Unit-3

GRID FRAMEWORK

3.1 Virtualization of IT systems

Virtualization is the latest in a long line of technical innovations designed to increase the level of system abstraction and enable IT users to harness ever-increasing levels of computer performance.

At its simplest level, virtualization allows you to have two or more computers, running two or more completely different environments, on one piece of hardware. For example, with virtualization, both Linux operating system and Microsoft Windows operating system can be used on one server.

In slightly more technical terms, virtualization essentially decouples users and applications from the specific hardware characteristics of the systems they use to perform computational tasks. This technology is likely to usher in an entirely new wave of hardware and software innovation. For example, and among other benefits, virtualization can simplify system upgrades (and in some cases may eliminate the need for such upgrades) by allowing users to capture the state of a virtual machine (VM), and then transporting that state in its entirety from an old to a new host system.

Virtualization is also designed to enable a generation of more energy-efficient computing. Processor, memory, and storage resources that today must be delivered in fixed amounts determined by real hardware system configurations will be delivered with finer granularity via dynamically tuned VMs.

What is a virtual machine (VM)?

In the simplest terms possible, a virtual machine (VM) is a virtual representation of a physical computer.

Virtualization allows an organization to create multiple virtual machines—each with their own operating system (OS) and applications—on a single physical machine.

A virtual machine can't interact directly with a physical computer.

Instead, it needs a lightweight software layer called a hypervisor to coordinate with the physical hardware upon which it runs.

What is a hypervisor?

The hypervisor is essential to virtualization—it's a thin software layer that allows multiple operating systems to run alongside each other and share the same physical computing resources.

These operating systems come as the aforementioned virtual machines (VMs)—virtual representations of a physical computer—and the hypervisor assigns each VM its own portion of the underlying computing power, memory, and storage.

This prevents the VMs from interfering with each other

The Benefits of Virtualization

Up to 80 percent greater utilization of every server.

Reductions in hardware requirements by a ratio of 10:1 or better.

Capital and operations expenses cut by half, with annual savings of more than $1,500 for each server virtualized.

Robust, affordable high availability.

How does Virtualization Help Green Computing?

Virtualization results in far more efficient use of resources, including energy.

Virtualization's purpose in a simple way is virtualize and make a single piece of hardware function as multiple parts.

Different user interfaces isolate different parts of the hardware, thereby making each one behave and function as an individual.

Installing virtual infrastructure allows several operating systems and applications to run on a lesser number of servers, helping to reduce the overall energy used for the data centre and for its cooling.

The energy saved per server would translate into approximately 7000 Kilo Watt hours per year, which is a tremendous potential for energy savings, Virtualization is the best to practice green computing, especially data centres.

3.1.1 Virtualisation can be classified into 3 categories, namely:-

Desktop Virtualisation

Server Virtualisation

Storage Virtualisation

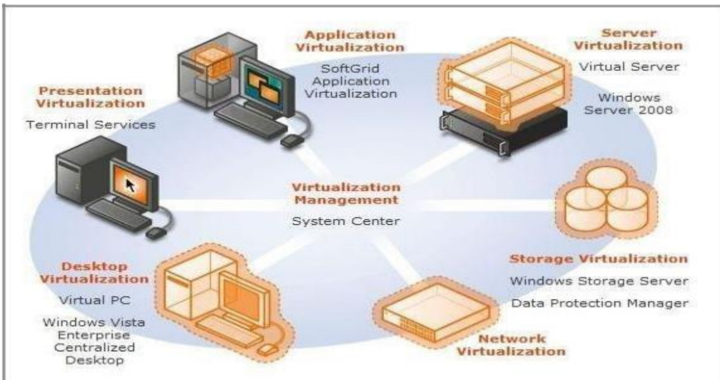


Figure 3.1 Virtualization Management

3.1.1.1 Desktop Virtualisation

Desktop virtualization, often called client virtualization, is a virtualization technology used to separate a computer desktop environment from the physical computer.

Desktop virtualization is considered a type of client-server computing model because the "virtualized" desktop is stored on a centralized, or remote, server and not the physical machine being virtualized.

Desktop virtualization "virtualizes desktop computers" and these virtual desktop environments are "served" to users on the network.

Another benefit of desktop virtualization is that is lets you remotely log in to access your desktop from any location.

Essential documents on Desktop Virtualisation

Managing the Desktop estate: the low risk route to desktop virtualisation

Ten Reasons to modernise the desktop

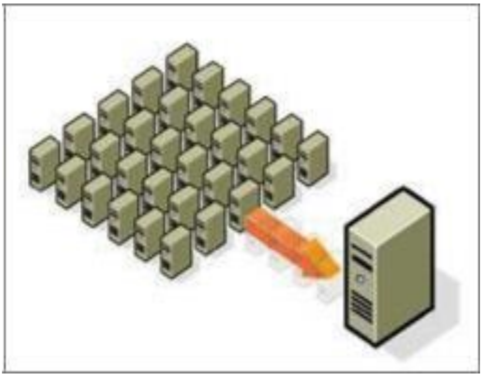
A Peer Survey: Desktop Virtualisation – Separating the Hype from Reality

The Next Generation Virtual Desktop Solution for Growing businesses

Best Practices for testing Desktop Virtualisation

Desktop Virtualisation: **A buyer's checklist**

3.1.1.2 Server Virtualisation



Server virtualization is the partitioning of a physical server into smaller virtual servers.

In server virtualization the resources of the server itself are hidden, or masked, from users, and software is used to divide the physical server into multiple virtual environments, called virtual or private servers.

One common usage of this technology is in Web servers. Virtual Web servers are a very popular way of providing low-cost web hosting services.

Instead of requiring a separate computer for each server, dozens of virtual servers can co-reside on the same computer.

Essential documents on Server Virtualisation

The Business Value Of Virtualization

The Future of Virtualization

Virtualizing Business-Critical Applications

Five Steps to Determine When to virtualise Your Servers

Benefitting from Server Virtualization - Beyond Initial Workload Consolidation

Getting the most out of virtualisation

User Survey Analysis: Next Steps for Server Virtualisation in the mid market.

3.1.1.3 Storage Virtualisation

Storage virtualization is the amalgamation of multiple network storage devices into what appears to be a single storage unit. Storage virtualization is often used in SAN (storage area network), a high-speed sub-network of shared storage devices.

The management of storage devices can be tedious and time-consuming. Storage virtualization helps the storage administrator perform the tasks of backup, archiving, and recovery more easily, and in less time, by disguising the actual complexity of the SAN.

Users can implement virtualization with software applications or by using hardware and software hybrid appliances.

The technology can be placed on different levels of a storage area network.

Essential documents on Storage Virtualisation

Learn about Storage virtualisation, its benefits and what it can mean for your business and storage infrastructure

Evaluating Storage Technologies For Virtual Server Environments

Storage Virtualisation- what to know and what to look for

Server and Storage Virtualization: A Complete Solution

3.2 Role of Electric Utilities

IT equipment has become the third largest source of power demand in the commercial sector, accounting for more **than 10% of an organization's energy use.**

In fact, IT and related communications technologies now account for more than 2% of all global CO2 emissions.

To improving the energy efficiency and environmental friendliness of your IT Department can be a real challenge.

The easiest way to reduce energy costs is to implement an easy and cost-effective PC power management solution.

The Challenge of Power Management

A typical PC consumes between 400 kWh (kilowatt hours) and 600 kWh of electricity each year, depending on the brand, how it is equipped (e.g. LCD or CRT monitor), and how hard the CPU is working.

The average cost of a kilowatt hour of electricity in the United States averaged $.0898, and ranged from $.0533 to $.2536.

Assuming all computers in a 10,000 machine environment are left turned on all of the time these rates would result in an annual cost for electricity of somewhere between $1,867,632 and $13,329,216.

If you consider that 50% of all PC's are left on both overnight and on weekends (70% of the total hours each **week), it's reasonable to expect that actively** implementing effective power management policies across the organization can result in savings of up to 35% (i.e. 50% of 70%) on your PC-related electrical bill.

Given the heat generated by a PC, reducing the number of hours that each PC is turned on each day will reduce the cost of electricity for air conditioning in warmer months.

3.2.1 Role of Telecommuting, Teleconferencing and Teleporting

Teleworking technologies are variously implemented for green computing initiatives and many advantages include lower greenhouse gas emissions related to travel, greater worker satisfaction and, as a result of lower overhead office costs, increased profit margins. Teleconferencing and telepresence technologies are often implemented in green computing initiatives.

The ways in which telecommuting is eco-friendly.

It reduces carbon emissions. **Whether it's by planes,** trains or automobiles, traveling in to work has a negative impact on the environment. Cutting the commute, thus prevents an excessive amount of carbon emissions to go into the air.

It reduces electricity. When people work in an office, almost everything is powered by electricity. From lights to computers and printers—even the coffee machine—everything consumes large quantities of electricity.

Working at home allow reduce electricity consumption to what it really takes to make home office run.

It reduces paper printing.

It makes you take better care of your equipment. Think about how often you actually shut down your computer at work.

In addition to flexible schedule and saving time and money, telecommuting also greatly helps the environment.

Why Telecommuting is a Green Way to Work

Studies have shown that remote workforces contribute to sustainable, environmentally-friendly workplaces by reducing congestion, lowering fuel consumption, minimizing construction, lessening pollution emissions, reducing the strain on transportation systems, and improving air quality.

Example: Dell and Xerox have experienced this first-hand.

The average U.S. commuter produces an estimated 380 lbs. of CO2 each year during rush hour, but switching to full-time telecommuting **reduces each person's work**-related carbon footprint by 98 percent.

According to Global Workplace Analytics, if workers in the U.S. who held telework-compatible jobs (50 percent) and wanted to (79 percent) worked from home just two days a week, the U.S. as a whole would:

Gas Use: Save nearly 52 million gallons of gas—the greenhouse gas equivalent of taking approximately 88,000 vehicles off the road per year.

Oil: Save over 2.6 million barrels of oil, valued at over $264 million.

Roads: Reduce wear and tear on highways by over 1 billion miles a year.

The advantages are many-

Increased worker satisfaction,

Reduction of greenhouse gas emissions related to travel, and

Increased profit margins as a result of lower overhead costs for office space, heat, lighting, etc.

Implementation

Blackle

Fit-PC: a tiny PC that draws only 5w

Zonbu Computer

The Asus Eee PC and other ultra portables

Blackle

Blackle is a search-engine site powered by Google Search.

Blackle came into being based on the concept that when a computer screen is white, presenting an empty word page or the Google home page, your computer consumes 74W.When the screen is black it consumes only 59W.

Based on this theory if everyone switched from Google to Blackle, mother earth would save 750MW each year.

Fit-PC:

A tiny PC that draws only 5w

Fit-PC is the size of a paperback and absolutely silent, yet fit enough to run Windows XP or Linux.

Fit-PC is designed to fit where a standard PC is too bulky, noisy and power hungry.

Fit-PC draws only 5 Watts, consuming in a day less power than a traditional PC consumes in 1 hour.

Zonbu Computer

The Zonbu is a new, very energy efficient PC.

The Zonbu consumes just one third of the power of a typical light bulb.

The device runs the Linux operating system using a 1.2 gigahertz processor and 512 meg of RAM. It also contains no moving parts, and does even contain a fan.

The Asus Eee PC and other ultra portables

The "ultra-portable" class of personal computers is characterized by a small size, fairly low power CPU, compact screen, low cost and innovations such as using flash memory for storage rather than hard drives with spinning plotters.

These factors combine to enable them to run more efficiently and use less power than a standard form factor laptop. The Asus Eee PC is one example of anultraportable.

3.2.2 Limitations

Green Computing could be quite costly.

Some computers that are green may be considerably underpowered.

Rapid technology change.

3.3 Materials Recycling

3.3.1 E-Waste Definition

E-Waste for short - or Waste Electrical and Electronic Equipment - is the term used to describe old, end-of-life or discarded appliances using electricity.

It includes computers, consumer electronics, fridges etc which have been disposed of by their original users.

"e-waste" is used as a generic term embracing all types of waste containing electrically powered components.

e-Waste contains both valuable materials as well as hazardous materials which require special handling and recycling methods.

Examples: Computers, LCD / CRT screens, cooling appliances, mobile phones, etc., contain precious metals, flame retarded plastics, CFC foams and many other substances.

3.3.2 Categories of e-waste

Large Household Appliances

Washing machines, Dryers, Refrigerators, Airconditioners, etc.

Small Household Appliances

Vacuum cleaners, Coffee Machines, Irons, Toasters, etc.

Office, Information & Communication Equipment

PCs, Laptops, Mobiles, Telephones, Fax Machines, Copiers, Printers etc.

Entertainment & Consumer Electronics

Televisions, VCR/DVD/CD players, Hi-Fi sets, Radios, etc

Lighting Equipment

Fluorescent tubes, sodium lamps etc. (Except: Bulbs, Halogen Bulbs)

Electric and Electronic Tools

Drills, Electric saws, Sewing Machines, Lawn Mowers etc.

Toys, Leisure, Sports and Recreational Equipment Electric

train sets, coin slot machines, treadmills etc.

Medical Instruments and Equipment Surveillance and

Control Equipment Automatic Issuing Machine

Figure 3.2 E-waste types

3.4 Recycling Technologies

e-Waste management practices comprise of various means of final disposal of end-of-life equipment which have different impacts on human health and the environment. It can be distinguished between state-of-the-art recycling technologies, which comply with high environmental and occupational health standards and hazardous technologies that bear a great risk for both health and the environment and are often applied in countries, where no strict standards exist.

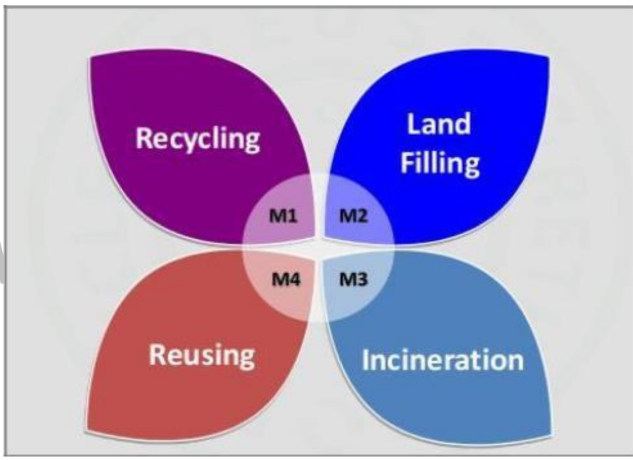


Figure 3.3 e-waste disposal

3.4.1 Hazardous Technologies

Incineration:

Incineration is the process of destroying waste through burning. Because of the variety of substances found in e-waste, incineration is associated with a major risk of generating and dispersing contaminants and toxic substances.

Open Burning:

Since open fires burn at relatively low temperatures, they release many more pollutants than in a controlled incineration process at an MSWI-plant. Inhalation of open fire emissions can trigger asthma attacks, respiratory infections, and cause other problems such as coughing, wheezing, chest pain, and eye irritation. Often open fires burn with a lack of oxygen, forming carbon monoxide, which poisons the blood when inhaled.

Land filling:

Land filling is one of the most widely used methods of waste disposal. However, it is common knowledge that all landfills leak. The leach ate often contains heavy metals and other toxic substances which can contaminate ground and water resources.

3.4.2 State-of-the-art Recycling Technologies

The state-of-the-art recycling of e-waste comprises three steps

Figure 3.4 e-waste management services

Detoxication

The first step in the recycling process is the removal of critical components from the e-waste in order to avoid dilution of and / or contamination with toxic substances during the downstream processes. Critical components include, e.g., lead glass from CRT screens, CFC gases from refrigerators, light bulbs and batteries.

Shredding

Mechanical processing is the next step in e-waste treatment, normally an industrial large scale operation to obtain concentrates of recyclable materials in a dedicated fraction and also to further separate hazardous materials.

Refining

The third step of e-waste recycling is refining. Refining of resources in e-waste is possible and the technical solutions exist to get back raw with minimal environmental impact. Most of the fractions need to be refined or conditioned in order to be sold as secondary raw materials or to be disposed of in a final disposal site, respectively. During the refining process, to three flows of materials is paid attention: Metals, plastics and glass.

3.4.3 E-waste Management – Six Steps

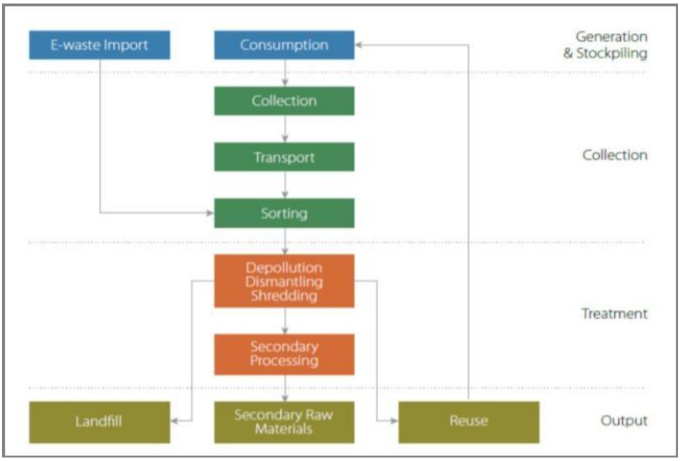


Figure 3.5 six steps to e-waste management

3.4.4 Benefits of recycling

Recycling raw materials from end-of-life electronics is the most effective solution to the growing e-waste problem. Most electronic devices contain a variety of materials, including metals that can be recovered for future uses. By dismantling and providing reuse possibilities, intact natural resources are conserved and air and water pollution caused by hazardous disposal is avoided. Additionally, recycling reduces the amount of greenhouse gas emissions caused by the manufacturing of new products.

3.6 GREEN DATA CENTRE

The demand for data centre capacity world wide has been on the rise. This has also lead to a steady increase in carbon emissions.

This is so because servers will not only handle greater volume but will also require greater processing.

Data centres house a suit of large computers and associated networks of the organization, forming the heart of most businesses.

Data servers can be seen as powerful computers that have the capacity to store as well as process vast amount of multiformatted data.

As Cloud computing makes rapid strides, data, in its myriad multimedia format will have to be stored and instantly made available upon request.

The business users need to store data endlessly and also comply with the legislations. The demand of storing and processing of data is unabating.

The businesses that particularly deal with contents have to improve their data centres through innovative strategies in data management.

The data management solutions need to be agile so as to cater to rapidly changing data needs.

Dynamic and agile data management implies ability to modify, update, backup, and mirror data even as the organizational needs of the data keep changing.

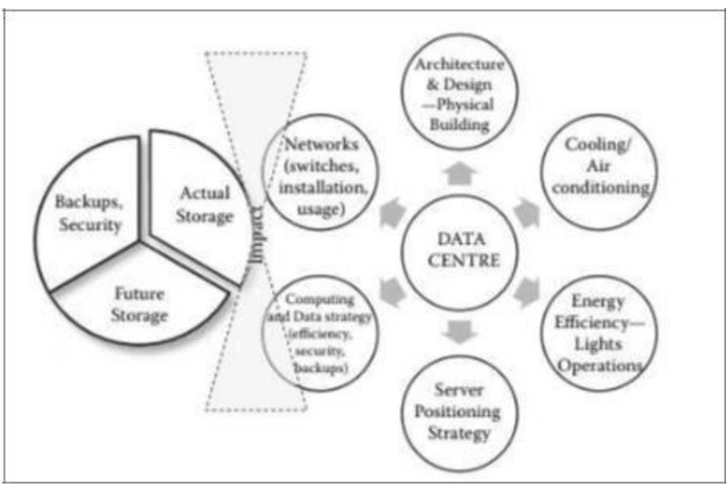
Innovation, together with disciplined operational management of the data centre is required. Costs and carbon emissions are also closely tied together in case of data centres.

3.6.1 Influencing factors of green data centres

Data centre design, layout, and location:

Physical building in which the data centre resides. This can be one building, or multiple buildings that house the machines but are themselves spread across geographical regions.

Architecture and design of the building, its geographical region and the material used in construction of the building are all valid considerations h ere.



The size and design of rooms in which servers are housed and also the location of the server rooms within the data centre can play a role in carbon reduction.

Cooling, air conditioning, power source and power consumption:

This includes the cooling strategies of the servers; and the air conditioning relating to the actual building.

This also includes use of green energy sources.

The impact of the physical location of the rooms to be cooled, that are housing the servers.

Power management:

This includes lights and operational aspect, number of people working, opening and closing of doors.

This would include procurement and installation of green products and use of green services.

Servers:

Their numbers, positioning and corresponding energy-efficient computing plays pivotal role.

Physical location of the racks, t heir positioning (hot isle/cold isle), architecture and the physical rooms in which they are placed are also important.

Design of each server—water cooled, air cooled, and other efficiencies are also to be considered.

Data strategy:

The main concerns here are including security and backup.

Virtualization within each server, and combined virtualization.

Organization of a cluster of servers—private cloud,

Space storage and usage strategy.

Virtualization aims to pool resources together to deliver data centre services by pooling resources that may be otherwise underutilized.

Adopting virtualization strategies will foster the development of many virtualization architectures that will enhance the data centre energy efficiency.

Networks and communications equipment:

This made up of land-based as well as wireless communications such as switchgears, routers, and modems.

The numbers and capacities of these equipment in the data centre contribute to its carbon footprint.

3.6.2 Data Centre ICT Equipment—Server Strategies

They are housed within the green data centre and require specific strategies for positioning, cooling, and usage. Servers are powerful computers that form a significant part of the IT assets of an organization. Increasingly these powerful servers provide the organization with the ability to access, provide, analyze, and store data, information, knowledge, and intelligence in myriad different ways.

There is ever increasing demand for more powerful servers with increased storage and processing facilities. With more powerful processors and proliferating number of servers the power consumption continues to climb rapidly. Servers belong to the data centre manager who is responsible for providing a service to the rest of the organization rather than using it directly themselves.

The following are a list of green server strategy considerations:

Online, real-time list of server inventory that enables location and uses of the servers.

Power consumption bill in real time—mapped to carbon generation, that provides operational feedback to the entire organization.

Bit to carbon ration as part of comprehensive data **strategy that provides metrics on not only the used ―bits**‖ but also the carbon generated by the provisioned bits.

Mirroring backup strategies that are balanced by the **―acceptable risks‖ of the data** centre director.

Data capacity forecasting: Server capacities need to be estimated on a continuous basis as the business changes. The correlation between business change and growth, and corresponding data centre capacity, is ascertained based on statistical analysis, trend spotting, and estimating the impact of technological innovativeness.

Carbon-cost visibility: Lack of visibility of server costs and particularly its mapping to individual or departmental use of space.

Efficient decommissioning: Once the purpose of a server is consummated, there is a need for a formal yet quick way of decommissioning the server.

Incorporation right redundancy

Enhanced server distribution: Need to distribute, through proper assignment, the use of the data space across and between various departments/users.

Incorporate server switching: Data servers should be capable of being switched from one type of usage to another.

Incorporate Cloud computing and server virtualization.

3.6.3 Data Strategy and the Carbon Emitting Bit

Data strategy encompasses the use, storage, mirroring, security, backups, clean ups, and architectures for data. It covers both external and internal approaches to data management. Data efficiency in relational database management systems includes use of techniques such as data normalization and incremental storage. Such practices enable creation of nonredundant and flexible data structures which tend to save data storage space when multiplied on a large scale. Using the correct data type would also affect the amount of data space that is being used in **every ―bit‖ of data. Every ―bit‖ adds to the carbon generation** from the data centre. Following are the impact of one extra bit in a data centre on the green performance of the organization:

Additional free s pace provisioning.

Speed and density.

Backup

Mirroring.

Quality and reliability.

Security.

Provisioning. Each bit requires provisioning for spare capacity, with corresponding need for spare room space, people and infrastructure.

[***1 bit + m b it (additional) leads to → 1.m bit × n w atts (direct energy need) → leads to nxp watts (support energy-infrastructure) influences → People (attitude)]***

In addition to the data server strategies discussed thus far, there is also a need to compliment those strategies with astute IT governances that ensure incremental improvements to the data centre performance. IT governance with additional focus on data centres help to manage the overall number of servers, their lifecycle and the underlying server virtualization strategies.

3.6.4 Data Servers Optimization

Optimization of servers deals primarily with the numbers, usage, and collaborations amongst the servers. This data server optimization can be improved through better organization of the databases including t heir design, provisioning for redundancy, and improved capacity forecasting.

Optimization also includes consolidation of various physical servers that would reduce their total numbers. Some of the techniques that could be considered by an organization for server optimization are:

Undertake intense and iterative capacity planning for the data centre.

Undertake in-depth optimization through identification of unused capacity of servers and storage disks within them.

Implement full storage virtualization that will enable hosting of multiple data warehouses on the same server.

Efficient server operations.

Efficient management of air-conditioning and cooling equipment that require, at times, even more power to cool the servers than required to operate them.

Decommissioning servers once their service level agreement has expired.

Applying virtualization during architecture and design of the servers, corresponding operating systems, and even applications.

Making use of infrastructural and hardware economies of scale.

Increasing B2B relation for a more common and efficient solution service

3.6.5 Data Servers Virtualization

Data server virtualization, as a key strategy, includes creation of many virtual servers from one physical server. Virtualization has been popular as an efficient hardware resource utilization; however, it also has significant impact on reducing carbon emissions. A rough virtualization, data centres can consolidate their physical server infrastructure as multiple virtual serversarehosted on lesser number of servers. This data centre specific program aims to improve energy monitoring, advanced 3-D power management and thermal modeling capabilities, better design techniques, cutting-edge virtualization technologies, enhanced power management systems, and new energy- efficient liquid cooling infrastructures. These initiatives can not only improve building use, data server use, but also reduce carbon emissions by almost 7,500 tons a year. Virtualization has to be supported by the operating system that would separate the underlying hardware from corresponding application software. Various types of virtualization are:

presentation virtualization- wherein users get a feel for owning the presentation of an application, whereas it is actually shared

application virtualization- enables multiple users to use the same application

desktop virtualization- applies the virtualization techniques of the servers at a local, desktop level

storage virtualization-applied to databases

network virtualization- relates to the communications and networking equipments of the data centre.

3.6.6 Physical Data Server Organization and Cooling

The physical arrangements of data servers, their organization, and the manner in which the floor space and racks are physically organized also impacts the overall carbon emission from that data centre

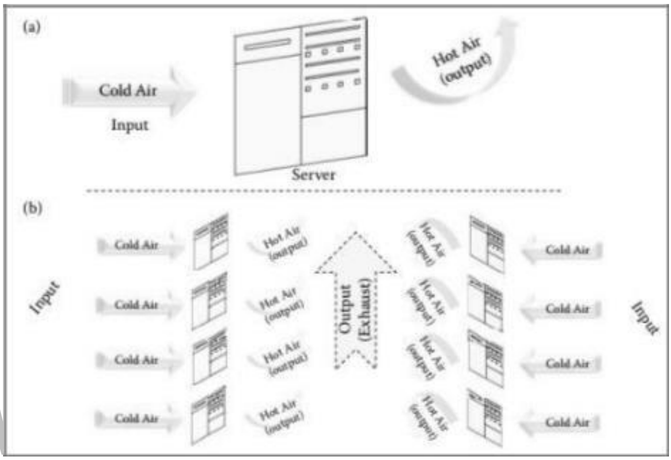


Fig 3. 7: Two ways of physical arrangement of servers

Data centres use a number of techniques to cool their servers.

Water cooling has been popular to handle the heat dissipation issues

Air cooling of servers using the concepts of hot-aisle and cold-aisle

They not only reduce the carbon footprint of the organization but, at the same time, improve its economic performance by reducing power consumption. Therefore, physical organization of the data servers, their operational effectiveness and cooling strategies all play a crucial role inthe overall reduction in carbon footprint.

Physical arrangements of servers require the following considerations:

Server optimization

Disk identification.

Implement a multitiered storage solution.

Specify low-power consumption, low voltage servers together with high-efficiency Power Supply Units

Equipment Reuse.

Re-engineer Layout.

3.6.7 Cloud Computing and Data Centres

Cloud computing provides lot of opportunities for organizations to consolidate their hardware and data space requirements. Cloud computing cuts the costs of services and also reduce carbon emissions. Saas can be used to to access key enterprise applications such as customer relationship management (CRM) and supply chain management (SCM) through the Internet. The opportunities to reduce carbon emissions increase with consolidation of both hardware and software applications. Furthermore, the payment models for SaaS-based applications is usually based on its usage. The typical data centre planning that makes provision for eventualities can be sidestepped for an overall planning by the cloud service provider.

3.6.8 Networking and Communications Infrastructure

The data centres hold the communication equipment and related assets. These communications infrastructure support the internal and external networks of an organization and play a significant role in its carbon footprint. Some of the communication devices that contribute to carbon emissions includes switches, routers, the LAN, WAN, and associated mobile transmission devices. Monitoring of networks, their interoperability, their uptimes and full-times, are also factors contributing to the carbon footprint. Reduction of communication traffic reduces server load, thus minimizing the memory and processing time of the server. Following are the categories of which demands attention in the context of carbon emissions:

Local Area Networks (LAN): Local networks of the organization that are made up of the physical connections amongst the machines and data centre. Usually they lack planning and architecture for LANs is a major factor in consuming substantial power and thereby adding to the cooling requirements.

Wide Area Networks (WAN): This enables communication amongst its desktop and laptop machines with and beyond its data centre. WAN comprises use of communication lines that make up the virtual private network (VPN) of the organization.

Mobile Networks: The mobile communications infrastructure stack is made up of TCP/IP at the base, followed by Well-integrated and optimized networks. They incorporate combination of centralized and decentralized approaches and plug-in sensors which can increasingly play a major role in reducing carbon effects.

Other techniques: Personal Area Networking (PAN), Metropolitan Area Networks (MAN), the IEEE 802.1x group of standards and Infrared, Bluetooth, RFID, WiMax, and Wireless VoIP also produce carbon.

Wireless L AN/WAN: While wireless communication may give the impression of reduced hardware and infrastructure it may still be inefficient and result in substantial carbon if not properly architected during installation and not monitored during operation.

WiMax: Mobile standard for point-to-point communication that is based on radio frequency standardized technology (IEEE 802.16) that tends to consume power, especially when it is on but not in use. WiMax, made up of transceivers to base antennas, need standards to ensure these networks are switched on-and-off depending on their usage pattern.

3.5 BEST WAYS FOR GREEN PC

The hardware aspect of Green IT deals with the architecture and design of IT hardware, the manner in which it is procured and operated. The operational energy consumption is a major issue for computer manufacturers. The impact a good, energy optimum design can have on the overall energy consumed by a piece of hardware over its entire life has to be studied with utmost care. A purpose-built computer chip, or an efficient laptop battery design has potentially greater impact in reducing carbon emissions over its lifetime than its operation would have.

Following is a more detailed description of these IT hardware assets of an organization:

Data servers: deals with the physical machines and the specific buildings in which they are housed. These servers have both wired and wireless networks and other corresponding communications equipment associated with them that are directly emitting carbon.

End-user computers: laptops, desktops, their capacities, operational efficiencies, and their disposal need to be discussed from t heir P-O-D viewpoint. While the efficient design and manufacturing of these end-user devices remains the perceiver of the hardware manufacturers, the efficient operation and disposal is with the user organization.

Mobile devices: the mobile devices and associated hardware, their batteries including the recharging mechanism and disposal of the batteries and the policies

and actions when the devices become outdated. The mobile devices P-O-D is heavily affected by the **user's** attitude. Thus, a sociocultural issue is an important contributor to the carbon behavior of these devices.

Peripherals: printers, photocopiers, shredders, and so on. These electronic gadgets are of immense interest in Green IT due to their large numbers and overuse. These devices has more operational waste and the carbon associated with the eventual disposal of these fast moving items.

The carbon emissions from each of these Green IT hardware group mentioned above is affected by its procurement, operations, and disposal (Green P-O-D) phases in its lifecycle. Procurement focuses on well-designed, low-carbon emitting data servers or monitors, buying it from a green supplier and using the most efficient means of packaging and transporting the equipment. Operation is the ongoing use of hardware in an efficient and effective manner. Attitude of the end-user, affected usually by visible metrics, plays a significant part here. Disposal of IT equipment requires utmost care. The Green P-O-D phases are practiced based on the policies of the organization.

3.5.1 Best practices for Green PC

The following are some of the tips to accomplish green PC:

Buy energy efficient hardware:

New offerings from major hardware vendors include notebooks, workstations, and servers that meet the EPA's Energy Star guidelines for lower power consumption.

Multicore processors increase processing output without substantially increasing energy usage.

Also look for high efficiency (80%) power supplies, variable speed temperature controlled fans, small form factor hard drives, and low voltage processors

Use power management technology and best practices:

Modern operating systems running on Advanced Configuration and Power Interface (ACPI)-enabled systems incorporate power-saving features that allows to configure monitors and hard disks to power down after a specified period of inactivity.

Systems can be set to hibernate when not in use, thus powering down the CPU and RAM as well.

Hardware vendors have their own power management software, which they load on their systems or offer as options.

There are also many third-party power management products that can provide further flexibility and control over computers' energy consumption.

Use virtualization technology to consolidate servers:

The number of physical servers can be reduced, and thus the energy consumption, by using virtualization technology to run multiple virtual machines on a single physical server.

Because many servers are severely underutilized the savings can be dramatic.

Consolidate storage with SAN/NAS solutions:

Just as server consolidation saves energy, so does consolidation of storage using storage area networks and network attached storage solutions.

The Storage Networking Industry Association (SNIA) proposes such practices as powering down selected drives, using slower drives where possible, and not overbuilding power/cooling equipment based on peak power requirements shown in label ratings.

Optimize data centre design:

Data centres are huge consumers of energy, and cooling all the equipment is a big issue.

Data centre design that incorporates hot aisle and cold aisle layout, coupled cooling, and liquid cooling can tremendously reduce the energy needed to run the data centre.

Another way to "green" the data centre is to use low-powered blade servers and more energy-efficient uninterruptible power supplies, which can use 70 percent less power than a legacy UPS.

Optimum data centre design for saving energy should also take into account the big picture, by considering the use of alternative energy technologies and catalytic converters on backup generators, and from the ground up, by minimizing the footprints of the buildings themselves.

Energy-monitoring systems provide the information you need to measure efficiency.

Use thin clients to reduce GPU power usage

Another way to reduce the amount of energy consumed by computers is to deploy thin clients.

Because most of the processing is done on the server, the thin clients use very little energy.

A typical thin client uses less power while up and running applications than an Energy Star compliant PC uses in sleep mode.

Thin clients are also ecologically friendly because they generate less e-waste.

There's no hard drive, less memory, and fewer components to be dealt with at the end of their lifecycles.

Use more efficient displays

Replace the old CRT monitors with LCD displays. This can save up to 70 percent in energy costs.

Not all LCD monitors are created equal when it comes to power consumption.

High efficiency LCDs are available from several vendors.

Recycle systems and supplies

To reduce the load on already overtaxed landfills and to avoid sending hazardous materials to those landfills, old systems and supplies can be reused, repurposed, and/or recycled.

This hand-me-down method allows two workers to get better systems than they had, while requiring the purchase of only one new machine.

Old electronics devices can also be reused by those outside the company.

Much electronic waste can be recycled, the parts used to make new items. Things like old printer cartridges, old cell phones, and paper can all be recycled.

Reduce paper consumption

Another way to save money while reducing your company's impact on the environment is to reduce your consumption of paper.

This can be done by switching from a paper-based to an electronic workflow: creating, editing, viewing, and delivering documents in digital rather than printed form.

Send documents as e-mail attachments rather than faxing.

When printing is unavoidable, you can still reduce waste and save money by setting your printers to use duplex (double-sided) printing.

Encourage telecommuting

The ultimate way to have a greener office to have less office.

By encouraging as many workers as possible to telecommute, you can reduce the amount of office space that needs to be heated and cooled, the number of computers required on site, and the number of miles driven by employees to get to and from work.

Telecommuting reduces costs for both employers and employees and can also reduce the spread of contagious diseases.

3.7 GREEN GRID FRAMEWORK

The Green Grid is a nonprofit consortium whose mission is to become the global authority on resource efficiency in information technology and data centres. According to The Green Grid website, the organization provides a forum for IT directors, facilities managers and C-level executives to come together and discuss different options for improving resource efficiency. Findings and recommendations from these forums are published on a regular basis. Metrics created and endorsed by The Green Grid include:

Electronic Disposal Efficiency (EDE) - the percentage of decommissioned information technology electronics and electrical equipment that is disposed of through known responsible entities.

Power Usage Effectiveness (PUE) - the ratio of total facilities energy to IT equipment energy.

Data Centre Infrastructure Efficiency (DCIE) - the ratio of IT equipment power to total facility power.

Carbon Usage Effectiveness (CUE) - the product of the

amount of carbon dioxide emitted per kilowatt hour (CEF) and the data centre's annual PUE.

Water Usage Effectiveness (WUE) - the ratio of the annual site water usage in liters to the IT equipment energy usage in kilowatt hours (Kwh).

Data Centre Productivity (DCP) - the quantity of useful information processing completed relative to the amount of some resource consumed in producing the work.

Deliverables of Green Grid:

Data Collection

Data Centre Standards and Metrics Inventory – this study will document existing standards and metrics for energy efficiency, identify coverage gaps and make recommendations for future development.

The Green Grid Metrics: Describing Data Centre Power Efficiency – this study will be an update to The Green Grid's existing study on data centre efficiency metrics and will look at workload classification through a data centre segmentation model.

Operationalizing Energy-Efficiency Data Collection – this study will identify the requirements for collecting and aggregating data centre power consumption data.

Data Assessment

Data Centre Efficiency Baseline Market Study – this study on the current state of the industry will allow The Green Grid to identify key factors driving companies to take action on data centre power consumption and the challenges in doing so. Collecting and analyzing this data will help to provide companies with a baseline to compare their own initiatives, goals and performance.

Operational Best Practices – these studies will focus on right-sizing the data centre and will outline best practices in the adoption of virtualization and consolidation technologies.

Database for Data Centre Performance – The Green Grid will begin development work on a database focused on data centre characteristics and performance schema.

Technology Proposals

Initial Technology Roadmap – this roadmap provides an initial assessment of existing and emerging technologies affecting data centre efficiency and performance, taking into consideration both return on investment and risk to the end user.

Power Distribution Options for the Data CentreStudy

– this study will look at the qualitative advantages and

disadvantages of data centre power distribution configurations.

Cooling Options Study – this study will focus on the qualitative advantages and disadvantages of data centre cooling architectures.