Educational Resource Management in Grid Community Based on Learning Object Metadata Standard

https://doi.org/10.3991/ijet.v13i11.9606

Yuhang Chen
Hohai University, Jiangsu, China
yuhangchen3917@163.com

Abstract—To manage the educational resources of the grid community based on the standard of learning object metadata, the resource classification standard of the learning object metadata standard is taken as the basis of the grid community division. According to the principle of the classification of educational resources, and based on the characteristics of the grid management system and the features of the grid community, the construction and internal structure of grid community are discussed, and the idea of constructing peer community group is proposed. In accordance with the idea of peer community, similar educational resources achieve a logical connection between peer communities. The results show that the mechanism of information sharing and information diffusion is established among communities, and the framework of educational resource management is constructed through simulation and evaluation.

Keywords—learning object metadata, grid community, educational resources

1 Introduction

Educational resources refer to teaching materials, courseware, reference materials, teaching standards and process specifications used for teaching process and its evaluation and management. At present, more and more educational resources are generated in digital form and are applied through computer systems and networks. Educational resources can also be called learning resources and learning objects. Educational resources have many characteristics, such as large amount of data, various forms, strong pertinence and strong education. The management of educational resources has gone through the stages of document catalogue, special website, subject website, resource management database, resource center, and distributed education resource network. At present, the construction and management of educational resources in China are mainly carried out in the form of campus network resource system, regional education resource system, and educational backbone network resource system. However, there are still some problems in the management of educational resources: information island, search difficulties, and sharing difficulties. It is one of the important issues faced by the educational information how to integrate scattered and disordered educational resources, so that users can easily and efficiently use them in their own learning and work, and achieve sharing in a large scope.

The grid technology is applied to the management of educational resources, expecting to integrate the existing educational resources to the maximum and change the current situation of the disorder of educational resources management.

2 Literature review

Golubev et al. (2014) studied the intelligent grid system, and introduced the development direction of the current models, algorithms and tools of the grid system software (including artificial intelligence elements) [1]. Grid computing environment is a parallel and distributed system, which collects all kinds of computing power to solve large-scale computing problems. Jiang and Chen believed that task scheduling was a key problem in grid computing. In task scheduling, tasks were mapped to the system processor, and the purpose was to achieve good performance in minimizing the total execution time [2]. Mohtashami et al. (2017) proposed an optimization model for managing distributed generation system based on traditional network and smart grid technology [3]. Zheng and Veeravalli (2017) realized a win-win situation between resource providers and users, derived the optimal scheme for maximizing revenue in a multiuser environment, and evaluated the performance of the proposed algorithm by simulation [4]. Entezari-Maleki et al. (2014) proposed a mathematical model used to evaluate the performance of grid resources when resource availability was questioned [5]. Yu et al. (2014) proposed a MAS-based optimal network resource allocation method to meet the needs of users and service providers [6]. Carvalho et al. (2015) showed an application program that benefited from the grid computing resources to support the portfolio decision making of the plastic companies, and proposed an analysis of the grid related issues that drive the current industrial design. [7]. Hasanzadeh and Meybodi (2014) studied the problem of resource discovery in grid. The grid resource discovery included location and retrieval of computing resources. The existing solution of resource discovery could not adapt to the dynamic and heterogeneity features of grid. Query propagation proposed by scholars was a novel way to transfer unsupported queries from their resident peers to adjacent peers [8].

To sum up, the above research is mainly aimed at the use of grid computing technology in different fields, but there is not much research on educational resource management. Therefore, based on the above research status, the community is constructed according to the classification characteristics of educational resources, and the dynamic index relationship of the community is established on the basis of the grid community and the stratified model of the community. In addition, the association of the same kind of educational resources is realized through the construction of the peer community, which lays the foundation for the overall management of the educational resources, to meet the needs of educational resource management in grid communities.

3 Method

In order to facilitate the information management of educational resources, several parts formed by the classification of nodes according to some educational metadata standard is called the grid community based education resource (abbreviated as GC).

Definition 1: the physical node Node in the grid is a terminal device for data storage, data transmission, and performance in all kinds of physics. The node has a unique identifier, and the node can be accessed according to the address.

Definition 2: super node sp is a node of resource centralization in the community. To facilitate the search and management of resource information in the community, the super node is used to store the nodes of community organization information library and adjacency tables to summarize the community organization information.

Definition 3: resource node m is the node used to store educational resources. All resource nodes constitute the set of educational resources: R-Nodes.

Definition 4: the classification R of the community is a classification method of educational resources according to the classification attributes of the learning object metadata (LOM) standard. R can ensure that all educational resource nodes have community ownership. In addition, a node can belong to a number of communities, that is:

$$\mathrm{R} = \{\mathrm{r}_1, \mathrm{r}_2, \cdots \mathrm{r}_m | \forall \mathrm{m}_i \in R - \mathrm{Nodes}, \exists \mathrm{r}_j, \mathrm{r}_j(\mathrm{m}_i) = TRUE\}. \quad (1)$$

Definition 5: educational resource grid community i (recorded as GC_i) is the classification method R in accordance with LOM, and it conforms to the node set of community rule r_i, that is:

$$\mathrm{CG}_i = \{\mathrm{m}_i | \mathrm{m}_j \in R - \mathrm{Nodes}, \exists \mathrm{r}_j, \mathrm{r}_j(\mathrm{m}_i) = TRUE\}. \quad (2)$$

Definition 6: the classification node S is a node that provides educational resource classification service according to the LOM standard.

The physical layer consists of educational resources nodes that are actually distributed in different areas, which is the material basis that constitutes the educational resources. The community layer is the logical organization formed by the classification of the physical layer according to the standard of the educational resource LOM. Assuming that the grid G contains m communities, each community GQ has a thousand physical resources, and the virtual resources in the community are mapped by the actual resources of the physical layer, then the different virtual resources can be mapped to the same physical resources. It indicates that different communities can share physical resources, and the actual physical resources are transparent to users. The index layer: the division of the community is realized by the classification information of the teaching resource standard LOM. But because of the huge difference in the distribution of educational resources around the world, it is not only because of the large number of educational resources, a community cannot contain all the educational resources of the same kind, and because the classification of LOM is only a coarse grained division. Therefore, based on the same classification of educational resources, according to the difference of its key index, there are many similar communities and one community group. These community groups have similar educational resource attributes, and each community has similar service types and attributes.

4 Results and discussion

4.1 Division and internal structure of the grid community

LOM will be used as metadata standard for the reference standard of educational resource grid community. Among them, the classification information describes the attributes of the teaching objects and the location in a system, which will be used as the basis for dividing the community and the form of RDF will be used to describe it.

According to the definition of RDF, {Subject, Predicate, Object}, the information specification described by learning resources can be standardized as a triple form: (LO, P, V). Among them, LO indicates that learning resources and predicates are used to distinguish the different attributes and object values of learning resources.

Since the community is the basic unit of teaching resource management, sharing and publishing, and retrieval, the formation of the community is a core issue. Taking into account the knowledge characteristics of teaching resources, the communities are divided according to the resource classification shared by the nodes.

Assuming that all learning resources use the same classification system, and the Classification description in its LOM standard can be divided into m large categories, then the whole system can be divided into m communities, recorded as GC_1, GC_2,..., GC_m, respectively. Community classification methods can be recorded through classified catalogs in classified nodes, and the community attribution is calculated. According to the definition of the community classification, R={r_1, r_2,…,r_m}, where r_j corresponds to community GC_j, the calculation method of $r_j(m_i)$ is shown below:

m_i contains q shared learning resources LO_k, and their location in the classification system can be described as:(LO_k,"lom/classification/taxon/id"T_k"). it meets the following conditions:

$$\text{if}\left[\left[\sum_{i=1}^{q} T_k \in GC_j ? I : 0\right] \geq Thresholk\right], then\, r_j(m_i) = TRUE. \quad (3)$$

$$then\, r_j(m_i) = FALSE. \quad (4)$$

In practice, each node can store various types of educational resources, and the same or similar educational resources can exist on different nodes. Therefore, according to the type of educational resources, a node can belong to different communities. The community attribution judgment of learning resources can be achieved according to the following criteria:

For(LO_k, "lom/classification/taxon/id"Tk")

If $T_k \in GC_i$

Then LO_k should be stored in Community GC_i

The retrieval of the educational resources of nodes can be described as: "in community C_i, for the values of P_k and v_k in a given (X, P_i, V_i), the value of X is calculated on nodes".

When retrieving the resources, as the node $Node_k$ is accessed, by accessing the metadata set managed by the node, each triple form (LO_i, P_i,V_i) of the node resource metadata set is compared, and if $V_i = V_k$, then it is the solution required.

Because of the distribution and dispersion of educational resources, in order to manage the resource information of all the nodes in the community conveniently, and to master the resource distribution of the related communities in the whole grid community, a super node sp is set up for each community organization, used to store the information base of the community and the adjacency list of the resources and information.

The content needs to be stored in the super node is the information base and the resource adjacency table in the community. When the grid resource is found, it is a crucial step to find the relevant information in the super node, and the super node needs to have quite stable nature. Therefore, the super node needs to be a large and stable node.

The composition of the super node is shown in Figure 1. The following is a brief introduction to the design structure of the community information base and the information table of the adjacent community.

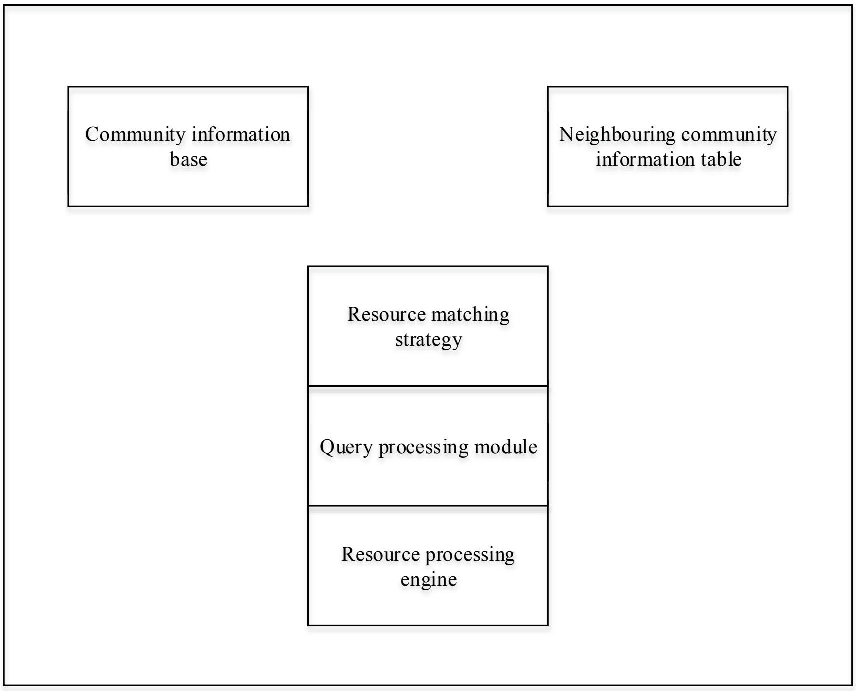

Fig.1. Schematic diagram of super node structure in community

After introducing the concept of the grid community, the infinite educational grid resource system is divided into limited independent space - community. The community is a set of educational resources according to the standard of LOM, which can meet the needs of specific users for educational resources. To create a new community, first of all, it is necessary to input some necessary data, such as new community name, host name as super node, port number, community information storage directory and community description through the LOM classification standard given by the classified nodes and the corresponding interface. If other communities with similar educational resources exist, index associations can be established with other similar communities through the registration of classification nodes. The deletion of community is to remove node from the grid system, which is the inverse process of community creation. For the community model established here, community deletion is an operation conducted at index level. Delete the LDAP community information in the sp node of the community, and then delete links with other communities. When new resource nodes are registered to join the community, they can enter after the "consent" of the super node. "Consent" means that the super node can be calculated and judged in accordance with the community attribution of educational resources to meet the classification conditions of educational resources and then enter. Before entering, the upper limit is also required to be judged. If the number of nodes in the community has reached the upper limit, the nodes that are required to join need to re-choose other correlated communities or reorganize a new community. After the new resource node is added, the resource type, data, IP address and related information included in the node should be added to the community information resource database to update the resource information in the community. If a resource node in the community leaves the community, it should be registered in the community, and the community should also inform other neighboring communities the information that the node has left.

4.2 Construction of grid community group

When the community is divided, it is also necessary to take into account the characteristics of the geographical location, and divide the community with the super node as the clustering center for the same kind of educational resources. In this way, there may be many communities with the same kind of educational resources. In order to realize the association and communication between the similar educational resources communities, it is necessary to establish the peer community of the same kind of educational resources in the grid, and to establish the information sharing mechanism and the communication system between these communities, so as to facilitate the quick checking of the resources.

Definition 1: There are several communities in the grid according to the LOM classification standard of educational resources: $C_1,C_2,\ldots,C_n$, recorded as: $GC_i\{C_1,C_2,\ldots,C_n\}$.

Definition 2: A community set $\{C_1,C_2,\ldots,C_n\}$ which consists of similar educational resources constitutes a community group for this kind of educational resources.

Definition 3: If two communities in the grid are peer-to-peer, they are called adjacent.

Definition 4: supposing Ci={NodehNode2, Nodem}, $Node_1$, $Node_2$, and $Node_m$ have the same type of LOM attribute of educational resources.

Definition 5: $Node_i=K(Id_i, Id_{ci})$ means that any node is composed of two parts.

Definition 6: The definition of membership function: a fuzzy set on a given region U is A, and for any "u∈U", a number $f_A(u) \in [0,1]$ is specified to correspond to it, and $f_A(u)$ is called the membership of U to A.

To sum up, nodes can select the corresponding communities to join in according to membership function. It is like that the only groups in the human society are difficult to form society, only isolated communities cannot form a grid system for sharing resources and working together. The reciprocal communities have the following properties:

Property1: for any two communities C_i and C_j, if:

$$C_i \cap C_j \neq \emptyset (i \neq j). \tag{5}$$

Then there is a connection between the peer-to-peer communities that make up the grid system.

Property 2: for any two communities C_i and C_j, if:

$$C_i \cap C_j = \emptyset (i \neq j). \tag{6}$$

Then there is no correlation (that is, isolated) between the peer-to-peer communities that make up the grid system.

There is a super node sp in the grid community that forms educational resources, which stores the IP addresses of all nodes in the community. In order to establish community groups, the community's super node sp should find the community with the same educational resources in the index layer and join the community index through the calculation of the membership function values of the community and the classification node. Therefore, the design process of grid system based on peer-to-peer virtual community is as follows:

Step l: initialize: set up the scope of resource requirement set, application requirement set and membership function value range based on grid monitoring historical data;

Step 2: classify: calculate the membership function values of resource requirements and application requirements, and classify the nodes with some kind of resources and applications into the corresponding community according to the membership function values;

Step 3: establish the routing information of the super node sp;

Step 4: apply to the education resource classification node to join the index of the similar education resources community. Establish the peer-to-peer grid community group through the routing information of sp and other similar educational resources communities;

Step 5: modify the corresponding items in sp according to the dynamic join and exit of nodes;

Step 6: map the grid system to the corresponding physical nodes.

4.3 Information sharing mechanism between communities

In order to establish information sharing relationship inside and between the communities, the information sharing mechanism is designed, in which there are four types of messages: neighbor message, accept message, detect message and logout message. Neighbor message: when a community needs to build information sharing relationships with other communities, neighbor messages are sent to other communities through the network by multicast, and the community that requests the message will be added to its neighbors. Every once in a while, the neighbor message is re-sent to inform the neighbors about the availability of the community, so as to maintain the existence of the information sharing relationship. The neighbor algorithm is shown as follows:

Algorithm neighbor
Input: T_k Information of this GC
Output: neighbor message
Whenever a GC join the other GC
Multicast neighbor message;
End whenever
For each neighbor do
while(Time_current-TimeJasts_end>T_k) do
send neighbor message;
end while
end for

Accept message: when a community receives neighbor messages, it decides whether to accept the request according to its classification management strategy of educational resource. If accepted, send the accept message to the other person and tell him that he has agreed to add it to his neighbor. Then, the two sides exchange some information according to their own management strategy. The accept algorithm is as shown as follows:

Algorithm accept
Input: neighbor message
Output: accept message
Whenever a neighbor message arrives do
If accept this neighbor, then
Reply accept message
end if
end whenever

4.4 Message diffusion mechanism between communities

At present, there are flooding algorithms, Gossip algorithm and so on, which can be used to spread messages in virtual communities. Gossip algorithm is a reliable distributed information diffusion mechanism for large-scale crime group communication information diffusion.

Based on the traditional Gossip algorithm, an improved two-level message diffusion mechanism is proposed based on the characteristics of the grid community. The first level is the diffusion between the community levels, that is, the message spreads among the different communities; the second level is the diffusion of messages in the various communities within the grid.

There is a Gossip thread in each community's super node, which is responsible for periodic diffusion of message containing local community information to the neighbor, so as to update the information stored in other nodes. Periodic time interval can be set according to different requirements of information update degree. For the first level Gossip, the purpose is to spread the message from the community in the sending node to the neighboring community within the local community. The second level of Gossip diffusion will spread the message in the nodes in the arriving community.

The two important parameters of the Gossip: the number of message diffusion k and the message forwarding round i, which are determined according to the size of the resource grid (the first level is based on the number of nodes within the community, and the second level is based on the number of adjacent communities in the grid). The initial launch node of Gossip sets the forwarding round through the super node of the community, and then starts the Gossip algorithm to randomly select k targets from the neighborhood community and spread to them. The Gossip algorithm is shown as follows:

```
Algorithm Gossip
Input: Gossip message (information of RDF), k,i
Output: Gossip message
While (Time_current-Time_lst_receive>Tk) do
send message to k neighbors;
end while
whenever a Gossip message anive do
 if (have received this message previously) then
discard this message;
else
update local information;
if (message's number of rounds < i) then
send Gossip message to k neighbors randomly;
end if
end if
end whenever
```

In the two-level community Gossip algorithm proposed, in formula k=log n+c, if c=2 is selected, then exp(-exp (-c))=0.873, that is, the probability of obtaining the message for each node is 87.3%. In large-scale grid systems, this means that more than 4/5 nodes will be able to get the message, and the success rate of diffusion is much higher than the actual demand.

There are n nodes with similar educational resources in the grid. Assuming that the community is average in size, and each community has m nodes, then there are a total of n/m grids with the same educational resources in the whole grid. According to the diffusion mechanism of the two-level Gossip algorithm, Gossip diffuses at two levels. First, it diffuses among communities, and then diffuses within the community. The following analysis can be carried out:

Gossip diffusion among communities with similar educational resources in the grid:

The number of messages sent at each time:

$$k = \log(\mathrm{n}/\mathrm{m}) + c. \tag{7}$$

Gossip diffusion among nodes within a community:
The number of messages sent by each node is: k'=logm+c.

$$k' = \log \mathrm{m} + c. \tag{8}$$

The expected value of the number of messages sent per node is E:

$$[(\log(n/m) + c) + (\log \mathrm{m} + c)]/n = ((\log \mathrm{n}\ /m + c)/m) + (\log \mathrm{m} + c). \tag{9}$$

The following is for the grid environment for several cases, the results of the comparison of two kinds of Gossip diffusions for dividing communities and undivided communities. The scale of the grid is set to n=10^7 and c=2.

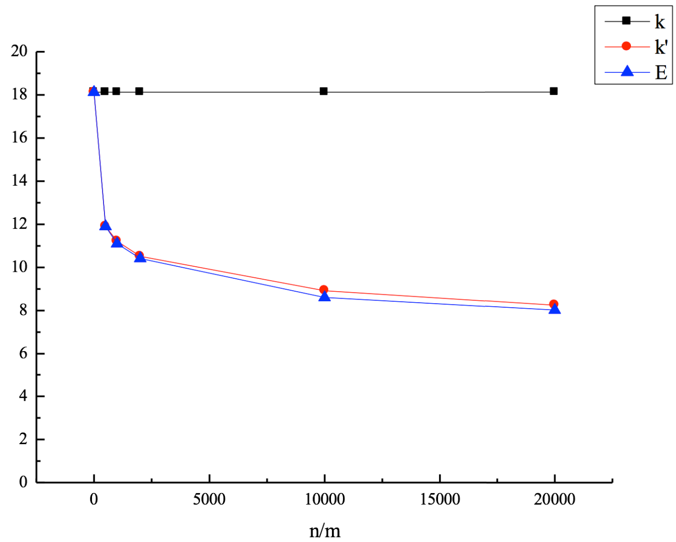

Fig.2. Two message diffusion diagrams (horizontal axis indicates the number of communities)

As can be seen from the figure above, when the number of communities varies from 500 to 20000, the average number of messages sent by each node is E, which is 66% or less of the traditional Gossip algorithm. The fewer the number of nodes m in each community is, the thinner the grid is. Then, the two-level Gossip algorithm can divide the Gossip under the entire grid into the Gossip diffusion in the smaller domain, which makes the load of the message diffusion smaller. When m=500, that is, the number of nodes in the community is 500, the number of messages sent by each node is 45% before classification.

4.5 System simulation experiment and evaluation

The grid simulator GridSim toolkit is used to construct the simulation experiment environment of the grid community. Through the simulation experiment, the performance of the two-level Gossip diffusion mechanism in the query response rate, the message spread overhead, the query response time and the number of resource matching is analyzed, and it is compared with the traditional Gossip diffusion mechanism.

The number of grid tasks is set to be 200, and the task length will be increased from 20 to 200, increasing 20 per scheduling. Deviate% is 10, Granularity time is 20, resources are all resources, and Overhead time for grouping is 10. The results are shown in Table 1.

Table.1. Influence of different length grid tasks (Ml) on simulation time

Average Ml	Group	Total Simulation Time
20	4	232.19
40	7	263.33
60	10	306.81
80	15	383.75
100	19	439.43
120	23	531.20
140	26	563.07
I60	31	627.14
180	35	692.91
200	39	762.06

The total simulation time increases with the increase of average grid task length. This is because, when the grid task length increases, the processing load of the resource increases. The grid task grouping depends on the MIPS of the resources provided, so the number of total grid task groups will increase as the grid task length increases. The number of grid tasks increases, resulting in total simulation time growth.

Average MI is 20, Deviate% is 10, Granularity time is 10, resource is all resources, and Overhead time for grouping is 10, and the results are shown in Table 2.

Table.2. The impact of group and ungroup on simulation time

	Group		Ungroup
Gridlets	***Group***	***Total Simulation Time***	***Total Simulation Time***
100	4	155,02	808.13
200	7	192.28	1613.65
300	13	288.28	2408.78
4(8)	15	320.28	3207.18
500	18	368.28	4008.03
600	22	445.66	4810.52
700	25	480.60	5614.15
800	31	576.60	6411.73
900	33	608.60	7214.93
1000	36	656.99	8016.81

When the grid task ungroup is applied, with the increase of grid task number, the total simulation time is almost proportional to the number of grid tasks; when the grid task group is applied, the total simulation time will not increase with the number of grid tasks increasing.

Average MI value is 20, Deviate% is 10, resources are all resources, Overhead time for grouping is 10, and Granularity time is 5, 10, 15, 20, and 25, respectively, then the results are shown in Table 3.

Table.3. Influence of different granularity time on simulation time by grouping method

	Total Simulation Time				
Gridlets	***Granularity time : 5***	***Granularity time : 10***	***Granularity time : 15***	***Granularity time : 20***	***Granularity time : 25***
100	229.90	155.2	128.35	125.50	130.76
200	287.90	192.28	200.62	232.19	205.30
300	399.90	288.28	227.62	240.33	215.46
400	512.76	320.28	296.62	264.47	282.16
500	624.91	368.28	298.22	304.24	297.40
600	736.93	445.66	360.62	345.20	309.00
700	848.90	480.6	392.62	384.16	339.62
800	976.93	576.6	456.62	384.36	355.65
900	1088.93	608.6	486.25	408.97	424.29
1000	1184.93	656.99	504.62	442.79	424.29

When grid tasks are grouped, the higher the granularity time is, the shorter the total simulation time is. The reason is that, before the simulation begins, the given granularity time multiplies with the MIPS of the resource, and the product's MIPS determines the MI that the resource can handle at a given granularity time. Therefore, the higher the granularity time is, the more the MI can be supported by each resource.

For the parameters of the message diffusion based on the improved Gossip algorithm in the experiment, the following settings are made: the number of message diffusion is k=3, and the message forwarding round is i=2. In addition, in order to facilitate the comparative analysis, the traditional Gossip message diffusion mechanism is used, and the same simulation experiment is carried out. The diffusion parameters are set to the following three cases: k=3, i=2; k=3, i=3; k=4, i=3.

The average query response rate, the message diffusion overhead, that is, the number of Gossip messages, the query response time, and the number of matching resources per query of the 100 users assumed above are counted. Repeat the experiment 100 times and get the average result, as shown in Figure 3.

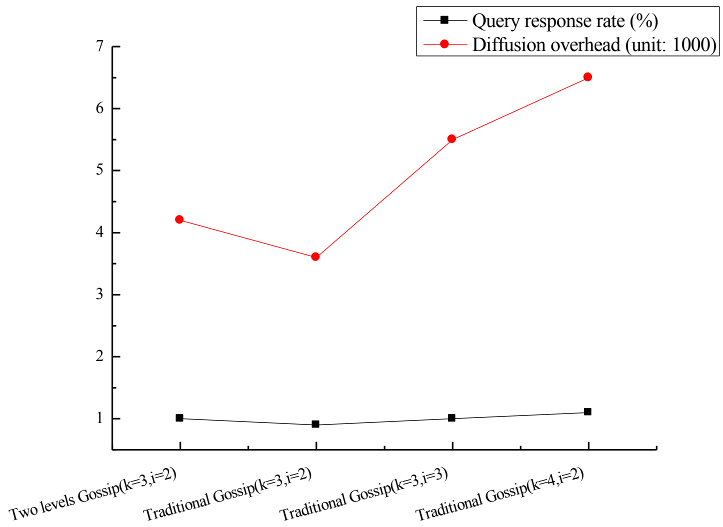

Fig.3. Simulation experiment results

Query response rate: the average query response rate of 100 users uniformly distributed in the grid is counted. From Figure 3, it can be seen that the response rate of the two-level diffusion mechanism is about 20% when the two-level diffusion mechanism and the traditional Gossip diffusion mechanism take the same value of k and i. With the increase of k and i in the traditional Gossip diffusion, the query response rate increases correspondingly. When in the traditional Gossip diffusion mechanism, there is k=4 and i=3, the query response rate is still lower than the value of k=3 and i=2 in the two-level diffusion mechanism. Message diffusion overhead: it is the number of intermediate nodes experienced by the message to reach the target node. From Figure 3, it can be seen that the diffusion overhead of the two-level diffusion mechanism and the traditional Gossip diffusion mechanism is approximately the same when k and i of the two mechanism are the same. But at this time, the response rate of the two-level diffusion mechanism is 20% higher than that of the traditional Gossip. With the increase of k and i values of traditional Gossip, the diffusion overhead of messages is also increasing rapidly. When k=4 and i=3, the message diffusion overhead is increased by nearly one time, and the response rate of its query is still lower than that of k=3 and i=2 in the two-level diffusion.

5 Conclusion

The problem of grid community education resource management based on object metadata standard is discussed. According to the characteristics of resource distribution in the grid, the idea of building a peer-to-peer community group is put forward. In accordance with the equivalent concept of the same kind of educational resources, through the index layer, it makes the logical association between the peer communities achieved. The resource sharing mechanism and the message diffusion mechanism are established between the communities, the communication between the communities is realized, the corresponding algorithms are complied, and simulation and evaluation of the results are carried out. The research work provides a more important reference for the sharing and management of educational resources based on the grid environment, and provides some valuable reference examples.

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7 Author

Yuhang Chen is with the School of Public Administration, Hohai University, Jiangsu 210098, China (yuhangchen3917@163.com).

Article submitted 23 September 2018. Resubmitted 26 October 2018. Final acceptance 04 November 2018. Final version published as submitted by the author.