

Virtual Memory

A Project for CS854

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Our proposal has 3 parts:

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- 1 Literature Review

Our proposal has 3 parts:

- ① Literature Review
- ② Experimental Design

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- ③ Implementation

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Proposal: Literature Review

We wish to investigate the following operating systems:

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- 1 Linux
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- How is physical memory managed?

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- Are there data structures for physical pages, separate from the page tables?

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- How is memory freed?
 - What happens when the kernel runs out of memory?

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- Are there data structures for physical pages, separate from the page tables?
- How are contiguous regions of memory managed?
- How is memory freed?
 - What happens when the kernel runs out of memory?
- Do they do anything special on Non-Uniform Memory Access (NUMA) architectures?

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- Example:
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 - Test performance

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Proposal: Implementation

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- Optional

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High-level design

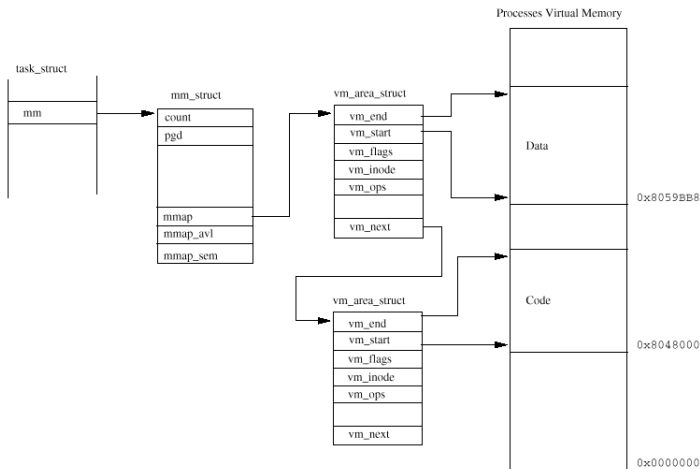
High-level design:

- Linux
- NetBSD
- OpenIndiana

High-level: Linux

- vm_area_struct

```
44 struct vm_area_struct {
45     struct mm_struct * vm_mm;
46     unsigned long vm_start;
47     unsigned long vm_end;
48
49     /* linked list of VM areas per task, sorted by address */
50     struct vm_area_struct *vm_next;
51
52     pgprot_t vm_page_prot;
53     unsigned long vm_flags;
54
55     rb_node_t vm_rb;
56
57     struct vm_area_struct *vm_next_share;
58     struct vm_area_struct **vm_pprev_share;
59
60     /* Function pointers to deal with this struct. */
61     struct vm_operations_struct * vm_ops;
62
63     /* Information about our backing store: */
64     unsigned long vm_pgoff;
65     struct file * vm_file;
66     unsigned long vm_raend;
67     void * vm_private_data;
68 };
```



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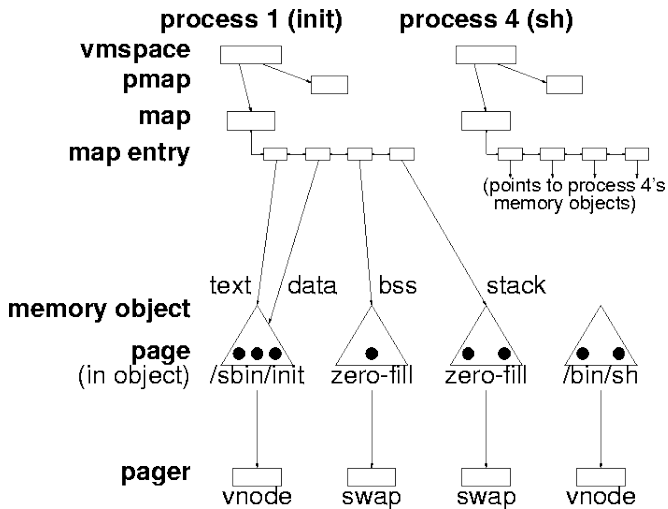
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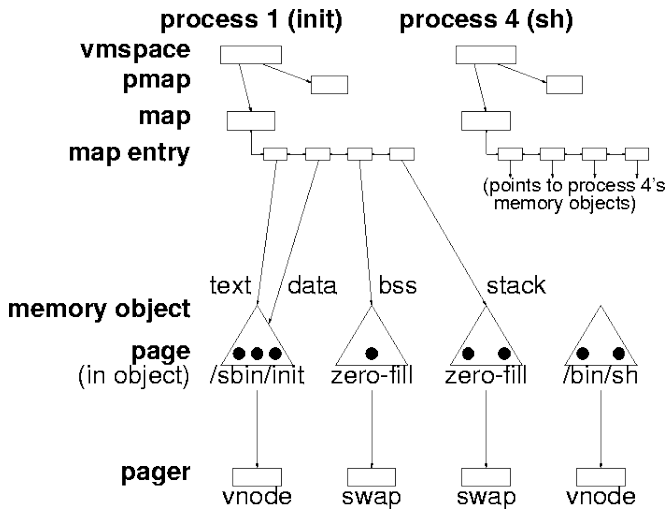
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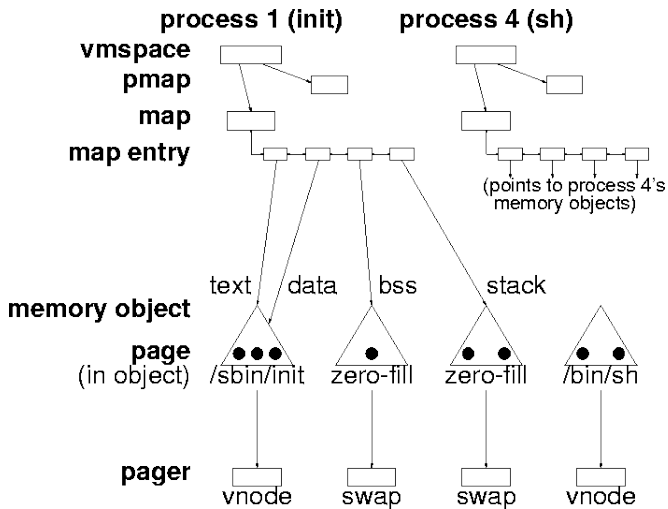
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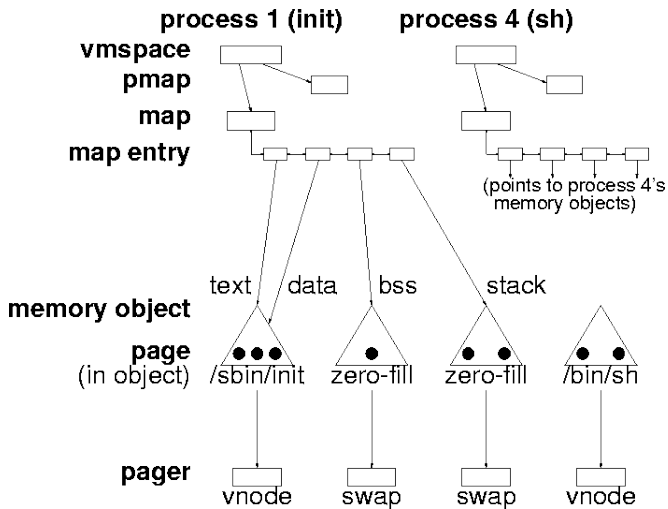
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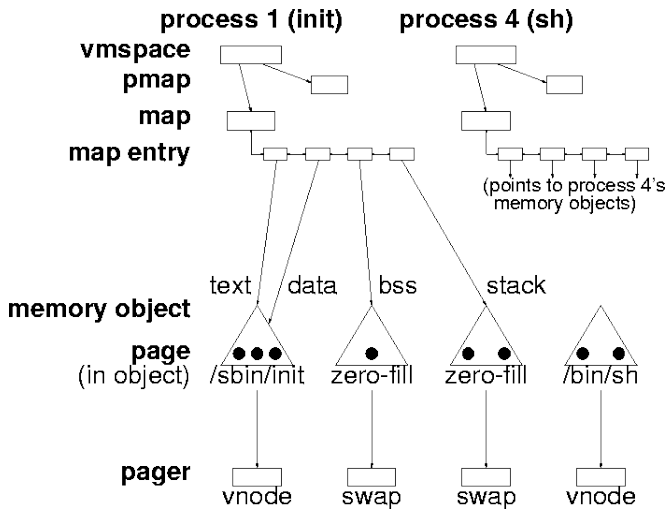
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High-level: NetBSD



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 - 5 page Usenix paper
- Minor modifications since then

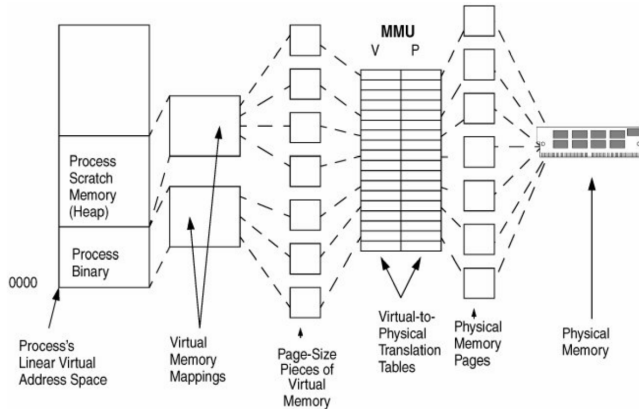
High-level: OpenIndiana

- 1 Open source fork of OpenSolaris after Oracle take over
- 2 Stewarded by the Illumos Foundation

Virtual memory management unit

- 1 Solaris kernel breaks up virtual address space into mappings for each type of memory (eg., heap, stack)
- 2 Hardware MMU maps pages to physical memory using platform-specific translation tables
- 3 Memory management to manage pages is basically swapping and demand paging

Solaris 10 Virtual to Physical Memory Management



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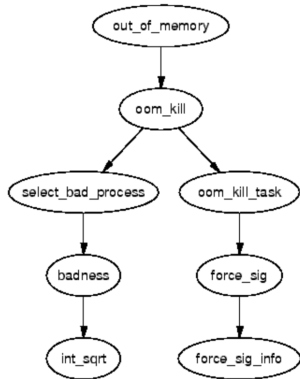
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- What happens when the kernel runs out of memory?
- How does the kernel access user memory?
- What are the copy-on-write mechanisms?

What happens when the kernel runs out of memory?

Linux:

- Start killing processes



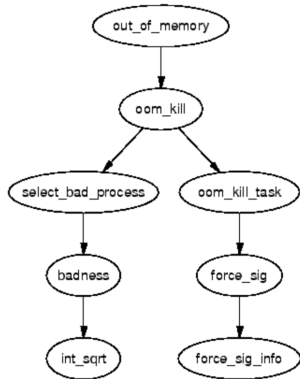
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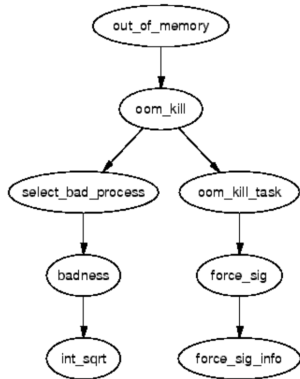
- Panic!



What happens when the kernel runs out of memory?

Linux:

- Start killing processes



NetBSD:

- Panic!

OpenIndiana:

- Periodically checks kernel space, and "snaps" data to user space if kernel space is low
- If kernel runs out of memory, crashes as far as I can tell

How does the kernel access user memory?

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- Map all of physical memory into kernel's virtual address space

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What are the copy-on-write mechanisms?

Linux:

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Linux:

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OpenIndiana:

- Anonymous maps

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Linux:

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OpenIndiana:

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NetBSD:

- Copied SunOS/Solaris

Summary

- ① Literature Review
 - High-level design
 - Differences
- ② Experimental Design
- ③ Implementation

References

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- McDougall, Richard, and Jim Mauro. Solaris internals: Solaris 10 and OpenSolaris kernel architecture. Pearson Education, 2006.

- NetBSD data structure diagram from:

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- Linux vm_area_struct source from:

???

- Linux data structures diagram from:

???

- Linux OOM diagram from:

???

- Solaris VM diagram:

McDougall, Richard, and Jim Mauro. Solaris internals: Solaris 10 and OpenSolaris kernel architecture. Pearson Education, 2006.

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