Background and Motivation

- Isolated infrastructure as a Service (IaaS) systems are gaining significant leverage among developers. These systems widely use virtual machine monitors such as Type I hypervisors: Xen, KVM, VMware ESX (Figure 2).
- Developers working in these systems need powerful tools for performance evaluation. Commonly used performance analysis tools (e.g., PAPI) cannot be used because existing VMMs and guests do not provide necessary per-thread instrumentation support.
- To support per-thread monitoring in virtualized environments, the hardware event counters must be isolated. It may be challenging because of the mutual blocking of the hypervisor and guest threads. Both inter-domain and intra-domain context switches must be taken into account as shown in Figure 2.

Table 1. Libraries and framework for performance measurement

<table>
<thead>
<tr>
<th>Library</th>
<th>Framework</th>
<th>Purpose</th>
<th>Language</th>
<th>Interface</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPCToolkit</td>
<td>Profiler</td>
<td>Per thread</td>
<td>Java</td>
<td>ioctl, mmap</td>
<td>PAPI</td>
</tr>
<tr>
<td>PerfExplorer</td>
<td>Profiler</td>
<td>Per thread</td>
<td>C</td>
<td>ioctl, mmap</td>
<td>PAPI</td>
</tr>
<tr>
<td>TAU</td>
<td>Profiler</td>
<td>Per thread</td>
<td>C</td>
<td>ioctl, mmap</td>
<td>PAPI</td>
</tr>
</tbody>
</table>

Implementation

- Our framework is based on perthread library which is widely used for non-virtualized environments, and is fully compatible with many well-known models such as PAPI and HPCToolkit.
- We developed a framework for performance counter virtualization which is fully compatible with commonly used virtualized environments such as PAPI, HPCToolkit, TAU, PerfExplorer, so that they can be used in virtualized environments. Performance Monitoring Unit (PMU) is always architecture-specific. We want to make such architecture-dependent code possible so that new virtual architectures can be added easily to our framework from the existing codebase.

Result

- We developed a framework for performance counter virtualization which is fully compatible with widely used perthread library. Our framework is very efficient, accounts for all possible scenarios.
- We have shown the viability of our framework using a number of different applications such as SPEC CPU 2006 and HPCToolkit.

Contributions

- We developed a framework for performance counter virtualization which is fully compatible with widely used perthread library. Our framework is very efficient, accounts for all possible scenarios.
- We have shown the viability of our framework using a number of different applications such as SPEC CPU 2006 and HPCToolkit.
- Our framework is available under an open-source license at http://sourceforge.net.