



Virtual Memory

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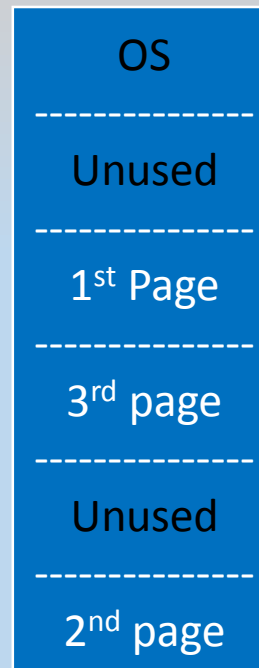
- Paging
- Hello World Kernel Module

Operating System Memory Management

- Segmentation
 - A segment is a contiguous part of memory (code, stack and heap)
 - Segment : (Base Address) + (Bound or size)
 - Space fragmentation
- Paging
 - Split up physical into fixed sized pieces called pages
 - View physical memory as an array of fixed-sized slots called page frames
 - + Flexible
 - + Simple

Page Table

- A per process data structure for mapping virtual addresses (VA) to physical addresses (PA)
- Rule: Address translation from virtual address to physical address



Address Translation

$[[\text{Virtual Page Number (VPA)}] [\text{Offset}]]$

VA $\Rightarrow$ PA

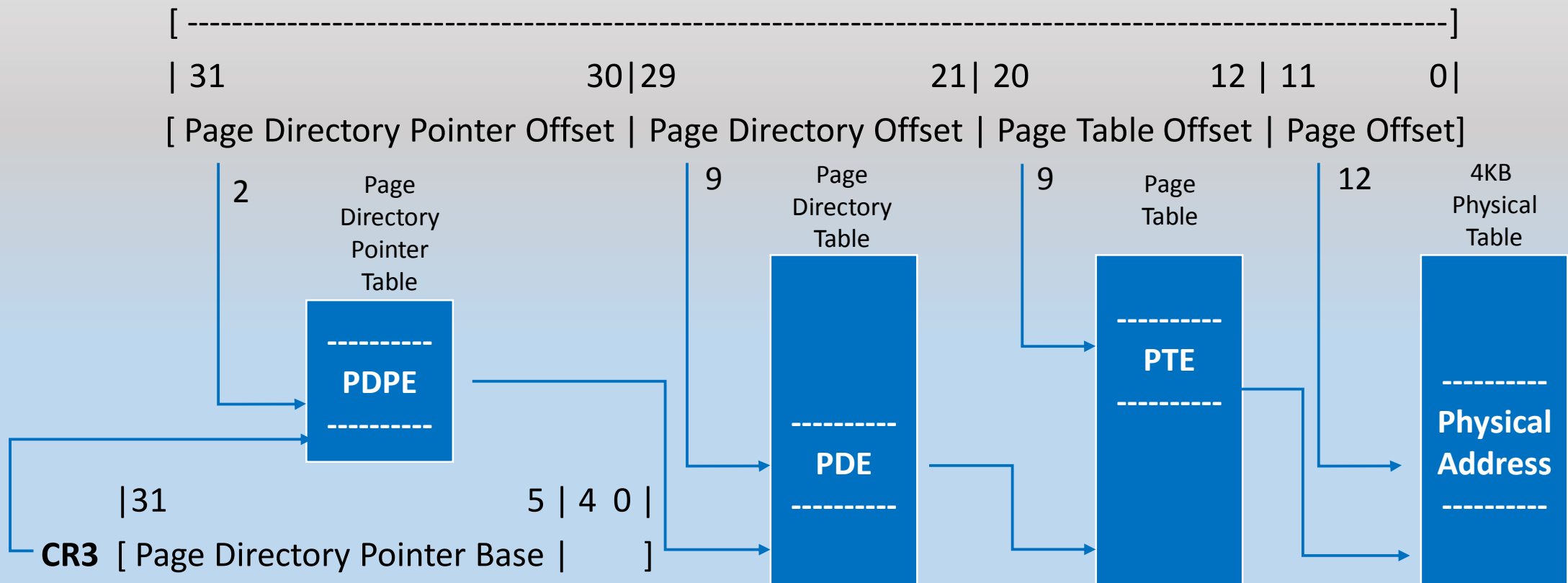
Decimal $\Rightarrow$ Binary

21 $\Rightarrow$ 010101

VPA		Offset
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[0 1		0 1 0 1]
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Legacy Mode - 4KB Page Translation (With PAE)



Hello World Kernel Module

hello.c

```
#include <linux/init.h>
#include <linux/module.h>
MODULE_LICENSE("Dual BSD/GPL");
static int hello_init(void)
{
    printk(KERN_ALERT "Hello, world\n");
    return 0;
}
static void hello_exit(void)
{
    printk(KERN_ALERT "Goodbye, cruel world\n");
}
module_init(hello_init);
module_exit(hello_exit);
```

Makefile

```
LINUX_KERN=/usr/src/kernels/$(shell uname -r)
obj-m := hello.o
```

```
all:
    $(MAKE) -C $(LINUX_KERN) M=$(PWD) modules
```

```
clean:
    $(MAKE) -C $(LINUX_KERN) M=$(PWD) clean
```

insert/remove

```
insmod hello.ko % Insert module
rmmod hello.ko % remove module
```

Useful References

- [1] Jonathan Corbet et al. “Linux Device Driver”, 2005
- [2] Remzi H. Arpaci-Dusseau et al. “Operating Systems: Three Easy Pieces”, 2015
- [3] AMD64 Technology “AMD64 Architecture Programmer’s Manual Volume 2: System Programming”, 2015
- [4] Thomas W. Barr et al. “Translation Caching: Skip, Don’t Walk (the Page Table)”, *ACM SIGARCH Computer Architecture News*, 2010