DYNAMIC MEMORY ALLOCATION

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WHY DYNAMIC MEMORY ALLOCATION?

- Situations where static and automatic allocation aren't sufficient:
  - We need memory that persists across multiple function calls but not for the whole lifetime of the program
  - We need more memory than can fit on the Stack
  - We need memory whose size is not known in advance
    - *e.g.*, reading file input:

```
// this is pseudo-C code
char* ReadFile(char* filename) {
  int size = GetFileSize(filename);
  char* buffer = AllocateMem(size);

  ReadFileIntoBuffer(filename, buffer);
  return buffer;
}
```

Aside : NULL

- NULL is a memory location that is guaranteed to be invalid
  - In C on Linux, NULL is 0x0 and an attempt to dereference NULL *causes a segmentation fault*
- Useful as an indicator of an uninitialized (or currently unused) pointer or allocation error
  - It's better to cause a segfault than to allow the corruption of memory!

segfault.c

```
int main(int argc, char** argv) {
  int* p = NULL;
  *p = 1;   // causes a segmentation fault
  return EXIT_SUCCESS;
}
```

malloc();

- General usage: `var = (type*) malloc(size in bytes)`
- `malloc` allocates an uninitialized block of heap memory of at least the requested size
  - Returns a pointer to the first byte of that memory; returns NULL if the memory allocation failed!
  - Stylistically, you'll want to (1) use `sizeof` in your argument, (2) cast the return value, and (3) error check the return value

```
// allocate a 10-float array
float* arr = (float*) malloc(10*sizeof(float));
if (arr == NULL) {
  return errcode;
}
...   // do stuff with arr
```

- Also, see `calloc()` and `realloc()`

free();

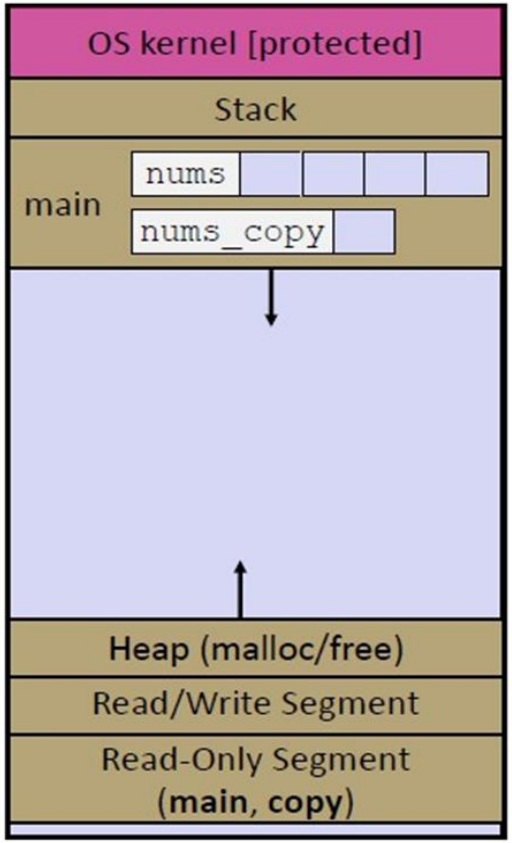
- Usage: `free(pointer);`
- Deallocates the memory pointed-to by the pointer
  - Pointer *must* point to the first byte of heap-allocated memory (*i.e.*, something previously returned by `malloc` or `calloc`)
  - Freed memory becomes eligible for future allocation
  - Freeing `NULL` has no effect
  - The bits stored in the pointer are *not changed* by calling free
    - Defensive programming: can set pointer to `NULL` after freeing it

```
float* arr = (float*) malloc(10*sizeof(float));
if (arr == NULL)
  return errcode;
...             // do stuff with arr
free(arr);
arr = NULL;     // OPTIONAL
```

HEAP AND STACK EXAMPLE

arraycopy.c

```c
#include <stdlib.h>

int* Copy(int a[], int size) {
  int i, *a2;

  a2 = malloc(size * sizeof(int));
  if (a2 == NULL)
    return NULL;

  for (i = 0; i < size; i++)
    a2[i] = a[i];

  return a2;
}

int main(int argc, char** argv) {
  int nums[4] = {1, 2, 3, 4};
  int* nums_copy = Copy(nums, 4);
  // .. do stuff with the array ..
  free(nums_copy);
  return EXIT_SUCCESS;
}
```



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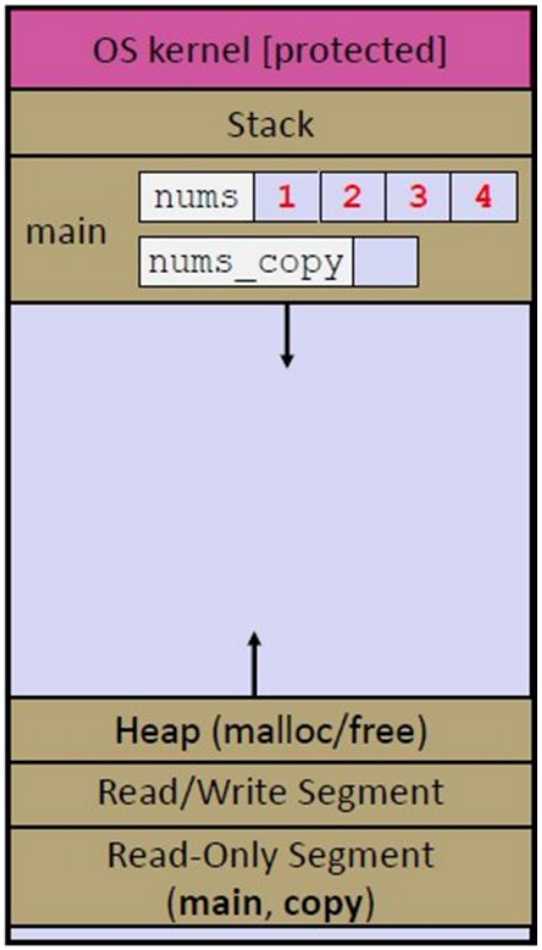

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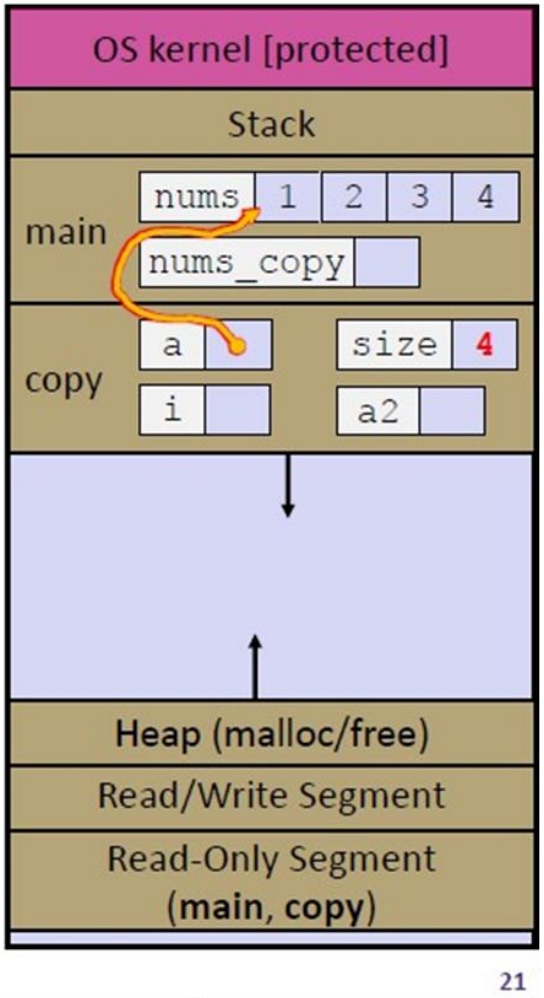

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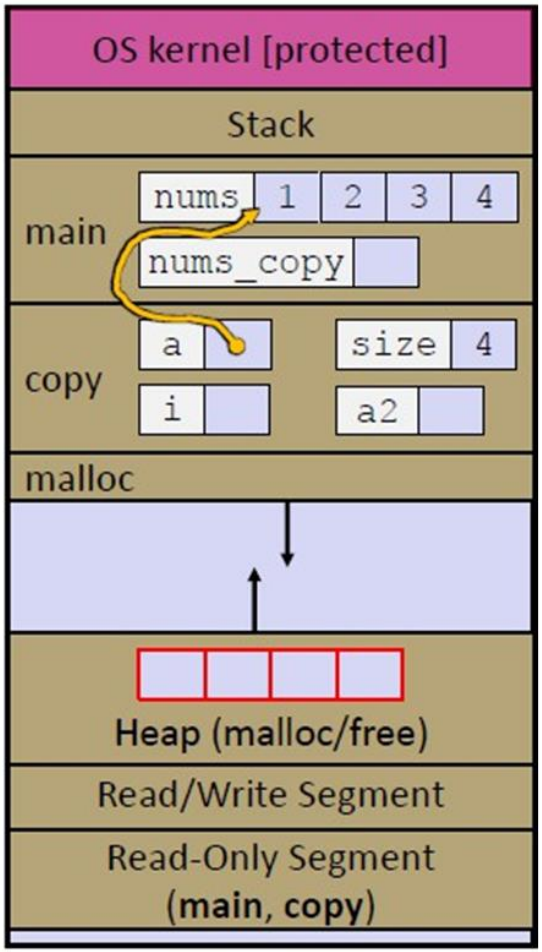

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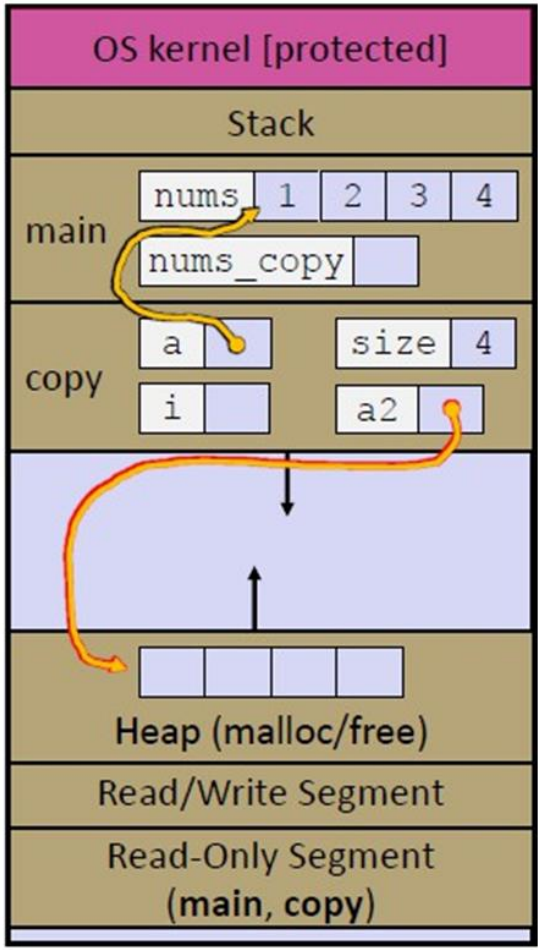

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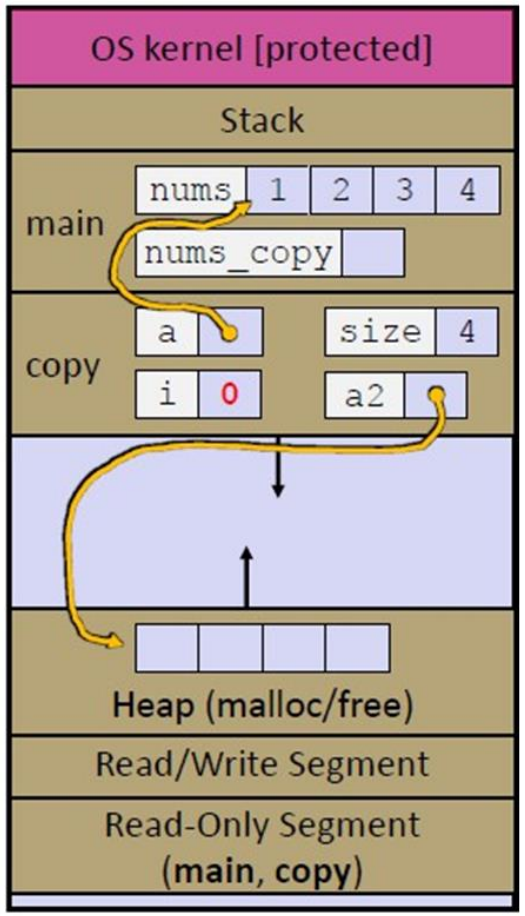

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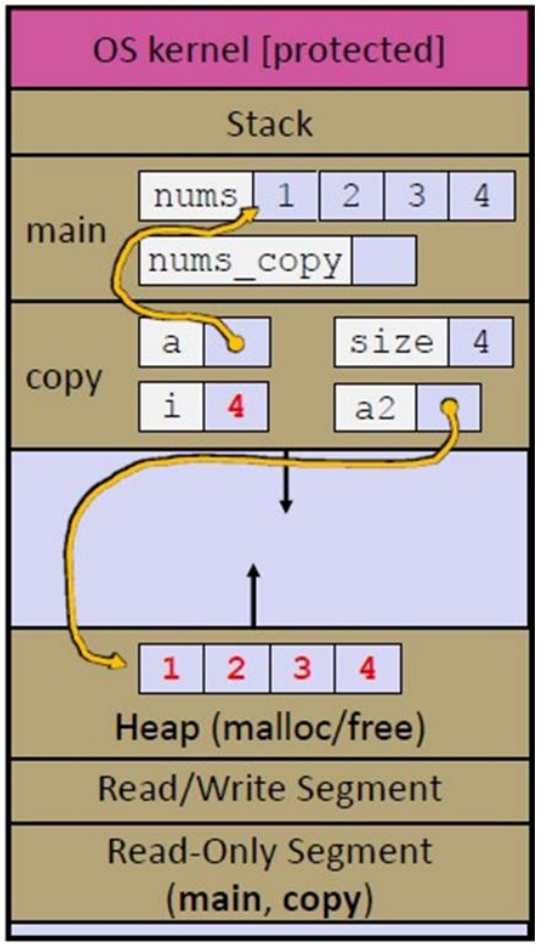

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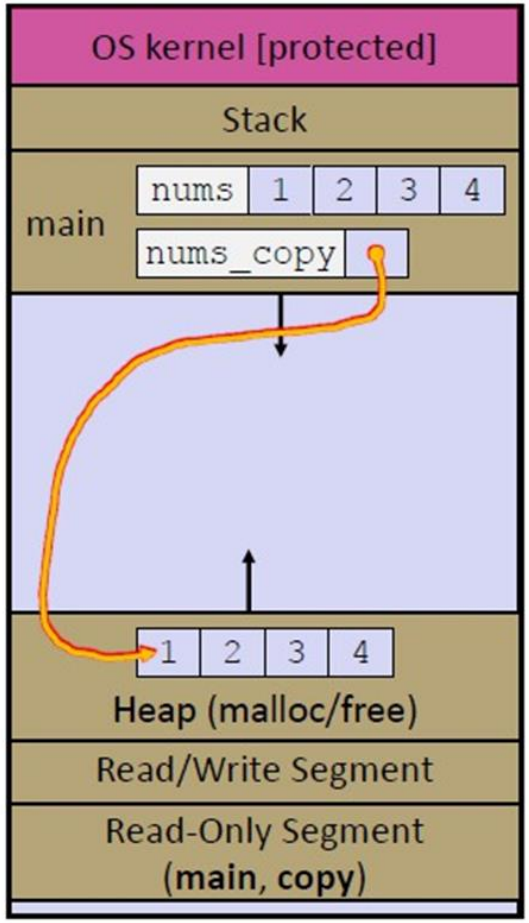

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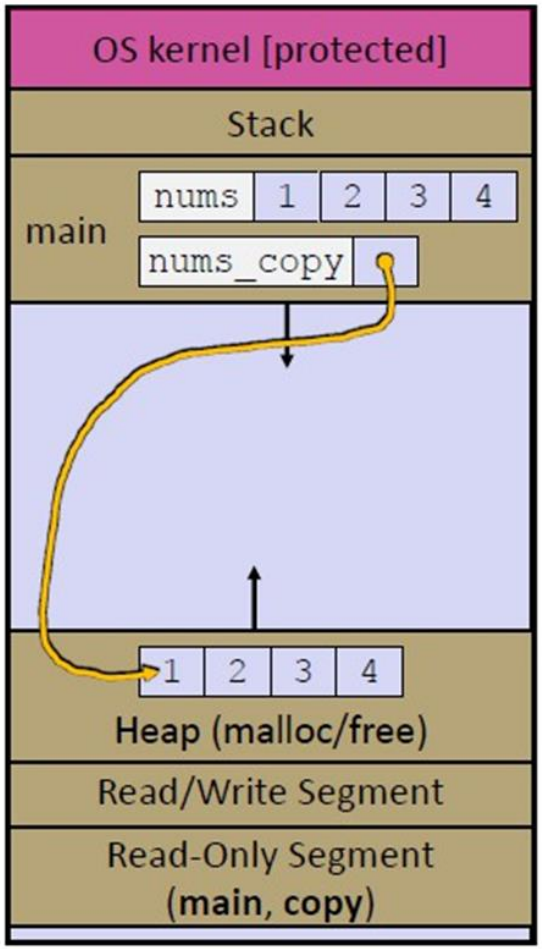

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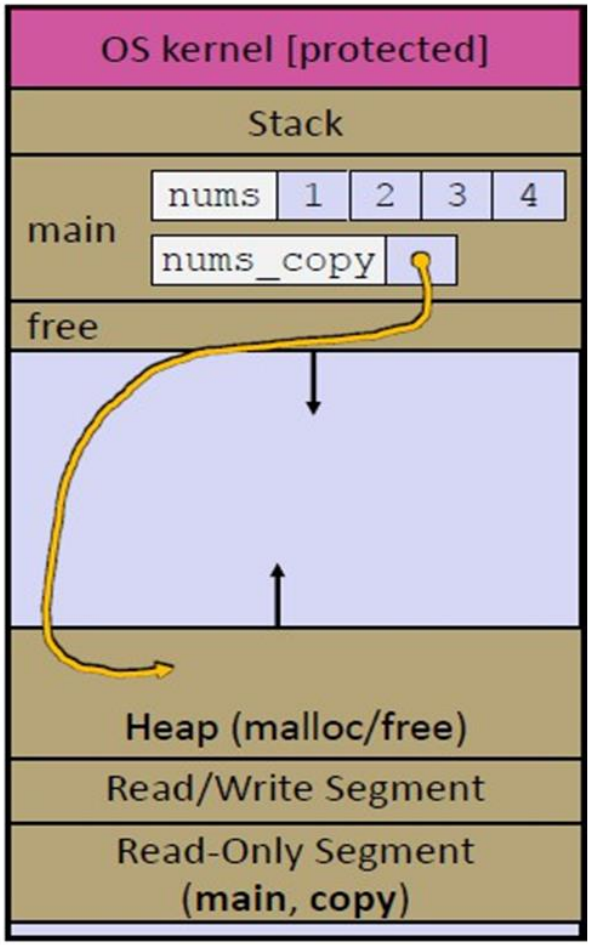

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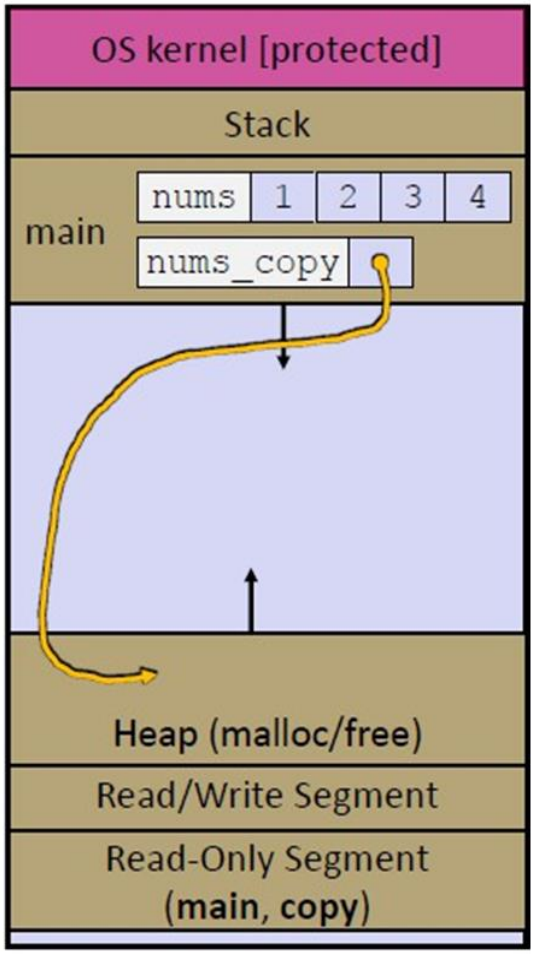

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THANK YOU