Locality of Reference and Virtual Memory

CS 240 - The University of Illinois

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Keeping Data Close

In working with memory in any computer system, we want to access data **as quickly as possible**.

Keeping Data Close

CPU Registers: 1 word /register

__ general purpose registers

Keeping Data Close

CPU Cache: Stores 4 KB “pages” of memory

Intel i9-10900KF: 256 KB /CPU (L2)

+ 20 MB (L3)

Keeping Data Close

RAM: 128 GB in our “Class Computer”

Key Idea: Locality of Reference

System Memory (RAM)

All computers have a fixed amount of RAM:

[1]:

System Memory (RAM)

[2]:

System Memory (RAM)

[3]:

System Memory (RAM)

To help to organize RAM, we will break RAM up into chunks called:

```
$ getconf PAGESIZE
```

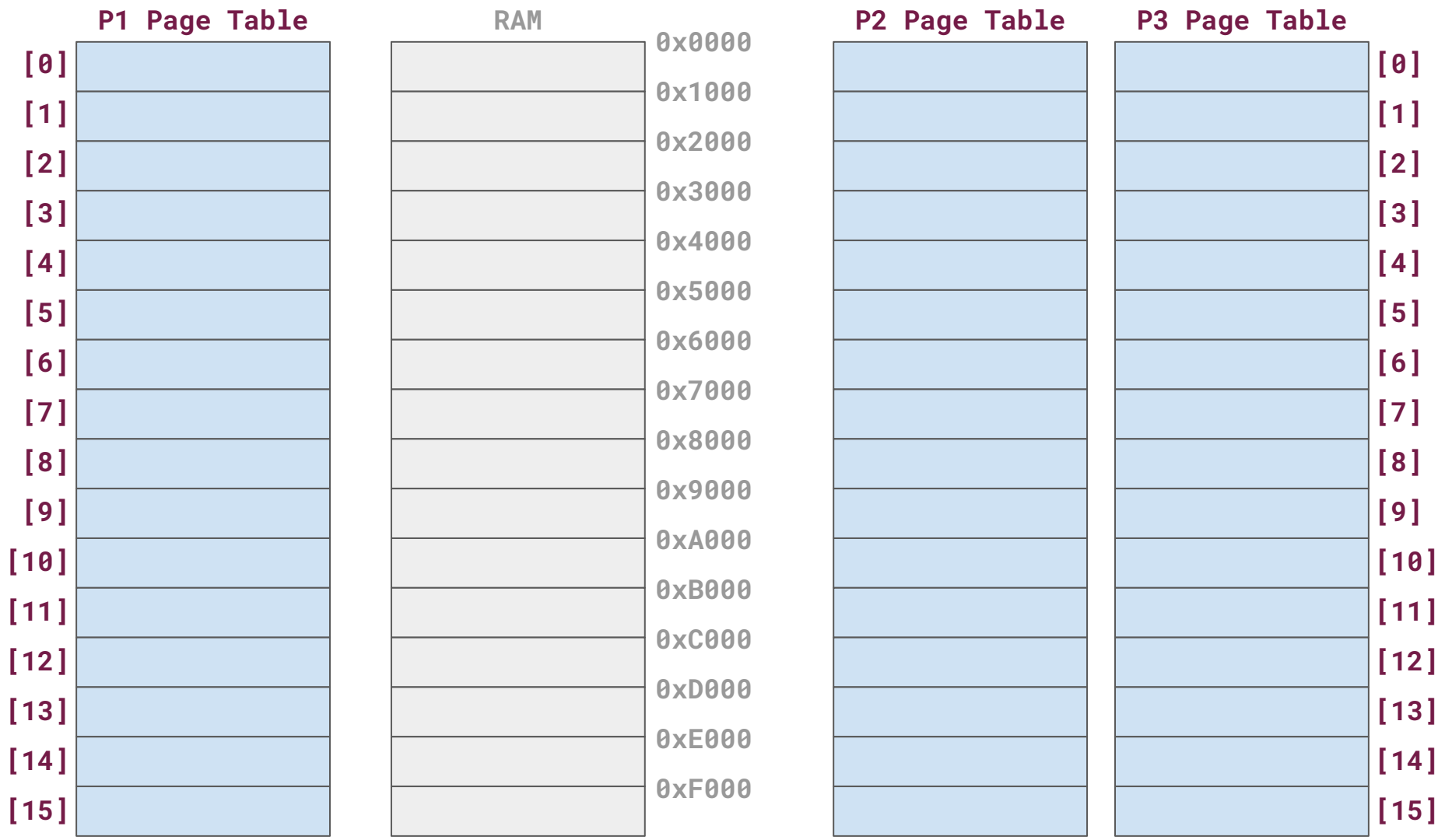
Virtual Memory

An abstraction between _____ and _____.

Virtual Memory

- A _____ translates:

- Page tables are **NOT** shared:


P1 Page Table
RAM
P2 Page Table
P3 Page Table
[0]
[1]
[2]
[3]
[4]
[5]
[6]
[7]
[8]
[9]
[10]
[11]
[12]
[13]
[14]
[15]
0x0000
0x1000
0x2000
0x3000
0x4000
0x5000
0x6000
0x7000
0x8000
0x9000
0xA000
0xB000
0xC000
0xD000
0xE000
0xF000

Can we meet all allocation requests?

Are we limited to just RAM?

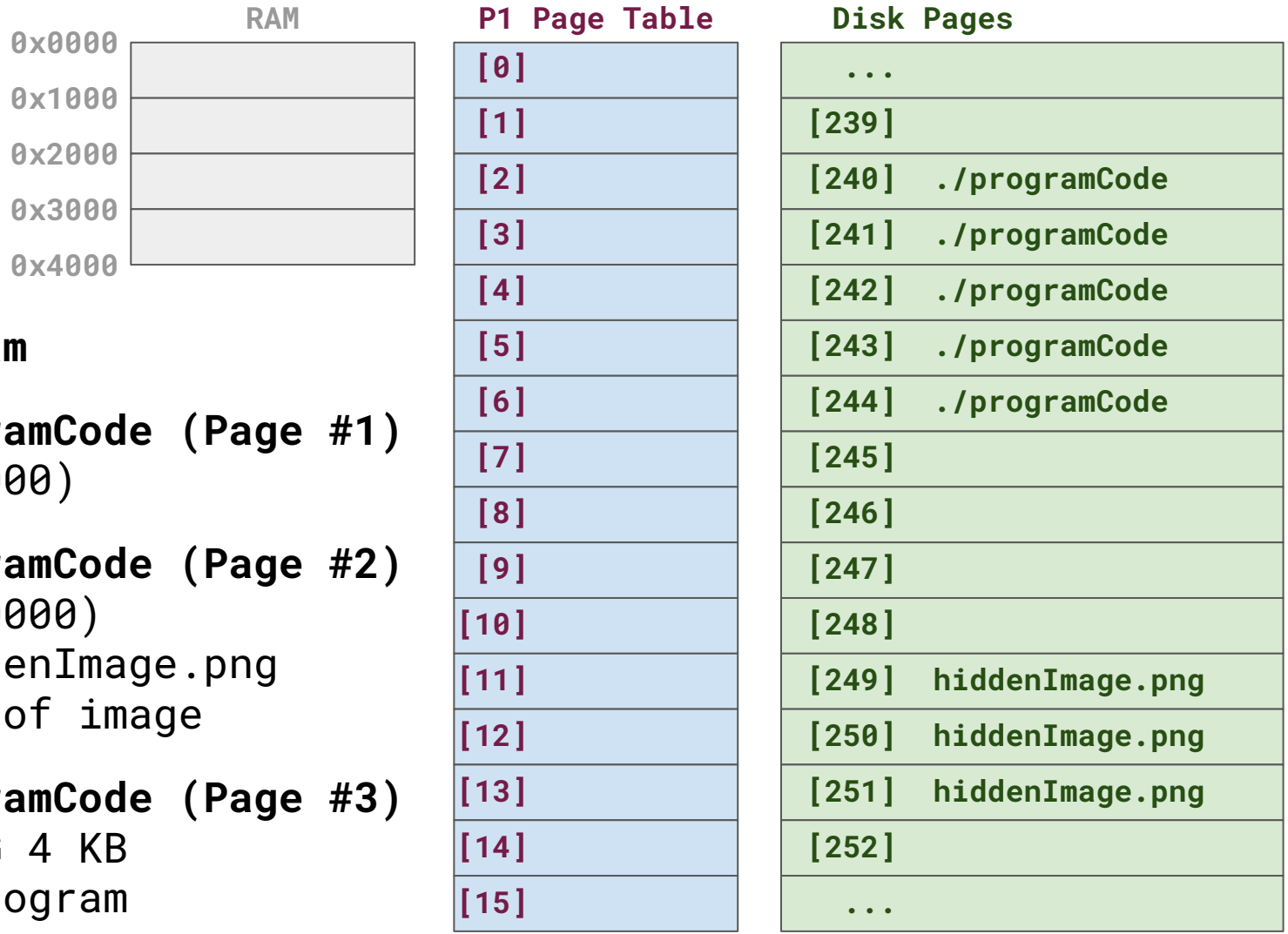
Advantages of a Virtual Memory System?

Virtual Memory

- [External Storage]:

Program: 05.c

```
13 unsigned int *array = malloc(SIZE * SIZE *
                                    sizeof(unsigned int));
14
15 // Add data to each element of the array:
16 printf("  Start of `array`: %p\n", array);
17 printf("    End of `array`: %p\n",
                                  &(array[(SIZE*SIZE)-1 ]) );
```



1: Load Program

2: Run ./programCode (Page #1)
- malloc(4000)

3. Run ./programCode (Page #2)
- malloc(10000)
- Open hiddenImage.png
- Read all of image

4: Run ./programCode (Page #3)
- Access OG 4 KB
- Finish program

Q1: What is the range of possible file sizes for **`hiddenImage.png`**?

Q2: What is the range of possible file sizes for `./programCode`?

Q3: What is the size of the heap immediately before the program finishes?