The Small-World Phenomenon Applied to a Self-adaptive Resources Selection Model

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Abstract. Small-world property is found in a wide range of natural, biological, social or transport networks. The main idea of this phenomenon is that seemingly distant nodes actually have very short path lengths due to the presence of a small number of shortcut edges running between clusters of nodes. In the present work, we apply this principle for solving the resources selection problem in grid computing environments (distributed systems composed by heterogeneous and geographically dispersed resources). The proposed model expects to find the most efficient resources for a particular grid application in a short number of steps. It also provides a self-adaptive ability for dealing with environmental changes. Finally, this selection model is tested in a real grid infrastructure. From the results obtained it is concluded that both a reduction in execution time and an increase in the successfully completed tasks rate are achieved.

Keywords: Small-world phenomenon, Optimization, Grid computing, Self-adaptability.

1 Introduction

A grid computing environment [6][5] is a distributed system which coordinates heterogeneous resources by using open standard protocols and interfaces without applying a centralized control. In this way, a grid system interconnects resources from different administration domains; by maintaining the internal security policies and the resources management software of every domain. This leads to a dynamic and changing environment. Moreover, this type of infrastructures presents a double heterogeneity: on the one hand, there are several groups of resources according to their functionalities. On the other hand, there are heterogeneous resources within a particular group because they are provided by different centres. This fact along with the grid dynamic and changing nature varies resources performance and availability, worsening applications execution performance. Nowadays, applications require real-time information of grid infrastructures for
dealing with the environmental changes. Consequently, it has become a challenge
to efficiently perform the resources discovery, resources-application matching, re-
sources allocation, planning and monitoring (i.e. solving resources management
problems).

Recently, grid communities are addressing the adaptation concept for solving
resources management. In this regard, manifold strategies have been presented:
efficient tasks management frameworks, adaptive and autonomous grid systems,
new monitoring and discovery processes, etc (see section 2). However, none of
these implementations has been extended in a global way across the different
grid platforms. For that reason, the present contribution proposes an Efficient
Resources Selection (ERS) model which improves the infrastructure throughput
without modifying it. This model is defined from the user point of view and
located in the application layer, guiding applications during their deployment
on grid infrastructures. Two main goals were fixed: on the one hand, a reduction
of the application execution time and, on the other hand, an improvement of the
successfully finished tasks rate. In this regard, we are interested in discovering
the most efficient resources in the shortest possible time. That fact has motivated
us to apply the Small-world phenomenon [10] [13] during the selection process.
Concerning this algorithm, D. Watts and S. Strogatz [13] focussed on analysing
a certain type of random graphs with peculiar connectivity properties. They
showed that these networks could be reproduced by a random rewiring process
between nodes in a lattice network. In that seminal paper, the authors proposed
to define small-world networks as those holding a small value of characteristic
path length, like random graphs [4], and a high clustering coefficient, like regular
lattices. Regarding our proposed model, it is expected to find the most efficient
resources in a small number of steps by applying this algorithm. The model
is tested in a real grid infrastructure belonging to the Spanish National Grid
Initiative (ES-NGI). During this evaluation phase two scenarios were defined
to determine if the objectives had been fulfilled (see section 4).

The rest of the paper is structured as follows. In Section 2 grid computing
adaptation related work is presented. Section 3 includes the Efficient Resources
Selection model description along with basic grid concepts for a better under-
standing of the model. Next, the model evaluation and the resulting data are
discussed in Section 4. Finally, Section 5 concludes the paper and summarizes
future work.

2 Related Work

As mentioned, there are some approaches in the grid community exploiting the
adaptation concept for solving the resources management as well as for dealing
with the dynamic nature of such infrastructures. In this regard, [2] describes the
AppLes project, whose goal is to provide an adaptive ability to grid systems. A
methodology for an adaptive application scheduling is proposed, which means,