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Research paper

Cloud infrastructure solution: Building cost effective model for real time hands-on labs using computing methodologies for productive learning solutions in academics

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Abstract

By in 2021, more than half of global enterprises already using cloud today adopt an all in cloud strategy [6]. Is today the world of modern infrastructure using digital transformation results cost effective approach? If yes, than how it has to be transformed and if No, than what are the differences between approaches applied. The cost effective methodology and its implementation is primary approach towards cost computing to bring effectiveness with the proper requirements and provides proper solution.

The productive learning with different approach is the vital requirement for today's Cloud infrastructure building from student's perspective needs to be understood [13 - 15]. The paper aims in building and implementing the Lab infrastructure using developed model for cost effective approach by comparing On-premise vendors with cloud vendors. The technology that is used for the experiment are open-source and Proprietary. The paper results with the best approach used in cost computing methodology providing best solution for the given requirement in academic environment.

Keywords: *Cost Computing; Cost Effective Methodology; Cloud Infrastructure; Return on Investment; Total Cost of Ownership.*

1. Introduction

Understanding Cloud infrastructure components and its functionality is essential which is covered in the first section. It also covers the 'YGCIS' methodology that is used for building Cloud infrastructure for On-premise and public cloud. In second section the paper covers the TCO using 'YGCCS' methodology for cost effective approach in different stages. These three stages of 'YGCCS' methodologies plays a major role in cost computing.

Implementation section covers cloud infrastructure implementation on On-premises, public cloud with proper configuration, checklist, and testing of lab requirement. Analysis section covers TCO cost computing parameters of 'On-premises vendors' with 'off premises vendors' for open-source category and proprietary with BCP category. The result section in analysis covers cost effective and best methodology approach for different requirement and operational needs.

2. Problem statement

As per IDC the Cloud computing spending grew at 4.5 times the rate of IT spending since 2009. It is expected to grow more than six times in 2015 through 2020 [5]. The requirement and building of advance lab in Academic for Cloud infrastructure building is a major challenge and it impacts student's productive learning. There are some courses in computer science stream such as cloud computing, advance cloud computing, cloud solution. This cloud courses consists the topics such as TCO, ROI, computing methodology, where hands-on approach is unavailable [7 - 10]. Due to this disadvantage there is lack in labs building and creating advance lab for best productive learning [16], [17]. If this learning is developed by students, and then they have to face major challenges in industries on production operations. As per the expanding digital transformation in IT infrastructure is observed, it is lacking in Indian academic organization. Further this challenge should not lose the carrier opportunities and proper direction toward the domain work as per academic concern [3], [11], [12], and [18].

3. Cloud Infrastructure deployment model

The Cloud deployment model plays a vital role in Cloud Infrastructure building [1], [2]. The On-premise private cloud is built in the premises of the enterprise as shown in Figure 1. The important components in On-premise private cloud infrastructure are enterprise resources such as hardware, hypervisor which creates virtual machines for deployment of operating system, applications; network with proper high computing servers as shown in Figure 1.

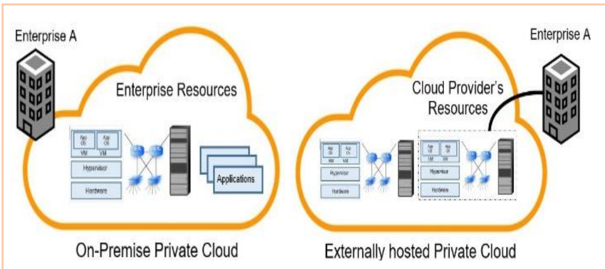

Fig. 1: Cloud Infrastructure Architecture.

4. Cloud infrastructure building: implementing 'YGCIS' methodology

In, private cloud infrastructure the resource availability is the major challenge, if not meet than it becomes critical for the enterprise to provide better solution. The challenge can be mitigated using the public cloud infrastructure, where the availability is not the concern but well planning for the resource utilization is important. For, implementation of the experiment in academic environment the 'YGCIS' [YG-Cloud Infrastructure Solution] methodology is built as shown in Figure. 2, where the configuration for the lab is considered from the Table. 1. Each student has a cluster access with available VM with the host machine that is connected through network as shown in Figure. 2. The experiment using 'YGCIS' methodology is built for advance lab where infrastructure and its resources play a vital role [4].

Table 1: Batch Lab Configuration for 'YGCIS' Methodology

Batch Lab Configuration requirement				
Sr.	**LAB Configuration**	**Group**	**Each Student**	**Each VM**
1	Students	30	1	0
2	VM	100	3	1
3	CPU	180	6	2
4	RAM [GB]	300	10	3.5
5	Storage [GB]	5000	150	50
6	NW [Bandwidth MB]-OP	5000	167	50
7	NW [Bandwidth MB]-CV	1000	30	10
8	Backup for BCP [GB]	1000	33	11
9	Archive for Data Protection	500	16.5	5.5

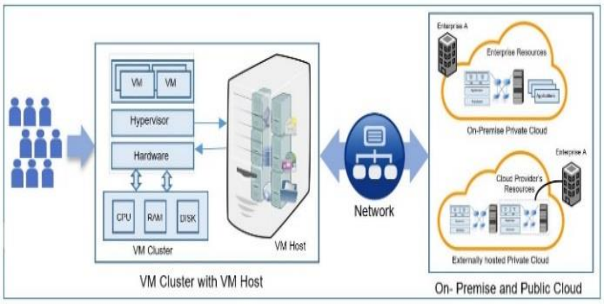

Fig. 2: 'YGCIS' Methodology: Cloud Infrastructure Building.

The lab configuration requirement is unique to all On-premise vendor and cloud vendor, it only differs in storage while using BCP solution due to the requirement for fault tolerance. The requirement remains same from initial stage to final stage of experiment built. It meets the advance lab requirement where additional resources if required becomes a challenge or creates a critical condition.

5. TCO: using 'YGCCS' methodology for cost effective approach

The cost effective approach for Total Cost Ownership [TCO] is implemented using 'YGCCS' [YG-Cost Computing Solution] framework as shown in Figure. 3. The framework consists of three stages. The first stage is for building of TCO computing framework using parameters such as core requirement, compute, storage, network, and IT labor by collecting required information from different enterprise and different vendors as shown in table. 2. The second stage is for infrastructure testing for different vendor's that collect all the cost details and making different categories as per the stage 1 and computing the cost as shown in Table. 3 and 4.
The last stage is predicting analysis obtained through stage 2 for cost effectiveness by different computing methods as shown in Figure. 3. Thus the result obtained by implementing 'YGCCS' methodology is cost effective or not needs to be well observed and computed.

Table 2: TCO Primary requirement details for On-premises and Cloud Vendors

TCO Primary requirement details for On-premises and Cloud Vendors			
Layer	**Components**	**Type I**	**Type II**
Core Requirement	TCO- Basic / Advance	Advance	Advance
	Currency- INR	INR	INR
	Environment Type- On-premises / Colocation	On-premises	Colocation
	Region- Datacenter / Service Provider	Asia Pacific	Asia Pacific
	Workload Type- General / Other	General	General
	Manual Input	Yes	Yes
	Servers [Physical Servers / Virtual Machines]	VM	VM
Compute	Compute- Service Category [DB / Non DB]	DB	DB
	Environment- Physical / VM	One Region	Multi Region
	Operating System [Guest OS]	Open-source OS	Window OS and Open-source OS
	VM's	100	100
	Virtualization- Hypervisor	VMware / Xen KVM	VMware, Hyper-V
	Virtualization- Host	Host- CPU, Core & RAM	Host- CPU, Core & RAM
	Cores	2 to 5	2 to 5
	RAM [GB]	3.5	3.5
	Optimization [CPU/RAM]	RAM	CPU & RAM
Storage	Storage Type [SAN, NAS, Local Disk, Object, BLOB]	SAN	SAN
	Disk Type [HDD, SDD]	HDD	HDD
	Capacity [Raw Storage]	50-65	65
	Backup %	30-50%	100% [Business Continuity] 10 TB
	Archive	10-20%	40-60%
	GRS Geo Redundant Storage [Enable or Not]	No	Yes
NW	Networking Bandwidth [On-premise]	1 Gbps	1 Gbps
	Bandwidth [Datacenter Bandwidth]	5 Gbps	5 Gbps
IT Labor	Burdened Annual Salary [Administrator and Datacenter Staff]	Average	Average
	Number of VMs per Admin	200	200

Table 3: Type I- Open-source use: On-premises vs. Cloud vendors

Type I- Open-source use: On-premises Vs. Cloud Vendors					
On-premises Vendors				**Cloud Vendors**	
Sr	**TCO Comp Parameters**	Vendor 1 Cost [₹]	Vendor 2 Cost [₹]	Vendor 1 Cost [₹]	Vendor 2 Cost [₹]
1	**Compute**	92,275,509	52,552,478	29,912,200	22,743,849
2	**Data center**	4,532,385	4,234,485	0	0
3	**Networking**	16,420,735	3,265,370	0	0
4	**Storage**	9,454,058	14,749,083	3,551,054	6,466,046
5	**IT labor**	7,433,194	6,722,334	3,795,591	3,765,761
	Total cost	**130,115,881**	**81,523,750**	**37,258,845**	**32,975,656**

Table 4: Type II- Proprietary Use and BCP: On-premises vs. Cloud Vendors

Type II- Proprietary use and BCP: On-premises Vs. Cloud Vendors					
On-premises Vendors				Cloud Vendor	
Sr	TCO Comp Parameters	Vendor 1 Cost [₹]	Vendor 2 Cost [₹]	Vendor 1 Cost [₹]	Vendor 2 Cost [₹]
1	**Compute**	32,708,866	29,619,561	27,701,598	0
2	**Data center**	5,476,405	4,234,485	0	0
3	**Networking**	938,010	505,200	0	12,180,764
4	**Storage**	29,279,740	26,070,306	6,961,494	16,965,971
5	**IT labor**	159,233	130,008	58,865	600,000
	Total cost	**68,562,254**	**60,559,560**	**34,721,957**	**29,746,735**

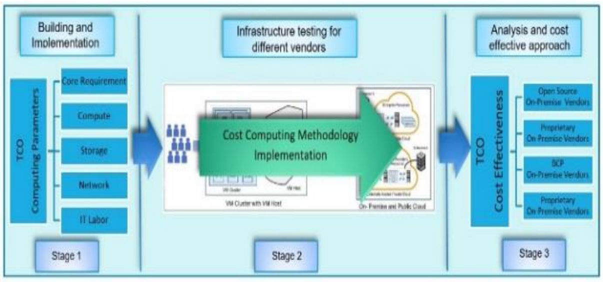

Fig. 3: 'YGCCS' Methodology Framework for cost Effective Approach in TCO.

6. TCO cost computing: cost effective model

The following equations are required for analysis of cost computing and to find the cost effective model for best solution for different enterprises.

$$\sum_{V1}^{N} \text{COMPUTE} = \sum_{V1}^{N} \text{HW}(1..N) + \sum_{V1}^{N} \text{SW}(1..N) + \sum_{V1}^{N} \text{PW}(1..N) + \sum_{V1}^{N} \text{VIRT}(1..N) \quad (1)$$

Where V is vendor, HW is Hardware, SW is Software, PW is Power and VIRT is Virtualization.

$$\sum_{V1}^{N} \text{DC} = \sum_{V1}^{N} \text{DCR1}(1..N) + \sum_{V1}^{N} \text{DCR2}(1..N) + \sum_{V1}^{N} \text{DCR3}(1..N) + \sum_{V1}^{N} \text{DCR..N}(1..N) \quad (2)$$

Where DC is Datacenter, DCR1 is Datacenter Resource 1 and so on.

$$\sum_{V1}^{N} \text{NW} = \sum_{V1}^{N} \text{NWR1}(1..N) + \sum_{V1}^{N} \text{NWR2}(1..N) + \sum_{V1}^{N} \text{NWR3}(1..N) + \sum_{V1}^{N} \text{NWR..N}(1..N) \quad (3)$$

Where NW is Network, NWR1 is Network Resource 1 and so on.

$$\sum_{V1}^{N} \text{ST} = \sum_{V1}^{N} \text{STR1}(1..N) + \sum_{V1}^{N} \text{STR2}(1..N) + \sum_{V1}^{N} \text{STR3}(1..N) + \sum_{V1}^{N} \text{STR..N}(1..N) \quad (4)$$

Where ST is Storage, STR1 is Storage Resource 1 and so on.

$$\sum_{V1}^{N} \text{ITL} = \sum_{V1}^{N} \text{ITLR1}(1..N) + \sum_{V1}^{N} \text{ITLR2}(1..N) + \sum_{V1}^{N} \text{ITLR3}(1..N) + \sum_{V1}^{N} \text{ITLR..N}(1..N) \quad (5)$$

Where ITL is IT Labor, ITLR1 is IT Labor Resource 1 and so on.

$$\text{Min}\left(\sum_{V1}^{N} \text{TCO}(1..N)\right) = \text{Min}\left(\sum_{V1}^{N} \text{COMPUTE}(1..N)\right) + \text{Min}\left(\sum_{V1}^{N} \text{DC}(1..N)\right) + \text{Min}\left(\sum_{V1}^{N} \text{NW}(1..N)\right) + \text{Min}\left(\sum_{V1}^{N} \text{ST}(1..N)\right) + \text{Min}\left(\sum_{V1}^{N} \text{ITL}(1..N)\right) \quad (6)$$

Where TCO is Total Cost of ownership.

$$\text{Cost Eff}\left(\sum_{V1}^{N} \text{TCO\_open\_source}(1..N)\right) = \text{Min}\left(\sum_{V1}^{N} \text{TCO\_op}(1..N)\right), \text{Min}\left(\sum_{V1}^{N} \text{TCO\_cv}(1..N)\right) \quad (7)$$

Where TCO_open_source is Total Cost of ownership for Open-source, TCO_op is TCO On-premise, TCO_cv is TCO Cloud Vendor.

$$\text{Cost Eff}\left(\sum_{V1}^{N} \text{TCO\_prop\_bcp}(1..N)\right) = \text{Min}\left(\sum_{V1}^{N} \text{TCO\_prop}(1..N)\right), \text{Min}\left(\sum_{V1}^{N} \text{TCO\_bcp}(1..N)\right) \quad (8)$$

Where TCO_prop_bcp is Total Cost of ownership for Proprietor and BCP (Business Continuity Plan).

$$\text{Cost Eff}\left(\sum_{V1}^{N} \text{TCO\_cost\_effm}(1..N)\right) = \text{Cost Eff}\left(\sum_{V1}^{N} \text{TCO\_open\_source}(1..N)\right), \text{Cost Eff}\left(\sum_{V1}^{N} \text{TCO\_prop\_bcp}(1..N)\right) \quad (9)$$

Where TCO_cost_effm is Total Cost of ownership for Cost Effective Model.

7. TCO result

7.1. On-premises

The On-premises infrastructure for different vendors is shown in Fig. 4. Most of the software's used are open-source software due to which the change in cost parameter can be observed. The more cost is observed at compute level that is compared to other computing parameters in Fig. 4. Between two vendors 19% of difference is observed in open-source and 10% of difference in proprietary vendors in On-premises.

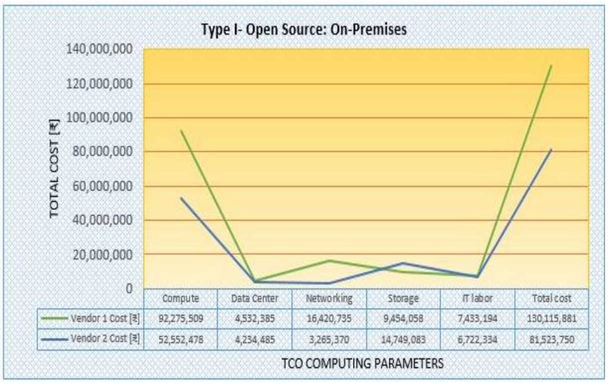

Fig. 4: Type I- Open-source: On-premises.

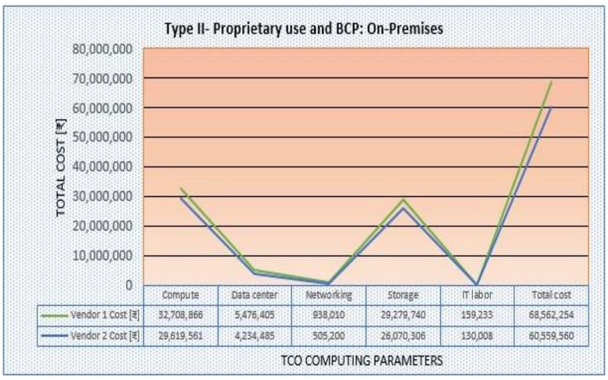

Fig. 5: Type II- Proprietary: On-premises.

7.2. Single cloud vendor

The single cloud vendor with parameter such as web direct, one year reserved VM, and three years reserved are considered for stakeholder or enterprise requirement as per performance and cost computing as observed in Fig. 6 and 7. There are minor differences between different cost computing parameters.

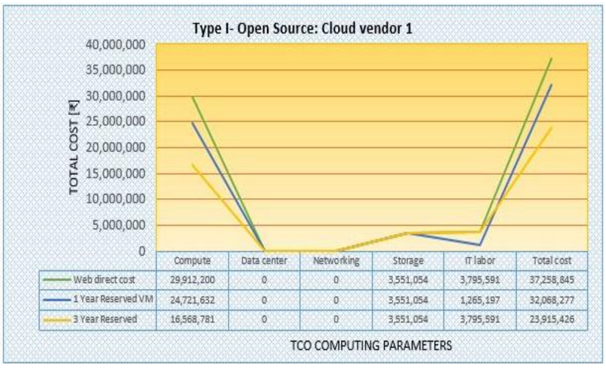

Fig. 6: Type I- Open-source: Cloud Vendor.

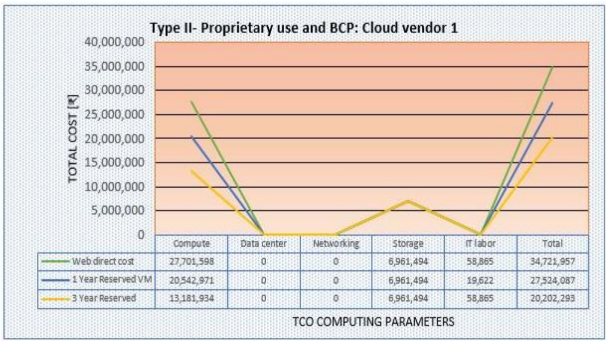

Fig. 7: Type II- Proprietary: Cloud Vendor.

7.3. Cloud vendor

The cloud vendors play a vital role in cloud infrastructure by allocating resources as per the requirement of the enterprise. There is more cost requirement in compute in open-source and compute with storage in proprietary use that is observed in Fig. 7 and 8.

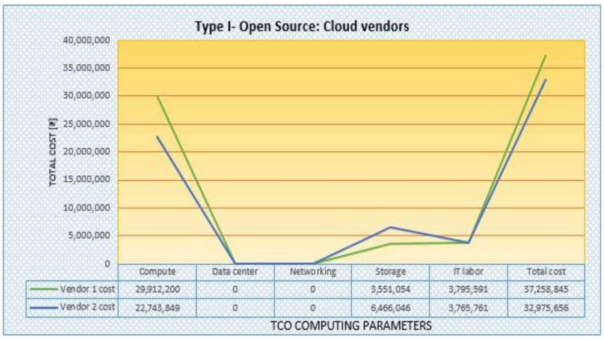

Fig. 8: Type I- Open-source: Cloud Vendors.

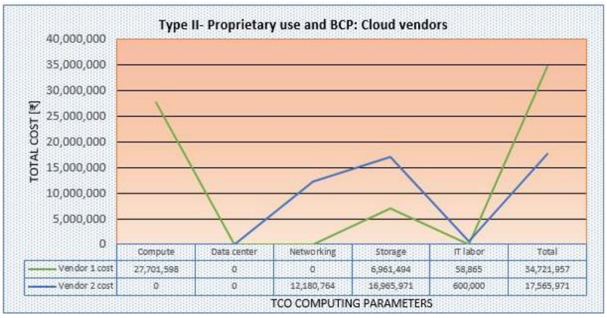

Fig. 9: Type II- Proprietary: Cloud Vendors.

7.4. On-premises vs. cloud vendor

The TCO difference observed between the On-premise and cloud vendors results that the cost of Compute is more in On-premise and compute with storage is more in proprietary as per observation obtained. The cloud vendors such as vendor 1 and 2 are more effective compare to On-premise vendors that is observed in Fig. 10. and 11.

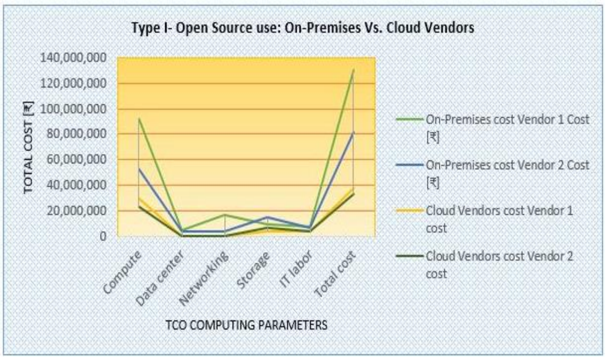

Fig. 10: Type I- Open-source: On-premises vs. Cloud Vendors.

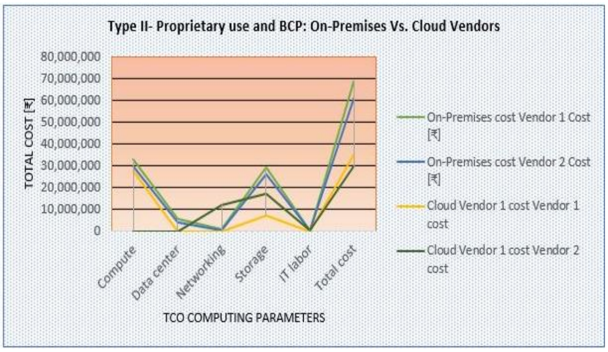

Fig. 11: Type II- Proprietary: On-premises vs. Cloud Vendors.

7.5. Result cost effective solution

The TCO cost effective solution is obtained using 'YGCCS' is observed in Fig. 12 is impactful. The 54% cost difference is observed between Cloud vendors and On-premise vendors in open-source category. The important result observed in Fig. 12 is cost effectiveness impact for all TCO computing parameters is high. The paper results to opt for cloud vendors for open-source environment that is observed in Fig. 12.

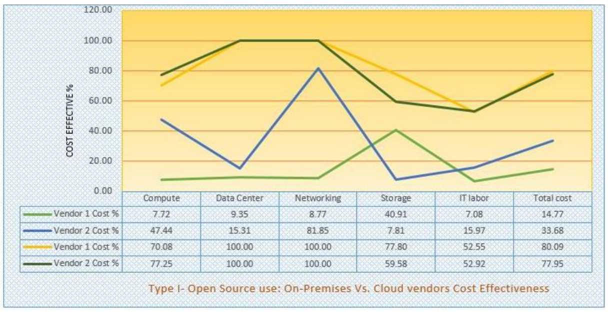

Fig. 12: Type I- Open-source: On-premises vs. Cloud Vendors.

The observation for cost effective solution using 'YGCCS' in Fig. 13 is impactful. The 22% cost difference is observed between Cloud vendors and On-premise vendors in Proprietary with BCP category. Therefore the paper comes with the result is to opt for cloud vendors for proprietary using BCP environment that is observed in Fig. 13.

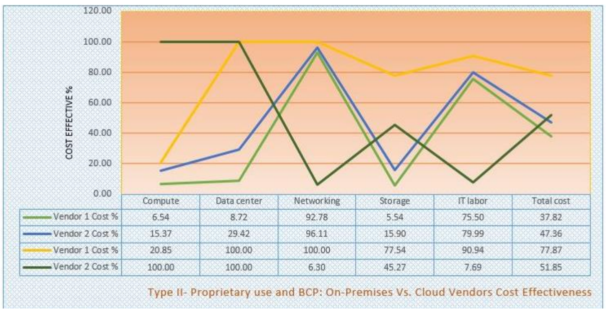

Fig. 13: Type II- Proprietary: On-premises vs. Cloud Vendors.

8. Concluding remarks and future directions

The overall cost effective solution using 'YGCCS' methodology is impactful by 38% for Cloud vendors that are compared to On-premise vendors. The cost effective framework and its implementation is useful in building Cloud infrastructure towards cost effective solution. The future research and its study will be compared with hybrid cloud and multicloud infrastructure for finding effective solutions as per different requirements and the needs under enterprise.

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