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SURVEY ARTICLE

Survey on Architecture of Leading Hypervisors and Their Live Migration Techniques

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Abstract— In the virtualization technique, numbers of different components are involved to manage the network, storage, memory. Live migration is the key concept in which the live or active virtual machine is migrated from one host to another host i.e. physical server without disturbing the live environment and the services. This feature is useful for handling the different tasks like power management, IT maintenance, load balancing. In today's market different virtualization techniques are available and their live migration techniques are differing as per their hypervisor architecture and the supporting environment. In this paper we will discuss the exactly how the virtualization plays an important role in the data center and their architecture.

Keywords— Virtualization, Server, Hypervisor, Live migration, Data centre

I. INTRODUCTION

A data center is the place where all the servers are placed in the racks with proper management of power, networking and cooling. Hosting companies are offering the actual services of cloud computing like SaaS, IaaS and PaaS. In the datacenter different types of servers are located according to their service offering structure. Shared servers are set up by the data center admin and customers using this platform for hosting their websites and applications through the FTP. Bandwidth, disk space, number of domains, FTP accounts, number of databases is given to each account as per the hosting plan. This is the real PaaS, in which customer is having access to the already installed platform, he can't alter the server setting, in the same manner SaaS is providing the access to the only installed software. Among the most familiar SaaS applications for business are customer relationship management applications like Salesforce and Google Apps. SaaS applications tend to reduce the cost of software ownership by removing the need for technical staff to manage the all other tasks such as management, installation, and up gradation. IaaS infrastructure as a service means providing the infrastructure for installing the software and application as per the client's requirement. In the data center dedicated server or virtual machine is provided to the client so the client can use the virtual or physical infrastructure to mange his own business. In this client not having the physical access to the server but he can manage and access the server from remote services. Also client would not be able to change the network and storage setting. In this environment client applications may demand more resources according to the website traffic and business so every data center must have the provision to scale up his resources as per the demand and requirement. Cloud computing is giving the service of auto scaling and dynamic resource management.

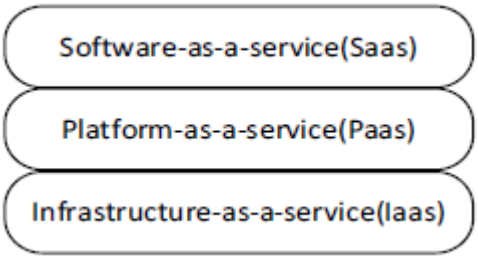

Fig1: Cloud services

Offering the physical server to each and every client is not best practice and also many customers does not want to use full resource as their applications and software's require different amount of resources and they only wish you pay as per their usage. So the technique is evolved called as a "Virtualization" which fulfills the all the requirement of all types of customers. This enables the partitioning of physical host in to multiple virtual machines. One data center can have multiple cloud technologies and the hypervisors support. Marketing strategies and the performance tactics attracts the clients towards the particular cloud technology. Data center management team increases the resources as per the business growth and the customer demands but the customer application demands the more resources randomly then data center should have enough resources to fulfill the demand of his particular application or server. Every time monitoring the resources of each virtual machine is not possible that's why cloud developers acquired the term called "migration" in which VM is automatically migrated from one host to another or suitable host which is having the enough resources to satisfy the requirement. Main and important thing in the live migration is "environment should not disturb and no downtime while migrating the VM from one PM to another PM". Live migration is done on the threshold value but we need to calculate the future prediction of CPU demand so we can migrate the VM on a host which will able to provide the resources which will require in the future for that particular VM. We will discuss the how live migration is done in different cloud technologies their algorithms and comparisons, Impact of live migration and different algorithms of CPU usage prediction. This survey paper also includes the simulation technology which helps to researchers and students to develop their own algorithm to test them in simulation tools rather than building the separate cloud environment for testing purpose only. This simulation saves a lot of time and the cost.

II. VIRTUALIZATION TYPES

Virtualization means creating the virtual instance of resource or device which relies on physical entity but acts as a separate entity in the virtual environment. We can say that dividing the resource in to partitions and using them as separate resource and treat as an execution environment. Virtualization can be in the form of storage, network, server, application and operating system level. A virtual environment is created on the physical entities which executing the process on those virtual entities and provide the result same as like a physical resources. Network, storage and server virtualization are most important in the DC operations.

1) *Network virtualization*: This is the virtualization in which the available bandwidth is splitting up in to the multiple channels and each channel is independent from other one and can be assigned to different server.

2) *Server virtualization:* In this type of virtualization the server is divided in to multiple servers and acting as virtual server which is having all the things like physical server. The OS which is running on the VM called a guest OS.

3) *Storage virtualization:* Pooling the resources from multiple network storage devices and appears as a single storage which can be manage and handle from the central console.

The whole concept splits in two separate parts:

1) *Full virtualization:* All the services of physical system is provided to virtual machines through the virtual machine monitors. Guest OS is totally or fully abstracted from the hardware by the layer of virtualization. The guest OS is not required any modification, the hypervisor translating all the instructions on time and caches the result for future purpose. VMware and Hyper-V is the example of full virtualization.

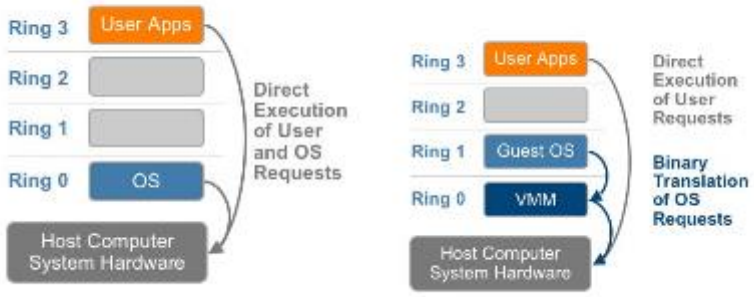

Fig2: Full virtualization

2) *Para virtualization:* This is called the alongside virtualization and in this type OS and hypervisor works together more efficiently and communicating with each other to improve performance and efficiency. There is a modified OS kernel with removing the non- virtualized instructions with the hyper calls for communicating with the hypervisor layer. Para virtualization is not supporting to the unmodified OS. It requires deep kernel level knowledge for modifications and Xen is the best example of para virtualization hypervisor.

Fig3: Para virtualization

III. ARCHITECTURAL DIFFERENCE IN LEADING HYPERVISORS

To provide the virtualization hypervisor is the major component and acts as fundamental software which is also called as a VMM (Virtual machine monitor) for monitoring the virtual machines which are running on it. For running the virtualization hardware assistant is required that's why AMD and Intel created new processor extension like AMD-VT and Intel VT-x. VMM classified into Type I Hypervisor and Type II Hypervisor. In type l, hypervisor also called as "bare metal" or "native hypervisor" as it directly runs on the top of the underlying hardware layer. VMM plays an important role in scheduling and allocation of system resources to virtual machines because it is bare metal which is running without any OS VMware ESX and Xen cause it provides the device drivers to guest OS for directly accessing underlying hardware.

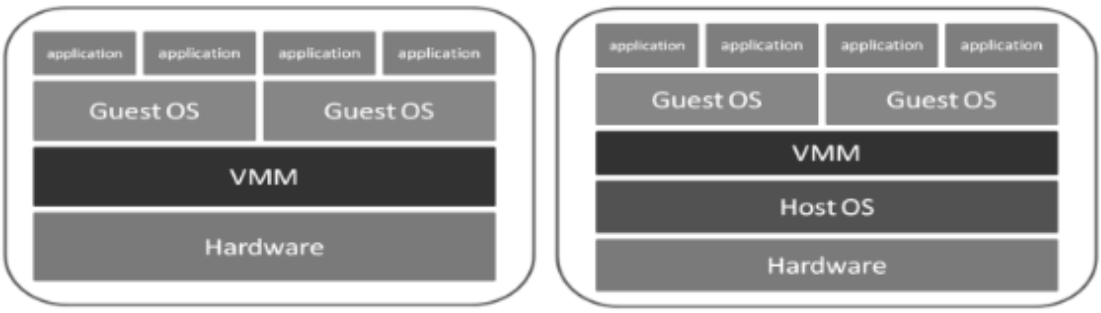

Fig4: Type 1 and Type 2 hypervisor

In second type hypervisor is running on the normal operating system as an application and host Os does not having any knowledge about the VMM simply it treats it as a process and performing the I/O behalf of the guest OS. Every request that is issued from the guest OS trapped by the host OS and send to device drivers that performs I/O and this trapped request again route back to the guest OS.

Following are the leading hypervisors in the market.

A. *Hyper-V*

Hyper-V comes in the windows server operating system in the form of role. After installing this role on the windows operating system we can make the virtual machine on the host machine. Microsoft is providing the enhanced versions of the windows OS and applying the new licensing policy and services in the Hyper-V role. In this isolated execution environment called as "partition" is a logical unit in which OS executes. The basic requirement is the hypervisor must have the root parent partition which will create the child partition via hyper call API that host the guest OS. Partitions do not have any access to the physical process instead they are having the virtual view and also runs in a virtual memory address which is private for a guest partition. The virtual view considers every device as a virtual device and request are redirected either via the VMBus or parent partition of hypervisor. VSP which communicates over the VMBus to handle device access requests from child partition.

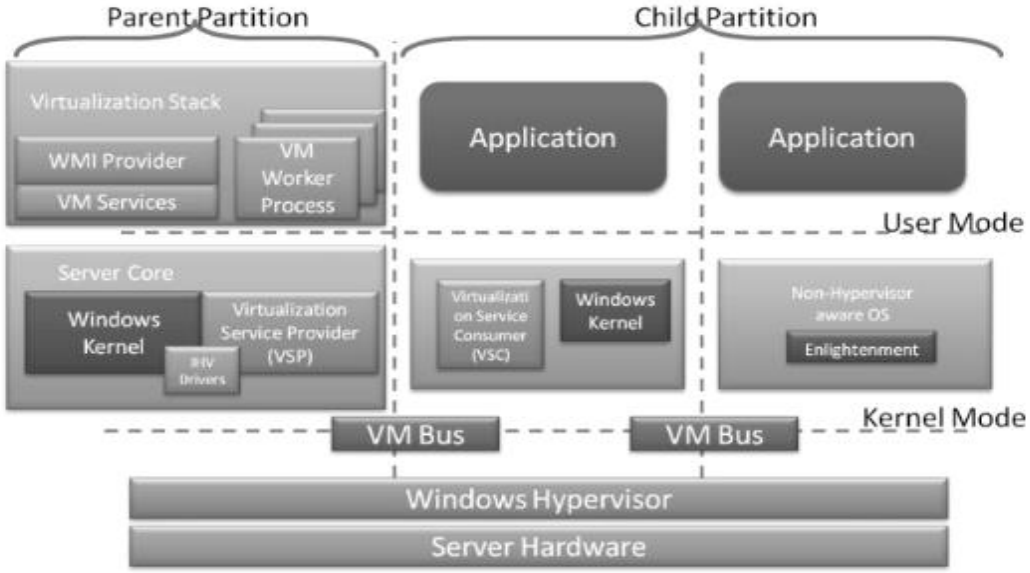

Fig5: Architecture of Hyper-V

Virtual service providers and virtual service consumers communicating with each other over the VMBus. Only parent partition is having the physical access over the resources for giving the i/o access child partition the hypervisor using the virtualization stack- a group of software components which works together and provides such access also stack includes VM services, VM worker process and WMI services through which the virtual machine management service spawns a separate a worker process for each VM also exposes a WMI based API's for managing and controlling the VM's.

B. *KVM*

Kernel based virtual machine is a loadable kernel module which is converting the linux kernel module into the bare metal hypervisor and hardware should have virtualization extensions like Intel VT-X and AMD. KVM has two important modules.

- KVM.ko : A loadable kernel module that provides the core virtualization infrastructure.
- Kvm-[intel|amd].ko: This is processor based module specially Intel and AMD.

Every Linux machine treated as a Linux process this allows taking the benefits of Linux kernel architecture, which makes KVM as a more mature hypervisor in comparison with other hypervisors. Also in addition it uses the QEMU to emulate the motherboard hardware; network interface ROM bios, memory controller, etc. this is useful in running the one OS on another.

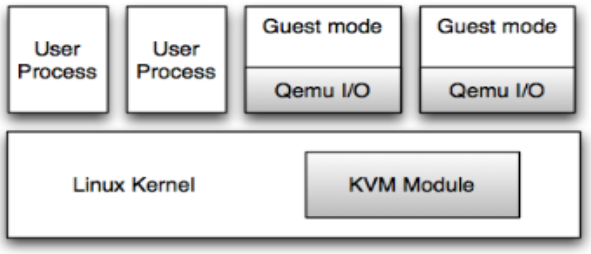

Fig6: Architecture of KVM

Memory management feature is inherited in the KVM hypervisor and the memory of virtual machine is stored like a memory of any Linux process so the management of process memory is easier in the KVM. Kernel same page merging (KSM) is useful in the memory page sharing is scans the memory of each virtual machine and merges the similar pages in to single copy. If any VM wants to update the memory copy a individual copy is provided to guest OS for the up-gradation. KVM is easily accommodating the different types of up-gradation.

C. *XEN*

Xen hypervisor is a software layer which sits on the hardware that allow multiple virtual guest OS to run in a secure and efficient manner. This is responsible for the CPU and memory management in visualize way also managing the scheduling of virtual machines. Dom 0 and Dom U are the key important domains in the Xen hypervisor. Dom 0 is the specialized modified Linux OS and this domain is having the rights to access the physical I/O resources as well as able to interact with the other virtual machines which are running on that physical hardware. Dom 0 is the basic requirement for Xen virtualization running environment to run any virtual machine. Dom U is the guest domain for guest machines. Dom 0 also contains the backend and local disk access request from the guest domain that contain front end for accessing the underlying hardware. This technique creates an illusion like each component having a dedicated device to that domain where as backend acts as a proxy and understands the details regarding physical device and send the information to frontend.

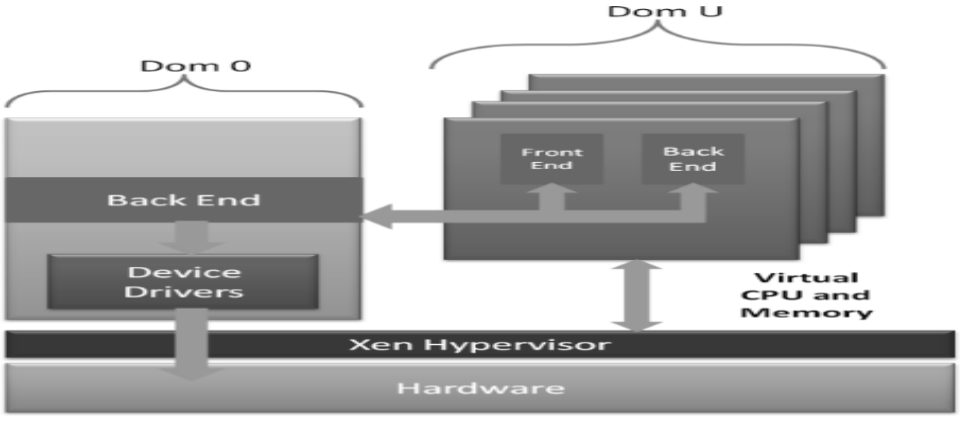

Fig7: Architecture of Xen

D. *VMware*

VMware launched the VMware workstation in the market for desktop virtualization after the successful launching of the workstation VMware came in to the server virtualization and released the VMware GSX in late 2000. Later in 2001 they have released the first version of Elastic Sky X (ESX) which was having the different approaches like VMware workstation. This ESX is having the three main modules which are responsible for the managing and regulating the resources. Physical host server on which actual ESX is runs at bare metal level. VMkernal is the high performance OS developed by VMware to run on the ESX server also it having modular design to add new devices without recompiling them. Console operating system (COS) is responsible for providing the execution environment which helps in monitoring and administrating the ESX.

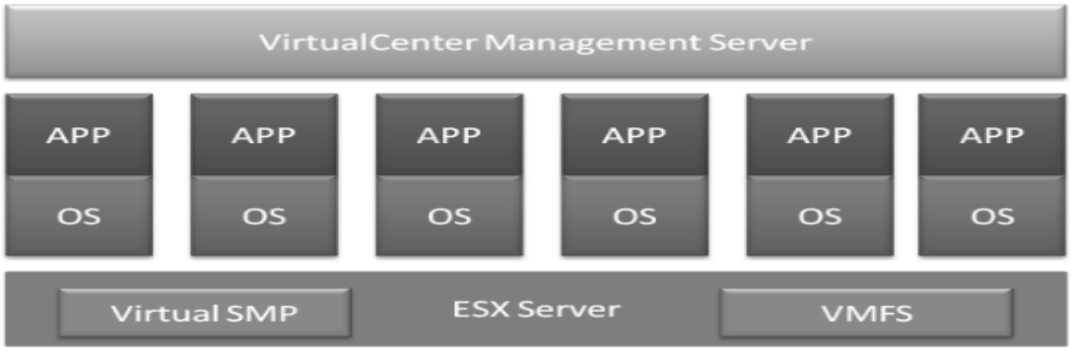

Fig8: Architecture of VMware

VMware using the VMFS (virtual machine file system) which gives the high performance and this file system is very useful in the VMware clusters. After installing the ESX on each host server we can manage the whole cluster from vCenter (Virtual centre). HA (high availability), FT (fault tolerance), DRS(distributes resource sharing), DPM (distributed power management) are the key features of the VMware cloud.

IV. BACKGROUND OF LIVE MIGRATION

Live migration of VM from one PM to another PM mainly required for load balancing and the server consolidation. It can be done either manually or automatically in the cloud setup and depends upon the type of hypervisor used in the set up. Live migration term is different in the leading hypervisor but the main purpose is the resource scheduling and 100% uptime mentioned in the service level agreement while signing up. Maintenance is also one of the major reasons for migration of the virtual machines from the particular physical host.

There are two approaches of the migration of virtual machines, Pre-copy and post-copy memory migration. In the post copy migration scenario first need to suspend the VM and source side and then copies the processor state to the target host and then resumes the VM state. Once server resumes then it fetches the memory pages over the network from the source node or host. Pre-copy approach includes the warm-up phase and stops and copy phase. Warm-up means keeping the VM in running state on the source host and copying the all memory pages to the destination. Whatever the changes are done while copying the pages they will be recopied until the rate of recopied pages not less than the page dirtying rate in the whole process. In Stop and wait phase first VM is suspended in the source node and then copy is started from source to destination node. After this process server status is resumed over the destination node. Some important performance metrics in the live migration process are; preparation time, Number of pages transferred, downtime, resume time, migration time and the degradation in the performance. In pre-copy phase the copying is done in different rounds first it copies the active memory pages and the next iteration transfers the dirtied pages most important thing is VM is in running state on the source and the copies done in multiple iteration.

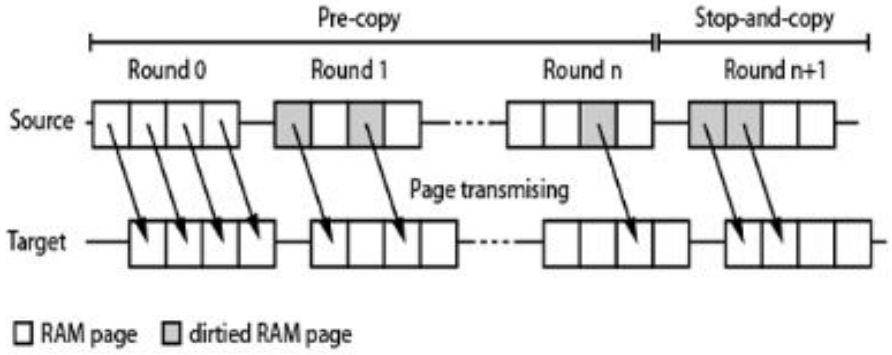

Fig9: Page copy iteration

This method considering the thrasholds to terminate the pre-copy iterations after the reachinghte trashold the copy process is terminationg to avoid the indefinite looping process.

V. MIGRATION TECHNIQUE IN LEADING HYPERVISORS

A. *Migration in VMWARE*

vMotion and DRS (distributed resource scheduler) are the two techniques avilable in the Vmware cloud for live migrating the virtual machines and managing the dynamic load balancing of processor and memory. For saving the energy during the live migartion process there is another phenomenon called as Dynamic power management (DPM) which saves the energy by balancing the load across all physical nodes and those who are having less load or small number of VM's automatically switched off. Resorce pools are defined on the reservation, Limit and share basis. High avialability, Fault tolarance and the Affinity rules are well managed under the Vmware cloud with the basis of following algorithms. Vm's cpu demand is calculated on the actual consumption of resources. But the most difficult part of the VMware is licensing cost. Al these features are coming with only enterprise and enterprise editions which is costly.

B. *Migration in Xen*

In the Xen hypervisor live migration is called as XenMotion and the best thing is all the editions of Xenserver supports the XenMotion. The basic requirement for performing the XenMotion is multiple hosts and the resource pool. The processor of all hosts should be of same family and configuration. It can not be performed between Intel and AMD. Gigabit Ethernet and the shared remote storage gives the ability to perform the live migration between multiple host. If you are looking for the load balancing feature on the Xenserver you need to purchase the enterprise and platinum edition. If the VM is not located on the shared storage and having each host his local storage there is one feature available in the Xenserver called as the "Storage XenMotion". This feature additionally allows VMs to be migrated from one physical host to another, where the VMs are not located on storage shared between the two hosts. All VMs stored on local storage can be migrated without downtime and VMs can be moved from one pool to another.

This enables system administrators to:

- Rebalance VMs between XenServer pools (for example from a development environment to a production environment).
- Upgrade XenServer hosts without any VM downtime.
- upgrade XenServer host hardware.

C. *Migration in Hyper-V*

Hyper-V is also providing the feature of live migration but the requirement for doing the set up of Failover cluster which is totally different from the other hyperviosrs technique. For configuring the setup; failover clustering feature to be added and configured on the servers running Hyper-V role. Live migration of virtual machine allows you to easily move running virtual machines from one node of the failover cluster to another node in the same cluster without a dropped network connection or downtime. Failover clustering needs shared storage for the cluster physical nodes. This includes an iSCSI or Fiber-Channel SAN. All virtual machines are stored in the shared storage, and the virtual machine state is managed by one of the nodes.

Following are the requirement for configuring the failover clustering:

- Ffailover cluster must run on the x64-based version or the Itanium architecture-based version
- Each servers should have the same software updates and service pack.
- Installtion mode should be same full installation or a Server Core installation.
- Only 64 nodes can be configured in the cluster of windows server 2012/r2

D. *Migration in KVM*

Like same way KVM also supports the live migration feature as it is based on the linux kernel and treating as a every VM as linux kernel process that's why the live migration is performed on the basis of pre copy and post copy based methods. Qemu and KVM are handling the dirty pages as per the context.

VI. IMPORTANCE OF RESOURCE MONITORING

Live migration and the resource allocation can not be done without calculating the server and virtual machines current resource allocation. Server deployment and the server termination records are more important in the data center, because client are changing on the daily basis many of them regsitering the new server with the same company and they require their new server on the same node with the specific IP range. An efficient

monitoring technique is very helpful to manage all the tasks but if we improve the monitoring system by integrating the multiple cloud under one platform from which all the clouds can be managed from that platform without login and enetring in the real envirnoment. Datacenter mnagemnt is the crucial task for every DC team, so the monitoing plays an important role in thse type of tasks. In today's market multiple monitoring tools are avilable but these tools are not sutaible for every DC, that's why most of data center developing their own monitoring tools which suits I their envirnoment

VII. NEED OF CPU USAGE PREDICTION

While reviewing the above technologies one thing is common that the live migration is performed according to the static threshold of the virtual machine. If the value is reach up to this threshold, it means the virtual machine requires more resources and migrated over the other node. In this case only resources are calculated and the VM is migrated on the available node which is having the resources. But what will be the case after migration the resource of the destination node will not able to fulfill the requirement of other VM. In the proposed we will calculate the future resource requirement of the particular VM and will migrate them on the dynamic threshold of CPU usage prediction. There are multiple algorithms are available in the mathematics two calculate the other variable values from the existing one and also we can use the concept of "skewness" to calculate the unevenness of the VM resource requirement.

VIII. CONCLUSIONS

In this paper we have studied the detail architecture of leading hypervisors and the live migration techniques used in their cloud computing environment. Also we have take the detailed review on the cloud computing core services from the perspective of the data center hosting platform. Resource scheduling and the live migration is the popular and important aspect of every cloud service provider, this review will help in the choosing the best cloud platform according to the application requirement and also help in improving the live migration process using different mathematics terminologies.

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