Lifecycle Issues of Computers

Week 14b – April 27

Total Costs of Ownership (TCO)

- 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

Educational Institutions TCO Example

- (one particular) Virginia School District (2004)
  - 71,600 client devices (64,000 computers + PDAs etc.)
  - Costs
    - Hardware < Software < Direct Labor < Indirect Labor

Unit	Total Cost	Direct Cost	Indirect Labor Cost
Overall District Cost	$233,059,569	$88,923,705	$144,135,864
District Cost per Client Computer	$3,255	$1,242	$2,013

Unit	Hardware	Software	Direct Labor	External Application Providers
District Cost	$13,441,774	$15,664,322	$58,613,663	$1,203,946
District Cost per Client Computer	$188	$219	$819	$17

Direct Labor Category	Total Cost	Cost Per Client Computer ($ US)	Client Computers per Staff
Operations and Financial	$44,603,683	$623	129
Professional Development and Training	$12,204,265	$170	499
Curriculum Development and Support	$1,805,715	$25	3,193
Total Support	$58,613,663	$819	99

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 "office" marketing
  - Usage
  - End-of-life
    - Reuse
    - Recycle
    - Disposal → Land fill

stockpile

Environmental Impacts of ICT

- Energy
- Materials
- *Both require a Lifecycle analysis to properly measure*
  - Direct
  - Indirect

Lifecycle Analyses

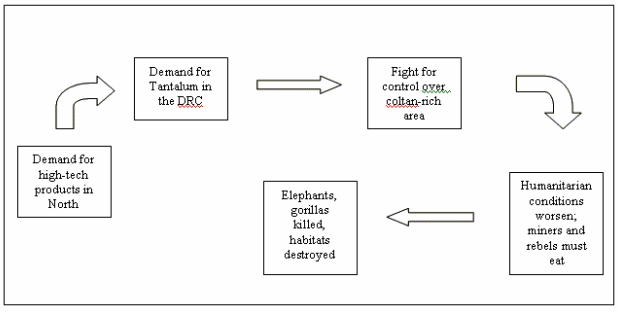
- Computers case from Matthews, et. al.
  - Depends on assumptions of end-of-life scenarios
- Improvements can come from
  - Reduction in materials
  - Change in materials
    - Tradeoffs abound – plastics may be lighter but more pollution
      - Coke: Glass bottle vs. can vs. plastic bottle
  - Design 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



Source: Natalie Ware, American U.

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

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

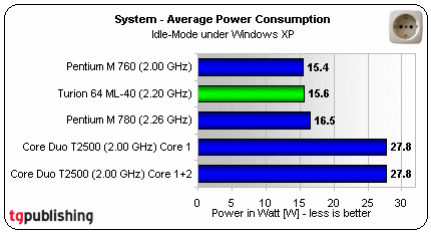
How Much Electricity Does ICT Use?

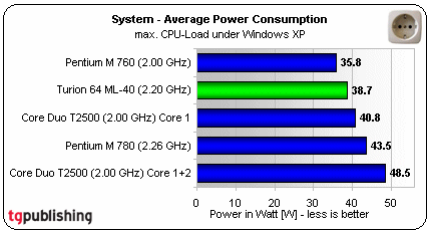
- Numbers as high as 13% of US electricity were claimed (bubble - days)
  - End users, servers, networking, etc.
  - Later debunked
- ICT – Energy (Power) linkages
  - Greater Service Economy, even in developing countries
  - But, increased globalization

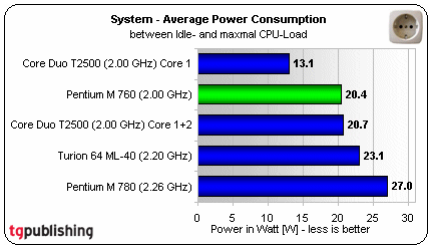
What Consumes Power (ICT Applications)?

- 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-1.26GHz - 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*3)+(25*21)]*365
  - = [750 + 525]*365
  - = 465,375 W-hr
  - = 465.375 kWh
- Cluster/Enterprise
  - 8 hrs/day full power
    - 200 W
  - 16 hrs/day no user
    - 40 W
  - = [(200*8)+(40*16)]*365
  - = [1600 + 640]*365
  - = 817,600 W-hr
  - = 817.600 kWh

Standby power is a bigger deal than people think…
…Applies to all ICT and appliances and gadgets and A/V!