Green Computing

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GREEN COMPUTING
Overview

1. Introduction to Green Computing
2. Need for Green Computing
   a. Road to Green Computing
   b. The current situation of world
   c. Estimation of the volume of IC market to assess its impact
   d. Power consumption of modern CPUs/Processors
   e. Power consumption of data centres
   f. Environmental impacts
   g. Economic Impacts
3. A perfect green computing example
4. Solutions in the Green Computing Style
   a. What can we do to reduce power
   b. Understanding all levels of computing & finding solutions in each level
   c. Cooling solutions for data centres
   d. Economic Benefits
   e. Tips for normal users
5. Initiatives taken by different companies
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Green Computing

- Green Computing:
  - Maximize energy efficiency
  - Reduce of the use of hazardous materials such as lead
  - Reuse and Recycle

- “Green Computing” in view of energy efficiency at the nanometer scale - design low power consumption integrated circuits at 180nm and below.
Road to Green Computing

To comprehensively and effectively address the environmental impacts of computing/IT, we must adopt

- Green use
- Green disposal
- Green designing
- Green manufacturing

These four paths span a number of focus areas and activities, including:

- design for environmental sustainability
- energy-efficient computing
- power management
- data centre design, layout, and location
The Current Situation

- Energy provisioning is arguably the most important business, geo-political, and societal issue.

- Global Warming is influencing policies and laws which require less energy usage and controlled greenhouse emissions.

- The cost of energy and increases in IT power requirements present significant expense, supply, and handling challenges for data centers.
Integrated Circuit Market

- Semiconductor annual revenue of 2004 is estimated at US $211.4 billion.

- New users in China (178 million) and India (80 million) will require the creation of new computers by 2010.

- Disposal of these devices constitute 20-50 million tons per year (about 5% of the total waste of the planet)
  - this waste is called e-waste
  - where are we going to put all of it?
Power Consumption

- Total Personal Computer (400 million) energy usage in 2000 = 26 nuclear power plants
- Power-bottleneck of improving performance
- Power consumption causes excessive heating problems
- As circuit speed increases, power consumption grows
- Low power consumption is listed as the second greatest challenge for the IT industry
Power Consumption & Data Centers

- Where are the web pages you browse?

- Data Centers

- One single room in Datacenter contains 100 Racks

- 1 Rack = 5 to 20 kW
- 200 M tons of CO2 = CO2 produced by 40 million cars

- Current coolants for data centres: CFCs and HCFCs = Ozone Depletion

- The other alternative coolant for data centres: HFC = increase in greenhouse emission 1300 times
Energy Usage of Data Centers

2006: $15 Billion for energy usage

**Impact of 10% Reduction of Power Consumption of Data Centers**

- $15b \times 10\% = $1.5 billion in savings

- 200 \times 10\% = 20 million tons of CO₂ = Emissions from 40 million cars
A Perfect “Green Computing” Example

- A super low-power “processor”:
  - 800x faster
  - 1000x more memory
  - \textit{3000x less power}

<table>
<thead>
<tr>
<th></th>
<th>Modern Processor made by hundreds of PH.D. researchers (The MOS transistor was built from Silicon, the pre-dominant atom in rock and sand, after processed in a high temperature.)</th>
<th>Human Brain (containing 100 billion neurons, each linked to as many as 10,000 other neurons.)</th>
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<tbody>
<tr>
<td>Speed</td>
<td>2.0 GHz</td>
<td>Equivalent to 1,700 GHz processor</td>
</tr>
<tr>
<td>Memory</td>
<td>100 GB</td>
<td>100,000 GB</td>
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<tr>
<td>(Source: Oracle Corporation: <a href="http://library.thinkquest.org/Co01501/the_saga/compare.htm">http://library.thinkquest.org/Co01501/the_saga/compare.htm</a>, computer vs. brain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>45 mW/cm$^3$</td>
<td>15 mW/cm$^3$</td>
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<td>(Source: UC Berkeley, EE241 class)</td>
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Solutions in a Greener way

✓ Reduce Computer Operating Costs
✓ Energy Efficient Computing
  o Enable Power Management Features
  o Turn Off When Not in Use
✓ Screen Savers Don’t Save Energy
✓ Reduce paper Waste
✓ Campus Environmental Policies
✓ Recycle Toner Cartridges, Diskettes and CD’s
✓ Purchasing Energy efficient hardware & software
✓ Reusing & Recycling Old computers
What can we do to reduce power?

- Understand all levels of the computer
- Understand where power is dissipated
- Think about ways to reduce power usage at all levels
The 6 Levels of a Computer

5. High Level Programming
4. Assembly Language
3. Operating System
2. Instruction Set Architecture
1. Digital Logic
0. Integrated Circuit
Processor Clock

- Power consumption is proportional to clock frequency.
- Traditionally only one edge of the clock is used to process information, and the other edge is ignored.

- Figure shows the Clock signal
  - Rising edge is used while falling clock edge (dot line) is not used for data information processing
Using Double Edge Clocking

- Using double edge clocking, the clock frequency can be reduced to half.

Conventional Single edge Design:

Falling clock edge (dot line) is not used for data information processing.

Proposed Design:

Both rising and falling clock edges are used for data information processing, the clock frequency is reduced to half (clock period is doubled).

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Digital Logic Solutions

- Reducing the no of logic gates required in a logic circuit without compromising the efficiency of the circuit

- Using logic gates which work on Double edge clocking
Instruction Set Architecture Solutions

- Some programs allow the user to manually adjust the voltages supplied to the CPU which
  - Reduces the amount of heat produced.
  - Reduces the amount electricity consumed. This process is called undervolting.

- Some CPUs can automatically undervolt the processor depending on the workload
  - This technology is called "SpeedStep" on Intel processors,
  - "PowerNow!"/ "Cool'n'Quiet" on AMD chips.
Operating system issues

- The Advanced Configuration and Power Interface (ACPI) allows an OS to directly control the power saving aspects of its underlying hardware.

- Use power management softwares like Auto Shutdown Manager, Faronics.

- Use in-built power management features of the OS

- Avoid using Windows as till date it is the most power consuming OS
  
  - Windows XP - 150 watts
  - Windows Vista - 300 watts
Assembly Language

- The efficiency of algorithms has an impact on the amount of computer resources required for any job.

- Efficient algorithms can be used to route data to data centers efficiently where electricity is less expensive.

- A study by Alex Wissner-Gross, a physicist at Harvard,
  - Estimated that the average Google search released 7 grams of carbon dioxide ($\text{CO}_2$).
  - However, Google disputes this figure, arguing instead that a typical search produces only 0.2 grams of $\text{CO}_2$. 

Back
High Level Language Solutions

➢ Solutions at highest level of programming requires revolutionary ideas & a change in programming approach

➢ A perfect example of this is Blackle search engine from Google.
   • Blackle saves energy by displaying a black background and using grayish-white font color for search results.
   • As of March 13, 2010, Blackle claims to have saved over 1,772 kilowatt hours.
Cooling the Data Center

- Moving Data centres to exotic locations will reduce the amount of power required to cool the data centres such as
  
  - Microsoft - Cold Siberia,
  
  - Sun - Underground in Japan
Potential Savings

33% \times 0.5 = 15\%

\$15b \times 15\% = \$2.25b
Tips for normal users

- Purchase an Energy Star–compliant computer. Note that laptop models use much less energy than desktop units.

- Choose the latest Intel or VIA processors over AMD as they use less power.

- Choose Corded Keyboard and Mouse over wireless.

- Purchase flat-screen monitors—they use significantly less energy and are not as hard on your eyes as CRTs.

- Enable the standby/sleep mode and power management settings on your computer.

- Power off your monitor when you are not using it instead of using screen savers. Screen savers do not save energy.
Initiatives taken by different companies

- The Green Grid is a global consortium for advancing energy efficiency in data centers and business computing ecosystems.

- Its members include Dell, Intel, AMD, Microsoft, HP etc.

- **Nokia**: Almost all of its products are free from top worst chemicals.

- **Apple**: Has provided concrete timelines to eliminate the worst chemicals from all of its products.

- **DELL**: DELL has all its products marked as “green” and fully biodegradable.
  - Its packing materials are found to be 100% recyclable.
IBM - Enterprise Computing Model

Virtualize – IBM Data Centers

*Improved operational costs up to 70% with aggressive distributed platform virtualization*

**Client requirements**
- Improve IT equipment utilization
- Reduce IT hardware requirements

**Solution**
- Advanced POWER Virtualization (APV) and VMWare
- Reduced number of physical servers
  - Windows from 11,000 to 1,500
  - UNIX from 8,500 to 1,500
- Three times improvement in server utilization
- Formed a Virtualization Center of Excellence to implement best practices across geographies

**Benefits**
- Operational savings of up to 70%
  - Space, power and cooling, maintenance, software support and personnel costs
Initiatives taken by different Governments

- The **Energy Star** program was revised in October 2006
  - to include stricter efficiency requirements for computer equipment
  - and a tiered ranking system for approved products.

- The European Union's directives **2002/95/EC (RoHS)** and **2002/96/EC (WEEE)**
  - requires the substitution of heavy metals and flame retardants like PBBs and PBDEs in all electronic equipment from July 1, 2006.
  - manufacturers responsible for the gathering and recycling of old equipment.
Final Conclusion

- Enjoy energy savings of approximately 42 percent for an average 25,000 square foot data center

- Optimize your IT infrastructure

- Reduce data center energy consumption

- Benefit from energy efficient technology, products and services

- Maximize cooling and power efficiency

- Free-up space while maintaining proper air flow and cooling

- Identify issues that could impact operations or areas where energy savings can be made
THANK YOU