The Heisenberg Measuring Uncertainty in Lightweight Virtualization Testbeds

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Outline

- Background
- Architecture
- Methodology
- Experiment Set Up
- Experiment Result
- Conclusion
- Future Work
The Heisenberg Uncertainty Principle

\[ \Delta X \Delta P \geq \frac{\hbar}{2}. \]

In Computer Science?

Increasing the frequency of measurement can decrease the number of concurrent containers we can utilize without interfering with the performance of the experiment itself.

- When testbeds scale up to hundreds of lightweight containers
  - how system resources managed
  - how the containers interact with each other
  - Is the fidelity maintained
The architecture

* VEE: Virtual Execution Environment, also known as container
Technical Approach

• Analysis of the memory consumption by container
  ‣ Shared and non-shared memory pages
  ‣ Disk consumptions

• Run-time analysis
  ‣ Number of containers running on the same host
  ‣ Different sampling interval
  ‣ Statistics from /proc
  ‣ Measure CPU, memory, network load and observe system behavior
## Static Analysis of Memory Consumption

<table>
<thead>
<tr>
<th>Processes</th>
<th>RSS</th>
<th>shared</th>
<th>non-shared</th>
</tr>
</thead>
<tbody>
<tr>
<td>init</td>
<td>860</td>
<td>604</td>
<td>256</td>
</tr>
<tr>
<td>syslogd</td>
<td>640</td>
<td>508</td>
<td>132</td>
</tr>
<tr>
<td>dbus-daemon</td>
<td>684</td>
<td>508</td>
<td>176</td>
</tr>
<tr>
<td>sshd</td>
<td>992</td>
<td>644</td>
<td>348</td>
</tr>
<tr>
<td>Sum</td>
<td>2264</td>
<td>912</td>
<td></td>
</tr>
</tbody>
</table>

**Table**: ubuntu-8.04-i386-minimal container template process memory consumption in kB
Experimental Setup

**Client side**
- Dell PE 1950 2.66GHz
- OpenVZ containers + Unionfs stackable filesystem
- Run experiment with 100-1400 containers
- 1 wget process per container.
- 1-10s random sleeping time between requests
- 4 sampling intervals (0.1, 0.01, 0.005, 0.001)

**Server side**
- Dell PE 1950 2.66GHz
- Apache 2.2.9 on Fedora 9
- MaxClient : 4000
- Gigabit LAN connection
Container Average CPU Utilization

- 0.1
- 0.01
- 0.005
- 0.001

CPU Usage (%)

Number of Containers

100 200 300 400 500 600 700
Contribution and Limitation

- First time unveiled uncertainty problem due to system resource contention in a lightweight virtualization environment

- The desirable accuracy of measurement is largely dependent on the high sampling frequency, which potentially deprives the containers of available resources and adversely interferes with the experiment

- No quantitative analysis or formula yet
Conclusion

• Virtualization has some limitations due to the sharing of host resources (CPU, network, memory, and disk) among the same host VEEs.

• The Heisenberg uncertainty principle for host resource measurements: increasing the precision and fidelity of the resource measurements can interfere with the behavior of the experiment.

• It is not a trivial task to determine the maximum number of VEEs that can be run concurrently in a physical machine without perturbing the experimental outcome.
Future Vision

• More experiments to delve deeper and investigate the kernel data structures to achieve fine-grained resource management

• Modeling the host environment, guide the implementation of virtualization