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Topological Evaluation of Cloud Computing Networks and Real-Time Scenario-Based Effective Usage

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Abstract

Cloud technology provides computing services over the internet, enabling entrepreneurs to access tools and services previously only available to large organizations, enhancing efficiency, business scaling, and competitiveness. With a step-by-step practical performance, the study builds real-time clouds using several lab scenarios. The research offers recommendations for cloud computing networks' performance, security, and awareness in this way. The study investigates and improves cloud computing networks in IoT and other network architectures using cheminformatics, a combination of chemistry, computer, and mathematics. It computes topological invariants, such as K-banhatti sombor (KBSO) invariants (KBSO), Dharwad Invariants, K-banhatti Redefined Zagreb (KBRZ), their different forms, and Quadratic-contra harmonic invariants (QCI), to explore and enhance their characteristics like scalability, efficiency, higher throughput, reduced latency, and best-fit topology. The main objective is to develop formulas to check the topology, and performance of certain cloud networks without experiments and produce mathematical modeling results with graphical results. It also gives the optimized ranges of the network with one optimized value. After these evaluations, the network graph also checks for irregularities if exist with the help of the Irregularity Sombor (ISO) index. The study also produced real-time scenario-based clouds and performance-based use. The results will help researchers construct and improve these networks with different physical characteristics.

Keywords: Cloud Network, real-time clouds, topological evaluation, performance, scalability

1. Introduction

Cloud computing is a pretty amazing concept. Imagine having a bunch of powerful computers somewhere far away, and you can use them right from your laptop or phone. That's cloud computing in a nutshell. The best part? You don't have to worry about maintaining these computers. The companies that own them, like Amazon, Google, or Microsoft, handle all the updates and repairs. You just use the services and storage as you need it. Plus, you can access your stuff from anywhere in the world, as long as you have an internet connection. It's kind of like Netflix for computing. Instead of buying a bunch of DVDs (or in this case, expensive computers and software), you just stream what you need, when you need it. In short, cloud computing is a big game-changer. It's making technology easier and more accessible for everyone, whether you're running a business or just storing your holiday photos. Cloud computing is like a superhero in the world of technology (Ray, 2018). Let's break it down under

1.1 Importance

Accessibility	Cost-Effective	Flexibility & Scalability	Collaboration Made Easy
Disaster Recovery	Update & Maintenance (Not You Problem)	Security	

Cloud computing provides any kind of help in the modern world:

Cloud computing is like a Swiss Army knife for the modern world – it's packed with tools and features that help in so many ways. Let's check out some of the cool things it does:

Business Growth and Innovation	Smart Cities and IoT
Remote Work and Learning	E-commerce
Healthcare Advances	Environmental Benefits
Entertainment and Media	Artificial Intelligence and Machine Learning

1.2 On-premises Network

It is divided into three layers

1. Access
2. Distribution/ Aggregation
3. Core

Access/Distribution/Core are the part of Infrastructure

The end user is interested in Services – for which we have to run applications.

We need for it Hardware/Operating System/ Application

1.3 Major Reason to Migrate to Cloud

In Future Jobs * Cloud Administration/ Cloud Security

Data centers: A place filled with heavy-duty machines – Rays floor – Cooling Devices and Cabling in an organized manner.

1.4 Problems with Traditional IT Approach

1. Cover the data center's rent
2. Pay for cooling, power supply, and upkeep of Wapda, generators, and UPS backup systems.
3. It takes time to add and replace hardware.
4. Scaling is constrained
5. Hire a crew to watch the infrastructure around the clock.

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6. How should calamities be handled? (Fire, power outage, earthquake...)

7. Can we make all of this external?

1.5 Advantages of Cloud Computing

Cloud computing provides access to shared computing resources. E.g.--¬¬¬ Servers, storage, networks, applications, services, etc.

1. Compute
2. Storage
3. Network
4. App
5. Services

1.6 Features of the Cloud

1. On-demand self-service
2. Network Access
3. Resource Pooling
4. Elasticity – If I Need to scale up the resources, I can and If want to narrow down, I can scale down.
5. Metered or measured service. The service is metered and measured for the cost of usage.

1.7 Types of Cloud Computing/Provider

IAAS	PAAS	SAAS	FAAS	DBAAS	XAAS

Agility [On the click of mouse] + Cost Effective

IaaS→ Infrastructure as a Service

PaaS→Platform as a Service

SaaS→ software as a service

XaaS→Everything as a Service

FaaS→ Function as a Service

DBaaS→Data Base as a Service

1.8 IAAS Offers

Infrastructure as a Service (IaaS) is like renting heavy-duty machinery for your digital construction project. In short, IaaS offers:

Virtual Computing Resource	Scalable Storage	Networking Capability
Flexibility & Control	No Physical Maintenance	

Figure 1: IAAS Figure 2: PAAS Figure 3 : SAAS

Figure 1: IAAS

1.9 Pass Offers

Application and Data are the headaches of Users, everything else of the cloud. Elastic Bean stock, etc. Figure 2: PAAS

1.10 SAAS Offer

Everything is a Cloud Provider's Headache. Gmail, Facebook, etc. Figure 3: SAAS

1.11 Type of Cloud

Public Cloud	Private Cloud	Hybrid Cloud

1.12 Cloud Provider Companies

There are several key players in the cloud computing arena, each offering a range of services to cater to different needs. Let's take a look at some of the major companies:

Aws Cloud	Azure Cloud	GCP Cloud
IBM Cloud	Oracle Cloud	Ail-baba Cloud

Cloud has the Agility [On the click of mouse] + Cost Effective

These companies are heavyweights in cloud computing, each bringing unique strengths to the table. They're at the forefront of innovation in cloud technology, offering solutions that cater to businesses of all sizes across various industries.

1.13 What is Aws?

The most extensive and widely used cloud platform in the world, Amazon Web Services (AWS) provides over 200 fully functional services from data centers all over the world. Millions of users are utilizing AWS to cut costs, become more flexible, and innovate more quickly. These users include the biggest corporations, fastest-growing startups, and top government agencies.

1.14 AWS Marketplace & Others

33% → AWS

22% → Azure

10% → GCP

1.15 History of AWS

It was started in 2002 and launched internally.

2003→ Amazon Infrastructure is one of their core strengths. Idea to market

2004 → Launched publicly with SQS

2006 ➔ Re-launched publicly with SQS, S3, EC2
2007 ➔ Launched in Europe
2013 ➔ Certifications were launched.

1.16 AWS Global Infrastructure

- **Regions**
- **Availability Zones**
- **Data Center** ➔ Storage, Compute, Network
- **Region**: 32 launched regions
- **Availability Zones** ➔ 102
- **Minimum AZ** → 3
- **Maximum AZ** → 6
- **Availability Zone** ➔ Data Center [Maybe one, two, three … But all will be nearby]
- Local Zones: It is an extension of Availability Zones.
- North Virginia → launched in 2006. It has a total of 6 AZs,

1.17 Factors Impacting Regional Selection

- Governance
- Service Availability in the target region
- Cost-effectiveness – AWS Pricing Calculator
- Latency

1.18 Service offered by AWS

In April 2023, AWS (Amazon Web Services) offered over 200 services. It's like a giant buffet of digital tools!

1.19 Top 10 Services Offered by AWS

Figure 4: Services Offered by AWS

1.20 Marketplace


Figure 5: Marketplace by AWS


Figure 6: Marketplace by AWS B


Figure 7: AWS Live Market Place of EC2

These Are Some Examples of AWS Live Market Place of EC2

1.21 What is Azure?

Microsoft Azure is another big player in the cloud services arena, similar to AWS. As of my last update, Azure offered over 200 services too. It's like a treasure trove for tech enthusiasts.

1.22 History of Azure

Birth of Azure (2008-2010): Azure was announced in October 2008 as "Windows Azure." It was Microsoft's big leap into the cloud, a response to the growing demand for cloud computing services. In February 2010, Azure became generally available to

the public. Initially, it focused on providing a platform for building, testing, and deploying applications and services through Microsoft-managed data centers.
Expansion and Rebranding (2010-2014): After its launch, Azure began expanding rapidly. It added support for various programming languages, frameworks, and tools. In 2014, Microsoft rebranded it to "Microsoft Azure" to reflect its growing capabilities beyond just Windows services.
Rapid Growth and New Features (2014-Present): Post-rebranding, Azure took off. Microsoft kept adding a slew of new features and services, including advanced analytics.

1.23 Top Services Offers by Azure

- Azure DevOps
- Azure Virtual Machine
- Blob Storage
- Azure AD
- Cosmos DB
- Logic Apps
- Data Factory
- Azure CDN
- Azure Back Up
- API Management

1.24 Azure Live Marketplace

Figure 8: Azure Live Marketplace-A

Figure 9: Azure Live Marketplace-B

Cloud uses a "pay-as-you-go" model to reduce capital costs but may also cause high working costs for users. The industry's rapid growth has made it challenging for providers to manage large amounts of data and resources, requiring consistent resource distribution without compromising service benefits or client satisfaction. Framework as a Service (IaaS) is a rapidly evolving cloud computing paradigm that focuses on scalability, management, and cost viability. However, modern organizations face many challenges such as energy efficiency, and load balancing. Addressing these issues and reducing costs is crucial for cloud computing (Montazerolghaem et al., 2020) (Qian et al., 2009) (Khan et al., 2021) (Sasubilli & R, 2021) (W. Ahmad et al., 2022). The study addresses the cloud computing issues mentioned above (Lin et al., 2020). It solves existing networks using newly prepared topological invariants, providing the best-fit topology and basis for modeling new scalable networks. The study proposes using algebraic topology and in-variants to understand network dynamics. Topological indexes, derived from graphs, reflect the structural properties of a network and are numerical numbers associated with the structure. These invariants are used to correlate computer structures with specific physical qualities. The study uses KBSO, CQI, and Dharwad invariants for the solution of cloud computing networks (Hamid, Waseem Iqbal, Arif, et al., 2022).
Gutman's 2021 study defines sombor indices, a vertex degree-based invariant graph used to capture network boundaries and attributes. There are two variations: the KBSO index and its reduced adaptation form. These topological indexes provide a logical language for network characteristics. In 2021, V. R. Kulli introduced Dharwad indices, topological degree-based indices, following Gutman's sombor indices, to study sweet-smelling compounds. Meanwhile, cheminformatics, a new science combining computer sciences, mathematics, and chemistry, consolidates Quantitative Structure-Movement Relation (QSAR) and Quantitative Structure-Property Relation (QSPR) to assess the physicochemical qualities of manufactured blends. QSPR is a numerical display device that connects network structure properties with points of geography through graphs due to invariance and automorphism properties. It has numerous applications in computer sciences and chemistry (Kulli, 2022) (Hamid, Muhammad, Basit, Hamza, Bhatti, & Aqeel, 2022).

2. Literature Review

Cloud computing offers numerous benefits but also presents significant security risks. Proper preparation and understanding of potential risks, weaknesses, and potential solutions are crucial for successful cloud computing. This study examines the key organizational and information security risks associated with cloud frameworks, highlighting the potential impact of virtualization on security when poorly constructed and delivered. The study explores the integration of big data and cloud computing in photoelectric hybrid network design, highlighting its potential for enhanced communication and control over nearby connections (Hamid et al., 2023).

Cloud server farms have sparked interest in cloud application administrations, but increased energy consumption and supportability issues have arisen. To address these challenges, an AI-based all-encompassing asset board strategy called HUNTER is proposed, which addresses the need for adaptability and flexibility in cloud computing, particularly in non-fixed asset requirements. The proposed model, HUNTER, uses a Gated Graph Convolution Network to improve energy efficiency in server farms. It outperforms baselines in energy utilization, SLA infringement, planning time, cost, and temperature, outperforming other models by up to 3 percent. The study introduces RAFL, a metaheuristic-based asset designation system for cloud computing, aiming to reduce heap imbalance among dynamic machines and their asset limit-thinking. Results show that PPSO-DA outperforms other methods in determining optimal asset allocation, with measurable and benchmark testing supporting its superiority (Thakur & Goraya, 2022).

The RATS-HM technique, a combination of task scheduling streamlining and deep neural network, aims to optimize asset allocation and security in cloud computing and a lightweight encryption system (SUPREME). The proposed strategy is compared to current methods, showing improved performance in resource usage, energy usage, and reaction time. (Belgacem, 2022).

Cloud computing involves competing clients and suppliers, with evolving requirements. The CDARA model, a dynamic closeout-based asset allocation model, has been criticized for potential SLA violations and customer dissatisfaction. To address these issues, a flexible market-situated combinatorial two-fold sale asset allocation (AMO-CDARA) model is proposed. This model assigns services based on factors like price, QoS, and supplier positioning, distributing services to the most proficient clients based on their expected demand. The barker reviews pre-owned administrations and calculates supplier positioning for future sales. The model ensures SLA infringement up to 100%, with additional installments from 1-10% of the total value. It also addresses bidder drop by 10% by increasing administration costs. Cloud computing has gained popularity for transferring IT services and assets over the internet. Load balancing is crucial in this context, but assessing it in a real cloud environment can be challenging. To address this, various tools like CloudSim, WorkflowSim, CloudSim4DWf, GreenCloud, and CloudAnalyst are used to test load-balancing strategies under different conditions. This study compares these tools and categorizes them into three categories (M. Ahmad & Khan, 2018) (Kumar & Kumar, 2019).

Cloud computing offers pay-per-use access to information technology businesses, leading to increased operations and server farms. This study examines existing burden adjustment methods for engineers and scientists to improve task execution and resource utilization in equal and distributed cloud situations.

Mobile cloud computing offers advantages like battery life and versatility but still faces challenges like energy efficiency, heterogeneity, transmission capacity, information flow, synchronization, security, protection, and trust. This study compares 30 recently proposed research models and discusses future exploration challenges that require further consideration.

3. Real Time Scenario-Based Results

The study takes different types of lab scenarios and creates real-time clouds with step-by-step practical performance. In this way, the study provides guidelines regarding awareness, security, and performance of cloud computing networks. This study uses KBSO indices, QCI, and Dharwad index to solve the topology of a cloud computing network graph. The results are compared with existing data to develop a best-fit network model, which is verified and validated using the Maple simulation tool (Hamid, Bhatti, Hussain, et al., 2022) (Hamid & Iqbal, 2022) (Hamid, Ibrar, et al., 2024) (Hamid, Muhammad, Iqbal, et al., 2022) (Hamid, Aslam, et al., 2024) (Hamid, Muhammad, Basit, Hamza, Bhatti, Bukhari, et al., 2022) (Hamid et al., 2023).

3.1 Different Types of Lab Scenarios

A simple scenario of a lab

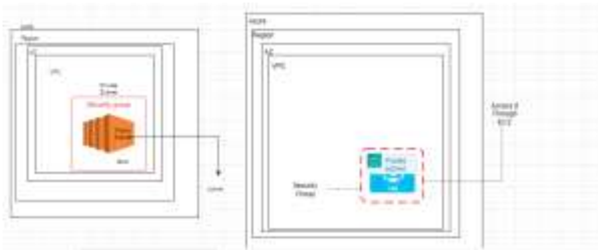


Figure 1: Load Balancing

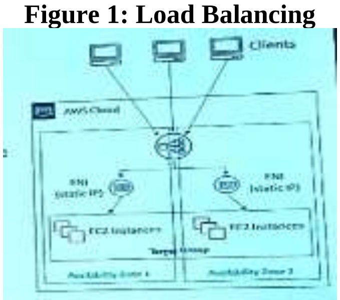


Figure 2: AWS Cloud

3.2 Amazon EFS

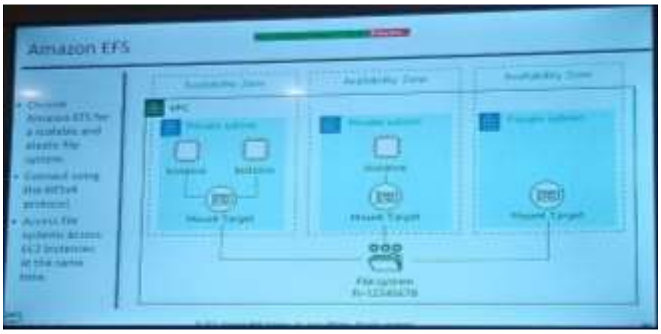


Figure 3: Amazon EFS

3.3 Gateway Transit

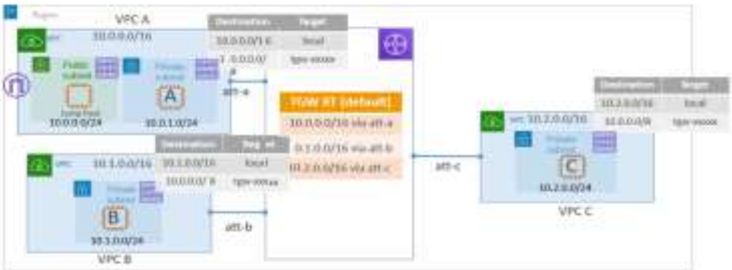


Figure 4: Gateway Transit

3.4 vpc Peering

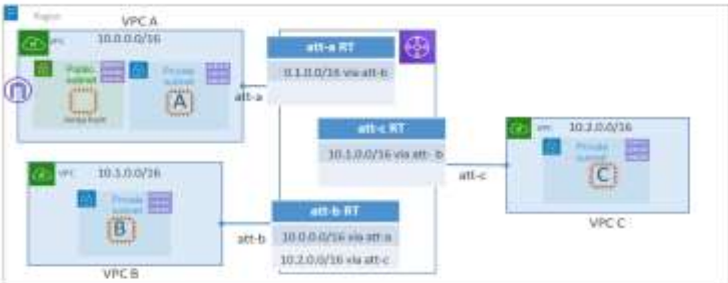


Figure 5: VPC Peering

3.5 Security Group

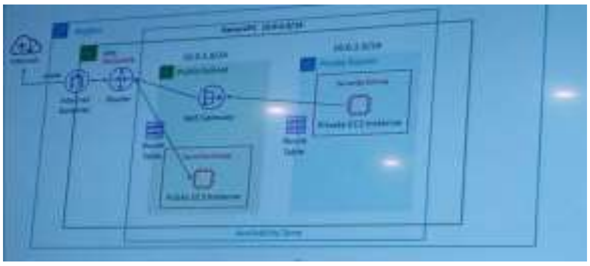


Figure 6: VPC Security

3.6 Private links using interface End Points

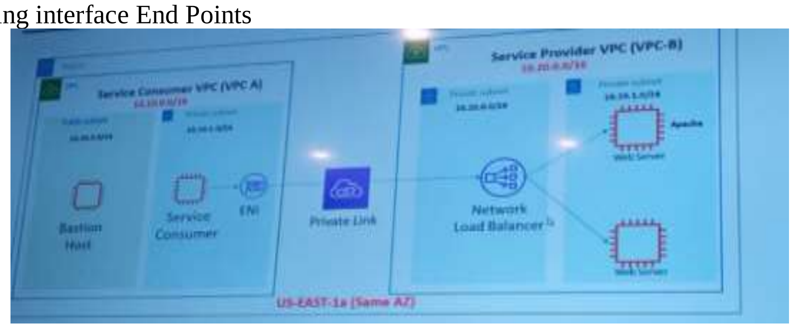


Figure 7: Private Links

3.7 Amazon rds

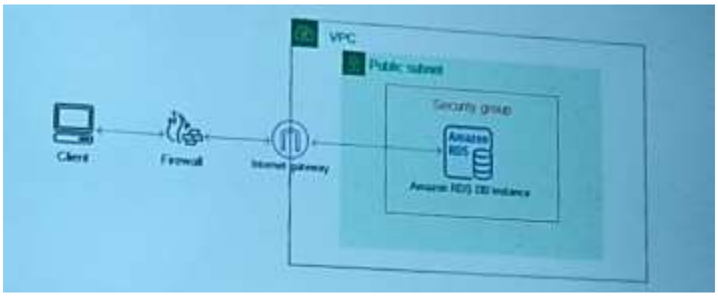


Figure 8: Amazon RDS

3.8 Some Real World Scenario

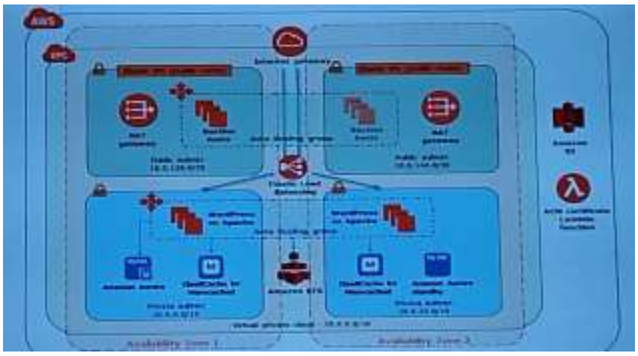


Figure 9: Real World Scenario-A

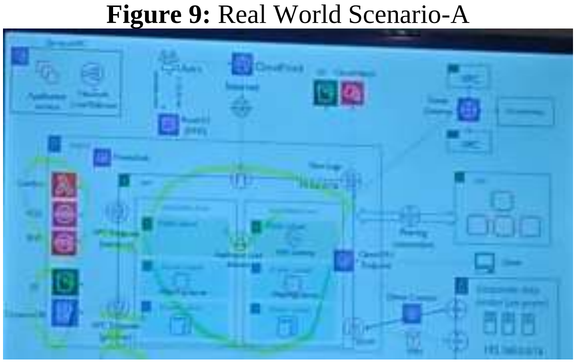


Figure 10: Real World Scenario-B

3.9 Practical Task Real-life Example

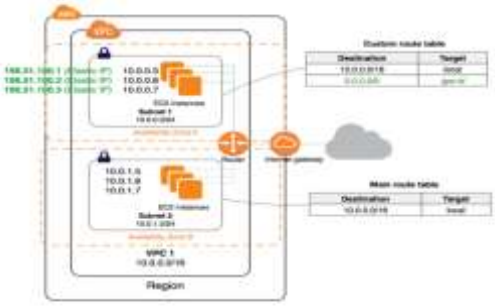


Figure 11: Real Life Example

3.10 Performed Task

Login to AWS management sign in as an IAM user and come to the dashboard of AWS.

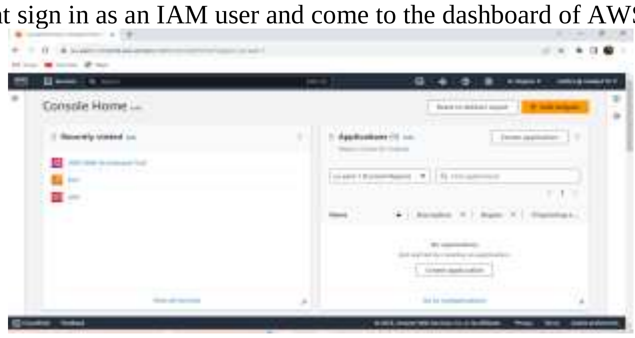


Figure 21: AWS Management

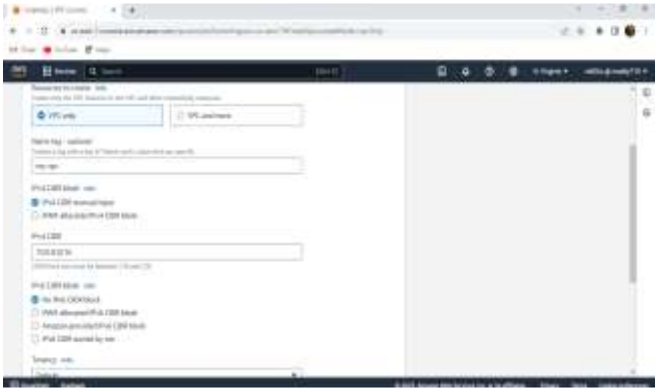
3.11 Steps

1-Create a vpc in the AWS console in any region or any availability zone.

2-Enter vpc name e.g my-vpc

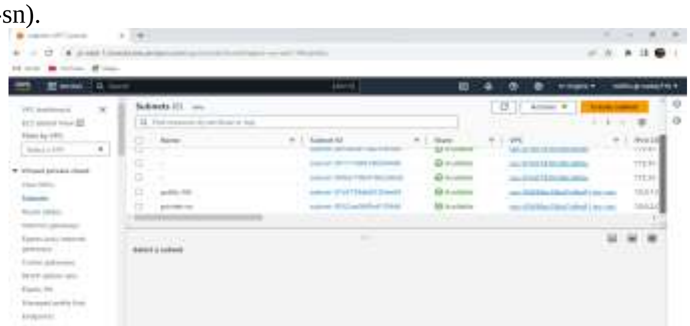
2-give ip to vpc (10.0.0.0/16)

3- Don’t change the Tenancy set it as default.

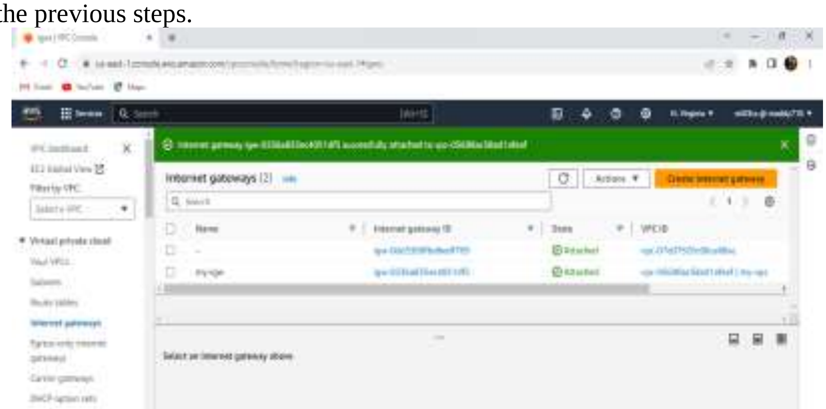


4- Create subnet * Move to the subnet dashboard and create a subnet name public-sn subnet*choice the vpc that was created in the previous step* select an availability zone *enter a subnet*(10.0.1.0/24)*create the subnet

5- Follow the same steps as above for creating a subnet, but choose a different CIDR block (e.g., 10.0.2.0/24) and a different name (e.g., Private-sn).

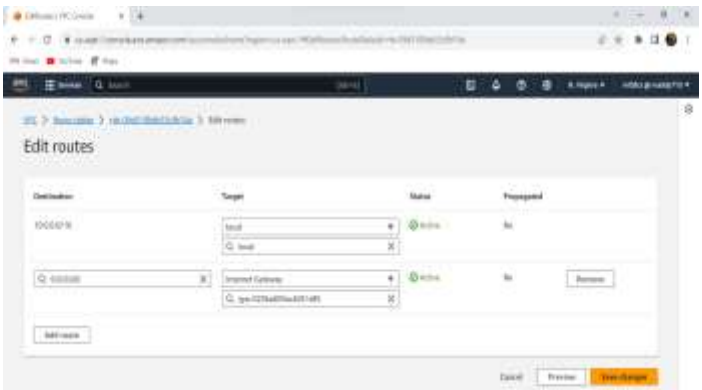


6- Now go to Internet Gateway and create an Internet gateway* name (my-igw)* create a gateway* and attach it to vpc that was created in the previous steps.

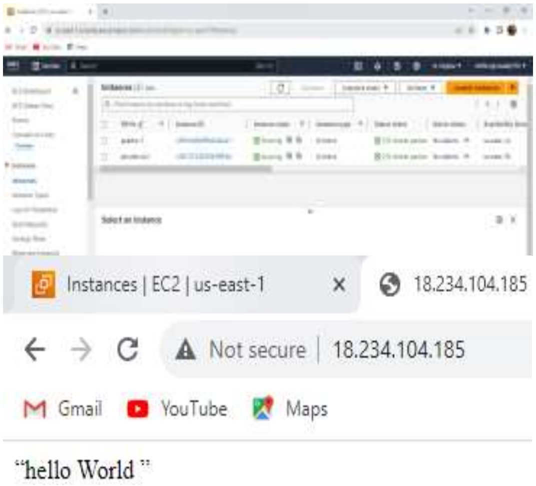


7- Go to the route table tab and create a route table name public-rt*select vpc * create route table * select created route table and associate it with public subnet*Then * create a new route table name private-rt*select vpc * create route table * select created route table and associate it with private subnet.

8- Edit the main route table and add a route: - Destination: 0.0.0.0/0 - Target: Choose the internet gateway created in the previous step.



9- Create an ec2 instance→go to the ec2 dashboard → launch Instance→Select t2 micro instance type→ select your created vpc →select public subnet-→add a security group and allow SSH anywhere to access it through mobaxterm. Create another ec2 instance named private-ec2→ instance t2 micro → to choose your created vpc and private subnet→select the security group that was selected by public subnet ec2 to access it or for a baston host.



10.- check the public ip machine online with apache server

11. Go to mobaxterm → session → start new session→ give public machine ip →username (ec2-user) → advance setting → upload key that was created at the time of creation → ok

Machine accessed → upload private-ec2 key and change its permissions using the command (chmod 0400)→ now type the command to access the private-ec2 key (ssh -i key-06-12 ec2-user@10.0.2.216) → press enter → type yes → your private machine accessed through the public machine in a with different availability zone.

4. Evaluating Results and Discussion

The study has used the following topological invariants for mapping and evaluation of the cloud network

$$KBSO(G) = \sum_{ue} \sqrt{d_u^2 + d_e^2} \quad (1)$$

$$KBSO_{red}(G) = \sum_{ue} \sqrt{(d_u - 1)^2 + (d_e - 1)^2} \quad (2)$$

$$CQI(G) = \sum_{uv \in E(G)} \frac{\sqrt{2(d_G(u)^2 + d_G(v)^2)}}{d_G(u) + d_G(v)} \quad (3)$$

$$QCI(G) = \sum_{uv \in E(G)} \frac{(d_G(u) + d_G(v))}{\sqrt{2(d_G(u)^2 + d_G(v)^2)}} \quad (4)$$

$$D(G) = \sum_{ue} \sqrt{du^3 + dv^3} \quad (5)$$

$$RD(G) = \sum_{ue} \sqrt{(du - 1)^3 + (dv - 1)^3} \quad (6)$$

The KBSO, Dharwad, and Contraharmonic-Quadratic indices and their reduced version are displayed in Equations (1), (2), (3), (4), (5), and (6). These forms will be utilized in the cloud computing network solution. The vertices of the graph C r, s under consideration are represented by the equations du and de, which illustrate edge partitions when 'u' and 'e' are involved.

Table 1: Edge partition of Cloud Network

E	ε (du , dv)	De	ε(du , de)	Recurrence
ε_1	ε(s-1, s-1)	2s-4	ε(s-1, 2s-4)	(r(s-1)(s-2))/2
ε_2	ε(s-1, r+s-2)	r+2s-5	ε(s-1, r+2s-5)	r(s-1)
ε_3	ε(r+s-2, r+s-2)	2r+2s-6	ε(r+s-2, 2r+2s-6)	R(s-1)/2

de = du + dv – 2

Tab. 1 illustrates edge partitions in a cloud computing network graph, with 'ε' representing edge, du and dv representing edge partitions, and 'u' and 'v' representing vertices (Hamid et al., 2023).

4.1 Main Results of Cloud Computing Graph

Graph C r, s is obtained from Kr and r duplicates of Ks, revealing KBSO, CQI, and Dharwad invariants. It is analyzed for decreased and topological structures.

Fig. 22. The diagram illustrates a cloud computing network with various clouds, with a larger centralized cloud represented by Kr and smaller clouds attached to a larger one by Ks. These clouds are converted into graphs and then evaluated through topological invariants by edge partitions.

4.1.1 Cloud Computing Graph

Let $C_{r,s}$ = G be a graph of the cloud computing network with edge partitions mentioned in Tab. 1.

4.1.2 Theorem 1

KBSO and $KBSO_{red}$ indices mapped and solved the cloud network as

$$KBSO\ (G) = \frac{1}{2}\sqrt{2}\sqrt{(s-1)^2+(2s-4)^2}\, r(s-1)(s-2) + \sqrt{(s-1)^2+(r+2s-5)^2}$$

$$r(s-1)+\frac{1}{2}\sqrt{(r+s-2)^2+(2r+2s-6)^2}\; r(s-1) \quad (7)$$

$$KBSO_{red}(G) = \frac{1}{2}\sqrt{(s-2)^2+(2s-5)^2}\; r(s-1)(s-2)+\sqrt{(s-2)^2+(r+2s-6)^2}$$
$$r(s-1)+\sqrt{(r+s-2)^2(2r+2s-7)^2}\; r(s-1) \quad (8)$$

The graph of C r, s in the cloud computing network, as depicted in Fig. 1, has been proven in Eq. (7) and Eq. (8).

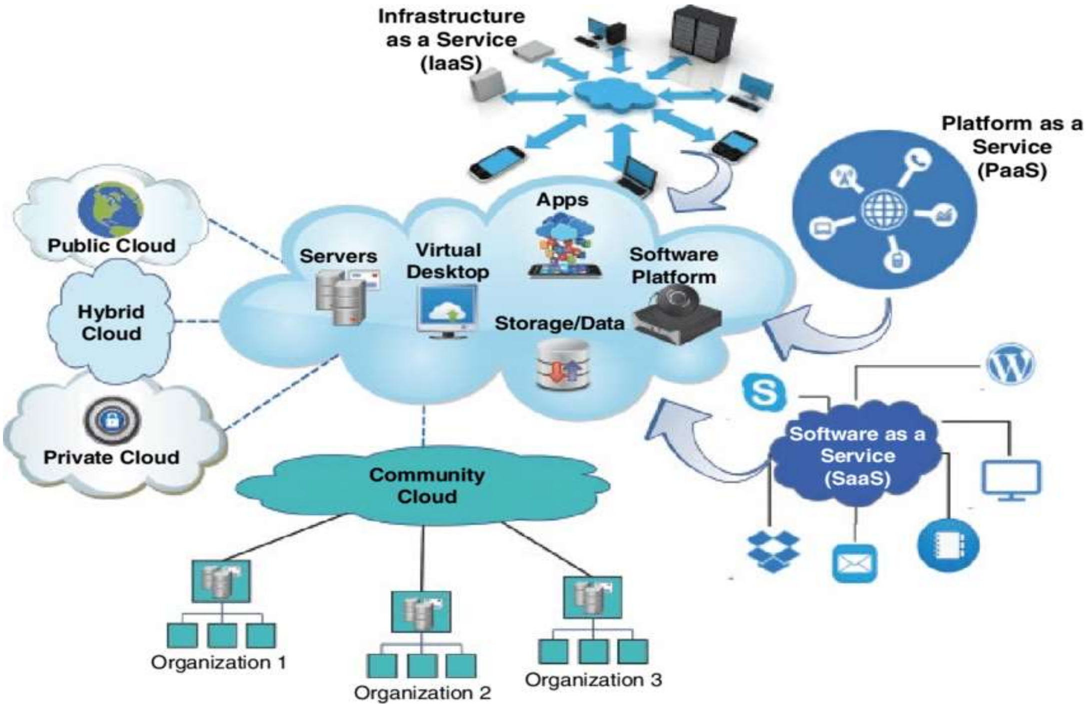


Figure 12: A cloud graph is created from a specific cloud computing network

4.1.3 Mapping and solving of C $_{r,s}$ of the cloud computing network Graph by KBSO Indices

Proof

$$KBSO(G) = \sum_{ue} \sqrt{d_u^2 + d_e^2}$$

$$KBSO(G)= \sqrt{(s-1)^2+(2s-4)^2}\,\frac{(r(s-1)(s-2))}{2}+\sqrt{(s-1)^2+(r+2s-5)^2}\,(r(s-1))+\sqrt{(r+s-2)^2+(2r+2s-6)^2}\,\frac{(r(s-1))}{2}$$

$$\mathbf{KBSO\ (G)} = \frac{1}{2}\sqrt{2}\sqrt{(s-1)^2+(2s-4)^2}\; r(s-1)(s-2)+$$
$$\sqrt{(s-1)^2+(r+2s-5)^2}\; r(s-1)+\frac{1}{2}\sqrt{(r+s-2)^2+(2r+2s-6)^2}\; r(s-1)$$

$$KBSO_{red}(G) = \sum_{ue} \sqrt{(d_u-1)^2+(d_e-1)^2}$$

$$KBSO_{red}(G) = \sqrt{(s-1-1)^2+(2s-4-1)^2}\left(\frac{(r(s-1)(s-2))}{2}\right)$$
$$+5\sqrt{(s-1-1)^2+(r+2s-5-1)^2}\,(r(s-1))+4\sqrt{(r+s-2-1)^2+(2r+2s-6-1)^2}\,\frac{(r(s-1))}{2}$$

$$\mathbf{KBSO_{red}\ (G)} = \frac{1}{2}\sqrt{(s-2)^2+(2s-5)^2}\; r(s-1)(s-2)+\sqrt{(s-2)^2+(r+2s-6)^2}\; r(s-1)+\sqrt{(r+s-2)^2+(2r+2s-7)^2}\; r(s-1)$$

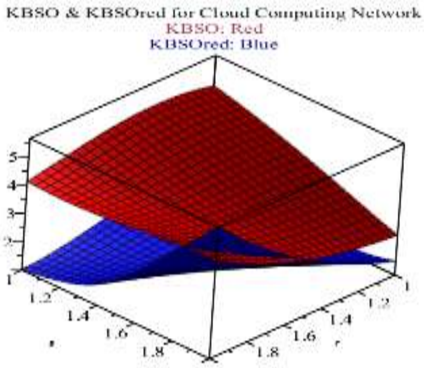


Figure 13: Results of KBSO and $KBSO_{red}$ invariants for cloud computing network

Fig. 23 displays the 3D results of KBSO and KBSOred invariants, indicating the upper and lower bounds of a cloud network in red and blue colors respectively.

4.1.4 Theorem 2

Let $C_{r,s} = G$ be a graph of the cloud computing network, then, CQI and QCI indices are

$$CQI(G) = \frac{\sqrt{((s-1)^2)}\, r(s-1)(s-2)}{2s-2} + \frac{\sqrt{2((s-1)^2+2(r+s-2)^2)}}{2s-3+r} r(s-1) + \frac{\sqrt{((r+s-2)^2)}\, r(s-1)}{2r+2s-4} \quad (9)$$

$$QCI(G) = \frac{\frac{1}{4}(2s-2)r(s-1)(s-2)}{\sqrt{(s-1)^2}} + \frac{(2s-3+r)r(s-1)}{\sqrt{2(s-1)^2+2(r+s-2)^2}} + \frac{1}{4}\frac{(2r+2s-4)r(s-1)}{\sqrt{(r+s-2)^2}} \quad (10)$$

The graph of the cloud computing network, as depicted in Fig. 1, has been proven in Eq. (9) and Eq. (10).

$$CQI(G) = \sum_{uv\in E(G)} \frac{\sqrt{2(d_G(u)^2+d_G(v)^2)}}{d_G(u)+d_G(v)}$$

$$CQI(G) = \frac{\sqrt{2((s-1)^2+(s-1)^2)}}{s-1+s-1}\frac{(r(s-1)(s-2))}{2} + \frac{\sqrt{2((s-1)^2+(r+s-2)^2)}}{s-1+r+s-2} r(s-1) + \frac{\sqrt{2((r+s-2)^2+(r+s-2)^2)}}{r+s-2+r+s-2}\frac{(r(s-1))}{2}$$

$$\boldsymbol{CQI(G)} = \frac{\sqrt{((s-1)^2)}\, r(s-1)(s-2)}{2s-2} + \frac{\sqrt{2((s-1)^2+2(r+s-2)^2)}}{2s-3+r} r(s-1) + \frac{\sqrt{((r+s-2)^2)}\, r(s-1)}{2r+2s-4}$$

$$QCI\ (G) = \sum_{uv\in E(G)} \frac{(d_G(u)+d_G(v))}{\sqrt{2(d_G(u)^2+d_G(v)^2)}}$$

$$QCI(G) = \frac{s-1+s-1}{\sqrt{2((s-1)^2+(s-1)^2)}}\frac{(r(s-1)(s-2))}{2} + \frac{s-1+r+s-2}{\sqrt{2((s-1)^2+(r+s-2)^2)}} r(s-1) + \frac{r+s-2+r+s-2}{\sqrt{2((r+s-2)^2+(r+s-2)^2)}}\frac{(r(s-1))}{2}$$

$$\boldsymbol{QCI(G)} = \frac{\frac{1}{4}(2s-2)r(s-1)(s-2)}{\sqrt{(s-1)^2}} + \frac{(2s-3+r)r(s-1)}{\sqrt{2(s-1)^2+2(r+s-2)^2}} + \frac{1}{4}\frac{(2r+2s-4)r(s-1)}{\sqrt{(r+s-2)^2}}$$

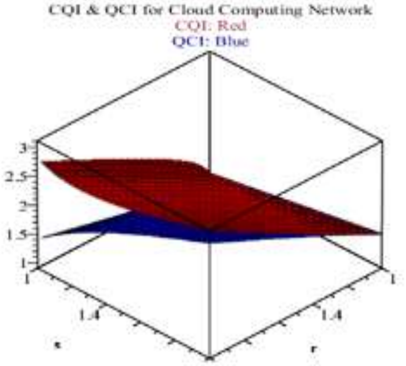


Figure 14: CQI and QCI for cloud network

The 3D version of Fig. 24 displays the results with clear upper and lower bounds (Equations 9 & 10) for CQI and QCI in red and blue colors.

4.1.5 Theorem 3

The Dharwad and Dharwadred indices are present in a graph of the cloud computing network, C r, s

$$D\ (G) = \frac{1}{2}\sqrt{2}\sqrt{(s-1)^3}\, r(s-1)(s-2) + \sqrt{(s-1)^3+(r+s-2)^3}\, r(s-1) + \frac{1}{2}\sqrt{2}\sqrt{(r+s-2)^3}\, r(s-1) \quad (11)$$

$$RD\ (G) = \frac{1}{2}\sqrt{2}\sqrt{(s-2)^3}\, r(s-1)(s-2) + \sqrt{(s-2)^3+(r+s-2)^3}\, r(s-1) + \frac{1}{2}\sqrt{2}\sqrt{(r+s-2)^3}\, r(s-1)$$

(12)

Eq. (11) and Eq. (12) show the proven results of Dharwad invariants

4.1.6 Mapping and Solving of Cloud Computing Graph by Dharwad Indices

Proof.

$$D(G) = \sum_{ue} \sqrt{du^3+dv^3}$$

$$D(G) = \sqrt{(s-1)^3+(s-1)^3}\frac{(r(s-1)(s-2))}{2} + \sqrt{(s-1)^3+(r+s-2)^3}\, r(s-1) + \sqrt{(r+s-2)^3+(r+s-2)^3}\frac{(r(s-1))}{2}$$

$$\boldsymbol{D\ (G)} = \frac{1}{2}\sqrt{2}\sqrt{(s-1)^3}\, r(s-1)(s-2) + \sqrt{(s-1)^3+(r+s-2)^3}\, r(s-1) + \frac{1}{2}\sqrt{2}\sqrt{(r+s-2)^3}\, r(s-1)$$

$$RD\ (G) = \sum_{ue} \sqrt{(du-1)^3+(dv-1)^3}$$

$$RD(G) = \sqrt{((s-1)-1)^3+((s-1)-1)^3}\frac{(r(s-1)(s-2))}{2} + \sqrt{((s-1)-1)^3+((r+s-2)-1)^3}\, r(s-1) + \sqrt{((r+s-2)-1)^3+((r+s-2)-1)^3}\frac{(r(s-1))}{2}$$

$$\boldsymbol{RD\ (G)} = \frac{1}{2}\sqrt{2}\sqrt{(s-2)^3}\, r(s-1)(s-2) + \sqrt{(s-2)^3+(r+s-2)^3}\, r(s-1) + \frac{1}{2}\sqrt{2}\sqrt{(r+s-2)^3}\, r(s-1)$$

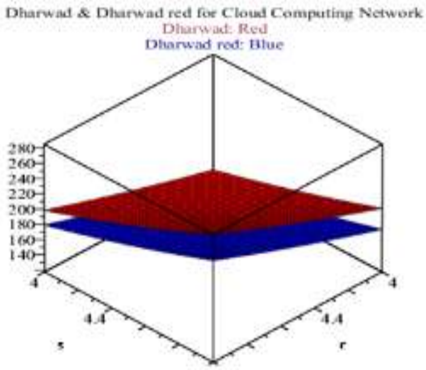


Figure 15: Dharwad and Dharwad_{red} invariants for cloud network

Fig. 25 displays the 3D results of equations 9 and 10 for Dharwad and Dharwad red, indicating the sharp upper and lower bounds of a network.

5. Conclusions

Through the provision of computing services via the Internet, cloud technology gives business owners access to resources and technologies that were previously exclusive to large enterprises, improving productivity, scalability, and competitiveness. The study builds real-time clouds with step-by-step practical performance using several lab scenario types. The study offers recommendations for cloud computing network awareness, security, and performance in this way. In many domains, including computer science, chemistry, biology, informatics, mathematics, material sciences, and many more, TIs are widely used and implemented, particularly in the Internet of Things and other network designs. However, the most important use is in the non-exact QSPR and QSAR. TIs are connected to the configuration of cloud networks that are utilized in cloud computing. The paper talks about the recently presented topological invariants for mapping and solving the cloud network. These invariants have many prediction properties that can be used to improve various cloud computing network variations in terms of scalability, efficiency, higher throughput, best-fit topology, latency, etc. These inferred findings from equations three to five will be applied to the building of various chemical structures with the best possible properties as well as the modeling and enhancement of cloud networks utilized in cloud computing.

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