Resource Management in Multi-Cluster Grid Configurations Adopting an Ontology-Fuzzy Approach

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Agenda

- Motivation
- Introduction
- Related Work
- Proposed Approach
- Experimental Environment and Results
- Conclusions and Future Work

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Motivation

- *Resource management in multi-cluster grid configurations is a challenging task which requires an efficient scheduling of distributed and parallel applications;*

- *Within a grid environment, it is also desirable to have transparency on how to match available resources and communication links to applications;*

Motivation

- In this research work, we present an approach that considers the management of both *computer resources* and *communication links* through an *ontology-fuzzy approach*;

- The *ontology paradigm* is employed as a means to provide *a standard interface* in which users can express their requirements for desired resources;

- *Fuzzy logic algorithms* are used *to gather parameters* for matching processor usage, and communication based on dynamically monitored values;

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Introduction

- *Multi-clusters*, if well orchestrated as in a grid environment, can represent significant computational power for the execution of several classes of applications, including parallel jobs;

- This *meta-computing environment* can be employed as a HPC facility inside a specific organization, or among different organizations, creating in both cases the concept of virtual organization (VO);

- *Inside a cluster configuration*, a local resource management system (RMS) will naturally provide *high priority to local applications*;

Introduction

- *Some* RMSs also support *advanced reservation* (AR), such as, MAUI/MOAB, PBS Professional, LSF and Loadlever;

- These RMS typically utilize *a private interface format* for the execution of advanced reservations;

- A *meta-scheduler* with an efficient algorithm for *co-reservation* and *co-allocation* is a key element in grid environments, especially those formed by *multi-cluster configurations*.

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Related Works

- A number of *meta-schedulers projects* for grid environments have already been proposed with *different characteristics*;

- Examples of grid *meta-schedulers* are *Calana, Deco, Gridway, GridARS and Viola*;

- Another import aspect of *meta-schedulers* is the *challenge* of dealing with *different heterogeneous* local resource management systems in multi-cluster configurations;

- This problem occurs because of the utilization of *private heterogeneous interfaces* from AR modules;

-Only a few projects, such as *Community Scheduler Framework (CSF)* , promise to have a standard interface for information exchange between RMSs;

- However, these efforts *are far from the final goal.*

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Proposed Approach

- The *ontology paradigm* has been considered an interesting solution to formal description of grid resources. Furthermore, it offers a base for the semantic matching;

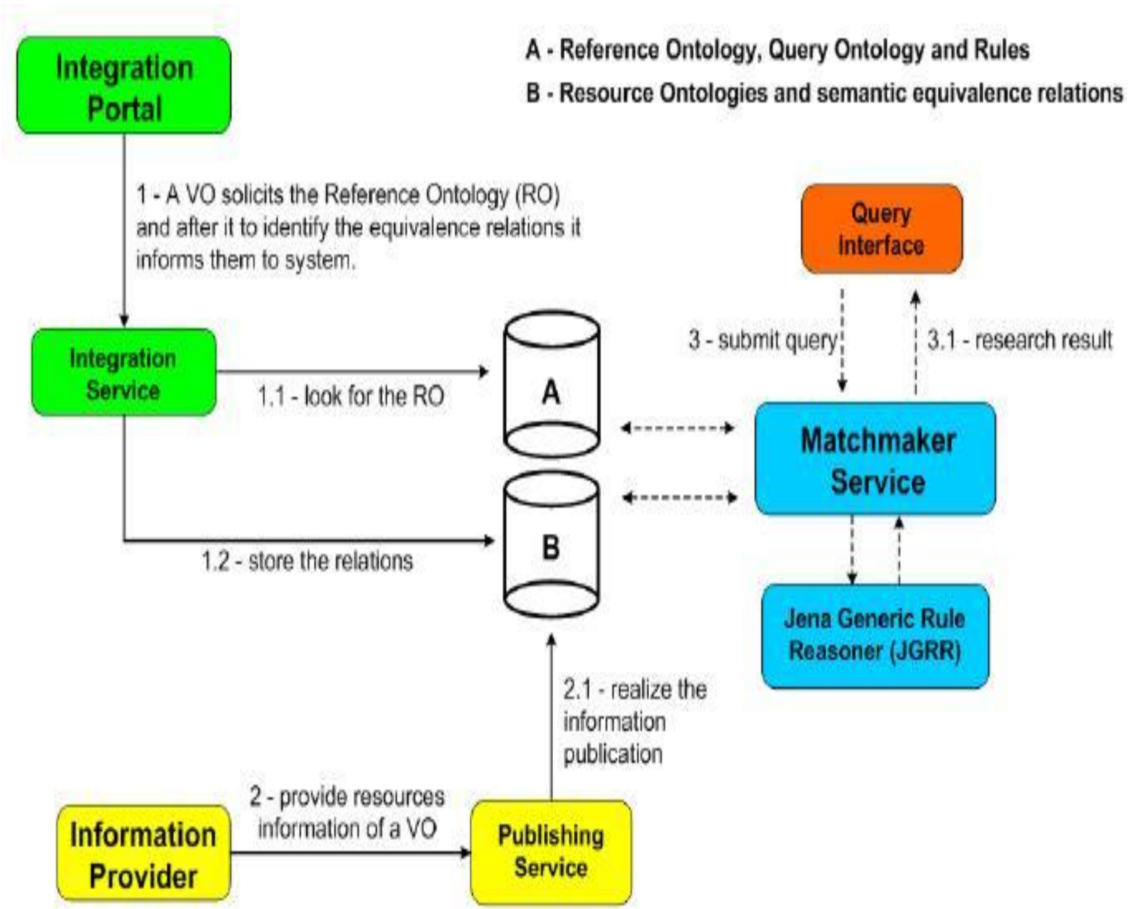


Fig. 1: The resource matching based on ontology

Proposed Approach

- Our approach modifies the original resource matching shown in Figure 1, by sending the submitted query to a *new Allocator* module that interfaces with the *fuzzy analysis module.*

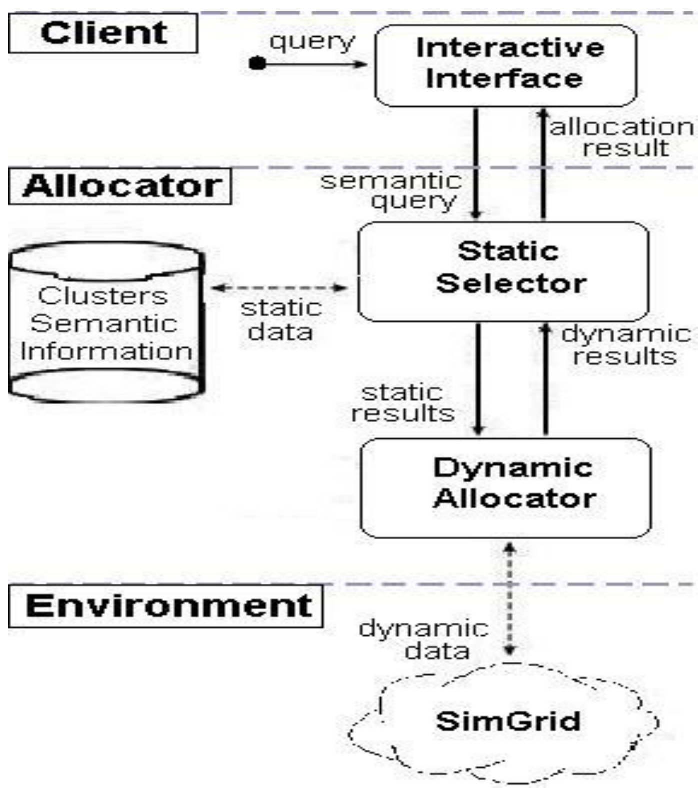


Fig. 2 : Main components of the approach

Proposed Approach

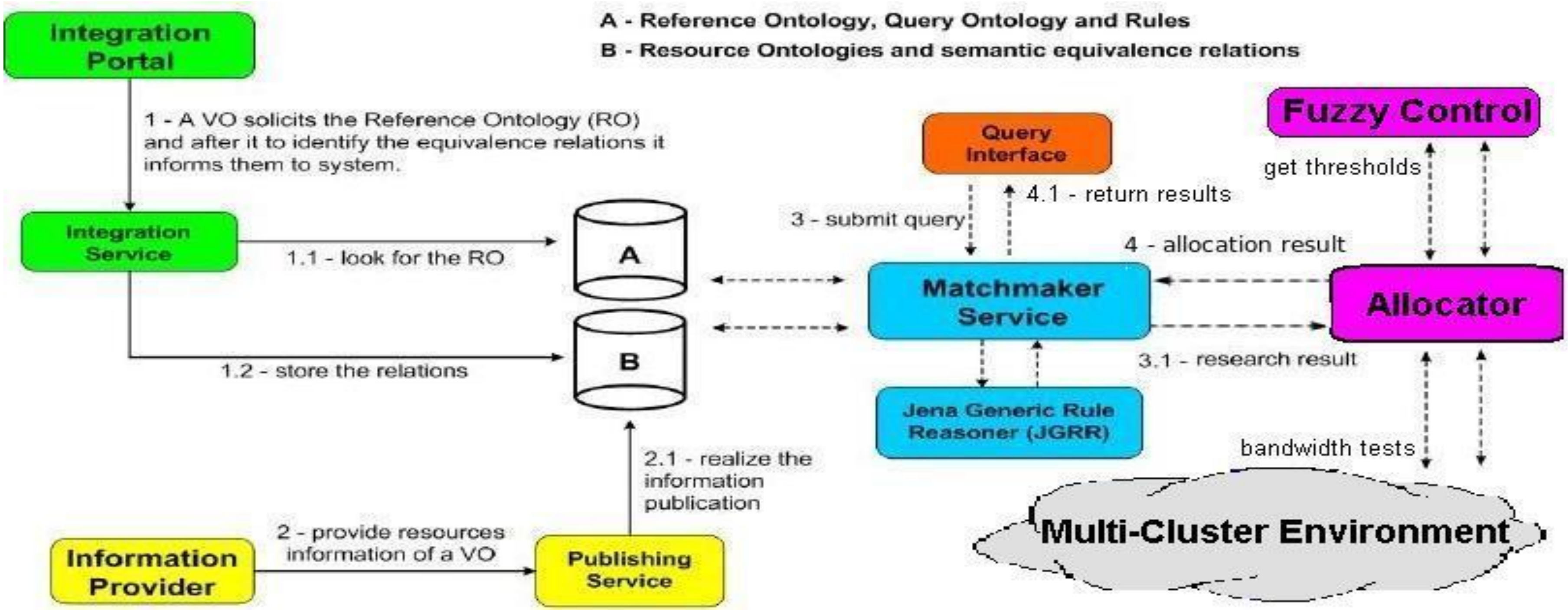
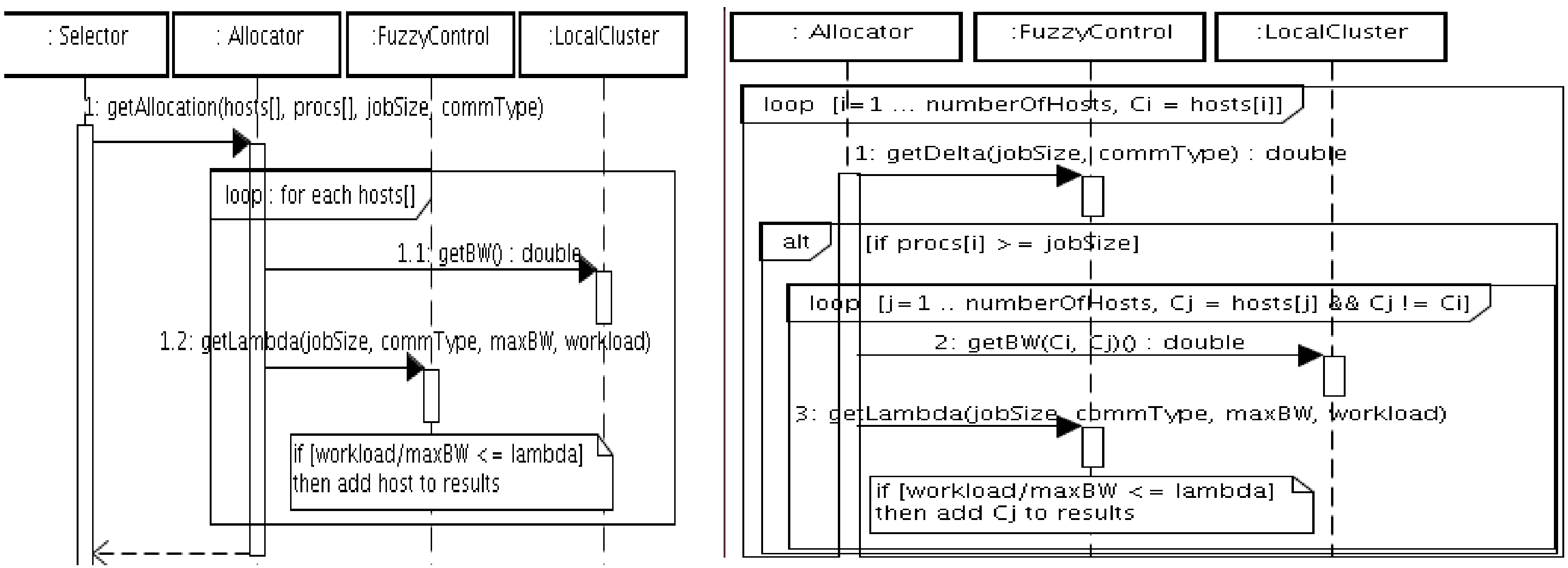


Fig. 3: The new proposed architecture

Proposed Approach



(a) Allocation through a unique cluster (b) Allocation among clusters

Fig. 4: Allocator sequence diagram

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Experimental Environment and Results

- The *ontology components* were built utilizing *Protégé 3.3.1* and the multi-cluster environment was simulated using the *SimGrid software package*;

-*The goal* of the SimGrid project is to facilitate research in the area of distributed and parallel application scheduling on distributed computing platforms, ranging from a simple network of workstations to *large computational grids*;

-The SimGrid toolkit provides *core functionalities* for the simulation of distributed applications in *heterogeneous distributed environments*;

-This characteristic of the package is interesting since it enables simulation of *multi-cluster configurations;*

VO-A	# processors	VO-B	# processors
Cluster_01	7	Cluster_1	4
Cluster_02	5	Cluster_2	4
Cluster_03	3	-	-

Table 1: Multi-cluster configuration

Experimental Environment and Results

- After creating the multi-cluster configuration, we identified *a number of basic concepts* to be used in *both virtual organizations* for requesting resources;

- Table 2 presents how *these request concepts* are understood in virtual organizations A and B. Virtual organization A represents a Canadian environment, whereas virtual B is a Brazilian configuration.

Request's Concepts	VO-B's Concepts	VO-A's Concepts
min_number_of_cpus	[numero_cpus]	[number_of_cpus]
min_virtual_memory_available	[swap_livre_MB]	[free_virtual_memory]
min_clock_speed	[velocidade_cpu]	[max_clock_speed]
owner	[nome_conta]	[login]
number_of_cpus	[numero_cpus]	[number_of_cpus]
min_physical_memory_available	[memoria_livre_MB]	[free_physical_memory]
min_free_disk_space	[espaco_disco_livre_GB]	[available_space]
os_type	[SO, SistemaOperacional]	[os_type]
max_load_cpu_15min		[percentage_load_15min]
max_load_cpu_5min		[percentage_load_5min]
max_load_cpu_1min		[percentage_load_1min]

Table 2: The ontology set utilized for the experiments

Experimental Environment and Results

- The first test was a query where a user required a certain minimum amount physical memory, operating system type (UNIX) and *number of processors equal to 2*.

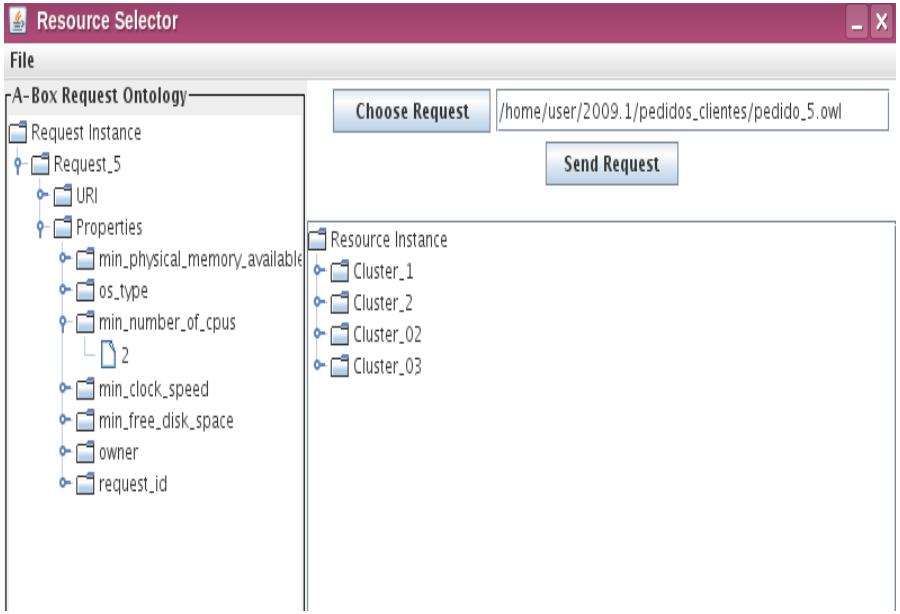

Fig. 5: The first test without dynamic information

Experimental Environment and Results

- Figure 6 shows the second test, where the *same query* was executed under the new system;
- In addition to the available environment, this figure *presents* numbers related to the *number of processors* in each node and *link workload to server*.

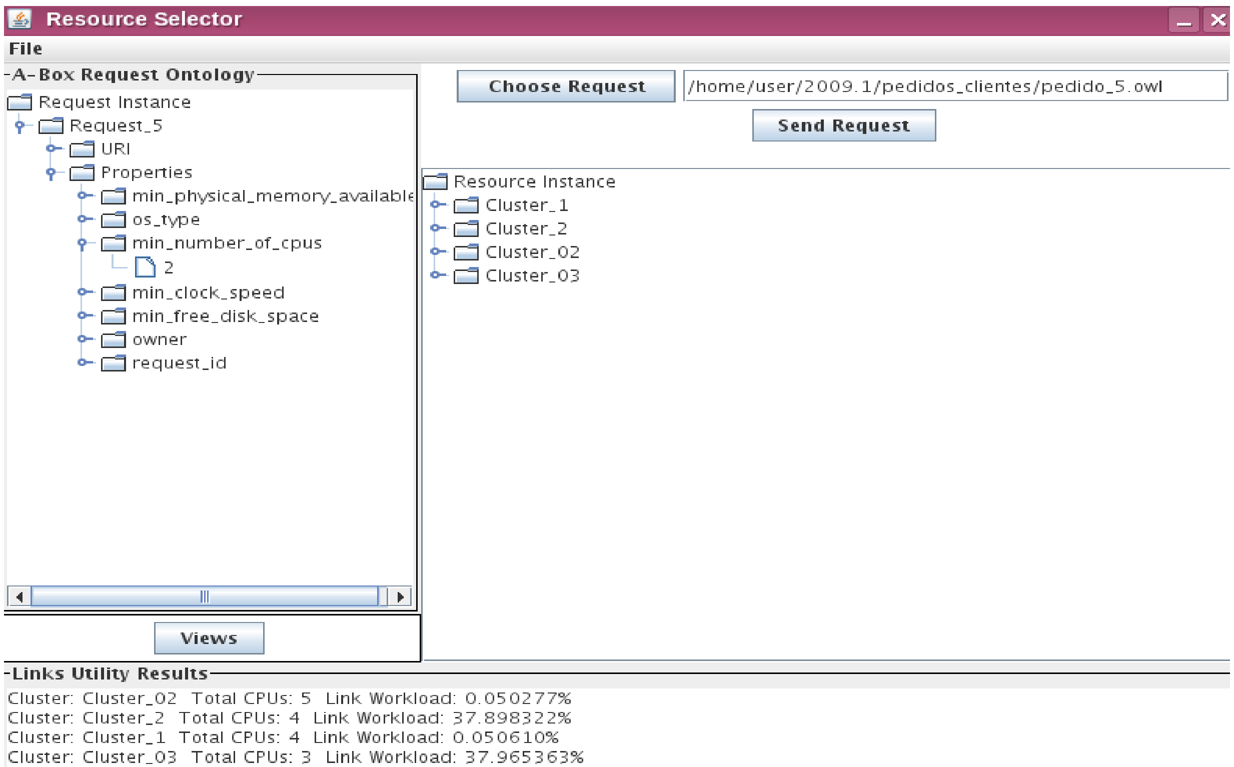

Fig. 6: The first query in the new environment

Experimental Environment and Results

-The third experiment represents a query as it was in the original environment, where *a user requires 6 processors*. Figure 7 shows the result for this query;
- *As expected*, the system replies that *no match was found*. This answer is based upon the *static information* available in the original system.

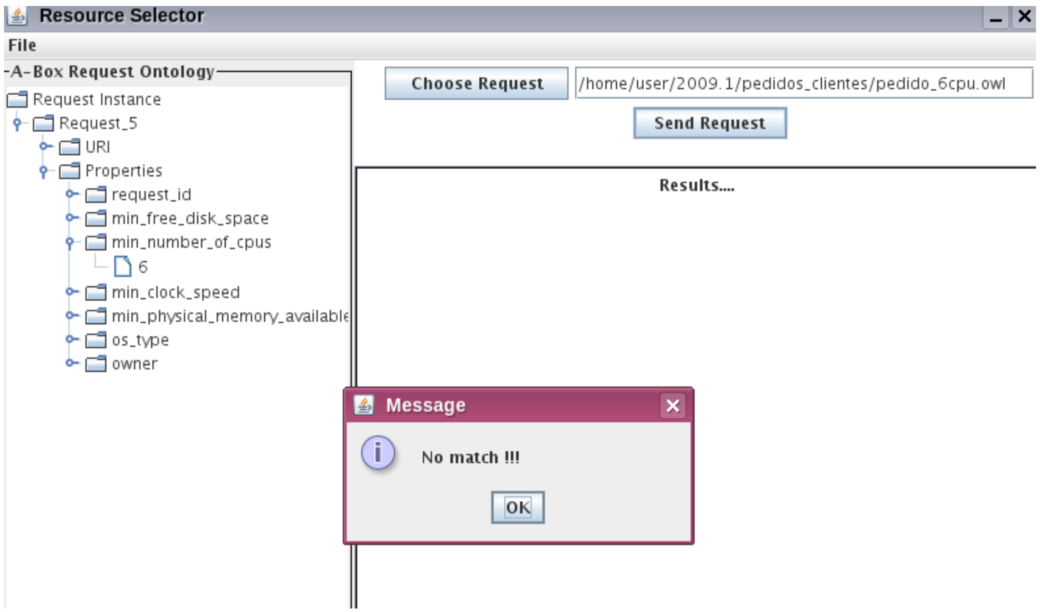

Figure 7: The third experiment without a dynamic information

Experimental Environment and Results

- The next experiment represents the *previous* one considering all *new features* of the new proposal;
- A comprehensive picture of available multi-clusters is presented in Figure 8;
- This figure shows the same third query, however now executed under the new proposal.

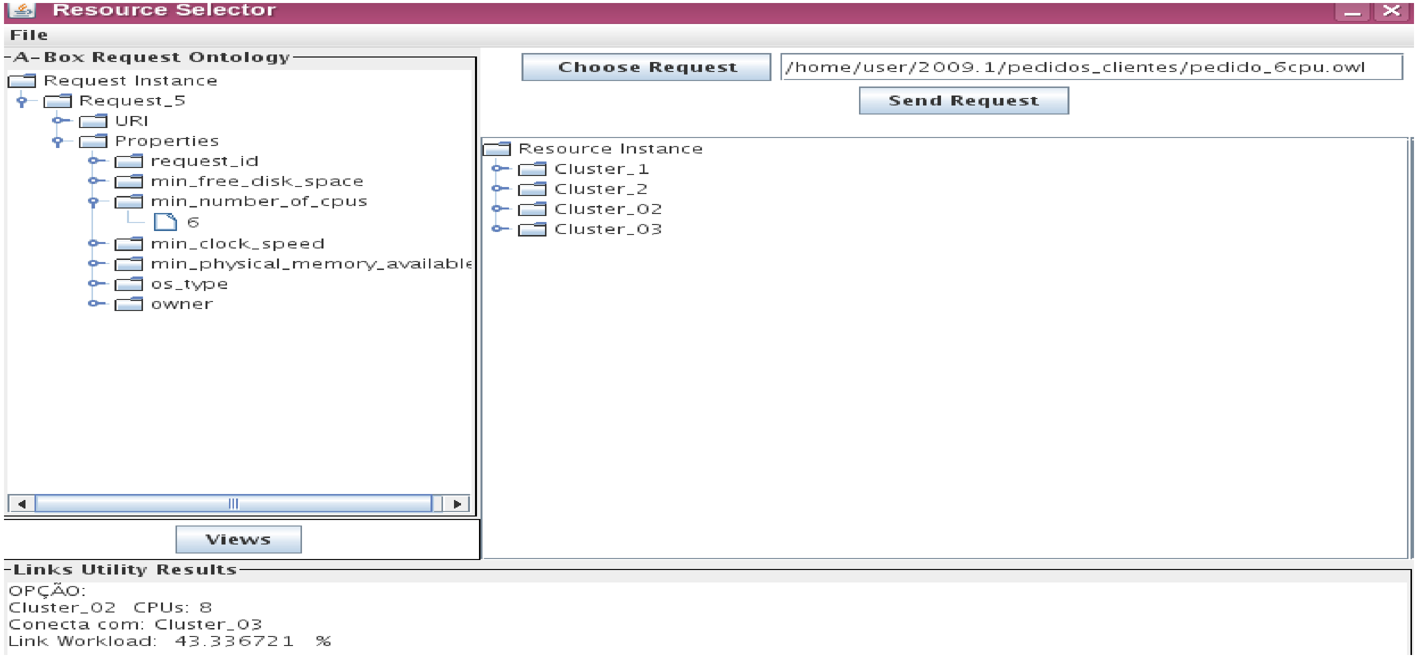

Figure 8: The third experiment under the new environment

Experimental Environment and Results

-The result involves *Cluster_02* and *Cluster_03* which combined reaches the quantity of *8 processors*, sufficient to execute the job;

- It is also shows the *link workload* between these two clusters;

- It is clear from Figure 6 that multi-clusters exist to support the query. The query under the new proposal considers all processors that exist inside all clusters that have one communication link;

- The final result also considers the communication patterns, thus suggesting the job splitting;

-The Result panel shows all clusters that satisfy the query. On the other hand, the *LinksResults* highlights the best calculated solution.

Agenda

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Conclusion and Future Work

-We have presented *a novel dynamic resource matching approach*, which considers computer resources and communication links characteristics, *to gather nodes from multi-cluster configurations as a grid environment*;

- The idea is to provide *a standard interface* to create a grid environment to execute distributed and parallel applications. The proposal can be understood as an *advance resource* (AR) function to execute application in multi-cluster configurations;

- The contribution adopted the *ontology and fuzzy logic paradigms* for a standard description of resources to *compound a multi-cluster* environment and to monitor resources, and also to dynamically *match end-users*' requests and available computer resources and communication link workloads.

Conclusion and Future Work

- The proposal was tested through the utilization of the *SimGrid simulator*;

- The proposal has reached a successful level, providing interesting multi-cluster configurations options to application programmers;

Conclusion and Future Work

- As a future work we are planning to implement co-reservation and co-allocation algorithms and build an entire *meta-scheduler environment*;

- This meta-scheduler would consider different type of multi-cluster configurations, including Ad Hoc nodes;

- We are also planning a *fault-tolerance module* to provide checkpoint facility to more complex applications;

- Finally, we are also planning a component to automatic execute an application in the *best selected configuration*.

Thank you !

Questions ?

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