Lifecycle Issues of Computers

Week 14b – April 27

Total Costs of Ownership

- Similar to lifecycle analyses
- What are the segments of costs of owning (and using) a computer?
  - Traditional accounting looks at capital expenditures (capex) and operating expenditures (opex)
  - Drilling down for computers
    - Hardware
      - Accessories
    - Software
    - Connectivity
    - Electricity
    - Manpower
      - Training
      - Operators
    - Maintenance
      - Physical
      - Support/Help
    - Security
      - Physical
      - Insurance
    - Individuals differ from firms
      - Managed resources
- Individuals differ from firms
  - Managed resources
Educational Institutions TCO Example


- 71,600 client devices (64,000 computers + PDAs etc.)
- Costs
  - Hardware < Software < Direct Labor < Indirect Labor

<table>
<thead>
<tr>
<th>Unit</th>
<th>Total Cost</th>
<th>Direct Cost</th>
<th>Indirect Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall District Cost</td>
<td>$233,050,560</td>
<td>$88,923,705</td>
<td>$144,125,864</td>
</tr>
<tr>
<td>District Cost per Client</td>
<td>$3,255</td>
<td>$1,242</td>
<td>$2,013</td>
</tr>
<tr>
<td>Computer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit</th>
<th>Hardware</th>
<th>Software</th>
<th>Direct Labor</th>
<th>External Application Provider</th>
</tr>
</thead>
<tbody>
<tr>
<td>District Cost</td>
<td>$13,441,774</td>
<td>$15,664,322</td>
<td>$58,613,663</td>
<td>$1,293,046</td>
</tr>
<tr>
<td>District Cost per Client</td>
<td>$188</td>
<td>$219</td>
<td>$819</td>
<td>$17</td>
</tr>
<tr>
<td>Computer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Direct Labor Category</th>
<th>Total Cost</th>
<th>Cost Per Client Computer ($ US)</th>
<th>Client Computers per Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations and Financial</td>
<td>$44,630,683</td>
<td>$623</td>
<td>129</td>
</tr>
<tr>
<td>Professional Development</td>
<td>$12,204,265</td>
<td>$170</td>
<td>499</td>
</tr>
<tr>
<td>and Training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curriculum Development and</td>
<td>$1,805,715</td>
<td>$25</td>
<td>3,193</td>
</tr>
<tr>
<td>Support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Support</td>
<td>$58,613,663</td>
<td>$819</td>
<td>99</td>
</tr>
</tbody>
</table>

Source: www.classroomtco.org

Virginia School District TCO (cont.)

Questions

- How is hardware so cheap?
- Why were some of the costs higher than other school districts?
- Subtle issues
  - How are content creation costs allocated?
- WAS THIS WORTH IT? (not directly addressed)

Things that may be important

- Legacy needs
- Mixing and matching solutions
- Average needs vs. peak needs of computing
Walking through TCO Calculations...

- Single PCs

Vs.

- Clusters and corporate (Enterprise) environments

Other issues
- Warranty
- Maintenance
- Spares

Lifecycle Analysis...More than Cradle to the Grave

- Q: Is bio-ethanol carbon neutral?

- In general, have to factor in costs and impacts of
  - Production
    - R&D (first of kind)
    - Incremental (small or large volume)
  - Supply chain
    - Shipping
    - Inventory
    - Marketing
  - Deployment/Installation
  - Usage
  - End-of-life
    - Reuse
    - Recycle
    - Disposal
    - Landfill
Environmental Impacts of ICT

- Energy
- Materials

Both require a Lifecycle analysis to properly measure
  - Direct
  - Indirect

Lifecycle Analyses

- Computers case from Matthews, et. al.
  - Depends on assumptions of end-of-life scenarios

- Improvements can come from
  - Reduction in materials
  - Change in materials
    - Tradeoffs abound – plastics may be lighter but more pollution
    - Coke: Glass bottle vs. can vs. plastic bottle
  - Design for disassembly/recycling
    - Most soda cans have 3 alloys in them
  - Modularization for re-use
How “Green” is a PC?

- UN University reports indicate PCs are very dirty to produce
  - Manufacturing one desktop computer + 17-inch CRT uses
  - 240 kg fossil fuels
  - 22 kg chemicals
  - 1,500 kg of water

- Some ingredients are scarce, perhaps toxic
  - Lead, Cadmium, etc.
  - Issue for
    - Manufacturing
    - Disposal

Environment and Human Rights

- Some materials come from regions in conflict
  - Mineral Coltan (Columbite-tantalite)
    - Used in power storing components of cell phones, computers, some power plants, etc.
    - 80% of reserves are in DRC (formerly, Zaire), undergoing civil war
e-Commerce

- Endgame (goal): Lower “friction” (i.e., greater efficiency)
  - Thus, more transactions
    - Often from further away!
      - Spurred by legal/trade agreements, e.g., WTO

- Globalization
  - Results in greater supply chain (transport) requirements
  - Also linked to the Winner-Takes-All phenomenon
  - Subtler issue is when different jurisdictions have different standards
    - Larry Summers signed off on a World Bank memo (internal, for discussion) that stated economics would indicate more migration of dirty industries and wastes to developing countries
      - Lower costs of impacts

In the end, it's all about energy!
Electricity - Fundamentals

- Electricity is a special form of energy (kWh)
- Does not exist in usable forms
  - Conversion usually requires prime movers (steam turbines, water turbines, etc.)
  - Access to fuels (primary energy) is a key issue for developing countries
- Electricity is only about 125 years old
  - Widespread use is much more recent
    - US required special programs
      - Rural Electrification Administration (REA) [now Rural Utilities Service]
      - TVA
- Electricity from the grid can not be easily stored (AC)
  - Most electronics use DC

Energy and Power 101

- Power is Energy per unit Time
- 1 Watt = 1 Joule/sec
- Light bulb is ??? Watts?
- 1 kWh is a standard measure of power
  - ~10 cents
  - Household consumptions are ~500 kWh/month
- Other units of energy are BTUs and calories
How Much Electricity Does ICT Use?

- Numbers as high as 13% of US electricity were claimed (bubble - days)
  - End users, servers, networking, etc.
  - Later debunked

- ICT – Energy (Power) linkages
  - Greater Service Economy, even in developing countries
  - But, increased globalization

What Consumes Power (ICT Applications)?

- Components of an ICT solution
  - Computing
  - Display
    - CRT 80 W normal 10 W suspend
    - LCD 15-25 W normal 5-10 W suspend
  - Storage variable
  - Uplinking 12 W Wifi 40 W VSAT

- Role of advanced technologies
  - Chips (processor is largest component)
    - Pentium 4 uses 50+ watts!
  - LCD screens, OLEDs, etc.
  - Wireless
    - Cognitive Radios – reduce power to lowest required level
    - But, emitted power is << power drawn from supply
      - 100 mW is legal limit for WiFi
  - Laptops – much less power but less robust (?)
Power Consumption of New Processors

Details of Desktop Power

AGP video card - 20-30W
PCI video card - 20W
AMD Athlon 900MHz-1.1GHz - 50W
AMD Athlon 1.2MHz-1.4GHz - 55-65W
Intel Pentium III 800MHz-1.2GHz - 30W
Intel Pentium 4 1.4GHz-1.7GHz - 65W
Intel Pentium 4 1.8GHz-2.0GHz - 75W
Intel Celeron 700MHz-900MHz - 25W
Intel Celeron 1.0GHz-1.1GHz - 35W
ATX Motherboard - 30W-40W
128MB RAM - 10W
256MB RAM - 20W
12X or higher IDE CD-RW Drive - 25W
32X or higher IDE CD-ROM Drive - 20W
10x or higher IDE DVD-ROM Drive - 20W
SCSI CD-RW Drive - 17W
SCSI CD-ROM Drive - 12W
5400RPM IDE Hard Drive - 10W
7200RPM IDE Hard Drive - 13W
7200RPM SCSI Hard Drive - 24W
10000RPM SCSI Hard Drive - 30W
Floppy Drive - 5W
Network Card - 4W
Modem - 5W
Sound Card - 5W
SCSI Controller Card - 20W
Firewire/USB Controller Card - 10W
Case Fan - 3W
CPU Fan - 3W

Source: FLECOM
How much Energy is Used in 1 Year? (Hypothetical, Estimate)

Incidental Personal Use
- 3 hrs/day full power
  - 250 W (with large CRT)
- 21 hrs/day standby
  - 25 W

\[= [(250 \times 3) + (25 \times 21)] \times 365\]
\[= [750 + 525] \times 365\]
\[= 465,375 \text{ W-hr}\]
\[= 465.375 \text{ kWh}\]

Cluster/Enterprise
- 8 hrs/day full power
  - 200 W
- 16 hrs/day no user
  - 40 W

\[= [(200 \times 8) + (40 \times 16)] \times 365\]
\[= [1600 + 640] \times 365\]
\[= 817,600 \text{ W-hr}\]
\[= 817.600 \text{ kWh}\]

Standby power is a bigger deal than people think…

...Applies to all ICT and appliances and gadgets and A/V!