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CONTAINER MIGRATION AND PLACEMENT IN HYBRID CLOUD-FOG ENVIRONMENT: SYSTEMATIC REVIEW

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Abstract- Virtualization is the key issue for both cloud and fog. The execution and efficient approach of container is becoming popular and it can work with recent fields like smart automation, smart parking, smart transportation etc. We discuss techniques for container migration and our objective is to get survey on energy aware container migration techniques. The focus of this paper is to make overall study on container migration and placement for hybrid cloud-fog system. It has been discussed various methods for placement and migration using container for both cloud and fog. The extension is carried out for energy efficient container migration to reduce computation power. The state-of-the-art study is shown how the migration and placement in fog are more challenging in comparison to cloud.

Keywords: Cloud Computing, Internet of Things (IoT), Fog Computing, Migration, Placement.

1. INTRODUCTION

In current era of technical progress [1], the data generated by IoT based smart devices are increased and therefore, it is the need to execute data with minimum delay using migration [2, 3] and placement in cloud/fog for smooth execution. Internet of Things (IoT) is the key element for the revolution and it makes to process the automation of objects through Internet.

In this system, the cloud/fog nodes are the main components for dealing with requests for computation or storage [4]. Cloud can provide three primary services: compute, storage and network. Few services are sensitive for providing request and response for example vehicular networks, game applications and such services are required to work with enormous data. The network bandwidth is adequate for IoT applications to process using fog computing. On the other hand, the network can be stuck for IoT data to execute or store for various applications in cloud computing. The fog is new paradigm to work with distributed computing and it manages the services of cloud at the edge of network. A newer way of computing is known as fog computing [5] which can make the network activity lighter to run and it is able to manage scalability of devices.

1.1. Cloud Computing

Cloud, a parallel and distributed system is used with on-demand access of network to provide services provided by agreement of services. The Internet, multiple computer network is a cloud and datacenter of cloud computing manages hardware and software for primarily compute and storage [3].

1.2. Fog Computing

The fog computing is the middle layer to perform various tasks between cloud datacenter and edge devices. The fog provides storage and compute facilities like cloud but at closer to user. The fog is able to work as the key solution for IoT-cloud based enormous data with faster solution approach and data analysis [1].

1.3. Hybrid Cloud-Fog System

As per Figure 1, the hybrid cloud-fog architecture is designed with three layers: Cloud, Fog and IoT devices. Fog infrastructure is designed in a way to give heterogeneity of nodes and it is able to resolve different hardware issues, among architectures, services and operating systems [6, 7].
The architecture is divided into three main parts:
1. Cloud datacenter
2. Fog nodes
3. End devices

The cloud data platform is used for data storage, and data computation. There are the two-way connections between both cloud to fog and vice versa. The number of fog nodes is connected to cloud data center. The fog manager is used to monitor whole ongoing activity with end devices. Each fog node is required to send data to fog manager to make a small centralized activity inside micro cloud. The fog manager is able to provide list of IoT devices.

1.3.1. Containers over Virtual Machines

The user requirement for processing power, memory etc. can be given by taking VM or container to deploy applications. Containers are known with its lightweight, faster process and newer dimension for virtualization. The performance of container is quite good than VM and it can be even more popular with increased use of micro-services. The major issue with the Hypervisor enabled current virtualization system has the performance overheads and so, the best alternative is found container-based virtualization [8]. With the advancement of container technology, network traffic can be minimized and the cost can also be reduced. Containers have following benefits: i) less time are required for migration between physical machines ii) required minimum processing time and less memory requirement iii) Containers can launch applications faster because of small size images iv) overall cost is reduced compared to VM and used for mobile applications for faster execution [8].

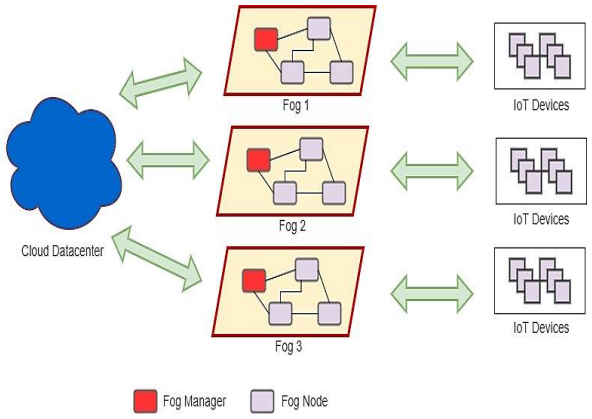

Figure 1. Architecture for hybrid cloud-fog system

1.3.2. VM Migration and Container Migration

Like VM migration [9, 10, 11, 12, 13, 14, 15], the new advancement called containers are also transferred or migrated between two systems and perform various applications to manage through physical systems. Containers can also work with delay-sensitivity of mobile applications for utilization and provisioning. Containers are developed in a way to achieve faster migration decision making.

1.3.3. The Virtual Machine Placement Problem

The placement problem of virtual machine is handled by keeping minimum VM on the top of PM [8]. The PM is selected to have more resources available so the suitable placement of VMs can be made possible.

1.3.4. The Container Placement Problem

The containers can be provided for different resources with memory intensive or CPU-intensive requirements. The goal is to occupy as minimum as possible VMs to reduce the cost [8]. In this paper, we plan to discuss virtualization, aspects of virtualization with VM and container, Container migration and placement in hybrid cloud-fog system.

2. RELATED WORK USING PRE-COPY FOR VM/CONTAINER

The pre-copy is able to give minimum downtime and it also reducing the amount of VM data to be transferred. The iterative phase and stop-and-copy phase are two key steps to get optimal downtime of system and total migration time. The Figure 2 shows the stages of VM / Container migration using pre-copy algorithm.

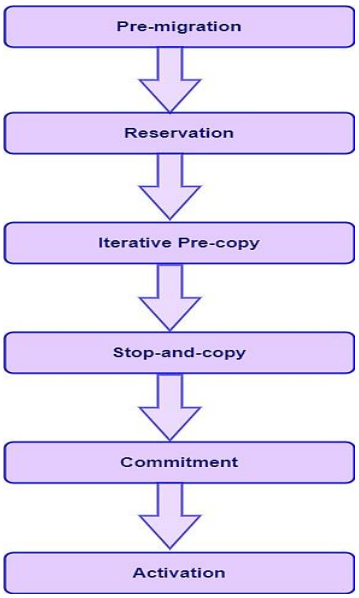

Figure 2. Pre-copy stages for VM / container migration [3]

The optimized migration mechanism [9] is described in which are designed with probability prediction algorithm. The dirty pages prediction is measured in this algorithm by designing accurate working set so the retransmission of dirty pages can be reduced. The probability of updated dirty pages is predicted using prediction model.

In pre-copy with time-series analysis [16], the rate of dirty pages generator is a key parameter that can enhances the existing pre-copy algorithm. It works to identify dirty pages based on past and future values. It is able transfer the frequently updated pages in the last round and hence, it can reduce repeated and useless transfer of dirty pages.

Comprehensive overview of different migration techniques for containers is discussed and these methods are: cold, pre-copy, post-copy, and hybrid migrations. In this paper, these techniques were evaluated on fog system [17]. In next section, the concepts on container and VM with virtualization technology are discussed.

3. VIRTUALIZATION: VM VS CONTAINER

In the process from cloud to fog [15, 17, 18], container is considered as most powerful solution compared to VM because the decentralized and lightweight nature of fog nodes make it possible to run data faster and securely. The containers in fog are able to reduce response time of running application as compared to cloud-based solution. The process of mapping containers to VMs can make efficient resource

management. It can also provide the detail on another case where the placement of containers to VMs on hosts is carried out. Here, Figure 3 shows the hypervisor, container and hybrid architectures.

3.1. Comparison between VM and Container

A hypervisor is used to manage VMs and it serves as a host for a guest OS by adding a layer of virtualization. Kernel-based Virtual Machine is a Linux based virtualization technology that turns it into a hypervisor.

A container is identical to a VM with the available virtualization features. In containers, it is not required to virtualizes the hardware but it is able to manage requests by modifying the host OS. The isolated containers are created and they are not allowed to access anything outside. Due to deeper isolation, it has potential strength and working standards so it can replace VM in near future. The edge node is able to collect information from virtual network using container-based technology. It performs re-connection with lost or weak network using container network functions [18].

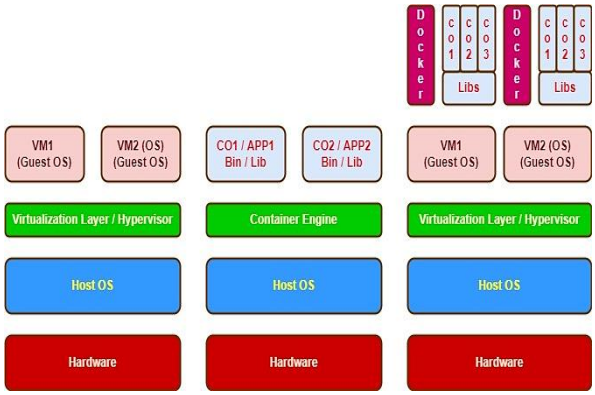

Figure 3. Hypervisor, container and hybrid architectures

4. CONTAINER MIGRATION OVER VM MIGRATION FROM CLOUD TO FOG

In this section, the strength of container migration over VM migration is discussed.

4.1. Reasons for Container Migration in Place of VM Migration:

- Location is changed by end IoT device
- The workload must be balanced to work with container system and it gives neither overloaded, or under loaded conditions.
- Unavailability of fog node or unexpected shutdown or a planned maintenance [edge migration]

4.2. Container Migration Over VM Migration

The Figure 4 is shown about VM migration and container migration. The physical machine will become idle host when migration and placement are performed. During VM migration, the movement of mobile users are not much focused and it was put to the consideration of history-based utilization. In such cases, the distribution of work is not proper and the algorithms were developed which give result to long delay in decision and algorithms are not acceptable. When the other migration which is container-based migration; the cost can be reduced effectively due to lightweight virtualization technology [18, 19, 20, 21, 22].

Stateless based migration can start a new container on receiver node and the old container is deleted from source node. Stateful based migration is able to keep the copy of container at destination once the migration is completed. cold migration has long downtime and hybrid migration has the issue of very long total migration time. With various scenarios, pre-copy and post-copy can work very well comparing to cold/hybrid migration. [17]

The delay and power consumption along with container migration cost and the movement of end users are the check points for efficient migration in fog computing. The location-aware activity of end users is a sequential decision-making scenario. Therefore, it is indeed to provide reinforcement learning method in making migration decisions [18].

The mobile application based various tasks can be managed in a container of a particular fog system which can be migrated [23, 24]. In this process, the migration algorithm has been designed with Markov Decision Process using Deep Reinforcement Learning to get fast decision making [25]. Container is able to give better performance and efficiency of cloud resource utilization. ECS- Elastic Container Service and Google Container Service are the Container as a Service (CaaS) solutions. It uses containers to deploy on VMs [23].

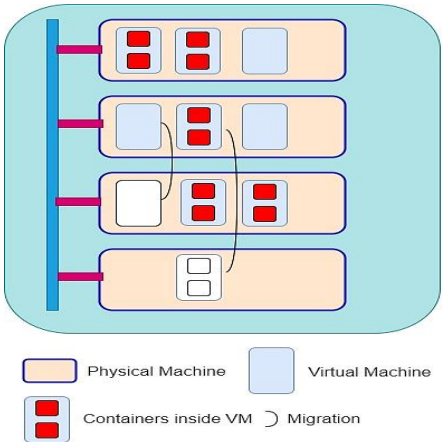

Figure 4. Energy efficient migration and placement of VMs and containers

5. CONTAINER PLACEMENT IN HYBRID CLOUD-FOG

The energy consumption in different computing systems is required to manage different resources. The energy consumption in computing systems has three layers:

I) application domains
II) computing environments
III) physical resources

The efficient energy consumption can be applied in these layers and so, it can have advantages of reduction of electricity bills, power budget and CO_2 emissions. The whole idea of container placement stands to work on reducing PM for achieving optimal placement.

The Virtual Machine Placement problem is considered as a vector bin packing problem. The best fit decreasing (BFD) algorithm can be used to find optimal host where the VM can be placed [8]. The bin-packing problem is defined with detail process as follows: given total number of items and total number of bins of fixed capacity, measure the minimum numbers of bins needed to contain all available items, such that total sum of the items used for each bin does not exceed the capacity of bin. For the vector generalization of the problem, each item is given as a d-dimensional vector, where the goal is to fit all items in bins, such the sum of the items assigned to each bin does not exceed the bin capacity for all dimensions.

Virtual Machine Placement is used a Multi-Objective Ant Colony System and in that, it uses to optimize placement of VMs on physical machines (PMs) to minimize resource usage and power consumption. It uses the First Fit Decreasing and Simplified Ant Colony System. The Ant Colony Optimization (ACO) is used to optimize placement of VMs on PMs for energy consumption and it gives optimal solution compared to greedy method [19]. The meta heuristic Ant Colony optimization is developed to improve a scheduler using Swarm Kit by which the performance improved by 15%. The Linear Programming Model to schedule containers is designed with Docker using MATLAB and it is able to give reduction in energy and network costs [26].

The scheduler is able to plan for managing requests to allocated containers and it can also make analysis on which nodes the containers are placed and what will be migration strategy of containers. The paper discussed the issues with container migration and placement for edge nodes. The placement of container is able to resolve with multi-objective-based optimization problem. In edge servers, the idea on container placement [8, 18, 23] and migration are implemented with scheduling models. These models are developed and extended with graph models or multi-objective optimization models.

The queuing and concurrent are two container placement algorithms. The queuing approach is able to manage requests with first-in-first-out or priority-based method. The container placement decision is worked on a container-by-container basis for selecting accurate PM. The drawback of queuing method is to get global optimal point. But, in concurrent method, the global optimal decision making is possible [18].

The GenPack, a generational scheduler, is implemented in cloud to get optimal energy. It is developed to measure runtime monitoring of the system containers. This scheduler was tested with Docker system and it is able to improve 23% energy-efficiency [26].

Various Approaches are used for container placement scheduling problem like Optimization Modelling [27], Markov Decision Process, Multi-dimensional Knapsack Problem, and Graph Network. The container placement-based scheduling issue is a complex NP-hard type problem and it can be resolved with heuristics graph-based or reinforcement learning [18]. The containers are useful in various mobile applications to increase the efficiency of data management [28].

6. CONCLUSIONS

In this paper, a pre-copy based live container migration and placement algorithms are discussed. The review on hybrid cloud-fog model is discussed for migration and placement. The comparison on container and virtual machine are discussed throughout the paper. The container migration over virtual machine migration is briefly given and it shows that how container is more powerful than virtual machine for real life applications. The survey on placement algorithms for both container and VM are briefly discussed and hybrid model is able to useful for container placement in multi-purpose applications. Our future work is to implement migration and placement algorithm for fog computing system.

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BIOGRAPHIES

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