CS 340
Computer Systems

#6: Memory Allocation and malloc

Sep. 7, 2023 · G Carl Evansr

Memory Hierarchy:

The third foundation of a computer system is the "memory" -- the storage of data to be processed by our CPU. There are many different types of common **memory** and **storage** in a system:

1.

2.

3.

4.

5.

6.

Key Idea: Locality of Reference

Sample Programs:

05-col.c

```
16  for (unsigned int c = 0; c < SIZE; c++) {
17    for (unsigned int r = 0; r < SIZE; r++) {
18      array[(r * SIZE) + c] = (r * SIZE) + c;
19    }
20  }
```

-vs-

05-row.c

```
16  for (unsigned int r = 0; r < SIZE; r++) {
17    for (unsigned int c = 0; c < SIZE; c++) {
18      array[(r * SIZE) + c] = (r * SIZE) + c;
19    }
20  }
```

...what is different about **`05-col.c`** and **`05-row.c`**?

Running Times: **`05-col.c`**:

`05-row.c`:

In working with memory in any computer system, we want to access it as quickly as possible. However, space is extremely limited in the fastest memory, so we need strategies on what data to keep close.

General Purpose Memory:

- CPU Registers:
- CPU Cache (i9-13900K, Released Q4'22):
- RAM:

Types of Locality :

1.

2.

Process Memory:

1. Heap

2. Stack

3. Text

4. Data

System Memory:

1. **[Limited]**:
2. **[Shared]**:
3. **[Simple]**:

To help us to begin to organize this RAM, we divide the RAM up into chunks called _____.

On Linux, find the size of a page:

```
# getconf PAGESIZE
```

...on most modern systems, a page is _____ KB.

Virtual Memory:
Modern systems provide an abstraction between _____ and _____:

1. A _____ translates a _____ into a **physical address**. *It's just a pointer!*
2. Every memory address is made up of the _____ and the _____.
3. Virtual Memory is **NOT shared** between processes/apps.
4. **EVERY memory address** _____ is a virtual memory address!!

Virtual Memory Example:

P1 Page Table:

[0]:
[1]:
[2]:
[3]:
[4]:
[5]:
[6]:
[7]:
[8]:
[9]:
[10]:
[11]:
[12]:
[13]:
[14]:
[15]:

RAM:

[0]:
[1]:
[2]:
[3]:
[4]:
[5]:
[6]:
[7]:
[8]:
[9]:
[10]:
[11]:
[12]:
[13]:
[14]:
[15]:

P2 Page Table:

[0]:
[1]:
[2]:
[3]:
[4]:
[5]:
[6]:
[7]:
[8]:
[9]:
[10]:
[11]:
[12]:
[13]:
[14]:
[15]:

P3 Page Table:

[0]:
[1]:
[2]:
[3]:
[4]:
[5]:
[6]:
[7]:
[8]:
[9]:
[10]:
[11]:
[12]:
[13]:
[14]:
[15]:

OS Logs:

```
P1: 3 pages (a)
P3: 5 pages (b)
P1: 2 pages (c)
P3 exits
P2: 4 pages (d)
P2: 5 pages (e)
P1:
  Extend a to
  5 pages
  (ex: realloc)
```