

ECE 220

Lecture x0010 - 10/22/24
Dynamic Memory Allocation

Slides based on material originally by: Yuting Chen & Thomas Moon

Announcements

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- Thursday's lecture by Mike Montano.

Recap

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- Examples

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 - A. write struct to file
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Dynamic memory allocation

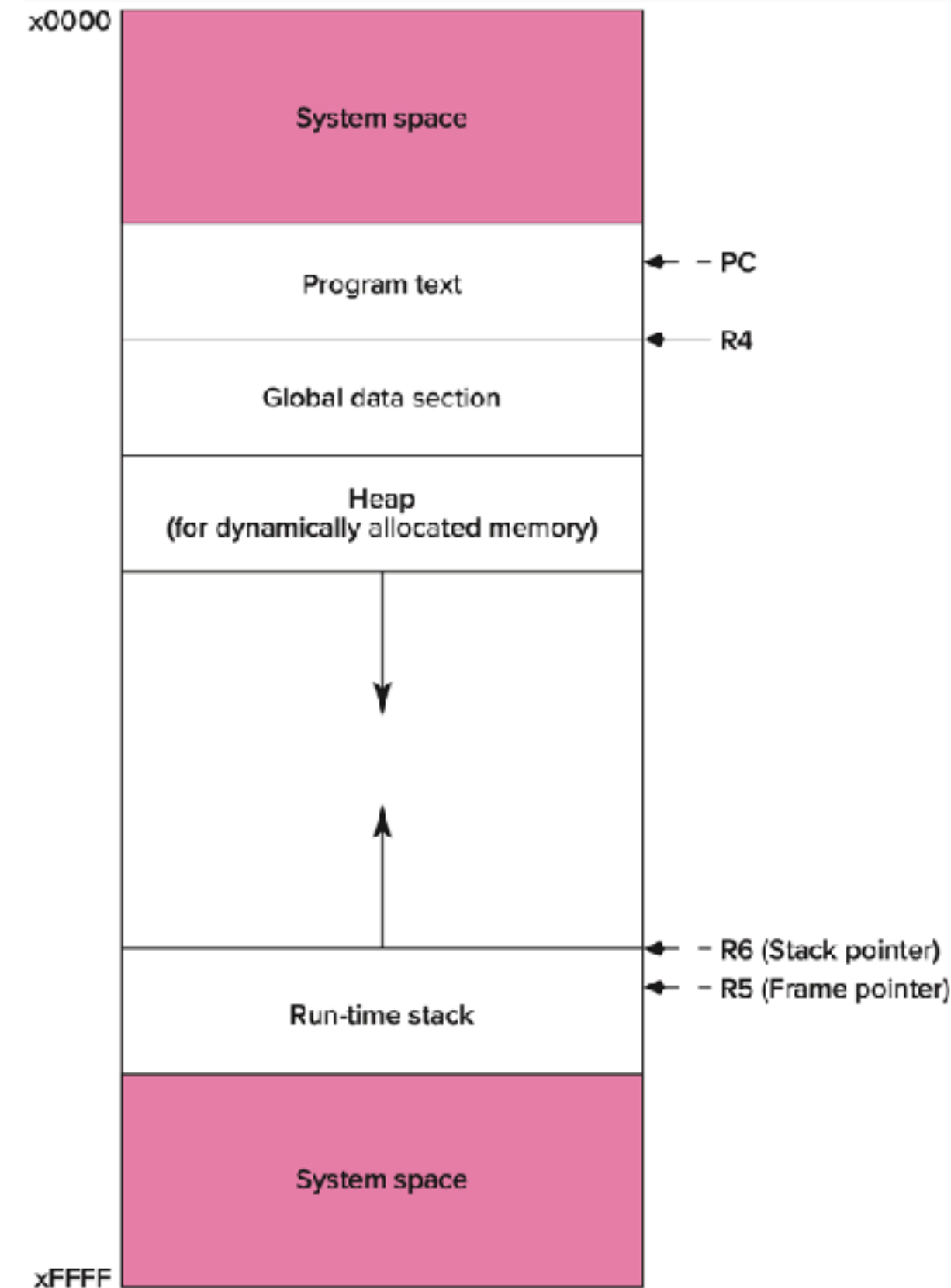
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 - If usually only ~ 3 flights, then memory is wasted.
 - If we read in a large file > 50 then not enough memory is allocated.
- Ideally, we want to allocate as much memory as needed rather than a pre-set amount.
- In most cases, this memory comes from an area of the architecture called the *heap*.

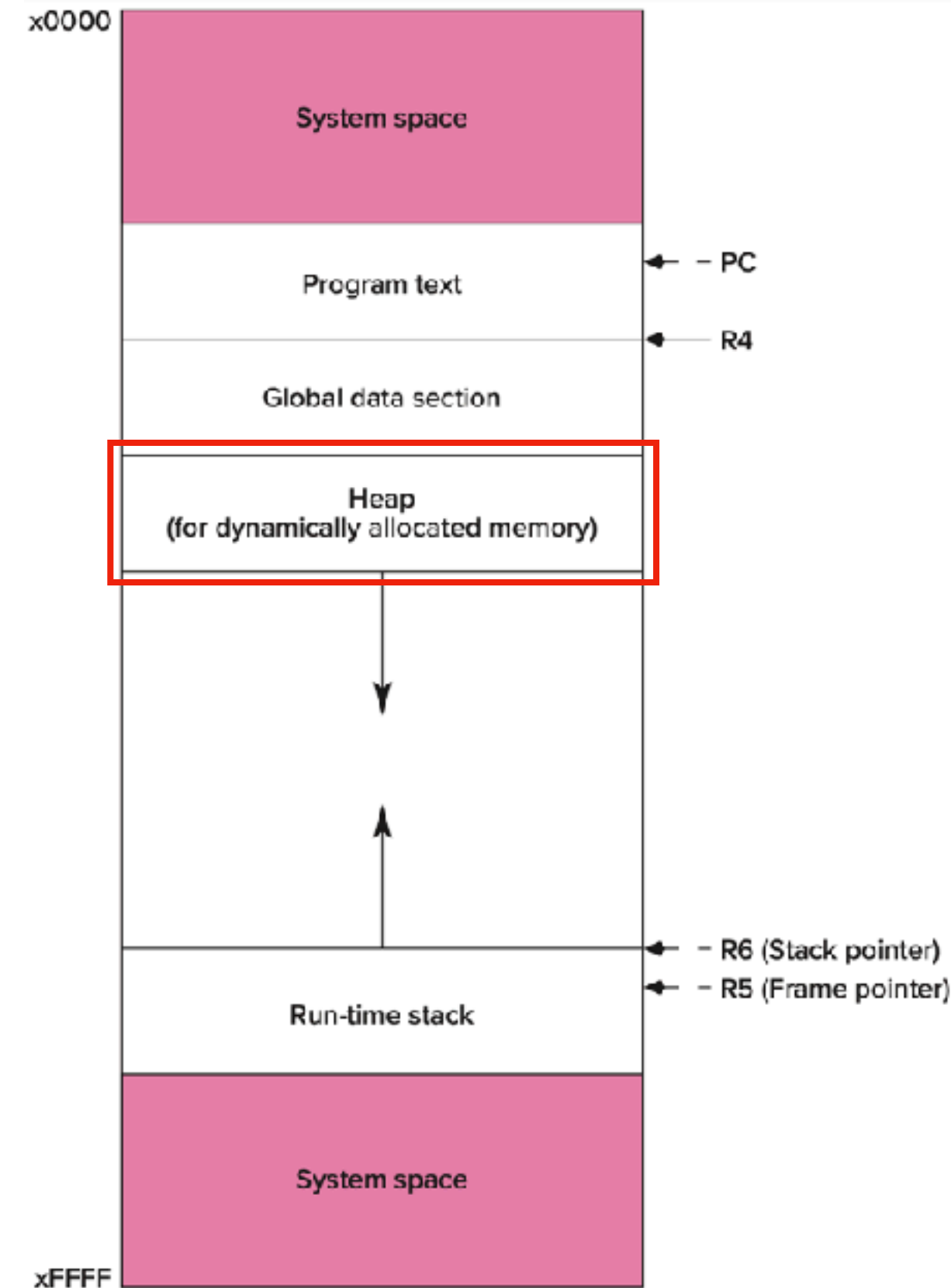
Dynamic memory allocation

- During the execution, a program makes a request to the memory allocator for a contiguous piece of memory of a particular size



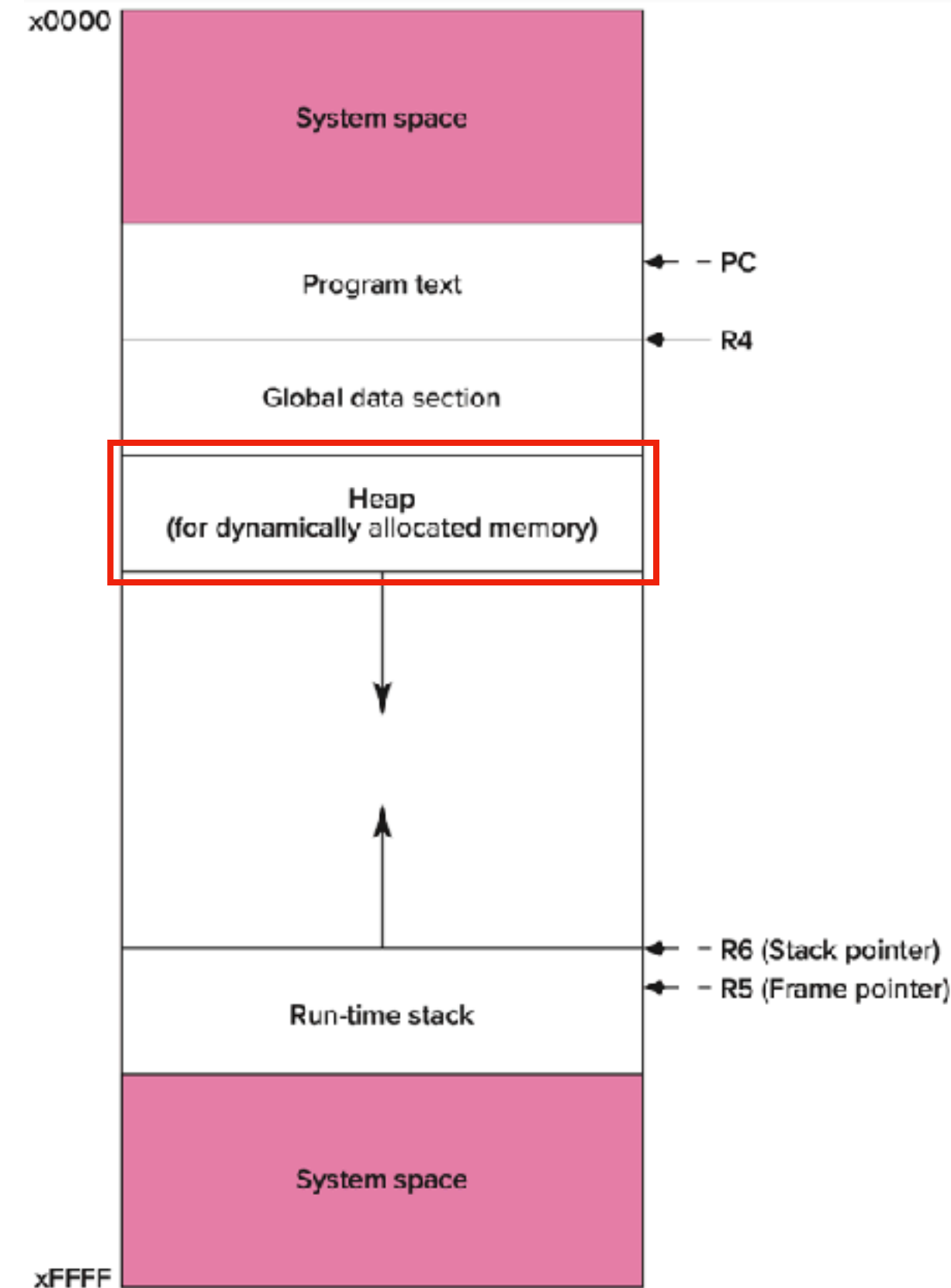
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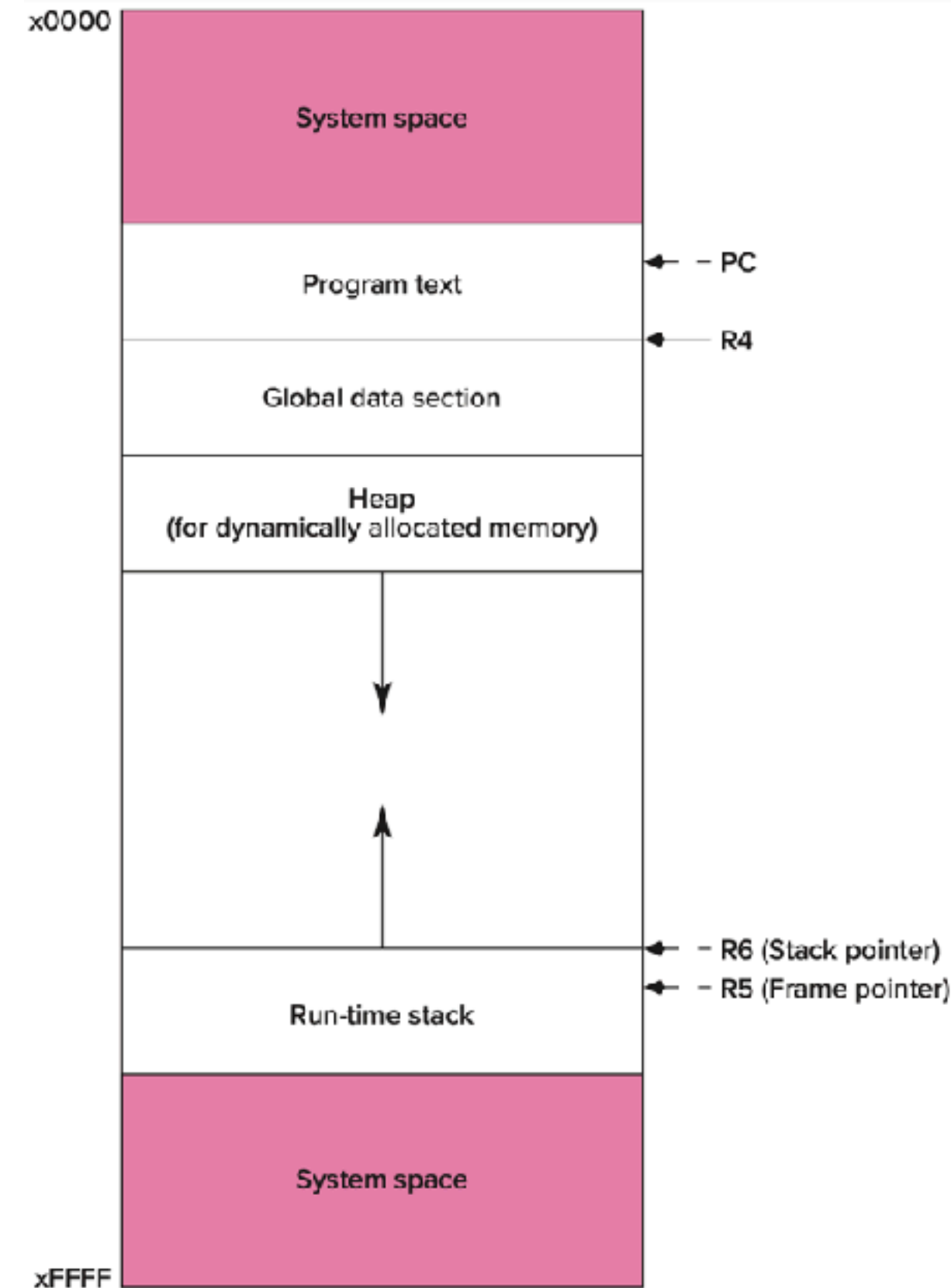
- During the execution, a program makes a request to the memory allocator for a contiguous piece of memory of a particular size
- The allocator reserves the memory and returns a pointer to it. We interact with the memory allocation manager by using *malloc* family & *free* functions.



Automatic vs dynamic memory

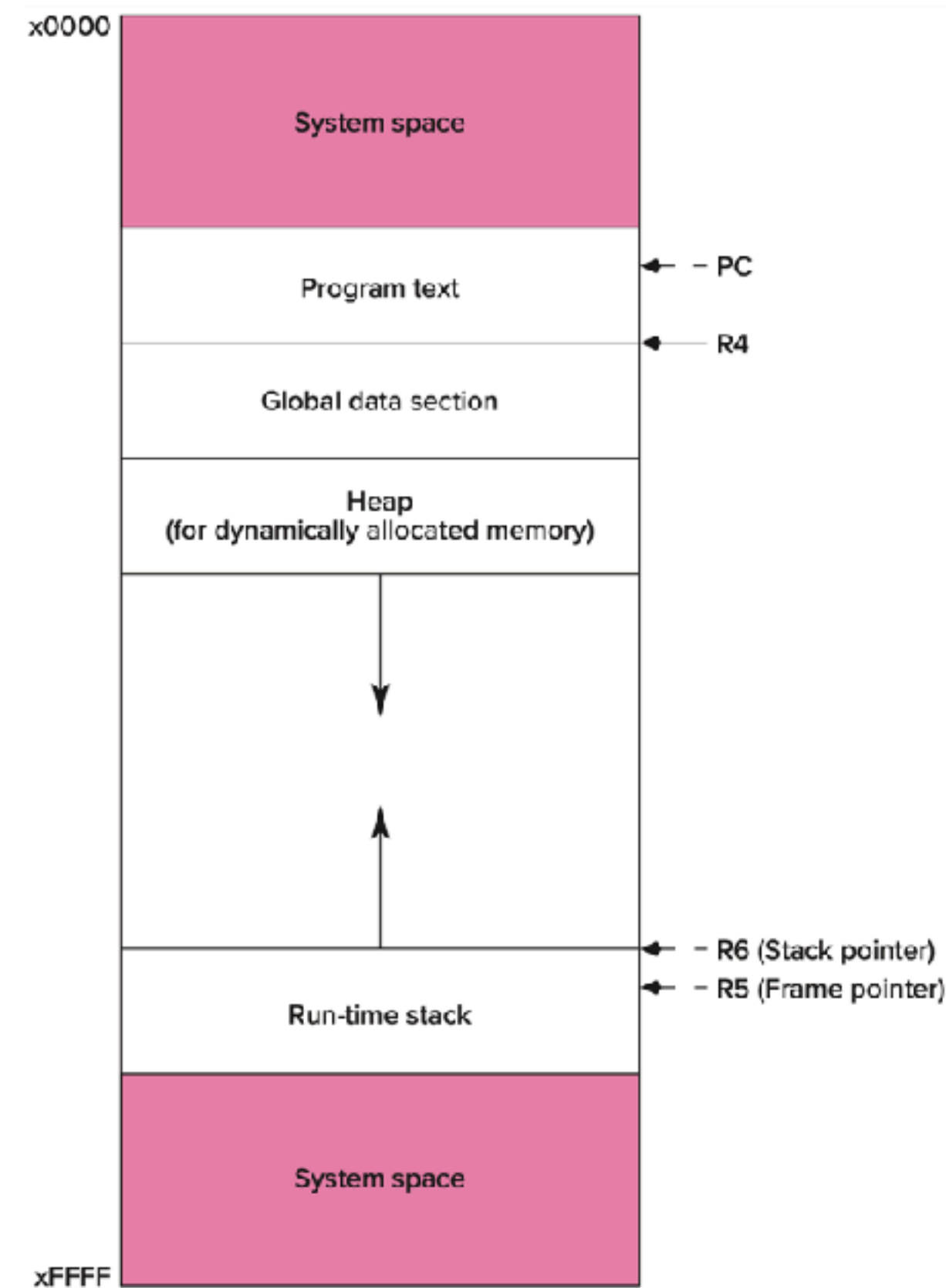
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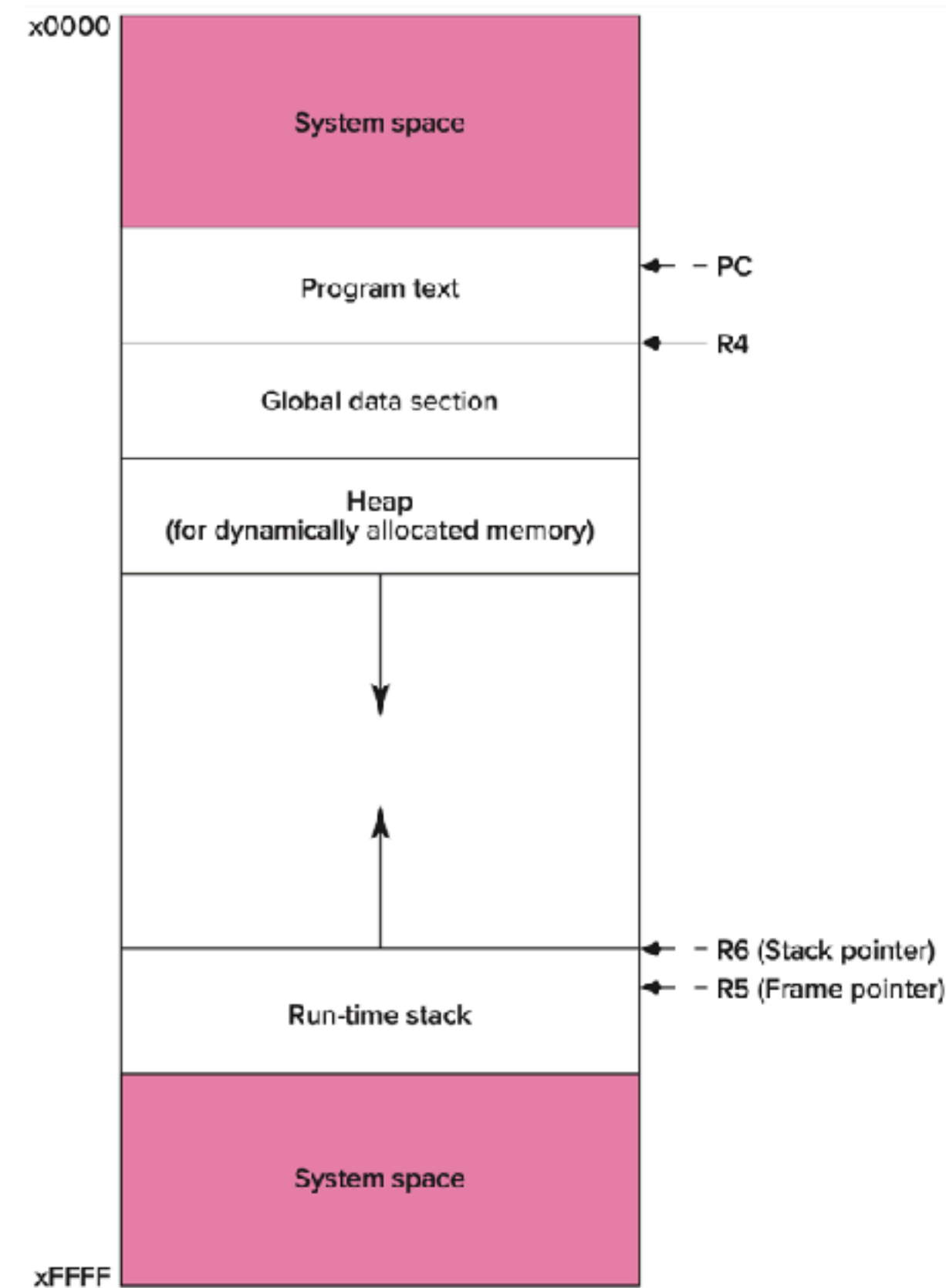
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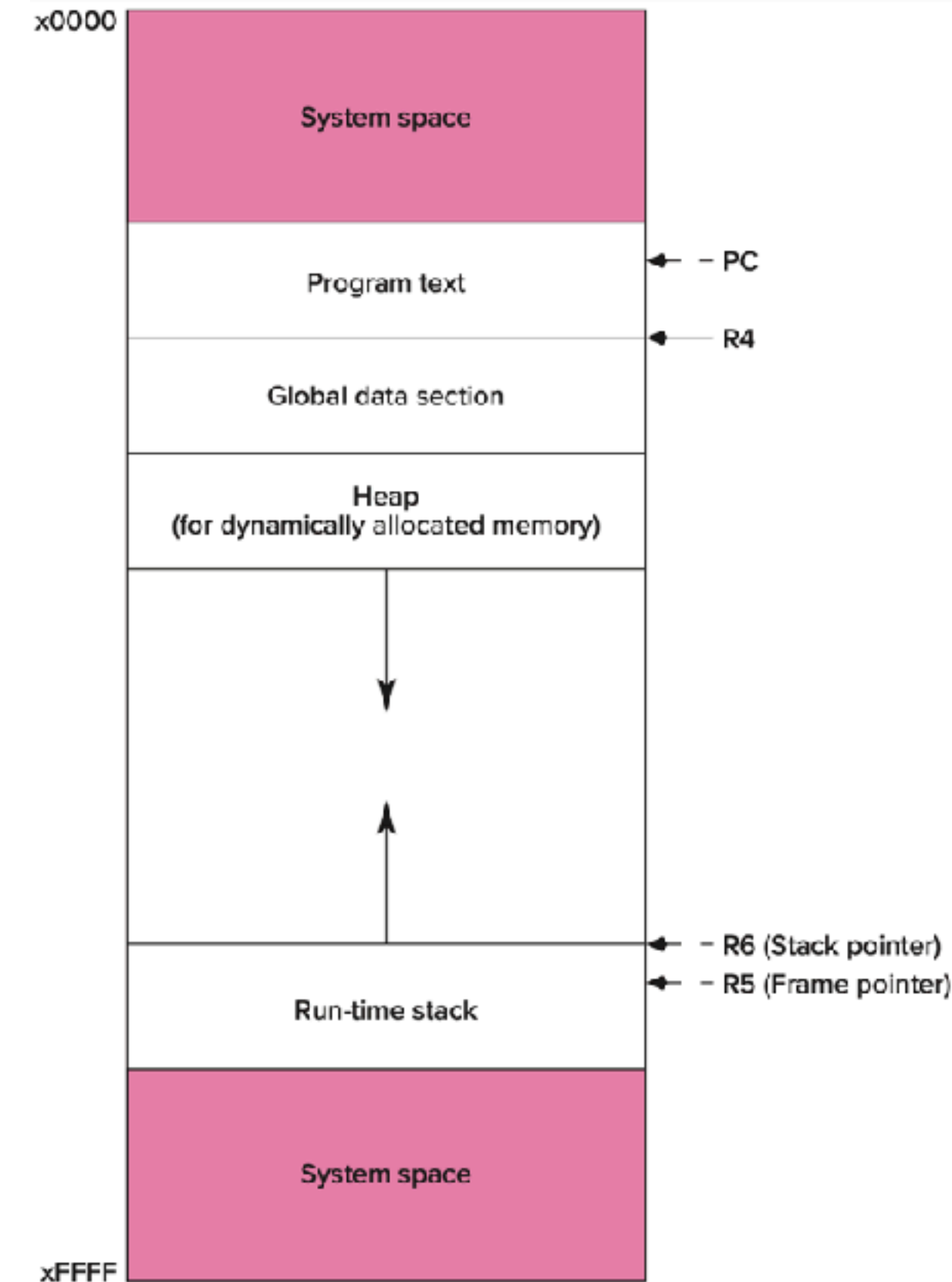
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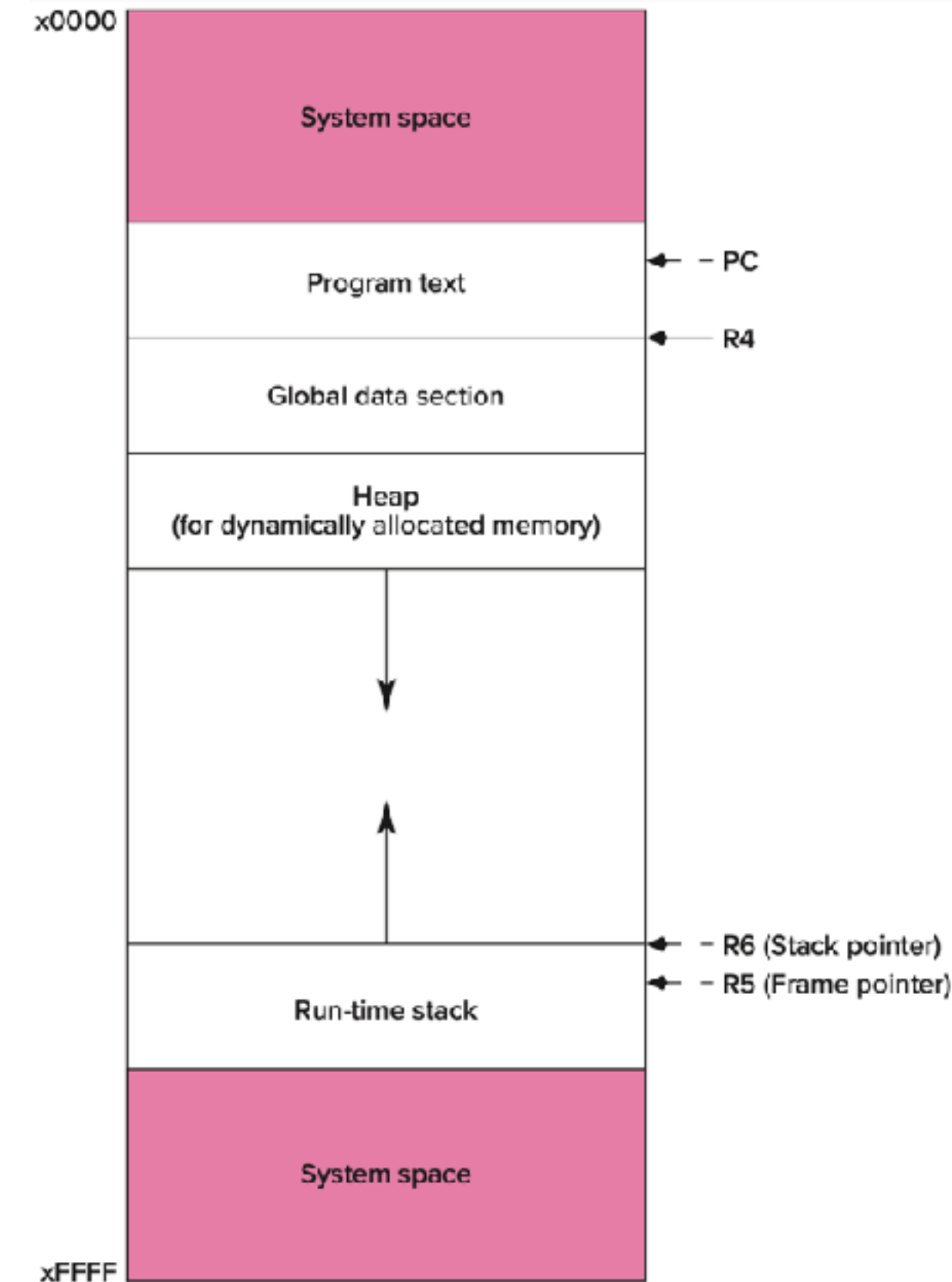
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Standard pointer declaration `int *ptr` = `(int *) malloc(sizeof(int));`

malloc returns void pointer

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Standard pointer declaration `int *ptr` = $\frac{\text{malloc returns void pointer}}{\text{Juxtaposition with } (int *) \text{ casts the void pointer as an int pointer}}$ `(int *) malloc(sizeof(int));`

The free function

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- Use `valgrind` to check for memory leaks

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- Identical to `malloc`, except `calloc` initializes memory to zero.

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 - `ptr` must have been returned by the `malloc` family

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 - Sorta-kind of a fib (C can tell by looking at LHS, but C++ won't)
 - Types can be built-in or user-defined.

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int main(){
    int *ptr1 = (int *) malloc(sizeof(int));
    if(ptr1==NULL){
        printf("Error - malloc failure\n");
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    *ptr1 = 10;
    int *ptr2 = (int *) malloc(sizeof(int));
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Didn't free memory allocated!

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    ptr1 = ptr2; ← Swap
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```
int *ptr;
int *ptr_new;

// What does this code do?
ptr = (int *) calloc(2, sizeof(int));
*ptr = 10;

// What is the contents of memory now?
ptr_new = (int *) realloc(ptr, 4*sizeof(int));
*(ptr_new+2) = 30;
*(ptr_new+3) = 40;

// How much memory are we deallocating here?
free(ptr_new)
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Do we need `free(ptr)`?

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FILE *infile = fopen("mat.csv", "r");
int nr, nc;

fscanf(infile, "%d, %d", &nr, &nc);
int *mat = (int *) malloc(sizeof(int)*nr*nc);

for (int i=0; i < nr; i++)
    for (int j=0; j < nc; j++)
        fscanf(infile, "%d, ", &mat[i*nc+j]);

fclose(infile);
```

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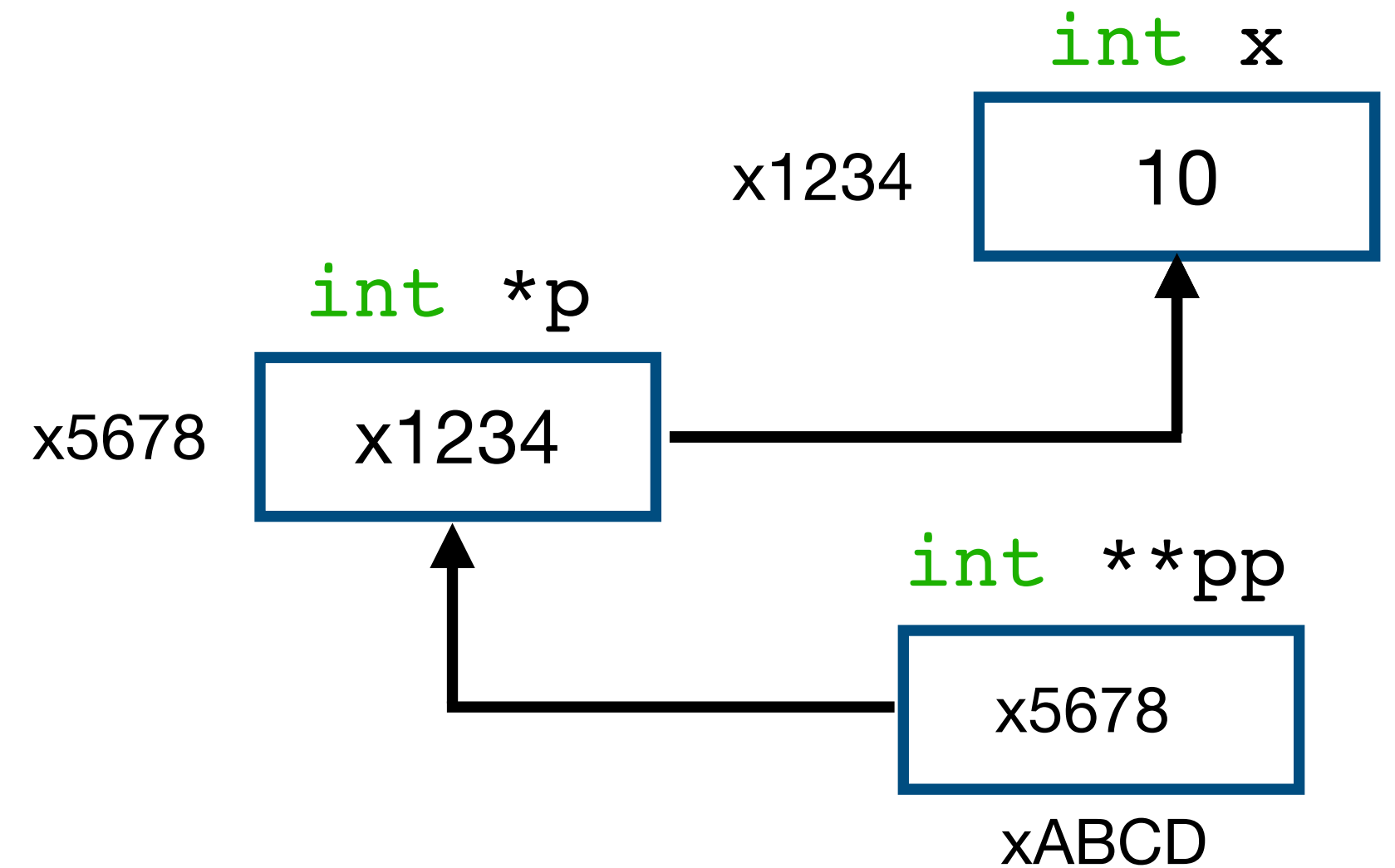
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for(i=0;i<nrows;i++)
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    array[i] = (int*) malloc(ncols*sizeof(int));
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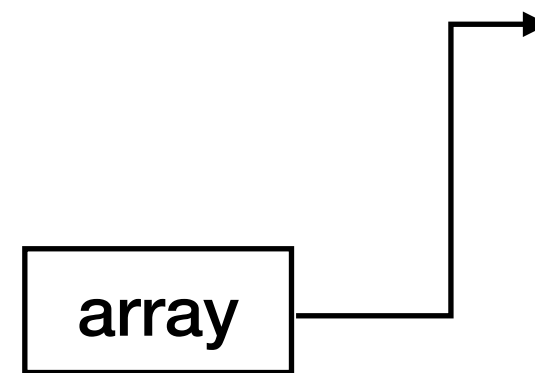
array = (int**) malloc(nrows*sizeof(int*));
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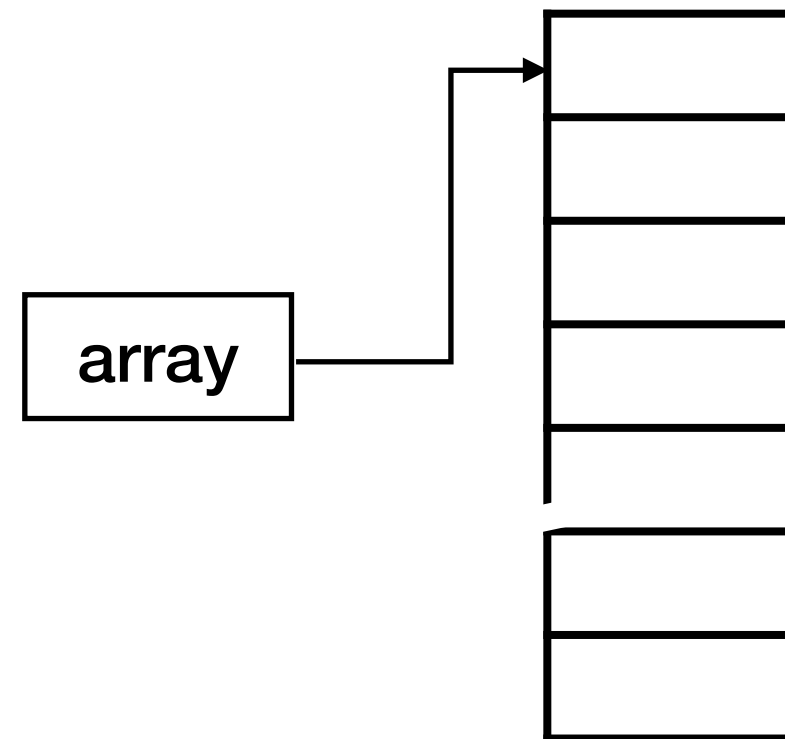
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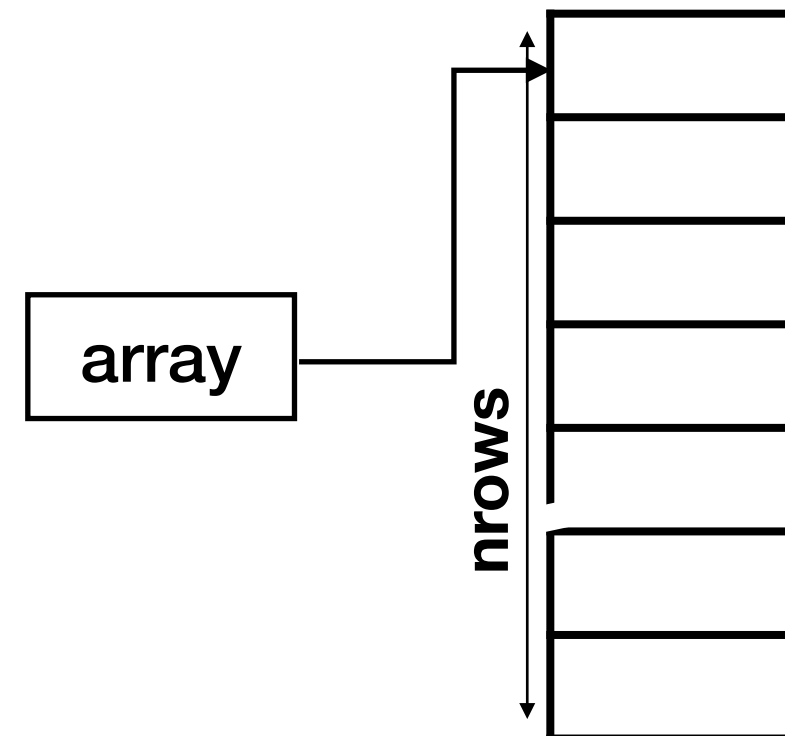
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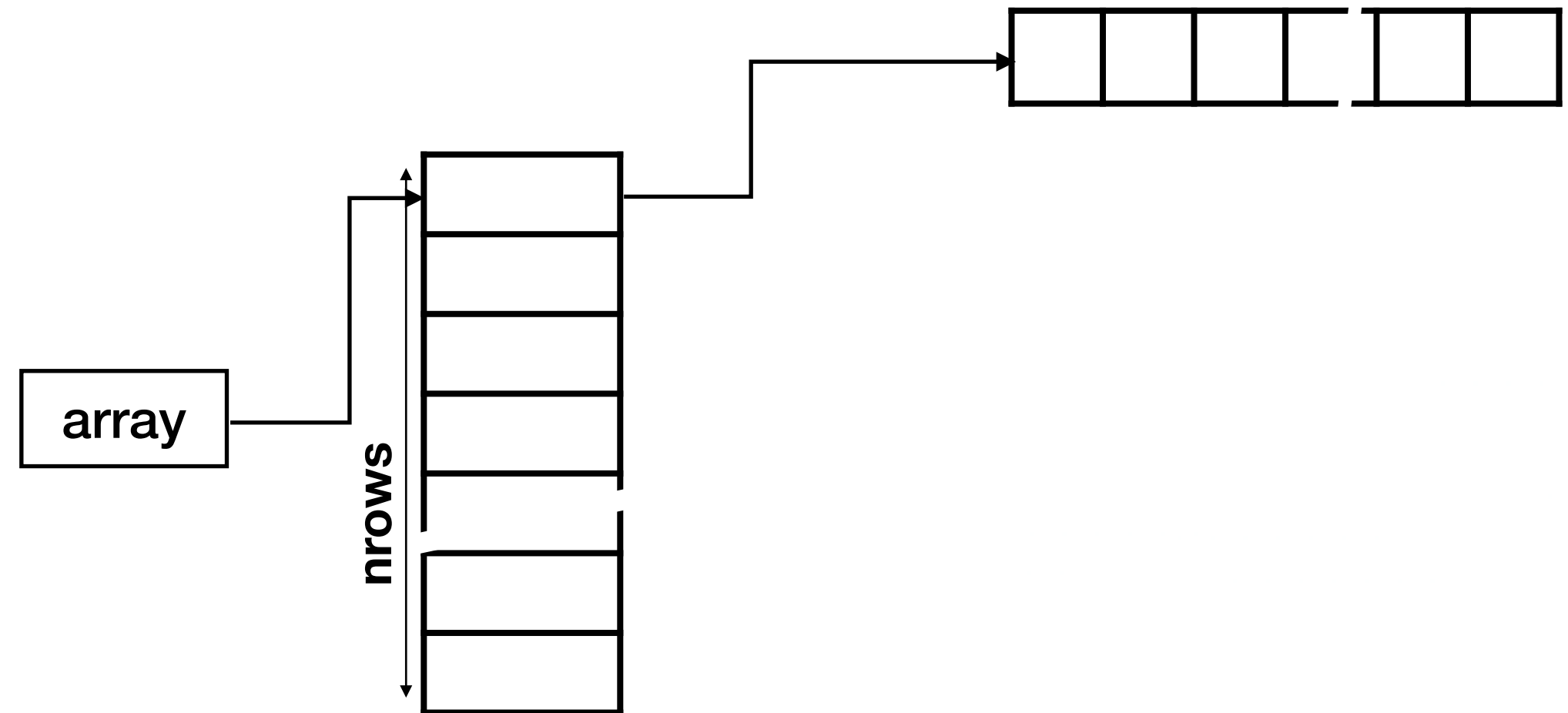
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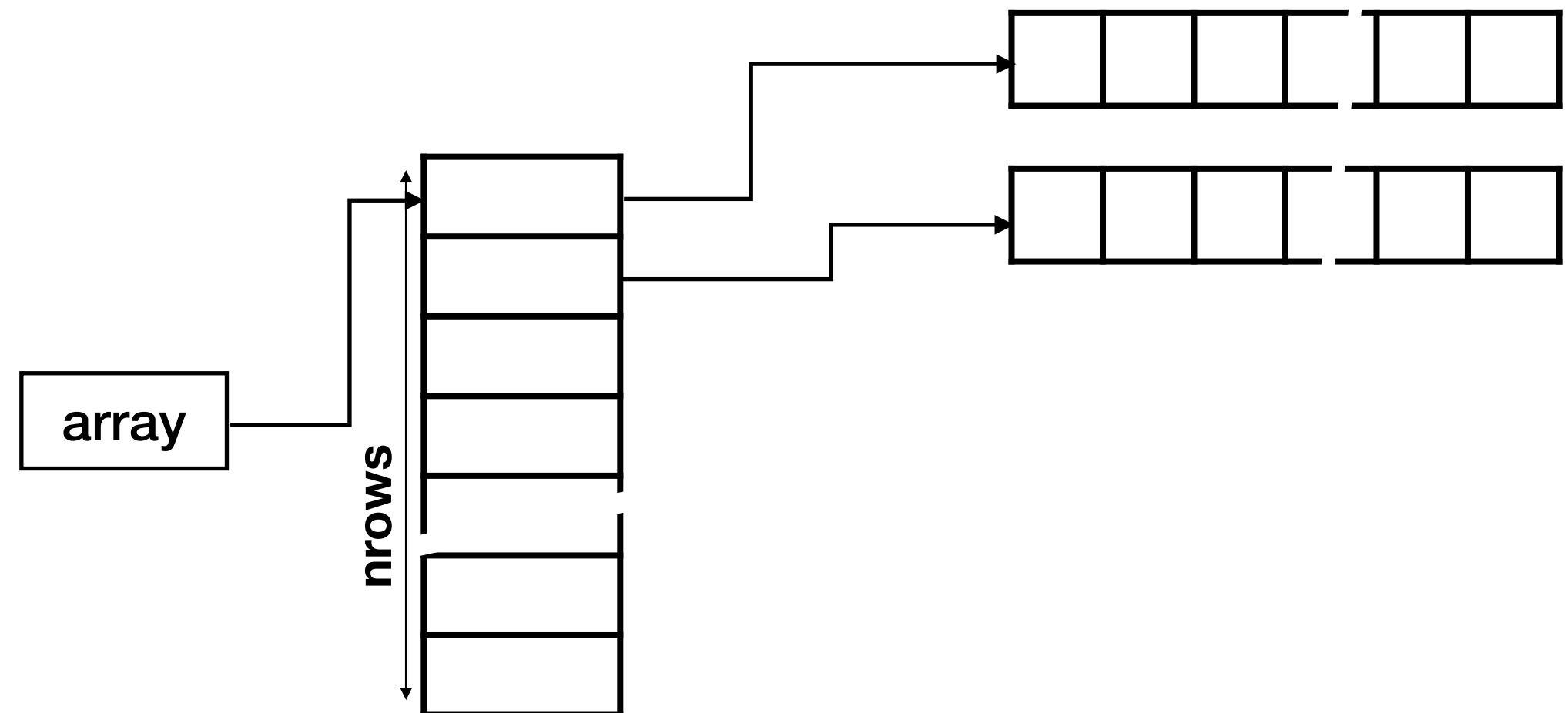
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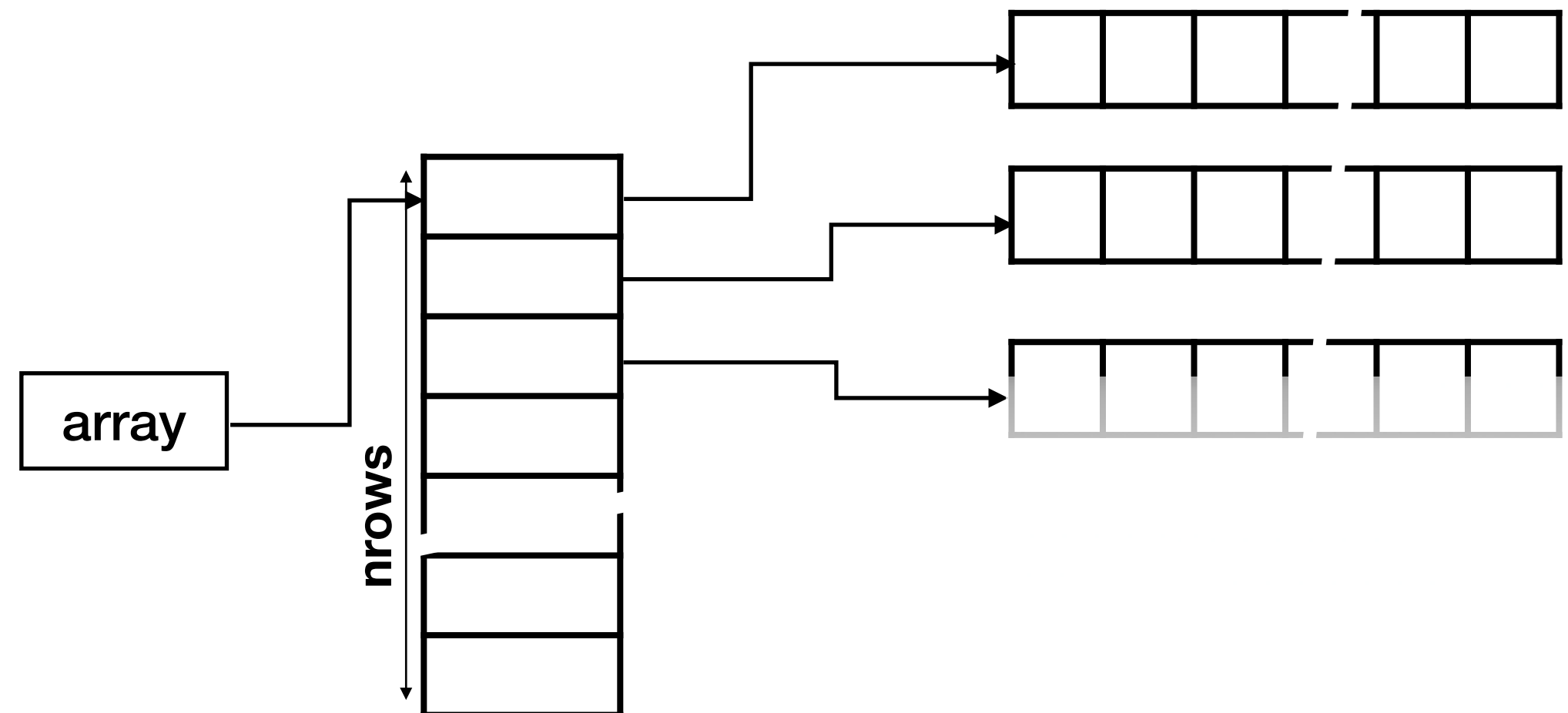
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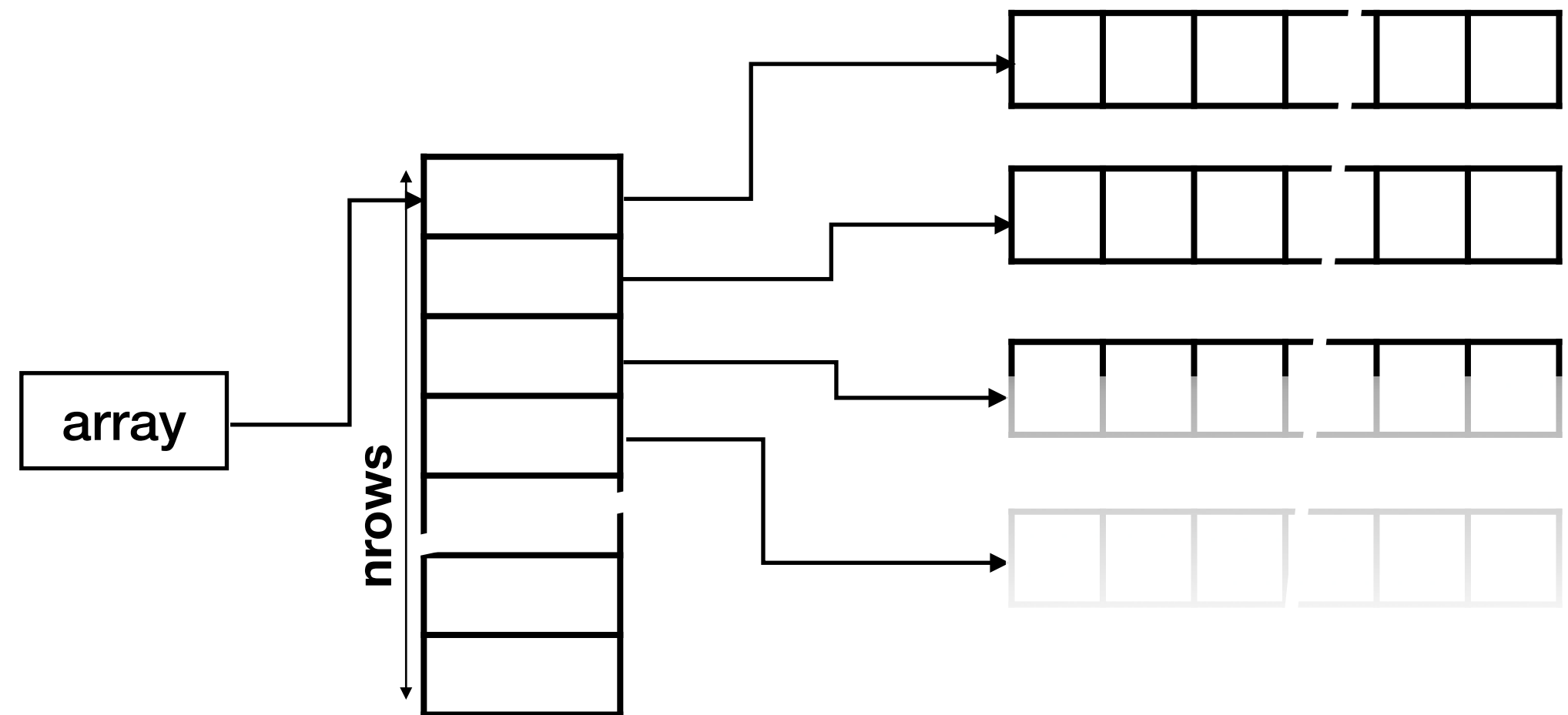
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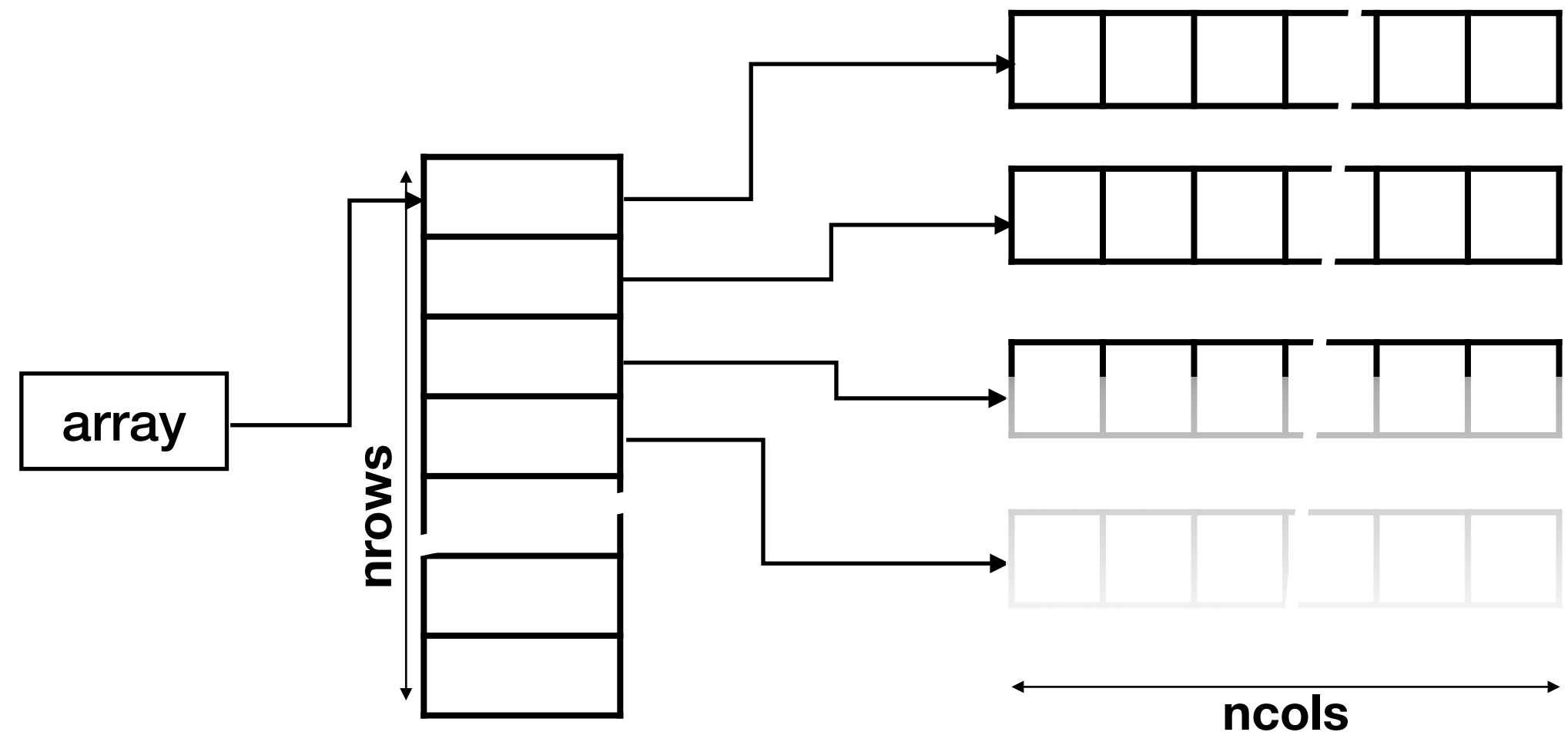
Allocating 2D arrays - another way

```
int **array;  
  
array = (int**) malloc(nrows*sizeof(int*));  
for(i=0;i<nrows;i++)  
    array[i] = (int*) malloc(ncols*sizeof(int));  
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```



Pointer to pointer - caveat

- How do you **deallocate** a 2D array?
 - Method 1: Free the single pointer: `int * mat`
 - Method 2: Need to free **each** pointer separately!!
 - **Not** enough to free the top level pointer (`int **array`)
 - Unless made free, lower level pointers (`int *`) will leak memory!

Exercise

- Use this second method of memory allocation for 2D arrays to read in a given file (`matrix.csv`) and print out its transpose.
- The first row of the file lists the number of rows and columns of the matrix.

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```
void fun(int n)
{
    int arr[n];
    /* More code follows
    ...
    ...
    */
}
int main()
{
    fun(6);
}
```

Example with *valgrind*

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- Get on to EWS. Compile the standard way. Then run:

```
> valgrind ./a.out
```

- Can you figure out where the leaks are?

Example with *valgrind*

```
#include <stdio.h>
#include <stdlib.h>

int main(void){
    char *p;

    /* Allocation #1 of 19 bytes */
    p = (char *) malloc(19);

    /* Allocation #2 of 12 bytes */
    p = (char *) malloc(12);
    free(p);

    /* Allocation #3 of 16 bytes */
    p = (char *) malloc(16);

    return 0;
}
```

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- Write a function to read the provided binary file and return a struct containing the n-th flight record. Discard the first n-1.

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- Make sure to free memory!

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- So far our use of `malloc` has been to load records or data from a file
 - Thus we no longer have to know the sizes at compile time
 - Nevertheless `realloc/malloc/free` is cumbersome to keep using
 - Need a data structure that takes care of this automatically - enter *linked-lists*.

Time permitting - *key idea*

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- Basic idea of a linked list:

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typedef struct node{  
    char *name;  
    struct node * next;  
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Thursday - learn
it from the
GOAT!

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