CS 240
Computer Systems

#7: Page Eviction, Threads, and pthreads

Feb. 8, 2022 · Wade Fagen-Ulmschneider

Big Picture – CPU, Memory, and Pages:

Page Eviction/Replacement Strategies:

When we need to remove a page from RAM and store it on disk, how do we decide which page to remove given a **page access pattern**?

Strategy #1:

	17	33	40	17	43	8	99	33	99	17
RAM										

Strategy #2:

	17	33	40	17	43	8	99	33	99	17
RAM										

Strategy #3:

	17	33	40	17	43	8	99	33	99	17
RAM										

Strategy #4:

	17	33	40	17	43	8	99	33	99	17
RAM										

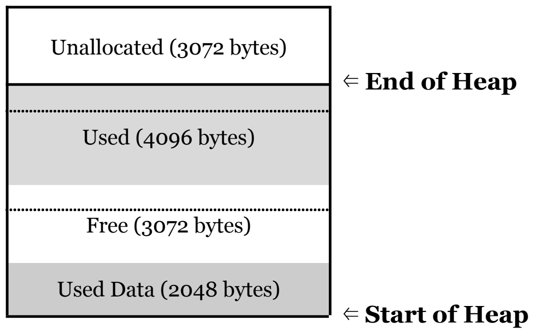
Other Strategies:

Fragmentation

As we develop various systems for storage, we want to minimize **fragmentation**.

- [Fragmentation]:
- [Internal Fragmentation]:
- [External Fragmentation]:

Fragmentation Example in Heap Memory:



Computer Peripherals

- Every other piece of hardware we consider to be a "peripheral".
- Interface managed by the ______________________________.
    - ...and managed using ___________________________.
- Examples:

Threads: The Unit of Computation in an Operating System
As a programmer, the single most important construct in an Operating System is a thread.

- Every thread has a **program counter**, a pointer that stores the next instruction to be read by a program.
- A _______________ is an organization of one or more threads in the same context. A simple process has only one thread.
- In C, the initial thread is called the ______________________.
    - It is what starts running your main() function!

Creating Additional Threads in C
The pthread library is the POSIX thread library allowing you to create additional threads beyond the main thread.

Creating a new thread is a complex call with four arguments:

```
int pthread_create(
  pthread_t *thread,              /* thread struct */
  const pthread_attr_t *attr,     /* usually NULL  */
  void *(*start_routine) (void *), /* start func    */
  void *arg                     /* thread start arg  */
);
```

The start_routine has a very interesting type signature:

```
void *(*start_routine) (void *)
```

This signature is a **function pointer** ("functor") and is the syntax we can use to pass a pointer to a function. Therefore, the third argument into pthread_create must be a function with the following prototype:

```
void *__________(void *ptr);
```

...you can use any name for the function name.

Example: Launching Fifteen Threads

07/fifteen-threads.c

```
#include <pthread.h>

const int num_threads = 15;

void *thread_start(void *ptr) {
  int id = *((int *)ptr);
  printf("Thread %d running...\n", id);
  return NULL;
}

int main(int argc, char *argv[]) {
  // Create threads:
  int i;
  pthread_t tid[num_threads];
  for (i = 0; i < num_threads; i++) {
    pthread_create(&tid[i], NULL,
                                 thread_start, (void *)&i);
  }

  printf("Done!\n");
  return 0;
}
```

Q1: What is the expected output of this program?

Q2: What actually happens?

Q3: What do we know about threads in C?