Memory

CSCI 2330

Addresses

RAM as an array of bytes

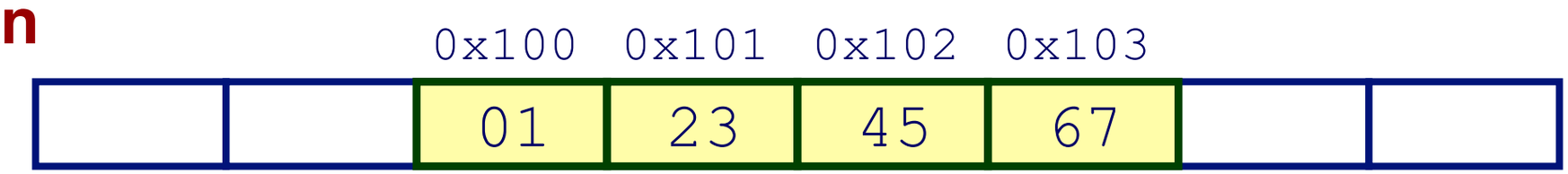
Content:	FF	00	57	92	B3	8A	... ...	10	46	DC

Address:
000 000 000
000 000 001
000 000 002
000 000 003
000 000 004
000 000 005
... ...
134 217 725
134 217 726
134 217 727

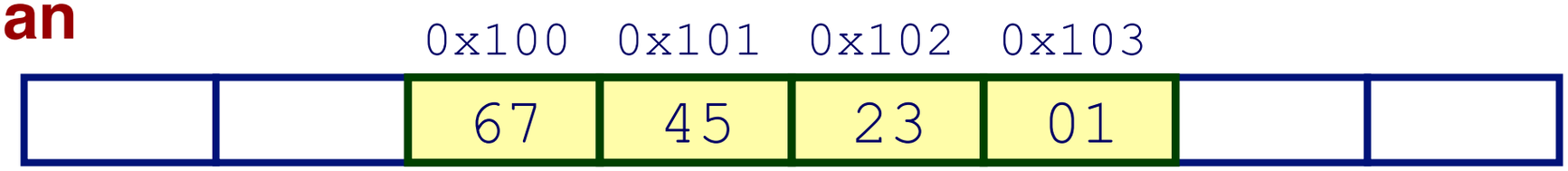
Endian

int x = 0x01234567; // stored at address 0x100

Big Endian



Little Endian



Some memory

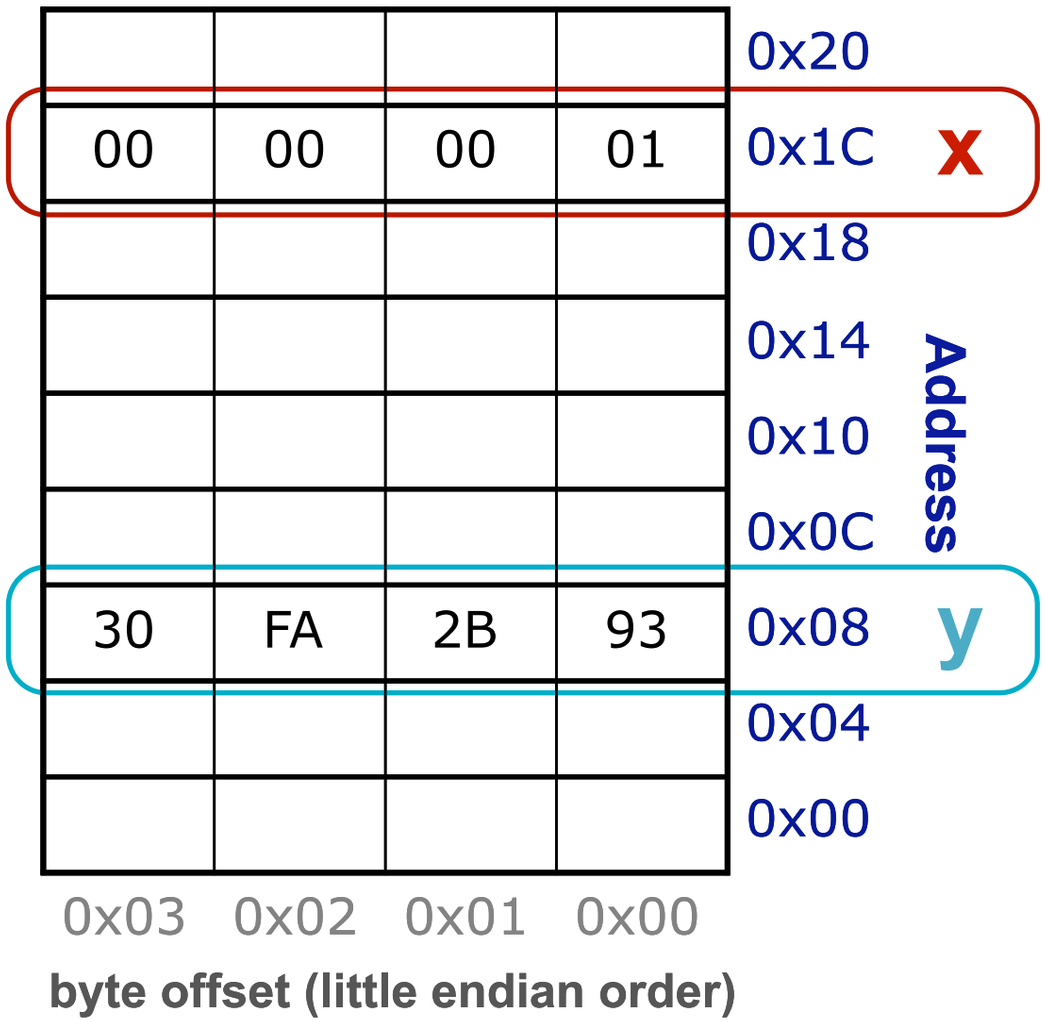
				0x20
00	00	00	01	0x1C
00	00	00	00	0x18
				0x14
00	00	00	FF	0x10
				0x0C
30	FA	2B	93	0x08
				0x04
00	00	00	13	0x00
0x03	0x02	0x01	0x00	

Address

byte offset (little endian order)

Variables in RAM

```
int x; // x at 0x1C
int y; // y at 0x08

x = 1;
y = 0x30FA2B93;
```



Java Objects

```
class Blob {
  // ... instance variables ...
}
```

```
public void doStuff() {

  Blob b1 = new Blob();
  Blob b2 = new Blob();

}
```

```
public void doStuff() {

  Blob b1 = new Blob();
  Blob b2 = b1;

}
```

Pointers

address = index of a byte in memory

pointer = a piece of data storing an address

`T* p;`	declare a pointer `p` that will point to something of type `T`
`&x`	**address of** `x` (get a pointer to `x`)
`*p`	**contents at** address given by pointer `p` (aka "**dereference** `p`" – follow the pointer)

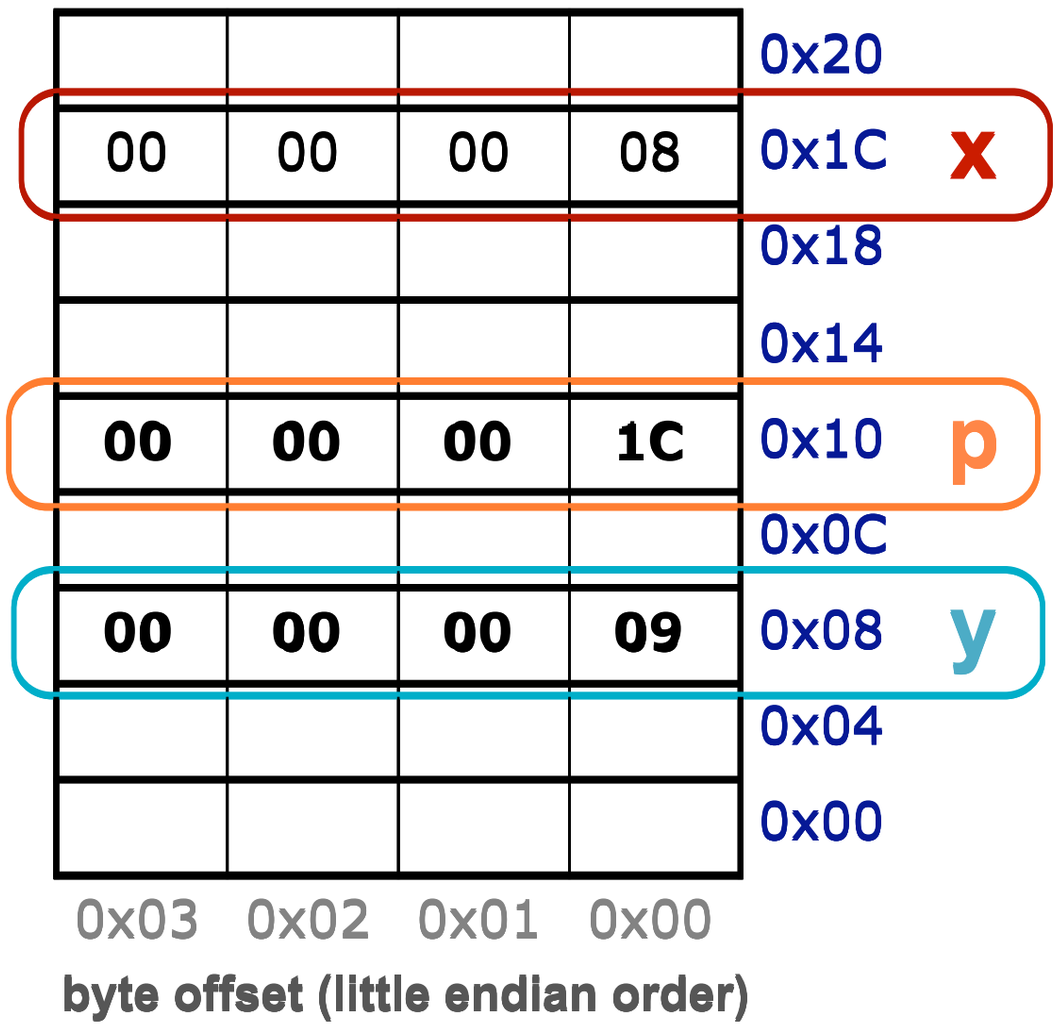
An Example

```
int* p; // p: 0x10

int x = 8; // x: 0x1C
int y = 3; // y: 0x08
```

```
p = &x;
```

```
y = 1 + *p;
```

```
*p = 100;
```

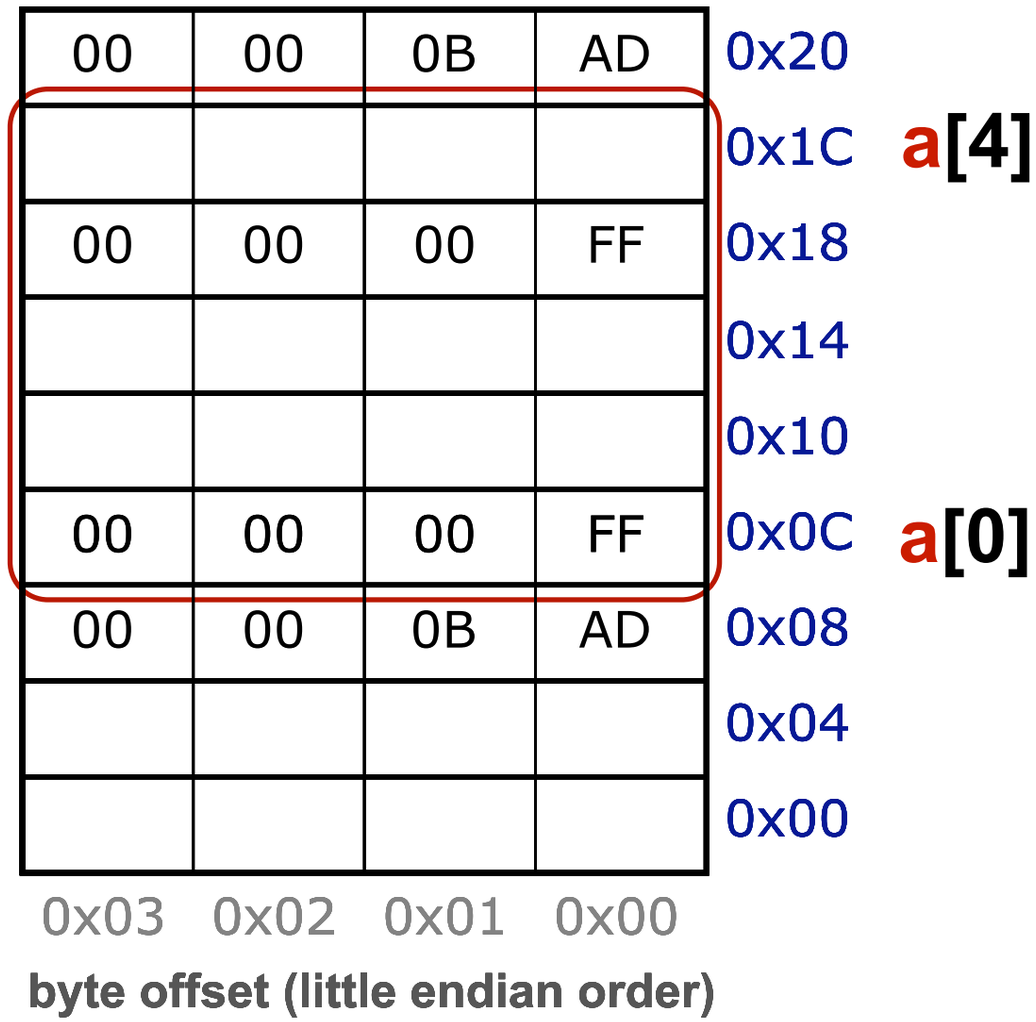


Another Example

```
void do_something(int* p1, int* p2) {
    int temp = *p1;
    *p1 = *p2;
    *p2 = temp;
}

void main() {
    int x = 5;
    int y = 3;

    printf("%d %d\n", x, y); // "5 3"

    do_something(&x, &y); // swap!

    printf("%d %d\n", x, y); // "3 5"
}
```

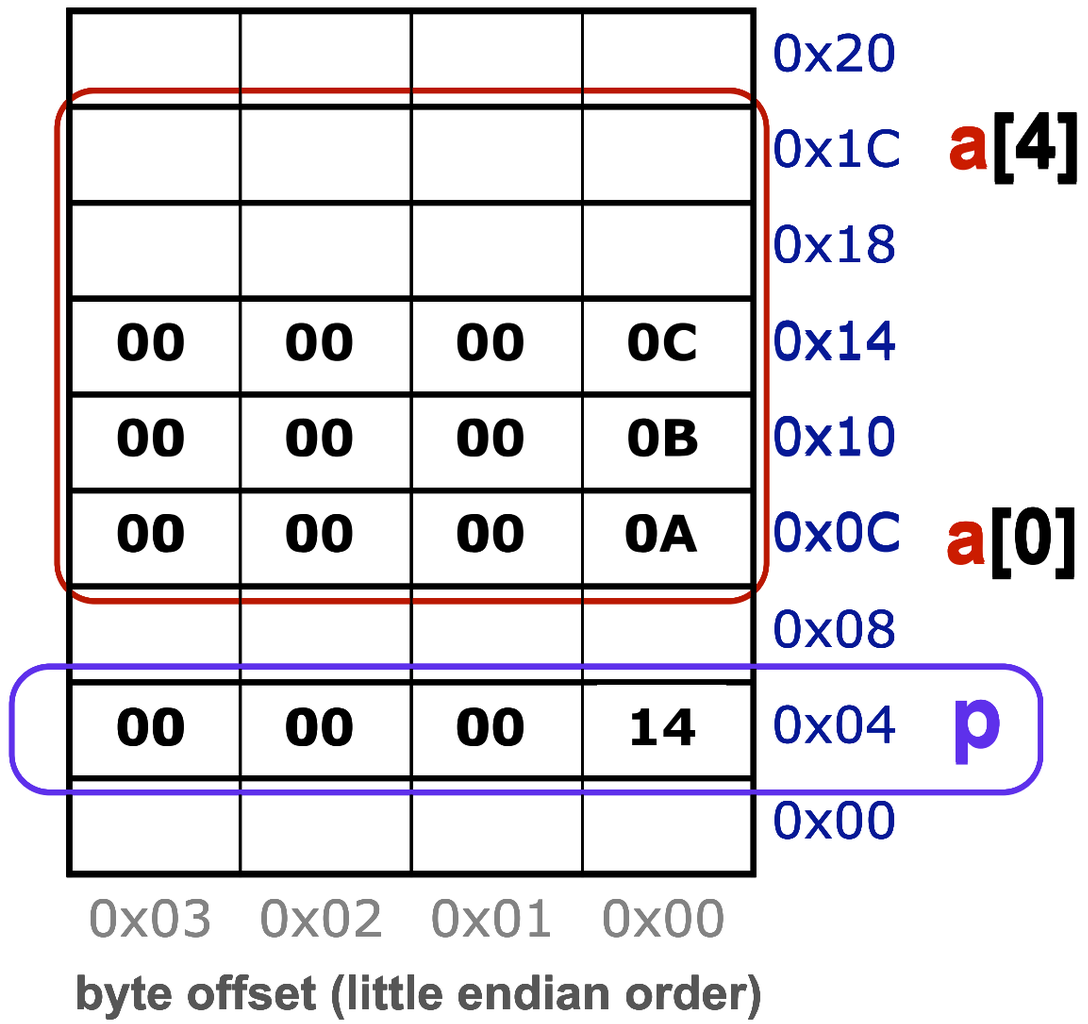
C Array

```
int a[5]; // creation

a[0] = 0xFF; // indexing
a[3] = a[0];

a[5] = 0xBAD; // uh oh
a[-1] = 0xBAD; // x2

~~a.length~~; // nope!
```



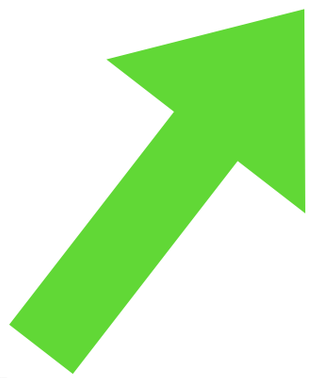
Arrays and Pointers

```
int a[5];

int* p;

p = &a[0]; // or p = a;

*p = 0xA;
p[1] = 0xB;
*(p + 1) = 0xB; // Same

p = p + 2; // 2 ints!
*p = a[1] + 1;
```



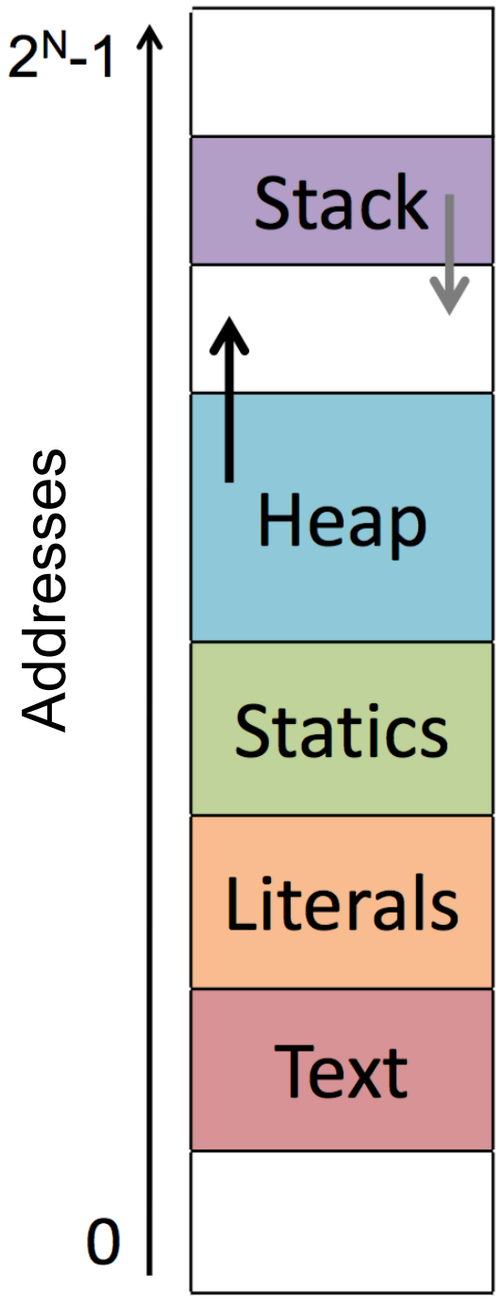
C Strings

0x43	0x53	0x43	0x49	0x20	0x32	0x33	0x33	0x30	0x00
‘C’	‘S’	‘C’	‘I’	‘ ’	‘2’	‘3’	‘3’	‘0’	‘\0’



NULL character

Memory Layout



Function context, local variables

Persistent data structures

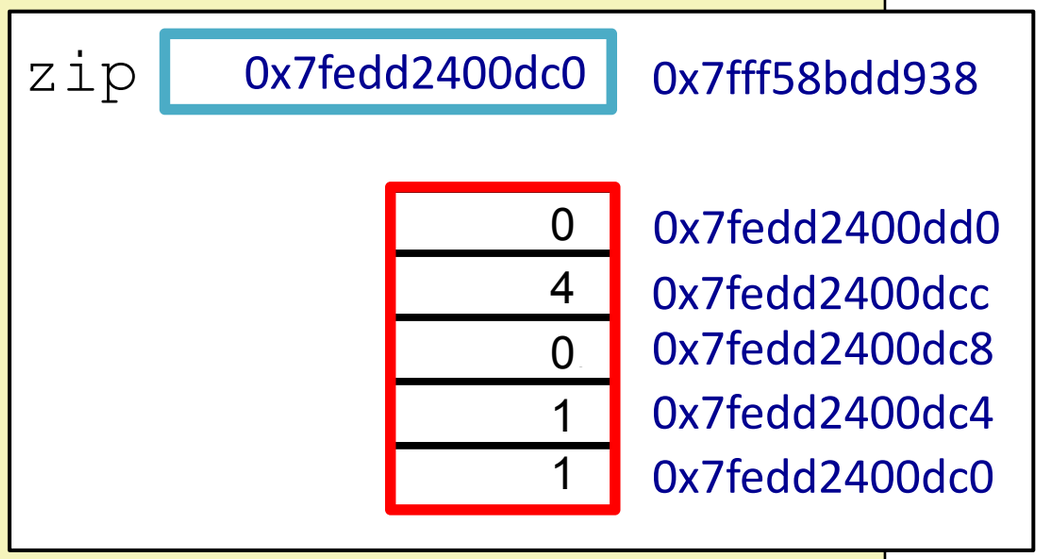
Global variables

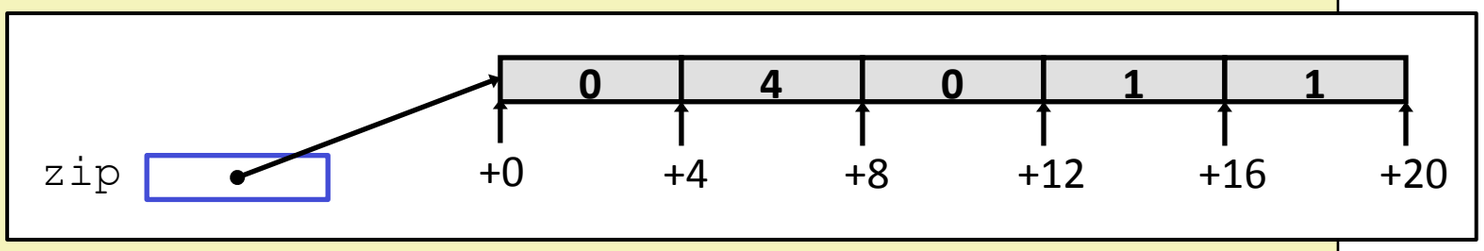
String literals

Program code (instructions)

Dynamic Memory

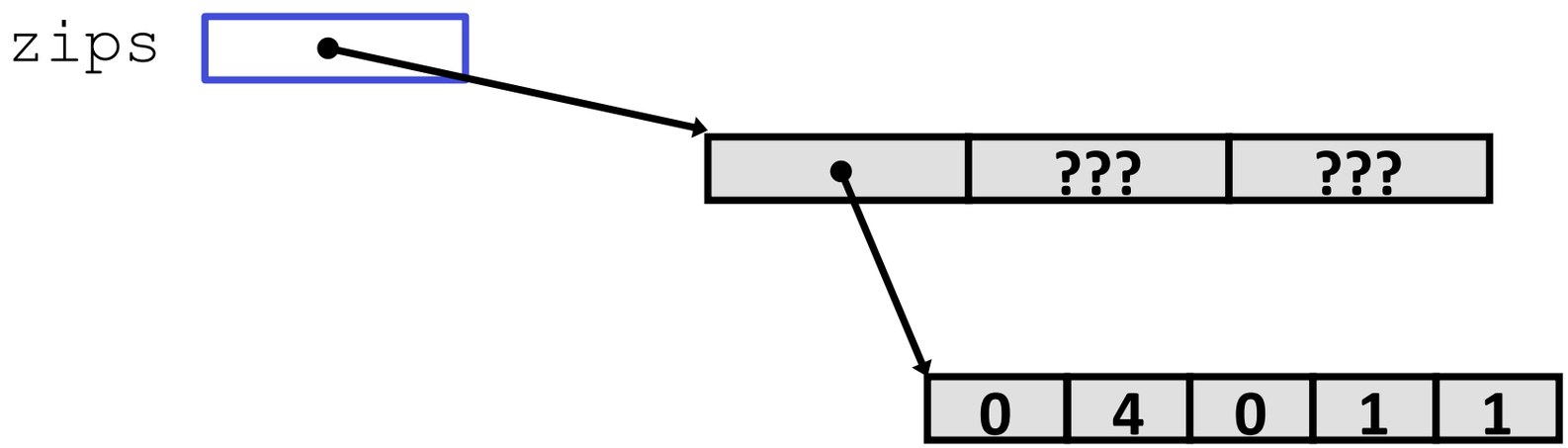
```
#define ZIP_LENGTH 5

int* zip = (int*) malloc(sizeof(int) * ZIP_LENGTH);
if (zip == NULL) {
    perror("malloc failed");
    exit(0);
}

zip[0] = 0;
zip[1] = 4;
zip[2] = 0;
zip[3] = 1;
zip[4] = 1;

printf("zip is");
for (int i = 0; i < ZIP_LENGTH; i++) {
    printf(" %d", zip[i]);
}
printf("\n");

free(zip);
```





Pointers to Pointers

```
#define NUM_ZIPS 3

int** zips = (int**) malloc(sizeof(int*) * NUM_ZIPS);
...
zips[0] = (int*) malloc(sizeof(int) * ZIP_LENGTH);
...
int* first_zip = zips[0];
first_zip[0] = 0;
zips[0][1] = 4;
zips[0][2] = 0;
first_zip[3] = 1;
zips[0][4] = 1;
```



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