

LEVEL HASH TABLE RESOURCE DISCOVERY MECHANISM IN GRID ENVIRONMENT

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Abstract: Resource discovery is important in Grid. In this paper, a novel resource discovery mechanism based on level hash table is presented. The Grid resources are hashed into keys, and each LHT Node stores keys that could be mapped into resources registered on LHT Nodes of current sub-tree. We give the detail implementation of it and the simulation results show it works efficiently.

1 INTRODUCTION

A basic service in grid is resource discovery: given a description of resources desired, a resource discovery mechanism returns a set of (contact addresses of) resources that match the description. Resource discovery in a grid is made challenging by the potentially large number of resources and users (perhaps millions) and considerable heterogeneity in resource types and user requests (Ian, 2001).

Several research works have made their efforts on resource discovery. Some of them used the centralized architecture (Condor), and some used the decentralized architecture. Their results show that a decentralized approach is suited for resource discovery in Grid environment.

Peer-to-peer systems and applications are distributed systems without any centralized control or hierarchical organization (Stoica, 2001). P2P systems can be categorized as either unstructured or structured networks. These systems provide failure tolerant approaches to looking up the location of an object (Min C., 2004).

The Gnutella (Clip2) P2P file sharing system uses an unstructured network among peers, and each query for an object location is flooded to the whole network. But, recent studies show that this approach does not scale well because of the large volume of query messages generated by flooding.

On the other hand, structured P2P networks such as those using distributed hash tables (DHT) maintain a structured overlay network among peers and use message routing instead of flooding. Recent proposed DHT systems include Tapestry (Ben, 2001), Pastry (Antony, 2001), Chord (Stoica, 2001),

CAN (Ratnasamy, 2001) and Koorde (Kaashoek, 2003). In these systems, objects are associated with a key produced by hashing the object name. The DHT nodes maintain an overlay network, with each node having several other nodes as neighbors. When a lookup (key) request is issued from one node, the lookup message is routed through the overlay network to the node responsible for the key. Therefore, these DHT systems provide good scalability as well as failure resilience.

Existing P2P location mechanisms focus on specific data sharing environments and, therefore, on specific requirements (Adriana, 2002). In Gnutella, the emphasis is on easy sharing and fast file retrieval, with no guarantees that files will always be located. In contrast, systems such as CAN and Chord guarantee that files are always located, while accepting increased overhead of file insertion and removal.

To gain good resource discovery performance in Grid environment, we investigate a new LHT mechanism on tree-based network architecture. Instead of flooding mechanism, we employ a purposeful routing mechanism based on hash algorithm.

The rest of paper is organized as follows. Section 2 describes LHT mechanism, section 3 shows simulation result; finally, section 4 concludes the paper and gives the future works.

2 LHT MECHANISM DESIGN

In general, LHT resource discovery mechanism uses a hash-based keyword matching algorithm. We assume that each resource has one attribute as its identity, such as its name. So resource is associated with a key produced, for instance, by hashing its identity.

Due to the limited hash space, the resources with different names may have the same key value, so, there must be a certain quantity of resources with the same hash key in our system, which is the point that benefits our LHT mechanism design most.

So, based on LHT Mechanism, users could pick up the resources - which meet their requirement - from the result list. Or, we could deal with result list further with other attributes to improve the Quality of Service.

2.1 LHT Architecture

The network structure LHT mechanism runs on is organized as a tree. That means an LHT Node has only one parent node, and has several child nodes.

Before they can be discovered, they have to register on an LHT Node. The resources from other computers or devices, or from the node itself, can be registered on the LHT Node. Each LHT Node in the system is responsible for storing a certain range of keys.

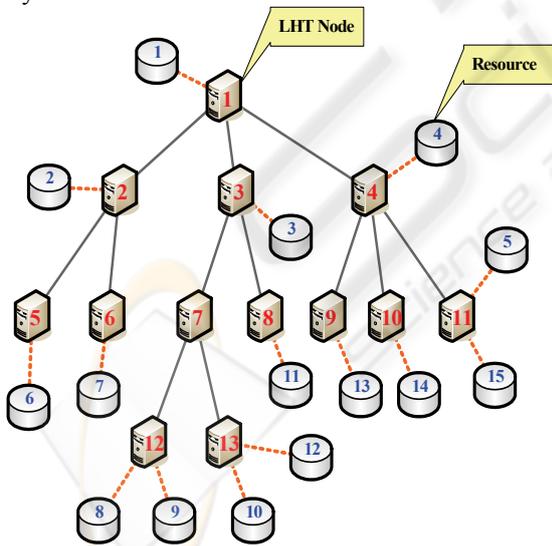


Figure 1: Architecture of LHT Mechanism.

That certain range of keys could be mapped to the resources registered on it or on its child nodes. Figure 1 shows the architecture of LHT mechanism.

The children number of one LHT Node is limited in the system. But we can adjust it to adapt

dynamic factors, such as the whole number of LHT Nodes, to maximize the performance. When a new node wants to join the system, it would find the nearest LHT Node and register as a child node. Thus, the tree will tend to balance naturally, because the nodes join the system from each place has the same probability.

When a query is sent to a LHT Node, system will compute the hash key and the searching process is launched from the root to the right nodes. At last a resources address list will be returned. This resource discovery mechanism allows nodes to get resources based on their key, thereby supporting the hash-table-like interface.

2.2 Data Structures and Operations

Each LHT Node should maintain Resource Register Table (RRT) and Resource Hash Table (RHT). And when resource register event occurs, or new LHT Node join the system, RHT must be transformed to a new type of table - Resource Mapped Table (RMT) - which will be sent to higher level LHT Nodes.

Now we will describe these data structures based on LHT architecture shown in Figure 1. There are two resources registered on LHT Node 12. Table 1 shows the Resource Register Table maintained by LHT Node 12. Note that $h(\text{resource}8)$ means the hash key produced by the identity of Resource 8.

Table 1: Resource Register Table of LHT Node 12.

Hash Key	$h(\text{resource}8)$	$h(\text{resource}9)$
Resource Name	Resource 8	Resource 9
Resource Address	Location 8	Location 9
Resource Description	Description 8	Description 9
Other Attributes	Attributes 8	Attributes 9

Resource Register Table It stores detail of all the resources registered on current node. In this table, the resources are indexed by the hash key, so that we can access the detail information of the resources directly. The operations associated with RRT are Resource Register Operation and Resource Unregistered Operation.

Resource Hash Table It has two dimensions. The columns are LHT Nodes list, including current node and child nodes *DIRECTLY UNDER* current node. The rows are keys list of the whole hash space. RHT is shown in Table 2.

In Resource Hash Table, resources with the same key will be organized in one row. The data of the table could be designed as a bitmap. The Boolean value of a cell shows that whether the resource with

this hash key (row name) is registered/indexed on that LHT Node (column name).

When the RRT is changed, that means new resources register or some resources unregistered, modification operations must be called. Insert Modification Operation deals with new resources register events. What we only should do is to modify the local node column of the bitmap, change the correspondence value to positive. On the contrary, Delete Modification Operation will also modify the local node column of the bitmap, and turn the correspondence value to negative.

Table 2: Resource Hash Table of LHT Node 12.

LHT Node Key Space	LHT Node 12
...	...
$h(\text{resource8})$	1
...	...
$h(\text{resource9})$	1
...	...

Higher level LHT Node knows that the key hashed by a certain resource could exist in which sub-trees of its child nodes, so it can route the query to the lower level LHT Nodes. When resource register event occurs, or new LHT Node join the system, RHT must be transformed to Resource Mapped Table which will be sent to higher level LHT Nodes.

Resource Mapped Table The structure of Resource Mapped Table is same with RHT, but it has only one column. Each cell value in RMT is the result by computing logical OR operation among all the cells value of the same row in RHT. In other word, RMT shows which key can be found in current node's sub-tree, but ignores the resource associate with the key is registered exactly on which node of the sub-tree.

And when parent LHT Node receives the RMT sent by its child nodes, it will merge it into its Resource Hash Table. So the query can easily be routed to lower level nodes. The purpose of design takes the advantages of distributed system, and avoids network traffic by flooding mechanism. Table 3 shows the RHT of LHT Node 7, after merging the RMT sent from LHT Node 12 and 13, and also shows the RMT of LHT Node 7, which will be sent to parent node.

Table 3: An example of Resource Hash Table.

LHT Node Key Space	LHT Node 7	LHT Node 12	LHT Node 13
...
$h(\text{resource8})$	0	1	0
...
$h(\text{resource9})$	0	1	0
...
$h(\text{resource10})$	0	0	1
...
$h(\text{resource12})$	0	0	1
...

→ transform →

LHT Node Key Space	LHT Node 7
...	...
$h(\text{resource8})$	1
...	...
$h(\text{resource9})$	1
...	...
$h(\text{resource10})$	1
...	...
$h(\text{resource12})$	1
...	...

2.3 Resource Register Service

The resources must register on an LHT Node to join the Grid system. And when it is temporarily unavailable, the owner of the resource can unregister it, or the resource is unregistered by Grid Monitor Service. So the Resource Register Service has to provide a parameter which used in the request, to determine whether the resource should be registered or unregistered.

When Resource Register Service receives a resource register request, the resource's detail would be added into the RRT of current LHT Node by Resource Register Operation. Then Insert Modification Operation should be called to modify the local node column of RHT. Next, RMT is generated from RHT and sent to parent node. Parent node calls Update Merging Operation to modify its RHT, and transforms to RMT sent to higher level node.

Similarly, if the Resource Register Service receives a resource unregistered request, the operations have to be called are Resource Unregistered Operation, Delete Modification Operation on local node, and Update Merging Operation on higher level nodes.

2.4 Resource Discovery Service

Resource Discovery Service is the key process of LHT Mechanism. In our system, although the resources are registered on distributed nodes, we do not have to search for request resource by traversing all nodes, and also do not need to search for request resource on a centralized server with heavy load.

In LHT mechanism, once a requester submits his resources requirement to an LHT Node, the following processes will be launched.

The LHT Node received the original request could be called Request Node. It must compute the

hash key of the request resource and send the searching request with the key to root LHT Node.

When a LHT Node receives a request, it fetches the row of its RHT which row name is that key. Check the cells value in this row, if all the value is negative, the request is dropped. Otherwise, pick the columns whose cell value is positive. Now we find all child nodes matching that key then the request will be sent to them, then repeat 2). Certainly, if the nodes we found contains current node itself, which means resources with that key had been registered on local node directly, we should check the RRT and send a message with detail of this resource to Request Node, and then go to 3).

Request Node returns resources list to the user. Then user browses the resources description to see whether there are resources he really wants. If there is at least one resource he wants, the process of resource discovery is finished.

This process can be simply described as Figure 2.

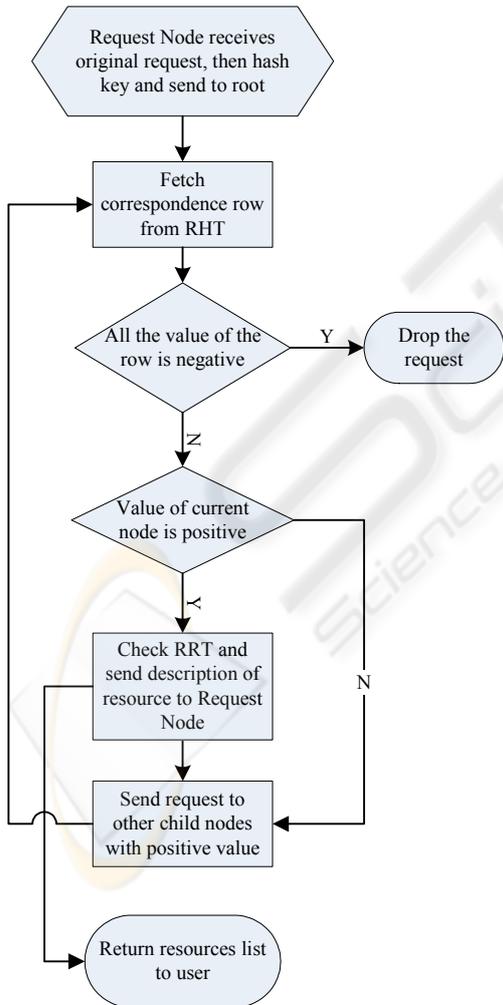


Figure 2: Chart discription of resource discovery.

3 PERFORMANCE ANALYSES AND SIMULATION RESULTS

The simulation tool we used is GridSim toolkit (Buyya, 2002). Above all, some variables should be defined. The number of LHT Nodes in the system is p , and the children number of one node is limited to q . There are N resource exist in the system. The space of hash algorithm is H .

a) Storage Space needed by one LHT Node.

RRT contains information of all the resources registered on local LHT Node. On average, there are N/p resources registered on a LHT Node.

RHT contains information of the mapping relations between keys and child nodes. The row number of RHT is the hash space H .

In one word, storage space is limited by system variables and it won't increase significantly along with network size.

b) Resource Discovery Efficiency.

Obviously, LHT routing mechanism can guarantee to finish discovery operation in $O(\log_q p)$ hops when the tree-based structure is close to completely balanced. Now we assume the resources have to be found at the leaf nodes of the tree. Figure 3 shows the relation between query latency and network size.

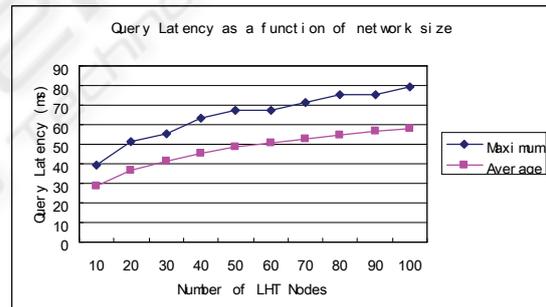


Figure 3: Query latency.

And the children number of nodes will also influence the query performance. When the network size is fixed, changing the children number properly will improve the query latency. Figure 4 shows that the relation between query latency and children number of nodes.

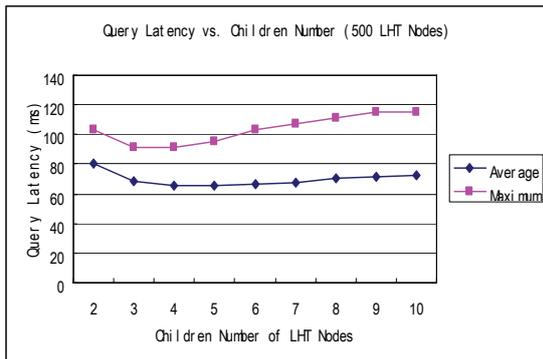


Figure 4: The relation between query latency and children number of nodes.

At last, we will demonstrate that LHT Mechanism is superior to flooding mechanism. We can see the simulation result in Figure 5.

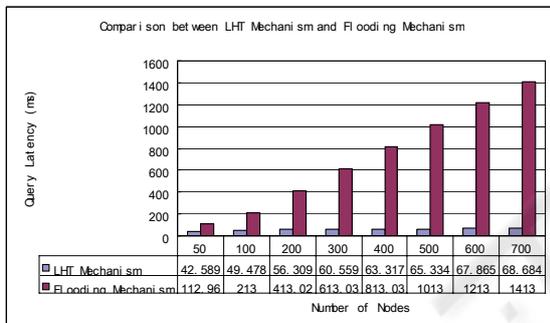


Figure 5: Comparison with flooding mechanism.

4 CONCLUSIONS AND FUTURE WORKS

In this paper, we introduce a LHT Resource Discovery Mechanism. The performance analyses and simulation results show that when network topology is definite, LHT Mechanism can find resources in certain hops. The results also tell us that the change of network topology will influence the resource discovery performance. The tree-based structure is more balanced, and then the performance will be better.

We are developing a prototype of LHT Mechanism. In future, we will improve our mechanism to provide multi-attributes resource discovery, such as QoS parameters.

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