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A Performance Comparison of Edge Cover Graph Coloring Approach for Resource Allocation in Cloud Computing Environment

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Abstract— In the present era cloud computing is widely used by businesses and individuals. By the survey of requirement of recourse allocation strategy and algorithms, it has been found that to provide maximum services with minimum resources. In this research paper we have compared an ECGCA algorithm that used in cloud environment to make effective schedule of resources for customer.

Index Terms— Cloud computing, Resource allocation, Graph coloring.

I. INTRODUCTION

Cloud computing is a large pool of utility resources. The cloud computing is a platform based on internet providing diverse of services on the basis of pay per use. It is a model which provides computing resources as a service to IT users on the basis of their requirements. Everything provided by the cloud to the users are considered as a service to customer [1][2][3].

II. TYPES OF CLOUD COMPUTING

Cloud computing types are classified in two different ways either based on the cloud infrastructure development model or on the based on service provided by cloud. This section elaborated the all types based on both categories.

1.1 Cloud Infrastructure Development Model

Programs or services that are needed by any IT user are located on a server which is available on remote location. This server is owned by service provider organization. Service seekers are located on different location. This infrastructure is developed in such a way that performance of system should not compromise the quality of services. It should give economic solution to the users. The server computer system which usually stores the program and data is known as cloud. Based on cloud infrastructure development model, cloud computing is mainly divided in to four different types [4] as shown in figure 1.1.

Public Cloud: - In this type of cloud infrastructure, cloud environment is developed and controlled by service provider and located on remote location. Cloud location remains isolated from cloud users. In this type of cloud, users do not have any control on the activities of cloud operations. Users only take the services and pay for services. In public cloud most of the services are open access. Form the security point of view public cloud is considered as less secure cloud than other types. Although lots of security checks and technology protect cloud user's data and applications, but due to open access features its security is always point on concern.

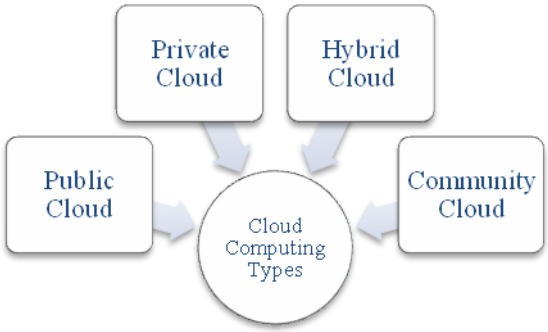

Figure 1.1: Cloud Computing Types (on the basis of Infrastructure)

Private Cloud: - In this type of cloud infrastructure, entire services and hardware are owned by a single company or person. Company or individual person has all control of services and access to the cloud. It is developed for personal use. No other company or person can access the services of private cloud. There are two implementation options for private cloud; one is "on-premises" private cloud. This cloud is developed on the same location where company is located. This option is good for IT companies, but more expensive for non IT companies. Another option is "off-premises" cloud, in which cloud are developed and managed by third party company. But overall control is available to owned company or person.

Hybrid Cloud: - As word hybrid giving meaning, this type of clouds have the features and services of both private and public clouds. Some of the services are provided in public mode and some of in private mode. Customer does not have any controls on public mode services, they are totally owned and maintain by owned company. Hybrid cloud develops private mode services for their own use. Public cloud provide elastic scalability and provide to handle dynamic demand of services. However performance issue is always with public cloud, whereas private cloud provides more security and control over the services. Hybrid clouds are developed based on requirements.

Community Cloud: - Economically it is not possible for small organization to develop their own private cloud. Due to

security issues and non customized services or public cloud some organizations don't want to go for public cloud, for these types of organization go for community cloud. When more than one organization share the cloud infrastructure and use services provided by the cloud is known as community cloud. Community cloud is developed in such a way that hardware and infrastructure is maintain by a centralized data center and services are taken by group of organizations. Mostly these types of clouds infrastructures are developed and used by government of any country, because they have different organization. Similar to the private cloud community cloud can be located in both way either "on-premises" or "off-premises".

1.2 Cloud Service Model [5][6]

Cloud computing technology provided IT services to the user. Cloud service stack contains three main services, one over another as shown in figure 1.2.

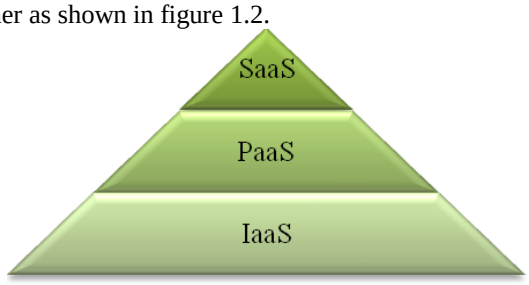

Figure 1.2: Cloud Computing Service Stack

There three services are Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). Through these three layered service model all cloud users can take required services.

IaaS:- This is the bottom most service layer of cloud service stack. This service layer directly provides the services to the cloud users like storage servers, computer network services, computing nodes and virtual computing resources. This service layer is base layer for PaaS layer. Paas run over the IaaS service layer. Service provider creates and manages the virtual machine (VM). These virtual machines represent pool of resources to the users. Virtual machine, operating system (OS) and storage creates independent environment for users.[7]

Through IaaS users can create, manage and destroy storage allocation and virtual machine using web interface. Accountability of resource used is also managed in IaaS for proper billing. Figure 1.4 shows the architecture of IaaS. This architecture consist three layers infrastructure, virtualization and physical layer. Infrastructure layer provide infrastructure management and virtual machine management functionality. Virtualization layer provide space for running virtual machine and hypervisor. Physical layer consist physical resources like storage, server, communication network etc. All other service models works on top of the IaaS, so that security issues is always with IaaS. Many companies share the resources of cloud and user has access to many functionality in IaaS. It create IaaS services less secure than other services (PaaS and SaaS)[8].

PaaS:- These services are built on top of the IaaS. Cloud users can take many development platforms related to services from this. Table 1.1 shows the some of the platform services provided by PaaS to the users.

Table 1.1: PaaS provided by Cloud

S.No.	Service
1	Programming Language
2	Compiler
3	Interpreter
4	Assembler
5	Operating System
6	Computing Utility
7	Application Program Interface (API)
8	Development Environment
9	Application Testing Environment

By these services (as shown in Table 1.1) cloud users can get dynamic development environment to develop their applications on a very low cost. User can also configure development environment as per their requirements and also get already configured applications development environment which also reduce the initial administrative setup time required to install and configure software. Developed applications can be delivered to end users through web directly. No need physical interaction between developer and end user[9]. There are many cloud service provider who provides PaaS services to the users like Google AppEngine, SalesForce, Microsoft Azure etc[10].

There are variety of compilers, tools, OS, and development environment available in cloud computing PaaS layer. One of the main challenges in PaaS cloud services is to fulfill the requirement of customers according to their need[11]. PaaS can be provided services in two different way one is full PaaS and second is partial. In full PaaS the entire development environment is provided by cloud, User does not need to install any development. Customer has to install on a thin client to interact with cloud services. But in partial PaaS some of the services are taken from cloud environment and some are prepared by developer itself at user end.

Table 1.2: Cloud Computing SaaS services

S.No.	Services (SaaS)
1	CRM (Customer Relationship Management)
2	e-Newsletter Services
3	Database Administrative Services
4	Word Processing Applications
5	Fax Services
6	Web Hosting Services
7	Payroll Applications
8	e-Commerce Applicators
9	Email Services
10	Document Converter
11	Blog Services
12	Website development services

SaaS:- This service layer comes on the top of PaaS service layer. Users can directly access the software and applications on the basis of pay per use basis. Cloud users does not required any specific configuration or platform to access SaaS services. Only a thin client like web browser is required. It is most secure and preferred services in cloud computing. It reduces the hardware and software requirement of user system. Through this operating cast of any individual or organization may reduce up to certain level. Google Apps[12], Google Docs, Gmail [18] are the popular SaaS level services provided by Google. Table 1.2 shows SaaS services provided by cloud computing.

III. Resource Allocation Strategy

The Cloud computing resource allocation is an important cloud management and service optimization part of cloud ecosystem. It is a method to allocate available resources to the cloud customers who requested the services. This allocation should be in such a manner that maximum customers can get resources and resource utilization should be maximized. Resource provisioning is the technique by which any cloud service provider can allocate and manage cloud resources to the user of cloud.

There must be a proper cloud resource allocation strategy so that cloud service provider can serve maximum cloud users with available resources in cloud infrastructure. Through resource allocation strategy cloud service provider can increase the availability of resources, decrease the idle time of infrastructure and increase the profits. Cloud service provider should follow contain guidelines to implementation of resource allocation strategy in cloud computing infrastructure.

1. When more than one request came for same resource at the same time. It must be handled carefully.
2. If cloud have limited resources and provider wants to serve maximum clients than security is also a major issue. Because multiple users share common resources using virtualization. If virtualization is not implemented with proper security mechanism than users data can be compromised.
3. Some time resources are not properly integrated to each others. This can also create problems in required resource allocation.
4. Improper resource isolation can also case the difficulties in available resource allocation.
5. Surplus availability of resources can also case the issue in resource allocation. Some resource may get idle for long time.
6. Service provider and cloud users may also face the problem of deadlock condition. When resources are allocated less than demanded in that condition application hold the available resources and wait for more resources. Some time it leads to the deadlock situation[13].

Designing a resource allocation strategy of cloud computing infrastructure is a challenging task. There are many parameters involve in designing the resource allocation strategy. Table 2.1 shows certain parameters used in resource allocation.

Table 2.1: Resource Allocation Strategy Parameters

S.No.	Parameter
1	Resource allocation algorithm execution time
2	Development model of virtual machine
3	Polices of cloud computing
4	Gossip protocol for large scale cloud infrastructure [23]
5	Cost function
6	QoS (Quality of Service) objectives [24]
7	Performance function
8	Hardware utilization [25]
9	Virtualization management [26]
10	Application type
11	Service level argument (SLA)

IV. Graph Coloring

Cloud resource allocation problem is an optimization problem. Many optimization technique and algorithms are used by researchers and developers to solve this problem as discussed in previous section. Similarly graph coloring problem (GCP) is an optimization problem solving approach. Graph coloring is a well known NP-Hard problem used to solve many real world optimization problems. CPU register allocation[14], Flight scheduling management[15], Radio station frequency assignment problem[16], and time table scheduling[17] are some real world optimization problems, which can be solved using graph coloring approach. This research work is also focused on solving cloud resource allocation problem using graph coloring approach.

There are many algorithms and techniques were proposed and implemented by researchers for resource allocation in cloud ecosystem like Ant Colony Optimization[18], Bee's Algorithm[19], Priority Algorithm[20], Bin-Packing Algorithm[21], Evolutionary Algorithm[22], Dynamic Resource Allocation Scheme[23], Markov Decision Process (MDP) Based Algorithm[24]. Resource allocation is basically an optimization problem, because any cloud service provider wants to provide maximum serviced with minimum resources. Graph coloring is a well know approach to solve the optimization problem. There are many graph coloring algorithms developed by researchers. These algorithms are used by many real world applications to solve the optimization problem like exam time table scheduling[25], air traffic management[26], assigning frequency to radio stations[27], CPU register allocation[28], sparse matrix computations[29], Micro code optimization [30] etc.

This research work compared the some well know graph coloring algorithms to identified the best suitable algorithm in terms of time complexity and chromatic number.

4.1.Edge Cover based Graph Coloring Algorithm (ECGCA) [31]

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ECGCA is fast and efficient graph coloring algorithm. ECGCA algorithm is based on Edge cover technique to find independent set in graph. After finding independent sets, each independent set is colored with the same color. So that each connected vertex get different color in graph. ECGCA required data in the form of edge list format. So that before applying ECGCA all requests data need be covert into edge list. Figure 3 shows the format of edge list. This edge list is store in a text file and this text file is input for the ECGCA. After process this data algorithm generates output contains information about resource instance allotment to requests.

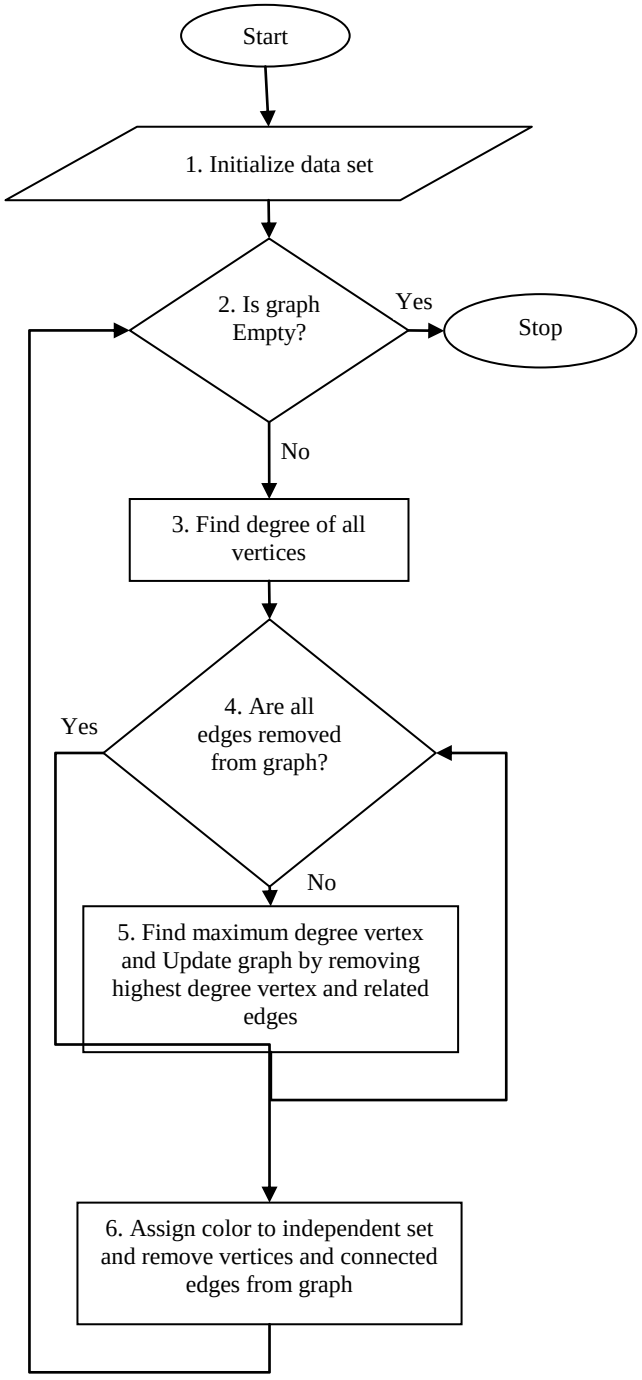

Figure 3.1: Flow Chart of Base Algorithm (ECGCA)

V. Comparison of ECGCA with Other Algorithms

There are many other algorithms for solving the optimization problem using graph coloring approach. So to find the better one we have compared the results of two well know graph coloring algorithm with selected algorithm. ECGCA is compared with Hybrid Parallel Genetic Algorithm (HPGAGCP) [16] and Ant-Based Graph Coloring Algorithm (ABAC) [18].

5.1 ECGCAAlgoritm Vs HPGAGCP

Table 4.1 shows the comparision of execution time of ECGCA and HPGAGCP [32]. Total 15 graph instances are compared. Avearge time taken by ECGCA in this experiment is 0.396 second and for the same instances average time taken by HPGAGCP is 8.755 seconds. Figure 4.1 shows the graphical comparision of execution time of ECGCA (base algorihtm) and HPGAGCP.

Table 4.1: Excution Time (in Seconds) Comparision of Base Algorithm (ECGCA) and HPGAGCP

S. No.	Instance	ECGCA Time (s)	HPGAGCP Time (s)
1	Anna	0.281	0.058
2	David	0.235	0.019
3	fpsol2.i.1	1.954	22.656
4	games120	0.344	0.027
5	Huck	0.218	0.015
6	Jean	0.196	0.015
7	miles1000	1.406	48.559
8	miles250	0.297	0.076
9	myciel3	0.031	0.003
10	myciel4	0.047	0.006
11	myciel5	0.094	0.014
12	queen5_5	0.094	0.031
13	queen6_6	0.171	6.1
14	queen7_7	0.25	6.27
15	queen8_8	0.329	47.482

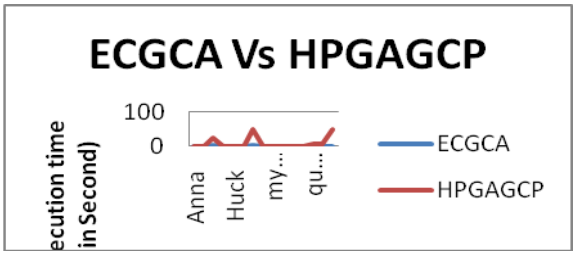

Figure 4.1: Execution Time Comparison of ECGCA Vs HPGAGCP

A. 4.2ECGCAAlgoritm Vs ABCA

Table 4.2 shows the comparision of execution time of ECGCA and ABCA [4]. Total 38 graph instances are compared. Avearge time taken by ECGCA in this experiment is 2.568 seconds and for the same instances average time taken by ABCA is 14.850 seconds. Figure 4.2 shows the graphical comparision of execution time of ECGCA and ABCA.

Table 4.2: Excution Time (in Seconds) Comparision of Base Algorithm (ECGCA) and ABCA

S.No.	Instance	Base Algorithm (ECGCA) Time (s)	ABCA Time (s)
1	1-FullIns_4	0.198	0.31
2	2-Insertions_4	0.233	0.74
3	2-Insertions_5	0.863	17.82
4	3-FullIns_4	0.683	11.22
5	4-FullIns_3	0.215	0.73
6	4-FullIns_5	38.601	170.05
7	4-Insertions_4	0.539	12.9
8	ash331GPIA	1.096	17.45
9	David	0.27	0.38
10	DSJC125.1	0.327	0.92
11	DSJC250.5	4.115	13.11
12	DSJC250.9	16.022	23.57
13	games120	0.396	0.72
14	Jean	0.225	0.35
15	le450_15c	4.244	41.7
16	le450_25c	4.672	39.55
17	le450_25d	5.288	40.71
18	le450_5a	1.277	16.15
19	le450_5b	1.366	16.4
20	le450_5c	1.314	20.44
21	le450_5d	1.456	20.71
22	miles250	0.342	0.57
23	mug100_1	0.144	0.25
24	mug100_25	0.144	0.35
25	mulsol.i.1	1.204	7.3
26	mulsol.i.2	0.773	5.69
27	mulsol.i.3	0.827	5.86
28	mulsol.i.4	0.822	5.81
29	mulsol.i.5	0.773	5.85
30	myciel6	0.252	0.56
31	queen10_10	0.575	0.99
32	queen7_7	0.288	0.06
33	queen8_8	0.378	0.14
34	school1_nsh	3.363	16.87
35	will199GPIA	1.618	22.44
36	zeroin.i.1	1.196	8.81
37	zeroin.i.2	0.737	8.58
38	zeroin.i.3	0.756	8.23

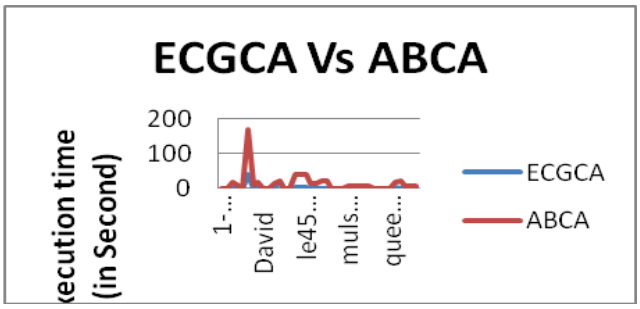

Figure 4.2. Execution Time Comparison of ECGCA Vs ABCA

By the comparison of this parameter it has been found that Edge Cover based Graph Coloring Algorithm (ECGCA) is well suited for the implementation of cloud resource allocation. Experimental results of different algorithms are compared to identify most suitable approach for designing cloud resource allocation algorithm. HPGAGCP, and ABCA results are compared with base algorihtm ECGCA. By these comparison it has been found that ECGCA takes less time to generate results.

VI. CONCLUSION

ECGCA coloring approach is efficient optimization algorithm and it has vast area of application. But other than graph coloring approach there are many other optimization approaches are there so one can do research for identification of new optimization approach and use to implement cloud resource allocation.

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