The Architecture of Autonomic Cloud Resource Management

Poorva Shukla, Prashant Richhariya, Bhupesh Kumar Dewangan, Tanupriya Choudhury, and Jung-Sup Um

1 Introduction

Cloud computing [1] as a rising innovation has reformed the data innovation industry by versatile on-request allocation and deallocation of registering assets. Cloud computing [2, 3] is a new rising computing mechanism where the suppliers center around sharing of processing assets through a web-based, versatile serving, and "pay more only as costs rise" way to encourage client's solicitations. With thoughtfulness regarding the quick development of an enormous measure of information producing, the requirement for calculation of assets and collected information is remarkable. Cloud computing [4, 5] provides immense profitable and environmental data collection for the IT industry to decrease the cost of the industry using Industry 4.0 technologies in cloud computing [6–8]. In the cloud computing [9] world, there are services used in cloud [10] technology such as IaaS (Infrastructure as a service), PaaS (platform as a service), and SaaS (Software as a service). Due to this, a few arrangements were applied to arrive at proficient energy, vitality the board for these Datacenters, for example, improving IT foundations (Servers and stockpiles, organize gear), structuring equipment with vitality productive designs, vitality mindful occupation booking, power appropriation methods, dynamic voltage and

P. Shukla (✉) · P. Richhariya
Department of Computer Science and Engineering, IIST, Indore, India

B. K. Dewangan · T. Choudhury
Department of Informatics, School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttarakhand, India
e-mail: tanupriya@ddn.upes.ac.in

J.-S. Um
Department of Geography, College of Social Sciences, Kyungpook National University, Daegu, South Korea

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recurrence scaling (DVFS), advanced setup and force interface strategies, power the executive procedures (union, provisioning, and virtualization), turn unused hubs to turning off mode, and different strategies [11, 12]. Industry 4.0 (the 'fourth mechanical upset') is the advancement to raise computerization, M-to-M and H-to-M correspondence, man-made reasoning, i.e., AI, and proceeded with innovative enhancements and modification in assembling.

Industry 4.0 has the following four interruptions:

- Increase in data generation.
- Analysis of generated data and connectivity.
- Development of examination and business insight capacities—for example new types of human–machine communication, for example, contact interfaces, and enlarged reality frameworks [11, 12].
- Upgrades in moving computerized directions to the physical world, for example, propelled mechanical technology and 3D printing.

The meaning of cloud computing is that data can be stored and accessed over the Internet instead of our personal home computer and network. The cloud is called a metaphor for the Internet. To decrease the upkeep cost of registering situations, the organizations are progressively incorporating their registered foundations which are along these lines overseen by explicit organizations which we call suppliers.

1.1 What is Autonomic Computing

Autonomic computing is one of the new terminologies used in the field of cloud computing, and it is a PC's capacity to oversee itself consequently through versatile advances that further figure abilities and cut down on the time required by PC experts to determine framework troubles and other upkeep, for example, programming refreshes. The concept of autonomic computing is developed by IBM. It is one of the autonomic systems that does not involve human interaction and that type of computing believes in autonomic computation without much interference from end users. IBM explains the four major fields of autonomic computing

1. Self-agreement or configuration.
2. Self-remedy or healing.
3. Self-control of autonomic resources (awareness).
4. Self-identification from intruders attacks.

There are four main fields of autonomic computing, where the AC works independently without the interference of human interaction. Now the emerging technology, autonomic computing system, works on 3 As which include Automation [13], Adaptivity, and Awareness. The mechanism of autonomic computing works like nervous system of the human body; it purely works on the human nervous system. An autonomic nervous system takes all decisions independently and reacts accordingly. In autonomic computing, the nervous system of autonomic computing

behaves according to the nature of the data, and full consciousness of input data means data are entered and what environment they require to execute. Functions of autonomic computing environment used a high level of AI (Artificial intelligence), while the rest of the data is invisible to the user.

1.2 Why Autonomic Computing Is Used

Autonomic figuring or computing is one of the structure squares of inescapable processing, a foreseen future registering model in which small—even imperceptible—PCs will be surrounding us, imparting through progressively interconnected systems prompting the idea of Internet of Everything (IoE). Numerous industry chiefs explore different parts of autonomic figuring and autonomic computing. The main reason to use autonomic computing is to minimize the cost of purchasing softwares. The main advantage of using autonomic computing is to minimize the environmental cost, continuity cost purchasing price packet delivery ratio, throughput time, delay time, and improving reliability of the IT industry system. All this is possible when we use autonomic computing in Industry 4.0. Besides, why do we use autonomic computing? The major reason to use autonomic computing is to give an opportunity to another industry or companies to run their own business very smoothly online only based on cloud. Due to this, they are able to accept other business policies without the need for any basic platform because autonomic computing fulfills the need of industry policy. They also give an update on modified applications based on the changing environment. Now, with the use of autonomic computing, we can increase reliability, storage, availability, and reduce human efforts or manpower cost to maintain large programs, software, and applications on the server.

The future of autonomic computing is very bright because autonomic processing vows to streamline the administration of figuring frameworks. Be that as it may, that ability will give the premise to substantially more powerful cloud computing. Different applications incorporate server load adjusting, process allotment, observing force gracefully, programmed refreshing of programming and drivers, pre-disappointment cautioning, memory mistake amendment, computerized framework reinforcement and recuperation, and so forth.

1.3 Role of Autonomic Cloud Resource Management in Autonomic Computing

The main role of cloud resource management in autonomic computing is the self-agreement, or the self-configurable nature of cloud resources means they are able to work independently. Cloud computing agreements are similar to traditional software

licensing agreements but often have more in common with hosting or application service provider agreements. So they can make an agreement to consult the hosting service provider as per their requirements without human interference because autonomic cloud resource management works under autonomic computing, and autonomic computing works based on the human body's nervous system. Autonomic cloud resource management system can accept the changing environment and they automatically interact with their nearest system. These kinds of cloud resources make communication with the neighboring cloud resources with an appropriate communication protocol. The cloud resource management system is much more intelligent compared to traditional because they know which resource is capable, what limitation they have, which communication protocol is used and how, and why they are communicating with the connected resources. The management of cloud resources depends on their configuration capability, which is much higher than that of traditional cloud resources because traditional cloud resources are managed by human nervous system itself, but in autonomic cloud, resource management is used in autonomic computing; so they are intelligent systems and they know where and which resource needs updated configuration and where they need service provider agreements. That is why we say that this autonomic management system is self-agreement or configuration, self-remedy or healing, self-control of autonomic resources (awareness), and self-identification from intruders attacks [14].

The autonomic systems are capable to configure and reconfigure automatically which totally depends upon changes in real-time computing environment and make the system very optimistic and deployable in an efficient computing process. The process flow of interaction with autonomic manager is shown in Fig. 1.

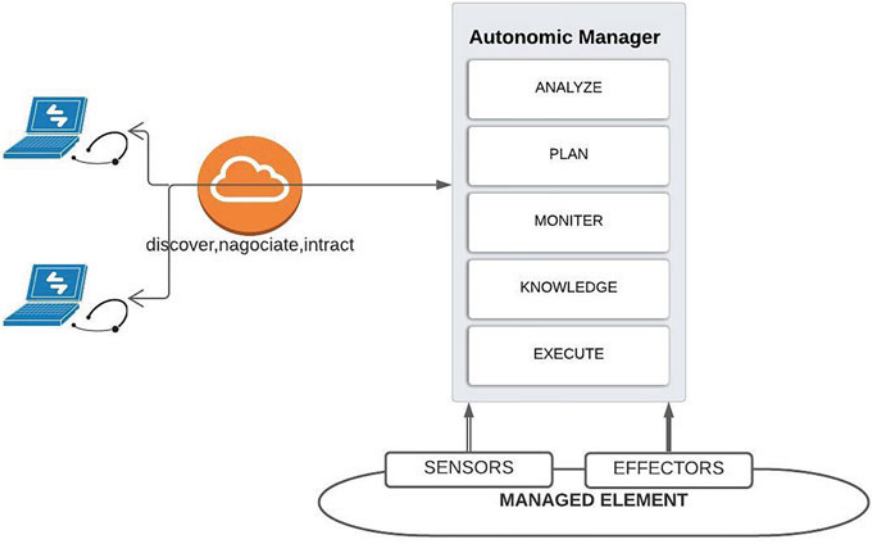

Fig. 1 Interaction with autonomic manager

2 Literature Survey

A writing survey gives the setting, advises philosophy, expands development, stays away from duplicative exploration, and guarantees that proficient principles are met. Writing audits require some investment, are iterative, and should proceed all through the examination procedure.

The main reason for a writing survey is to spot each work with regard to its commitment to understanding the examination issue being considered; portray the relationship of each work to the others viable; and recognize better approaches to decipher earlier examination.

2.1 Investigation Method

There are so many aspects where we can investigate the result. In this chapter, we read 40 research papers and Internet articles related to architecture of cloud resource management and deep study of architecture of autonomic cloud resource management, but only references 20 research papers are included in this chapter.

Dewangan et al. [15] describe autonomic cloud resource management system. In cloud resource management, autonomic computing is one of the famous models in business industry that is useful for service providers, and it gives benefits in terms of cost, and service providers can use these cloud resources, but the main thing is in what manner these resources are allocated among customers in the Industry 4.0. Various researchers researched cloud resources, and they succeeded in this field, but the need is to make efficient use of resources through which we can save our atmosphere. Now, in this article the author gives an efficient approach for using autonomic cloud resources based on classification of the current study like techniques used in cloud resource management functions. Now cloud resource management is most popularly used in the business model. Autonomic cloud resource management is highly used in Industry 4.0 which gives profit to each and all IT industry and business industry. Autonomic cloud resource management is based on on-demand and pay-per-use methods; whenever the need arises then ACRM is used to allocate adoptable resources that are compatible for the required platform. Here some concept of virtualization and virtual machine is used. ACRM is fully based on on-demand policy [16–18]. So multiple autonomic cloud resources are available. ACRM gives facility to choose compatible cloud resources as per the user demand; but without the interference of human power, they automatically understand what is the need of the user to run particular application or softwares. So free resource pools are available. The ACRM chooses compatible resource for particular user applications or softwares and allocate among customers (end users). Once the user completes their work, all the compatible resources which allocate among end users at the time of execution are deallocated and free the cloud resources in cloud. After the completion of execution, it means the allotted resources are free

if another user wants to pick the particular resource in the resource pool, they take it and work for its execution process.

The use of autonomic cloud resources directly affects the price of services that are provided by the cloud. Now the demand for cloud resources is increasing day by day. Due to this increasing demand of cloud resources, the service provider has to maintain the quality of service provided to customers' security, service-level agreement (SLA) violations, rate energy utilization by resources, price, rate of packet transfer, throughput, delivery ratio, etc. During the survey we found that energy utilization has decreased through self-improvement (optimization), SLA violation rate is reduced by self-remedy (Healing), and find defective virtual machine from cloud resource pool and make a separate resource pool of defective virtual machine. In proceeding, the working expense of assets improves, and reduced execution time has been recorded [16]. The author in autonomic cloud resource management gives an architecture, where the cloud resource management gives an architecture where the cloud users collect the data sets of workloads and submit it for clustering where all the workload data sets are divided into clusters. Depending on the working of each cluster, the resource manager is responsible for QOS and SLA of each cluster.

In self-optimization method, check whether the data sets give an optimal solution or not according to their fitness value. If it meets optimal solution, then they choose the compatible resources in the resource pool. But if the optimal solution does not meet, then data sets check their fitness value again until and unless it gives an optimal solution. During the optimization, some fault may occur and the fault prediction mechanism finds whether node failure occurs; if yes then the fault manager tries to the resolve node performance, but if node failure does not occur, then this node is replaced with another one after that resource scheduler prepares their schedule for execution. After that it is submitted to the cloud user to check QOS and SLA for satisfactory result. Some problems are trying to reduce problems in their proposed work for better performance. The problems are as follows.

- Service-level agreement violations rate.
- Execution time would be very high.
- Use of resource utilization.
- Improve fault tolerance technique.
- Price of resources is high.
- More energy consumption.

Distributed computing gives a stage where administrations are encouraging the cloud client through the web, either liberated from cost or rent base. The cloud client and requests are expanding, and because of this, a huge number of administration demands are submitted to the cloud specialist organization. The similar examination of all the studied calculations as far as various execution measurements. The perception of the overview gives some exploration holes to improve the productivity of the current asset in the board framework [17].

In this paper, the author gives the concept of STAR (Standardized Testing and Reporting). The principle reason to give STAR is to limit the SLA infringement

Table 1 The comparative analysis of different autonomic computing techniques in cloud are presented in Table 1.

Strategy given by	SLA	ACRM	PBM	IT	Industry 4.0	Method
Mehrdad Maeen et al. [6]	√	√	√	×	√	×
Lenk et al. [11]	×	√	×	√	×	√
Bahrami et al. [12]	√	√	√		√	√
Pooja Dehraj et al. [14]	×	√	√	√	√	√
Choudhury et al. [15]	√	√	√	√	√	√
Agarwal et al. [17]	√	√	√	√	√	√
Venkatadri et al. [19]	√	√	√	√	√	√
Pasricha et al. [20]	√	√	√	√	√	√
Dewangan et al. [21]	√	√	√	√	√	√
Sukhpal Singh and Inder et al. [18]	√	√	√	×	×	√
Qiu et al. [22]	×	√	√	√	×	√
Özer et al. [18]	√	×	√	×	×	×
Yumin Wang et al. [23]	√	×	√	×	√	√
Atul Vikas Lakra et al. [24]	√	√	×	√	×	×
Saraswathi and Kalaashri et al. [25]	√	√	×		×	√
Tahir M et al. [26]	√	×	√	√		√
Sukhpal Singh et al. [27]	×	√	×		√	√
Salah [28]	√	×	×	√	√	√
Salah et al. [29]	√	×	√	√	√	√
Nazir et al. [30]	×	√	√	×	×	√
Vikas Mangotra et al. [31]	×	√	√	×	×	√
Nima Jafari Navimipour et al. [32]	×	×	√	√	×	√
Anjum Mohd Aslam et al. [33]	×	×	√	√	×	√
Aarti Singh et al. [34]	√	×	√	√	×	√
Son et al. [35]	×	×	√	√	×	√
Dewangan et al. [13]	√	√	√	√	√	√

and upgrade the client fulfillment by giving their QoS as required (Table 1). In this paper, creator contemplations, the accompanying SLA like execution dependent on cost, inactivity, execution time, availability, and unwavering quality to limit the SLA infringement to fulfilled QoS. This calculation is actualized and executed in a real cloud condition at Thapar University, and the results show the exhibition for SLA infringement is better as far as an existing asset the board procedures [18]. Planning can be expressed as an occasion to occur at a specific time. There are numerous kinds of planning calculations accessible in disseminated figuring for asset booking. Numerous calculations are to be used in the circulated framework by proper validation. The motivation behind the booking calculation is to accomplish extreme throughput. For a cloud situation, the standard methodologies cannot accomplish the ideal effectiveness [17].

Resource planning for distributed computing is an apparatus, which influences the operational expense of the specialist co-op and the cloud client. Numerous

scientists have been working toward resource planning in various angles like burden adjusting, make span, remaining tasks at hand need, asset accessibility, and cost. In this paper, the author will diverse asset planning systems and their methods, and perceptions of this examination show that a large number of these structures are not completely computerized and based on a smaller number of execution target work, and the assets are booked. Because of the expanding administration request, this work likewise finds that the accommodation of outstanding tasks at hand by cloud client to booking the assets, and computerized approach is required [17, 18].

The author gives the concept of self-improved vitality of effective resource executives methodology has been considered, which gives the ideal answer for expanding the resource usage and distinguish the defective resource to protect from misdirecting of planning. The executives in cloud are basic necessity for specialist co-op and cloud client too. The resource provisioning in the cloud should be low in cost and execution. In view of these two boundaries, the accompanying perception completed: SLA infringement rate is high, execution time can be less, scope to boost the resource usage, energy utilization can be less, fault-tolerant strategies should be executed to distinguish broken VM's, and resource cost can be less. Energy utilization and some faulty resources are two key points. The resources are overseen by selecting the best VM esteem through self-improvement, and defective VM is distinguished through self-mending qualities. The quality virtual machine is distinguishing the remaining burdens to other VMs, so the virtual machine can be used for better outcomes. The rate of energy utilization and effectiveness investigation is registering and found that it is performing better [22].

The supplier's compensation has three fragments: the compensation of the favorable position, the expense of the VM occasions that regulate to the clients, and the expense of keeping whatever is left of the advantages sit out of apparatus and Proposes a model, called ABRA (Auction-Based Resource Co-Allocation) to deal with the benefit allotment issue. It powers discipline costs on unallocated resources after a closeout with a particular ultimate objective to improve the asset use [23, 24].

Autonomic cloud computing provides an environment where there are so many services available for users for where the basic need is only Internet connectivity, and the user may use this facility either cost free or pay per use. The cloud services demand is increasing day by day. Due to increasing environment, we have to scale out the existing policies. Scaling comes at the expense of substantial vitality utilization because of the incorporation of various server farms and servers. The superfluous force utilization influences the working costs, which thus, influences its clients. In this paper, the author proposes simulated cloud resource allocation conditions and figures vitality utilization for various outstanding tasks at hand amount and it expands the exhibition of various multi-goals capacities to amplify the asset usage. It contrasted and existing structures and examination results show that the proposed system performs most extreme.

The ESCORT system was introduced to advance vitality utilization, execution cost, and SLA infringement rate. This structure is actualized and reenacted in the clouds condition. The outcome may differ when it will be executed in the genuine

cloud. In this, it is introduced in a point-by-point stream of ESCORT that, how to apply the proposed system to limit the vitality utilization, SLA infringement rate, execution time, and cost to augment the exhibition for planning in the cloud. The examination of proposed work with different procedures guarantees that ESCORT performs most extreme. ESCORT recreation results limit the SLA infringement rate, execution cost, and amplify the use of the asset. The confinement of this work is that no separating strategies are applied for pernicious remaining task at hand; in future, it will be actualized to ad lib the proposed work [23]. To minimize the computing cost by which increasing demand of companies or IT sectors and IT sector elaborate their infrastructure. So, the cloud resources are in high demand.

The increased market will be maintained by the service provider or call providers. They have to deliver quality services because the overall expenditure of the market depends upon the industries or IT sectors. On-request asset allotment is one of the primary administrations that such a situation must guarantee. It must permit the portion of asset varying and asset de-allocation when they are not utilized any longer. This paper depicts various situations, which comprise guaranteeing dynamic asset allotment for a bunched J2EE application conveyed in a facilitating focus. It very well may be utilized to screen applications in a facilitating focus and at whatever point it is required, allot another machine, send the necessary programming parts on that hub and reconfigure the application to incorporate these new segments [19]. The expression "asset provisioning" has been characterized in various settings found in the literature. We saw the constant commitment has been made by International Symposium on Cluster, Cloud, and Grid Computing (CCGrid) in the field of cloud asset provisioning for head way of exploration. Ongoing exploration portrays that powerful asset provisioning systems give better asset booking. It is exceptionally hard to track down the best asset and outstanding task at hand pair for productive planning. So, it is recommended that as opposed to recognizing outstanding task at hand and asset, we ought to have the legitimate determination of asset and QoS necessities of remaining burdens for better asset the board [35].

2.2 Problem Identification and Challenges in Autonomic Cloud Resource Management

Autonomic cloud computing is very advanced technology in Industry 4.0 which makes our work easy and simple, with the basic requirement of proper Internet connectivity in the user's point of view. In autonomic cloud computing technology, autonomic cloud resource management is one of the major problems from provider's point of view. Major problems include SLA violation rate, execution time is very high, resource utilization, load stability, timing slot per job, cost, vitality improvement and accessibility, fault-tolerance problem in faulty node due to which resources are allocated to faulty node and if faulty node occupies the resources the

other resources are in waiting state, so it creates major issues in autonomic cloud resource management. Hence, we need a mechanism that finds nature of executing job and then decide which resource is compatible for that particular job (Table 2).

3 Methodology

In this architecture, autonomic cloud resources are fully used by the executing job. After the execution of job, this mechanism has to follow some mechanism. It means that this mechanism first identified at the user level. Data sets and overall workloads will be available with the end user itself, and if data set is large then it splits it into number of clusters (small packets) and work on each cluster, and if data set is smaller, it can directly check its configurability with autonomic cloud resource management in Industry 4.0. Here the mechanism automatically checks whether the node is self-configurable (optimizable) or not; if it gives optimal solution, then the resource will be allocated in the resource pool to each and every node to execute their job completely on time. Now the second part shows that if the node does not give any optimal solution, then it goes for fault-tolerance mechanism where they can identify the faulty node; if faulty node is present then this faulty node is replaced with a new node. Then it is again submitted to end users, but if no faulty node is identified by fault tolerance mechanism it is then again submitted for optimization method, where the data set is again optimized for efficient resource allocation. Autonomic computing plays an important role in autonomic cloud resource management in Industry 4.0. Industry 4.0 is revolution in the field of industry or fourth revolution which is mainly used for automation.

The main components used in flow diagram presented in Fig. 2:

USER:
User is one of the main important entity that is related to real-time action. User is the one who gives instructions to other entity in real time, and in this architecture, the user works over different types of data sets. This is also called real-time entity.

Larger data set:
Larger data set means whose size is greater than defined size. Larger data sets need to be split into different data sets which is called clustering.

Smaller data set:
Smaller data set means whose size is smaller than the defined size. It means no need to split into different data sets.

Self-configurable:
The term self-configurable in architecture of autonomic computing in resource management is any node that requires compatible resource to execute the data; they do not need to wait for any other entity or user. They provide the resource system automatically provide resource as per the requirement of resource means automatically configurable without the interference of human brain.

Table 2 Comparative analysis of different frameworks used in different technologies in autonomic cloud management

S.no	Framework	Step by step processor	Reason (parameters)	Evaluation technique	Platform
1.	Allocation scheme of resources	Resource scheduling	Based on priority	Autonomic cloud resource management	Cloud
2.	STAR	Self-maintenance	Rate of SLA violation	Price, throughput, reliability	Cloud
3.	ACRM	Self-healing (configuring) management	VM	Reduced execution time	Cloud
4.	PBM	Process scheduling	Depends on data set workload	Execution cost	Cloud
5.	Optimal resource utilization	Antlion optimization	Resource utilization (to remove faulty resources)	Qos and SLA violation	Cloud
6.	Static behavior of system	Genetic–algorithm ant colony swarm-optimization	SLA violation & Qos	–	Cloud
7.	Self-characteristics scheduling	Energy-efficient resource scheduling	Better resource utilization	Operative cost and execution time	Cloud
8.	Dynamic optimization	Self-characteristics	Without human interaction	Find energy cost and time	Cloud
9.	PC and electronic framework	Continuous administration	Innovation	Fault tolerance	Cloud
10.	Fault-tolerant management	EAR	VM based rejection of faulty machine	Energy consumption	Cloud
11.	Cloudsim toolkit		SLA violation	Operative cost, energy efficiency	Cloud
12.	Resource allocation issue	ABRA (auction-based resource allocation)	Unallocated resources	–	Cloud
13.	OCRP	OCRP algorithm	Provisioning assets	Cost for assets	Cloud
14.	Data centers	Vitality utilization	Qos and reduce energy consumption	Cloud resources in data center	Cloud

(continued)

Table 2 (continued)

S.no	Framework	Step by step processor	Reason (parameters)	Evaluation technique	Platform
15.	ESCORT	Energy consumption algorithm	SLA violation	Execution cost	Cloud
16.	Industry 4.0	ACRM	Self-configurable		Cloud
17.	KMGA	Swarn optimization and genetic algorithm	Minimized number of VMs	Reduce energy consumption of Datacenters and Qos	Cloudsim tool
18.	MyDAQ		Laboratory experiment	Reduced the cost of hardware and computation	Cloud
19.	Deadline based resource provisioning and scheduling algorithm	DBRPSA	Scheduling of resources automatically	Execution time and cost	Cloud
20.	Cluster,cloud & grid computing	CCGrid	Cloud resource provisioning	Proper Qos specification	Cloud
21	Task scheduling	Cuckoo search algorithm	Automatically resource scheduling	Scheduling process	Cloud

Fault detection:

The term fault detection in architecture of autonomic computing in resource management is error. If error occurs due to connection establishment between source to destination and in resource configuration or battery backup, then it would be automatically detected and recovered with the help of given architecture.

Resource pool:

Multiple resources are available in one place; whenever any node requires any resource, they can opt from the resource pool.

Qos:

Quality of service means providing good services without any problem.

SLA violation:

SLA (Service-Level Agreement) which gives full agreement between the communicating parties means if both the sending and receiving parties have SLA then its fine, but if they don't have agreement, then this comes under SLA violation and means this parties unauthorized access.

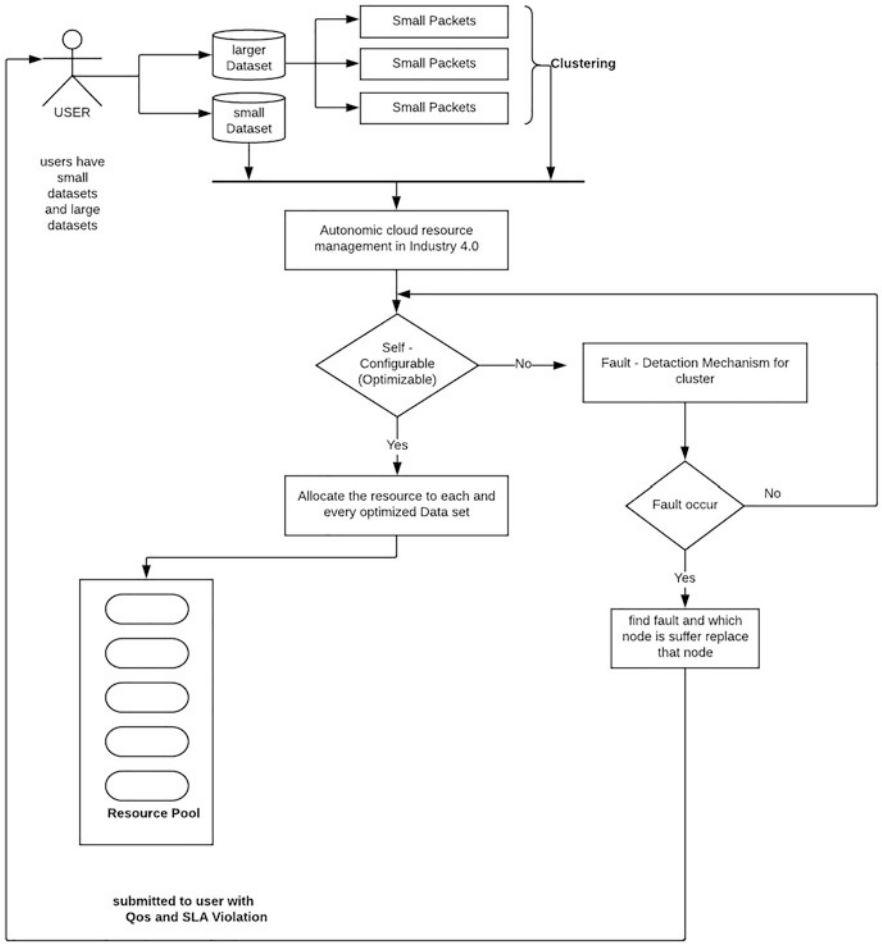

Fig. 2 Architecture for autonomic cloud resource management

4 Conclusion and Future Research Scope

Industry 4.0 means the fourth revolution in the field of industry or fourth revolution which is mainly used for automation M to M, H to M communication, digitization, etc., and exchanging of data in different technology. This is very beneficial for cloud computing automatic technologies and IOT. Autonomic cloud computing is an advanced technology in Industry 4.0 which makes our work easy and simple with only basic requirement of proper Internet connectivity from the user's point of view. In autonomic cloud computing technology, autonomic cloud resource management is one of the major problems from the provider's point of view. Autonomic cloud computing provides an environment where there are many services available for

the users and the basic need is only Internet connectivity, and the user may use this facility either cost free or pay per use. Nowadays, this cloud services demand is increasing day by day. Due to increasing environment, we have to scale out the existing policies. The scaling comes at the expense of substantial vitality utilization because of the incorporation of various server farms and servers. The superfluous force utilization influences the working costs, which, thus, influences its clients. In this chapter, the architecture of autonomic cloud resources is fully used by the executing job. After the execution of job, this mechanism has to follow some mechanism and resolve some problem issue using autonomic cloud resource management in Industry 4.0.

Appendix

Qos	Quality of service
ACRM	Autonomic computing and resource management
VM	Virtual machine
GA	Genetic algorithm
DVM	Digital variable multisystem
PBM	Profit base management
SLA	Service level agreement
IT	Infrastructure technology
RPS	Resource provisioning strategy
OCRP	Optimal cloud resource provisioning
PSO	Particle swarm optimization
MHOD	Markov host overload
RPM	Resource provisioning mechanism
FM	Fault tolerance mechanism
RIC	Resource information center
CPU	Central processing unit
CCGrid	Cluster cloud grid algorithm
STAR	Standardized testing and reporting
PC	Personal computer
EAR	Energy-aware resource
ABRA	Auction based resource allocation
ESCORT	Energy consumption
KMGA	k-means genetic algorithm
MYDAQ	Data acquisition (DAQ)
DBRPSA	Dead line-based resource provisioning and scheduling
IOE	Internet of everything

References

1. Choudhury, T., Gupta, A., Pradhan, S., Kumar, P., & Rathore, Y. S. (2017). Privacy and security of cloud-based internet of things (IoT). 2017 3rd international conference on computational intelligence and networks (CINE) (pp. 40–45).
2. Sharma, A., Choudhury, T., & Kumar, P. (2018). Health monitoring & management using IoT devices in a cloud based framework. 2018 international conference on advances in computing and communication engineering (ICACCE) (pp. 219–224).
3. Mittal, A., Khan, F. S., Kumar, P., & Choudhury, T. (2018). Cloud based intelligent attendance system through video streaming. Proceedings of the 2017 international conference on smart technology for smart nation, SmartTechCon 2017. https://doi.org/10.1109/SmartTechCon.2017.8358587.
4. Kumra, S., Choudhury, T., Nhu, N. G., & Nalwa, T. (2018). Challenges faced by cloud computing. Proceedings of the 2017 3rd international conference on applied and theoretical computing and communication technology, ICATccT 2017. https://doi.org/10.1109/ICATCCT.2017.8389105.
5. Dinote, A., Sharma, D. P., Gure, A. T., Singh, B. K., & Choudhury, T. (2020). Medication processes automation using unified green computing and communication model. *Journal of Green Engineering, 10*(9), 5763–5778.
6. Maeen, M., Haghparast, M, & Askarizad, M. (2018). An energy-efficient dynamic resource management approach based on clustering and meta-heuristic algorithms in cloud computing iaas platforms. © Springer Science+Business Media, LLC, part of Springer Nature.
7. Singh, B. K., Sharma, D. P., Alemu, M., & Adane, A. (2020). Cloud-Based Outsourcing Framework for Efficient IT Project Management Practices. *(IJACSA) International Journal of Advanced Computer Science and Applications, 11*(9), 114–152.
8. Tomar, R., Khanna, A., Bansal, A., & Fore, V. (2018). An architectural view towards autonomic cloud computing. In Data engineering and intelligent computing.
9. Yadav, A. K., Tomar, R., Kumar, D., & Gupta, H. (2012). Security and privacy concerns in cloud computing. In Computer science and software engineering.
10. Dewangan, B. K., Jain, A., & Choudhury, T. (2020). GAP: Hybrid task scheduling algorithm for cloud. *Revue d'Intelligence Artificielle, 34*(4), 479–485. https://doi.org/10.18280/ria.340413.
11. Lenk, A., Klems, M., Nimis, J., Tai, S., Sandholm, T. (2009). What's inside the cloud? An architectural map of the cloud landscape. *IEEE Computer Society*.
12. Bahrami, M., & Singhal, M. (2015). The role of cloud computing architecture in big data. In *Information granularity, big data, and computational intelligence*. Cham: Springer. https://doi.org/10.1007/978-3-319-08254-7_13.
13. Faruqui, N., Yousuf, M. A., Chakraborty, P., & Hossain, M. S. (2020). Innovative automation algorithm in micro-multinational data-entry industry. In Lecture notes of the institute for computer sciences, social-informatics and telecommunications engineering, LNICST (Vol. 325 LNICST, pp. 680–692). Springer. https://doi.org/10.1007/978-3-030-52856-0_54
14. Dehraj, P., & Sharma, A. (2020). A review on architecture and models for autonomic software systems. Springer.
15. Choudhury, T., Agarwal, A., Pasricha, A., & Chandra Satapathy, S. (2020). "Extensive review of cloud resource management techniques in industry 4.0: Issue and challenges. *Software: Practice and Experience*. https://doi.org/10.33889/IJMEMS.2020.5.4.060
16. Sukhpal S., Inderveer, C., & Buyya, R. (2016). STAR: SLA-aware autonomic management of cloud resources. IEEE transactions on cloud computing (pp. 1–14).

17. Agarwal, A., Venkatadri, M., & Pasricha, A. (2019). Self-characteristics based energy-efficient resource scheduling for cloud. *Procedia Computer Science, 152*, 204–211. https://doi.org/10.1016/j.procs.2019.05.044.
18. Özer, A. H., & Özturan, C., (2009, September). An auction based mathematical model and heuristics for resource co-allocation problem in grids and clouds. In Soft computing, computing with words, and perceptions in system analysis, decision and control, 2009. ICSCCW 2009. Fifth international conference on (pp. 1–4). IEEE.
19. Venkatadri, M., Agarwal, A., & Pasricha, A. (2018, December). Autonomic cloud resource management. In 2018 fifth international, conference on parallel, distributed and grid computing (PDGC) (pp. 138–143). IEEE. https://doi.org/10.1109/PDGC.2018.8745977.
20. Pasricha, A., Agarwal, A., & Venkatadri, M. (2019). Energy-aware autonomic resource scheduling framework for cloud. *International Journal of Mathematical, Engineering and Management Sciences, 4*(1), 41–55. https://doi.org/10.33889/IJMEMS.2019.4.1-004.
21. Dewangan, M. B. K., & Shende, M. P. (2012). Survey on user behavior trust evaluation in cloud computing. *International Journal of Science, Engineering and Technology Research, 1*(5), 113.
22. Qiu, X., Dai, Y., Xiang, Y., & Xing, L. (2017). Correlation modeling and resource optimization for cloud service with fault recovery. *IEEE Transactions on Cloud Computing, 5*(1), 1–13.
23. Yumin, W., Li, J., & Haoxiang Wang, H. (2017). Cluster and cloud computing framework for scientific metrology in flow control. Springer.
24. Lakra, A. V., & Yadav, D. K. (2015). Multi-objective tasks scheduling algorithm for cloud computing throughput optimization. In *International conference on intelligent computing, communication & convergence* (pp. 107–113). Bhubaneswar: Elsevier.
25. Saraswathi, A. T., Kalaashri, Y. R. A., & Padmavathi, S. (2015). Dynamic resource allocation scheme in cloud computing. *Procedia Computer Science, 47*, 30–36.
26. Tahir, M., Ashraf, Q. M., & Dabbagh, M. (2019). Towards enabling autonomic computing in IoT ecosystem. In 2019 IEEE international conference on dependable, autonomic and secure computing, international conference on pervasive intelligence and computing, international conference on cloud and big data. computing, international conference on cyber science and technology congress (DASC/PiCom/CBDCom/CyberSciTech) (pp. 646–651). IEEE.
27. Sukhpal, S., & Inderveer, C. (2016). Cloud resource provisioning: survey, status and future research directions © Springer-Verlag London.
28. Salah, K. (2013). A queueing model to achieve proper elasticity for cloud cluster jobs. In 2013 IEEE sixth international conference on CLOUD computing (CLOUD). IEEE.
29. Salah, K., Calero, J. M. A., Zeadally, S., Al-Mulla, S., & Alzaabi, M. (2013). Using cloud computing to implement a security overlay network. *IEEE Security and Privacy, 11*(1), 44–53.
30. Nazir, S., Patel, S., & Patel, D. (2017). Autonomic computing meets SCADA security. In Proceedings of 2017 IEEE 16th international conference on cognitive informatics and cognitive computing, ICCI* CC 2017. London South Bank University (pp. 498–502).
31. Vikas, M., & Richa, D. (2018). Cloud reliability enhancement mechanism: A survey. *International Journal on Scientific Research in Computer Science and Engineering, 6*(3), 31–34.
32. Nima, J., & Navimipour, F. S. (2015). Task scheduling in the cloud computing based on the cuckoo search algorithm. *International Journal of Modeling and Optimization, 5*(1), 44–47.
33. Aslam, A. M., & Jaur, M. (2018). A review on energy efficient technique in green cloud: Open research challenges and issues. *International Journal on Scientific Research in Computer Science and Engineering, 6*(3), 44–50.
34. Aarti, S., & Dimple, J. (2015). Autonomous agent-based load balancing algorithm in cloud computing. International conference on advanced computing technologies and applications (pp. 832–841).
35. Son, S., & Jun, S. C. (2013). Negotiation-based flexible SLA establishment with SLA-driven resource allocation in cloud computing. Paper presented at Proceedings of the 2013 13th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid) (pp. 168–171). IEEE.