A Peer-to-Peer Approach to Resource Location in Grid Environments

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Computational grids provide mechanisms for sharing and accessing large and heterogeneous collections of remote resources such as computers, online instruments, storage space, data, and applications. Resources are requested by specifying a set of desired attributes. Resource attributes have various degrees of dynamism, from mostly static attributes, such as operating system version, to highly dynamic ones, such as available network bandwidth or CPU load. Another dimension of dynamism is introduced by variable and highly diverse sharing policies: resources are made available to the grid community based on locally defined and potentially changing policies.

In such a dynamic environment it is often more efficient to forward requests than to disseminate resource information that soon becomes stale. We investigate a set of request forwarding strategies in a peer-to-peer like architecture: each peer acts independently, based on possibly inaccurate information about the rest of the system and forwards the requests it cannot solve to another peer. We investigate these strategies in emulated environments with different sharing characteristics, different request distributions, and on networks of up to 32,768 (2^{15}) peers. The results allow us to characterize the correlation between resource discovery performance based on request forwarding, resource sharing characteristics, and user request patterns.

We modeled the following parameters that define a grid environment: (a) *resource information distribution and density* refers to sharing fairness—some nodes will share information about more resources than others; (b) *requests distribution* encapsulates information on users' behavior. We analyze four request forwarding strategies under two extreme resource distributions: perfectly balanced, where all nodes have information about the same number of resources and unbalanced, where a small number of nodes have most of the resources in the system. We considered two request distributions: a uniform distribution, with all requests having the same probability of being submitted, and Condor traces, that follow a distribution close to Zipf (hence, a small number of requests are frequently asked). In these experiments we assume static resource attributes and no failures.

We considered four request-forwarding algorithms:

- *Random forwarding* (random walk).
- *Learning*: nodes record the requests answered by other nodes. A request is forwarded to the peer that answered similar requests previously or randomly if no relevant experience exists.
- *Best neighbor* records the number of answers received from each peer (without recording the type of request answered). A request is forwarded to the peer who answered the largest number of requests.
- *Learning + best neighbor*: identical with the learning, except that, when no relevant experience exists, the request is forwarded to the best neighbor.

Figure 1 presents the average number of hops traversed per request for the learning-based strategy under various Grid characteristics: balanced (B) and unbalanced (U) resource distributions. A detailed presentation and discussion of our simulation results is presented in a technical report[1].

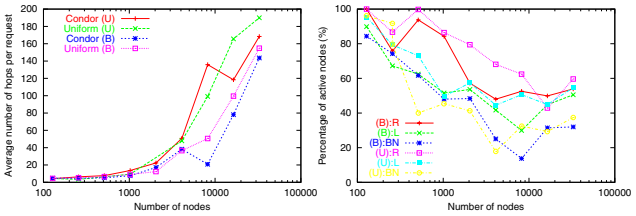

Figure 1. Left: Average number of hops per request (learning strategy). Right: Percentage of actively participating nodes.

The Grid emulator we built for these simulations and the quantitative evaluations obtained provide the basis for designing more sophisticated, efficient resource location mechanisms that combine request forwarding and replication techniques.

[1] A. Iamnitchi, I. Foster, D. Nurmi, "A Peer-to-Peer Approach to Resource Discovery in Grid Environments", TR-2002-06, U. of Chicago

Proceedings of the 11 th IEEE International Symposium on High Performance Distributed Computing HPDC-11 2002 (HPDC'02)
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