Cloud Computing

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1. Virtualization

What is virtualization?

Wikipedia uses the following definition**: "In computing, virtualization is a broad term that refers to the abstraction of computer resources.**

Virtualization hides the physical characteristics of computing resources from their users, be they applications, or end users. This includes making a single physical resource (such as a server, an operating system, an application, or storage device) appear to function as multiple virtual resources; it can also include making multiple physical resources (such as storage devices or servers) appear as a single virtual resource..."

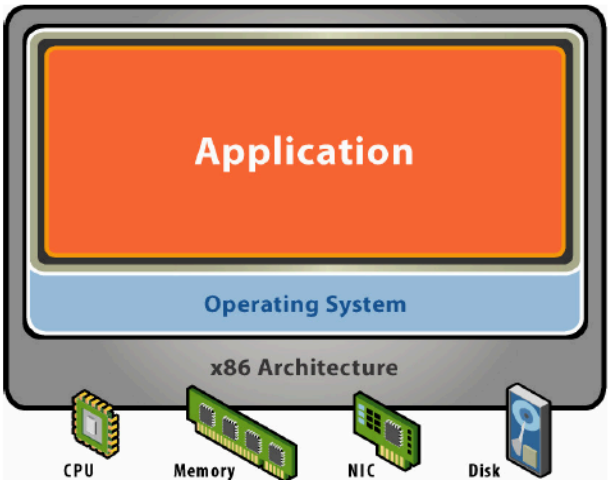

Fig: Traditional Stack

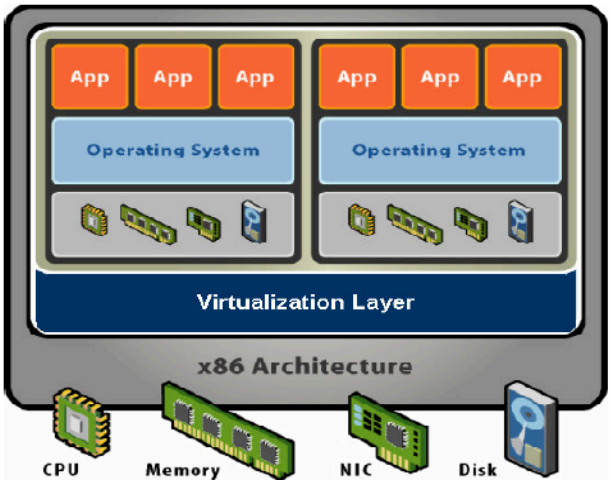

Fig: Virtualized Stack

Types of Virtualization

Today the term virtualization is widely applied to a number of concepts including:

1. **Server Virtualization**
2. **Client / Desktop / Application Virtualization**
3. **Network Virtualization**
4. **Storage Virtualization**
5. **Service / Application Infrastructure Virtualization**

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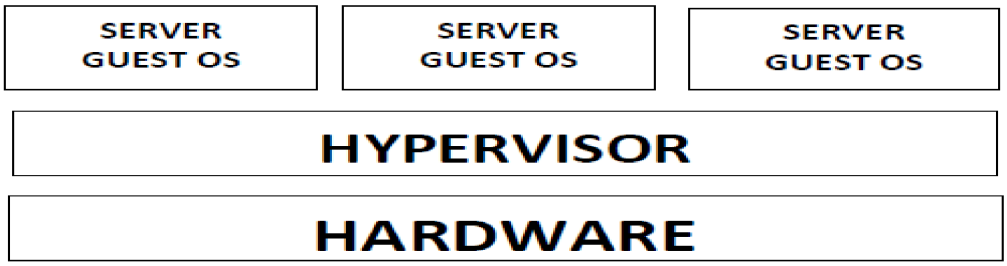
In most of these cases, either virtualizing one physical resource into many virtual resources or turning many physical resources into one virtual resource is occurring.

Server Virtualization

Server virtualization is the most active segment of the virtualization industry featuring established companies such as VMware, Microsoft, and Citrix. **With server virtualization one physical machine is divided many virtual servers.** At the core of such virtualization is the concept of a hypervisor (virtual machine monitor).

A hypervisor is a thin software layer that intercepts operating system calls to hardware. Hypervisors typically provide a virtualized CPU and memory for the guests running on top of them. The term was first used in conjunction with the IBM CP-370.



Hypervisors are classified as one of two types:

Type 1 – This type of hypervisor is also known as native or bare-metal. They run directly on the hardware with guest operating systems running on top of them. Examples include VMware ESX, Citrix XenServer, and Microsoft'sHyper-V.

Type 2 – This type of hypervisor runs on top of an existing operating system with guests running at a third level above hardware. Examples include VMware Workstation and SWSoft's Parallels Desktop.

Related to type 1 hypervisors is the concept of paravirtualization. Paravirtualization is a technique in which a software interface that is similar but not identical to the underlying hardware is presented. Operating systems must be ported to run on top of a paravirtualized hypervisor. Modified operating systems use the "hyper calls" supported by the paravirtualized hypervisor to interface

directly with the hardware. The popular Xen project makes use of this type of virtualization. Starting with version 3.0 however Xen is also able to make use of the hardware assisted virtualization technologies of Intel (VT-x) and AMD (AMD-V). These extensions allow Xen to run unmodified operating systems such as Microsoft Windows.

Advantages/Benefits:

- **Increased Hardware Utilization** – This results in hardware saving, reduced administration overhead, and energy savings.
- **Security** – Clean images can be used to restore compromised systems. Virtual machines can also provide sandboxing and isolation to limit attacks.
- **Development** – Debugging and performance monitoring scenarios can be easily setup in a repeatable fashion. Developers also have easy access to operating systems they might not otherwise be able to install on their desktops.

Disadvantages/Drawbacks/Downsides:

- **Security** – There are now more entry points such as the hypervisor and virtual networking layer to monitor. A compromised image can also be propagated easily with virtualization technology.
- **Administration** – While there are less physical machines to maintain there may be more machines in aggregate. Such maintenance may require new skills and familiarity with software that administrators otherwise would not need.
- **Licensing/Cost Accounting** – Many software-licensing schemes do not take virtualization into account. **For example** running 4 copies of Windows on one box may require 4 separate licenses.
- **Performance** – Virtualization effectively partitions resources such as RAM and CPU on a physical machine. This combined with hypervisor overhead does not result in an environment that focuses on maximizing performance.

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Application/Desktop Virtualization

Virtualization offers a number of uses on the client side at both the desktop and application level. Such virtualization can be broken out into four categories:

- Local Application Virtualization/Streaming
- Hosted Application Virtualization
- Hosted Desktop Virtualization
- Local Desktop Virtualization

Application virtualization is an umbrella term that describes software technologies that improve manageability and compatibility of legacy applications by encapsulating applications from the underlying operating system on which they are executed. Application virtualization differs from operating system virtualization in that in the latter case, the whole operating system is virtualized rather than only specific applications.

With streamed and local application virtualization an application can be installed on demand as needed. If streaming is enabled then the portions of the application needed for startup are sent first optimizing startup time. Locally virtualized applications also frequently make use of virtual registries and file systems to maintain separation and cleanness from the user's physical machine. Examples of local application virtualization solutions include Citrix Presentation Server and Microsoft SoftGrid.

Hosted application virtualization allows the user to access applications from their local computer that are physically running on a server somewhere else on the network. Technologies such as Microsoft's RemoteApp allow for the user experience to be relatively seamless include the ability for the remote application to be a file handler for local file types.

Benefits of application virtualization include:

- **Security** – Virtual applications often run in user mode isolating them from OS level functions.

- **Management** – Virtual applications can be managed and patched from a central location.
- **Legacy Support** – Through virtualization technologies legacy applications can be run on modern operating systems they were not originally designed for.
- **Access** – Virtual applications can be installed on demand from central locations that provide failover and replication.

Disadvantages include:

- **Packaging** – Applications must first be packaged before they can be used.
- **Resources** – Virtual applications may require more resources in terms of storage and CPU.
- **Compatibility** – Not all applications can be virtualized easily.

Wikipedia defines desktop virtualization as:

Desktop virtualization (or Virtual Desktop Infrastructure) is a server-centric computing model that borrows from the traditional thin-client model but is designed to give administrators and end users the best of both worlds: the ability to host and centrally manage desktop virtual machines in the data center while giving end users a full PC desktop experience.

Hosted desktop virtualization is similar to hosted application virtualization, expanding the user experience to be the entire desktop. Commercial products include Microsoft's Terminal Services, Citrix's XenDesktop, and VMware's VDI.

Benefits of desktop virtualization include most of those with application virtualization as well as:

- **High Availability** – Downtime can be minimized with replication and fault tolerant hosted configurations.
- **Extended Refresh Cycles** – Larger capacity servers as well as limited demands on the client PCs can extend their lifespan.

- **Multiple Desktops** – Users can access multiple desktops suited for various tasks from the same client PC.

Disadvantages/Drawbacks/Downsides:

Disadvantages of desktop virtualization are **similar to server virtualization**. There is also the added disadvantage that clients must have network connectivity to access their virtual desktops.

The final segment of **client virtualization** is local desktop virtualization. It could be said that this is where the recent resurgence of virtualization began with VMware's introduction of VMware Workstation in the late 90's. Today the market includes competitors such as Microsoft Virtual PC and Parallels Desktop. Local desktop virtualization has also played a key part in the increasing success of Apple's move to Intel processors since products like VMware Fusion and Parallels allow easy access to Windows applications. Some the benefits of local desktop virtualization include:

- **Security** – With local virtualization organizations can lock down and encrypt just the valuable contents of the virtual machine/disk. This can be more performant than encrypting a user's entire disk or operating system.
- **Isolation** – Related to security is isolation. Virtual machines allow corporations to isolate corporate assets from third party machines they do not control. This allows employees to use personal computers for corporate use in some instances.
- **Development/Legacy Support** – Local virtualization allows a users computer to support many configurations and environments it would otherwise not be able to support without different hardware or host operating system. Examples of this include running Windows in a virtualized environment on OS X and legacy testing Windows 98 support on a machine that's primary OS is Vista.

Network Virtualization

Up to this point the types of virtualization covered have centered on applications or entire machines. Other computing concepts also lend themselves to being software virtualized as well. Network virtualization is one such concept.

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Network Virtualization **is the process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network.** Network virtualization involves platform virtualization, often combined with resource virtualization.

Network virtualization is categorized as either **external**, combining many networks, or parts of networks, into a virtual unit, or **internal**, providing network-like functionality to the software containers on a single system…

Using the internal definition of the term, desktop and server virtualization solutions provide networking access between both the host and guest as well as between many guests. On the server side virtual switches are gaining acceptance as a part of the virtualization stack. The external definition of network virtualization is probably the more used version of the term however. Virtual Private Networks (VPNs) have been a common component of the network administrators' toolbox for years with most companies allowing VPN use. Virtual LANs (VLANs) are another commonly used network virtualization concept.

Advantages/Benefits:

- **Customization of Access** – Administrators can quickly customize access and network options such as bandwidth throttling and quality of service.
- **Consolidation** – Physical networks can be combined into one virtual network for overall simplification of management.

Disadvantages/Drawbacks/Downsides:

- **Increased complexity**
- **Performance overhead**
- **Need for administrators to have a larger skill set.**

Storage Virtualization

Storage virtualization **refers to the process of abstracting logical storage from physical storage.**

The term storage virtualization typically includes additional concepts such as **data migration and caching**. Storage virtualization is hard to define in a fixed manner due to the variety of ways that the functionality can be provided. Typically, it is provided as a feature of:

- Host Based with Special Device Drivers
- Array Controllers
- Network Switches
- Stand Alone Network Appliances

Another primary way that storage virtualization is classified is whether it is in-band or out-of-band**. In-band (often called symmetric) virtualization** sits between the host and the storage device allowing caching. **Out-of-band (often called asymmetric) virtualization** makes use of special host based device drivers that first lookup the meta data (indicating where a file resides) and then allows the host to directly retrieve the file from the storage location. Caching at the virtualization level is not possible with this approach.

Advantages/Benefits:

- **Migration** – Data can be easily migrated between storage locations without interrupting live access to the virtual partition with most technologies.
- **Utilization** – Similar to server virtualization, utilization of storage devices can be balanced to address over and underutilization.
- **Management** – Many hosts can leverage storage on one physical device that can be centrally managed.

Disadvantages/Drawbacks/Downsides:

- **Lack of Standards and Interoperability** – Storage virtualization is a concept and not a standard. As a result vendors frequently do not easily interoperate.
- **Metadata** – Since there is a mapping between logical and physical location, the storage metadata and its management becomes key to a working reliable system.

- **Backout** – The mapping between local and physical locations also makes the backout of virtualization technology from a system a less than trivial process.

Service / Application Infrastructure Virtualization

Application infrastructure virtualization (sometimes referred to as application fabrics) unbundle an application from a physical OS and hardware. Application developers can then write to a virtualization layer. The fabric can then handle features such as deployment and scaling. In essence this process is the evolution of grid computing into a fabric form that provides virtualization level features. Companies such as Appistry and DataSynapse provides features including:

- Virtualized Distribution
- Virtualized Processing
- Dynamic Resource Discovery

IBM has also embraced the virtualization concept at the application infrastructure level with the rebranding and continued of enhancement of Websphere XD as Websphere Virtual Enterprise. The product provides features such as service level management, performance monitoring, and fault tolerance. The software runs on a variety of Windows, Unix, and Linux based operating systems and works with popular application servers such as WebSphere, Apache, BEA, JBoss, and PHP application servers. This lets administrators deploy and move application servers at a virtualization layer level instead of at the physical machine level.

2. VIRTUAL MACHINES & VIRTUALIZATION MIDDLEWARE

A conventional computer has a single OS (Operating System) image. Single OS image offers a rigid architecture that tightly couples application software to a specific hardware platform.

Some software running well on one machine may not be executable on another platform with a different instruction set under a fixed OS.

The below diagram shows the comparison between physical machine and three VM architectures

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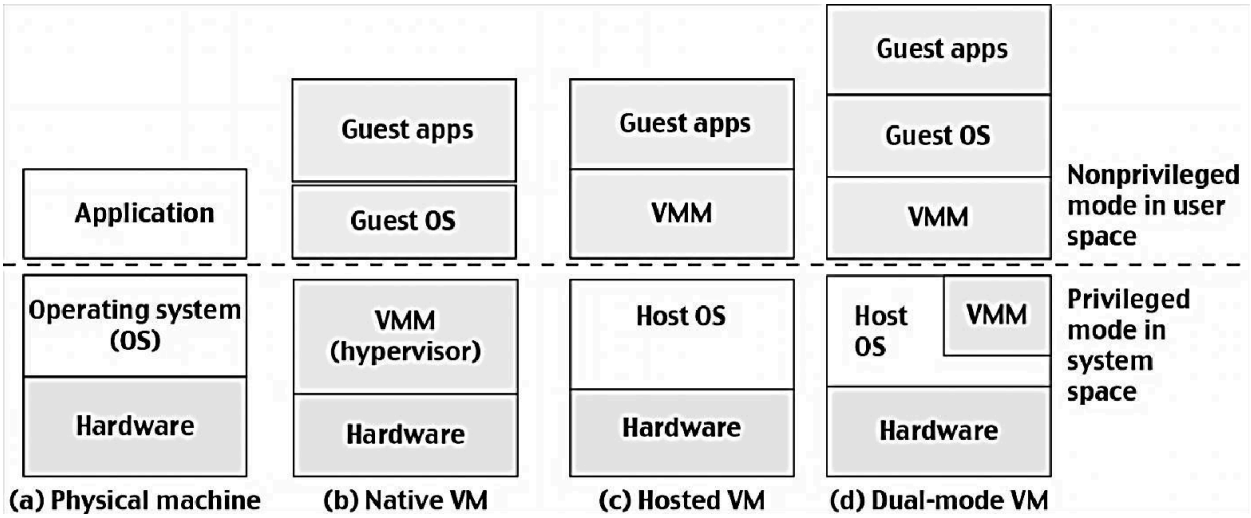

In **FIG-A: -** X-86 architecture desktop running its installed windows OS.
FIG-B: - shows a native VM installed with the use of VMM called Hypervisor in privileged mode.

Virtual machines (VM's) offer solutions to

1. Underutilized resources,
2. Application inflexibility,
3. Software manageability
4. Security concerns in existing physical machines.

Hypervisor approach is also called Bare-Metal VM because the hypervisor handle bare hardware (CPU, Memory, and I/O) devices directly. The VM can be provisioned for any hardware system, the VM is built with virtual resources managed by guest OS to run a specific application.

The VM is built with virtual resources managed by guest OS to run a specific application. Between VM's and host platform one need s to deploy a middleware layer called VMM (Virtual Machine Monitor).

In FIG-C, VMM runs in non-privileged mode. The host OS need not be modified.
In FIG-D, the VM is implemented in dual mode. Part of VMM runs at user level and another part runs at supervisor level.

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In this case the host OS may have to be modified to some extent. The VM approach offers hardware independence of OS and applications. The user application running on its dedicated OS could be bundled together as a virtual appliance that can be ported to any hardware platform

VM Primitive Operations

The VMM provides VM abstraction to the guest OS. With full virtualization, the VMM exports a VM abstraction identical to physical machine so that a standard OS (windows 2000 or Linux) can run just as it would on the physical hardware.
The following are the low level VMM operations

1. Multiplexing
2. Suspension
3. Provision
4. Life migration.

First VM's can be multiplexed between hardware machines
Second a VM can be suspended and stored in stable storage. Third a suspended VM can be resumed or provisioned to a new hardware platform.

Finally a VM can be migrated from one hardware platform to another. These VM operations enable a VM to be provisioned to any available hardware platforms.

The VM approach will significantly enhance the utilization of server resources. Multiple server functions can be consolidated on the same hardware platform to achieve higher system efficiency.

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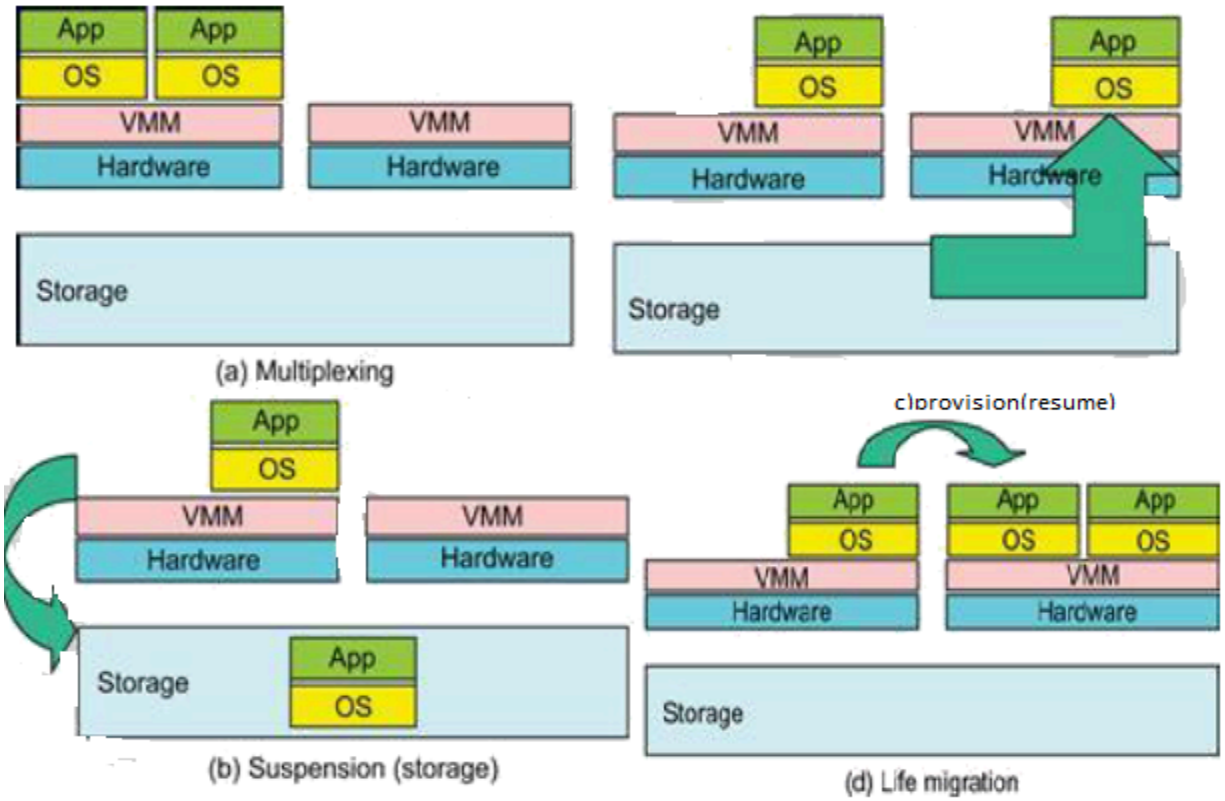

Software as a Service

SaaS is a software delivery method that provides access to software and its functions remotely as a Web-based service. Software as a Service allows organizations to access business functionality at a cost typically less than paying for licensed applications since SaaS pricing is based on a monthly fee.

Also, because the software is hosted remotely, users don't need to invest in additional hardware. Software as a Service removes the need for organizations to handle the installation, set-up and often daily upkeep and maintenance. Software as a Service may also be referred to as simply hosted applications.

SaaS is a model of software deployment where an application is hosted as a service provided to customers across the Internet.

SaaS alleviates the burden of software maintenance/support

- But users relinquish control over software versions and requirements

Terms that are used in this sphere include

- Platform as a Service (PaaS) and

- Infrastructure as a Service (IaaS)

Software as a Service (SaaS) makes use of a cloud computing infrastructure to deliver one application to many users, regardless of their location, rather than the traditional model of one application per desktop. It allows activities to be managed from central locations in a one-to-many model, including architecture, pricing, partnering, and management characteristics.

Five reasons to consider SaaS:

1. You want to lower expenses associated with software acquisitions in the near term.
2. You want to shift some of your IT budget from capital expense to operational expense.
3. You have limited IT resources to deploy and maintain needed hardware and software.
4. You need to refocus your IT staff from deployment and maintenance to high-priority projects.
5. You want to reduce energy consumption and expense

Seven tips to help you get started:

1. Compare the up-front cost savings to long-term subscription usage, because fees don't necessarily decline over time.
2. Look for the ability to customize or configure the application for your environment. Not all SaaS providers allow configuration.
3. Make sure a SaaS solution has all the features you want. Some hosted versions are not identical to their desktop counterparts.
4. Ensure the possibility of sharing your solution with other agencies.
5. Don't focus solely on costs—look for ways to improve your business. For example, can on-demand resources free your time to offer more mission-critical services to workers or citizens, to reduce time spent on more mundane IT chores, or to get features into use more quickly?
6. Realize that applications have been running in the cloud for years, but a variety of approaches exist.

Look for service-oriented architectures (SOA), web services standards, and web application frameworks— they're easier to integrate.

7. Make sure you own your data. Your service agreement with a provider should explicitly specify that the client owns the data—without a time limit.

Applicability of Saas

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Enterprise Software Application

- Perform business functions
- Organize internal and external information
- Share data among internal and external users
- The most standard type of software applicable to Saas model
- Example: Saleforce.com CRM application, Siebel On-demandapplication

Single-User software application

- Organize personal information
- Run on users' own local computer
- Serve only one user at a time
- Inapplicable to Saas model
- Data security issue
- Network performance issue
- Example: Microsoft office suite

Infrastructure software

- Serve as the foundation for most other enterprise software application
- Inapplicable to Saas model
- Installation locally is required
- Form the basis to run other application
- Example: Window XP, Oracle database

Embedded Software

- Software component for embedded system
- Support the functionality of the hardware device
- Inapplicable to Saas model
- Embedded software and hardware is combined together and is inseparable
- ü Example: software embedded in ATM machines, cell phones, routers, medical equipment, etc

Service Oriented Architecture

- A style of building reliable distributed systems
- SOA delivers functionalities as services emphasizing loose coupling between interacting services

Characteristics of Service

- Service- a software component accessed via a network

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- Services defined by well-published interfaces
- Services are loosely coupled and promote location transparency
- Services encapsulate reusable business services
- They communicate with each other via messages passing

Overview of SOA

Services are natural building blocks allowing to organize capabilities naturally, similar to objects and components SOA consists of a service provider and service consumer that requested a service. Loose coupling is closely associated with SOA

Its benefits are: flexibility, scalability, replacability and fault tolerance

SOA Design and Development

- Identify different units of business logic and work units
- Explain functionality of various units in terms of services
- Identify core infrastructure services
- Identify major links of common functionality between different services
- Capture service functionalities in terms of services
- Define events of interest in the service
- Create workflows to enable service choreography
- Publish services in a registry or multiple registries

v From the point of view of the business:

SOA is a set of services that are configured to form composite applications with dynamic and flexible process flows. Those processes and services can be exposed to customers and partners, or to other parts of the organization

v From the point of view of an enterprise architect:

SOA is an architectural style that promotes the concepts of business processes and the orchestration of enterprise-level business services. It is also a set of architectural principles, patterns and criteria which address characteristics such as modularity, encapsulation, loose coupling, separation-of-concerns, reuse and composability.

v From the point of view of a project manager

SOA is a development approach supporting highly productive parallel development

v From the point of view of a tester and/or quality assurance engineer

SOA represents a way to simplify overall system testing.

v From the point of view of a software developer

SOA is a programming model supported by standards, tools and technologies including, but not limited to Web Services.

Benefits of SOA:

-Greater interoperability
– Increased reuse
– Greater business flexibility
– Reduced maintenance and development costs
– Improved visibility

On Demand Computing (ODC)

On-demand (OD) computing is an increasingly popular enterprise model in which computing resources are made available to the user as needed. The resources may be maintained within the user's enterprise, or made available by a service provider.

The on-demand model was developed to overcome the common challenge to an enterprise of being able to meet fluctuating demands efficiently. Because an enterprise's demand on computing resources can vary drastically from one time to another, maintaining sufficient resources to meet peak requirements can be costly. Conversely, if the enterprise cuts costs by only maintaining minimal computing resources, there will not be sufficient resources to meet peak requirements.

On-demand computing products are rapidly becoming prevalent in the marketplace. Computer Associates, HP, IBM, Microsoft, and Sun Microsystems are among the more prominent on-demand vendors. These companies refer to their on-demand products and services by a variety of names. IBM calls theirs "On Demand Computing" (without the hypen).

Concepts such as grid computing, utility computing, autonomic computing, and adaptive management seem very similar to the concept of on-demand computing. JasonBloomberg, Senior Analyst with ZapThink, says that on-demand computing is a broad category that includes all the other terms, each of which means something slightly different. Utility computing, for example, is an on-demand approach that combines outsourced computing resources and infrastructure management with a usage-based payment structure (this approach is sometimes known as metered services).

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Definition - What does On-Demand Computing (ODC) mean?

On-demand computing (ODC) is an enterprise-level model of technology and computing in which resources are provided on an as-needed and when-needed basis. ODC make computing resources such as storage capacity, computational speed and software applications available to users as and when needed for specific temporary projects, known or unexpected workloads, routine work, or long-term technological and computing requirements.

Web services and other specialized tasks are sometimes referenced as types of ODC.

ODC is succinctly defined as “pay and use” computing power. It is also known as OD computing or utility computing.

Techopedia explains On-Demand Computing (ODC)

The major advantage of ODC is low initial cost, as computational resources are essentially rented when they are required. This provides cost savings over purchasing them outright.

The concept of ODC is not new. John McCarthy at the Massachusetts Institute of Technology (MIT) made the prophetic and insightful comment in 1961 that someday computing may be organized to provide services much like public utilities do. Over the following two decades, IBM and other mainframe providers made computing power and database storage available to many banks and other large organizations all over the world. Later, the business model changed as low-cost computers became ubiquitous in the business world.

By the late 1990s, computer data centers were filled with thousands of servers, and utility computing emerged. On-demand computing, software-as-a-service and cloud computing are all models for repackaging computational, software application and network services.

The conceptual and actual technologies that allow these companies to develop ODC services include virtualization, computer clusters, supercomputers and distributed computing.