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Performance Evaluation of Game Theory Based Efficient Task Scheduling For Edge Computing

Dr. S. Smys,
Professor, Department of Computer Science and Engineering,
RVS Technical Campus,
Coimbatore, India.
Email: smys375@gmail.com

Dr. G. Ranganathan,
Professor, Department of Electronics and Communication Engineering,
Gnanamani College of Technology,
Namakkal, India.
Email: profranganathang@gmail.com

Abstract: The edge paradigm that is intended as prominent computing due to its low computation latencies faces multiple issues and challenges due to the restrictions in the computing capabilities and its resource availability especially in the huge populace scenarios. To examine the problems faced during the task scheduling when the edge computing is called up by multiple users at time, the paper puts forward the game theory approach. Utilizing the game theory strategy the paper puts forth the a novel multi-tasking scheduling in the edge computing from the user perception developing an algorithm taking into consideration the consistency of the stable tasks. The analysis of the proposed algorithm used in the allocation of the tasks is done on terms of average time consumed for the execution of the task and the waiting time. The results acquired showed that the proposed method provides a maximized throughput, minimizing the waiting time compared to the conventional methods used in optimizing the parameters of scheduling.

Keywords: Edge Computing, Cloud Computing, Game Theory Approach, Task Scheduling, Co-Operative and Non-Co-Operative

1. Introduction

The edge computing provides an effective way to relive the over burdens on the cloud computing. The Edge computing enabled by the wireless network and the processing capacities that are powerful allows multiple users to enjoy accessing ample resources for computing eluding the internet delays and jitters. Despite its

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processing capacities and plentiful resources it is still considered to be feeble when compared to the ability and the proficiency of the cloud data centers for example the Microsoft Azure, Amazon and the AWS. The capabilities aforementioned are very less when the edge paradigm is preferred by vast number of users, further the advancements in the mobile devices such as the laptops, personal digital assistance, mobile phones and wearables has tenanted the need for enhancing the capabilities of the edge computing.

The task scheduling that is usually performed in the cloud paradigm to improve the system performance is nowadays becoming more prominent in the edge computing paradigm as huge number of users prefer the closer by edge computing than the remote cloud data center due to its reduced latencies. The task scheduling is necessitated process in the edge paradigm due to its limited resource availabilities as the scheduling of task is done to execute a process with the fewer amounts of available resources. The failure in utilizing the process of task-scheduling or eluding the scheduling process would result in the inefficient usage of resources and resulting in longer waiting time that some time exceeds even the deadline allotted for the requests. This becomes very serious when processing request of emergent health care situations and major disaster conditions where the immediate response for the emergency vehicles are required. The figure.1 shown presents the overview of the processing done in the edge.

Figure.1 Edge level processing

ISSN: 2582-1369 (online)

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The edge processing can be depicted as three layer frame work as shown in figure .1 with the sensing devices at the bottom layer and the processing at the edge layer that is placed in middle of the cloud and the sensing or the user layer and the cloud layer on the top to store the processing results. Delay in the processing at the edge is very much reduced compared to the processing in the cloud this is the reason why the edge is more preferred than the cloud. Some of the benefits that make more preferable than the cloud are listed in the table.1 below. It enables to have a clear scoping of computing resourcing for optimal process.

Benefits of Edge Computing	Description
Reduces latency	As it processes the time sensitive data with at its origin by the local processors
Utilizes Intermediary servers	Helpful In make real time decisions as the data is processed closer to the source.
Provides Service at the Edge	Reducing the cost transmission cost increasing the , latency and enhancing the quality of service.
Enhances security	As the process is done near to source with protected firewalls and security points
Augmented Scalability	saves the cost on real time data transmission by grouping the capabilities of the CPU logically as required.

Table.1 Benefits of Edge Computing

In spite of the benefits of the edge than cloud due to its limited resource capabilities the edge computing suffers from delivering quality services when there are enormous service requisitions so as to make the edge computing more compatible enhancing its performance, the task scheduling is preferred in edge. The paper puts forth the game theory based task scheduling in the edge computing and evinces the quality of service delivered by analyzing the time taken to complete the task and the average waiting time of the task. Main scope of the paper is to maximize the throughput minimizing the waiting time, by executing the process before the dead line is reached.

The paper is explains the proposed process of tasking scheduling with the related works in the second part, the problem statement in the third part, the game based scheduling in the fourth part , its performance analysis in the fifth part and its conclusion in the sixth part followed by references.

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2. Related works

Kumar, Dinesh et al [1] elaborates the "review on task scheduling in the cloud that is ubiquitous", Selvarani, S et al [2] proposes the algorithm for task scheduling in cloud to minimize the cost consumed for the computation in cloud, Kumar, T. Senthil et al [3] puts forth the novel method for allocating of resources in the fog network for the internet of things to enhance its quality of the service,

Liu, et al [4] proposes the multi-tasking scheduling based on the work load in the cloud manufacturing**,** Smys, S., et al [5], puts forward a "A Stochastic Mobile Data Traffic Model for Vehicular Ad Hoc Networks." and Awad, et al [6] utilizes the particle swarm optimization, to schedule the tasks in the cloud computing , Shakya, Subarnaet al [7] details the "An Efficient Security Framework for Data Migration in a Cloud Computing Environment." , Kaur et al [8] utilizes the genetic algorithm, to schedule the tasks in the cloud computing, Karunakaran et al [9] ,uses the GSA and the NGSA method to schedule the resources in the cloud paradigm, to bring down the energy y optimized in the computation of tasks.

Li**,** et al [10] also proposes the scheduling to minimize the energy consumption in the task processing in cloud. Bashar et al [11] proposes a "Secure and Cost Efficient Implementation of the Mobile Computing Using Offloading Technique." , Liu et al [12] shows the scheduling in the mobile-edge to minimize further the delay observed in the mobile- edge paradigm Smys, S et al [13] "Special issue on evolutionary computing and intelligent sustainable systems.", Sinnen et al [14] presents the realistic scheduling model to enhance the performance of the cloud., Raj, Jennifer S. et al [15] presents the. "Energy Efficient Localization And Routing Strategy For Cluster Based Sensor Networks." Zhu et al [16] puts forth the deadline aware task scheduling for the mobile edge computing, whereas the method put forth in the paper utilizes the gaming model to allocate appropriate resources to the users request based on the processing speed of the resources, prioritizing the user request using the PSO, in order to maximize the throughput and enhance the quality of service.

3. Problem Statement

The task scheduling that was usually performed in the cloud paradigm is preferred in the edge platform to enhance the performance of the edge computing in terms of computation time (C_T) and waiting time (W_T) there by maximizing the throughput (TPT). The edge paradigm that is most preferred due to its reduced latencies turns out to be inaccessible as the number of user requests increases and becomes massive. so to

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handle the huge number of requisition by timely process before the dead line is reached the scheduling of tasks enabling to process the tasks with the minimum resources available is opted in the edge platform. So the proposed method utilizes the game theory the "the study that causes interaction between the player who are competing and independent to perceive an optimal scheduling of resources for the service requisitions handled at the edge.

4. Proposed Work

4.1. System Model

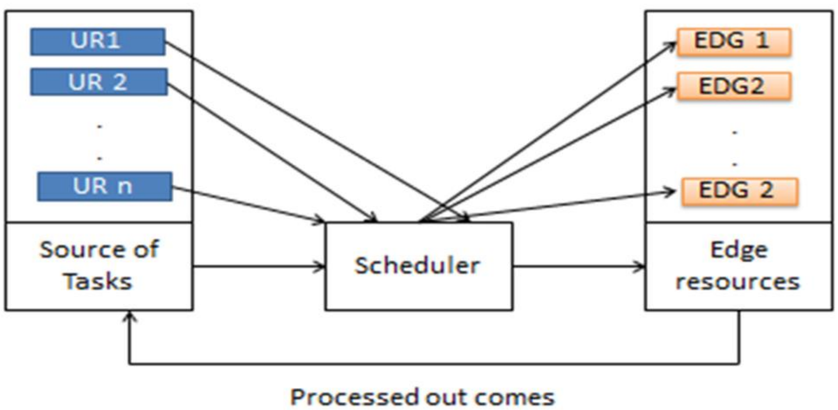

Figure.2 System Model

The system model presented in the figure.2 above shows that the tasking scheduling process is mainly comprised of three components, where the primary requirement for scheduling the task is the user requests and then the scheduler algorithm and finally the resources that are to be allotted or scheduled. The user request gathered by the consumer side is dispatched to the scheduler algorithm let the user request gathered be represented as$\{UR_1, UR_2, \ldots \ldots UR_n\}$, where each user request is considered to be a task. Every user request received is examined to identify the time of arrival (T_{arr}), the deadline line of the request (Req_{Dl}) and the total size of the request (Ts_{Req}) now the probable time of computation $(Prob_{C_T})$ is enumerated by (Ts_{Req}) of the request to the processing speed $(Proc_{Spd})$ and the actual time taken for execution (Act_{ET}) is given by time of scheduling (T_{Sch}) the request to resources combined with the$Prob_{C_T}$. and the waiting

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time (W_T) is enumerated by finding the difference between the T_{Sch} and the T_{arr}. The set of the resources at the edge are represented as $\{EDG_1, EDG_2, \ldots.EDG_i\}$, the `scheduling process here is done utilizing the game theory, by initiating a two player game to select the optimal resources.

4.2. Proposed Algorithm

Initially the requests are prioritized by examining the time of arrival (T_{arr}), the deadline line of the request (Req_{Dl}) and the total size of the request (Ts_{Req}) by applying the particle swarm optimization [6] and the prioritized in the ascending order with the lowest deadline first. Now the game theory is applied to the request, as numerous requests are processed, the two player model is used considering 'j' number of schedulers that plays two tasks on the same time; the proposed system model can hold $j = m/2$ schedulers

4.2.1. Game Theory Approach

The game could be defined as the "interaction between the multiple players where the each players decision disturbs the reward the other there are three main constituents that makes possible the game model they are (i) player himself, (ii) his strategies in a particular circumstances and (iii) reward which might either be the loss or the benefit gained by the users on behalf of the strategy followed. The proposed method utilizes two types of game model co-operative and non-cooperative with each requested designated as the players, the resources termed as the strategies and the Act_{ET} and the W_T to be the reward metrics.

a) Co-operative Gaming

1. Create pay off matrix using the completion time of the resources for UR_1, UR_2

UR_1 \ UR_2	EDG_1	EDG_2	EDG_3
EDG_1	(6,4)	(2,5)	(7,3)
EDG_2	(6,2)	(3,6)	(2,5)
EDG_3	(6,7)	(3,4)	(5,8)

2. Normalize the matrix subtracting the UR_2 reward with the UR_1 reward and taking the mod

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Pages: 50- 61
http://irojournals.com/iroismac/
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UR_2 / UR_1	EDG_1	EDG_2	EDG_3
EDG_1	2	3	4
EDG_2	4	3	3
EDG_3	1	1	3

3. Here the large value obtained indicates the large variation in the gain of the player and small value represents the opposite to it.
4. The reward with the small value is selected and the corresponding resources on the row and the column are assigned to the UR_1 and UR_2 respectively.
5. The same is followed in evaluating theW_T .

b) Non –Cooperative Gaming

1. Create pay off matrix using the completion time of the resources for UR_1, UR_2

UR_2 / UR_1	EDG_1	EDG_2	EDG_3
EDG_1	(5,2)	(8,5)	(5,7)
EDG_2	(3,2)	(3,5)	(1,6)
EDG_3	(4,8)	(2,1)	(9,5)

2. Normalize the matrix subtracting the UR_2 reward with the UR_1 reward.

UR_2 / UR_1	EDG_1	EDG_2	EDG_3
EDG_1	3	3	-2
EDG_2	1	-2	-5
EDG_3	-4	1	4

3. The rewards with the positive values represent the gains of UR_2 and loss of UR_1 and the reward with the negative values represents the gains of UR_1 and the loss of UR_2.

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4. Identify the maximum rewards from each row and picks the minimum one as the optimal resource for the UR_1 (as UR_1 follows the min-max principle in order to minimize the maximum loss) so the resource selection is given by $minimum_{\forall x}\left(maximum_{\forall y} M \left|x\right|\left|y\right|\right)$
5. And the UR_2 follows the max-min principle and identifies the maximum among the minimum which is given by$maximum_{\forall x}\left(minimum_{\forall y} M \left|x\right|\left|y\right|\right)$.
6. The same is followed in evaluating theW_T

Thus the proposed method uses the gaming model to schedule the user requests identifying the execution speed of the resources and allocates the user request based on the rewards identified. The resource with the maximum speed and less waiting time is determined as the optimal resources for the request with the minimum deadline and the request that are time insensitive are forwarded to the cloud for processing. The process is completed in the edge and the results are sent back to the users and the summary of the process is submitted to the cloud database for future reference.

5. Results Evaluation

The proposed model designed with the PSO for arranging the user request according to the deadlines and co-operative/non –cooperative game model for scheduling task based on the rewards enumerating the Act_{ET} and the W_T is evaluated with the network simulator –II to validate its performance for different number (20, 40, 60, 80,100) of users who prefer edge computing and the co-operative and the non-cooperative model are separately evaluated to find out the optimal gaming model. The simulation parameters used are tabulated in the table.2 below.

Parameters	Values
Users Request	100
Resources count	20
Capacity of Resources	4500 MIPS
Task distribution	Poisson distribution
Task size	5k to 10k MI

Table.2 Simulation Parameters

ISSN: 2582-1369 (online)

Journal of ISMAC (2020)
Vol.02/ No. 01
Pages: 50- 61
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The completion time taken by the PSO +Co-operative model and the PSO +Non-cooperative model are evaluated and compared with the evolutionary algorithms that were employed previously in the process of scheduling the user request such as the Genetic Algorithm, NGSA and GSA. The figure.3 below is the results observed on the actual completion time consumed.

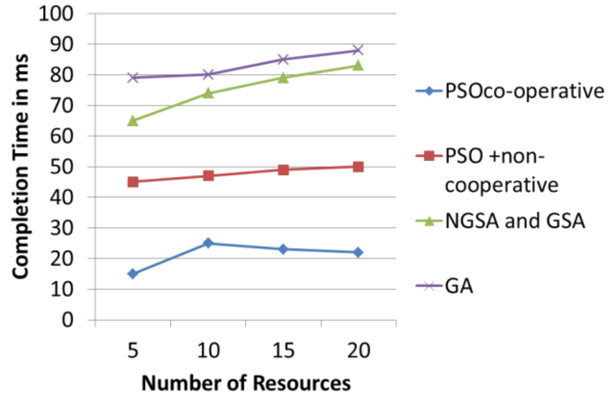

Figure.3 Completion Time

Where the $Act_{ET} = T_{Sch} + Prob_{C_T}$ and the $Prob_{C_T} = (Ts_{Req} / Proc_{Spd})$,

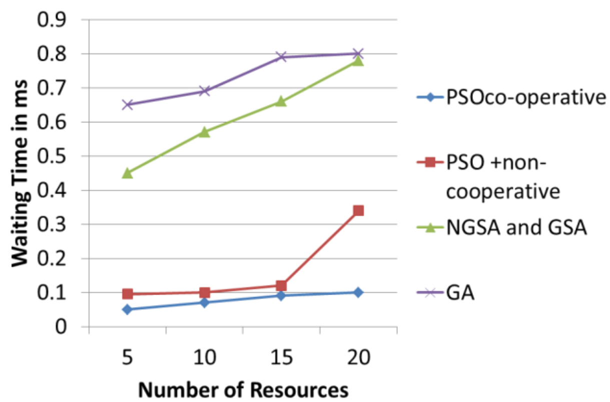

Figure.4 Waiting Time

ISSN: 2582-1369 (online)

Journal of ISMAC (2020)
Vol.02/ No. 01
Pages: 50- 61
http://irojournals.com/iroismac/
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The figure.4 is results observed on the W_T caused by the by the PSO +Co-operative model and the PSO +Non-cooperative model and are compared with the evolutionary algorithms that were employed previously in the process of scheduling the user request such as the Genetic Algorithm[8], NGSA and GSA [9] were the $W_T = T_{Sch} - T_{arr}$.

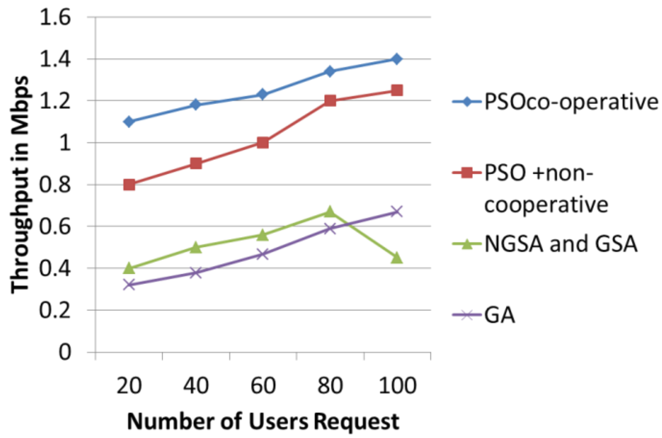

Figure.5 Throughput

The results observed shows that the gaming model identifies resources with the better Act_{ET} and W_T and enhances the performance of the edge by providing a quality service to the request with the minimum dead line. The figure.5 below provides the maximum throughput achieved by the gaming model compared to the other methods. Though gaming model enhances the performance among the two gaming model the co-operative method seems to be more optimal than the non-co-operative as the Act_{ET} and W_T of the co-operative method is less compared to the non-co-operative.

6. Conclusion

The edge paradigm that is more convenient due to its reduced latency also faces problem as it holds only limited resources and lacks proper scheduling of tasks. To subdue this paper puts forth the task scheduling process that is fully handled by the game theory and employs the PSO in prioritizing the request of the users. The capability of the resources in terms of the actual completion time and waiting time is identified

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based on the rewards using the gaming model that is co-operative and non-co-operative. This method is evaluated to evince the performance of the gaming model with the other methods like GA, NGSA and GSA and it was found that the proposed method had a better Act_{ET} and W_T and the results observed for the co-operative model was found better than the non-co-operative model.

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Vol.02/ No. 01
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