

## Working for exercises in lecture on VM

32bit virtual address, 4Byte page table entries, 4kB pages.

Given multi-level page table structure as described on previous slide, how much memory is needed for the page table(s) for a process using 512MB of memory?

What about for a process using 1MB of memory?

Remember

$$512\text{MB} = 29\text{MB} = 2^9 \times 2^{10} \times 2^{10} \text{ bytes}$$

$$1\text{MB} = 2^{20}\text{bytes}$$

To store 512MB first work out how many pages is that?

$$\text{numpages} = \text{memory} / \text{page\_size} = 2^{29} / 2^{12} = 2^{17}$$

So we need  $2^{17}$  pages.

Each table page can hold  $2^{12}/4 = 2^{10}$  entries.

So we need  $2^{17}/2^{10} = 2^7$  pages of table+1 for the top level.

So total memory for page table =  $(2^7+1) \cdot 4\text{K} = 516\text{kB}$

Sanity check?

$$512\text{MB}/4\text{GB} = 1/2^3 = 1/8$$

What proportion of total possible page table entries would we use?

$$\text{Total page table entries} = 1024 \cdot 1024 = 2^{20}$$

We need to use  $2^{17}$  and  $2^{17}/2^{20} = 1/8$

For 1MB we need  $2^{20}/2^{12} = 2^8$  pages.

That is less than the  $2^{10}$  that a single table page can store so we need a total of 2 pages.

Which is 8k

With 8kB pages...

(a) If the system uses single level page tables how much memory is used by the page table for a process?

A single page can store  $2^{13}/4$  entries. So a single table page can address  $2^{13}/4 \cdot 8\text{kB} = 2^{24}\text{B}$ .

So to cover the whole address space we would need  $2^{32}/2^{24} = 2^8$  table pages.

Ie a total memory of  $2^8 \cdot 8\text{kB} = 2^{21}\text{bytes}$

If the system uses two-level page tables how much memory is used by page tables for a process using  $2^{30}\text{B}$ ?

From the previous part a single table page covers  $2^{24}\text{B}$ .

So we need  $2^{30}/2^{24} = 2^6 + 1$  table pages.

Which gives a total of  $(2^6+1) \cdot 8\text{K}$