Efficient Load Balancing in Cloud Computing using Multi-Layered Mamdani Fuzzy Inference Expert System

Naila Samar Naz[1], Sagheer Abbas[2], Muhammad Adnan Khan[2], Benish Abid[3], Nadeem Tariq[3], Muhammad Farrukh Khan[4]
Department of Computer Science, University of Lahore, Pakistan[1, 3]
School of Computer Science, National College of Business Administration & Economics, Lahore, Pakistan[2]
National College of Business Administration & Economics, Lahore, Pakistan[4]

***Abstract*—In this article, a new Multi-Layered mamdani fuzzy inference system (ML-MFIS) is propound for the Assessment of Efficient Load Balancing (ELB). The proposed ELB-ML-MFIS expert System can categorise the level of ELB in Cloud computing into Excellent, Normal or Low. ELB-ML-MFIS Expert System for ELB in cloud computing is developed under the guidelines from the Microsoft Organization and Pakistan's Punjab Information Technology Board (PITB) Standard. ELB-ML-MFIS Expert System uses input Cloud Computing parameters such as Data-Center, Virtual-Machine, and Inter –of-Things (IOT) for different layers. This article also analyses the intensities of the Parametres and the results achieved by using the Proposed ELB-ML-MFIS Expert System. All these parameters and results are discussed with the experts of Pakistan's Punjab Information Technology Board (PITB), Lahore. The accuracy of the proposed ELB-ML-MFIS Expert System is more accurate as compared to other approaches used for it.**

***Keywords*—PITB; IOT; Virtual-Machine; Data-center; ML, ELB; MFIS**

I. Introduction

Cloud computing [1] [2] is an emerging business framework and an Internet-based model where clients' information can be accessed by Internet browsers. This is a calculation mode that is determined by the availability of potent and extensible resources that services is used to represent platforms, software platforms, or storage. Cloud computing has been defined more broadly for everything related to offering web hosting services. This concept is based on computer sharing, Web Storage, and software resources provided by third parties.

Many types of clouds can be developed as a public, private cloud and hybrid [2]. The Framework of cloud computing is used only for a consortium and that is managed by a consortium or third party and may be on or off campus. On the other hand, public clouds sell resources to everyone on the Internet, and their infrastructure is provided to the public and belongs to an organization that sells cloud resources. Private cloud is a proprietary site or database that provides limited-edition hosting services or groups of people. Hybrid Clouds are a cloudy climate that includes the benefits of various cloud types. This organization provides and controls some of the resources inside and gives outsiders in the cloud. Ideally, hybrid cloud technology allows businesses to benefit from scalability, efficiency, flexibility and cost effectiveness.

II. Literature Review

In [3] research article an Algorithm designed by using the approach of centralized inherent efficiency, which was energy efficient and error-tolerant for the distributed environment like cloud computing. This was also give the best solution for the problem of Load Balancing in Cloud Computing by using the resource of interactive power aware line up.

This article [4] the researchers searched for the word "cloud computing", its pros, cons and many repairs for existing platforms. Also discuss the quantitative results conducted by Planet Lab, a computer cloud platform. This two-step process Algorithm also used the three level network of cloud computing for the combining of LBO (load balanced Opportunities) and LBOM (load balancing of mines). That can use better performance and maintain a balanced system load. [6].

PALB [7] keeps the status of all the tablet tabs and depending on the usage rate, the number of computer nodes to work. It shows a load balancing method based on cloud computing and provide access to local compute node resources while minimizing the total energy used by the local cloud.

Companies and institutions are focusing on computer use and large-scale archives and scanners, which are implemented through the use of various agents and collaborations with cloud computing. The different purpose of this task is that data operations are adapted to work in distribution mode, using additional images that can be saved and handled separately by different agents in a system that facilitates parallel large image processing [8].

Balance in the cloud storage as a way to be implemented in different data centers to ensure the possibility of using the network by reducing the computer hardware to reject austerity programs and reducing recurrence presence of clouds is a major problem in the cloud computing [9].

The Researchers analyzes the performance of computer services for the use of scientific data and measures the amount of presence in the Many-Task-Computing (MTC) users who freely use the program for scientific purposes. They have also made a real assessment of four type of commercial cloud computing services [10].

III. Load Balancing

A. Load Balancing in Virtual Data Centers

Virtual Data Centers that have unforeseeable user traffic need a good balance strategy. The response time automatically increase to process a request when the data center load focused on multiple servers, while the other freeware. Distributing storage between all fake printers can provide better response time. Previous work gives many techniques for balancing of burdens. These approaches are defineed as follows:

B. First Come First Serve (FC-FS)

This is the first balanced load model with the simplest working principle [10]. Without the prior knowledge, it usually sends the request to the next virtual machine. It starts from the Virtual-Machine first after you have assigned the last Virtual-Machine task to the list.

C. Min-Min Load Balancer (MM-LB)

In the Minimum Minute Balance storage [11], the best response time is used to schedule tasks to match the Virtual-Machine. The lowest time the Virtual-Machine has done to complete the request is the best response time [12]. It also calculates the current response time of all Virtual-Machines. Response Time is the time it takes to show the last user request. VM's current response time is lower than the best response time, with this Method. MM-LB Instant updates, best response times with current response time, and timing of the work of the VM, or scheduling the VM with the best response time [13].

D. Active Monitoring Load Balancer (AM-LB)

Active load balances are more stable for checking than RR balance loads [14-15]. It checks the current load status of each VM and defines the loaded VM tasks very little. This LB immediately enact for the Balance Surveillance Balance Load to obtain the appropriate Virtual-Machine [16]. An Overview of this Algorithm given in paragraph 1.1 in the Active LB sweeps the recent work of each Virtual-Machine and returns the Virtual-Machine with the minimal task level [17]. Then it expands the number of its tasks by 1. [18] When the process is completed in the Virtual-Machine, the AM-LB Data Center is divided to reduce the current distribution of the Virtual-Machine.

IV. Proposed Efficient Load Balancing in Cloud Computing Multi-Layered MFIS based Expert System (ELB-ML-MFIS ES)

In this article, a novel multi-layered HMFIS based Expert System is proposed for the ELB in cloud computing as shown in Fig. 1. In propound ELB in cloud computing Multi-Layered MFIS based Expert System (ELB-ML-MFIS-ES) use all possible suitable parameters about Cloud Computing. Some other Cloud Computing elements are not used which are not applicable in Cloud Computing. By Cloud Computing elements characteristics, the expert system is divided into multiple layers which present the complete structure of the proposed method shown in Fig. 2. Level-1 layers exams the existence of Data Center elements, Virtual Machine, and IoT parameters. Final layer calculates the ELB in Cloud Computing on the bases of level-1 layers output as shown in Fig. 2 and 3.

The values of Data -Centre, Virtual- Machine and IOT parameter are also used to build up a lookup table of proposed ELB-ML-HMFIS-ES as shown in Table I. In propound system thirteen, input parameters are used to Assessment the ELB in Cloud Computing. Propound ELB-Multilayer fuzzy inference expert system mathematically can be written as

$$\mu_{D\cap V\cap I}(d,v,i) = \min[\mu_D(d), \mu_V(v), \mu_E(e), \mu_I(i)] \quad (1)$$

1) Input fuzzy sets: To Assessment the ELB the statistical values of fuzzy input variables are used. The numerical values are divided into three categories which are Excellent, Medium and Low (Low and balancing in cloud computing) after the discussion with IT- expert. The portrayal of all information factors with their numerical qualities are appeared Table I.

2) Fuzzy output variable: In this research, multi-layered architecture is propounded to Assessment the ELB in Cloud Computing. The output variables of all level-1 layers & final layer are shown in Table II.

3) Membership functions: The participation capacity of this framework gives bend an incentive between 0, 1 and furthermore gives a scientific capacity which offers measurable estimations of information and yield variable [5]. Member ship functions of Input and output variables are used in Propound ELB- Multilayer-mamdani fuzzy inference Expert System which are given in Table III.

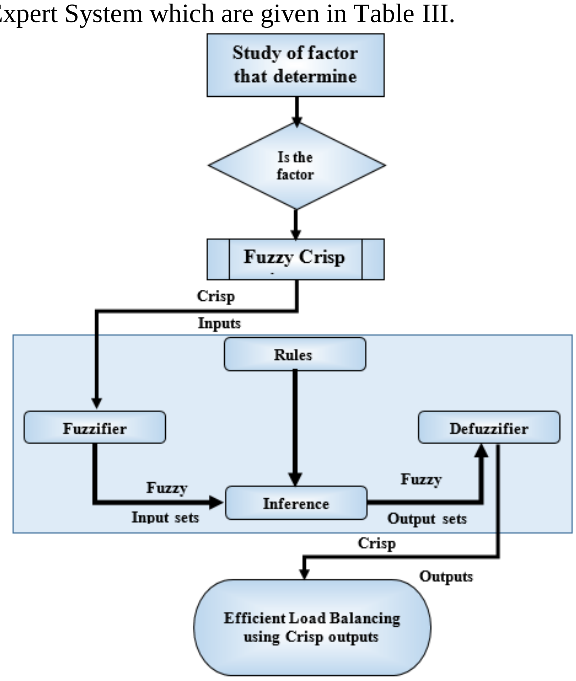


Fig. 1. Propound ELB-Multilayer-Mamdani Fuzzy Inference Expert System Methodology.

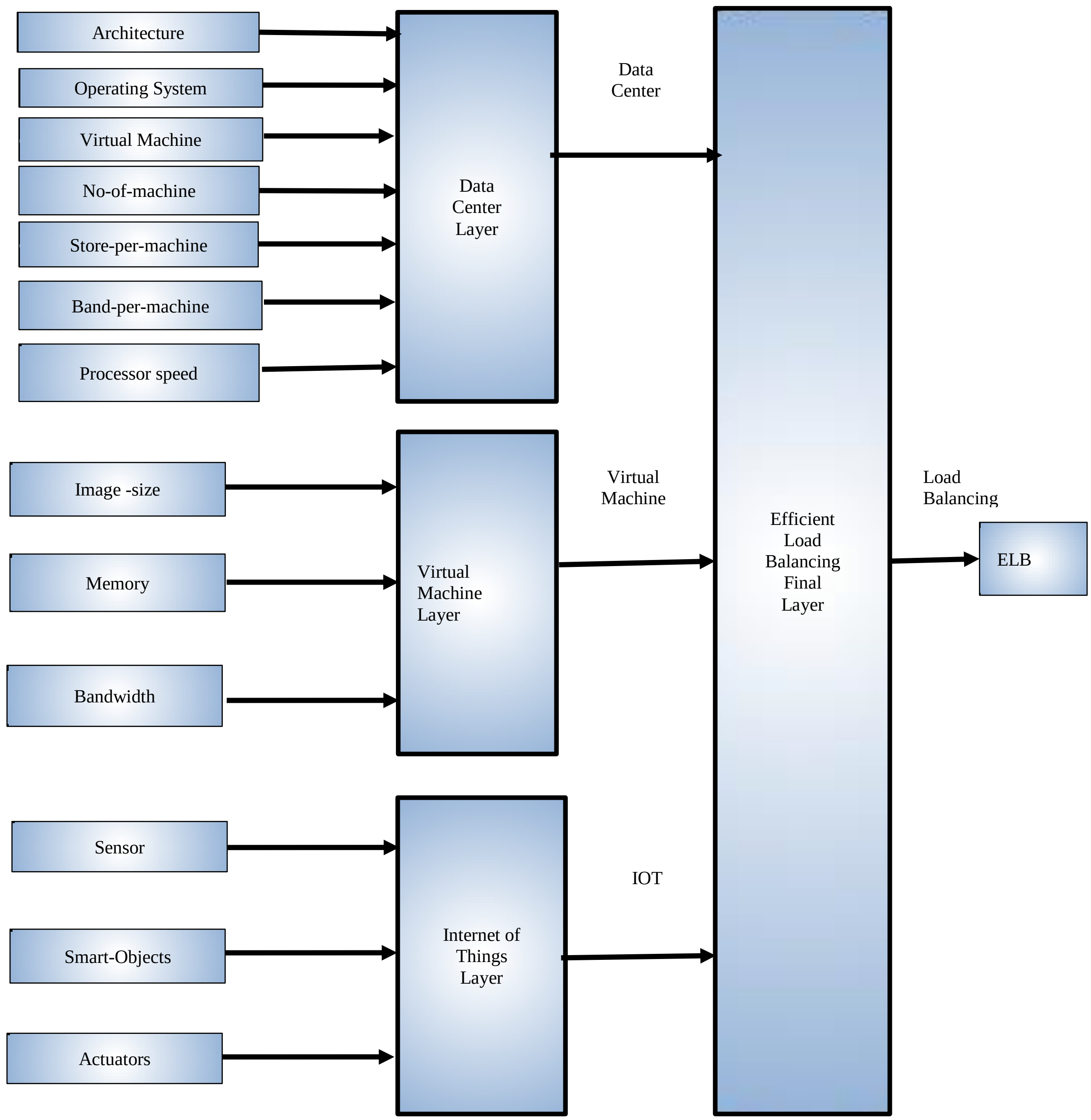


Fig. 2. Propound ELB-Multilayer-Mamdani Fuzzy Inference Expert System.

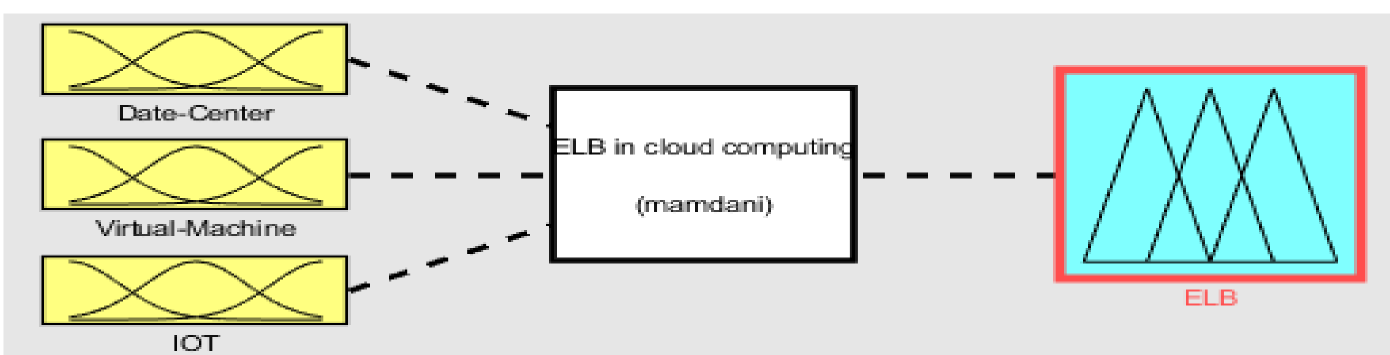


Fig. 3. Final Layer of Propound ELB-Multilayer-Mamdani Fuzzy Inference Expert System.

TABLE I. INPUT VARIABLE OF PROPOUND ELB- MULTILAYER-MAMDANI FUZZY INFERENCE EXPERT SYSTEM [11, 13]

Data-Center			
Properties/Parameter	**Excellent**	**Medium**	**Low**
Architecture(A)	$\leq 30\,X$	$30\,X \leq$N$\leq 60X$	$60\,X \geq$
Operating-System(OS)	No	No	Yes
VMM	No	No	Yes
Processor Speed	$\leq 20\,MIPS$	$20\,MIPS \leq T \leq 50\,Mips$	$50\,MIPS \geq$
No-of-Machine	≤ 200	$170 \leq T \leq 530$	$500 \geq$
Memory-per-Machine	≤ 600	$550 \leq T \leq 1050$	$1000 \geq$
Virtual-Machine			
Properties/Parameter	**Excellent**	**Medium**	**Low**
Image-size(IS)	$0.14 - 0.22$	≤ 0.16	≥ 0.2
Memory (M)	$0.0038 - 0.0052$	≤ 0.004	≥ 0.005
Bandwidth (B)	$0.038 - 0.052$	≤ 0.04	≥ 0.05
IOT			
Properties/Parameter	**Excellent**	**Medium**	**Low**
Sensors (S)	≤ 0.01	$0.008 - 0.052$	≥ 0.05
Smart-Objects(SO)	≤ 0.6	$0.5 - 1.6$	≥ 1.5
Actuators(A)	≤ 0.012	$0.01 - 0.052$	≥ 0.05

4) Fuzzy prepositions: A fuzzy compound suggestion is a structure of nuclear fuzzy recommendations utilizing the connectives "or," "and," and "not" which speak to the fuzzy association, crossing points and supplement, separately [12-14]. Here, d, v, & i variables represent Data-center, virtual machine, and IOT. Then the following fuzzy propositions hold:

$$t: d \times v \times i \rightarrow L_b \quad (2)$$

fuzzy master framework chips away at likelihood so all info and yield variable qualities are mapped from genuine range to likelihood ranges (range 0-1).[19] Here the function t-norm for final layer in equation (2) is defined as:

$$t: [0,1] \times [0,1] \times [0,1] \times \rightarrow [0,1] \quad (3)$$

Equation (3) changes the participation elements of fuzzy arrangements of Data-centre, Virtual-Machine, and IOT for a Final layer of propound fuzzy derivation framework among enrolment capacity of the crossing point of Data-centre, Virtual-Machine and IOT that is:

$$\mathrm{t}[\mu_D(d), \mu_V(v), \mu_I(i)] = \min[\mu_D(d), \mu_V(v), \mu_I(i)] \quad (4)$$

In Equation (3), for the capacity t; getting qualified as a crossing point, following sayings must be fulfilled and will be called as t-standard:

Axiom t1: Bounded Condition

$t(0,0) = 0; t(\gamma, 1) = t(1, \gamma) = \gamma$

Axiom t2: Commutativity

$t(\alpha, \beta) = t(\beta, \alpha)$

Axiom t3: Non-decreasing

If $\alpha \leq \alpha'$ and $\beta \leq \beta'$, then $t(\alpha, \beta) \leq t(\alpha', \beta')$

Axiom t4: Associativity

$t[t(\alpha, \beta), \gamma] = t[\alpha, t(\beta, \gamma)]$

Eq. (4) can be written regarding t-norm as:

$$\mu_{D \cap V \cap I \cap T}(d, v, i) = t[\mu_D(d), \mu_V(v), \mu_I(i)] \quad (5)$$

From Eq. (4) & (5)

$$\mu_{D \cap V \cap I \cap T}(d, v, i) = \min[\mu_D(d), \mu_V(v), \mu_I(i)] \quad (6)$$

5) Lookup table: Table for propound ELB- Multilayer-mamdani fuzzy inference Expert System contains 20 input, output rules from 30 as shown in table 4. In this table, we have 3 inputs and one output that represents multiple rules base on the inputs and respected outputs are obtained. With the help of IT-Expert and The Punjab Information Technology Board Department, Pakistan, this lookup table is developed.

TABLE II. OUTPUT VARIABLE OF PROPOUND ELB- MULTILAYER-MAMDANI FUZZY INFERENCE EXPERT SYSTEM

Sr #	**Layers**	**Output Variables**	**Semantic Sign**
1	Level-1 Layers	Data-Center, Virtual- machine, Internet-of-Things(IOT)	Excellent
			Medium
			Low
2	Final Layer	Efficient Load Balancing	Excellent
			Medium
			Low

TABLE III. MEMBERSHIP FUNCTIONS OF INPUT AND OUTPUT VARIABLES USED IN PROPOUND ELB-MULTILAYER-MAMDANI FUZZY INFERENCE EXPERT SYSTEM

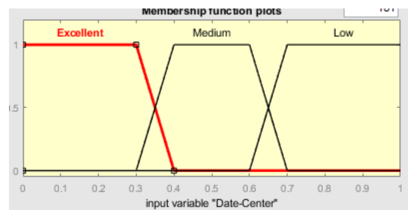
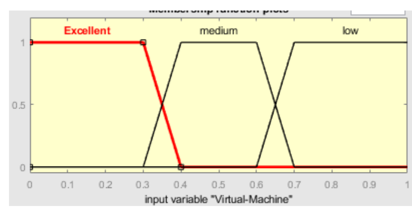
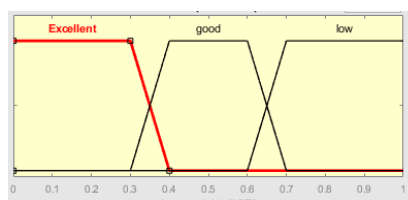
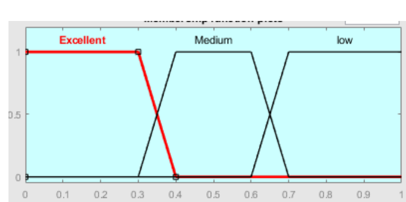
Variables	membership function(MF)	graphical representation of membership functions
Data center=D $\mu_D(d)$	$\mu_{D,Excellent}(d)=\begin{cases}1, & 0\le d\le 0.3\\ \frac{0.3-d}{1.0}, & 0.3\le d\le 0.35\\ 0, & d\ge 0.35\end{cases}$ $\mu_{D,Medium}(d)=\begin{cases}\frac{d-0.3}{1.0}, & 0.3\le d\le 0.35\\ 1, & 0.35\le d\le 0.4\\ \frac{0.7-d}{1.0}, & 0.4\le d\le 0.6\\ 0, & d\ge 0.6\end{cases}$ $\mu_{D,low}(d)=\begin{cases}0, & 0.6\le d\le 0.65\\ \frac{0.7-d}{2}, & 0.65\le d\le 0.7\\ 1, & d\ge 0.7\end{cases}$	
Virtual-Machine=V $\mu_V(v)$	$\mu_{V,Excellent}(v)=\begin{cases}1, & 0\le v\le 0.3\\ \frac{0.3-v}{1.0}, & 0.3\le v\le 0.35\\ 0, & v\ge 0.35\end{cases}$ $\mu_{V,Medium}(v)=\begin{cases}\frac{v-0.3}{1.0}, & 0.3\le v\le 0.35\\ 1, & 0.35\le v\le 0.4\\ \frac{0.7-v}{1.0}, & 0.4\le v\le 0.6\\ 0, & v\ge 0.6\end{cases}$ $\mu_{V,low}(v)=\begin{cases}0, & 0.6\le v\le 0.65\\ \frac{0.7-v}{2}, & 0.65\le v\le 0.7\\ 1, & v\ge 0.7\end{cases}$	
IOT=I $\mu_I(i)$	$\mu_{I,Excellent}(i)=\begin{cases}1, & 0\le i\le 0.3\\ \frac{0.3-i}{1.0}, & 0.3\le i\le 0.35\\ 0, & i\ge 0.35\end{cases}$ $\mu_{I,Medium}(i)=\begin{cases}\frac{i-0.3}{1.0}, & 0.3\le i\le 0.35\\ 1, & 0.35\le i\le 0.4\\ \frac{0.7-i}{1.0}, & 0.4\le i\le 0.6\\ 0, & i\ge 0.6\end{cases}$ $\mu_{I,low}(i)=\begin{cases}0, & 0.6\le i\le 0.65\\ \frac{0.7-i}{2}, & 0.65\le i\le 0.7\\ 1, & i\ge 0.7\end{cases}$	
Output $(\mu_{ELB}(L_b))$	$\mu_{ELB,excellent}(L_B)=\begin{cases}1, & 0\le lb\le 0.3\\ \frac{0.3-lb}{1.0}, & 0.3\le lb\le 0.35\\ 0, & lb\ge 0.35\end{cases}$ $\mu_{ELB,Medium}(L_B)=\begin{cases}\frac{lb-0.3}{1.0}, & 0.3\le lb\le 0.35\\ 1, & 0.35\le lb\le 0.4\\ \frac{0.7-lb}{1.0}, & 0.4\le lb\le 0.6\\ 0, & lb\ge 0.6\end{cases}$ $\mu_{ELB,Low}(L_B)=\begin{cases}0, & 0.6\le lb\le 0.65\\ \frac{0.7-lb}{2}, & 0.65\le lb\le 0.7\\ 1, & lb\ge 0.7\end{cases}$	

TABLE IV. LOOKUP TABLE OF PROPOUND ELB-MULTILAYER-MAMDANI FUZZY INFERENCE EXPERT SYSTEM

Rules	Data-Center	Virtual-Machine	IOT	ELB
1	E	E	E	E
2	E	E	M	E
3	E	E	L	M
4	E	M	E	E
5	E	M	M	M
6	E	M	L	M
7	E	L	E	E
8	E	L	M	M
9	E	L	L	L
10	M	E	E	E
11	M	E	M	M
12	M	E	L	M
13	M	M	E	M
14	M	M	M	M
15	M	M	L	M
16	L	E	E	E
17	L	M	E/M/L	L
18	L	L	E	L
19	L	E	E	E
20	E/M/L	E/M/L	E/M/L	L

Fuzzy IF-THEN standards are the contingent explanation connected to the participation capacities. These principles are components of the fuzzy standard base. Others parts like tenets surface, rules watcher, and so on are rely on fuzzy guideline base so fuzzy principles base is a noteworthy component of FIS. Fuzzy rule base of our expert system has 30 rules at the final layer. Rules are denoted by $RL^n, where\ 1 \leq n \leq 30$.

RL^1= **IF** Data-center is Excellent AND Virtual-Machine elements are excellent AND IOT are excellent **THEN** Load Balancing is Excellent

RL^2=**IF** Data-center is Excellent AND Virtual-Machine elements are excellent AND IOT are medium**THEN** Load Balancing is Excellent

RL^3= **IF** Data-center is Excellent AND Virtual-Machine elements are excellent AND IOT are low **THEN** Load Balancing is low

RL^{30}= **IF** Data-center is low AND Virtual-Machine elements are low AND IOT are low **THEN** Load Balancing is low

6) Inference engine: Fuzzy surmising is the path toward mapping from an offered commitment to a yield using fuzzy rationale. Its fundamental segment of Fuzzy surmising is enrollment capacities, fuzzy rationale administrators, and on the off chance that rules. A single fluffy association is made by all precepts in the fluffy rule base. It lies under the interior thing on the information which can be seen as a simply fuzzy IFTHEN rule.[19-20] All guidelines in the fluffy principle base are joined into a solitary fluffy connection that lies under inward item on info universes of talk, which is then seen as a just fuzzy IFTHEN rule. A sensible administrator for joining the principles is association. Let Rl^n be a fuzzy relation that represents fuzzy IF-THEN rule of the Final Layer of the propound ELB-ML-MFIS Expert System; which is,

$$Rl^n = D^n \times V^n \times I^n \to {L_b}^n \quad (7)$$

The Equation (7) can be written as

$$\mu_{D\cap V\cap I}(d, v, i,) = \mu_D(d) \cap \mu_V(v) \cap \mu_I(i)] \quad (8)$$

The rules of the final layer are interpreted as a single fuzzy relation defined by

$$R_{30} = \cup_{n=1}^{30} RL^n \quad (9)$$

This blend of principles is called Mamdani mix. Expect I and Ψ be any two fuzzy sets and furthermore info and yield of fuzzy surmising motor individually. To see R30 as a solitary fuzzy IF-THEN principle by utilizing the summed up modus ponens, we get the output of the fuzzy inference engine as

$$\mu_{Execellent\cap Medium\cap Low}(\Psi)$$
$$= sup_{i\in(D,V,I)}\ t\left[\mu_i(d, v, i), \mu_{R_{30}}(d, v, i, L_b)\right] \quad (10)$$

The Product Inference Engine (PIE) of proposed ELB-ML-MFIS Expert System can be written as

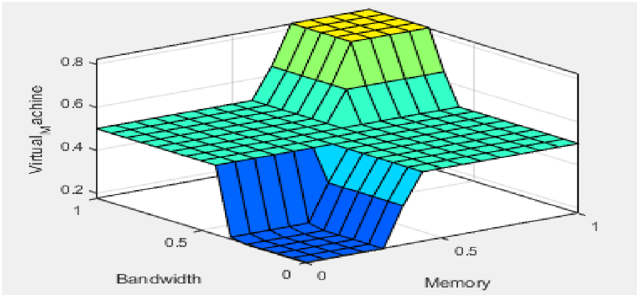
$$\mu_{\Psi}\,(LoadBalancing) = \max_{1\leq n\leq 30}$$
$$\left[sup_{i\in(d,V,I,)}\left(\prod_{j=1}^{90}\begin{pmatrix}\mu_{D_j,V_j,I_j}\,(d, v, i,), \mu_{D_{1_i}V_{2_i},I_{3_i}}\\ (d_1, v_2, i_3)\end{pmatrix}\right)\right] \quad (11)$$

7) De-Fuzzifier: A standout amongst the most basic segments of an Expert framework is Defuzzifier. It the way toward mapping the fuzzy sent to the fresh yield. There are Three types of the defuzzifier COG Defuzzifier, the center of Average Defuzzifier and Maximum defuzzifier. From these, the best Defuzzifier is "center of gravity Defuzzifier". [21-22]In our propound ELB-ML-MFIS expert system the COG Defuzzifier is used. The COG Defuzzifier indicates the λ* as the focal point of the region secured by the participation capacity of Ψ, that is,

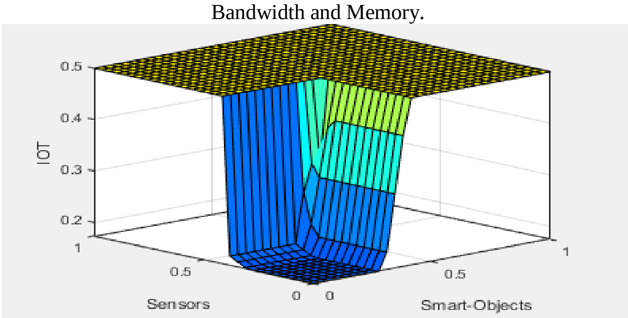
$$\lambda^* = \frac{\int \Psi\,\mu_\Psi\,(\Psi)d\Psi}{\int \mu_\Psi\,(\Psi)d\Psi} \quad (12)$$

The Graphical Representation of Defuzzifier of all layers of propound ELB-ML-MFIS Expert System is shown in Fig. 4(a)-4(d).

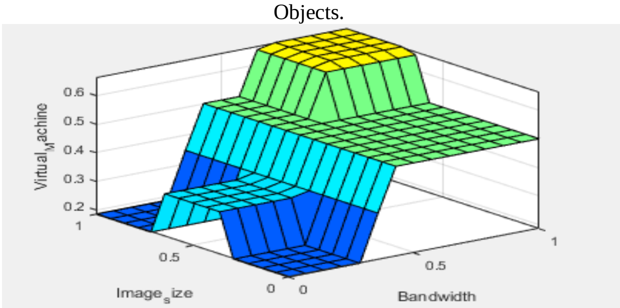
Fig. 4(a) shows load balancing of cloud concerning virtual machine components (bandwidth and Memory). It observed that in Fig. 4(a) load balancing of cloud is Excellent (Yellow shade) when Memory is ≤ 13 and Bandwidth is ≤3. And load balancing of cloud is Medium (Greenish Shade) when Memory lies between 12 to 16 Bandwidth & Bandwidth is occupied between 2.5 to 5.5. Another wise load balancing of cloud is slow.



(a) Rules Surface of Load Balancing based Upon Virtual Machine Values: Bandwidth and Memory.



(b) Rules Surface of Load Balancing based Upon IOT: Sensors and Smart Objects.



(c) Rules Surface of Load Balancing based Upon Virtual Machine: Image Size and Bandwidth.

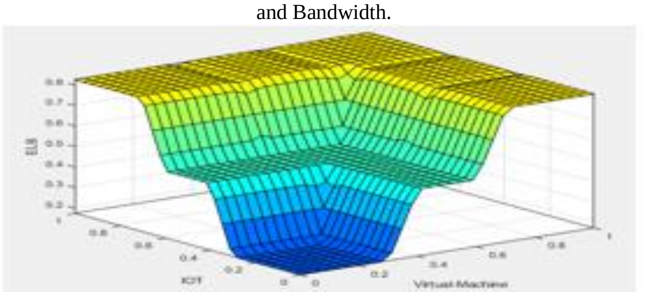


Fig. 4. (d) Rules Surface of Load Balancing Final Layer based upon IOT and Virtual Machine.

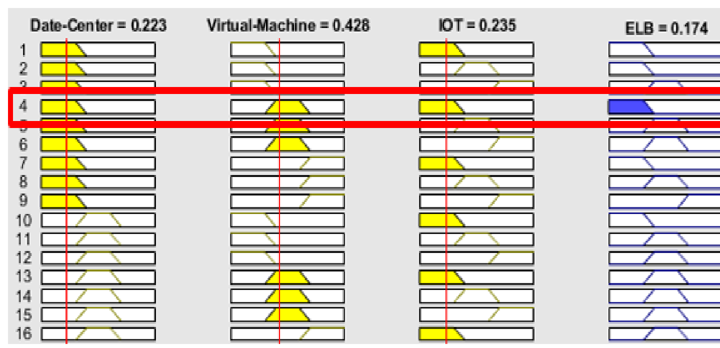
Fig. 4(d) shows load balancing of cloud concerning IOT & Virtual Machine components. It observed that in Fig. 4(d) load balancing of cloud is Excellent (Yellow shade) when Probability of both components intensity is ≥ 0.65. And load balancing of cloud is Normal (Greenish Shade) when Probability of both components intensity is lies between 0.35 to 0.65. Otherwise, load balancing of cloud is low.

Similarly, remaining Fig. 4(b)-4(c) are also representing the water quality by prevailing different input parameter values. Yellow, Greenish & Bluish shade represents water quality is Excellent, Normal & low (polluted) respectively.

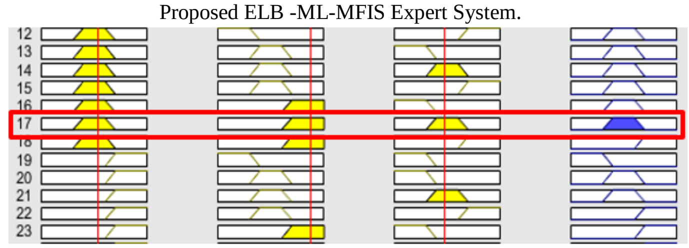
8) Simulation results: Fig. 5(a) shows that if Data-Center detection value is low, Virtual-Machine value is medium and IOT is low then the load balancing in cloud computing is low (Not good).

Fig. 5(b) shows that if Data-Center detection value is medium, Virtual-Machine is excellent and IOT is Normal, the load balancing in cloud computing is medium. (Good)

Fig. 5(c) shows that if Data-Center detection value is excellent, Virtual-Machine is and IOT is Excellent then load balancing in cloud computing is Excellent. (Good)



(a) Final Layer, Lookup Diagram of Low Load Balancing in Cloud for Proposed ELB -ML-MFIS Expert System.



(b) Final Layer, Lookup Diagram of Normal Load Balancing in Cloud for Proposed ELB -ML-MFIS Expert System.

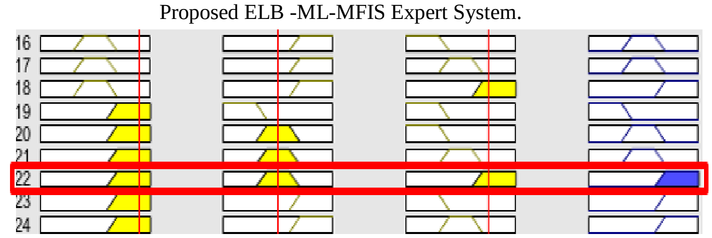


Fig. 5. (c) Final Layer, Lookup Diagram of Excellent Load Balancing in Cloud for Proposed ELB-ML-MFIS Expert System.

TABLE V. ACCURACY OF THE PROPOSED ELB-ML-MFIS EXPERT SYSTEM

Rules	Data-center	Virtual-Machine	IOT	Human Expert Decision	Proposed ELB-ML-MFIS-ES Decision	Probability of Correctness(P_c)	The probability of Error's (P_e=1-P_c)
1	E(0.87)	E(0.79)	M(0.51)	E (Good)	E (Good)	1	0
2	M(0.61)	E(0.91)	E(0.86)	E (Good)	E (Good)		
3	E(0.92)	E(0.76)	E(0.83)	E (Good)	E (Good)		
4	E(0.88)	M(0.56)	E(0.89)	E (Good)	E (Good)		
5	M(0.61)	M(0.36)	E(0.71)	E (Good)	M(Good)		
6	M(0.48)	E(0.87)	E(0.87)	E (Good)	E (Good)		
7	M(0.64)	E(0.86)	M(0.47)	E (Good)	E (Good)		
8	M(0.56)	E(0.93)	E(0.75)	E (Good)	E (Good)		
9	M(0.55)	E(0.79)	M(0.54)	M(Good)	M(Good)		
10	E(0.69)	M(0.48)	M(0.53)	M(Good)	M(Good)		
11	E(0.95)	M(0.59)	M(0.59)	M(Good)	M(Good)		
12	E(0.85)	M(0.68)	E(0.93)	M(Good)	E(Good)		
13	M(0.53)	E(0.80)	M(0.46)	M(Good)	M(Good)		
14	M(0.55)	M(0.61)	M(0.55)	M(Good)	M(Good)		
15	M(0.47)	M(0.51)	E(0.75)	L (Not-good)	L (Not-good)	1	0
16	M(0.49)	B(0.19)	L(0.21)	L (Not-good)	L (Not-good)		
17	M(0.61)	M(0.44)	L(0.11)	L (Not-good)	L (Not-good)		
18	E(0.89)	M(0.42)	E(0.79)	L (Not-good)	L (Not-good)		
19	M(0.54)	E(0.78)	L(0.01)	L (Not-good)	L (Not-good)		
20	E(0.71)	E(0.81)	L(0.21)	L (Not-good)	L (Not-good)		

V. CONCLUSION

The main impartial of this research is to design an expert system to the assessment of ELB in Cloud Computing developed under the guidelines from the Microsoft Cloud Computing Organization and Punjab Information Technology Board, Pakistan. The propound Expert System is straightforward to use for professional and non-professionals. The proposed ELB-multilayer-mamdani fuzzy inference Expert System can categorise the level of Load Balancing in cloud computing into Excellent, Normal or Low. ELB-multilayer-mamdani fuzzy inference Expert System uses input Cloud Computing parameters such as bacterial, physical, chemical and radioactive for different layers. It's also observed that Propound ELB- multilayer-mamdani fuzzy inference Expert System gives more accurate results. The coherence of the proposed system can be ameliorate using other soft computing approaches like Neural network, Neuro-Fuzzy, etc.

REFERENCES

[1] Rajkumar Buyya, Chee Shin Yeo, Srikumar Venugopal, James Broberg, and Ivona Brandic, Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility, Future Generation Computer Systems, Volume 25, Number 6, Pages: 599-616, ISSN: 0167-739X, Elsevier Science, Amsterdam, The Netherlands, June 2009.

[2] Rodrigo N. Calheiros, Rajiv Ranjan, Anton Beloglazov, César A. F. De Rose, and Rajkumar Buyya, "CloudSim: A Toolkit for Modeling and Simulation of Cloud Computing Environments and Evaluation of Resource Provisioning Algorithms", Software: Practice and Experience, Volume 41, Issue 1, pages 23–50, January 2011.

[3] T V R Anandarajan, M A Bhagyabini, "Co-operative scheduled Energy aware load-balancing technique for an efficient computational cloud", IJCSI, volume 8, issue 2, March 2011.

[4] D A Mansai, P NGO, "Understanding Cloud Computing: Experimentation and Capacity Planning", Proc. Computer Measurement Group Conf, Dallas, TX, Dec. 7-11, 2009.

[5] Menno Dobber, Rob van der Mei, and Ger Koole "Dynamic Load Balancing and Job Replication in a Global -Scale Grid Environment: A Comparison" IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS, vol. 20, no.2, pp 207, Feb 2009.

[6] Kuo-Qin Yan; Wen-Pin Liao; Shun-Sheng Wang, "Towards a Load Balancing in a three-level cloud computing network", 3rd IEEE International Conference on Computer Science and Information Technology (ICCSIT), 2010, Vol -1, pp.-108-113, 2010.

[7] Jeffrey M. Galloway, Karl L. Smith, Susan S. Vrbsky, "Power Aware Load Balancing for Cloud Computing", Proceedings of the World Congress on Engineering and Computer Science 2011 Vol I WCECS 2011, October 19-21, 2011.

[8] Raul´ Alonso-Calvo, Jose Crespo, Miguel Garcia´ıa- Remesal, Alberto Anguita, and Victor Maojo "On distributing load in cloud computing: A real application for very-large image datasets", International Conference on Computational Science, ICCS 2010, pp. - 2669-2677, 2010.

[9] Zenon Chaczko Venkatesh Mahadevan, Shahrzad Aslanzadeh and Christopher Mcdermid, "Availability and Load Balancing in Cloud Computing", 2011 International Conference on Computer and Software Modeling IPCSIT vol.14, IACSIT Press, Singapore, 2011.

[10] B. Wickremasinghe, R. Calheiros, and R. Buyya, "CloudAnalyst: A CloudSim-Based Visual Modeller for Analysing Cloud Computing Environments and Applications," in 24th IEEE Int. Conf. on Advanced Information Networking and Applications, Perth, Australia, 2010, pp.446-452.

[11] X. Kon, C. Lin, Y. Jiang, W. Yan, and X. Chu, "Efficient Dynamic Task Scheduling in Virtualized Data Centers with Fuzzy Prediction," J. of Network and Computer Applications, vol. 34, issue. 4, pp.1068-1077, July 2011.

[12] Alexandru Iosup, Member, IEEE, Simon Ostermann, Nezih Yigitbasi, Member, IEEE, Radu Prodan, Member, IEEE, Thomas Fahringer, Member, IEEE, and Dick Epema, Member, IEEE, "Performance Analysis of Cloud Computing Services for Many -Tasks Scientific Computing", IEEE TPDS, MANY-TASK COMPUTING, NOVEMBER 2010.

[13] Martin Randles, David Lamb, A. Taleb-Bendiab,"AComparative Study into Distributed Load Balancing Algorithms for Cloud Computing", IEEE 24th International Conference on Advanced Information Networking and Applications Workshops, 20-23, pp. 551-556, April 2010.

[14] Meenakshi Sharma, Pankaj Sharma, Sandeep Sharma, "Efficient Load Balancing Algorithm in VM Cloud Environment", IJCST Vol. 3, Issue 1, pp.- 439-441, Jan. - March 2012

[15] R. Shimonski. "Windows 2000 & Windows Server 2003 Clustering and Load Balancing", Emeryville. McGraw-Hill Professional Publishing, CA, USA (2003), p 2, 2003.

[16] Ali M. Alakeel, "A Guide to Dynamic Load Balancing in Distributed Computer Systems", IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.6, June 2010.

[17] R. X. T. and X. F. Z, "A Load Balancing Strategy Based on the Combination of Static and Dynamic, in Database Technology and Applications (DBTA), 2010 2nd International Workshop 2010, pp. 1-4, 2010.

[18] IETF, 2010, Extensible Messaging and Presence Protocol (XMPP): CoreRFC3920, http://datatracker.ietf.org/doc/rfc3920/, viewed on 25th of Nov 2010.

[19] Y. F. Wong and W. C. Wong. "A fuzzy-decision-based routing protocol for mobile ad hoc networks" 10th IEEE International Conference on Network, pp. 317–322, 2002.

[20] G. V. S. Raju, G. Hernandez, and Q. Zou, "Quality of service routing in ad hoc networks", IEEE Wireless Communications and Networking Conference, Vol. 1, pp. 263 –265,2000.

[21] W. Pedrycz and F. Gomide, "An introduction to fuzzy sets: analysis and design", complex adaptive systems. MIT Press, 1998.

[22] J. J. Buckley, E. Eslami, and E. Esfandiar." An introduction to fuzzy logic and fuzzy sets" advances in soft computing, Physica Verlag, 2002.