in these studies are that there is a concern among researchers and grid users in making the best use of available resources. This is because the dynamics in which resources are assigned and removed from the grid is very large. This resource management influences the allocation of resources for jobs, the quality of service (QoS) offered and grid performance. It is noteworthy that even in articles that addressed architecture of a grid, in a large part of them resource management was also a subject matter.

6.3. Computacional grids security

Regarding the topic security, all the papers mentioned or issues related to user authentication in a grid, or ways to define security policies that virtual organizations implement to the features that give way to a grid. This last point is worth noting, is directly related to the allocation of resources for jobs, because the policy implemented by a virtual organization to its resources implies directly in the form in which such funds will be used by the grid.

In the study [E4], the authors propose a policy model based on events to allow better management of grid resources. The work [E15] describes a simple logical method to improve safety on a computational grid. Grid architecture based on object is an architecture based on the orientation of the object concept and so make use of these features to improve security in grids. Article [E29] seeks to make management access to grid resources easier. For that, it is presented an access control solution based on roles that have credentials with different access levels for each user. The [E34] authors analyze the main aspects related to security grids and make recommendations for the development of applications for grids. A comparison between the following techniques for resource scheduling is presented in [E38]: AppLeS, Condor-G, Nimrod /G and GrADS.

The [E42] authors propose a security architecture solution in 5 layers and a new set of security policies. In [E51] is risen the state art with respect to RBAC, which is the default access control for the grid. Then, it proposed an architecture, which is made managing access by Community Authorization Service (CAS), Virtual Organization (VO) based on the access requested by the User.

Thus, one realizes that access to resources and a reliable data transfer in grid environment are issues that, even in a smaller proportion in relation to other matters, still arouse concern, and where improvements are always possible and welcomed.

6.4. Computacional grid overview

Addressing the grid basics and show how their operation occurs, was the third most subject matter that was even to safely, as it can be seen in Graph 5. Now, out of the total the work which sought to spend an overview of a grid, 75% has the country of origin been in India. Most of these selected works were published between the years 2011 and 2013. In none of these articles an Indian computational grid reference was used. Only basic grids issues are addressed, as necessary infrastructure, steps to be performed in the implementation, ratings for grids, grids components and the art state that it is found at.

I this [E11] article, it seeks to present an IT infrastructure fit for a computational grid as a solution to the business needs change today. It introduces the concept of grid through an evolutionary process and examines organizations that employ successfully the grid as a tool. In the study [E14], it provides a discussion of how to implement a computational grid environment planning its steps and as such, cover the basic requirements for setting up a grid computing environment, and make an appropriate topology and a project to set an initial grid for research and data processing in academic institutions.

The study [E16] aims to present the art state of a computational grids architecture and related issues such as security, data storage space to be processed and distributed environment. The work [E17], it is based on several possible definitions and classifications grids platforms and lists the challenges and different research areas. The authors expose the use of semantic web technologies in computational grid context. The work [E26] also seeks to explain a grid architecture and how its components work. Yet the [E44] authors explain what is a computational grid and lists its benefits. The main concepts related to grids and a comparison between the main middleware is presented in [E54].

Specifically in relation to this topic, it is possible to outline a recent India interest on this subject; however, such technology still seems to be the object of experiments, only initial surveys prospects. At least in the institutions that house the authors of the papers, there seems not to have computational grids.

6.5. Middlewares

In Graph 6, it can be seen that among the middleware used in the work, the vast majority used the Globus toolkit. A lot of it is due to such middleware be distributed with open-source license and it has a modular architecture, which makes it suitable for a wide case studies variety. Thus, resource discovery, resource management, resource monitoring, security, and file management, for example, they are implemented in each of its specific module.

6.6. Countries with more primary studies included

Graph 7 allows us to visualize who, in selected primary studies, most of them have India or China as country origin. The phenomenon related to Indian articles already discussed above. Now with respect to the Chinese works origin, they treat improvements that can be applied to grids, as issues related to resources management [E05, E08, E10], parallel and distributed computing techniques applied to grids [E09], the security resource access [E34], and integration of cloud computing with grid [E48]. China is really making use and implementing computacional grids. In some studies, we found that the grid is from a Chinese origin [E04, E08].

6.7. Diverse

The Graph 8 shows the mean number of citations obtained by considering the issue in which the article was classified. One can see that most quotes are in the works that address issues related to grid resources management, followed respectively by articles that discuss architecture and security grids. When analyzing the graphs 4 and 8 one can notice a relationship between most discussed topics in articles and the issues of the most cited articles. This shows that such issues are not new, but still many of them promote research and experimentation.

In this sense, we can see that there is a permanent researchers and users concern in grids that often are improving this computational model, through new proposals for its architecture. The new range mobile computing devices emergence and cloud computing has spurred proposals enabling the integration of such resources to a grid. As much as the archetype of computational grid is not new, there are still many studies trying to use it in order to improve the tasks performance that have high computational cost, as this model still presented as a solution often more accessible economically than a supercomputer. This makes it clear that even with this computational model maturation, issues related to user safety, the assigned resources are still exploited, and new alternative are proposed.

VII.CONCLUSIONS

This study aimed to summarize the state art in scientific research challenges and tendencies in computational grids. To achieve this goal, a literature review was carried out, which is considered the first stage of evidence-based research paradigm. The results confirmed that grid computing is a research field that still arouses the interest of many researchers, who still seek improvements model itself as well as new opportunities for its application.

In addition, some research areas domain appear to be more active than others, especially in countries with a developing economy but does not always have available the technical resources required for a grid. In this study, the large works number originated from China and India evidenced this.

The most active research topic seems to be computational architecture grids and key issues within this subject proved to be the use of new computing devices as resource providers for grids, techniques to improve grid performance and the grids use to solve computationally expensive problems.

Furthermore, research on middleware used in the grid seems to be very interesting, mainly because the Globus middleware adoption proved dominant over the other. Much of this is due to such middleware be an open-source, reducing project costs and it has a modular architecture, which allows its users to suit it according to his/her purpose.

Considering the primary studies included in this study and used as bibliographic reference, it is noticeable the great interest and care that is with a grid resource management. The possibility of using different computers with different features provided the grid and from different virtual organizations, makes the subject, despite not being the most researched topic, presents itself as the embryo of all other issues related to this computational model.

Considering the results obtained in this work, it was possible to answer the questions raised and thus map the aspects which were more exciting in computational grids and also how this computational model is updating to show been current among so many new technological possibilities**.**

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Appendix A

Classification of studies included

RESEARCH TOPICS IN GRID COMPUTING			Articles References
Research Topic	**Frequency**	**Percentage**	
Architecture	26	48,21%	[E01], [E02], [E03], [E06], [E07], [E08], [E13], [E18], [E19], [E20], [E21], [E22], [E23], [E24], [E25], [E35],[E37], [E40], [E48], [E43], [E47], [E50] , [E52], [E55], [E09], [E49]
Resources Managing	15	19,64%	[E05], [E10], [E12], [E27], [E28], [E30], [E31], [E32], [E33], [E36], [E39], [E45], [E46], [E53], [E56]
Overview	7	14,29%	[E11], [E14], [E16], [E17], [E26], [E44], [E54]
Security	7	17,86%	[E04], [E15], [E29], [E34], [E38], [E42], [E51]

Appendix B

Included Studies in the review

[E01] Alfred Park, Richard Fujimoto, Optimistic Parallel Simulation over Public Resource-Computing Infrastructures and Desktop Grids, 2th IEEE/ACM International Symposium on Distributed Simulation and Real-Time Applications, Vancouver, Canadá, 27-29 de outubro de 2008, pp, 149-156.

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