1.3 Scoop on Power

In the past decade, a lot of research has been carried out aiming at providing better battery life to the mobile devices like PDAs, mobile phones and Laptops. However with the advent of data centres, Greening of Computing also deals with energy efficient designs for servers and to lower costs and carbon emissions produced by Data centres. A recent survey shows that quite a lot of power used in office buildings and colleges are spent on Computing. The scope of optimizing the usage of power are as follows:

- Input and Output devices – Black CRT utilizes less power than White CRT

Brightness	White CRT	Grey CRT	Black CRT
100	85	74	63
50	84	67.5	60.5
0	77.7	65	60.0

Table 2 – Comparison of Brightness in various CRT models

Power Consumption Parameter	CRT Monitor	LCD Monitor
Avg. consumption	76 W	20 W
Screen color sensitivity	Extremely sensitive. Consumes lot more power (43% more) when displaying white on screen.	Completely insensitive. Consumes same power for all colors on screen.
Brightness setting sensitivity	Moderately sensitive. Consumes more power at higher brightness.	Sensitive. Consumes higher power for higher brightness
Contrast setting sensitivity	Less sensitive. (Almost insensitive when brightness setting is low.)	Completely insensitive. Consumes same power for all contrast
Consumption when turned off from computer power settings	2W	0 W

Table 3 – Comparison between CRT and LCD monitor

- Storage Units
- Processors
- Operating Systems

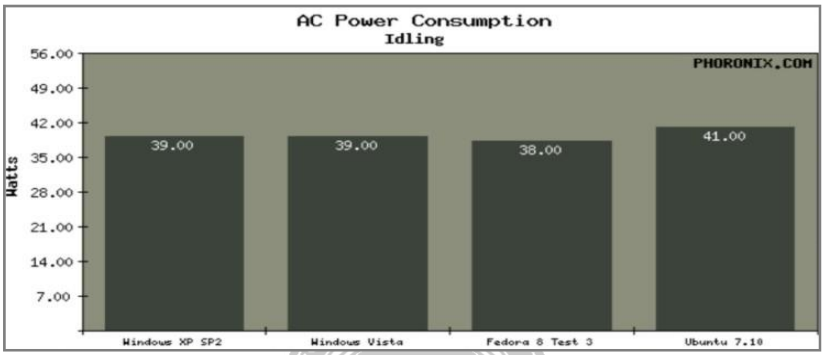

Figure 1.12 – Power Consumption of various Operatiing Systems

- Frequency of operation in any Computing Devices.

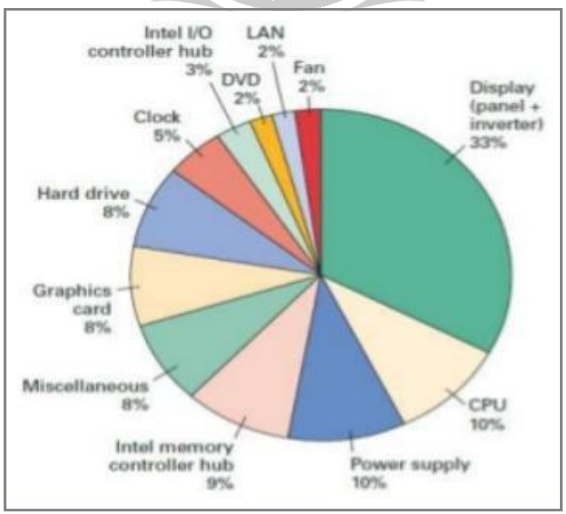

Figure 1.13- Power consumption in an average Laptop

Data Centres

- A Data Centre is a facility housing a large number of servers and data storage.
- In reality the electricity bill for a data centre is close to 6 million a month with about 20 percent of the powerspent on cooling the data centres.
- The average amount of money spent on buying the servers amortized over a period of three years is almost equal to the cost of powering the servers.
- This shows that it is necessary to effectively utilize the electricity used by the Data centres.

Power Usage Effectiveness

- Power Usage Effectiveness = Total Facility Power/IT Equipment Power
- The PUE is a ratio of the input power to the actualamount of power required by the servers at a Data Centre.
- If the amount of power required to cool the system is 100 percent , then the PUE grows to 2 which is undesirable.

Low PUE Design

Better Power Infrastructure

- If there are multiple data centres in different locations then one way of making using of power infrastructure is to shift the load to the data centre that has a low-price period.

- The power generally undergoes a conversion from AC-DC a number of times before it reaches the server, by reducing the number of conversion the conversion loss can be avoided.
- Multi-phase power (use of a 3 phase AC) can help provide efficient power usage.

Better air conditioning

- Cold air is allowed to pass through the servers.
- On passing through the servers the cold air turns hot and this is cooled and then reused.
- Balancing load across the data centre helps eliminating hot spots Another means of cooling is to use the outside air to cool the machines.
- Iceland being a cold country and being a good source of Geo-thermal energy hosts a few data centres.
- Microsoft conducted an experiment by placing the servers outside and using the outside air to cool the systems. The servers worked fine even with temperatures in the late 90s.
- However they faced issues with filtering the outside air which contained leaves and other dust particles.

Better server and IT equipment

- It is observed that the servers consume 65% of the power.
- A server is not to be energy proportional if the power usage scales linearly with the workload intensity.

- However in practice, servers are not energy proportional and consume close to half the power even when they are in the idle state. This is attributed to various components like Disk , RAM, motherboard and network card which consume power even in the idle state.
- In practice it is observed that the servers are around 10-30% utilized all the time.
- The amount of work done by the server for each joule of energy used is defined as the efficiency. The servers are not efficient either. This is due to the unused CPU features like the large caches, complex architecture.
- If the CPU is not the bottleneck for the application then the use of a CPU with limited features can solve the problem and also make the server more efficient.
- The server is most efficient when its utilization is 100%. The efficiency of a server is also linked with the software flexibility.
- By using Virtualization, the CPU/memory usage can be controlled.
- Migrating virtual machines to a subset of the physical machines and switching the other machines off also helps in efficient usage.

Common Approaches

- One common approach is to make the Ensembles energy proportional.

- This is achieved by distributing the workload and with the decrease in utilization the components are turned off and the word-load is migrated to active components.
- If there is an increase in the utilization the components are turned on and the load is migrated to the newly active components.
- However, this method does have problems. Moving the workload might take a long time and turning on/off of the components takes a long time.
- It also does not work if the workload intensity changes faster than the data transfer and if the workload is not distributed.
- Some of the other IT components like the switches and the routers are much inefficient when compared to the servers. They are at 100% Utilization all the time.
- Turning off RAM memory banks is rarely done. Mechanical disks are not energy proportional. Flash disk use no energy but they are expensive

Renewables

- The Main reasons behind using renewables is due to the Bad press for using many fossil fuels, electricity costs and also to reduce carbon emissions.
- However with renewables the word-load and the available power are now changing and there is a need to match supply and demand since storage of power brings in additional overhead.

Information technology can be used to make the building more green using sensors, smart software, smart appliances and smart meters

Smart Buildings

- In order to make the building smart, there is a need to monitor the energy usage.
- The user must be able to control electricity usage by automatically turning devices on and off.
- Green Computing comes up with means to satisfy these needs cheaply and reliably.
- The Building Management Systems are existing systems that monitor the energy usage but lacks load balancing methods.

Monitoring Energy Usage

- Energy usage can be monitored at multiple levels of the wiring right from the electricity incoming level to the outgoing level. But this is not same with data transfer, which a tedious process is done using wireless networking techniques like Zigbee and Wifi.
- The most Challenging task to place sensors at every load since it's expensive, it may not look good and it's unreliable due to the bandwidth constraints.
- Some Alternatives include collecting high bandwidth data at the source, disaggregating data into multiple chucks or loads by using well placed sensors.

Controlling Energy Usage

- Programming load control switches are needed to control the energy usage.
- Generally the control involves switching a device on/off. The switching mechanism may be external or internal.
- An example of a Wi-Fi enabled washer and dryer has been provided. The control is provided by means of a mobile application.

Environment Monitoring

- It has similar issues as energy monitoring which monitoring weather, thermostats, and doors as well tracking motion.
- Energy usage can be implemented using recommendations via smart phones, enabling remote but manual control, automated scheduling policies.
- The main aim of the computing for greening is to optimize for lower costs, lower energy usage, lower peaks and aligning consumption with renewable generation.

1.4 Green IT Strategies: Driver's, Dimensions and Goals

Green IT Strategies

- Each enterprises must develop a holistic, comprehensive green IT strategy and policies that outline aims, objectives, goals, plan of action and schedules.

- A Large enterprise must appoint an environmental sustainability officer to implement their green policy and to monitor the progress and achievements.

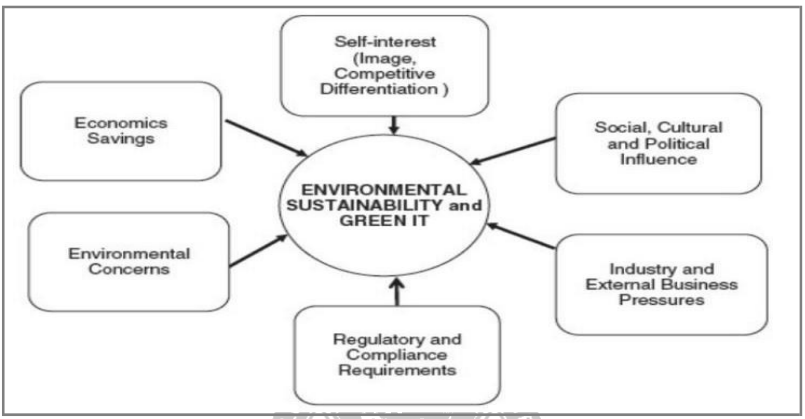

Figure 1.14 – Various factors responsible for Environemental Sustainability

- Every enterprise must have a tactical incremental approach with green goal such as reducing energy consumption.
- It must also have measures adopting policies and practices namely power management, switching off computers when not in use.
- Enterprises must conduct audit of its IT infrastructure and its use from an environmental perspective.
- Enterprises also adopts additional measures such as implementing a carbon offset policy to neutralize GHG emissions – including planting trees, buying carbon credits from one of many carbon exchanges or using green power generated from solar or wind energy.