E2CC: Building Energy Efficient Class Cloud using DRBL

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Outline

- The ClassCloud Project
- E2CC Experiment Design
- Discussion
- Conclusion
- Q&A
The ClassCloud Project
What is ClassCloud?

**ClassCloud** helps to easily build economical Cloud infrastructure in PC classrooms!
The ClassCloud Architecture
The ClassCloud Software stack

DRBL
(TFTPd, NISd DHCPd, NFSd)

Kernel Modules

Kernel
(Patched by Xen)

Xen Hypervisor

Xen tools

User Space

Kernel Space
Why Xen?

- Xen aims to be able to execute multiple operating systems on one physical x86 machine
  - Support popular OS (Linux, Windows XP, NetBSD)
  - Scalable up to around 100 VMs
  - Securely
  - With close-to-native performance.
- Support heterogeneous applications using one physical machine (I.E. Win32 and Linux apps)
- Suspend / Resume & Live Migration

Reference: http://acet.reading.ac.uk/~mjeg/docs/xen_hantslug_08-2005.ppt
E2CC Experiment Design
Experiment Architecture

- 1 PDU
  - A device that distributes electric power
  - A device for taking high voltage and current
- 1 Electricity monitor
- 1 ClassCloud server
- 12 ClassCloud clients
Some pictures ...
Calculation Model

\[
W = \left(\frac{(a+b)}{2} + \frac{(b+c)}{2} + \frac{(c+d)}{2}\right) \times \frac{1}{60} \times \frac{t_1-t_0}{T_3-T_0} \times \frac{V_s}{1000}
\]

\[
= \frac{(a+b)+(b+c)+(c+d)}{120} \times \frac{t_1-t_0}{T_3-T_0} \times \frac{V_s}{1000}
\]

**W:** total power usage (Kilowatt hour)

**V_s:** utility power source voltage (Volt)

**a,b,c,d:** electric current usage (Amp)

**T_0, T_3:** PDU sample time duration (Minutes)

**t_0, t_1:** actual time duration (Minutes)
Discussion
**Experiment result – Boot & I/O**

**Boot Time**

- **“dd” command**
  - PXE Boot without HD saves almost **18.31%**

- **“tar” command**
  - PXE Boot without HD wastes almost **2598%**

- **Bonnie++**
  - PXE Boot without HD wastes almost **2000%**
I/O Performance result

Worse for I/O-bound apps
Experiment result – Make kernel

Saves 33.33%
Saves 16.59%
Saves 10.67%
Saves 22.22%
CPU Performance result

Better for CPU-bound apps
Conclusion

- DRBL helps to save 7% to 33% power consumption for CPU intensive application.
- *Diskless design of DRBL* really brings notable effect on power saving for *CPU-bound applications*.
- ClassCloud helps to turn your PC classrooms into a *small-scale computing center for Cloud Computing* quickly and efficiently.
Questions ?

Great! ?????