Exertion-based billing for cloud storage access

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Cloud accounting

- Infrastructure-as-a-Service (IaaS)
  - Provider makes resources available to clients
  - Clients pay for resources used

- Provider wants to recover costs
- Client wants to pay fairly for use

- This talk: Focus on storage
Provider: Recovering costs

- More bytes stored → more disks needed
  - Bill for capacity
    ✓ Providers do this

- More time spent on requests → more disks needed
  - Bill for access
    ✗ Not all providers do this
    ✗ Those that do, use the wrong metric
Billing for access

• Providers currently bill for:
  • IOs
  • Bytes transferred
  • Performance

✘ None matches time used × cost of resources
Suppose provider charges $0.01 per IO but it takes $0.01/ms to operate a disk

<table>
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<tr>
<th>Request scenario</th>
<th>Disk time</th>
<th>Real cost</th>
<th>Bill</th>
</tr>
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<tbody>
<tr>
<td>Cache miss, sequential</td>
<td>1 ms</td>
<td>$0.01</td>
<td>$0.01</td>
</tr>
<tr>
<td>Cache miss, long seek</td>
<td>20 ms</td>
<td>$0.20</td>
<td>$0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Provider loses money</strong></td>
</tr>
<tr>
<td>Cache hit</td>
<td>0 ms</td>
<td>$0.00</td>
<td>$0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Client pays too much</strong></td>
</tr>
</tbody>
</table>
Alternatives

- Charge per byte or performance
  - Both also vary as in previous example

- Charge for worst case ($0.20/IO instead of $0.01)
  - Clients with “easy” requests pay too much

- Charge for the average case
  - Some clients subsidize others
  - Will the average change over time?
Suppose it takes $0.01/ms to operate a disk and the provider charges $0.01/ms.

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✓ Costs recovered fairly
But, a technical problem remains…

• Resources may be shared across tenants
• Workload A may be affected by Workload B
  • Workload A sequential, Workload B disrupts locality
  • Workload A cacheable, Workload B evicts A’s pages
  ❌ Workload B drives up Workload A’s bill
Interference example

<table>
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<tr>
<th>Workload</th>
<th>Standalone exertion</th>
<th>Exertion w/ interference</th>
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<tr>
<td>Sequential 1 MB/s</td>
<td>1.6%</td>
<td>23%</td>
</tr>
<tr>
<td>Random 1 MB/s</td>
<td>67%</td>
<td>74%</td>
</tr>
</tbody>
</table>

✖ Random workload increases Sequential workload’s exertion
How to solve?

• Bill Workload B for its impact on Workload A?
  ❌ Not the “fault” of B that it coexists poorly with A

• Provider absorbs the cost?
  ❌ Provider will either lose money or pass it along as a hidden cost to customers

✓ Avoid the interference in the first place
Performance insulation is needed

- *Performance insulation*: System property
  - Another workload is not able to affect your…
    - Efficiency
    - Exertion
    - Performance (in your share of time)
  - … beyond a small (e.g. 10%) factor

- Strictly limits transient influences
How to insulate storage

- Preserve locality
  - Disk-head timeslicing
    - Seek between workloads infrequently

- Provide predictable cache allocation
  - Cache partitioning
    - Partition sizes based on access patterns

- Argon storage system [FAST 2007]
Insulation example

*Insulation limits impact of other workload to < 10%*

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<th>Exertion w/ insulation</th>
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<tr>
<td>Sequential 1 MB/s</td>
<td>1.6%</td>
<td>≤ 1.8%</td>
</tr>
<tr>
<td>Random 1 MB/s</td>
<td>67%</td>
<td>≤ 75%</td>
</tr>
</tbody>
</table>

✓ Each workload’s exertion is close to ideal because it receives dedicated disk time & cache space.
Summary

- Clients should pay for resources used

- Storage: both capacity and access cost money

- Disk time is what costs, should be the metric

- Bills should be independent and predictable

- Performance insulation is needed to make it fair