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A Grid resource brokering strategy based on resource and network performance in Grid

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ABSTRACT

To achieve high performance distributed data access and computing in Grid environment, monitoring of resource and network performance is vital. Our proposed Grid network monitoring architecture is modeled by the Grid scheduler. The proposed Grid network monitoring retrieves network metrics using sensors as network monitoring tools. The mobile agents are migrated to start the sensors to measure the network metrics in all Grid Resources from the Resource Broker. The raw data provided by the monitoring tools is used to produce a high level view of the Grid through the set of internal cost functions. The network cost function is formed by combining various network metrics such as bandwidth, Round Trip Time, jitter and packet loss to measure the network performance. This paper presents the Grid Resource Brokering strategy which analyzes the network metrics along with the resource metrics for the selection of the Grid resource to submit the job and the proposed approach is integrated with CARE Resource Broker (CRB) for job submission. The experimental results are evident for the minimization of job completion time for the submitted job. The simulation results also prove that the more number of jobs are completed with the proposed strategy which influences the better utilization of the Grid resources.

1. Introduction

A Grid is a collection of computing elements which shares the resources among virtual organizations. As the computing resources and applications are scattered in Grid environments, there is a need of building the monitoring system to achieve an effective utilization of the Grid resources [1–3]. Network monitoring is the process of monitoring the network metrics such as bandwidth, latency, packet loss rate, throughput, jitter and Round Trip Time (RTT). Network monitoring is very much needed in Grids to avoid the problems which arise due to overloaded servers, failure of network connections, etc.

The computational Grids facilitate the software applications to integrate instruments, displays, and computational resources which are managed by various organizations from extensive locations. So the performance measure of the network in Grids becomes cognizant because it consists of many heterogeneous links and constantly varying in nature [4]. The network performance monitoring and prediction provides the necessary information for the enrichment of scheduling the best resources such as where to get or put the data and where to execute the job, fault detection and trouble-shooting, identifying the bottleneck, performance analysis and tuning. The existing monitoring strategy will significantly increase the system overhead when the size of the computing facility grows [5].

Activating all monitoring tools for different resources involved with an application, collecting such data, filtering them for obtaining useful information may become a major problem. In this scenario, the mobile agent technology can play a vital role because of its capability to cope up with the system's heterogeneity [6]. Mobile agents are autonomous, intelligent programs that travel in a network, searching for the required information and return the results on the user's behalf. The mobile agents reduce the network load because they use less bandwidth by moving logic near data, and their actions are dependent on the state of the host environment [7]. They are capable of working without a dynamic connection between nodes, hence not affected by network failures. So the mobile agents are extensively used in resource discovery and monitoring applications for information retrieval, and also for monitoring the network performance [6]. In this scenario, we propose a Grid Resource Brokering strategy for resource allocation by handling both the resource metrics as well as the network metrics and integrated with CARE Resource Broker (CRB) for job submission using mobile agents. This paper mainly focuses on network monitoring in Grid which is based on Grid Monitoring Architecture (GMA) and network performance measurements to improve the resource utilization and reduce the load on the Grid resources. This paper is organized as follows. Section 2 illustrates the related works in Grid monitoring. Section 3 describes the proposed architecture and the Section 4 describe about the Grid

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Network Monitoring at the Resource level. The Section 5 deals with the evaluation of proposed cost function. The Network Aware Grid Monitoring algorithm for resource selection is explained in the Section 6. The experimental results are discussed in the Section 7. Section 8 concludes the paper and also presents the future work in the domain.

2. Related work

Resource monitoring is vital in a Grid environment because of the dynamic and unpredictable nature of its resources and to prevent resource starvation [8]. Global Grid Forum (GGF) Performance Working Group proposed a Grid Monitoring Architecture (GMA), which describes the major components of a monitoring architecture and their essential interactions [9]. The eminent Grid Middleware, Globus Tool kit 4(GT4) [10], MDS (Monitoring and Discovery Service) does the resource monitoring in Grids which uses LDAP (Lightweight Directory Access Protocol) service to access the resource metrics through LDAP schema (MDS) [11]. MDS does not support complex querying, whereas mobile agents enable complex querying and the response times for all nodes are optimum even there is an increase of index size and also collects the most recent data [8]. The relational implementation would enhance the complex query processing, like in R-GMA (Relational Grid Monitoring Architecture) [12,13].

Grid environments have recently emerged as an integrating infrastructure for distributed high-performance scientific applications [2]. In a complex system like Grid, monitoring is essential for understanding its operation, debugging, and failure detection and also for performance optimization. Although, many ideas had been presented in the field of network management for Grid environment, most of the techniques suffer from scalability related issues [14,15]. The IETF IP Performance Metrics Working Group (IPPM-WG) and GGF Network Measurement Working Group (NM-WG) categorizes a set of network characteristics to identity the various types of network measurements [16]. The proposed network monitoring system follows these guidelines for the network measurement classification and identification. Network monitoring in Grids is an immense research and different architectures have been discussed in [13]. NetLogger [17] presents an overall view of the performance bottlenecks with significant intrusiveness because of the activation nodes periodically polling the activation manager, and the applications checks their configuration file periodically. JAMM [18] has sensors to filter the incoming events according to the consumer queries but not supporting the replication. NWS is used for network performance measurement and prediction system in Grids but it suffers from intrusiveness and scalability [19].

The users, services, and data are in need of communication over networks, so the network information is necessary for efficient Grid schedulers to perform their tasks [20]. The three types of network measurements and monitoring are active measurement, passive measurement and SNMP-based measurement [21]. With the support of passive and active measurements in a Grid environment, it is trouble-free to produce large amount of raw data. The unplanned network monitoring is needed when the job is submitted to the resource broker and it does not need a measurement database. The planned network monitoring relies on the availability of powerful information repository of network measurements, i.e. past experience [22]. The proposed approach also explores both the monitoring techniques.

A Network-based Grid Optimization Service has an optimizer which provides network quality estimation service between Grid nodes for Grid applications, but only three basic network metrics such as the average round trip time, the packet loss probability and throughput are considered [23]. Richard et al. presented a meta-scheduling approach called Data Intensive and Network Aware (DIANA) which considers network characteristics for scheduling decision making in Grid [24]. In DIANA, once the job gets a CPU, then abort that job and move that job to other Grid site is difficult because it uses non pre-emptive mode of execution. The system will be overloaded due to bulk submission of large jobs. Agustìn et al. proposed a strategy to perform peer-to-peer stimulated meta-scheduling in Grids by considering the network characteristics [25]. The nodes forward job queries to all neighbors using routing indices approach, but the peer-to-peer approach uses physical topology, which is not providing most efficient query forwarding which influence the scalability. Developers of high-performance distributed systems often observe performance problems such as unexpectedly low throughput or high latency. To determine the source of these problems, detailed end-to-end monitoring data from applications, networks, operating systems, and hardware must be correlated across time and space. Detailed comparison of these data from a variety of angles is desired. To address this problem, this paper presents a monitoring system using Mobile Agents for efficient handle high-volume streams of monitoring data.

3. Proposed architecture

The proposed architecture is based on OGSA compliant layered architecture which is shown in Fig. 1. In our proposed approach we have used CARE Resource Broker (CRB) for job submission [26]. The CRB is implemented by the Centre for Advanced Computing Research and Education (CARE), Anna University, India.

Fabric layer

The Grid fabric layer defines protocols for the publication, discovery, negotiation, monitoring, accounting and payment of the operations on individual resources. The resources may be computational resources, storage systems, catalogs, network resources and sensors or may be a logical entity, such as a distributed file system, computer cluster, or distributed computer pool. The allocation of computational resources and monitoring and control of computation on those resources, and Grid File Transfer are done through Grid Resource Access and Management (GRAM) protocol.

Resource and connectivity layer

This layer consists of low-level middleware that provides secure and unified access to remote resources. Depending on the type of resources, different middleware can be chosen such as Globus, Unicore, Alchemi, and Storage Resource Broker. Using services of such low-level middleware layer, one can create high-level middleware services that support rapid creation and deployment of applications on global Grids.

Collective layer

The proposed architecture is modeled in this layer with a Grid scheduler. The Request handler which resides in CRB receives job requests from the users. The controller is in CRB which controls the scheduling, selection of the suitable resource for job submission from the matched resource list, monitors the execution of jobs in Grid, and also maintains the status of the submitted jobs. CRB selects the suitable resource using resource metrics. The network monitoring is fit in this layer to retrieve the network metrics which have influence on the resource selection.

More sensors are deployed in Grid resources to provide more network metrics so that the measurement of the network performance becomes more reliable. The sensors are the network monitoring tools and utilities which are started through migration of mobile agents from resource broker to all resource sites when there is a need of unplanned monitoring in the Grid environment. The planned network monitoring gathers the network metrics from information repository, because the sensors are the network