# CS 11 C track: lecture 4

- Last week: arrays
- This week:
  - Recursion
  - Introduction to pointers

## Lab 4

- Harder than previous labs
- One non-obvious trick
  - hints on web page
  - email me if get stuck
- Support code supplied for you
- Read carefully!

## Recursion (1)

- Should be familiar from CS 1
- Recursive functions call themselves
- Useful for problems that can be decomposed in terms of smaller versions of themselves

## Recursion (2)

```
int factorial(int n) {
    assert(n >= 0);
    if (n == 0) {
        return 1;  /* Base case. */
    } else {
        /* Recursive step: */
        return n * factorial(n - 1);
    }
}
```

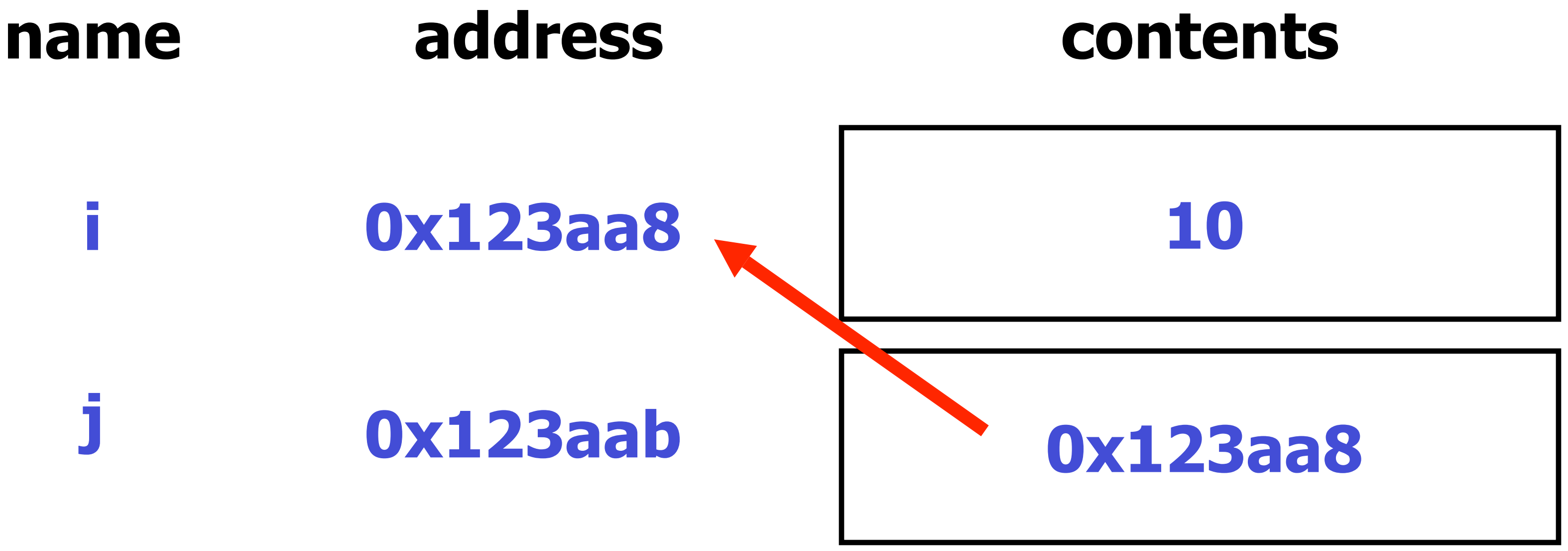
## Recursion (3)

```
factorial(5)
--> 5 * factorial(4)
--> 5 * 4 * factorial(3)
--> 5 * 4 * 3 * factorial(2)
--> 5 * 4 * 3 * 2 * factorial(1)
--> 5 * 4 * 3 * 2 * 1 * factorial(0)
--> 5 * 4 * 3 * 2 * 1 * 1
--> 120
```

## Pointers (1)

- Address:
  - A location in memory where data can be stored
  - e.g. a variable or an array
  - Address of variable `x` is written `&x`
- Pointer:
  - A variable which holds an address

# Pointers (2)



| name | address | contents |
|---|---|---|
| i | 0x123aa8 | 10 |
| j | 0x123aab | 0x123aa8 |

```
int  i = 10;
int *j = &i;   /* j "points" to i */
```

# Pointers (3)

```
int  i = 10;
int *j = &i;
printf("i = %d\n", i);
printf("j = %x\n", j);
printf("j points to: %d\n", *j);
```

## Pointers (4)

- `&i` is the address of variable `i`
- `*j` is the contents of the address stored in pointer variable `j`
  - i.e. what `j` points to
- `*` operator dereferences the pointer `j`

# Pointers (5)

- The many meanings of the * operator:
  - Multiplication

    ```
    a =  b * c;
    ```

  - Declaring a pointer variable

    ```
    int *a;
    ```

  - Dereferencing a pointer

    ```
    printf("%d", *a);
    ```

## Pointer pitfalls (1)

- Declaring multiple pointer variables:

```
int *a, *b;  /* a, b are ptrs to int */
```

- If you do this:

```
int *a, b;   /* b is just an int */
```

- Then only the first variable will be a pointer
- Rule: every pointer variable in declaration must be preceded by a `*`

## Pointer pitfalls (2)

- Note that

```
int *j = &i;
```

- really means

```
int *j; /* j is a pointer to int */
j = &i; /* assign i's addr to j */
```

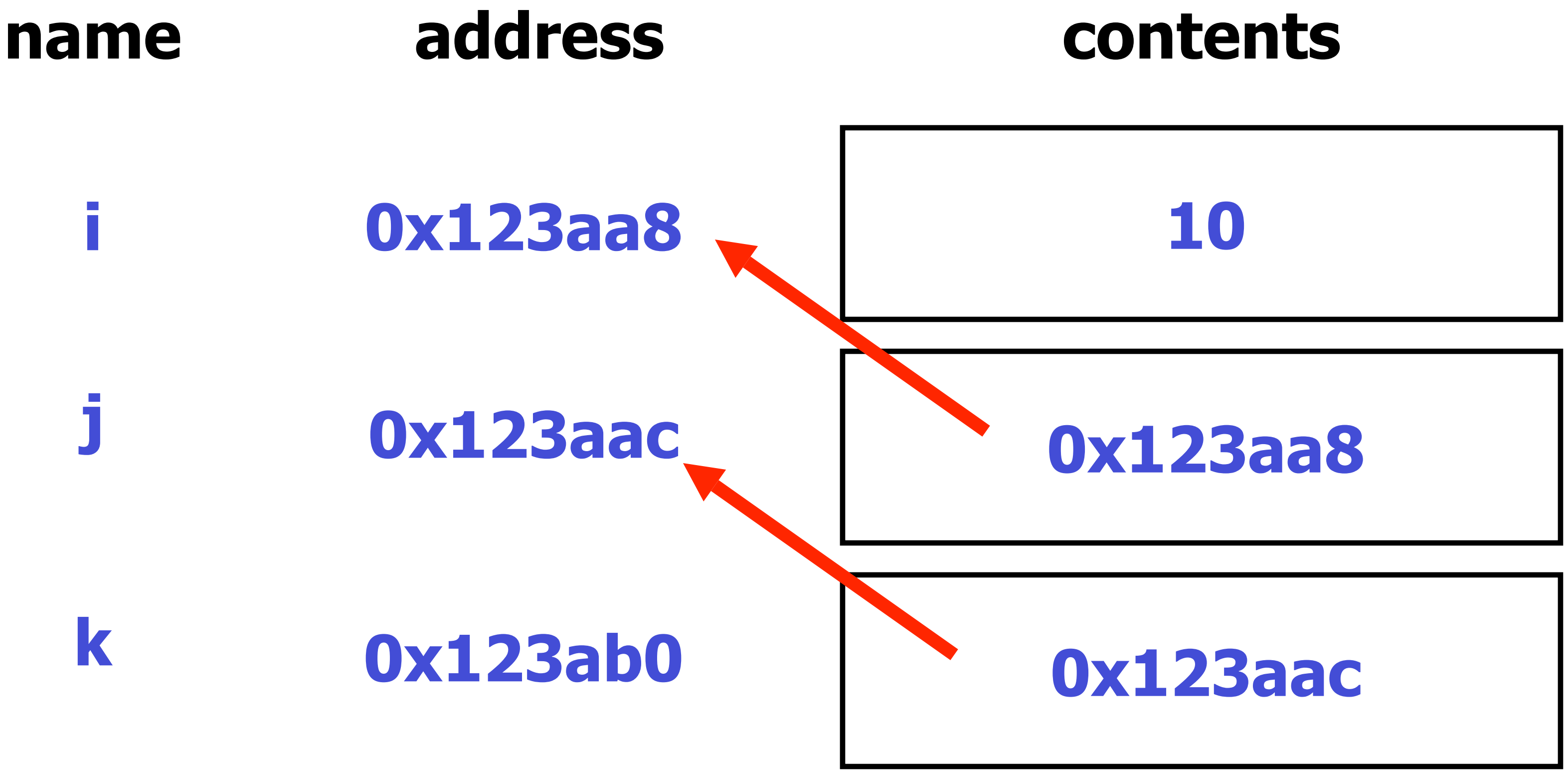
- Don't confuse this `*j` with a dereference!

## Pointers (6)

- A harder problem:

```
int   i = 10;
int  *j = &i;
int **k = &j;
printf("%x\t%d\n", &i, i);
printf("%x\t%x\t%d\n", &j, j, *j);
printf("%x\t%x\t%x\t%d\n",
       &k, k, *k, **k);
```

## Pointers (7)



| name | address | contents |
|---|---|---|
| i | 0x123aa8 | 10 |
| j | 0x123aac | 0x123aa8 |
| k | 0x123ab0 | 0x123aac |

## Assigning to pointers (1)

```
int i = 10;
int *j = &i;
int *k;
/* Assign to what j points to: */
*j = 20;  /* Now i is 20. */
/* Assign j to k: */
k = j;     /* Now k points to i too. */
/* Assign to what j points to: */
*j = *k + i;  /* Now i is 40. */
```

## Assigning to pointers (2)

- When pointer variable is on left-hand side of an assignment statement, what happens depends on whether it's dereferenced or not
  - no dereference: assign the value on RHS (an address) to the pointer variable on the LHS

```
j = k;
```

  - dereference: assign value on RHS into location corresponding to <u>where pointer points to</u>

```
*j = *k + 10;
```

## Assigning to pointers (3)

- When pointer variable is declared and assigned to on the same line:

```
int *j = k;
```

- it means:

```
int *j;  /* declare j   */
j = k;   /* assign to j */
```

- i.e. assign the value on RHS (an address) to the pointer variable on the LHS

## Mnemonics: fetch/store

- When you use the `*` (dereference) operator in an expression, you *fetch* the contents at that address

```
printf("j's contents are: %d", *j);
```

- When you use the `*` (deference) operator on the left-hand side of the `=` sign in an assignment statement, you *store* into that address

```
*j = 42;  /* store 42 into address */
```

## Pointers – call by reference (1)

- Can use pointers for a non-obvious trick
- Recall: in C, variables are copied before being sent to a function
  - referred to as "call-by-value"
- Significance is that passing a variable to a function cannot change the variable's value
- But sometimes we <u>want</u> to change the variable's value when function returns

# Pointers – call by reference (2)

```
void incr(int i) {
    i++;
}
/* ... later ... */
int j = 10;
incr(j); /* want to increment j */
/* What is j now? */
/* Still 10 - incr() does nothing. */
```

## Pointers – call by reference (3)

```
void incr(int *i) {
    (*i)++;
}
/* ... later ... */
int j = 10;
incr(&j);
/* What is j now? */
/* Yep, it's 11. */
```

## Pointers – call by reference (4)

```
int j = 10;
incr(&j);
```

- You should be able to work out why this works
- Where have we seen this before?

```
int i;
scanf("%d", &i); /* read in i */
```

# Pointers – call by reference (5)

- Easy mistake to make:

```
void incr(int *i) {
    *i++;  /* Won't work! */
    /* Parsed as: *(i++); */
}
```

- Need to say `(*i)++` here
- Precedence rules again; use parens `()` if any confusion can exist

## Next week

- Pointers and arrays

  (the untold story)

- Dynamic memory allocation