ROS: Redesigning the OS System Call Interface for Manycore

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Problem: Current operating systems are not designed for manycore architectures
- Do not scale well in a multi-core environment
- Do not support high performance parallel applications

Our idea: Structure the operating system asymmetrically
- Provide an asynchronous syscall interface to users
- Service syscalls on dedicated kernel cores

Solution:
- Built an OS from scratch
- Implemented asynchronous remote syscalls
- Compared them to traditional approach
Outline

- Architecture
- Implementation
- Evaluation Methodology
- Results
- Conclusion
- Future Work
Architecture

- Asymmetric OS on symmetric hardware
Asynchronous Remote Syscall Interface

- **Syscall interface**
  - Regular syscall marshaled in a structure and copied into shared memory Xen-style ring buffer
  - Kernel polls for new requests and user process polls for responses
  - Notification via IPI in the future

- **User level library**
  - Library calls (e.g. printf_async) provide descriptors that the user program can wait on
  - Single library call can contain many syscalls
  - Wait on a group of syscall descriptors
Asynchronous Remote Syscall Interface

- **Advantages**
  - Less contention on shared data structure
  - No cache interference between kernel and user level programs
  - Saves the cost of switching between user and kernel mode
  - Batching and reordering of system calls

- **Disadvantages**
  - Higher latency for a single call
  - Potentially more copying to maximize asynchrony
Evaluation Methodology

Nehalem Intel Core i7

- Compare to traditional synchronous syscalls
  - Null syscall
  - Cache contending syscall
  - User process interference

- Measure
  - Latency
  - Throughput
Evaluation - Null Syscall Latency

- SYSENTER 4x faster compared to interrupt-based implementation
- Our implementation is comparable

![Null() Syscall Measurements](image)

- **SYS_ENTER Based Syscall**
- **Remote Syscall**
- **Interrupt Based Syscall**
Evaluation – Cache Contending Syscall

- Designed a syscall that writes to many cache lines to investigate cache contention
- Simulates a kernel intensive workload (e.g. file system)
Cache Contending Syscall Internals

- What does it cost to run the cache contending syscall? Local vs. Remote
- Expected: Poor performance with multiple cores servicing kernel calls due to cache contention
- Surprise: average service time comparable

![Graph showing average service time and std deviation of service time for remote vs local syscalls.](image)
Evaluation – Throughput Comparison

Remote locked syscalls generally have higher throughput

Remote syscalls do not interfere with user progress
Conclusions

- Effect of cache contention was not as significant as initially thought
  - Cache contending syscall may not be representative of real workload
- Cost of code shipping may be higher than the cost of context switching and cache contentions
- Kernel processing on a remote core allows user processes to make more progress
Future Work

- Profiling different stages of both asynchronous remote syscall and synchronous syscall
- Performance counters for cache misses and other specific events
- Macrobenchmarks and a real kernel workload (file system, network stack, etc)
- Experiment with different architectures
  - More cores
  - No globally shared L3 cache
- Asynchronous notification through Interprocessor Interrupts
- Multiple kernel cores and load balancing issues
Questions?
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