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MOBILE & WIRELESS HEALTH

Brain Storm Optimization Graph Theory (BSOGT) and Energy Resource Aware Virtual Network Mapping (ERVNM) for Medical Image System in Cloud

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Abstract

With the development of Internet and the make use of Internet for medical information, the demand for huge scale and reliable managing medical information has brought out the huge scale Internet data centers. This work that has been presented here highlights the structural lay out and formulation of the medical information model. The aim of presenting this to aid medical departments as well as workers to exchange information and integrate available resources that help facilitate the analysis to be conducted on the given information. Software here comprises of medical information and offers a comprehensive service structure that benefits medical data centers. VNM or Virtual Network Mapping (VNM) essentially relates to substrate network that involves the installation and structuring of on demand virtual machines. These however are subjective to certain limitations that are applicable in relation to latency, capacity as well as bandwidth. Data centers need to dynamically handle cloud workloads effectively and efficiently. Simultaneously, since the mapping of virtual and physical networks with several providers' consumes more time along with energy. In order to resolve this issue, VNM has been mapped by making use of Graph Theory (GT) matching, a well-studied database topic. (i) Brain Storm Optimization Graph Theory (BSOGT) is introduced for modeling a virtual network request in the form of a GT with different resource constraints, and the substrate networks here is considered being a graph. For this graph the nodes and edges comprise of attributes that indicate their constraints. (ii) The algorithm that has been recently introduced executes graph decomposition into several topology patterns. Thereafter the BSOGT is executed to solve any issues that pertain to mapping. (iii) The model that has been presented here, ERVNM and the BSOGT are used with a specific mapping energy computation function.(iv) Issues pertaining to these are categorized as being those related to virtual network mapping as the ACGT and optimal solution are drawn by using effective integer linear programming. ACGT, pragmatic approach, as well as the precise and two-stage algorithms performance is evaluated by means of cloud Simulator environment. The results obtained from simulation indicate that the BSOGT algorithm attains the objectives of cloud service providers with respect to Acceptance ratio, mapping percentage, processing time as well as Convergence Time.

Keywords Virtual Network Mapping (VNM) · Brain Storm Optimization Graph Theory (BSGOT) · Virtualization quality of services (Qos) · Distributed cloud computing and optimization

Introduction

The success of Cloud computing in the form of a paradigm arises from the concepts which form the basis of its implementation. The dynamic stretching or shrinking capability of rendering the client with rented infrastructure on demand presents itself as a major advantage in comparison with conventional plan and buy model which is usually popularly deployed. This particular aspect is then integrated along with delivery over quick connections as well as the detailed pay-as-you go alternative offered in terms of pricing clearly indicates the

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popularity of choosing cloud amidst several organizational clients. However this particular precept that has enabled feature implementation essentially is virtualization. Using virtualization, several service providers offer a host of services which include dynamic platforms, computational power and storage that are essentially part of a commodity dependent design and it offers clients the freedom from the botheration of implementing details at a relatively low level. Clients can perform computation; routing and network control and connect with no overheads with regard to management of resources or network routing and control [1]. To achieve this goal, service providers that offer cloud services need systems that are effective and efficient, to ensure control and optimized resource virtualization, resource allocation as well as cloud data centers scheduling that takes place therein. Cloud data centers comprise of servers that number is thousands and are primarily concerned with the function of storage, data processing as well as data exchange of clients.

Network virtualization has less been in the radar of focus of several renowned individuals involved in the study and research in present scenarios. Thus, facilitating multiple virtual networks as operational over a single physical network. Though this advantage, does not eliminate network virtualization actually getting affected by the issues that arise on account of mapping the virtual links as well physical network nodes effectively. Meanwhile, management of both interdata center and intradata center networks are entirely carried out by the cloud provider. This issue pertaining to Virtual Network Mapping with resource and energy constraint is referred to as ERVNM. It is described to be the virtual nodes mapping issues as well as physical nodes and paths and their links [2].

VNM is crucial in the big data management. The frequency of big data distribution is high in data centers [3]. However, data center networks usually offer a major disadvantage in the case of dynamic cloud workloads that consist of multiple queries and data control. Usually in the case of networking platforms, network resources configuration is usually manual using static policies applicable on data, and innovative allocation of workload that is usually extended either for a few days or for weeks altogether. This signifies the importance and mandatory requirement for VNM, to enable virtual network deployment in data center network that is automated and acts as a response to requests that are actually made in real-time. However there is significant increase of VNM deployment in the industry today, as in the case of Amazon's EC2, VMware Data Center and Big Switch Networks. This has proven its effectiveness and efficiency in heightening server usage as well minimizing of server provisioning time (lowering several weeks and a number of days to minutes), capital expenses incurred on account of server and other operational expenditures [1]. Additionally there has been a significant amount of research and study carried out on methodologies deployed for big data virtualization methodologies [3] as well as for database systems [4].

Virtualization of network resources is involved with running several logical networks concurrently on top of the same physical infrastructure [5]. In order to create a virtual network, map virtual nodes as well as links over the physical infrastructure, also known as the Routing and Wavelength Assignment or RWA, is considered as a vital step [5]. An abstraction can be formed between the user and the physical resources by the process of virtualization, in which the user is offered an illusion of unswervingly communicating with the physical resources [6]. Or else said, virtualization has the ability of covering up the specifications related to the infrastructure of the network [7].

VN embedding problem clients also possess the facility of making connection requests. These connections will assist in the process of data exchange to occur amid the client Virtual Machines or between a client Virtual Machine and client's private cloud. The Virtual Machines can indicate the virtual network's vertices wherein each and every client is anticipated to uphold the accepted Quality-of-Service or QoS criteria without considering the fact concerning the number of additional clients, with whom the data center resources are shared simultaneously. A key criterion here is the capability of the system to assign the network resources to the VMs in a dynamic manner at any point of time.

However, getting a mapping between the virtual machines and hosts provides a solution to a fraction of the issue concerning mapping of a virtual environment to the physical environments. Another issue is acquiring for each and every link between two virtual machines, a path drawn out from the host in the physical infrastructure that operates one of the virtual machines to the host that is running the other machine. The issue behind the virtual network embedding itself is an extreme challenge already already also is considered to be NP-hard still in the case of offline. Consequently, a variety of heuristic and optimization based algorithms have been shown in the relevant literature [8–28]. However, pre-selection of node mappings with no consideration to its association to the phase of link mapping confines the space for solution space as well as it can lead to poor performance.

In this research work, a better correlation is introduced linking the resources that are virtual as well as physical by launching the Brain Storm Optimization Graph Theory also known as BSOGT. In the case of BSO, new energy value will be produced in order to get some of the old energy replaced if the BSO algorithm provides poor mapping results between the physical and virtual network mapping. Whether a BSOGT provides poor mapping results or not is decided by means of the Hamiltonian cycle length which can be obtained by including all the constraints of the physical nodes moved into an undirected weight graph. Mapping of the virtual nodes are done onto substrate nodes in a method that facilitates the virtual links mapping to physical paths in the subsequent phase. The novel algorithm employs the graph decomposition into topology patterns by using the BSOGT in order to resolve the mapping issue. Giving both in the data center as well as in-network hosting by taking into consideration network nodes with the intention of being able to provide determine as well as storage resources along with switching as well as routing functions. The newly introduced BSOGT algorithm was tested and assessed against the available algorithms making use of comprehensive simulations that indicates that the newly introduced BSOGT algorithm performs better than the other algorithms.

Literature review

Calheiros et al. [10] suggested a heuristic for mapping both the in the actual system both the virtual machines to hosts as well as the virtual links going amid virtual machines to paths. It is also essential to take into account that the Virtual Machine Monitor (VMM) exploits the resources of the host. Moreover, the problem addressed by the issue is defined, a solution is presented for it and it is evaluate in a variety of usage conditions.

Guo et al. [11] examined the issue of shared backup network provisioning intended for VN embedding as well as advised on strategies concerning two shared backup network provision for the purpose of virtual network embedding that considers Shared On-Demand approach or SOD _BK as well as Shared Proactive approach or SP_ BK. Through the process of sharing the bandwidth used by various VNs' restoration flows, the required backup bandwidth shall be largely minimized and more amount of resource concerning substrate could be saved for accepting VN requests in the future. Experimental Simulation indicates that both the newly introduced mechanisms make the best usage of substrate resources compared to the mechanism of dedicated backup devoid of sharing, while every one of them has its individual benefits.

Yeow et al. [12] concentrated on the issue of resource allocation for Virtual Infrastructure (VInfs) embedding with the guarantee of reliability. As a physical infrastructure hosts several VInfs, it offers more resource efficiency in sharing redundant nodes between VInfs. The physical footprint cast by redundant links can be minimized, by taking the maximum over every failure scenario when allocating the resources with a linear program taken from the Multi-Commodity Flow problem.

Xiong et al. [4] dealt with the challenge of how to smartly carry out the management of the resources management in a shared cloud database system as well as Smart Service Level Agreements or Smart SLAs that is considered to be a cost-sensitive resource management system is proposed. SmartSLA consists of two vital components which comprise of the modules of system modeling as well as the resource allocation decision module. The system modeling module utilizes machine learning methodologies for the purpose of learning a model that details the possible profit margins intended for each client in diverse resource allocations. The experimental results received also confirm that SmartSLA has the ability to provide a smart service differentiation on the basis of factors such as variable workloads, SLA levels, resource costs, in addition to enhanced profit margins delivery.

In their study Sun et al. [13] designed a efficient framework deployed primarily to facilitate the process of optimal provisioning of VN request by making use of mixed integer programming. In addition, the efficiency of this technique is demonstrated in enhancing the overall revenue by carrying out elaborate simulations on various networks.

Abedifar et al. [14] introduced a Particle Swarm Optimization (PSO) concept used for mapping of the virtual network. Five different cost functions are designed and a new technique concerning encoding designed for optical networks is proposed. The recently launched mechanism concerning optimization is replicated by acquiring various virtual networks' mapping on top of a physical infrastructure in order to optimize five different cost functions. The results obtained are given and elucidates for particular cost parameters.

Alhazmi et al. [15] introduced an extensive system for solving virtual network mapping transmitted by cloud clients for the purpose of executing a set of connection requests. Connections are collected in time intervals referred to as windows. The results received from simulation denote that the aims pertaining to the cloud service providers concerning ratio of served connections, resource usage as well as computational overhead are attained by the dynamic window size algorithm.

Cao et al. [16] introduced the modelling of a virtual network request in the form of a graph pattern that has multiple constraints, furthermore a substrate network is considered as a graph, in which the nodes as well as the edges contain attributes that denote their ability. Additionally, it is made known that numerous mapping requirements can be expressed in this particular model, such as placement of a virtual machine, network embedding in addition to priority mapping. It is verified experimentally that these algorithms are effective and are capable of finding high-quality mappings, making use of real-life and artificial data.

Alzahrani et al. [17] studied about energy sensitive particle swarm optimization algorithm to be used for distributed clouds. This specific algorithm aims at partitioning every Virtual Network Request ("VNR") to subgraphs, making use of the Heavy Clique Matching technique also known as "HCM" for generating a coarsened graph. Every coarsened node present in the coarsened graph is allocated to a suitable

Data Center or "DC". The newly introduced algorithm was analyzed and assessed against the available algorithms employing comprehensive simulations that are that indicate that the newly introduced algorithm performs better than the other algorithms.

Xiao et al. [18] studied about a Global Resource Capacity - Survivable Virtual Network Mapping embedding algorithm (IntD-GRC-SVNE), which provides the implementation of multi-domain mapping in network virtualization. The results obtained from simulation indicate that IntD-GRC-SVNE cannot just enhance the survivability of multi-domain communications network but also make the network load to be more balanced and hugely enhances the network acceptance rate owing to usage of GRC (global resource capacity).

Mechtri et al. [19] provided the solution of the issue pertaining to mapping of cloud and networking resources examined in distributed environments as well as hybrid cloud environments. A clear-cut algorithm is presented in order to map the joint nodes as well as links concerning the virtual infrastructure graph that from many providers has been requested to the physical graph. With the intention of dealing with complexity along with scalability concerning huge virtual as well as physical networks comprising of thousands of nodes, an effectual heuristic algorithm, on the basis of topology patterns as well as bipartite matching, is employed in order to provide near to optimal solutions furthermore diminishing the mapping delays in an order of around three to four magnitude.

Proposed methodology

In this work of research, better correlation is introduced amid the virtual resources as well as physical resources by means of proposing the Brain Storm Optimization Graph Theory or BSOGT. In the case of BSO, a new energy value will be produced in order to replace some of the old energy if the BSO algorithm provides poor mapping results between the physical and virtual network mapping. Whether a BSOGT provides poor mapping results or not, it is decided by the Hamiltonian cycle length which can be acquired by the transfer of every constraint of the physical nodes into an undirected weight graph. The mapping of virtual nodes onto substrate nodes is done in a manner that facilitates the virtual links mapping over physical paths in the subsequent phase. The newly introduced algorithm employs graph decomposition into topology patterns through utilization of BSOGT which is rendered for the purpose of resolving mapping related problems [26]. It is rendered in data center as well as in-network hosting by the process of considering network nodes into consideration with the aim of being capable of offering, determining and storing resources along with switching and routing functionalities.

Figure 1 shows the scope of the work and depicts the inputs and outputs of the newly introduced work (2 data centers, 1 network provider and 2 public providers for example). The BSOGT graph is the set of resources from private and public clouds visible to the algorithms. The resources are denoted in this second case by means of a service node bearing attributes and functions provided and are viewed in the form of a container or a hosting platform with the service provisioned with related agreement and quality of service [27]. As shown in Fig. 1, the model does the mapping of an input graph comprising of nodes and links to the reference infrastructure.

System model

The Energy Resource Aware Virtual Network Mapping (ERVNM) problem includes the mapping of a Graph (G) $A=(Ve_A, Ed_A)$where Ve_A indicates the set of virtual nodes and Ed_A referring the set of virtual links, to an Brain Storm Optimization Graph (BSOG) $B=(Ve_B, Ee_B\ )$ in nodes and links (present in vertices and edges).

The nodes are ordinary routers, servers and servers/routers. The set consisting of available servers in the data centers is denoted as S. The set of routers is indicated by R and the set of servers/routers is represented by SR. Making use of these notations, the set of vertices of the physical or reference graph B is denoted as $Ve_B=\{S\cup SR\cup R\}$.

Therefore the aim is to search for a injective function $I:$ $Ve_A\rightarrow Ve_B$, which maps every node present in Ve_A to a node in Ve_B, and which matches the edges in Ee_A to edges in Ee_B. That is $\forall(u,v)\in Ee_A\ (u,v)$ will get matched to (I(u), I(v)). This problem is near to the popular subgraph isomorphism problem explained in [19], which gets an optimal mapping between nodes and edges of two graphs G_1 and G_2 given with the number of vertices of G_1 lesser than the number of vertices of G_2.

As illustrated in Fig. 1, a tenant makes a request for a mapping of a service comprising of 4 interconnected VMs. Depending on the capacity available in the physical infrastructure; every node of the tenant requested graph will get mapped onto a server or a server/router with the help of algorithms. The equivalences are required for introducing an idea of energy between demand like the requested virtual resources or CPU, storage and memory and chosen physical resources with respect to input graph and reference graph resources.

$$\mathrm{C(i,j)}\Leftrightarrow\left(\mathrm{c_i}\le\mathrm{C_j}\right)\quad(1)$$

$$\mathrm{ST(i,j)}\Leftrightarrow\left(\mathrm{st_i}\le\mathrm{ST_j}\right)\quad(2)$$

$$\mathrm{M(i,j)}\Leftrightarrow\left(\mathrm{m_i}\le\mathrm{M_j}\right)\quad(3)$$

In this set, c_i ($st_i$and m_i) is defined as the amount of requested CPU (storage and memory) by VM i whereas C_j (ST_j and M_j) indicates the available (free) CPU (storage and memory)

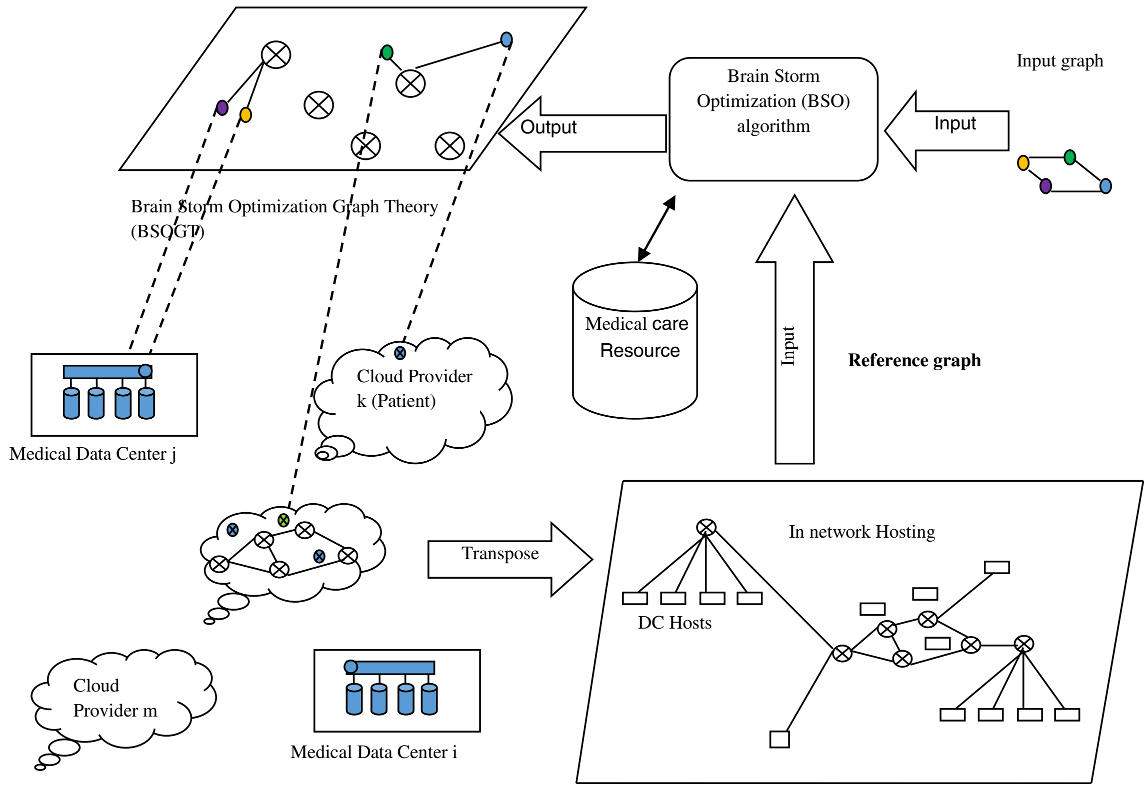


Fig. 1 Proposed BSOGT model

in a physical node j. Candidate nodes for selection includes all of the nodes, which satisfy the mapping criteria of Eqs. (1), (2) and (3).

Brain Storm Optimization Graph Theory (BSOGT)

The important objective of this technical work is to concentrate on the reduction of the embedding cost in addition to consumption of energy. In the newly introduced BSOG model, the nodes present in the SN will partition into two kinds. In the first, active nodes, which take part in the present mapping process, in the form of hosting nodes, or still active from the earlier one. The energy consumption (E) for ERVNM process is the energy required for powering the physical resources to on state in addition to the energy required for hosting the virtual resources.

$$E_1\left(i,j,A_{k_1,k_n}\right) = \left\{ \frac{\sum_{i=1,\forall j\in m}^{n} C(ij,k_1,k_n) + ST(ij,k_1,k_n) + M(i,k_n)}{0\ otherwise} \right. \quad (4)$$

$$E_2\left(i,j,A_{k_1,k_n}\right) = \begin{cases} 1\ if\, c_i + c_j \le C_{k_1} \\ 0\ otherwise \end{cases} \quad (5)$$

This energy measures how near a physical path is from the actually requested virtual link. These two energies are correspondingly provided by E_1 and E_2 in Eqs. (4) and (5) where i, $j\in Ve_A$ and $k_1, k_n \in Ve_B \backslash R.A_{k_1,k_n}$ indicates a path of length n with k_1 and k_n stands for the endpoints. The above distances provide the expression of the objective function to get the approximate match in nodes and links at the same time for the input graph in the physical graph.

$$\begin{aligned} \min Z = min\Big[& \sum_{i\in Ve_A} \sum_{k\in Ve_B\backslash R} f_{node}(i,k) \times E(i,k) \times x_{ik} \\ & + \sum_{(i,j)\in Ed_A} \sum_{k_1\in Ve_B\backslash Rk_1\neq k_n} \sum_{k_1\in Ve_{B\backslash R}} f_{link}(ij,k_1k_n) \\ & \times E_1(ij,A_{k1},k_n) \\ & \times y_{ij},k_1,k_n \sum_{(i,j)\in Ed_A} \sum_{k_1\in Ve_B\backslash Rk_1\neq k_n} f_{link}(ij,k_1,k_n) \\ & \times E_2(ij,A_{k1},k_n) \times y_{ij},k_1,k_1 \Big] \end{aligned} \quad (6)$$

where the bivalent variables used are expressed as below

$$x_{ik} = \begin{cases} 1\ iftheVMiismappedtok\in S\cup SR \\ 0\ otherwise \end{cases} \quad (7)$$

$$y_{ij,k_1,k_n} = \begin{cases} 1\ iftheiismappedtok_1, jismappedtok_n \\ andijismappedtoA_{k_1,k_n} \\ 0\ otherwise \end{cases} \quad (8)$$

The first term in the objective function ensures that the demaned resources are available on a candidate physical node k so that it can be chosen. The second term present in the objective function get the optimal physical path A_{k_1,k_n} for supporting the virtual link (i, j). The third term addresses all of the requests for co-localizing the virtual resources i and j on the same node k_1. There is a necessity to move to an effective heuristic algorithm to get the convergence times to practical values for implementation in operational networks [20].

In the Eqs. (5–6) the energy measure shows how near a physical path is from the actually requested virtual link. The problem of Energy determination is resolved by making use of the BSOGT algorithm. The duty of this BSOGT algorithm is getting the close to optimal solution for ERVNM in CC environment. In the newly introduced algorithm, all the physical nodes present in the CC model get transferred into an Undirected Weight Graph (UWG) at every mapping of ERVNM. After this, a Hamiltonian cycle and its length are acquired by using a modified cycle algorithm [21]. Then the convergent status of BSO is estimated depending on the ratio of the length of Hamiltonian cycle at two close generations. When this ratio becomes huge suddenly, some new energy will be created for replacing the old ones. This can maximize the diversity of the population and have the BSO escape from the local optima. The weighted graph is represented by $UWG = (Ve_{UWG}, Ed_{UWG}, UEd_{UWG})$, where Ve_{UWG} stands for a set of nodes, Ed_{UWG}indicates a set of directed edges, and UEd_{UWG} stands for a set of undirected edges. The nodes of Ve_{UWG}represent all of the operations Op_{UWG}, and $Ed_{UWG}$is associated with the precedence constraints between the physical and virtual nodes of the parts. NEd_{UWG}also denotes the set of edges that connects all probable combination of the nodes.

The process of brainstorming has been applied with success for solving the ERVNM problem. In an intuitive way, a BSOGT is developed dependent on the process of human being idea generation. The new BSOGT algorithm influenced by brainstorming process is provided in Algorithm 1 [22, 23]. In the process of the BSOGT algorithm depicted in Algorithm 1, the Step 1 becomes the initialization step like in other population-based algorithms; The choice of the initial node decides which requirements of the virtual resources can be machined first that impacts the outcome of ERVNM and the outcomes of BSOGT. Additionally, the undirected edges are combined from the initial physical nodes to the probably first visited virtual machine nodes. After this, steps 2–4 use the process of the physical node 'i' selecting the virtual node j depending on the energy objective function. Step 5 is carried out depending on the randomly chosen physical node i to any randomly chosen virtual link 'j'.when it energy objective value is smaller than the probability value, then the current physical node position is changed by choosing the center point. From this, the new energy value is decided at step 5 (b).when these criteria are not met, then move to else step 6 in algorithm 1, which does the simulation of the new computation of energy valuefor generating multiple ideas by utilizing the rules; the Step 6.a does the simulation of generation of new energy computation influenced by two available concepts from two diverse idea clusters, correspondingly; surely a new energy optimized value can also be an inspiration from more than two available optimized value, but it does not get simulated in the BSOGT for simplifying the algorithm; the number of clusters in Algorithm 1; the cluster center in every cluster acts the objective of better energy optimized value chosen up by ERVNM. The Step 6.b has the aim of maintaining the generation of better energy optimized value. The physical node size n does the simulation of the number of energy optimized value generated in every round of generation of energy optimized value during the process of brainstorming. For simplifying the algorithm, the size of the physical node generally is fixed to be a constant for every iteration in the BSOGT algorithm.

Algorithm 1: BSOGT algorithm
Begin

1. Randomly form *O*potential solutions.
2. Cluster (Map) *i* physical nodesinto '*j*' virtual machine node
3. Assess the *i* physical nodes
4. Rank *i* physical nodes in every map and record the best individual physical node as cluster center in every map.
5. Randomly generate a new energy value between 0 and 1

   a) If the value is lesser than a probability pr_a

- Randomly choose a new physical node 'i' as map center
- Randomly create a physical node to replace the chosen map center.

6. Else randomly choose two physical nodes to create new energy value

   a) Create a random value

- If it is less than a pre-defined probability p_b, the two physical nodes are merged and then added with random values to create new optimized energy value
- Else, two energy values from each chosen map are randomly chosen to be merged and added with random values to generate new energy value

   b) The newly found energy values are compared with the existing energyhaving the same physical index, the better one is kept and recorded as the new energy

7. If 'n' new optimized energy values have been create, go to Step 8,else go to Step 6.
8. Terminate if pre-defined maximum number of iterations has been reached; else go to Step 2.

End

The results of matching the *A* on the B are associated with the matching of the A Patterns on the B patterns generated by the bipartite graph matching. During this stage, just the root nodes of every A Pattern get mapped precisely on the root nodes of the Patterns of B. For meeting the goal of simultaneous node and link mapping, these mappings of roots on roots have to be verified if they are complying to with the latency demands also. In case the target latency is not satisfied, carry out a check on all virtual nodes that are labeled with root and leaves in the order below:

1) **Mapping as a root with leaves**: first by searching and getting a shortest path between the A root (for which there is no confirmation on the latency compliance once the root to root mapping in the bipartite graph step that involves A and B is done) and a leaf in the B Patterns in the reference graph;
2) **Mapping as a leaf with roots**: second by the computation of a shortest path between this root considered as a leaf in the other Patterns with the remaining roots and having just the first root, which meets the latency demands;
3) **Mapping as a leaf with leaves**: finally, by also getting a shortest path between the leaf representation of this root found in the other Patterns and every other leaf as steps 1 and 2 have not been successful.

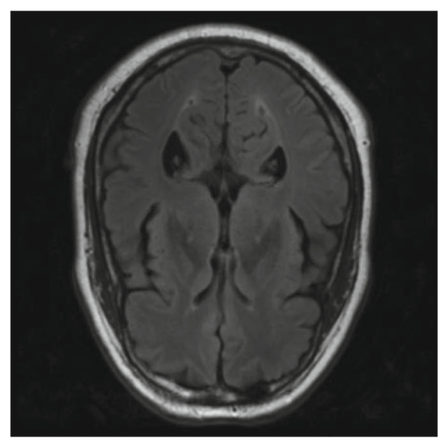
Performance analysis

The algorithms were assessed with the help of a 2:53 GHz Quad Core server along with 24 GBytes of available RAM. The GT-ITM tool [24] was utilized for generating the input and reference graphs. The algorithms are implemented via the use of cloud simulator in JAVA environment. In the simulations and assessments, for the sake of simplicity, just computational resources (CPU) are taken into consideration in virtual and physical nodes with no generality loss. Random CPU capacity requests ranging between 1 and 5 units are created for every virtual node and random latency demands ranging between 1 and 100 time units are obtained for every virtual link. For every scenario, 100 independent runs are seen at an average to generate every performance point. These algorithms are implemented via the use of the JAVA environment.

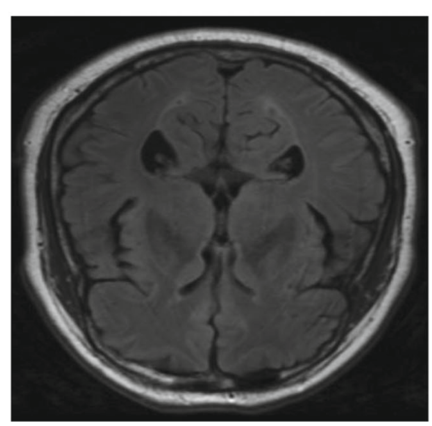
The data source is majorly consists of hospitals or other sectors have the Picture Archiving and Communications System (PACS). PACS is an information management scheme which is designed for the management of medical images created by means of radioactive equipment with CT, MRE, etc. With the help of the MRI and cognitive data got from the Alzheimer's disease Neuroimaging Initiative (ADNI) database (adni.loni.usc.edu), the presented method, CORNLIN, was assessed. One objective of ADNI is to test whether serial MRI, positron emission tomography (PET), other biological markers, and medical and neuropsychological evaluation is united to gauge the development of mild cognitive impairment (MCI) and premature AD. For current information, see www.adni-info.org. Figure 2 (a) shows the sample input MRI image of AD- T1 sample 1 and input MRI image of AD- T1 sample 2.

The first experiment comprises of having a comparison made between the actual and heuristic algorithms for a B size fixed at 15 virtual nodes. The behaviour in the form of a function of increasing B graph size is found for both algorithms for sensibly small to medium A graph sizes in the range [50, 200]. Figure 3 illustrates the convergence performance comparison results obtained of the heuristic, exact and newly introduced BSOGT algorithm. It can be concluded from the Fig. 2, that the novel BSOGT algorithm outperforms with all the assessed scenarios. The newly introduced work consumes just 57 msec for optimizing the energy values.

As observed in Fig. 4, the number of physical nodes is maintained constant at 50 for studying the behaviour of the



(a) Input MRI image of AD- T1 sample 1



(b) Input MRI image of AD- T1 sample 2

Fig. 2 **a** Input MRI image of AD- T1 sample 1. **b** Input MRI image of AD- T1 sample 2

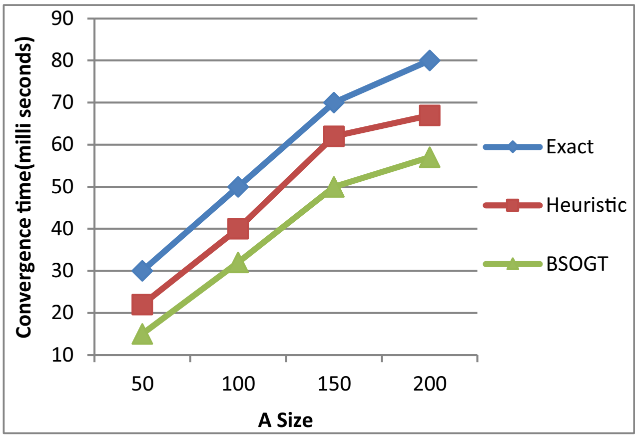


Fig. 3 Optimization Algorithms on convergence with B sizes

algorithms with increasing 'A' sizes from 5 to 30 virtual nodes. It is demonstrated from the Fig. 3 that the newly introduced BSOGT algorithm performs faster for various A sizes, for instance to A = 30 it takes just 72 msec, while other algorithms like exact and heuristic consumes 120 msec and 85 msec correspondingly.

For the case of simulated instances existing in the ranges A from 50 to 300 and for B = 500 as shown in Fig. 5, the newly introduced BSOGT algorithm performs very near to optimal and can match the optimal solutions 86.51% to 92% of the runs in nearly not-so-favorable conditions, while the other algorithms like the exact and heuristic yields 85.63% and 87.85% correspondingly. For studying the performance algorithms acceptance ratio, the number of A nodes is taken in random between 2 and 10. The reference graph is set to 100 nodes.

The requested resources (demanded CPU) are obtained and then produced from the Google cluster workload traces given in [25]. The ratio measures the percentage of IG requests are accepted by an algorithm. The results match with that of those which are found in Fig. 7. It can be concluded from the Fig. 6 that the newly introduced BSOGT algorithm generates 0.93 for a processing time of 9000, while the other algorithms like

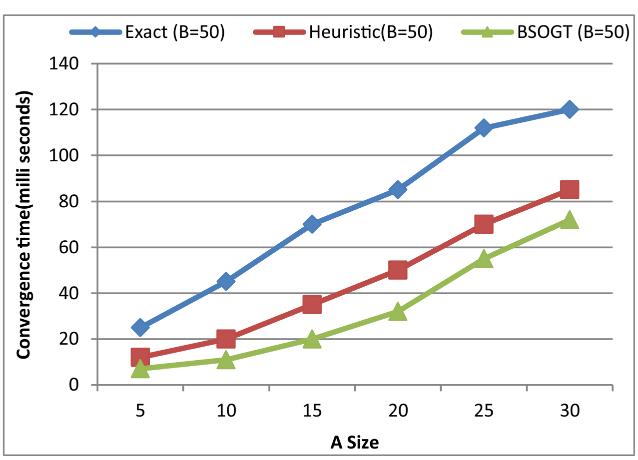


Fig. 4 Optimization Algorithms on convergence time with A sizes

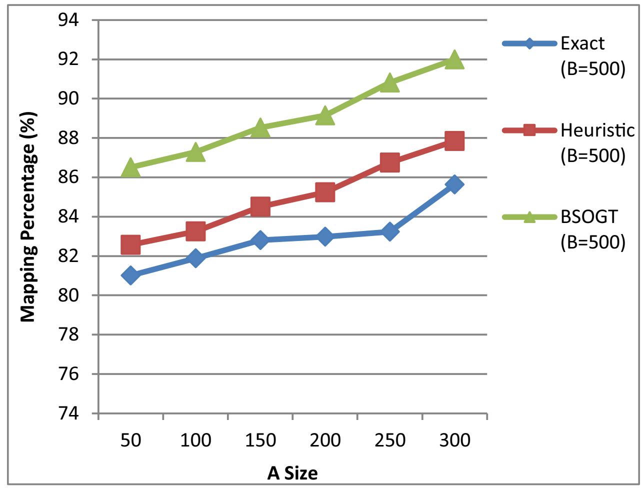


Fig. 5 Optimal mapping percentage vs. different Algorithms

the exact and heuristic yield only 0.734 and 0.846 correspondingly.

Delays in processing of the graphs, particularly the time required for the graph decompositions of the input or reference graph into patterns and the time necessary for updating the reference graph after every mapping are given in Table 1.

Figure 7 illustrates the results of the performance comparison made with the various exact, heuristic and new BSOGT algorithms, which are measured corresponding to the processing time (milli seconds). It can be concluded from the results that the newly introduced BSOGT algorithm incurs very less delay of 102 m seconds, while the other techniques like exact, and heuristic consumes longer processing time of 130 ms and 121 ms correspondingly for A = 200. It is concluded that the new BSOGT algorithm performs better compared to the other two techniques.

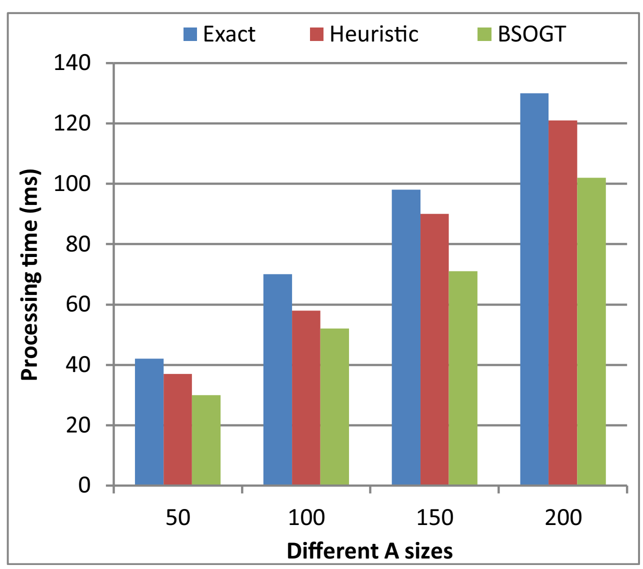


Fig. 7 ERVNM processing time vs. optimization algorithms

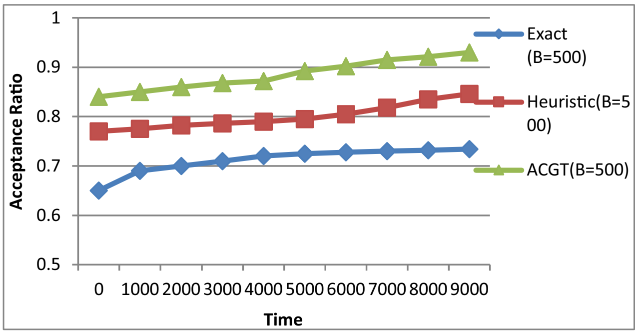


Fig. 6 B request acceptance ratio over time

Conclusion and future work

This research work is focused the significance of Cloud Computing (CC) and network virtualization to satisfy the growth needs for provisioning the resources. One among the most essential challenges in resources provisioning is the mapping of the virtual resources to the respective physical one. This challenge is described as ERVNM problem. ERVNM is regarded as NP-hard problem and it has gained a serious attention in the past few years. In this work, a better correlation between the virtual and physical resources is introduced by proposing the Brain Storm Optimization Graph Theory (BSOGT). In BSO, a new energy value will be created for replacing some old energy if the BSO algorithm provides poor mapping results between the physical and virtual network mapping. The objective of BSOGT is about getting a mapping, which balances the load of the hosts with regard to the usage of CPU, with due respect to the limitations enforced by hosts resources (memory and storage) and also maintaining the links constraints (bandwidth and latency). The results obtained from the experiments also show that the newly introduced BSOGT algorithm reduces the time needed to have the experiment run on the simulation environment. More work is chiefly focused on the below two aspects: (1) investigating the BSOGT adaptability in various physical network environments and the effect of physical resources on algorithm performance and (2) exploring the multidomain network issue and trying to minimize the effect of network services outages.

Table 1 ERVNM Processing time comparison vs. different algorithms (A = 200 nodes)

A	ERVNM processing time (ms)		
	Exact	Heuristic	BSOGT
50	42	37	30
100	70	58	52
150	98	90	71
200	130	121	102

Compliance with ethical standards

Conflict of interest The Authors and Co-Authors have no conflicts of Interests. The Paper is not submitted to any other Journals.

Ethical approval (involving human participants and/or animals) This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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