ECE 353: Systems Software
Lecture 14

Page Tables

1.2.0

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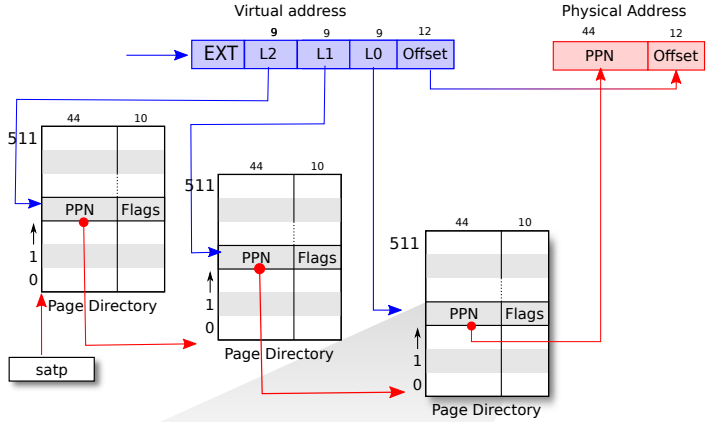
February 8, 2023

Multi-Level Page Tables Save Space for Sparse Allocations



Page Allocation Uses A Free List

Given physical pages, the operating system maintains a free list (linked list)

The unused pages themselves contain the `next` pointer in the free list

- Physical memory gets initialized at boot

To allocate a page, you remove it from the free list

- To deallocate a page you add it back to the free list

Insight: Use a Page for Each Smaller Page Table

There are 512 (2^9) entries of 8 bytes(2^3) each, which is 4096 bytes

The PTE for L(N) points to the page table for L(N-1)

You follow these page tables until L0 and that contains the `PPN`

The Smaller Page Tables are Just Like Arrays

Instead of:

```
int page_table[512] // What's the size of this?
```

or

```
x = page_table[2] // What's the offset of index 2?
```

You have:

```
PTE page_table[512]
```

where:

```
sizeof(page_table) == PAGE_SIZE
```

and

```
sizeof(page_table) = number of entries * sizeof(PTE)
```

Consider Just One Additional Level

Assume our process uses just one virtual address at `0x3FFFF008`

or `0b11_1111_1111_1111_1111_0000_0000_1000`

or `0b111111111_111111111_000000001000`

We'll just consider a 30-bit virtual address with a page size of 4096 bytes

We would need a 2 MiB page table if we only had one ($2^{18} \times 2^3$)

Instead we have a 4 KiB L1 page table ($2^9 \times 2^3$) and a 4 KiB L0 page table

Total of 8 KiB instead of 2 MiB

Note: worst case if we used all virtual addresses we would consume 2 MiB + 4 KiB

Translating `3FFFF008` with 2 Page Tables

Consider the L1 table with the entry:

Index	PPN
511	0x8

Consider the L0 table located at `0x8000` with the entry:

Index	PPN
511	0xCAFE

The final translated physical address would be: `0xCAFE008`