Resource Containers: A New Facility for Resource Management in Server Systems

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February 1999

Presented for EECS 443, Northwestern University
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January 26, 2009
Overview

- Introduction
- Traditional Servers
- Resource Containers
- Benefits of Resource Containers
- Summary
General Implementation

- Processes are used for protection domains and as resource primitives.
- Easy and straightforward, but can be inefficient when this model does not match ideally, as in the case of servers.
  - Examples will an HTTP server, although this could apply to other servers, as well.
Traditional Servers

- Traditional servers have multiple models.
  - Above, one master process gives work to multiple pre-forked working slave processes.
  - Right above, a single process is used to eliminate context switching and IPC costs.
  - Right below, a multithreaded process uses one thread per connection.
Downsides of Traditional Servers

- Traditional models do not work well when the protection domain should not match the resource principal.
  - Above, the traditional model works well for an application that does not go into the kernel much.
  - Right above, the traditional model fails to associate a network-intensive application’s work in the kernel with the application.
  - Right below, a multiple process application performing a single independent task cannot share the same resource principal in this model.

Fig. 4: A classical application.

Fig. 5: A classical network-intensive application.

Fig. 6: A multi-process application.
Downsides of Traditional Servers

- Traditional models do not work well when the protection domain should not match the resource principal.
  - Left, a multithreaded application performing different independent activities is required to share the same resource principals.
  - Right, a modified kernel using Lazy Receiver Processing (LRP) associates the work done in the kernel with the correct application. This is a more accurate model, but it still keeps the protection domain and the resource principal the same.
Resource Containers

- An entity that holds all system resources of an application for an independent activity used for scheduling.
  - Example: a Web server would include connection CPU time, sockets and other kernel objects, protocol control blocks, and network buffers used.
- Containers have attributes for scheduling, resource limits, and network QoS values.
- Can be hierarchical.
- Used in user and kernel modes.
Operations on Resource Containers

- Creating a new container
- Set a container’s parent
- Container release
- Sharing containers between processes
- Container attributes
- Container usage information

Operations for relationship control between containers, threads, sockets, and files

- Binding a thread to a container
- Reset the scheduler binding
- Binding a socket or file to a container

<table>
<thead>
<tr>
<th>Operation</th>
<th>Cost (μs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>create resource container</td>
<td>2.36</td>
</tr>
<tr>
<td>destroy resource container</td>
<td>2.10</td>
</tr>
<tr>
<td>change thread’s resource binding</td>
<td>1.04</td>
</tr>
<tr>
<td>obtain container resource usage</td>
<td>2.04</td>
</tr>
<tr>
<td>set/get container attributes</td>
<td>2.10</td>
</tr>
<tr>
<td>move container between processes</td>
<td>3.15</td>
</tr>
<tr>
<td>obtain handle for existing container</td>
<td>1.90</td>
</tr>
</tbody>
</table>

Table 1: Cost of resource container primitives.

- Extra costs of resource containers are relatively insignificant
Servers Using Resource Containers

- A new resource container is created for each new connection.
- That resource container is charged with the processing, including kernel processing.
Performance Benefits

- Using resource containers can give high priority tasks or connections more processing power.
- Graph above shows response time for a single high-priority client with an increasing number of low-priority clients connecting.
- Graphs to the right show throughput (above) and CPU usage of CGI (below) using a 1 KB cached static document and increasing amounts of CGI requests.
Protection Benefits

- Using connection filters, malicious connections can be placed into a resource container where it can be starved to protect the system.

Fig. 14: Server behavior under SYN-flooding attack.
Virtual Server Isolation

- Running multiple virtual servers on the same machine, each in its own resource container, an administrator can limit the resources each gets.
- Resources can then be divided proportionately to how much is being charged for each to run.
Summary

- By breaking the traditional model that a protection domain and a resource principal must coincide, many benefits are derived.
Any questions?
Thanks