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A New Distributed Resource Management in Mobile Grid for M-Learning

[1]Mansooreh Jalalyazdi, [2]Seyed Amin Hosseini Seno and [2]Rahmat budiarto

[1]School of Computer Engineering, Ghuchan University,
[2]School of Computer Sciences, Universiti Sains Malaysia

Abstract: Some Mobile Learning methods which are mostly at the experimental level are available. In addition, sharing information among the tutors and the learners which is a reason for using the Mobile Grids as the infrastructure of such solutions is a significant need. Employing a distributed management approach is rather a new subject in grid area. In this paper, a distributed resource management system for e-learning mobile grid called Semantic Distributed Mobile E-Learning Grid Resource Management (SDMEL) is proposed. We have compared the current methods of M-Learning with SDMEL method to show how robust our method is. There is no central server making a bottleneck in SDMEL. The gird is self-repairable and manages itself. Semantic information and context ones make it easier to know what the data is and what the learner looks for. Involving context information enables system to know the learner's needs more precisely. Searching semantically enables agents to show the learner an ordered list of resources or data that are relevant to what the person is searching for. Agent, semantic context information and searching semantically have been employed in SDMEL. Our experiments show that SDMEL does not have more overhead and it is scalable.

Key words: Grid resource management . M-Learning . semantic grid . grid service advertisement . grid service discovery . virtual organization

INTRODUCTION

M-Learning (Mobile Learning) is an important type of learning. It is an issue in the learning in which the learner can be mobile while he is learning. Learners can share knowledge and resources to each other [1]. The best infrastructure to make a suitable environment for mobile learning is mobile grid [2], a grid that its nodes can be mobile while providing or consuming services. At present, there is no comprehensive method to distributedly manage mobile grid resources, although there is a strong need for such a method. In fact, there is no scalable M-learning infrastructure now. In this paper we propose a way to manage resources of a mobile grid for learning. It can be used for other mobile grid usage by some changes. Since information is employed in semantic form by the proposal, any of the contexts such as semantic grid, context awareness, mobile grid and M-Learning help to clarify the proposal.

Semantic grid: The Semantic Grid is "an extension of the current Grid in which information and services are given well defined meaning, better enabling computers and people to work in cooperation" (http://www.semanticgrid.org/). The Semantic Grid is an initiative to systematically expose semantically rich information associated with resources to build more intelligent Grid services [3]. In such an environment agents can find grid resources based on the metadata defined semantically for each of them. It enables agents to find most relevant resources to what is needed if they can't find the exact matches.

Grids are organizationally reflected by Virtual Organizations (VOs) [4]. VOs must be able to produce, use and deploy knowledge as a basic element of advanced applications, aiming at the development of an environment for geographically distributed knowledge discovery applications [5].

Context awareness: In order to successfully embed pervasive devices capabilities in our everyday environments like what is needed in M-Learning, context-aware systems are required. Context is any information that can be used to characterize the situation of an entity [6]. The Context may include user attributes like spoken languages, disabilities, situational roles, beliefs, desires, intentions, environmental information like indoors/outdoors, geographical location information, time, events, device capabilities like display resolution and network capabilities like the bandwidth [7]. Modeling various types of contextual information, reasoning about it and managing it can be done by storing them in Semantic Web formats.

Corresponding Author: Mansooreh Jalalyazdi, School of Computer Engineering, Ghuchan University of Mashhad

Mobile grid: A mobile grid is considered as an extended knowledge grid with the ability of supporting mobile grid nodes in a seamless, transparent, secure and efficient way [5]. Integrating mobile devices into the grid platforms, offers significant challenges due to the inherent limitations in local resources (in terms of processing, speed and storage), reduced input capabilities, battery power and wireless communications capabilities of them [8]. Mobile Virtual Organizations (MVOs) are virtual organizations whose members are able to change locations while provided or consumed services remain available even after temporary loss of being reachable and while running or yet to be initiated workflows adapt to changed conditions [4], so that MVOs are characterized by a strong dynamic element with respect to their organizational composition and their business processes [9]. MVOs show enhancements compared with VOs in the areas of mobility support and dynamic.

M-learning: A definition of Mobile learning is: "Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies" [10]. Learning via mobile device knows no limits, neither in the geographical sense, nor in terms of content. This type of learning cannot only forms formal classrooms but offers new changes that make this distributed virtual classroom available all the time, all places and for every person who wants to learn. It takes place in a social context and learners have the opportunity to work collaboratively and closely with colleagues spread in geographically disparate teams to produce a shared outcome [11]. The Akogrimo project [12] is the only e-learning project that proposes such kind of learning done as a prototype.

Information needs to be presented to learners at the right time, in the right format, on the right device and with the right level of intrusiveness. In short, it needs to be sensitive to the context that changes rapidly and continually as the learner moves between locations and encounters localized resources, services and co-learners [13].

This paper proposes a new way to manage mobile grids in m-learning. Currently m-learning programs are based on central servers making the infrastructures not scalable. The proposed method is self-managed. It is extendable to use in other areas that need a mobile grid.

This paper is organized as follows. Next section gives a brief summary of related works. We introduce our proposal (SDMEL) in Section 3. Section 4 shows experimental results. Section 5 offers the conclusion and future works.

RELATED WORKS

As it was mentioned previously, M-learning is a new topic in which there is no implementation of it yet and as a theory it has only been described in the Akogrimo project. Akogrimo aimed to advance the pervasiveness of Grid computing across Europe by leveraging the large base of mobile users. One of its scenarios was M-learning. It was not managed distributedly. There were central servers managing the mobile grid, so it was not scalable [14].

There is not any completely distributed way for M-learning management yet, even the Akogrimo grid proposed for m-learning does not have a distributed management. Thus, a distributed M-learning management needs more consideration. Undistributed ways using one or some specific servers surely have one or some important failure points in the system. In addition, when the loading of the system is raised, the loading of the servers will also be raised making them bottlenecks [12].

There is also no grid management method specialized for mobile grids except what that is proposed in Akogrimo. As it was stated, mobile grid nodes has some limitations in comparison to normal gird nodes and if there was a distributed method for managing normal grids, it may not be suitable for mobile grids.

To propose a method, we considered an e-learning grid that their nodes have a similar aim of grid membership and it is learning. In such a mobile grid, join and disjoin rates are high. Management method of such a grid must have special characteristics. Keeping information in some central servers can not fit into such a grid.

We reviewed some m-learning applications. Table 1 gives information about 10 m-learning methods. It compares m-learning applications It is clear that no m-learning application uses grid for managing the devices. That is why no one is scalable and is not able to support many learners at the same time.

Based on the stated drawbacks in current M-Learning methods, a completely distributed resource management for M-learning is proposed. It will be discussed in the following section in detail. This proposal is extendable to other fields such as E-health easily.

DISTRIBUTED MANAGEMENT FOR M-LEARNING GRID

SDMEL gives the educators, trainers and learners the opportunity to exchange ideas and information and learn from one another, thus, it expands each

Table 1: Comparing m-learning applications

	Methods									
Factors	1[a]	2	3[b]	4	5	6[c]	7	8	9	10
Implemented	✓	✓	✓	✓	Not successful	✓	✓	✓	✓	-
Scalable	-	-	-	-	✓	✓	-	-	-	✓
Network-based		✓	-	✓	✓	✓	✓	✓	✓	✓
Using central servers	✓	✓	-	✓	-	-	✓	✓	✓	✓
Having distributed management	-	-	-	-	-	-	-	-	-	-

1: CREDIT; 2: MobiLearn [10]; 3: MyLearning; 4: Micolearning [15]; 5: ELeGl [16]; 6: MediaBoard; 7: Grupo Multimedia of EHU Method [17]; 8: MIThril [18]; 9: MyArtSpace [19]; 10: Akogrimo

[a]http://www.learningcitizen.net /related.shtml#credit, 2002; [b]http://www.mylearning.org/; [c]http://portal.m-learning.org/mboard.php

participant's global view and gains a broader perspective on a specific subject as well as on the world in general. In this type of learning, learners initiating and managing their own learning projects, for which they may create, store and modify learning content. For example, in such an environment course providers can easily disseminate information about their courses and students can easily find information about courses that suit their interests and needs.

The e-learning environment in SDMEL method is mobile. Each grid is made of VOs. In SDMEL grid the identification of each virtual organization, is the learning subject defined semantically. Each VO is composed of a group of learners who want to know more about a special topic. The learning groups in the system are easily established by the first membership and are destroyed when the last learner leaves it. Therefore in this learning grid, the VOs are dynamic and mobile. Since there is a variety of topics for learning and each learner could easily establish a new learning group, there would be so many VOs in this grid and number of members of each VO is almost very small. Due to the mobile devices inherent limitations in processing and memory, computations and storing information in SDMEL is done in a distributed way. As it was mentioned in previous sections, in order to offer the most relevant information to what the learner is searching for, context information is used.

Different VO types in SDMEL: There are two types of VOs in SDMEL as follows:

- **Dependent Virtual Organizations (DVO):** A VO is called dependent when it has a small number of members and the total amount of all shared memory in the whole VO is not enough for storing all other VOs characteristics. A dependent VO obtains other VOs characteristics from its Supplier VO; the supplier VO is an independent VO which is near the feeding dependent VO so that they can communicate with each other fast. Obviously each VO can become dependent and independent many times in its lifetime until it is destroyed.

- **Independent Virtual Organizations (IVO):** A VO is called independent when the total amount of all shared memory in the whole VO is enough for storing all other VOs characteristics. When a dependent VO becomes independent, an agent distributes the whole information about all other VOs characteristic to independent VO members based on each device shared memory and its resources capabilities. Figure 1 shows five VOs; the small DVO the learning subject of which is B, is supplied by its nearest IVO which its learning subject is A.

Managing VOs in SDMEL: There is no central server to manage the VOs. It is done in a distributed way that makes the system scalable. It also avoids problems like having a single failure point or an information

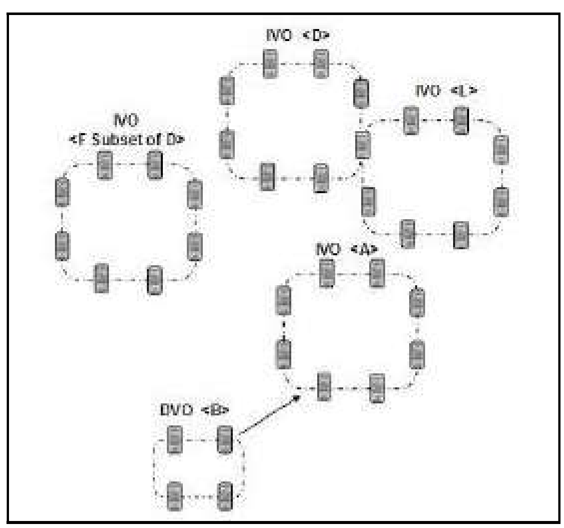

Fig. 1: Example of some DVO and IVO

bottleneck. The system is based on intelligent agents that can understand the meaning of the semantically defined information and respond accordingly. Each VO has a representative. It has no superiority and is only used to recognize a VO. At the beginning the representative of a VO is the first device which has established the learning group. If a VO representative leaves its group, a new one will be appointed by different algorithms e.g. the learner who has been in the group for the longest period of time would be nominated.

Storing VO's information in SDMEL: To manage the VOs efficiently, two different kinds of information are stored in each VO as follows: (i) *General information about all other VOs characteristics in learning grid.* Each VO keeps all VOs characteristics containing their semantically defined learning subjects and representatives' addresses. The size of each VO record is small. Since there are high numbers of VOs, the size of all records together is large. Because of the small amount of most mobile devices memory, this information has to get distributed in a VO; each VO member stores part of it so that by collecting information of all VO members, all other VOs characteristics can be obtained. The amount of information saved in each device is in accordance with the amount of device available memory which is shared in the grid by the learner. In the early phase of new learning group establishment there is small number of group members that cannot store all other VOs characteristics. In this case, the VO have to obtain other VOs characteristics from its nearest VO. (ii) *Detailed information on all devices shared resources in its own VO.* Each VO member keeps a list of all its VO devices addresses and their resources static characteristics. Resources static characteristics are those which their specifications do not change during learning e.g. device display screen type or its memory capacity. Due to the small number of learners in each VO these records are not large.

Early in the learning grid construction: Early in the learning grid construction, there is a small number of VOs, so, if a device wants to join a learning group, it may not find any devices near itself which is a member of a learning group in order to use its VO information about all other VOs subjects. Therefore, at the beginning of the learning grid construction, several devices are being allocated in different parts of the world that are members of a learning group about Thing. These devices make an independent VO named Primary VO. Thing is chosen as primary VO subject because all semantically defined are derived from thing class, therefore its VO data can be shown in all searches.

At the beginning, devices which join the learning grid either become a member of the primary VO or establish dependent VOs which are supplied by the primary VO. As the number of members of each learning group increases gradually, the group can become an independent VO. In order to decrease the waiting time for membership of a device in the grid, primary VO devices can be powerful ones that their addresses are provided to all devices interested in joining the learning groups. In this respect when a device wants to become a member of a learning group and cannot find a learning grid member near itself, it requests assistance of the primary VO.

SMDEL reaction in different learning situations: Many procedures for different learning situations in SMDEL are designed. Some important of them are listed as follows: (i) Checking a VO status; (ii) Becoming an independent VO; (iii) Becoming a dependent VO; (iv) Getting more information about a specific subject; (v) Becoming a member of one of the learning groups; (vi) Establishing a new learning group; and (vii) Leaving the learning group for any reason with or without informing it. Load balancing, message overhead, processing time, efficiency and memory usage are considered in designing the stated procedures in SMDEL.

Searching in SMDEL: There are two kinds of searching in SMDEL which are stated in this section. In both kinds, the learner identifies what he is searching for semantically. Looking for knowledge and matching results are also done semantically; Context information is considered in order to have the best results. These two kinds are as follows: (i) *Searching for resources:* A learner is looking for a resource having special characteristics in its group for example a printer which prints both letter sized and A3 papers, or a monitor which has a high resolution and is less than 5 meters away from the learner. As it was mentioned, each device keeps a list of semantically defined static characteristics of all its VO resources thus searching is fast. The searching steps for a resource are as follows:

- A device that wants to search for a resource, only needs to search its list semantically.
- It then sends agents to the found devices.
- Agents obtain devices dynamic characteristics and rank devices by comparing both their static and dynamic characteristics with resource characteristics needed by learner regarding context information.

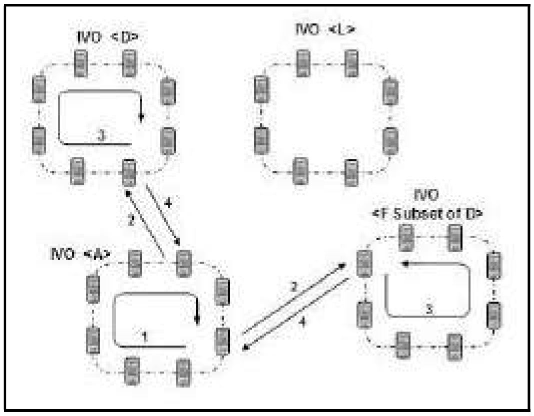

Fig. 2: Searching for data started by a device in an independent VO

- Resource characteristics are introduced to the learner ordered by their ranks.

It is notable that searching for a source is done only in the device VO and there is no need to other VOs referral. (ii) *Searching for data:* A learner looks for data about a specific subject, having special format, etc. For example a learner searches for an image of the pine tree the format of which is jpg or bmp and its size is preferably small, or a film which is about trees in spring season and its producer is from Asian countries. As it was mentioned, all searches are done semantically. Figure 2 shows needed steps for searching VOs information to find data started by a device in an independent VO. The searching steps for data in SMDEL are as follows:

- An agent gets all other VOs general information from devices in the VO of search starter device VO; it decides which VO subjects are semantically Related Works to the needed data.
- The VO of the starter device sends an agent to each VO, the address of which has been obtained in the previous stage.
- Each launched agent goes round its organization comparing semantically specified data in each VO device with needed data.
- All agents return to the starter VO; they rank found data by comparing its specification with needed data and context information. Found Data will be introduced to the learner ordered by their ranks.

If the starter device VO is dependent, it requests assistance of its supplier VO and assign the rest of the job to it. When the supplier VO finishes the job, it will send ordered data to the starter VO. Figure 3 shows needed steps for searching VOs information to find data started by a device in a dependent VO.

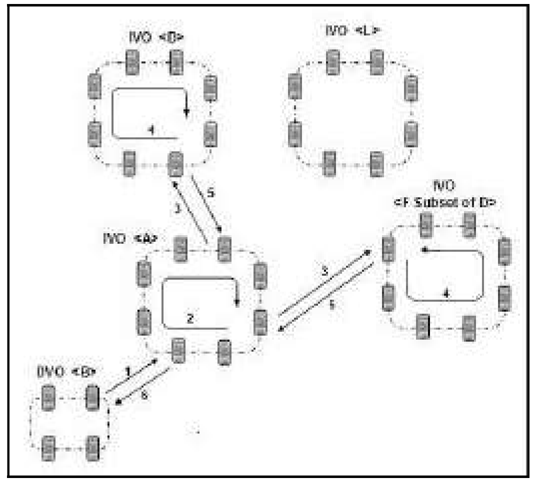

Fig. 3: Searching for data started by a device in an dependent VO

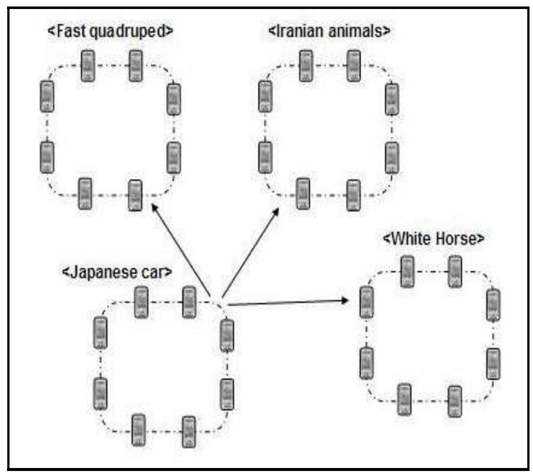

Fig. 4: Searching for data started by a learner in the group about Japanese cars

An example of searching for data in learning groups is shown in the Fig. 4. A Mashhad resident learner which is a member of a learning group about Japanese cars, is interested to have a picture of a wild horse in jpg format; therefore after comparing all learning groups subjects with the learner's favorite subject, some agents will be sent from the starter VO to the learning groups which are about quadruped running fast, white horse and Iranian animals. If launched agents can find jpg images that their specifications of which match the learner request semantically, they will rank results by considering their semantic descriptions matching with the learner's favorite subject and then they will be showed to the learner.

Specialties of searching in SDMEL: Two kinds of searching in SMDEL are stated. Based on them, the specialties of searching are considered as follows: (i) *Specialties of searching for resources:* When there is only one server, in order to find a resource a request/response interaction is needed. In SDMEL no message is needed because each device stores all information on its VO devices static characteristics. Obviously SDMEL is faster and generates no traffic in network. In both ways, agents must be sent to obtain devices dynamic characteristics. If searching is not based on semantics, the agents will only find exact matches to the learner's query. This could be overly restrictive. Semantic searching makes it possible for the agents to find relevant resources that better match what the learner needs and present an expanded list to the person.

SDMEL limitation in that it searches for a resource only in the VO of the device which has started the searching procedure. (ii) *Specialties of searching for data:* In SDMEL, in order to search for data, agents first find VOs which may contain the needed data; then they only search those VOs. This causes searching to be done fast. In single server method, there cannot be a server which can store all the information of all the VOs devices; even if a giant computer is found which can store all data, it would have to be updated whenever data is added to or deleted from a device in a VO. It is impossible especially in mobile grids that are dynamic. A method for solving this problem is to have a server for each VO and a main server to keep information on all VO servers. In this way, each VO needs its specific server; so single server problems still remains but this time in a smaller domain which is a VO. As searching for resources, since searching is done semantically, the data that semantically matches the needed one can be recognized and announced to the learner.

EXPERIMENTAL RESULTS

Not having any central server SDMEL is based on messages. Since the message overhead is important performance metric in the all types of networks which has many side effects on network efficiency and life time of mobile networks, we consider it as an important performance metric.. The most time-consuming item in SDMEL is number of messages sent to the other devices. So, to evaluate our method, we considered the relation that might exist between the number of messages that are passed and the number of devices. It can show us whether the system is scalable or not. Because there is neither a mobile grid toolkit nor a mobile grid simulating software, we write a program ourselves in java. New thread is created at random to simulate new learner joining the system and it get terminated when the learner leaves the system.

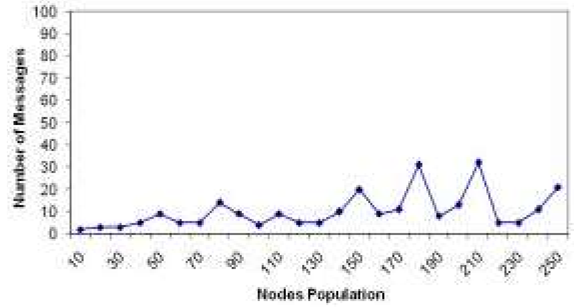

Fig. 5: Number of messages when a learner joins the e-learning grid

When a learner wants to join the system one of these two procedures may be called. They may join a learning group or create a new one. A random number specifies the learner behavior.

- becomeMemberOfOneOfLearningGroups (learnerDevice, learnerSharedResources, VO)
- establishNewLearningGroup (learnerDevice, topic, supplierVO)

When a device disjoins the grid not informing it, the following procedure is called.

leavingLearningGroupWithoutInforming (device, VO, beingRepresetative, reachesAgent)

The device may be the representative device of a VO. The VO of the device may be of dependent or independent type. According to these conditions, different procedures may be called. Again, a random generator function was used to determine if the node has leaved the system when accessing it to gather its information.

There are two procedures for searching.

searchForResources (neededResources, learnerDevice)
searchForData (neededData, learnerDevice)

Searching for data may be started by a device in a dependent VO or an independent one.

Number of messages sent when a new device attach the system: At first, there were 5 members in grid. Some new learners join the system and some older ones disjoint of it at random. Figure 5 shows number of message sent in the system.

As it is seen, while the number of devices increases, the number of messages does not increase. In fact there is no relation between them. It is worth mentioning that a large amount of messages are sent

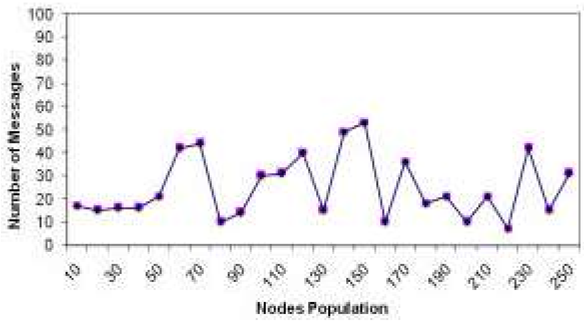

Fig. 6: Number of messages when a device leaves the grid not informing it

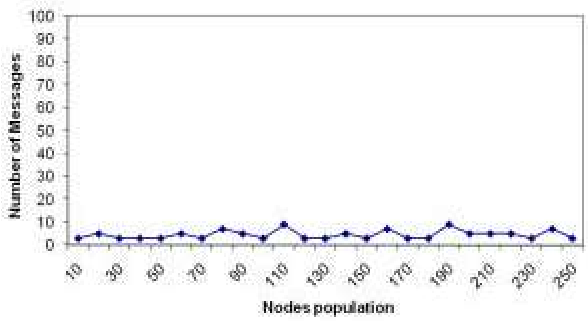

Fig. 7: Number of messages when a learner searches for a resource

between VO members are local in some learning groups.

Number of messages when a device leaves the grid without informing it

When the system understands that a device has left a VO, some messages must be sent to deal with the problem. Figure 6 shows the number of messages sent in the system.

Number of messages sent when a learner searches for a resource: Searching for resources is done only in the VO that the learner is a member of it. Because devices that are in the same VO are usually more probable to be physically neighboring each other and usually when a learner searches for a resource he wants a near one. As it was said, every device knows the static properties of all devices that are in its VO, so sending messages in needed only to find out the dynamic properties. In worst case, the number of messages would be one less than the number of resources in the VO of the searching device. Figure 7 shows the number of messages sent in the system.

Number of messages sent when a learner searches for data

All VOs must be searched when a device searches for data. At first, all VOs general information will be

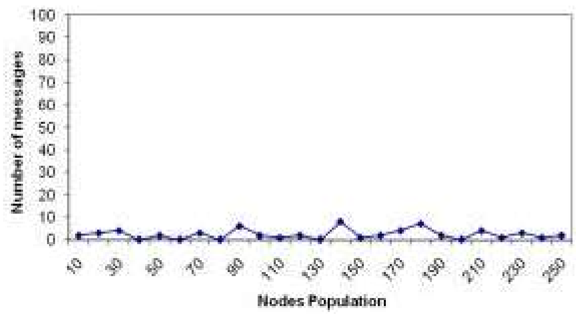

Fig. 8: Number of messages when a learner searches for data

gathered by an agent. After comparing VOs learning subject to the one that is going to be searched some VOs will be selected and agents will be launched to those VOs to search their data. Each agent will come back to the VO of the searching device and announce its searching results. Figure 8 shows the number of messages sent in the system. As it is seen, in all situations, there is indeed no relation between the number of devices and the number of messages needed.

CONCLUSION AND FUTURE WORKS

We proposed SDMEL which is a way to manage M-Learning grid distributed. In our method VOs play an important role in managing e-learning grid. Not having a central server in SDMEL causes the avoidance of bottlenecks. Distributed management of e-learning grid made it scalable. Our experiments show that our proposal does not have a significant overhead and confirmed the scalability. It also had the following advantages comparing to available protocols:

- Involving context information caused to know the learner needs more precisely.
- Storing and searching information semantically.
- Finding a list of similar resources, if agents can not find the exact results.
- Launching agents to devices for searching their data or getting their dynamic resources characteristics caused searching to be done more exactly.
- Most importantly, because mobile grid is very dynamic, it is not possible to manage it by central servers.

The gird is self-repairable and manages itself. Semantic information and context ones makes it easier to know what the data is and what the learner looks for. Involving context information enables the system to know the learner's needs more precisely. Searching semantically enables the agents to show the learner an ordered list of resources or data that are similar to what he was searching for.

Implementing SDMEL method in M-Learning grid, mobile network management, policy management, authentication, authorization, accounting and auditing and charging methods are some subjects which need to be considered as future work.

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