International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970)
Volume-3 Number-3 Issue-11 September-2013

Task Cost Based Approach for Grid Service Reliability Modeling on Fault Recovery

Nana Kacharu Zalte

Abstract

In recent year, solving Grid service reliability are not easy tasks because of the complexity and large scale of the system and resources. While concerning on large scale system, large subtasks requires time-consuming computation, therefore the reliability of grid service could be rather low. Our paper tries to focus on maximizing reliability and minimizing cost of grid resources. In the existing system all researchers focused on the remote node fault recovery where more waste is consumed on time and resources. Furthermore those systems did not incorporate the fault recovery and the practical constraints of grid resource on optimization. Resultantly our paper considers the Local Node Fault Recovery mechanism into grid systems, and presents a solution to simultaneously maximize the grid service reliability and minimizing the cost. Our proposed Grid Service Reliability & Node Recovery (GSRNR) mechanism considers some practical constraints such as the life times of subtasks, the numbers of recoveries performed in grid nodes. Presuming the proposed grid service reliability model, a multi-objective task cost scheduling optimization model is presented, and Min Max cost scheduling algorithm is developed to solve it effectively.

Keywords

Grid Computing, Fault Tolerance, Grid Service, Reliability.

1. Introduction

In grid systems contain various organizations that integrate or share their resources on the global grid. It enables the aggregation and sharing of geographically dispersed computational data and any program running on the grid can use those resources if it can be successfully connected to them and is authorized to access them [2]. Other resources as a single, integrated resource for solving large-scale compute and data intensive applications. The client of the grid can access the resources available in the grid without bearing in mind about heterogeneous environment. Still user can get information in the form of abstracted and the resources of the grid are virtualized form.

Management of these resources is an important infrastructure in the grid computing environment. And the procedures for a program to use the remote resources are controlled by the RMS (Resource Management System). Since grid resources are highly heterogeneous and dynamic, more faults may be raise in grid environment. Fault tolerance mechanism is an important in grid computing environment. Therefore it is important to note that the grid infrastructure should be designed to be fault tolerant. Fault tolerance is the capability of a system to achieve its function properly even in the existence of faults [2].

The RMS works in five layers that are program layer, request layer, management layer, network layer, and resource layer, respectively [10].

The grid system is depicted by Fig. 1, and how different resources are accessed by RMS is shown in figure 1 [10].

A. Theoretical Foundation and realization

Different resources are distributed in the grid system and different services can use a given set of resources. Each resource is directly connected to the RMS by a single communication channel, which forms the star topology. The service task consists of subtasks that should be executed by resources and each subtask is characterized by fixed complexity, and by fixed amounts of input & output data. The request for service (task execution) arrives to the RMS which assigns the subtasks to different resources for processing. The resources are specialized and can serve only a single subtask if it is available. On the other hand, the same subtask can be assigned to several resources of the same type for parallel execution. If the same subtask is processed by several resources, it is completed when first output is returned to the RMS. The entire task is completed when all of the subtasks are completed, and their results are returned to the RMS from the resources. Some subtasks require outputs from previous subtasks for their execution. Therefore, if resource failure or communication channel failure occurs before the end of the output data transmission from the resource to the RMS, the subtask cannot be completed.

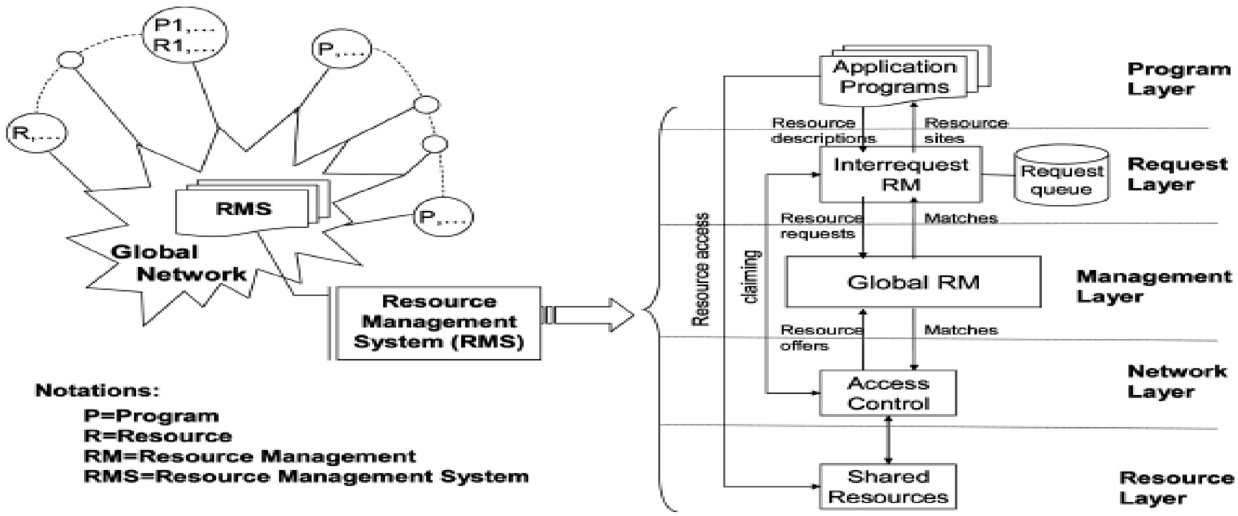

Fig.1: Grid System

We have set some predefines rules and guidelines for performing on fault tolerance system in grid environment that are as follows;

Rule 1) When the RMS receive all the necessary information for execution of subtask, it should sends the information to the corresponding resource immediately.

Rule 2) Each resource should starts the processing of the assigned subtask immediately and each resource sends the output data to the RMS

Rule 3) Each resource should have constant processing speed, constant failure rate and constant bandwidth when it is available.

Rule 4) it considers the indices service reliability that is task is accomplished within a specified time.

B. Realization of GSRNR

- Grid service reliability and Node Recovery can be defined as the probability of all of the subtasks involved in the considered service to be executed successfully.
- There is no concern on what the sources of failures are; but what matters is whether the end results can return to grid resource management system (RMS) or not.
- Remote Node Fault Recovery (RNFR) tool; i.e., when a failure occurs on a node, the state information can be migrated to another node, and the failed subtask execution is resumed from the interrupted point.
- In a worst-case scenario, much time has been spent in local node execution when the execution is terminated by a failure, which brings great waste of consumed time and resource on using RNFR.
- Local Node Fault Recovery (LNFR) tool could be more practical than RNFR to resume the subtask execution on the failed node once the node is recovered.
- The migration expense compared with RNFR is saved with LNFR. Moreover, because fault recovery modules are located at grid resources, resource providers can set customizable constraints on fault recovery, which makes it easy to achieve distributed management of fault tolerance.

Our paper solve Grid service reliability and Node Recovery (GSRNR) in grid systems, and presents a solution to simultaneously maximize the grid service reliability modeling and analysis with this kind of fault recovery thereby minimizing the cost.

This paper presents a Task Cost Based Approach for Grid Service Reliability Modeling on Fault Recovery. It also derives formulas and algorithms to effectively evaluate the grid service reliability. Section 2 describes the literature survey. Section 3 presents the proposed system. Section 4 presents the performance evaluation. Section 5 concludes this paper.

2. Literature Survey

Grid service reliability can be defined as the probability of all of the subtasks involved in the considered service to be executed successfully [6], [7].

The modeling and analysis of grid service reliability has attracted lots of attention. [2] Presented a virtual approach to modeling grid services, and derived the grid service reliability using the graphic theory. Dai [8], and Levitin and Dai [7] studied grid service reliability for grid systems with star topology, and tree topology, respectively. Dai [9] presented a hierarchical model from the mapping of the physical architecture, and the logical architecture in grid systems for grid service reliability analysis.

Levitin [6] studied grid service reliability taking the precedence constraints on programs execution into account. From the point of view of grid service, it does not matter what the sources of failures are; what matters is whether the end results can return to grid resource management system (RMS) or not. Nevertheless, with the dramatic increasing of grid size and complexity, the grid system is much more prone to errors and failures than ever before. Moreover, the likelihood of errors occurring may be exacerbated by the fact that many grid services will perform long tasks that may require several days of computation [10].

Recently, much effort in fault avoidance and fault removal has been invested so as to improve grid service reliability. Paul and Jie [10] developed an approach to fault tolerance based on job replication in grid systems.

Jozsef and Peter [5] introduced the concept of job migration to achieve fault tolerance in grid systems.
Moreover some researchers have studied the optimization on grid service reliability. Dai and Wang [11] studied optimal resource allocation for maximizing service reliability using a genetic algorithm.

Dai and Levitin [12] suggested an algorithm to study optimal resource allocation for maximizing performance while considering the service reliability factor in tree-structured grid systems. However, those works did not incorporate fault recovery, and did not investigate the influence of practical constraints of grid resources on optimization. In addition to the quality of services, the other focus of this system is to minimize resource consumption and the cost of requested services in the economic grid. The dynamic nature of this monitoring service leads to improve the availability and reliability of grid resources/services with low resource consumption. Suchang Guo, Hong-Zhong Huang, Zhonglai Wang, and Min Xie, suggested [1] an Ant Colony Optimization algorithm to solve the task scheduling problem. This algorithm considers some practical constraints and it also aims in improving the grid service reliability.

3. Proposed System

The basic approach proposed in the above researches on fault recovery in grid systems is a "Grid service reliability and Node Recovery" (GSRNR) mechanism. In which we are focusing on Local Node Recovery if any fault present. When a failure occurs on a node, the state information can be migrated to another node, and the failed subtask execution is resumed from the interrupted point, or the failed subtask can be dynamically rescheduled on another node, and the node restarts the subtask from the beginning. It is very useful and effective for GSRNR to recover grid tasks from failures. However, some complex tasks may require several days of computation. For those tasks, it will take a lot of time for GSRNR on the transmission of state information. Furthermore, in a worst-case scenario, much time has been spent in local node execution when the execution is terminated by a failure, which brings great waste of consumed time and resource.

A. GSRNR Framework and Design

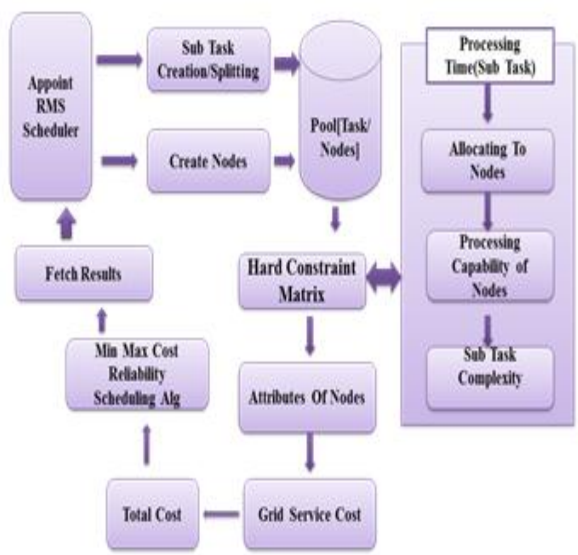

Fig 2: System Architecture

In this case, we can concentrate on Local Node Recovery (LNR) could be more practical than Remote Node Recovery (RNR) to resume the subtask execution on the failed node once the node is recovered. LNR offers an opportunity to resume execution from failure, and saves the migration expense compared with RNR. Moreover, because fault recovery modules are located at grid resources, resource suppliers can set customizable constraints on fault recovery, which makes it easy to achieve distributed management of fault tolerance. However, with the introduction of LNR, the state of resource failures may be divided into unrecoverable failures, and recoverable failures.

The grid service is divided into some subtasks; The RMS should quickly and effectively schedule those subtasks to the appropriate nodes according to the particular requirements of those subtasks, and the QoS demands of grid users. In the scheduling, it needs to take into account not only the hard constraints of a subtask (the processing capacity , link bandwidth available CPU, memory, disk space, etc.), And the software constraints such as the demanded reliability level of grid service, and the constraints on total financial cost should be considered for scheduling.

The proposed system has following Assumptions;

(a) The RMS is perfect during the processing of the grid service, i.e., the RMS never fails; and the time of task processing by the RMS is negligible when compared with subtask's processing time.
(b) When a service request arrives at the RMS, the RMS responds to it immediately; when a subtask is assigned to a node, the node executes the subtask immediately.
(c) There is no precedence constraint on the order of execution of subtasks.
(d) Each node can execute only one subtask at any time.
(e) The failures in different elements (nodes or communication links) are independent.

Distribution of Task Completion Time
According to the assumptions above, the entire task is divided into m subtasks such that

$$\sum_{j=1}^{m} = C \quad (1)$$

Where C is the computational complexity of the entire task, and c_j is the computational complexity of subtask j. When subtask j is assigned to resource k, the subtask processing time is a random variable that can take two possible values:

$$T_{kj} = \frac{c_j}{x_k} \quad (2)$$

if the resource does not fail until the subtask completion, and $T_{kj} = \infty$ otherwise

$$p_{kj} = e^{-\lambda_k \left(\frac{c_j}{x_k}\right)} \quad (3)$$

Where x_k is the processing speed of resource k.
The amount of data that should be transmitted for the subtask j (input data from the RMS to the resource, and output data from the resource to the RMS) is denoted by a_j .
If data transmission between the RMS and the resource k is accomplished through links belonging to a set γ_k, the data transmission speed is

$$\min_{y \in \gamma_k}(b_y) \quad (4)$$

Where b_y is the bandwidth of the link L_y.Thus, the random time of communication between the RMS

and the resource k that processes subtask j can take two values:

$$T_{kj} = \frac{a_j}{s_k} \quad (5)$$

if this communication channel does not fail until the subtask completion, and $T_{kj} = \infty$ otherwise. For constant failure rate the probability that communication channel k does not fail during processing of subtask j can be obtained as

$$q_{kj} = e^{-\pi_k \left(\frac{a_j}{s_k}\right)} \quad (6)$$

According to the assumptions, the subtask j can be successfully completed by resource k if the resource k and the communication links belonging to the set γ_k do not fail during the time of subtask processing and data transmission. From (2) & (5), we obtain this time as $\frac{c_j}{x_k} + \frac{a_j}{s_k}$
Taking into consideration software reliability and the reliability of communication links, the reliability of subtask j executed on node k, with the deadline $T^*_{Kj}$is

$$R_{kj} = p_{kj} q_{kj} \quad (7)$$

For ease of describing the recoverability of Software failures on node, a random variable is defined, which has two possible values (1, 0). If $X_j^k = 1$, it means that the failure on grid node is recoverable. If $X_j^k = 0$, it means that the failure on grid node k is unrecoverable. One subtask is allowed to be assigned at one node, and one node can only be allowed to execute one subtask at most. The hard constraints on subtask scheduling have two possible values (1, 0); value 1 if, it means that subtask can be allowed to be allocated on node; value 0 if, it means that subtask cannot be allowed to be allocated on node. Meanwhile, to satisfy users demands, i.e., maximizing the grid service reliability and minimizing the cost as called to be a soft constraint, the resource management system needs specific subtask scheduling mechanism. Here denote by σ a vector of $\{\sigma_{jk} | j \epsilon [1, m], k \epsilon [1, k]\}$ which represents a scheme of subtask on grid nodes. σ_{jk} also has two possible values(1,0): σ_{jk} =0 it means subtask j is not assigned on node k by the RMS, while σ_{jk} = 1 means that subtask j is assigned on node k.

Hence, given the structure on the nodes and links involved in the service, the grid service reliability can be determined in term of σ. Then the grid service reliability, and the total cost can be function of σ_{jk}, which are written respective as

$$R_s(\sigma) = \prod_{j=1}^{m}\{1 - \prod_{k=1}^{k}(1 - R_{jk})\sigma_{jk}\} \text{ , and} \quad (8)$$

$$C_s(\sigma) = \sum_{j=1}^{m}\sum_{k=1}^{k}\sigma_{jk}C_{jk} = \sum_{j=1}^{m}\sum_{k=1}^{k}\sigma_{jk}\gamma_k T_{jk} \quad (9)$$

Where γ_k is execution cost in node k per unit time, C_{jk} is the product of γ_k and the required execution time T_{jk}
To find the optimal solution of σ so as to maximize the grid service reliability and minimize the total cost simultaneously, a weighting summation to optimize the two criteria simultaneously is proposed, while satisfying all the system resource constraints.
Total cost can be calculated by using following formula

$$C_s(\sigma) = \{(\textstyle\sum_{j=1}^{m} Available\ Resources) - 1\} \quad (10)$$

Available resources such as RAM, Memory & CPU must be in percentage. Decision is taken regarding the Total Cost, arrival Time of Jobs, Grid Service Reliability Cost. Applying the algorithm (Min Max Cost Reliability Scheduling algorithm) the task are scheduled.

B. Min max cost reliability scheduling Algorithm

- for all tasks T_i in meta-task M
- for all resources R_j
- cost constraints are evaluated
- Selection probability of Jobs are evaluated =>
  $P_{jk} = C_{jk} + R_{jk}$
- do until all tasks in M are mapped

– for each task in M find the minimum probability of the jobs and the resource that obtains it
– assign task T_k to the resource R_k that gives the earliest completion time
– delete task T_k from M
– Update Status of Resource R_j
- End do

4. Performance Evaluation

By going through these our proposed system, we got following results;

Construct a grid environment with a possible set of nodes. The RMS divides the service request into subtasks. When scheduling these subtasks, the hard and the soft constraints are considered. For each of the task in the grid system, grid service cost is calculated and then the summation of the grid service cost is taken as the total cost.

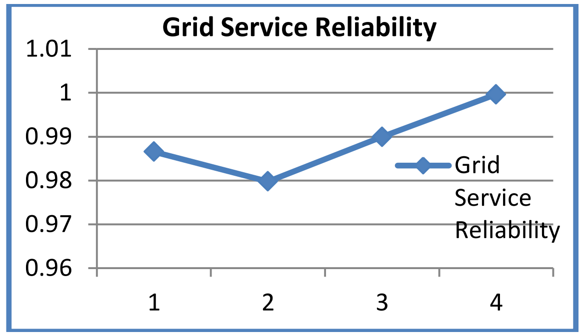

Fig 3: Grid service reliability with respect to the set of nodes

Finally, Optimized Cost Scheduling Approach is developed for minimizing the cost and maximizing the grid service reliability. This approach ranks the nodes in the grid system in order to determine the fault tolerant cost on each node so that the future loads can be assigned to those nodes.

Table 1: Grid Service Reliability

Nodes	Grid Service Reliability
1	0.986560912
2	0.979800106
3	0.989965231
4	0.999654232

Table 1 depicts the calculation of the reliability of the grid service with respect to a set of nodes ranging from 1 to 4.

5. Conclusion and Future Work

Resultantly our paper, a fault recovery mechanism is introduced into the task cost based approach for grid service reliability on fault recovery is presented. In order to make it more practical, a constraint on recovery amount is discussed in the modeling of grid service reliability. As for the implementation of fault recovery in grid resources, it can be achieved by embedding a fault recovery module in grid clients. In the module, there are options such as the allowed life times of grid subtasks, and the allowed numbers of recoveries performed. By those options, resource providers can be free to choose appropriate fault recovery strategies according to the local situations. Based on that, a task scheduling optimization model called Min Max Cost Reliability Scheduling Algorithm is proposed and maximizing the grid service reliability and minimizing the cost, as called to be soft constraints is attained in this approach.

Result shows that our proposed system is cost effective and in future will be extended still which could be applied in cloud computing domains.

Acknowledgment

I express sincere thanks to Prof. S. G. Shikalpure my project guide, who gave me his valuable and rich guidance and helped in presentation of this research paper.

References

[1] Suchang Guo, Hong-Zhong Huang, Member, IEEE, Zhonglai Wang, and Min Xie, Fellow, IEEE "Grid Service Reliability Modeling and Optimal Task Scheduling Considering Fault Recovery" IEEE transactions on reliability, vol. 60, no. 1, march 2011.

[2] Foster, "The Grid: A new infrastructure for 21st century science," Physics Today, vol. 55, no. 2, pp. 42–47, 2002.

[3] Y. S. Dai, M. Xie, and K. L. Poh, "Reliability of grid service systems," Computers and Industrial Engineering, vol. 50, no. 1–2, pp. 130–147, 2006.

[4] S. C. Guo, H.Wan, G. B.Wang, and M. Xie, "Analysis of grid resource compensation in market-oriented environment," Eksploatacja I Niezawodnooeæ— Maintenance and Reliability, vol. 45, no. 2, pp. 36–42, 2010.

[5] K. Krauter, R. Buyya, and M. Maheswaran, "A taxonomy and survey of grid resource management systems for distributed computing," Software— Practice and Experience, vol. 32, no. 2, pp. 135–164, 2002.

[6] C. L. Li and L. Y. Li, "Multiple QoS modeling and algorithm in computational grid," Journal of Systems Engineering and Electronics, vol. 18, no. 2, pp. 412–417, 2007.

[7] G. Levitin, Y. S. Dai, and B. H. Hanoch "Reliability and performance of star topology grid service with precedence constraints on subtask execution," IEEE Trans. Reliability, vol. 55, no. 3, pp. 507–515, 2006.

[8] G. Levitin and Y. S. Dai "Grid service reliability and performance in grid system with star topology," Reliability Engineering and System Safety, vol. 92, no. 1, pp. 40–46, 2007.

[9] Y. S. Dai, G. Levitin, and X. L. Wang, "Optimal task partition and distribution in grid service system with common cause failures," Future Generation Computer Systems, vol. 23, no. 2, pp. 209–218, 2007.

[10] Y. S. Dai, Y. Pan, and X. K. Zou, "A hierarchical modeling and analysis for grid service reliability," IEEE Trans. Computers, vol. 56, no. 5, pp. 681–691, 2007.

[11] T. Paul and X. Jie, "Fault tolerance within a grid environment," in Proceedings of UK e-Science All Hands Meeting, 2003.

[12] M. Affaan and M. A. Ansari, "Distributed fault management for computational grids," in Proceedings of the Fifth International Conference on Grid and Cooperative Computing, 2006.

[13] L. Jin, W. Q. Tong, J. Q. Tang, and B.Wang, "A fault-tolerance mechanism in grid," in Proceedings of IEEE International Conference on Industrial Informatics, 2003.

[14] K. Jozsef and K. Peter "A migration framework for executing parallel programs in the grid," in Proceedings of European across Grids Conference, 2004.

[15] Yuan-Shun Dai, Member, IEEE, and Gregory Levitin, Senior Member, IEEE "Reliability and Performance of Tree-Structured Grid Services" IEEE transactions on reliability, vol. 55, no. 2, june 2006.

[16] Y. S. Dai and X. L. Wang, "Optimal resource allocation on grid systems for maximizing service reliability using a genetic algorithm," Reliability Engineering and System Safety, vol. 91, no. 9, pp. 1071–1082, 2006.

[17] Y. S. Dai and G. Levitin, "Optimal resource allocation for maximizing performance and reliability in tree-structured grid services," IEEE Trans. Reliability, vol. 56, no. 3, pp. 444–453, 2007.

[18] Fuyang Chen, Bin Jiang, Gang Tao, Xinyu Zhang "Improved Adaptive Genetic Algorithm for Grid Resource scheduling Via Quantum control techniques" 978-1-4673-5534-6/13/2013 IEEE.

[19] Mr. N. K, Zalte, "A Novel Approach for Grid Service Reliability Modeling Optimal Task Scheduling Perceiving Fault Recovery**"** (IJSCE) ISSN 2231-2307 volume-3 issue-3 July 2013.

My birth place is Yeola Dist Nasik. & Birth Date is July 1983. I have completed my Bachelor of Engineering in Computer Engineering from North Maharashtra University, Jalgaon. I am pursuing PG in Government College of Engineering, Aurangabad, India. My research area is Grid Computing, Distributed System, Cloud Computing, Data Mining and Data Warehousing.