Single Address Space Operating Systems

Andrew Hoskins

November 27, 2012
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32-bit Address Spaces

Problem:
- Virtual address space is a scarce resource

Solution:
- Provide a per-process mapping from virtual to physical addresses
Private Virtual Address Spaces

Advantages:
- Entire virtual address space available to each process
- Protection via *address isolation*

Disadvantages:
- It is difficult to share pointer-based data structures
Shared Memory

- Pointer based structures can currently be shared via shared memory
- This requires all processes to map the shared memory to the same location in their virtual address spaces.
Persistant Storage

- Directly saving pointer-based data structures cannot occur, because the values of the pointers only of meaning in the address space the memory objects were allocated in.

- Serializing a data structure requires either replacing pointers with position independent references or object ids and performing the reverse operation during deserialization.
64-bit address spaces are commonplace

- Consuming a 64-bit address space by allocating 1 GB/sec would take over 500 years
- Virtual address space is no longer a scarce resource
- Use a single address space that spans all processes and includes persistent storage
- Addresses are permanently and uniquely bound to data and code objects
- Protection is managed by controlling which sections of the address space are accessible
Uniform addressing

- Data can be passed by reference between processes
- Data in memory and files can be accessed by reference
Modular protection

- Protection is not coupled with address spaces
- Access control choices can be made independently for each data item
Page table management

Global Hashed Resident Page Table

- Inverted page table
- Protection domains are assigned IDs
- Page table entries contain the IDs of protection domains allowed to access the given page
Page table management

When a protection domain switch occurs

- Flush the TLB
- On TLB misses, check if the page table entry contains the ID of the current protection domain
- On protection misses (and page faults), the capability list of the protection domain is examined
Page table management

- Rather than work at the page level, Opal manages segments of contiguous blocks of pages
- Segments can be shared individually
- Segments can be reclaimed when no references exist to them
Files can be viewed as having a virtual address space

In a SASOS, they can reside in the global address space

Files can be accessed with ordinary reads and writes without memory-map setup overhead
Network Virtual Address Spaces

- An network can share an address space
- A page table is needed for each node
Current Uses

So who uses SASOSs?