

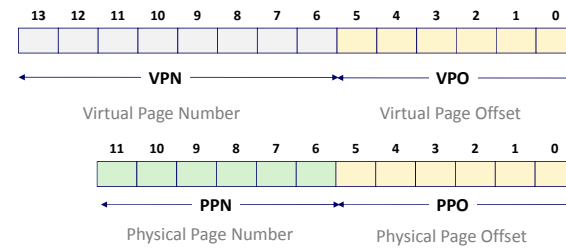
Virtual Memory: Systems

Kai Shen

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Simple Memory System Example

- Addressing
 - 14-bit virtual addresses
 - 12-bit physical address
 - Page size = 64 bytes



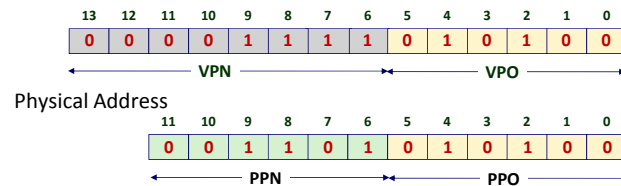
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Simple Memory System Page Table

Only show first 16 entries (out of 256)

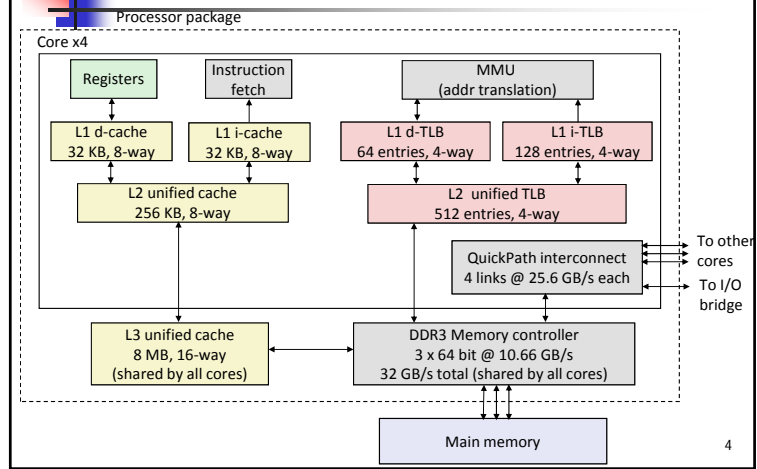
VPN	PPN	Valid	VPN	PPN	Valid
00	28	1	08	13	1
01	—	0	09	17	1
02	33	1	0A	09	1
03	02	1	0B	—	0
04	—	0	0C	—	0
05	16	1	0D	2D	1
06	—	0	0E	11	1
07	—	0	0F	0D	1

Virtual Address: 0x03D4

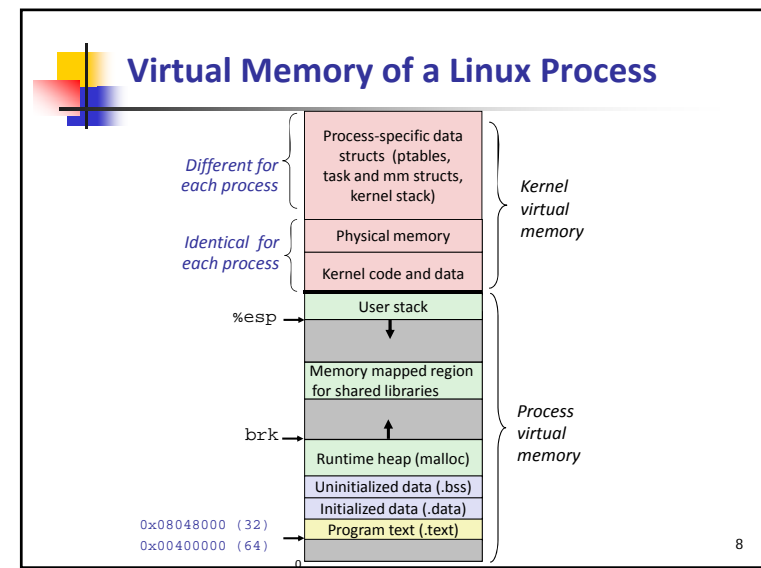
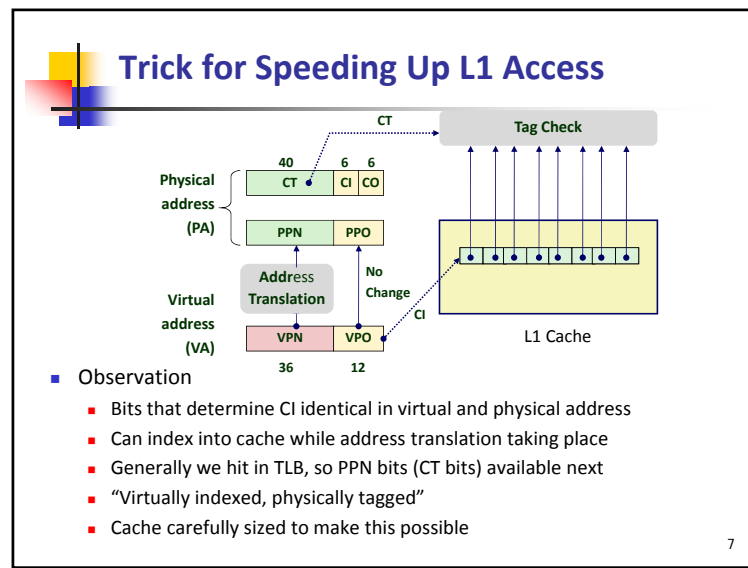
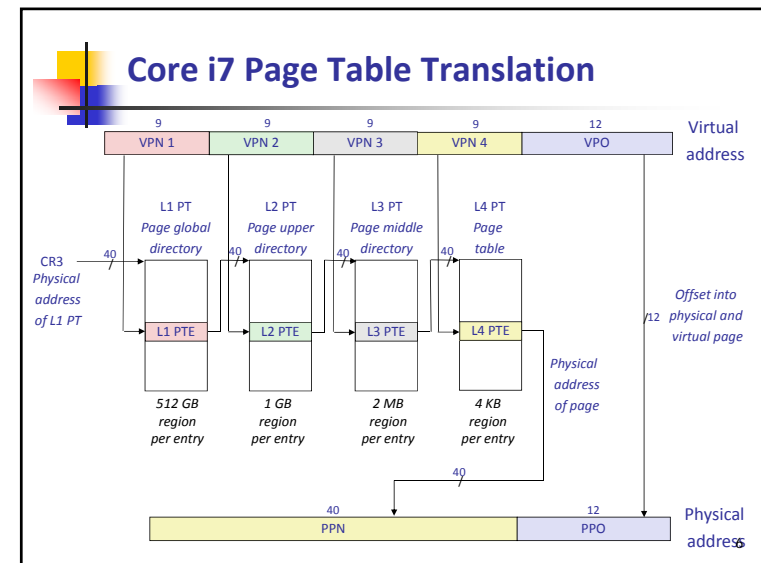
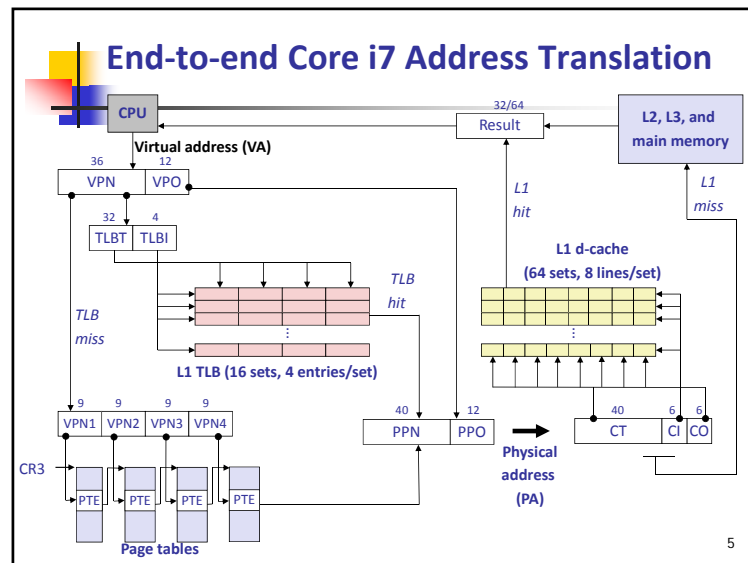


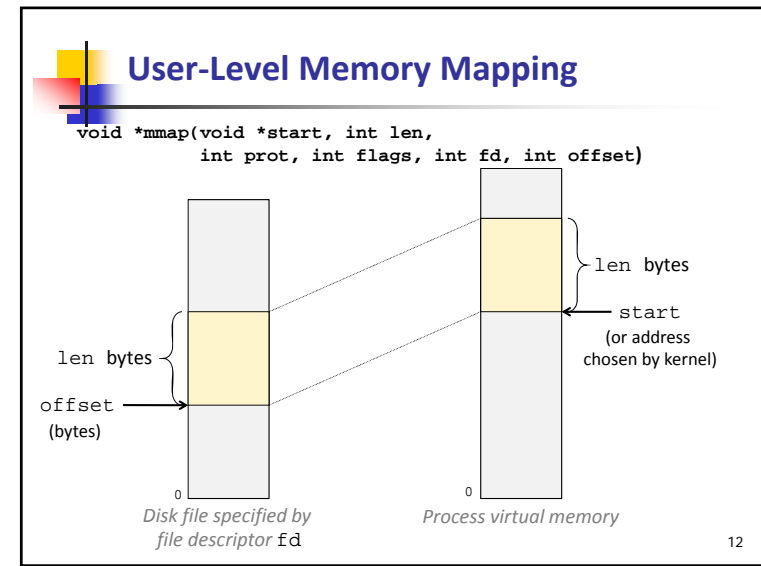
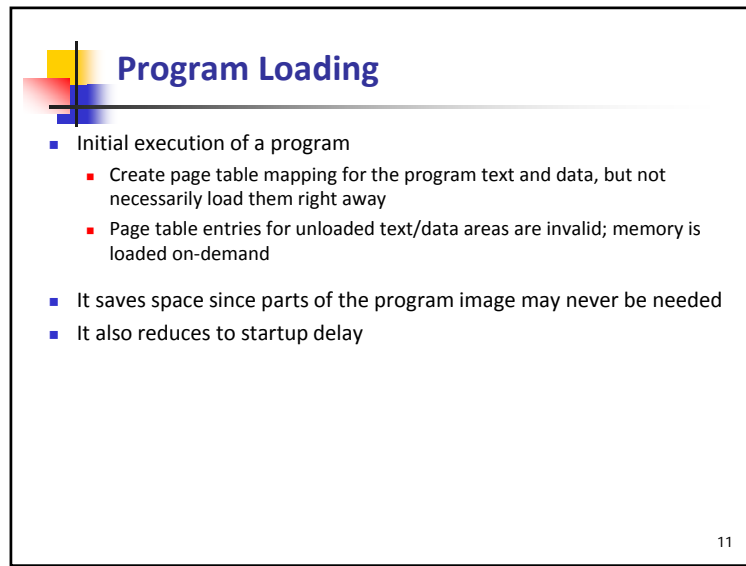
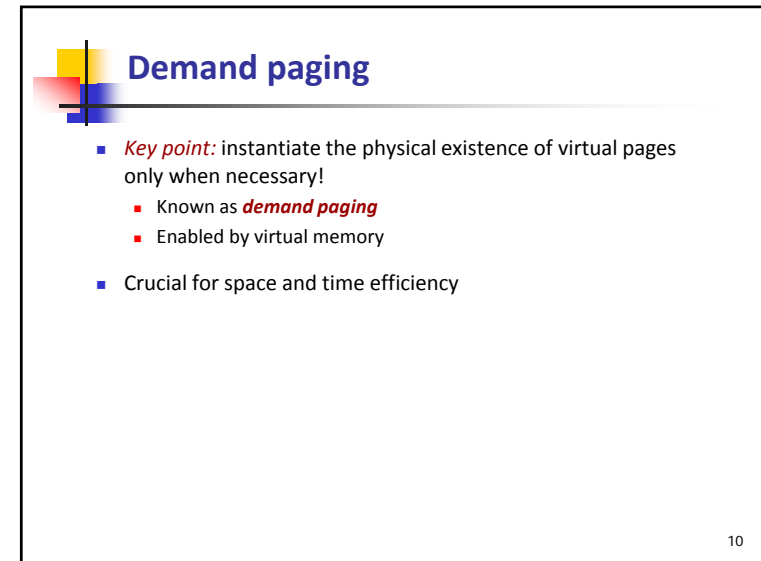
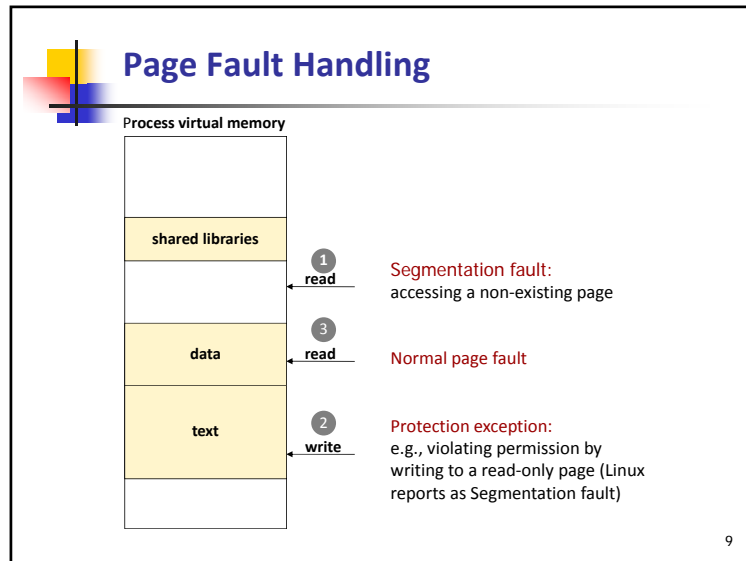
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Intel Core i7 Memory System



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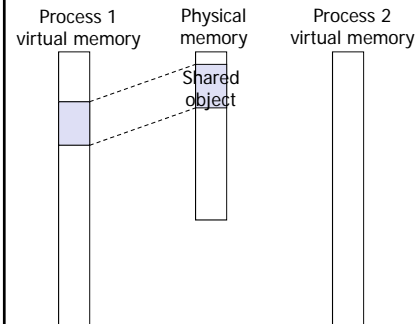
Using mmap to Read File

- `mmap` → lazy file read to buffer.
 - Fast start;
 - Real read is only performed on-demand.

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Sharing Revisited: Shared Objects

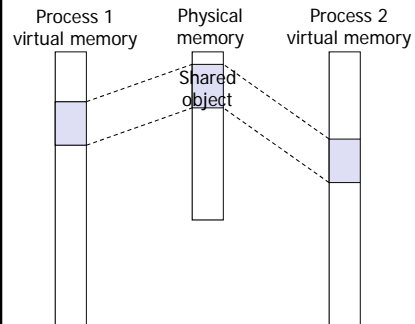


- Process 1 maps the shared object.

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Sharing Revisited: Shared Objects

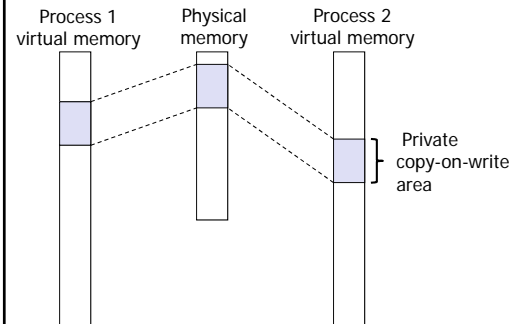


- Process 2 maps the shared object.
- Shared objects are typically read only.

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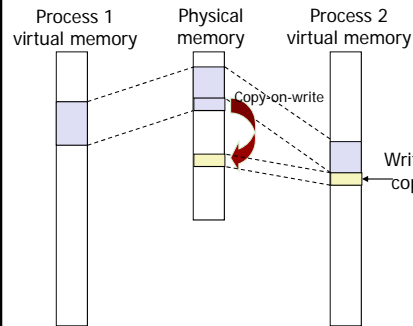
Sharing Revisited: Private Copy-on-write (COW) Objects



- Two processes mapping a *private copy-on-write (COW)* object.
- Area flagged as private copy-on-write
- PTEs in private areas are flagged as read-only

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Sharing Revisited: Private Copy-on-write (COW) Objects



- Instruction writing to private page triggers protection fault.
- Handler creates new R/W page.
- Instruction restarts upon handler return.
- Copying deferred as long as possible!

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The `fork` Function Revisited

- VM and memory mapping explain how `fork` provides private address space for each process.
- To create virtual address for new new process
 - Create exact copies of current memory area structures and page tables.
 - Flag each page in both processes as read-only
 - Flag each memory area in both processes as private COW
- On return, each process has exact copy of virtual memory.
- Subsequent writes create new pages using COW mechanism.

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Disclaimer

These slides were adapted from the CMU course slides provided along with the textbook of "Computer Systems: A programmer's Perspective" by Bryant and O'Hallaron. The slides are intended for the sole purpose of teaching the computer organization course at the University of Rochester.

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