6. GROUP SCHEDULING STRATEGY FOR FAILURE MANAGEMENT TO MINIMIZE JOB COMPLETION TIME

6.1 INTRODUCTION

In this chapter, Group Scheduling Strategy for Failure Management (GSS-FM) is introduced to combine a set of jobs into a group at the meta-scheduler before deployment for reducing the communication overhead. A large number of small jobs when submitted one by one on suitable grid resources over wide area networks increases the communication time and hence it increases the overall application completion time of grid jobs. GSS-FM aims at minimizing the total completion time of user applications to meet user requirements, considering the resource failure, the cost of resources and the job deadline.

6.2 GROUP SCHEDULING STRATEGY FOR FAILURE MANAGEMENT

The Group Scheduling Strategy for Failure Management (GSS-FM) intends to provide an effective failure management scheme that reduces the job completion time and improves resource utilization by assigning and executing the group of jobs to the suitable resource. The GSS-FM strategy considers the failure information, availability, speed and computational capability of resources while grouping and allocating the jobs to the appropriate resources. The GSS-FM strategy selects, allocates the suitable resources to the job groups, handles resource failure after it has occurred and completes the user jobs within the deadline to achieve the goal of a commercial application by satisfying both the user and the resource provider. The Model for Group Scheduling Strategy for Failure Management (GSS-FM) is shown in Figure 6.1.
GSS-FM strategy minimizes the probability of failure during the execution of the job groups by considering the reliability and the present status of the resources, minimizes the job completion time by grouping fine-grained jobs into the job groups before allocation to the suitable resources and maximizes the resource utilization by handling resource failures proactively and reactively. The GSS-FM algorithm performs job grouping and matches the job group to the selected resources, and completes the job with minimum completion time. The grid resources are selected based on the job size, computational power of the resources and the time deadline specified by the user. In this algorithm, the selected resources are much more utilized for the given time deadline.

For the given 'n' jobs of a user application, the jobs are grouped into job group based on job sizes and computational power of the grid resources. The jobs are sorted based on the job sizes add it to the job queue (JQ) and the list of available reliable resources is sorted based on the current resource computation power (CRCP). GSS-FM strategy decides the number of jobs to be grouped according to the job size and computation power of the resources, and the size of the job group (JG) is computed as shown in Equation 6.1.
\[ JG_k = \sum_{i=1}^{n} \text{Job Size}_i \] (6.1)

Where \( JG_k \leq \text{ResourceCapability}_{UT} \). Every job group ‘k’ has ‘n’ independent jobs grouped according to the job size of all jobs in the group. Hence, the total required resource power of ‘n’ jobs should be within the total computation power of the resource. The ResourceCapability\(_{UT}\) value is computed for the user-specified time deadline (UT) as shown in Equation 5.1 and the value of UT is used to find the number of jobs that can be completed within time deadline and is represented as,

\[ \text{Resource Capability}_{UT} = CRCP_j \ast UT \]

A unique id is assigned to the newly created job group and submits to the selected resource for execution. Similarly, jobs are submitted to the appropriately selected resources in the filtered resource list 2 (FRL2) until all the jobs are scheduled for execution. The group performance time (GPT) of job group on a selected resource is calculated using group execution time (GET) and group transfer time (GTT) of the job group between the scheduler and the selected resources as shown in Equation 6.2.

\[ \text{GPT}_k = \text{GET}_k + \text{GTT}_k \] (6.2)

The group execution time is dependent on the computation power required by the different jobs of the group and current resource computation power of selected resource \( R_j \), and it is computed as in Equation 6.3. The group transfer time is evaluated using the job size and the speed of the resource and it is computed using Equation 6.4.

\[ \text{GET}_k = \frac{\sum_{i=1}^{n} \text{Job Size}_i}{CRCP_j} \] (6.3)

\[ \text{GTT}_k = \frac{\sum_{i=1}^{n} \text{Job Size}_i}{\text{Network BW}_j} \] (6.4)

The total time of successful completion of user job on the suitable resource is considered to calculate the cost of the resource (COR) as shown in Equation 3.8. In
job scheduling, without grouping, each small size jobs upholds a small amount of transmission time at the grid resources. Therefore, the job completion time incurred by all the jobs at the grid resource is increased in terms of transmission time, which leads to higher resource cost. Whereas, in job scheduling with grouping, only small amount of completion time incurred by minimum numbers of job group, which leads to the reduction in resource cost. Using GSS-FM strategy the cost of the resources is reduced about 50% compared to the Min-Min strategy. After the job groups are assigned to a selected resource, the check-pointing manager finds the minimum number of checkpoints using improved check-pointing management.

### 6.2.1 Improved Check-pointing Management

The GSS-FM framework improves the performance of check-pointing management further by reducing the check-pointing time using the percentage of job completion along with the failure information of resources and the present status of job execution. If the resources are more stable that is if (JPET<MFTR) and (JCS>80%), the frequency of check-pointing will be reduced by increasing the check-pointing interval by 2I value and the current interval is calculated as the sum of old interval and 2I value as shown in Equation 6.5. Else the frequency of check-pointing will be increased by reducing the check-pointing interval by 2I value and the current interval is calculated as the difference of old interval and 2I value as shown in Equation 6.6.

\[
\text{Current Interval} = \text{Old Interval} + 2^*I \quad (6.5)
\]

\[
\text{Current Interval} = \text{Old Interval} - 2^*I \quad (6.6)
\]

Group Check-Pointing Time (GCPT) is evaluated as the sum of jobs check-pointing time in the group as shown in Equation 6.7, where single check-pointing time is calculated using the Equation 6.8.

\[
\text{GCPT}_k = \sum_{i=1}^{n} \text{NCP} * \text{SCT}_{ij} \quad (6.7)
\]

\[
\text{SCT}_{ij} = \left(\text{Checkpoint Size}_{ij} / \text{Disk BW}_{ij}\right) \quad (6.8)
\]
During execution of the submitted job, if the failure occurs, the failed group can be recovered by the recovery manager with the same resource or backup resource using flexible recovery method as discussed in Chapter 3.2.3. Finally, the successfully completed jobs returned to the user after ungrouping is carried out and the user satisfaction and resource utilization are evaluated.

The algorithmic steps of GSS-FM are as follows:

Step 1: Get the grid user job's QoS requirements

Step 2: Get resource specifications from GIS.

Step 3: For every resource R_j

   a. Calculate ORV using Equation 3.4.
      \[ ORV_j = \text{Reliability}_j \times w_3 + \text{CRS}_j \times w_4 \]

   b. For each client's request, the required resource value (RRV) is necessarily specified by the grid user

      If (ORV>=RRV), Select & Add the resources to the filtered resource list 1 (FRL1)

Step 4: For every resource R_j in FRL1

   a. Calculate the current resource computation power(CRCP)

   b. Sort the resources in descending order based on the available power of resource (ARCP). Then include the sorted resources in the filtered resource list 2 (FRL2)

Step 5: Sort the jobs in descending order according to job sizes and add it to the job queue (JQ).

Step 6: Sort the resources in FLR2 in descending order using job size

Step 7: For each job in the JQ

   For each resource R_j in FRL2
a. Find the number of jobs to be grouped according to the job size and computation power of the resources, and the size of the job group is computed as,

\[ \text{JG Size}_k = \sum_{i=1}^{n} \text{Job Size}_i \]

Where \( \text{JG Size}_k \leq \text{Resource Capability} \times \text{UT} \)

b. Get the user-specified time deadline (UT) and compute resource capability value using CRCP and UT as,

\[ \text{Resource Capability}_{\text{UT}} = \text{CRCP}_i \times \text{UT} \]

Step 8: Assign a unique id for the newly created job group and submit to the selected resource for execution.

Step 9: Repeat steps 7-8 until there are no jobs in the JQ.

Step 10: Calculate Group Performance Time (GPT) as,

\[ \text{GPT}_k = \text{GET}_k + \text{GTT}_k \]

Step 11: Set the checkpoints to job groups dynamically and calculate the Checkpointing time using improved check-pointing algorithm

\[ \text{GCPT}_{k,j} = \sum_{i=1}^{n} \text{NCP} \times \text{SCT}_{i,j} \]

Step 12: Scheduler waits for Time Interval of GPT+GCPT if failure occurs the failed group can be recovered with the same resource or backup resource using flexible recovery method

Step 13: Evaluate the resource utilization and Ungrouping the group of jobs & end the completed jobs to the user successfully.

Step 14: Stop.
6.3 PERFORMANCE EVALUATION OF GSS-FM

The implementation of the proposed GSS-FM algorithm is discussed, and the simulation was performed using grid simulation toolkit Gridsim Toolkit 5.2. The experiment is performed for ‘n’ different size jobs of the given application and the different parameters such as resource utilization and overall job completion time are evaluated. In GSS-FM model, the client application is assigned to an appropriate number of available reliable resources and the job is executed successfully within the specified time deadline. Hence the jobs are grouped accordingly and assigned to available resources. The different parameters such as group performance time and resource utilization are evaluated and proved the improved performance of GSS-FM over other algorithms. GSS-FM strategy minimizes the probability of failure during the execution of the job groups by considering the reliability and the present status of the resources, minimizes the job completion time by grouping fine-grained jobs into the job groups before allocation to the suitable resources and maximizes the resource utilization by handling resource failures reactively.

The GSS-FM strategy outperforms in terms of resource utilization with different resources. The resources are effectively utilized by selecting more suitable resources using reliability and availability for job groups submission. It improves the resource utilization further by selecting an appropriate recovery method after the failure has occurred. Hence the proposed GSS-FM strategy can attain the maximum resource utilization. The comparison of GSS-FM strategy with P-FH, R-FH, and Min-Min strategies in terms of resource utilization for varying number of jobs is shown as a sample illustration in Table 6.1 and the corresponding performance improvement is depicted in Figure 6.2.
Table 6.1. Resource Utilization

<table>
<thead>
<tr>
<th>Number of Jobs</th>
<th>Resource Utilization (%)</th>
<th>Min-Min</th>
<th>R-FH</th>
<th>P-FH</th>
<th>GSS-FM</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td></td>
<td>63.2</td>
<td>80.1</td>
<td>82.2</td>
<td>85</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>65.2</td>
<td>82.2</td>
<td>86</td>
<td>91.4</td>
</tr>
<tr>
<td>75</td>
<td></td>
<td>68.6</td>
<td>85.4</td>
<td>90.3</td>
<td>93</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>74</td>
<td>86.5</td>
<td>92</td>
<td>95.2</td>
</tr>
<tr>
<td>125</td>
<td></td>
<td>76</td>
<td>89</td>
<td>94.1</td>
<td>96.1</td>
</tr>
<tr>
<td>150</td>
<td></td>
<td>82</td>
<td>95.4</td>
<td>97</td>
<td>98.2</td>
</tr>
</tbody>
</table>

GSS-FM strategy assigns the job groups to the suitable resources based on reliability, availability, cost and computational capability and has achieved from 85% to 98.2% of resource utilization compared with the Min-Min strategy. The utilization for 150 jobs is achieved about 99%, and GSS-FM provides an improvement in resource utilization by 26.2% compared to Min-Min strategy.

![Figure 6.2. Resource Utilization in Grouping Strategy](image)

Expected job completion time (EJCT) of GSS-FM is reduced than P-FH and R-FH methods and much reduced compared to Min-Min technique. The comparison of GSS-FM strategy with P-FH, R-FH, and Min-Min strategies in terms of expected job completion time for the different number of jobs is shown as a sample illustration in Table 6.2 and the corresponding performance improvement is depicted in Figure 6.3.
Table 6.2. Completion Time of Jobs on Grid

<table>
<thead>
<tr>
<th>Number of Jobs</th>
<th>EJCT (m.sec)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min-Min</td>
<td>R-FH</td>
<td>P-FH</td>
<td>GSS-FM</td>
</tr>
<tr>
<td>25</td>
<td>780</td>
<td>670</td>
<td>610</td>
<td>490</td>
</tr>
<tr>
<td>50</td>
<td>900</td>
<td>780</td>
<td>720</td>
<td>570</td>
</tr>
<tr>
<td>75</td>
<td>990</td>
<td>870</td>
<td>860</td>
<td>730</td>
</tr>
<tr>
<td>100</td>
<td>1300</td>
<td>980</td>
<td>880</td>
<td>780</td>
</tr>
<tr>
<td>125</td>
<td>1500</td>
<td>1150</td>
<td>1000</td>
<td>870</td>
</tr>
<tr>
<td>150</td>
<td>1645</td>
<td>1250</td>
<td>1100</td>
<td>980</td>
</tr>
</tbody>
</table>

It is evident from Figure 6.3 that the EJCT of the jobs is very much minimized when jobs are submitted as groups instead of individually to suitable resources. The EJCT of the jobs has nearly reduced to 45% in the proposed GSS-FM strategy compared to the completion time of Min-Min strategy. The experimentation results are found and verified for user jobs between 25 and 150 and for a time specified by the user of 10 seconds. Even for more number of jobs submitted, GSS-FM algorithm proves a satisfactory performance as job completion time almost within the deadline. The total resource computation power (TRCP) and the specified time deadline (UT) decides the appropriate number of grid resources for job group completion.
6.4 CONCLUSION

The GSS-FM strategy is implemented for failure management in grouping based scheduling in which the set of jobs are combined into a group at the meta-scheduler before the deployment that resulted in the successful completion of jobs with higher resource utilization in minimum communication time. However, there is a need to provide suitable failure prevention methods using resource load prediction before scheduling the user jobs to reduce the number of reschedulings and improves the resource management further which will be discussed in the next chapter.