A Static approach to optimize time cost and reiliability in Distributed Processing Environment

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Abstract— Distributed Processing Environment refers setting up and managing computing and data exchange in a system of distributed computers. DPE is typically used in a larger network of computing system that includes different size servers scattered globally. In DPE more than one processor are used to perform the processing for an individual problem and numbers of tasks need to execute on different processors. Task allocation consist in finding an allocation of the tasks to the processors such that the total execution cost and time are minimized or processing reliability is maximized. So the ultimate objective of distributed processing is to improve the performance in terms to minimize cost and time and maximize reliability of DPE. In DPE a problem can be divided into one or multiple task modules and each of the task modules allocate on available processor for its execution. Different task modules processed on different processors in the DPE and sent back to the requested user/machine in combined form known as outcome or result. This research paper addresses task allocation problem for processing of 'm' tasks to 'n' processors (m>n) in a DPE. Task allocation approach, presented in this paper allocates the tasks to the processor to improve the performance of the DPE and it is based on the consideration of processing cost, time and reliability of the task to the processors. It also deals with various constraints of DPE like fault tolerance and resource accessibility in the event that one of the components fails. The nature of the assignment will be static.

Index Terms— Allocation Problem, Cost, Distributed Processing Environment, Processing Time, Optimization technique, Reliability, Task assignment

1 INTRODUCTION

A Distributed Processing Environment (DPE) consists of a set of multiple processors interconnected by communication links and equipped with software systems to produce an integrated and consistent processing environment. A very common and interesting problem in DPE is the task allocation. Task allocation problem deals with finding an optimal allocation of tasks to the processors so that the processing cost and processing time are be minimized and the processing reliability is maximized without violating any of the system constraints. Distributed data across processors unevenly so that each processor performs the volume of computation proportional to its speed is a common approach to solve allocation problem. This problem deals with finding an optimal allocation of tasks to the processors so that the processing time and cost can be minimized and processing reliability can be maximized for task allocation in DPE.

In DPE, the objective is to make processors busy executing tasks all the time by ensuring that it does not get idle and this serves the purpose. Task optimization is highly dependent on the tasks allocation method onto the available processor. In order to upgrade the processing capabilities of DPE, workloads are divided into small independents units called tasks and these tasks need to be executing on available processor through a task allocation model.

The task allocation method should be efficient in terms of optimize processing capabilities i.e. processing cost, processing time and processing reliability. Processing time is the time in which single instruction is processed, processing cost defined as amount of value of resource used and reliability can be consider as the reliability of its processors as well as the reliability of its communication links. In the present paper, a task allocation problem is considering with n number of processors and m number of tasks where m>n in DPE and these tasks are required to allocate on the available processors in optimize way with satisfying the constraints i.e. time, cost and reliability. The common issue arises in such a given scenario of task allocation problem, once available processors are occupied with a single task while the rest of tasks have to wait until the present allocated task will execute.

So to avoid such situation in a DPE, the employed approach have to make such arrangement where more than one task to a single processor can be allocate in order to get minimum execution time, processing cost and maximum processing reliability in DPE. Some of the task allocation schemes have been reported in the literature, such as Task Graph Scheduling [1], Execution Cost [2, 3, 8], network resources in a distributed stream processing platform [4], cost modeling approach [5, 6], Task Allocation [7, 9, 10, 14, 15], Reliability and cost optimization [11], scheduling performance and cost[12], inter process communication [13], static task scheduling [16], Optimized Time, Cost, and Reliability in a Distributed Computing System [17] and Task allocation for maximizing reliability [18, 19, 20]. In the present research paper, a new task allocation technique have proposed to task allocation in DPE to the existing number of the processor in such a way that overall load should also be balanced that avoid the situation of imbalance or overloading by using the proper utilization of processors of the DPE.

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2 NOTATIONS

p	Processor
t	Task
n	Number of Processors
m	Number of Tasks
TCTR	Task Cost Time Reliability
MTCTR	Modified Task Cost Time Reliability

3 OBJECTIVE

The objective of this research paper is to solve task allocation problem in an efficient way so that maximum level of optimization is achieved in order to minimize processing cost and time and maximize reliability by the proper utilization of resource in Distributed Processing Environment (DPE). The applied approach would also ensure that processing of all the tasks and its sub tasks as task modules are more than the numbers of processors in the DPE. The type of assignment of tasks to the processor is static. In this paper performance is measured in term of processing time, cost and reliability of the task that have to be get processed on the processors of the environment and it have to be optimally processed i.e., time, cost to be minimized and reliability maximized.

4 TECHNIQUE

In order to obtain the overall optimal processing cost or processing time or processing reliability of a Distributed Processing Environment (DPE), a problem of task allocation have considered where a set P = {p_1, p_2, p_3,……p_n} of 'n' processors with same configuration and a set T = {t_1, t_2, t_3,……t_m} of 'm' tasks, where m>n, every task has also contain some number of sub tasks module. Processing time, cost and reliability are known for each tasks module to the processor and arrange in TCTR. First task modules have to arrange in descending order of their processing cost or processing time or processing reliability. Then initially in first allocation, single task module would be assigned to each processor from the task queue which has been arranged in descending order. After that in each allocation assignment logic will find the processor with minimum load (cost or time) or maximum reliability and next task module will assign to that processor, these steps will be repeated until all the task module will assign to the processors in DPE. The function to calculate overall time [Etime], cost [Ecost] and reliability [Ereilability] is given here:

$$\text{Etime} = \left[\sum_{i=1}^{n}\left\{\sum_{i=1}^{n} ET_{ij}\ X_{ij}\right\}\right] \qquad \text{(i)}$$

$$\text{Ecost} = \left[\sum_{i=1}^{n}\left\{\sum_{i=1}^{n} EC_{ij}\ X_{ij}\right\}\right] \qquad \text{(ii)}$$

$$\text{Ereliablity} = \left[\prod_{i=1}^{n}\left\{\sum_{i=0}^{n} ER_{ij}\ X_{ij}\right\}\right] \qquad \text{(iii)}$$

5 ALGORITHM

Step 1: Start Algorithm

Step 2: Read the number of task in m

Step 3: Read the number of processors in n

Step 4: Input matrix TCTR (,,)

Step 5: Arrange the TCTR (,,) in descending order of their Processing time or cost or reliability and store them in TCTR $_{desc}$(,).

Step 6: From TCTR $_{desc}$(,) three separate tables for processing cost, processing time and reliability are derived.

Step 7: While all task! =ALLOCATED

Step 8: Search for the minimal value for processing cost and processing time by adding the processing cost or time $t_j = t_1$ to t_i and allocate the task to the relevant processor while maximum value for reliability by multiplying the same and allocate the task in similar manner.

Step 9 : End While

Step 10: Add all the processing cost or time and multiply reliability time Processor wise

Step 11: State the result

Step 12: End Algorithm

5 IMPLEMENTATION

In the present research paper, Distributed Processing Environment (DPE) have considered here which consist a set P of 3 processors {p_1, p_2, p_3}, and a set T of 3 tasks {t_1, t_2, t_3}. These tasks also contain some number of task modules. Here t_1 task has set of four modules {m_{11}, m_{12}, m_{13}, m_{14}}, t_2 contained set of four modules {m_{21}, m_{22}, m_{23}, m_{24}} and t_3 task having set of five modules {m_{31}, m_{32}, m_{33}, m_{34}, m_{35}}. It is shown by the figure 1.

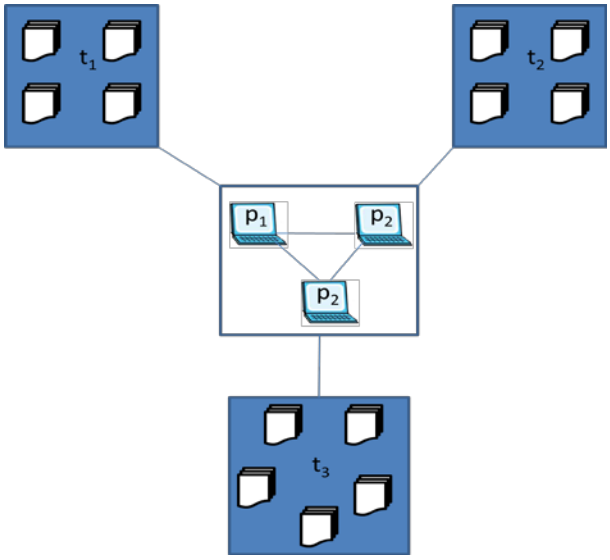

Figure 1: Different task modules are waiting to its execution in allocation queue

Each task contained different individual task components which are known as modules. The processing time (t), processing cost (c) and processing reliability (r) of each task modules are known and mentioned in Processing Cost Time Reliability (PCTR) matrix. Since the processors having same configuration so the value of processing cost, time and reliability for each tasks to any processor will be same in the environment. Time, cost and reliability for each processor are mentioned in Table 1.

Table 1: Processing Time Cost Reliability Matrix

Task	Modules	t-c-r
	m_{11}	110-2100-0.999450
	m_{12}	155-2800-0.999429
	m_{13}	105-2700-0.999428
t_1	m_{14}	115-2600-0.999418
	m_{21}	114-2300-0.999427
	m_{22}	195-2400-0.999425
	m_{23}	110-2200-0.999321
t_2	m_{24}	166-2700-0.999222
	m_{31}	085-2500-0.999220
	m_{32}	195-2300-0.999981
	m_{33}	185-3100-0.999781
	m_{34}	135-2200-0.999555
t_3	m_{35}	115-2700-0.999505

In order to solve task allocation problem in above matrix, this paper consider that t_1 is based on processing time (it may be processing cost or reliability), task t_2 is based on processing cost (it may be processing time and reliability) and task t_3 is based on processing reliability (it may be processing time and processing cost). That approach would enable to use data from PCTR in a new matrix named MPCTR where the processing time (t) will be represent for task t_1, processing cost (c) for task t_2 and processing reliability (r) for task t_3. New matrix MPCTR represent as Table 2:

Table 2: Modified Processor Cost Time Reliability Matrix (MCTR)

Task	Modules	t-c-r
	m_{11}	110 -… - …
	m_{12}	155 -… - …
	m_{13}	105 -… - …
t_1	m_{14}	115 -… - …
	m_{21}	… - 2300 -…
	m_{22}	… - 2400 -…
	m_{23}	… - 2200 -…
t_2	m_{24}	… - 2700 -…
	m_{31}	… - … - 0.999221
	m_{32}	… - … - 0.999981
	m_{33}	… - … - 0.999781
	m_{34}	… - … - 0.999555
t_3	m_{35}	… - … - 0.999505

Now MCTR matrix will arrange in descending order and can be break into three different tables for each constraint i.e. Table 3 for processing time, Table 4 for processing cost and Table 5 for processing reliability:

Table 3: Processing Time

Modules	Processing Time
m_{12}	155
m_{14}	115
m_{11}	110
m_{13}	105

Table 4: Processing Cost

Modules	Processing Cost
m_{24}	2700
m_{22}	2400
m_{21}	2300
m_{23}	2200

Table 5: Processing Reliability

Modules	Reliability
m_{32}	0.999981
m_{33}	0.999781
m_{34}	0.999555
m_{35}	0.999505
m_{31}	0.999221

In case of processing time and processing cost, there are four task modules, and these are in descending order, so assignment will be FCFS (First Come First Serve) basis for first three tasks and for remaining one task module in both cases (processing time and cost), assignment logic will search the minimum value or load on the processor and assign it to corresponding processor and will get overall processing time as mentioned in Table 6, overall processing cost as mentioned in

Table 7 and overall processing reliability as mentioned in Table 8.

Processors	Tasks Module	Processing Time	ETime
p_1	m_{12}	155	485
p_2	m_{14}	115	
p_3	$m_{11} * m_{13}$	215	

Resulting processing time can be shown in graphical form in Figure 2:

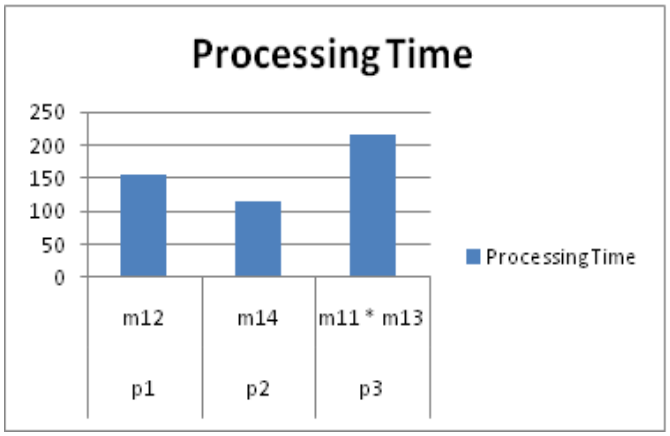

Figure 2: Processing Time taken by the processor

Table 7: Overall Processing Cost

Processors	Tasks Module	Processing cost	ECost
p_1	m_{24}	2700	9600
p_2	m_{22}	2400	
p_3	$m_{21} * m_{23}$	5500	

Resulting processing cost is representing in graphical in figure 3:

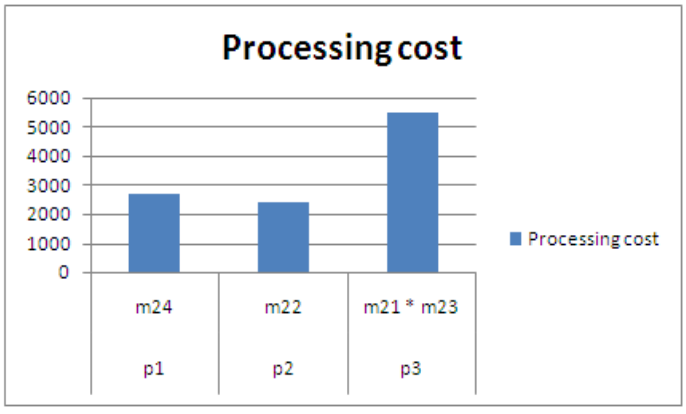

Figure 3: Processing cost occurred on the processing in DPE

Table 8: Overall Processing Reliability

Processors	Tasks Module	Processing Reliability	Ereliability
p_1	$m_{32} * m_{35}$	0.999486	0.998044
p_2	$m_{33} * m_{31}$	0.999002	
p_3	m_{34}	0.999555	

Resulting processing reliability is mentioned in graphical form as figure 4:

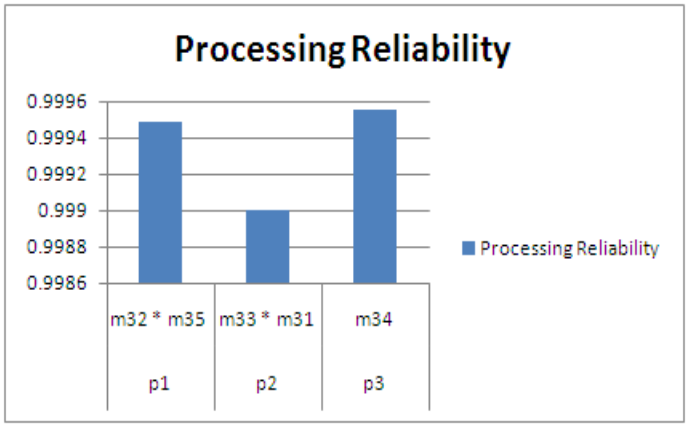

Figure 4: Processing Reliability to the processing in DPE

5 CONCLUSION

This research paper has solved the problem of task allocation through a newly designed algorithm, in which the number of the tasks is more than the number of processors in Distributed Processing Environment (DPE). The optimization technique will ensure to satisfy all the three constraints in regards DPE i.e. processing time, cost and reliability. The task allocation scheme is presented in pseudo code and implemented on the several sets of input data to test the performance and effectiveness of the pseudo code. It is the common requirement for any assignment problem that the task have to be processed with optimal time, cost and reliability. Three tasks i.e. t_1, t_2 and t_3 have been considered here with different tasks module and process t_1 with minimum time, t_2 process with minimum cost and t_3 process with maximum reliability in DPE. The optimal result of the example that is considered to test the allocation scheme is mentioned in the implementation section of the paper are as follows.

Table 9: Showing optimal results for allocated task modules

Task	p_1	p_2	p_3
t_1	m_{12}	m_{14}	$m_{11} * m_{13}$
t_2	m_{24}	m_{22}	$m_{21} * m_{23}$
t_3	$m_{32} * m_{35}$	$m_{33} * m_{31}$	m_{34}

Table 10: Showing optimal results for allocated task modules

Task	Optimal ETime	Optimal ECost	Optimal Ereliablity
t_1	485	---	---
t_2	---	9600	---
t_3	---	---	0.998044

All task modules will be assigned in optimize way as mentioned in figure 5:

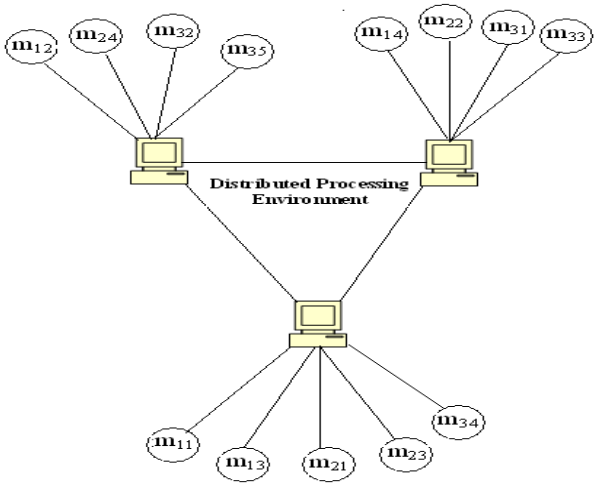

Figure 5: Showing task allocation results of given example

This research paper includes, calculating the time complexity of the present algorithm as it is a major factor to show the performance of the algorithm. Present paper also contains the comparison between results with some other recent algorithm [18] for proving the betterment of the present algorithm as mentioned in Table 11.

Table 11: Complexity comparison between present algorithm and algorithm [5]

Processors (n)	tasks (m)	Complexity of algorithm [5] O(mn)	Complexity of present algorithm O(m+n)
3	5	15	8
3	6	18	9
3	7	21	10
3	8	24	11
3	9	27	12
4	5	20	9
4	6	24	10
4	7	28	11
4	8	32	12
4	9	36	13
5	6	30	11
5	7	35	12
5	8	40	13
5	9	45	14
5	10	50	15

Comparing analysis of Time complexity is mentioned in Figure 6, 7 and 8.

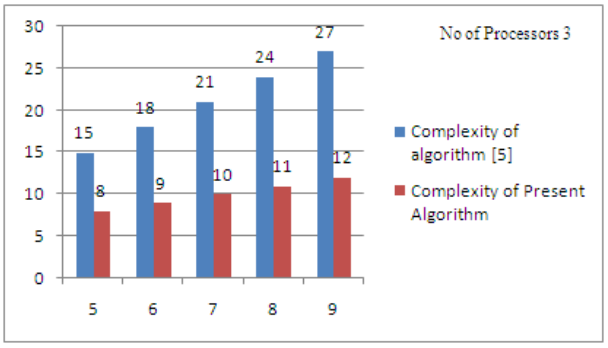

Figure 6: Time Complexity for No of Processors 3

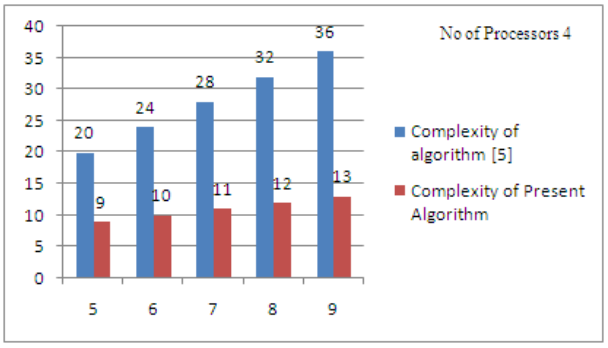

Figure 7: Time Complexity for No of Processors 4

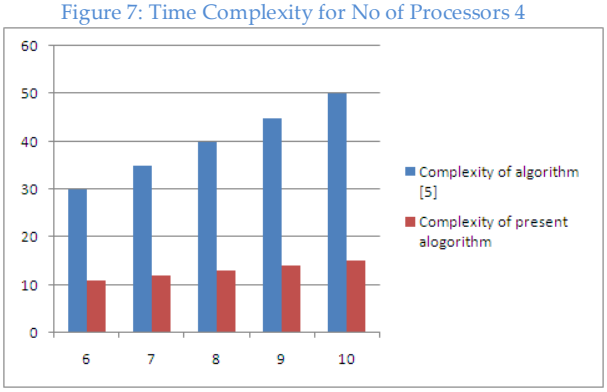

Figure 8: Time Complexity for No of Processors 5

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