

# Green Computing

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# Introduction



- 
- A rise of **two degrees** centigrade in global temperatures...
- ...is the threshold for catastrophic climate change, which will expose **millions to drought, hunger and flooding**.
- ...is "very unlikely" to be avoided!



“Some”  
Consequences  
(Sooner than you  
think)

- **Asia:** 1 billion people will suffer water shortages!

**America:** 350-600 million people will suffer water shortages!

**America:** Water shortages, coastal flooding, extreme weather events, forest fires, flash floods, new diseases etc.

**Australia:** Between 3000-5000 heat-related deaths a year, water shortages etc.

# UNITED NATIONS CLIMATE CHANGE CONFERENCE – COPENHAGEN (DEC 7 – DEC 18 2009)



GREENPEACE

# Green Computing?



- 
- Refers to environmentally sustainable computing or IT
- It is "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems effectively & efficiently".
- Green IT also strives to achieve economic viability and improved system performance and use, while abiding by our social and ethical responsibilities.

# Math I



- - An average CO<sub>2</sub> emission of a car  $\approx$  200 g / km
    - Assume that you drive 10000 km / year = 2.000.000 gr CO<sub>2</sub> / year = **2000** kg / year
  - A single Dell PowerEdge M600 blade server consumes an average of 383.75 W when idle and 454.39 W under stress. It also produces **3500** kg CO<sub>2</sub> / year.
  - **1 Dell server  $\approx$  3 car (!!!)**

# Math II



- - A typical desktop computer uses about 65 to 250 watts.
    - Let's say 1/3 of a Dell server
    - Let's say we use it 8 hours / day
  - Desktop computer produces about 500 kg CO<sub>2</sub> / year
  - **~ = Driving car for 1700 km!**
-

# (By The Way)

watts up?	Desktop (Windows XP)	Desktop (Ubuntu 7.10)	Laptop (Windows XP)
Run 1 Appr. Watts / Hr	165.6	150.0	24
Run 2 Appr. Watts / Hr	165.6	148.8	24
Run 3 Appr. Watts / Hr	166.8	148.8	25.2
Average Appr. Watts / Hr	166	149.2	24.4

**Use Laptop!**



# Math III



- Google claims; “An average query produces roughly 0.2 gr of CO<sub>2</sub>”
- Google.com served **7,5 billion** searches on July 2008
  - $\sim =$  **1.500 ton** CO<sub>2</sub> on July 2008 !
  - $\sim =$  **18.000** ton CO<sub>2</sub> on 2008!
  - $\sim =$  **90.000.000 km** travelling by car (equator = 40.075 km)
- Youtube: **1.2 billion** video streams / **day**
  - Yearly CO<sub>2</sub> emission  $\sim =$  **ERROR**
- 
-

# What's wrong with CO<sub>2</sub>?

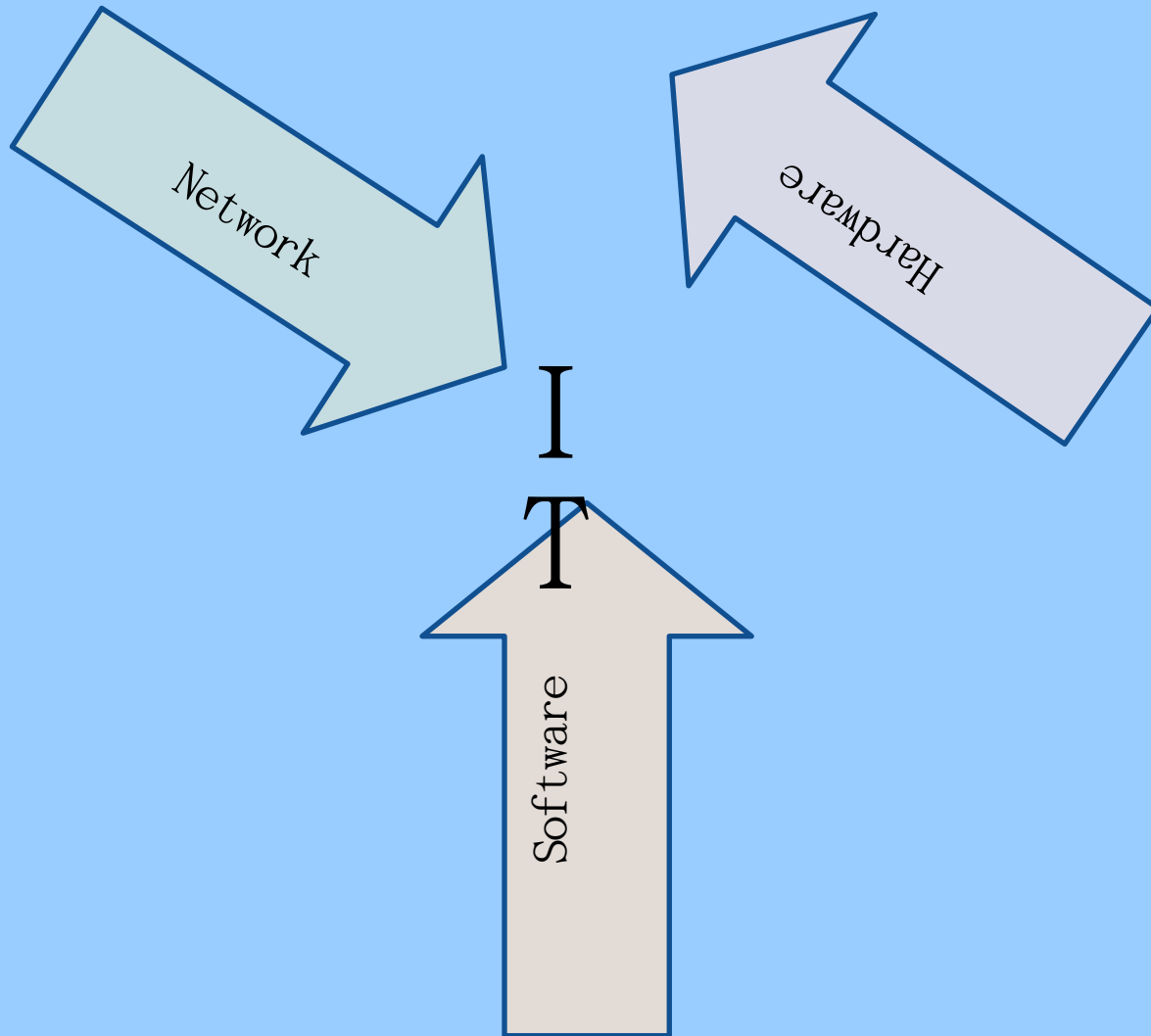
## The Greenhouse Effect



More CO<sub>2</sub> in atmosphere means **warmer** world!

# IT Components

- 
- 
- 
- 



# Network

- 
- Topology (Ring, Star etc.)
- Network Device (Repeater, Hub etc.)
- Cable (Coaxial, Fiber Optic etc.)
- Protocol (HTTP, FTP etc.)
- Infrastructure
- ...
- 
- Choose the most efficient element
-

# Hardware

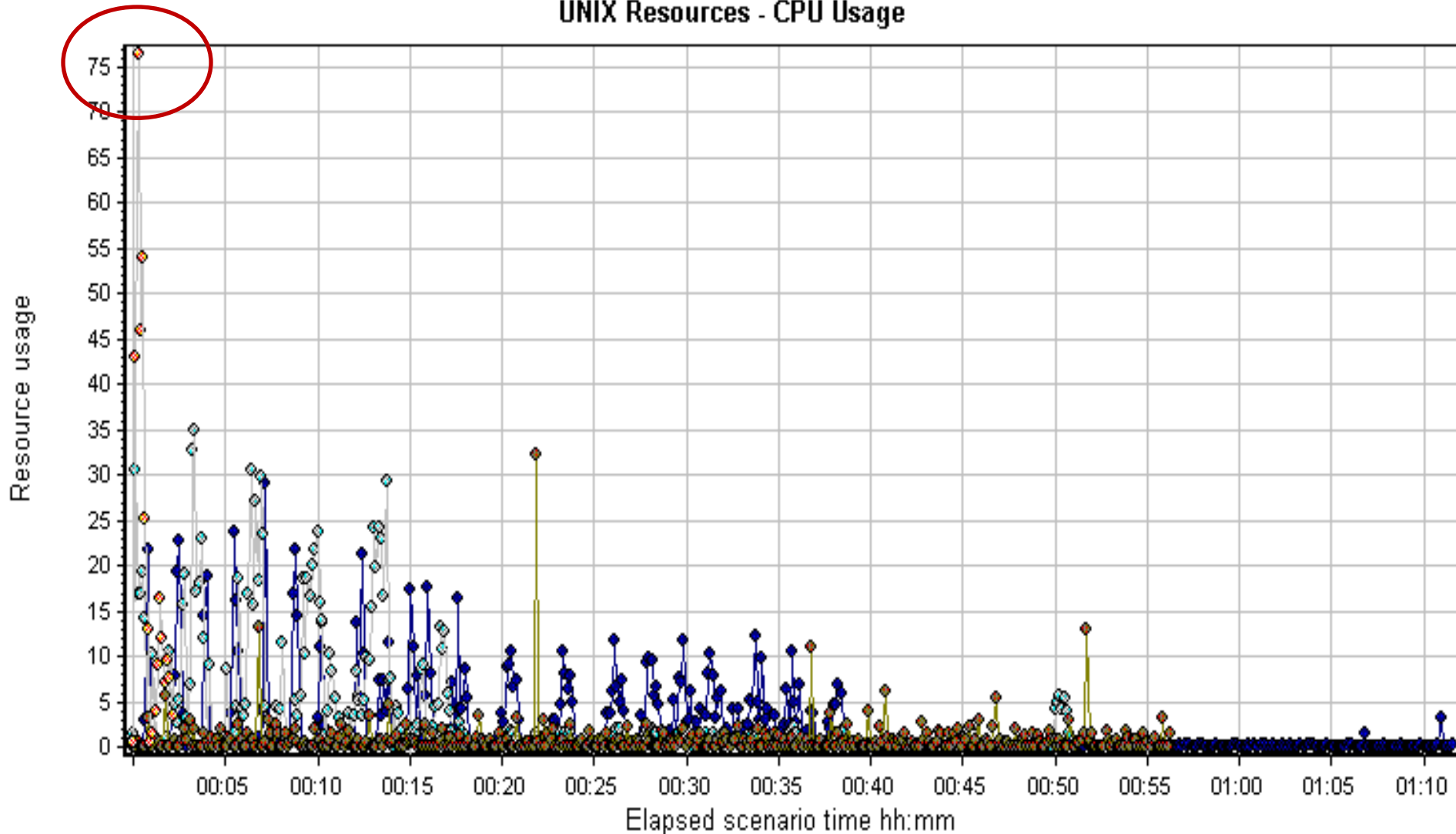
- Computer Components
  - CPU
  - Video Card
  - Battery
  - ...
- Virtualization
  - Cloud computing
- Data Center \*
- Recycling

# Data Centers

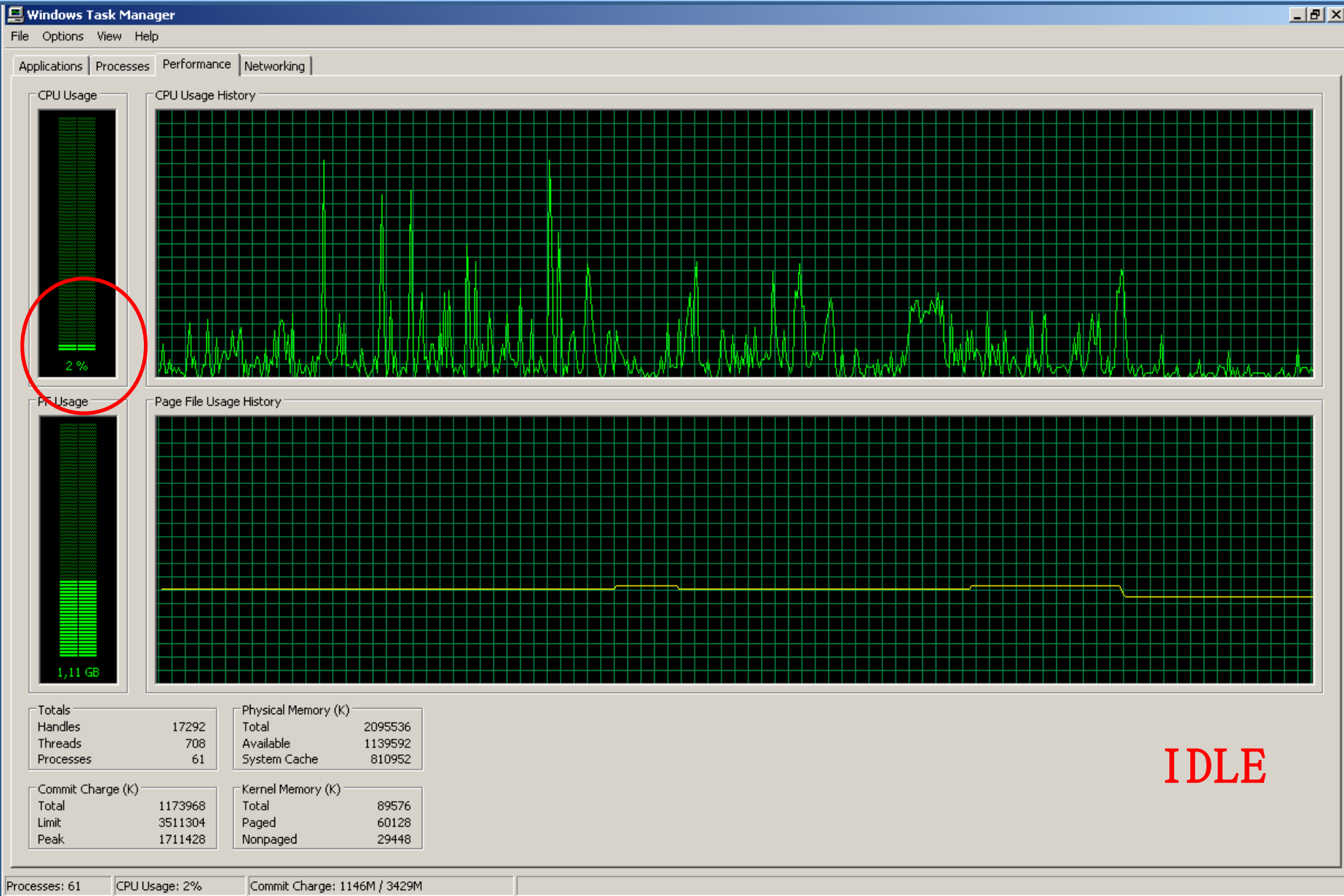
- 
- One of the fastest growing energy consumers.
  - Critical computational systems (servers, storage, ...)
  - Cooling systems
  - Power conversion such as power distribution units (PDU)
  - Hoteling (everything else: lighting, and so on).
- Governments have begun discussing hard limits on how much energy data centers can consume!
-

# Software - Server

UNIX Resources - CPU Usage



# Software - Client





# Software - Client

jQuery UI - Demos & Documentation - Mozilla Firefox

http://jqueryui.com/demos/draggable/

jQuery UI - Demos & Documentation

**jQuery**  
user interface

Download Demos & Documentation

**Interactions**

- Draggable
- Draggable
- Resizable
- Selectable
- Sortable

**Widgets**

- Accordion
- Datepicker
- Dialog
- Progressbar
- Slider
- Tabs

**Effects**

- Add Class
- Remove Class
- Animate
- Effect
- Hide
- Show

**FUNCTIONAL DEMO:**

## Draggable

Drag me around

Draggable + Sortable

Enable draggable functionality on any DOM element. Move the draggable object by clicking on it with the mouse and dragging it anywhere within the viewport.

Windows Task Manager

Applications Processes Performance Networking

CPU Usage: 55%

Physical Memory (K)

Total	2095536
Available	1014980
System Cache	797360

Kernel Memory (K)

Total	89648
Paged	60252
Nonpaged	29396

Totals

Handles	17644
Threads	718
Processes	62

Commit Charge (K)

Total	1270564
Limit	3511304
Peak	1711428

Processes: 62 CPU Usage: 55% Commit Charge: 1240M / 3429M

# Software - Client

Fotoğraf Makinesi, HD TV, Blu Ray, MP3 Çalar, Dizüstü Bilgisayar : Sony - Mozilla Firefox

File Options View Help

Applications Processes Performance Networking

CPU Usage 94 %

CPU Usage History

PF Usage 1,17 GB

Page File Usage History

Totals		Physical Memory (K)	
Handles	17549	Total	2095536
Threads	720	Available	1070876
Processes	62	System Cache	830468
Commit Charge (K)		Kernel Memory (K)	
Total	1237388	Total	93200
Limit	3511304	Paged	63940
Peak	1711428	Nonpaged	29260

Processes: 62 CPU Usage: 94% Commit Charge: 1208M / 3429M

7 müthiş mekanda Twilight Football  
Daha fazla bilgi edinin

Ürünler Alışveriş Destek

Ürünler

Blu-ray Disc™ oynatıcı Hi-fi Aksesuarlar Araç içi eğlence Kulaklıklar

Sony Deneyimi



.

- What if ODW could reduce CPU usage %10 both on client and server side?
  - (Multiply it by hits per day!)
- What if SONY could claim a **greener** website?

# Software - Client

YouTube - This Cat Betrayed His Girlfriend - Mozilla Firefox

Doğya Düzen Görünüm Geçmiş Yer İmleri Araçlar Yardım

http://www.youtube.com/watch?v=f3sX30NubTs&feature=popular

En çok ziyaret edilenler İlk Adım Haberler

Devre Dışı Çerezler CSS Hatası Yok Formlar Resimler Bilgi Çeşitli Ana Hatlar Boyutlandır Araçlar Kaynağı Göster Seçenekler

YouTube - This Cat Betrayed His Girlf...



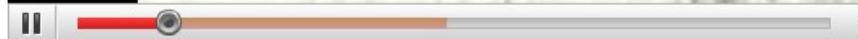
Search

Create Account or Sign In

Broadcast Yourself™ Home Videos Channels

Subscriptions History Upload

## This Cat Betrayed His Girlfriend



★★★★★ 5,658 ratings

Favorite Share Playlists Flag

MySpace Facebook Twitter

Windows Task Manager

File Options View Help

Applications Processes Performance Networking

CPU Usage: 24%

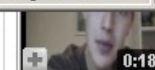
PF Usage: 1,23 GB

Totals		Physical Memory (K)	
Handles	17779	Total	2095536
Threads	720	Available	988564
Processes	62	System Cache	804744

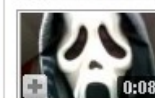
Commit Charge (K)		Kernel Memory (K)	
Total	1295240	Total	94848
Limit	3511304	Paged	64588
Peak	1711428	Nonpaged	30260

Processes: 62 CPU Usage: 24% Commit Charge: 1264M / 3429M

1,500,300 views



Girimeu  
40,173 views  
GoodCatsGoneBad



Re: This Cat Betrayed His Girlfriend  
8,089 views  
DrIceScreen



# What about database?

You are viewing: Mario Beck's Application

Firefox Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Fenster Hilfe

Browse Queries : MySQL Enterprise Dashboard

http://berlin.sunsolutioncenter.de:18080/BrowseQueries.action

Meistbesuchte Seit... Mailserv Internal Services Technologien Kollegen MyCal NameFinder

MySQL Enterprise Dashboard Refresh: Off

Servers

- All Servers (8)
  - berlin:13307
  - london:3306
  - moscow:3306
  - mysqlwinha:3306
  - oslo:3306
  - paris:3306
  - rome:3306
  - stockholm:3306
- Replication 1 (2)
  - london:3306
  - paris:3306
- Replication 2 (2)
  - moscow:3306
  - oslo:3306

Monitor Advisors Events Graphs Query Analyzer Replication Settings What's New?

Graph: CPU Utilization

Zoom: 1h 2h 4h 6h 12h 1d 2d

08:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 00:00 02:00 04:00 06:00 08:00 10:00 12:00

Legend: Kernel (orange), User (blue), Wait I/O (red), Total (light blue)

rome:3306 Browse Queries

Search Type: Contains Query Search: Query Type: All Database: Time Display: From / To From: 2009-12-09 Hours: 03 Minutes: 54 To: 2009-12-09 Hours: 04 Minutes: 13 Limit: 20 apply

Query	Database	Counts			Exec Time (hh:mm:ss.ms)			Rows			Bytes		
		Exec	Err	Warn	Total	Max	Avg	Total	Max	Avg	Total	Max	Avg
Benchmark wait statement	world	1,201	0	0	15:05:23.725	1:30.819	45.232	1,201	1	1	7.04 KB	6 B	6 B
SELECT * FROM City ORDER BY RAND() LIMIT ? ;	world	12,800	0	0	1:17:30.640	5.238	0.363	12,800	1	1	490.15 KB	65 B	39.21 B
SELECT Country . Name , ... City . CountryCode ) ;	world	1,329	0	0	49:28.609	11.968	2.234	58,756	57	44	1.71 MB	1.66 KB	1.31 KB
SELECT SLEEP( ? ) ;	world	11,200	0	0	44:11.204	0.833	0.237	11,200	1	1	65.62 KB	6 B	6 B
USE world ;	world	5,056	0	0	3:53.915	0.714	0.046	0	0	0	0 B	0 B	0 B
SELECT ROUND( Country ....ode GROUP BY Language ;	world	1,198	0	0	3:28.972	0.729	0.174	547,486	457	457	10.01 MB	8.56 KB	8.56 KB
USE test ;	world	3,856	0	0	3:06.209	0.643	0.048	0	0	0	0 B	0 B	0 B
SELECT COUNT( * ) AS Nu... ORDER BY Number DESC ;	world	1,198	0	0	2:35.791	0.722	0.130	35,940	30	30	245.68 KB	210 B	210 B
SELECT City . Name FROM...Name = Country . Name ;	world	1,198	0	0	2:04.658	0.647	0.104	7,188	6	6	90.08 KB	77 B	77 B
SELECT Country . Name , ...country . name = @land ;	world	1,331	0	0	1:16.055	0.478	0.057	1,331	1	1	22.23 KB	46 B	17.1 B
INSERT INTO test . 't' ...WHERE CountryCode = ? ;	world	1,329	0	0	1:13.947	0.639	0.056	19,935	15	15	0 B	0 B	0 B
SELECT SUM( 'a' ) , GRO...FROM 't' ORDER BY 'a' ;	world	1,329	0	4	1:10.787	0.544	0.053	1,199	1	1	264.31 KB	1.02 KB	203.65 B
SET @zufall = ROUND( RAND( ) * ? ) + ? ;	world	1,331	0	0	1:07.382	0.518	0.051	0	0	0	0 B	0 B	0 B
SELECT Country . Name , ...D City . ID = @zufall ;	world	1,331	0	0	1:06.982	0.502	0.050	1,331	1	1	0 B	0 B	0 B
DELETE FROM 't' WHERE 'a' > ? ;	world	1,198	0	0	59.917	0.607	0.050	19,935	150	17	0 B	0 B	0 B

# What can we do?

- Business analysts
  - Minimize gold-plating
  - Minimize assumptions
  - Think green!
- Architects
  - Follow “green patterns”\*
  - Reduce architectural complexity
  - 3rd party component? Are you sure?
  - Think green!

.



# GREEN OBJECT ORIENTED PROGRAMMING (GOOP)

- 
- Optimize your code
  - Dan Pritchett (eBay), estimates that inefficient programming techniques may increase eBay's energy consumption by 25-30%.
- Think “better” algorithms
- Use less resources
  - focus especially on CPU usage
- Yes, a simple “if statement” can kill the planet\*
- Think green!
-

# An innocent IF statement...

- 
- We performed a load test to a simple web page (10 min., 100 threads) 2 times
- Then added below lines to same page and run the same test 2 times again
  - ```
    if(true){
```
  - ```
    //
```
  - ```
    }
```
- The CPU usage was higher on both last tests!
-



# Green Patterns

- 
- 
- (Try to) forget Moore's Law
- Use JIT (Just In Time) Approach
  - Allocate it when you need it
- What is required? When is required?

•

•

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# Green Patterns

- 
- Use guesswork based on past experience
- Don't be risk-averse (much)
  - Bad: "Let's use 3 replica servers, if the other 2 crashes, the last one can save us"
  - Worse: "Let's use 4 replica servers, if the other 3 crashes, the last one can save us"
  - Balance recovery and robustness solutions with environmental objectives
- Measure everything

# EUP = Energy Usage Profile

| Component    | Idle Power Usage | Average Power Usage | Maximum Power Usage |
|--------------|------------------|---------------------|---------------------|
| Server 1     | 383.75           | 454.39              | 600 (Estimated)     |
| CPU          | 40.8             |                     | 130                 |
| HDD          | 14.35            |                     | 17                  |
| DIMM1        | 3                |                     | 3                   |
| DIMM2        | 3                |                     | 3                   |
| Video        | 18.3             |                     | 25.6                |
| Network Card | 4.95             |                     | 4.95                |
| CD/DVD       | 2                |                     | 18                  |

# EUP

- Create EUP for hardware
  - Can be obtained from manufacturers' Web sites and Web sites that perform independent hardware research.
- Create EUP for app.
  - Build a set of load tests that reflect both the average and peak loads for your application.
  - What is high priority in terms of performance improvement may not always be high priority for energy usage reduction.
- Create EUP for OP
  - Disable unnecessary services
  - Virtualization

# Green Computing:

- 
- 
- Saves World!
- Saves Money!
- Saves Your Family
- Saves YOU!



# Resources & further reading

- <http://msdn.microsoft.com/en-us/library/dd393307.aspx>
- <http://www.infoq.com/news/2008/12/Architecture-Green-Computing>
- <http://www.oricane.se/start/maximizing-the-efficiency-of-software-products-link.html>
- <http://www.thegreengrid.org/>
- <http://www.energyefficiencynews.com/policy/i/1576/>
- <http://earth2tech.com/2007/10/13/your-bad-code-is-killing-my-planet/>
- <http://msdn.microsoft.com/en-us/library/dd393312.aspx>
- <http://msdn.microsoft.com/en-us/library/dd393310.aspx>
- <http://msdn.microsoft.com/en-us/library/dd393308.aspx>
- <http://www.technewsworld.com/story/Sustainability-Software-Part-1-Its-Easy-Being-Green-68770.html>
- <http://www.energysmart.com.au/sedatoolbox/esm1.asp>
- <http://michaelbluejay.com/electricity/computers.html>
- <http://www.environmentalleader.com/2008/02/05/top-10-reasons-to-green-it/>
- [http://en.wikipedia.org/wiki/Green\\_computing](http://en.wikipedia.org/wiki/Green_computing)
- <http://timeforchange.org/what-is-a-carbon-footprint-definition>
- <http://shipsoftwareontime.com/2007/12/24/rules-for-being-a-green-software-engineer/>
- [http://www.theregister.co.uk/2007/07/21/green\\_software\\_possibility/](http://www.theregister.co.uk/2007/07/21/green_software_possibility/)
- <http://blog.technoetic.com/2007/03/25/green-software/>
- <http://www.examiner.com/x-12791-SF-Green-Careers-Examiner~y2009m8d5-What-is-green-software-design>
-

# Resources & further reading

- <http://www.techcrunch.com/2009/06/09/youtube-video-streams-top-1-billionday/>
- [http://en.wikipedia.org/wiki/Triple\\_bottom\\_line](http://en.wikipedia.org/wiki/Triple_bottom_line)
- <http://www.energyrating.gov.au/library/pubs/200905-data-centre-efficiency.pdf>
- <http://www.energyefficiencynews.com/policy/i/1576/>
- <http://www.google.com/corporate/green/datacenters/>
- <http://www.nrel.gov/docs/fy04osti/33905.pdf>
- <http://news.bbc.co.uk/2/hi/europe/6409741.stm>
- <http://msdn.microsoft.com/en-us/library/dd393312.aspx>
- [http://forgood.yahoo.com/go\\_green/](http://forgood.yahoo.com/go_green/)
- <http://www.ibm.com/ibm/green/index.shtml>
- [http://www.hp.com/hpinfo/newsroom/feature\\_stories/2007/07-360\\_greenup.html](http://www.hp.com/hpinfo/newsroom/feature_stories/2007/07-360_greenup.html)
- [www.dell.com/earth](http://www.dell.com/earth)
- <http://googleblog.blogspot.com/2009/01/powering-google-search.html>
- <http://www.technewsworld.com/story/Harvard-Prof-Sets-Record-Straight-on-Internet-Carbon-Study-65794.html>
- <http://www.computer.org/portal/web/csdl/abs/html/mags/it/2008/01/mit2008010012.htm#mit20080100121>
- [http://www.iea.org/textbase/nppdf/free/2009/key\\_stats\\_2009.pdf](http://www.iea.org/textbase/nppdf/free/2009/key_stats_2009.pdf)
- <http://www.greenpeace.org/usa/campaigns/global-warming-and-energy/science/co2-emissions>
- [www.foe.co.uk/resource/briefings/driving\\_up\\_co2\\_emissions.pdf](http://www.foe.co.uk/resource/briefings/driving_up_co2_emissions.pdf)
- <http://www.independent.co.uk/environment/climate-change/too-late-to-avoid-global-warming-say-scientists-402800.html>

THANK YOU

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