Resource Discovery in Wireless, Mobile and Ad hoc Grids – Issues and Challenges

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Abstract- **Recent advancements in technology and computing environments have extended the scope of classification criteria for traditional grids to include wireless, mobile and ad hoc grids based on the criteria of Accessibility. The realization of the benefits of grids to a larger extent is based on the effective discovery of resources (which could be heterogeneous in nature) that are part of the grid. Thus making resource discovery an integral part of grid environments. An Accessible grid is one that consists of a collection of devices (or resources) which could be fixed or mobile and the connectivity could be wired or wireless with infrastructure being pre-defined or adhoc. The accessibility criteria requires resource discovery to be dynamic as wireless grids focus on wireless connectivity, mobile grids on issues related to mobility and ad hoc grids on ad hoc nature. With resource discovery methods falling broadly under centralized, distributed and semi-distributed (hybrid) models and computing environments falling under structured (it includes grid and p2p), semi-structured (it includes p2p) and unstructured (it includes p2p and adhoc) categories, the suitability of existing resource discovery approaches to wireless, mobile and adhoc grids is still an open research issue.**

Keywords- **Grid, Grid Computing Classification, Resource Discovery, RD classification, Computing Environments**

I. I INTRODUCTION

Recent years have seen the emergence of a class of distributed systems that not only scale over the Internet but also operate under decentralized environments and exhibit dynamic behavior (in terms of membership). Grid Computing is part of this class of distributed systems with an increased focus on sharing of resources constituted by the Grids. The Grid has evolved as the new infrastructure for providing anytime; anywhere information needs in today's pervasive world. It is essentially an infrastructure that allows location independent access to the resources and services that are provided by geographically distributed resources.

Resources in grids could be physical or logical. Physical resources include storage, computational, network, and peripherals. Logical resources unlike physical are intangible. They constitute the driving force of grids and support the grids hardware operations [1]. They include data, knowledge and application resources. Both these resources could also be utilized and accessed to get different specific services viz., calculation via computational resources, access and use of hardware resources thus providing information service. A Grid information service must provide information about all Grid resources (including services), and should minimize the number of persistent information servers that have to be managed in order to enable Grid services and applications [2]. Service resources need to be discovered first before being accessed. Further the resource attributes are dynamic and heterogeneous viz., in their properties, capabilities, configurations and their status changes over time and needs to be periodically updated. Further resources could be fixed, replicable, mobile, dynamic and mobile and dynamic (in terms of location and properties)

One of the fundamental operations needed to support location-independent computing is resource discovery [3]. Resource Discovery has been critical for the effectiveness of Grids. In view of the heterogeneous, distributed nature of the resources and services being shared, the techniques adopted for resource discovery need to be location-independent as well as platform independent.

The paper is organized as follows. .In Section-II we look into the differences between traditional grids and wireless, mobile and adhoc grids. In Section-III describe the general and specific characteristics of centralized, peer-to-peer (which fall under distributed model) and agent based (which fall under both distributed and semi-distributed models) resource discovering strategies. In Section-IV we specifically address the requirements of wireless, mobile and adhoc grids with respect to their description, with respect to resource discovery and look into the different resource discovering models in the light of their suitability to grid classification based on accessibility criteria (i.e. wireless, mobile and adhoc). In Section-V list the different issues to be addressed by resource discovery methods for wireless, adhoc and mobile grids. In Section-VI we briefly list the requirements for resource discovery in wireless grids. Finally in Section-VII present the future scope.

II. TRADITIONAL GRIDS VERSUS ACCESSIBLE GRIDS (WIRELESS, MOBILE AND ADHOC)

With the advancement of wireless and mobile devices and technology, the different type of resources and the resource sharing potential has been augmented. The traditional grids classified based on the type of solutions they offer and their sizes has been extended to give the emerging grid classification environments which are based on accessibility, interactivity, personalization and management [4]

Traditional grids classified by solution offer computational cycles in highly aggregated capacity in the case of computational grids and its sub-classifications; provide an infrastructure for accessing, storing, and synchronizing data from distributed data repositories such as digital libraries or data warehouses in the case of data grids; provide commercial computer services such as CPU cycles and disk storage in case of Service or utility grids; provide multiple access points to the grid from which clients can issue requests and receive results in large-scale distributed meetings and training sessions[5] in the case of access grids.

Based on the classification of size grids could be global also referred as internet computing which could be on a voluntary or non-voluntary basis where internet users contribute their unused computer resources to collectively accomplish nonprofit, complex scientific computer-based tasks; could be government funded i.e. national and available to a country's government agencies; could be project specific and span multiple geographical and administrative domains and be available only to members and collaborating organizations through a special administrative authority; could be campus based where resources are restricted to those available within a single organization, and are only for the host organization's members to use; and restricting further they could be departmental and personal grids where the usage is very restricted.

Accessibility classification implies making grid resources available regardless of the access devices' physical capabilities and geographical locations. The main characteristic of accessible grids is their highly dynamic nature that results from the frequent changing structure of underlying networks and Virtual Organizations which in turn is caused due to nodes switching on and off, nodes entering and leaving, and mobility of node etc. Accessible grids are accessible from more geographical locations and social settings than traditional grids.

An accessible grid consists of a group of mobile or fixed devices with wired or wireless connectivity and predefined or ad hoc infrastructures. Thus Wireless, mobile, and ad hoc grids provide for grid accessibility.

The issue that is critical to accessible grids is having an accurate definition, or at least determination, of each grid type (ad hoc, wireless, and mobile). An accessible grid consists of a group of mobile or fixed devices with wired or wireless connectivity and predefined or ad hoc infrastructures. Thus Wireless, mobile, and ad hoc grids provide for grid accessibility.

III. RESOURCE DISCOVERY MODELS / STRATEGIES

The resource discovery models can be categorized as Centralized, Distributed/Decentralized/Peer2Peer and Semi-distributed/Hybrid.

A. Centralized Model

In this approach a single source called the central repository (CR) server (which) could be a single computer or group of computers collectively operating as CR) hosts complete information about the entire Grid resources. The resource information and various sharing policies are stored at the CR server. All updations for addition and deletion of resources is done at the CR. All client requests are directed to the CR server. This model is easy to design, implement and maintain. But it suffers from problems of Single Point Failure, poor fault tolerance, poor scalability (in presence of large user requests and reliability and security

B. **Distributed/Decentralized Model**

In this model the Grid Resource information is distributed across different sites (a single computer or a peer, each operating as a server or a cluster of peers collectively operating as server could be sites). Each peer hosts the directory of its local resources, an index or link to the resource registry of other peers. Whenever a resource request arises, a search query is sent to the immediate peer, if request cannot be satisfied or an appropriate match is not found it is forwarded next nearest peer and this process continues till a success or failure is reported . In case of failure, failure of any peer(s) does not affect the network. In contrast to centralized approach here there is no single point failure, it scales better, is more fault tolerance and reliable and give better response times. But it is difficult to maintain and track growing resources due to dispersion, requires periodic update of resource information between peers for resource data management and has a direct effect on efficiency of resource discovery mechanisms.

C. Semi-distributed/hybrid Model

It combines the centralized and distributed approaches into a consistent broker system which maintains the resource directory and registers each resource on the Grid. The broker is responsible for matching or assigning the right resource to the request query for resource discovery [1]. This approach could also be employed to develop Grid-enabled resource discovery systems by using various approaches, such as Parametric, Agent Based, Semantic and Hybrid. The direct benefit of this approach it provides a better option for creating resource/request brokering systems and facilitates the design of middleware packages. This at the cost of complexity which is caused by the technical-level integration requirements that make the management and maintenance of integrity and consistency of the entire architecture difficult.

IV. WIRELESS, MOBILE AND AD HOC GRIDS : DESCRIPTION AND REQUIEMENTS

The aspect that is critical to accessible grids is having an accurate definition, or at least determination, of each grid type (ad hoc, wireless, and mobile).

In adhoc grids the emphasis is on the ad hoc nature of virtual organizations, while in wireless grids emphasize is on wireless connectivity, and in mobile grids on issues of mobility such as migration of job and replication of data. Emergency communication, disaster and battlefield management, E-learning, and e-healthcare are some applications that fall as candidates under this classification. Ad hoc environment's constantly changing membership with a lack of structured communications infrastructure necessitates the need for Adhoc grids. Ad hoc grid is a logical community of spontaneous formations of cooperating heterogeneous computing nodes without any preconfigured fixed infrastructure and with minimal administrative requirements unlike the traditional static grid infrastructure that requires formal, well-defined, or agreed-upon grid entry points. Thus nodes can join as long as they can discover other members. Ad hoc grids could be defined as a grid environment without fixed infrastructures where all the grid components are mobile which is referred to as a mobile ad hoc grid. In ad hoc grids the focus is on the grid's ad hoc nature and not on nodes mobility. [1]

The main issue of ad hoc grids is their dynamic topology caused due to the node reboots and the movement or replacement of computational nodes. Peer-2-Peer and dynamically constructed virtual backbone architectures have been proposed for ad hoc grids. Examples of adhoc grids include OurGrid and myGrid.

The wireless grids extend grid resources to wireless devices of varying sizes and capabilities such as sensors, mobile phones, laptops, special instruments, and edge devices. These devices could be statically located, mobile, or nomadic, shifting across institutional boundaries and connected to the grid via nearby devices such as desktops. Wireless devices could be real grid nodes where part of data processing and storage is done or one in which all wireless devices are considered as only access devices without processing or storage capabilities and where required resources are got from a wired, resource-rich backbone grid.

The important issues are related to technical aspects like low bandwidth, high security risks, power consumption, and latency that need to be addressed while integrating the wireless device to the grid.

Mobile grids provide for grid services accessibility through mobile devices such as PDAs, smart phones and other mobile devices. Inspite of their resource limitations viz., processing power, persistent storage, runtime heap, battery lifetime, screen size, connectivity, and bandwidth, in view of its large user market, their processing power assumes significance given their mobility. Also their effective application emergency situations, such as natural disasters etc and on battlefields, wireless mobile devices might be the only available communication and computation services. Similar to wireless devices, mobile device integration into grid systems can be done in two ways. In the first, atleast one mobile node actively participates by providing computational or data services and in the. second, the mobile devices serve as an interface to a static grid sending requests and receiving results which is also called as mobile access grids.

Mobile grids can be realized through centralized [6] , P2P structure[7] intelligent mobile agents [8] mobile grid middleware[9] etc approcaches. Akogrimo is an example of mobile grids.

The issues related to migration and data replication need to be addressed.

V. RESOURCE DISCOVERY STRATEGIES' RELATED ISSUES FOR WIRELESS, MOBILE, AD HOC GRIDS

The issues to be addressed and the support required for wirelss, mobile and adhoc grids under the different resource discovery strategies are described in Table 1.

TABLE 1. SUPPORT FOR ISSUES TO BE ADDRESSED BY THE DIFFERENT RESOURCE DISCOVERY MODELS / STRATEGIES

Grid Type based on Accessibility	**Computing Environment Type**	**Issues specific to type**	**Resource Discovery Models / Strategy**		
			Centralized	**Distributed**	**Hybrid/ Semi-distributed**
Adhoc Grids	Unstructured	Dynamic topology	No direct support	Yes	Yes
		Frequent Resource Membership Updations	Difficult	Yes	Yes
		Unstructured Communication	No direct support	Yes	Yes
Mobile Grids	Unstructured / Semi-Structured	Resource Migration	No Direct support	Yes	Yes
		Resource Information Replication	No	Yes	Yes
Wireless Grids	Unstructured / Semi-Structured	Latency with respect to resource accessibility	High	Low	Low

VI. RESOURCE DISCOVERY REQUIREMENTS FOR WIRELESS GRIDS

As wireless grids provide access to different wireless devices of heterogeneous nature, variant sizes, either being fixed or providing support for mobility the task of resource discovery needs to account for these in its approach. Technical considerations of low bandwidth, security risks, power consumption and latency also assume significance.

Issues that resource discovery task needs to address are scalability, heterogeneity (in terms of information representation in the repository), mobility if existent. The computing environments for which these are suitable are semi-structured/unstructured. The model of resource discovery more suitable is either distributed / decentralized or hybrid keeping in minds the above factors. Any resource discovery approach needs to provide effective management of resource information repository, information dissemination and updations with minimum delay and low latency at the level of request processing.

VII. FUTURE SCOPE

In this paper we have given a comprehensive description of the characteristics of the new grid types based on the emerging grid classification of Accessibility that incorporates and harnesses the power of wireless and mobile resources which now form a sizeable resource potential. We have summarized the different resource discovery models, in terms of their strengths and weaknesses. We have also described the requirements for wireless, mobile, and adhoc grids. Analyzed and tabulated the existing resource discovery models in the context of the above grid types. Analyzed the existing related resource discovery works. Thus with the availability of newer wireless and mobile devices with varying characteristics, to capture the full resource potential of these resources it is necessary to look into the viability of existing resource discovery methods and extend them to be able to effectively address resource sharing in the context of this increasing resource potential. Therefore the need for newer resource discovery methods exists.

The tabulated analysis showing the computing environment provided by Wireless, Mobile and Ad hoc grid types, the extent of support provided by the different resource discovery models to the specific issues of these grid types in section-V serves as a basis for design and testing of new resource discovery methods. The new resource discovery methods to be proposed should try to incorporate the various requirements at the level of resource information repository, information dissemination and updation levels, at the level of request processing etc.

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