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A Non-cooperative Approach For Resource Allocation in Heterogeneous Distributed Computing Platform

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Abstract— HDCS(Heterogeneous Distributed Computing System) is a set of interconnected computing nodes so as to offers sharing of computational power, applications or network resources vigorously In this paper, our distributed system consists of diverse resources with numerous selfish customers that receive computationally rigorous tasks from users and settle on conveying them to resources. The consumers in the system work in parallel, of which attempts to allocate the inward tasks to resources with the purpose of optimizing the expected completion time of it`s tasks. In order to have a balanced system there should be equilibrium between these selfish consumers. Here we devise s decentralized dynamic resource allocation scheme in distributed computing systems has been modelled as a non-cooperative game among the computing nodes and nash equilibrium gives the optimal solution of this non-cooperative game .In the preceding accessible schemes allot tasks to the computing nodes which are having more processing capability but in dynamic environment its not sufficient to schedule tasks based on the processing powers. Think about resource availability along with the processing powers of computational resources is great connotation with regard to performance issue. In the proposed scheme resource allocation is based upon the processing powers of the computing nodes, communication delay and the resource availability(waiting time) of tasks at different computing nodes. **This scheme improves the fairness of the HDCS and minimizes make span of the tasks**
Keywords— ***Heterogeneity of tasks, Distributed Computing System, Resource Allocation, Nash Equilibrium, Non-cooperative Game***

I. INTRODUCTION

One of the aims of the load balancing has been to diminish the total execution time of tasks given to accessible resources in a distributed computing atmosphere The load balancing decisions depend on either a static study of the behaviour of system resources[3][10] or dynamic changes and current state of system behaviour. Schedulers or consumers use Static or dynamic information of system circumstances. There are two approaches: centralized [9][12][10] with Single decision maker and decentralized(distributed) ,with multiple ones on basis of the number of decision makers,. For a large number of computers, the operating cost of centralized become unaffordable and the central decision computer hold up. In distributed load balancing, Load balancing could be achieved by either Cooperative approach in which several decision makers work together in making the decisions such that each of them will handle at its optimum or Non-cooperative approach where decision makers that are not allowable to cooperate and each of them selfishly optimizes its own rejoinder time independently of the others and they all eventually reach an equilibrium.

II. RELATED WORK

In history works on load balancing considered optimization of the entire system expected response time [5][3][8][10] .In current years, there is evaluation of game theoretic approaches and market oriented models for the propose and examination of distributed systems and load balancing.

Oskar Morgensterm et al. premeditated non-cooperative games and invented load balancing algorithms for computing the Wardrop equilibrium in distributed systems[9]. Roughgarden [2] formulated the load balancing problem for non cooperative game. In this kind of non-cooperative game, one player acts as a organizer and the respite as cliques the problem is NP-hard to compute the optimal Stackelberg strategy and presents proficient algorithms to compute strategies inducing near-optimal solutions. Shailendra S.Aote and M.U.Karat a non-cooperative load balancing game [13] in distributed systems for minimizing response time of the tasks

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is formulated here by Shailendra S.Aote and M.U.Karat, they have measured accessible processing powers of computers and task arrival rate as a parameters for pronouncement the suitable computers for allocation of tasks.Daniel Grosu and Anthony chronopoulos estimated the self-interested load balancing in a heterogeneous distributed systems as a non-cooperative game [14] to get better response time of tasks submitted at any computer. This is a static approach which uses the processing power and task arrival rate for finding proper computers for task assignment.

A load balancing problem in computational grids is proposed by R .Subrata and Y.Zomaya as a non-cooperative game by making an allowance for the processing powers of computers and transfer time of the tasks to the other computers [15] with an objective of minimizing the average completion time of the tasks.

The queue theory is relevant to model in which waiting tasks should be processed at resources. Under the postulation of exponential service times and Poisson arrival, a small number of job allotment games for distributed systems were obtainable, though, no communication delays were taken into account[1][2][10]

III.STRATEGIC APPROACH

The purpose of this paper is to invent the load balancing problem in distributed systems as a non-cooperative game among clients whereas considering the multiple communication channels which bond each pairs of customer and resource. Here give a categorization of the Nash for computing the most favourable point for this game. At the Nash equilibrium a user cannot obtain any further improvement by changing its own decision equilibrium.

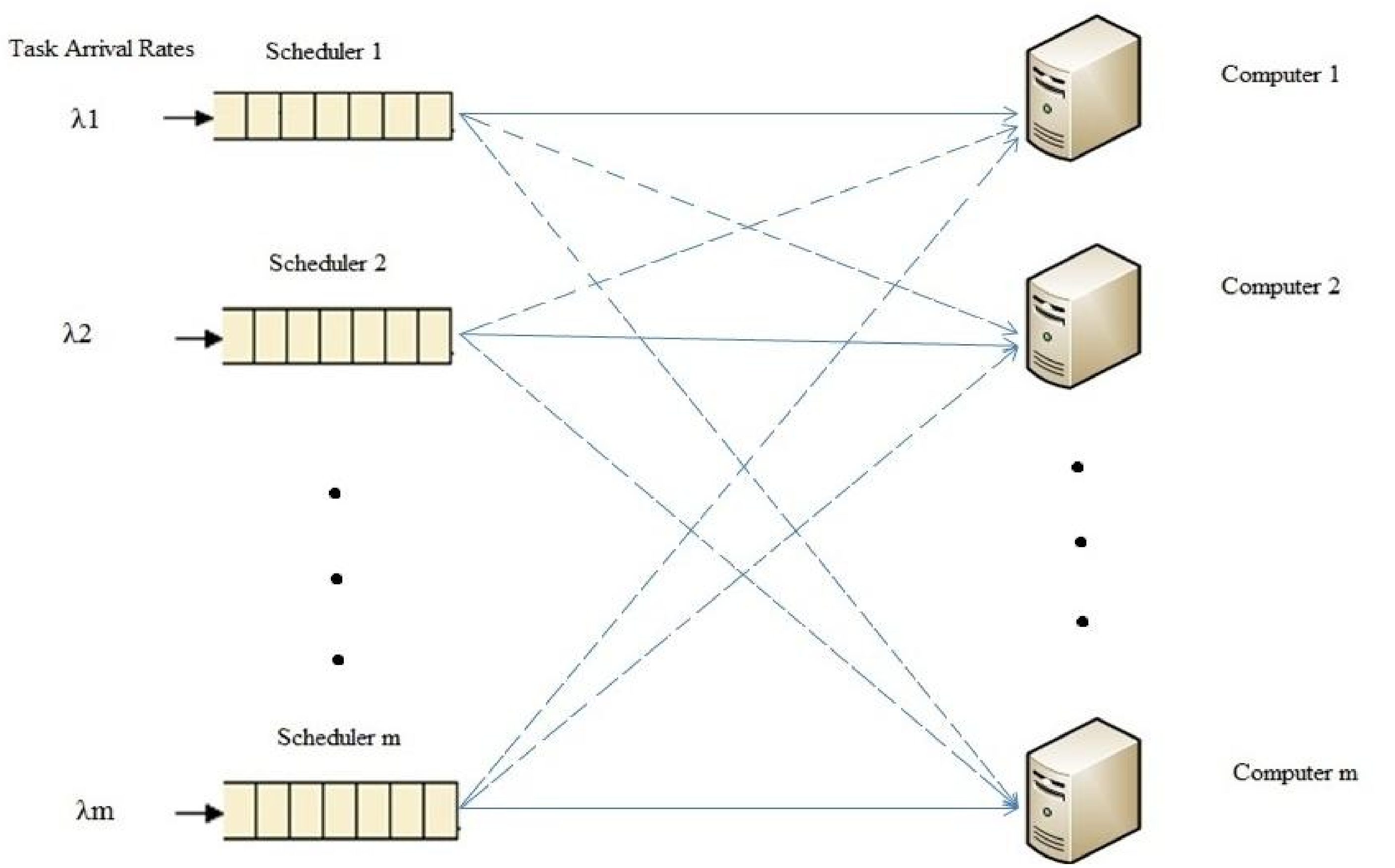

Fig -1: Allocation of Resources

In this paper consider a distributed computer system model that consists of *m* heterogeneous resources shared by *n* consumers. Each customer *i* contain the tasks at the same average rate λ_i sent by users and dispatches tasks to the resources. The decisions are taken by client which resource will process the task and assigns tasks to that resource and finally collects outcome such that the total expected execution time of its tasks is reduced.

The decision making of task scheduling has been modelled as the non-cooperative game and the optimality concept of this non-cooperative game is represented by the nash equilibrium.

In this dynamic non-cooperative approach communication delay between any two computing nodes is taken as hop count. On the basis of current waiting times, processing powers of computing nodes, communication delay and processing times of the tasks at different computing nodes, this approach focuses on allocating tasks to the computing nodes.

If there are n computing nodes then instead of assigning tasks to each computer, this approach schedules tasks to the selected computing nodes who available earlier. The performance of this non-cooperative scheme is analyzed under the performance parameters make span, fairness and communication delay.

The communication delay is integrated in the model. There is a single communication link between each consumer and all of the system resources independent of others.

We devise this dilemma as a non-cooperative game among customers under the hypothesis that clients are selfish. Meaning of that they minimize the expected response time of their own tasks by conveying the designated fraction of them to each resource. Every resource has a queue that holds tasks to be executed; each task is then executed as first-come-first-serve. Depending on the computational power provided by the resources, each resource *j* executes tasks at an average rate μ_j (tasks per second) .

IV. SIMULATION RESULTS

To evaluate the performance of the system under distinct performance metrics make span, fairness and the outcome of communication delay on make span of the system considered two heuristics Overall optimal scheme, Non-cooperative approach . Objective is to minimize the make span of tasks, get better the fairness of the distributed computing system and evaluate the consequence of communication delay on make span.

Graphs in the figure depicts consequence of workload on make span and here comparison of the make span of proposed non-cooperative with the OPTIM [15] scheme at dissimilar loads. From the figure 3 proposed non-cooperative scheme gives better make span as compared with the OPTIM [15] scheme. Here OPTIM scheme considers processing power of the computing nodes and tasks arrival rate but it does not focus on the current waiting times at diverse computing nodes i.e., based on the processing powers, it always assigns same number of tasks to each computing node, while in the anticipated non-cooperative scheme scheduling will be through based on the waiting times at diverse computing nodes i.e., more tasks will be migrated to computing nodes having less waiting times.

A. Proportional Scheme (PROP)

According to the proportional scheme allotment of tasks from one computing node to other computing nodes based on the proportion to their processing power i.e., computing node having high processing power will get more number of tasks than the computing node having low processing power.

$$p = \lambda * p_{wi} / \sum_{i=1}^{m} p$$

To calculate the fairness index of system under both of schemes, use following formula

$$I(F_i) = (\sum_{i=1}^{m} M_i)^2 / \sum_{i=1}^{m} Mi^2$$

Where F_i is the expected makespan time of customer i. We have calculated fairness index I or all above scheme.

TABLE 1: MAKE SPAN OF NON-COOP VS OPTIM

Numer of tasks	Non-cooperative	OPTIM
100	656	1125
200	1023	2229
300	2800	4542
400	4487	4959
500	4785	6175
600	4986	8523
700	5128	8268
800	4178	9962
900	7465	11283
1000	9527	12195

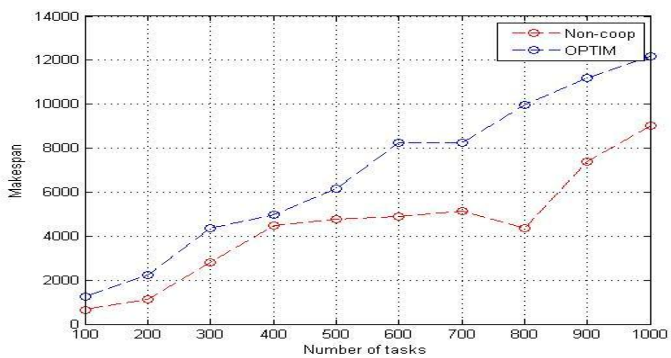

Figure 1: Make Span of Non-coop vs OPTIM

If all computers have same expected completion times then I=1, means system is 100% fair to all the computers and wholly load balanced i.e., here I gives percentage of computers having irregular completion times. If dissimilarity between M_j of different computers increases then load balancing scheme will nepotism only for some computers.

Figure 2 shows the fairness index of the system. Here comparisons of fairness of the proposed non-cooperative scheme with respect of waiting times only and the ratio of processing power to the waiting time .

Figure 3 depicts the consequence of communication delay on make span of the tasks inwards in the system.

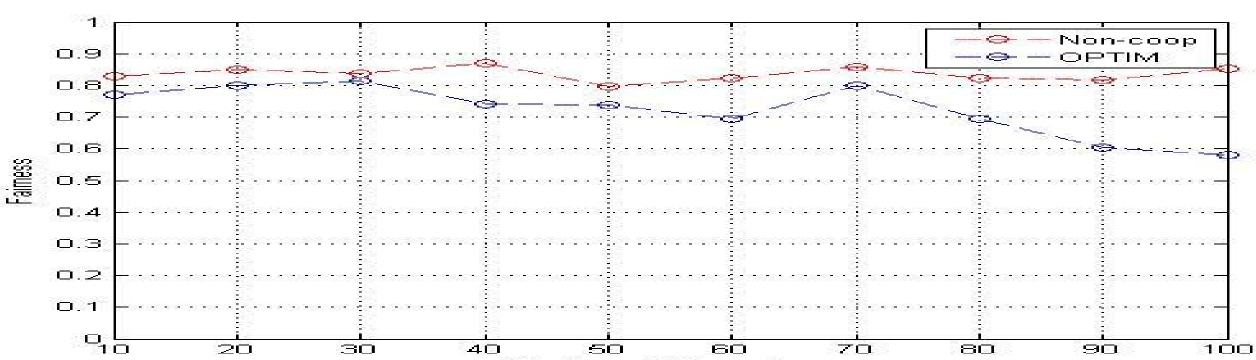

Figure 2: Fairness vs Number of Computers

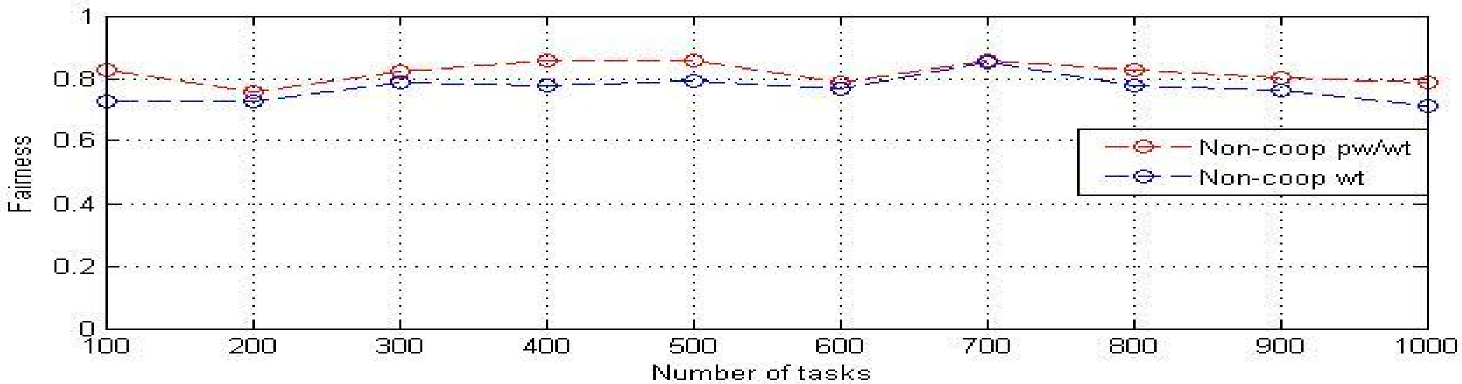

Figure 3: Fairness of non-cooperative scheme

V. CONCLUSIONS

This paper presents some basic concepts of game theory and implementation of proposed non-cooperative resource allocation in distributed computing systems. The performance of this approach is analyzed by the performance parameters fairness and communication delay. From the above results we can conclude that the proposed non-cooperative scheme is giving better fairness of this proposed non-cooperative scheme is 90% i.e. ,utilization of all the computing nodes in the system is almost same. 30% of the make span is due to the communication delay in the network and the communication delay highly depends on the network topology.

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