Energy and Cost Analysis of Cloud Computing

Erez Zadok and Radu Sion
Dept. of Computer Science
Stony Brook University
http://www.cs.sunysb.edu/

Clouds are Useful...

- Benefits:
  - Availability, opportunity, consolidation, reduced IT, ...
  - Cloud operations: high CPU use, efficient cooling, high power usage efficiency (PUE), better network/hardware deals, ...

- Costs:
  - Tech costs, data transfers, security, ...
  - IT people, energy, hardware, space.

...but to whom?

- Users (1–10 CPUs)
  - "no" rent/cooling/administration
- Small Enterprises (up to 1k)
  - no custom hardware, low utilization
- Mid-size Enterprises (up to 1–10k)
  - better network service, better utilization
- Large/Clouds (10k+)
  - Deepest discounts, custom hardware
So, is it worth it?

- Mostly yes:
  - 1 client cycle: 6–27 US picocents
  - 1 cloud cycle: 0.58 picocents
- But not always:
  - 1 client transfer bit: 60 picocents
  - 1 transfer to/from cloud bit: 500+ picocents

Now Add Security to Clouds

- Secure data storage
  - 700+ picocents/bit
- Private Information Retrieval (PIR)
  - 2–3 orders of magnitude worse
- Keyword searches
  - 4–5 orders of magnitude worse
- Range queries
  - 2–3 orders of magnitude worse
Can Clouds Be More Attractive?

- Reduce costs of data transfer
  - E.g., intelligent compression
- Improve software efficiency
  - Depends on precise hardware & software
  - Heavily depends on workloads
- Evaluate micro-costs of security
  - Give users “formula” to choose SLA levels

(1) Compression

- We studied compression benefits (local host)
- If you compress...
  - Higher client CPU costs
  - But reduced network & I/O transfers
- ... then you have to de-compress
  - Reduced I/O costs
  - Decompression cheaper than compression
- Caveat: depends on data type
- So, when is it worth it?
  - ... it depends

Server Performance: Text File
(2) Improving Software Efficiency

- Our method: **workload reduction**
  - Match workload to system configuration
- Studying traditional server workloads
  - Four Linux file systems
  - 32 combinations of format/mount options
  - 4 workloads: web, mail, OLTP, fileserver
**Web Server Results**

Is XFS the best for all workloads?

**Mail Server Results**

No, XFS is the worst for Mail Server

**Database Server Results**

2KB block size boosts efficiency by 2x
### File System Selection Matrix

<table>
<thead>
<tr>
<th>Workload</th>
<th>Best File System (Combination)</th>
<th>Improvement Range (compared to all default FS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web Server</td>
<td>XFS (inode-size-1K)</td>
<td>8% – 9.4x, 6% – 7.5x</td>
</tr>
<tr>
<td>File Server</td>
<td>ReiserFS (default)</td>
<td>0% – 1.9x, 0% – 2.0x</td>
</tr>
<tr>
<td>Mail Server</td>
<td>ReiserFS (notail)</td>
<td>29% – 5.8x, 28% – 5.7x</td>
</tr>
<tr>
<td>Database Server</td>
<td>XFS (BLK-2K)</td>
<td>2.0 – 2.4x, 2.0 – 2.4x</td>
</tr>
</tbody>
</table>

Even small savings add up to billions of dollars worldwide!

### (3) Client/Server Systems

- We are evaluating end-to-end impact of workloads on NFSv4 servers
- Several workloads
- Mix clients and servers
  - Same hardware
  - Linux (Ubuntu, CentOS), FreeBSD, OpenSolaris

### Results: Web Server, Server-wise

![Graph showing results](Image)
Results: Mail Server, Server-wise

Proposed Project Themes

- Evaluate performance, energy, security
- Use actual user data, workloads, hardware, and software
  - Hardware: clients and clouds
- Comprehensive study to find trends
- Develop predictive models
  - “If your application behaves as X, and you want Y level of security/SLA, your costs will be Z.”

Project Timelines

- Network based data compression
  - 3 months
- Client/cloud based cost/security eval.
  - 6 months
- Toolkit for users/operators to [re]run and [re]calibrate systems
  - 12 months
- Future: virtualization/migration costs?
Conclusions

- Cloud computing today can be costly
  - Especially when adding strong security
- But there is a huge amount of waste in software
  - Significant optimization opportunities
  - Lead to longer hardware/software lifetimes
    - Reduced IT costs
- Intelligent management needed
  - Must be workload- and environment-aware

The Bottom Line

YOU can sell better, cheaper, faster, more secure cloud services than your competitor, while reducing your own maintenance, energy, and IT costs.

Energy and Cost Analysis of Cloud Computing

Q&A
**Project Summary**

<table>
<thead>
<tr>
<th><strong>Project Name:</strong></th>
<th>Energy and Cost Analysis of Cloud Computing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Investigators:</strong></td>
<td>Erez Zadok and Radu Sion</td>
</tr>
</tbody>
</table>

**Description:**
Clouds are useful, but the cost of using them can be prohibitive to some users, especially when adding security. To make clouds more useful to a wider class of users, we propose to evaluate and reduce those costs.

There is a lot of waste in software today. Recent and ongoing studies show that performance and energy use can be improved by at least an order of magnitude. We found out that performance/energy depend heavily on the combination of hardware, software, configuration, and user workloads. When these four parameters remain relatively static, significant improvements can be made; otherwise, a re-calibration is needed.

We propose to evaluate these costs carefully under a wide range of user and cloud-operator environments. We will develop predictive models and a toolkit that can evaluate and recommend a configuration that would be optimal for a given customer's SLA/security needs.

**Experimental Plan (absolute times from start of project):**
- 3 months: Network based data compression
- 6 months: client/cloud based cost/security evaluation
- 12 months: toolkit for users and operators to re/run and re/calibrate systems

**Related Work Elsewhere:**
- very little performance/optimizations done
- very little cloud security work done anywhere

**How Ours Is Different:**
- We have demonstrated significant practical savings
- We are experts on performance/optimizations
- We are experts on security
- Our work is ready for commercialization in 12mo

**Related Work in Center:**
- n/a

**Milestones:**
- See Experimental Plan.

**Deliverables:**
- technical documents and data sets (after 6 mo)
- toolkit (after 12 months)

**Budget:** $150,000 (2 F/T Grads)

**Potential Benefits to Member Companies:**
- offer better/faster and more secure cloud services, better than competition, while reducing your IT/energy costs