Job scheduling with efficient resource utilization using the hybrid evolutionary algorithm in the cloud datacenter

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Abstract. Cloud computing is widely used in today's scientifically advanced era. It alludes to applications and administrations delivered over the Internet in a pay-as-you-go mode. Such services are extended by data centers round the globe, conjunctively identified as the cloud. In cloud environment, task scheduling is an prime issue that need to be settled. In order to optimize or efficiently use computing resources, it is always necessary to efficiently schedule tasks to avoid excessive or insufficient use of these resources. In this paper, we propose Johnson's Rule-Based Genetic Algorithm (JRGA),is a hybrid GA algorithm whose performance surpasses customary GA. This paper demonstrates the advantage of JRGA over traditional GA and also compares it with First-Come-First-Serve (FCFS), Shortest-Job-First (SJF) and Round-robin (RR) algorithms run by the CloudSim simulator, and their results clearly propose that JRGA outperforms the other substitute algorithms.

Keywords: Cloud Computing · Task Scheduling · Genetic Algorithm · Johnson's Algorithm

1 Introduction

Cloud computing is technologically advanced medium for storing and accessing data via the Internet. It has become a utility because of the benefits of high assessing power, lower administration costs, better performance, scalability, adaptability, openness and accessibility. Cloud processing has a few difficulties like unwavering quality, security, performance, resource administration etc. Scheduling is perhaps the main issue to improve the productivity of all cloud-based administrations. Task scheduling is a contrivance for assigning tasks or jobs to computing resources for computation. The task scheduler is ought to check whether resources are accessible to execute a specific task. Then, at that point, the specified task ought to go to another resource for execution.The main goals are to increase productivity, service quality, maintain efficiency between tasks and reduce costs.
This paper mainly focuses on the Johnson Rules-Based Genetic Algorithm (JRGA),

an hybrid algorithm that merges the GA and Johnson algorithms. JRGA is an refined hybrid GA,where the execution shows a greatly improved make span and optimization results contrasted with conventional GA. More explicitly, the GA was functionalized to apportion the jobs to fitting machines, and Johnson's rule was utilized as an unraveling strategy to decide the disposition in which tasks are to be handled by each machine. We also compare it to a few other algorithms namely First-Come-First-Serve, Shortest Job First, and Round Robin Algorithm and finally conclude that Johnson's rule-based algorithm is the most efficient of them all with the least make span time.
The rest of the paper outlines as given below: Section-2 provides an outline of related work and literature review. In Section-3, details our approach to programming in the cloud. Section-4 discusses Johnson's rule-based genetic algorithms and performance assessment and result. Lastly, the conclusions of our work and future advancements are given in Section-5.

1.1 Motivation and Contribution

The objective of cloud computing is to provide an ideal case scheduling of tasks, to deliver to clients and the whole cloud framework with ideal activity time, improved Quality of Service at the same time and Load Balancing. Task Scheduling is for the ideal coordinating of undertakings and resources. To outline and provide scheduling executive framework for designing execution in IaaS Clouds, in this paper we introduce an important algorithm of task scheduling. The objective is to enhance the operational performance of task scheduling while lowering the make span. A key goal is to foresee the ideal algorithm for the approaching/accessible information as and when required.
As described in Section-2, there are numerous works existing in literature regarding task scheduling in the cloud environment. This research paper offers the following novelty contribution:

- .We concentrate on undertaking the task scheduling complication in distributed computing servers can be tackled to curtail the make span.
- We convey that Johnson's standard rule can be well unified with GA for task scheduling complication,and we present a JRGA algorithm as a solution.
- We also compare the hybrid evolutionary algorithm with the other three algorithms and prove that the JRGA is the most efficient with the least makespan.

2 Related Work

In paper[5],the authors offer a model where Genetic algorithm is used for Scheduling of task in cloud environment.The flow of GA is studied through out its execution cycle. The genetic algorithm is compared against pre-existing standard scheduling algorithm for metrics like response time,utilization of resource,processing time.

In paper[7], the creator reads work planning issue for framework registering on meta computers as a combinable enhancement issue were execution of various blends of occupation requesting procedures, processor distribution calculations and meta PCs reproduction are done.Various pre existing algorithms are mixed to note the one which gives the best normal case execution.

In paper[1],the author utilizing the cloud Sim tool stash mimics Generalized priority algorithm for task execution and contrasts it with pre-existing standard Scheduling processes demonstrating the previous gives better execution analyzed line-up calculation.The execution time taken by both testing and comparison model are recorded when the metrics which are count of virtual machine,task assigned to each machine,data centers are varied.

In paper[6],the author prioritises the fact that tasks ought to be planned proficiently such that the implementation cost and time can be decreased and he proposed submits that meta-heuristic based planning is one of the way to achieve the above requirement.He consolidates two different cloud let processing techniques to frame a modified Genetic Algorithm (MGA) which under the substantial burdens displays a decent presentation and demonstrates that MH based planning limits execution time and cost

In paper[12], the author melds the standard genetic calculation into improvised form by adding the features of classic processing algorithm to obtain an hybrid which can plan various positions on different machines in a proficient mode taking least consummation time. This method can be adjusted in the distributed computing frameworks for better planning of errands to assets, with the goal that the clients' assignments can be finished in as slightest time as could be expected.

In paper[8], the author utilizes indistinct grouping strategy to adequately preprocess the cloud assets and Combines the rundown booking with the errand duplication planning producing new coordinated non-cyclic chart based planning calculation called soonest finish time duplication calculation which is more proficient than the mainstream heterogeneous most punctual completion time calculations.

In paper[4], the author does an intricate examination on planning model from the client's viewpoint considering various clients having diverse QoS Requirements,which are framework throughput, administration unwavering quality, administration cost,Latent limit.The model is advanced by the business instead of scholarly which decides its attention on client applications.So as per the given cutoff time and financial plan, this article conducts research on planning model from the client's point of view.

In paper[9], the author emphasizes on client driven meta scheduler, manages determination of appropriate assets to execute undeniable level positions. The framework driven virtual machine scheduler ideally sorts out the positions of processes for finer asset usage.Likewise author presents his proposition on planning techniques that experiment and estimate feasible solutions which can be consolidated at server-level to choose an ideal host for Virtual machine establishment.

In paper[3],the author proposes another scheduler which settles on a planning choice by assessing entire gathering of assignments in the work line and the new scheduler is enhanced by utilizing genetic calculation. The experimentation pass on that new scheduler can get a more limited completion slot for processing than conventional scheduling algorithms and accomplish a superior adjusted stack across the entirety of its hubs.

In paper[13], the author analysis of improved version of genetic algorithm which is obtained by the merging of Johnson's rule with genetic algorithm(JRGA). The result shows that JRGA is undeniably more predominant than standard listing algorithm. The mixture structure can also be applied to the machines with two-way process execution which include taking up the request from the client and processing it, then forwarding the processed request to the client.

2.1 Summary of the Literature

3 Proposed System

Fig[1] The process of Task scheduling involves laying out the incoming tasks in the form of request from the user to data broker, after receiving the tasks it forwards the tasks further to cloud controller which exclusively provides resource tracking and management the tasks, after the tasks are recorded in the log they are pushed down to data centre where 2 level scheduling takes place ie. host level where certain number of VM's are created and VM level where the tasks are mapped to certain VM's for execution based on availability of resources.The cloud data center broker contains scheduling algorithm utilizing which the approaching tasks are queued ,the queuing order relies upon the type of the algorithm obtainable in the cloud data broker.Task scheduling algorithm determines the order in which the tasked are executed. Giving equipment level administrations to the cloud clients is the obligation of the data center.Data center acts intermediary and obliterates VM as indicated by necessity of process. It additionally conceals the administration of VM from client.Virtual machine measures the assignments according to strategy given by cloud let scheduler.Cloud let is the running undertaking on the virtual machine.Data center in real scenario allude to the cloud service providers.A Virtual machine is a virtual domain that performs as an exclusive virtual computing system. It runs as an isolated portion on its host framework with its own functionalities like processing power, storage facility,working structure,networking facilities and other resources same as the native system.The outcomes of the solicitation are sent back as a response to the client application which had at first sent the solicitation.

isolated portion

Johnson's Rule

Step1 :The processing time all task in each machines is listed.

Table 1. Literature Survey - Summary

Author & year	**Contribution**	**Merits**	**Remarks & future Directions**
Xiong, Yonghua and Huang, Suzhen and Wu, Min and She, Jinhua and Jiang, Keyua [13], 2019	Analysis of improved version of genetic algorithm which is obtained by the merging of Johnson's rule with genetic algorithm(JRGA).The result shows that JRGA is far more superior compared standard listing algorithm	JRGA yields the makespan which is close to theoretical optimality and performs better than LS and ILS algorithms	Cost dependant study is not yet performed on the algorithms. The future work would proceed considering the scheduling with multiple heterogeneous machine and scheduling algorithm with lower complexity
Yujia Ge and G.Wei,[3], 2010	author proposes another scheduler which settles on a planning choice by assessing entire gathering of assignments in the work line and the new scheduler is enhanced by utilizing genetic calculation	The simulation convey that new scheduler can get a more limited completion time for assignment than the other compared models and achieve a better load distribution across the entirety of its hubs.	Usage of characteristics such energy consumption, resources requirement in the process of making tasks allocation decision using context-awareness framework.
Verma, Amandeep and Kumar, Pardeep [12], 2005	A new mixed structure obtained from the combination of divide and conquer technique and algorithm to pick slightest processing time into Genetic processing , which can schedule multiple tasks on multiple machines	The improvised algorithm provides an efficient mode,taking minimum completion time	Upgrading the calculation by supporting run time task queuing and furthermore considering the client's nature of administration and need of different applicational usage for different clients
Andysah Putera , Utama Siahaan [11], 2016	Author collated scheduling algorithms Sjf, Round-robin and fcfs. The objective is to verify which of these model is more appropriate for the various real world based test conditions	Its found that Fcfs calculation is superior to the rest in short length process based task handling whereas round-robin finer suited for multi-process based task handling	Implementation of an improvised version of FCFS,SJF,Round robin to individually broaden its application field.
Tai.C.Edwin Cheng, B.M.T Lin [2], 2009	Author analyzes the Johnson's standard rule for tackling flow shop planning to limit the total completion time for multi machine, by building up a connection between flow shop issue utilizing Johnson's standard and the movement issue of the tasks in multiple machines.	The concept of precedence in the tasks can be applied to decrease the computation time linked to queuing concept.	The future work would involve handling movement issue with transient imperatives,like processing time, delivery dates and expected date.

Jang Sung, Kim Tae , Jae-Kwon and Lee Jong [5], 2012	Author replaces standard scheduling algorithm with genetic algorithm for queuing of tasks in the cloud environment.He does a detailed behavioural study of genetic calculation and its various entities.The behaviour of genetic entities is observed for various test conditions	Genetic algorithm is compared against pre-existing standard scheduling algorithm for metrics like reaction time,effective utilization of various resources,processing time	The future work would include the behavioural testing of genetic algorithm for different loads across the entirety of its hubs.
R. Sharma and N.Sharma [10], 2013	Author explore the idea that for productive working of cloud different assignment boundaries should be taken into consideration to represent suitable planning. The accessible assets ought to be used effectively without influencing the help boundaries of cloud	The proposed priority mixed with greedy approach calculation improves cost and finishes task at earliest when contrasted with Sequential approach. The turn around time of task is limited independently to limit the normal turn around time	The future work may include clustering the expense before asset distribution as indicated by asset ability to diminish the correspondence overhead.
Pal, Souvik and Pattnaik, P.K. [10], 2016	Author executes Johnson Scheduling Algorithm that gives the ideal grouping.The holding up time and line length can be decreased utilizing lining model with multi-mainframe and limited apacity which improves the working of planning model.	Utilizing Johnson Sequencing Algorithm, an ideal grouping can be acquired and furthermore utilizing it combined with lining model, the holding up time and line length can be diminished.	The future work may include comparing the efficiency of Johnson calculation with other standard scheduling models to infer the best result, also the scope extends to combination of latter with Johnson to obtain an hybrid which will be fitter than Johnson and conventional algorithms .

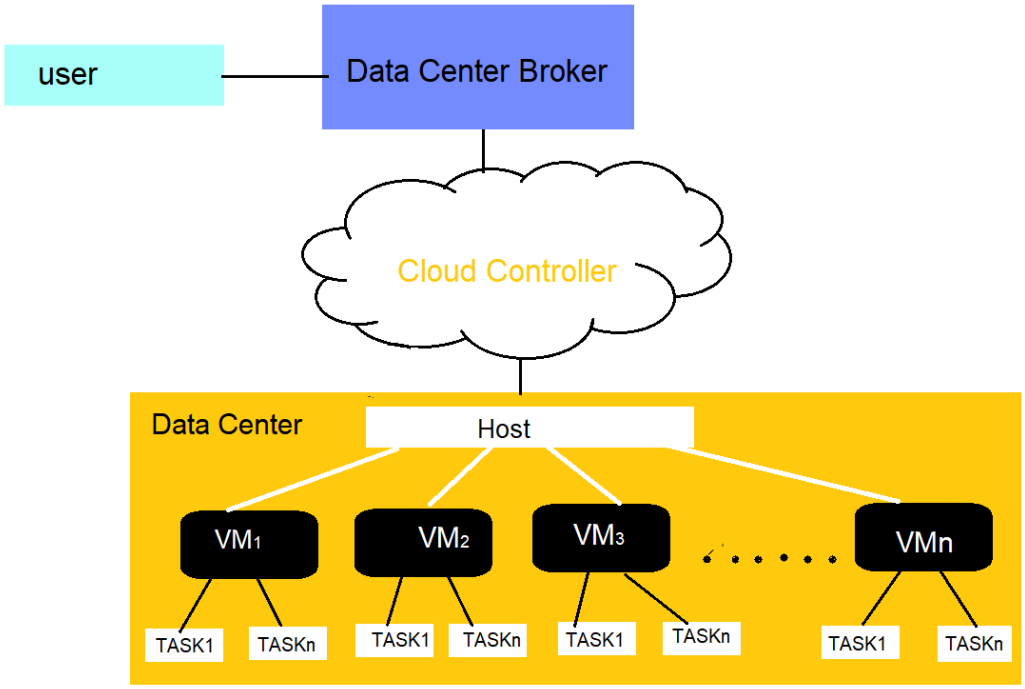

Fig. 1. the above architecture delineates the process of scheduling task in cloud environment and also depicts the components involved in the process.

Step2 Select the task with the briefest processing time.

Step3 a)Given the task with briefest time lies on the 1st machine, the job placed at front-end of the job queue.
b)Else if the briefest timed task lies on the 2nd machine, the job is placed at rear-end of the job queue.

Step4 Once the task is placed in the job queue, take it off the list. Repeat the above steps to remaining jobs and only stop when when all the jobs on the list are placed in job queue.

3.1 Proposed Algorithm

Johnson's rule based genetic algorithm

Step1 : Initialization
The Beginning populace are set of the multitude of individuals that are utilized to discover to find out the optimal sequence. Firstly initialize 3 parameters: size of population, crossing rate, mutation rate.

Step2 : Generation Population
The random generation of population initialize population bounded by a fixed range.

Step3 : Johnson's rule
Johnson's rule is implemented as to decoder which take an random key as input and returns a feasible solution the for optimization. Calculate the completion time of each undertaking in vm and thus calculate the maximum completion time required for each VM.

Step4 : Selection
Select individual from current population to be parents for next generation.

Step5 : Pairing
Pair the selected individual and select certain pair based on pre- initialized cross-over rate. The cross-over results in hybrid population which is considered as offspring. Here we follow two-point cross-over.

Step6 : Mutation
Mutation operation applied to population yield a new middle population which is considered as off spring.

Step7 : Re-decode
The above produced off springs are decoded using Johnson's rule and completion time of each undertaking in VM are noted and thus the maximum completion time required for each VM is calculated.

Step8 : Fitness
The completion time is used to calculate the fitness of individual to form new generation of parents. Higher the fitness, higher is the probability of being selected for parent generation

The maximum completion time that is the overall time-period required to carry out all the task in a machine determines the fitness of individual given by:

$$fitness(x) = \frac{1}{com'(s)} = \frac{1}{max[com_i(s)]}$$

Note: com$_i(s)$ *refers to completion time of the each task in a machine* $com'(s)$ *refers to the maximum completion time taken by the task*

Step9 : Termination
Follow the above step until termination criteria is satisfied. Here the termination criteria is number of iteration. If the criteria is not satisfied repeat the above step.

3.2 Models for comparison

a) FCFS The First-Come-First-Serve is the most straightforward scheduling algorithm orders the task in a queue based on the arrival time assigned to its VM.It depends on the FIFO for ordering the task.The implementation of FCFS is relatively less complex.The drawbacks are high waiting time for the late arrived tasks and the inefficient use of resources.

b) SJF The Shortest Job first scheduling algorithm sorts the task on the basis of its pre assigned priority.The Priority is assigned to the tasks based on the burst time of the task. The priority can be given in 2 ways (i.e. smallest task = highest priority or highest task smallest priority). Drawbacks include long waiting time for the tasks which are set down at the end of the queue.

c) Round Robin The Round-robin scheduling algorithm allocates task to the next VM in the queue based on time slice and rounded queue mode to the VM. The Round Robin does not consider the priority, the length of the tasks. All the tasks are executed bounded by the time slice. Major drawback of Round Robin is the degradation of performance.

To calculate the total completion time for fcfs,sjf,round-robin We create two matrices,one contains the length of each task assigned to the data centers.The

task length is randomly generated number.the other contains the execution time take by each tasks assigned to the datacenter.

$$result[j] += Matrix1[i][j] + Matrix2[i][j]; \quad (1)$$

Using the max function we select the make span from the result list

d) Genetic algorithm(GA) GA mirrors the process where the fittest individual are chosen for proliferation to deliver offspring for next generation.Firstly the population comprising of individual is created then the fitness score of each individual is computed,the one with the highest fitness score is selected as parent and crossed to obtain offspring.There are chances of offspring undergoing mutation at last when each generation of parents stops producing significantly different offspring the algorithm is terminated.

4 Experimental Setup and results

Below section describes the exploratory arrangement for the scheduling models in cloud environment.

4.1 CloudSim 3.0.3 Toolkit

It supports the modeling and simulation of the key functionality of cloud which includes creation of cloud entities which are cloud data center, brokers, cloudlets, initialising these entities according to user requirement. Other functionalities include task queue, processing of events .They also abide by the cloud policies which are the same as used in real time.
The steps involved in execution of algorithm in CloudSim are as follows:
Firstly creation of the datacenter followed by Creation of Broker then Creation VMs and Cloudlets and send them to broker, mapping if datacenterIds to cloudSim datacenterIds. Lastly simulation of the algorithm.

4.2 Setup

The simulation is conducted with regard to the assumptions that in cloud computing environment the numeral of tasks ought to be higher than the numeral of VMs, each and every VM made should execute more than one task and each undertaking is relegated to a single VM resource. Lastly VMs must be independent as far as control and resources.
table[3],[4]We made 5 Virtual Machines utilizing VM segment and set the RAM as 512 MB for every single virtual machines.Then,at that point we made around 30 tasks utilizing Cloudlet,with length of each cloud let being set to 300, all along contemplating 5 Virtual Machines each with MIPS of 250. The above Parameters were kept constant for the simulation of all four scheduling algorithm to obtain the Make-span against a uniform base.

Make-Span alludes to total completion period of all the cloud lets present in the queue. Table[5] gives us the diagnostics of all four algorithm using which we can infer that Johnson's rule based genetic algorithm outperforms the other 3 standard scheduling algorithm producing the least amount of make-span.
The follow-up of the above simulation is done by increasing the number of cloudlets for each trial, as the number of cloudlets/task increasing the make-up of the algorithm increases accordingly but even when this result is collectively analysed Johnson's rule based genetic algorithm is optimal compared to fcfs, sjf and round robin.

Table 2. Cohort Statistics: Details of data

Parameters	**Values**
Number of Data centers	5
Number of VM	5
Number of Cloudlets	30
Population Size	30
Mutation-probability	0.7
Crossover-probability	0.5
CrossOver Type	Two-point Crossover
Number of Iteration	50

Table 3. Cohort Statistics: Details regarding the various value concerned with cloudlet and VM

Parameters	**Values**
VM memory (MB)	512
Millions Instructions Per Second (MIPS)	250
Value of bandwidth	1000
Number of CPU's	1
Cloudlet input-size	300
Cloudlet output-size	300

5 Conclusions and future work

In aforementioned paper,we put forward JRGA algorithm to achieve the task scheduling with the least make span. Three more scheduling algorithms are discussed here, such as the FCFS, SJF, and RR scheduling algorithms. Experimental results proclaim that compared with the other three algorithms, the improved

Table 4. Cohort Statistics: Details regarding Host

Parameters	**Values**
Memory (MB)	2048
Millions Instructions Per Second (MIPS)	1000
Bandwidth	10000
Storage	1000000

Table 5. Cohort Statistics: Details regarding Data center Characteristics

Parameters	**Values**
Architecture	x86
OS	Linux
Storage-cost	0.1
Memory-cost	0.05
Processing-cost	3.0
Bandwidth-cost	0.1

Table 6. Result table: Comparison of different Models

Model	**Makespan(ms)**
FCFS	5875.954
SJF	4885.095
ROUND-ROBIN	4518.010
GA	3986.017
JRGA	2524.029

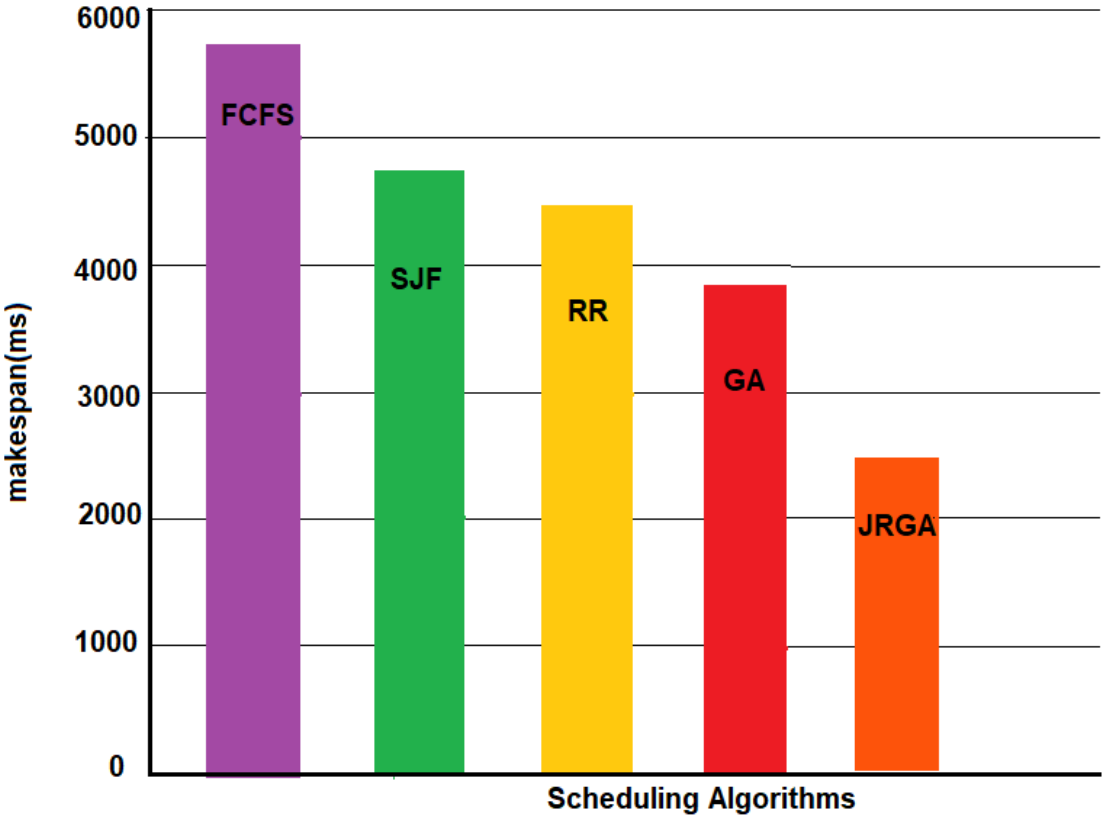

Fig. 2. The makespan comparisons of 5 different models.

genetic algorithm has the smallest make span and higher resource utilization efficiency. JRGA also curtails the overall downtime of the machine. Minimize the flow time from the onset of first job to furthest limit of last job. Here we define make span as criteria in order to check the fitness of the results.
With respect to future work, more work needs to be done to advance this research, and we can utilize the expense of resource as fitness norm. In existing cloud computing systems, we can use this method in order to reduce make span and make better use of resources. Depending on user requirements, further parameters can also be added. Additionally, there is scope of JRGA for heterogenous machines.

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