Introduction to C, C++, and Unix/Linux

CS 60

More on Functions

Today

→ Finish C!

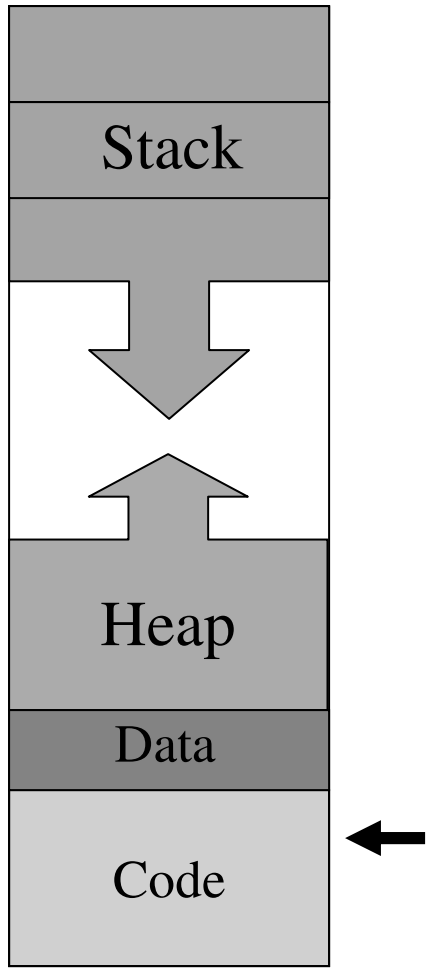
→ Reading [KR] Chapters 1-7

Notes

Questions?

Function pointers

- Functions (including **`main`**) are instructions that reside in the memory space of the application
- Function names are symbols (like variable names) that represent a memory address
- We can create pointers to functions and call functions through pointers



```
int func(int b)
{
   return(b+b);
}

int main(void)
{
  printf("Address of\n"
    "main():   %p\n"
    "func():   %p\n"
    "printf(): %p\n",
    &main, &func, &printf);
  return 0;
}
```

By the way...

"abc" "def" → "abcdef"

%p – prints pointer address

return 0 → return(0)

or **"main, func, printf);"**

Oddly, both work

`int f1(double);`	**`f1`** is a function that takes a double argument and returns an int
`int *f2(double);`	**`f2`** is a function that takes a double argument and returns a pointer to an int
`int (*f3)(double);`	**`f3`** is a pointer to a function that takes a double argument and returns an int
`f3 = f1;`	Assigns the pointer to a function
`/* f3 = f2; */`	Error – type mismatch
`x = (*f3)(3.14);`	Legal call to the function **`f1`**
`x = f3(3.14);`	Oddly, this is legal too!

```
int varfun(int index, int arg)
{
  int (*pf)(int);
  int val;

  pf = funlist(index);
  val = (*pf)(arg);

  return val;
}
```

pf is a pointer to a function that takes an integer argument and returns an int

funlist() is a function that returns a pointer to a function

```
int (*funlist(int index))(int)
{
  int (*pf)(int);
  switch (index) {
    case 1: pf = f1;
            break;
    case 2: pf = f2;
            break;
    default: pf = f3;
            break;
  }
  return pf;
}
```

```
int varfun(int i, int arg)
{
  int (*pf)(int);
  int val;

  pf = funlist(i);
  val = (*pf)(arg);

  return val;
}
```

Casting a function pointer

```
int x, (*f3)(double);
unsigned int addr = 0x8ff324;

f3 = addr; /* Warning */

f3 = (int (*)(double)) addr;

x = (*f3)(3.14159);
x = f3(3.14159);    /* or this way */
```

Recursive call to main

```
int main(void)
{
  typedef int (*PM)(void);
  ...
  PM fp = main; /* or &main */
  (*fp)();
  ...
}
```

or just call **`main()`**

To review…

- Variable **`x`**
  - A symbol (name) representing an address where we store some value of a certain type (**`int, double, char*, ...`**)
  - Address = **`&x`**, Value = **`x`**
- Array variable **`a`**
  - A symbol (name) representing an address where a block of memory has been reserved for values of a certain type
  - Address = **`a`**, Values = **`a[0], a[1], …`**
- Function name **`func`**
  - A symbol representing the address of a piece of code which we can jump to, and designating the parameter and return variable types
  - Address: **`&func`** or **`func`**

Passing parameters (pass-by-value)

```
a=1; b=2;
swap(a,b);
// After the call …
// a has value 1 and b has value 2
// because values are copied
void swap(int x, int y)
{
  int temp = x;
  x = y;
  y = temp;
}
```

Passing arrays ….

```
a[0]=0; a[1]=1;
swap(a);
// After the call …
// a[0] has value 1 and a[1] has a 0
// because address of first element of
// x is same as the first element of a.
void swap(int x[])
{
  int temp = x[0];
  x[0] = x[1];
  x[1] = temp;
}
```

Passing structs is expensive

- Huge structs are expensive to pass because they are copied.

Passing Pointer (like List* last class)

```
printit(header);

// The pointer to the header node
// stored in header is stored in
// variable x at the time of the call.
// Both header and x point to same loc.

void printit(List* x)
{
  // prints the List …
  …
}
```

Creating a list in function (like initialize list)

```
set_union(a_header,b_header,c_header);


void set_union(List* a_h,b_h,c_h)
{
  // Performs the union of sets a_h
  // and b_h leaving the result in a
  // newly created list c_h
  …
}
 // c_h does not get back when we do
 // c_h=(List*)malloc(sizeof(List));
 // in set_union
```

Creating a list in function (returning List*)

```
c_header=set_union(a_header,b_header);



List* set_union(List* a_h,b_h)
{
  // Performs the union of sets a_h
  // and b_h leaving the result in a
  // newly created list c_h which is
  // returned
  return(c_h);
}
// c_h gets back correctly.  But if
// before the call c_header had a value
// (a List) it will cause a memory leak
```

Passing parameters (pass-by-address)

```
a=1; b=2;
swap(&a,&b);
// After the call …
// a has value 2 and b has value 1
// becaue px becomes the address of a
// and py becomes the address of b
void swap(int *px, int *py)
{
  int temp = *px;
  *px = *py;
  *py = temp;
}
```

Passing parameters (pass-by-reference) in C++

```
a=1; b=2;
swap(a,b);
// After the call …
// a has value 2 and b has value 1
// becaue x is the same as a
// and y is the same as b
void swap(int& x, int& y)
{
  int temp = x;
  x = y;
  y = temp;
}
```

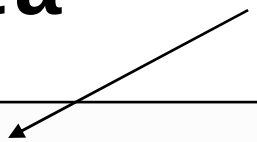
2D arrays: **data

```
int **data;
data = (int **)malloc(12*sizeof(int *));
for (i=0; i<12; i++)
  data[i] = (int *)malloc(4*sizeof(int));
```

Creates and allocates a 12x4 array of integers

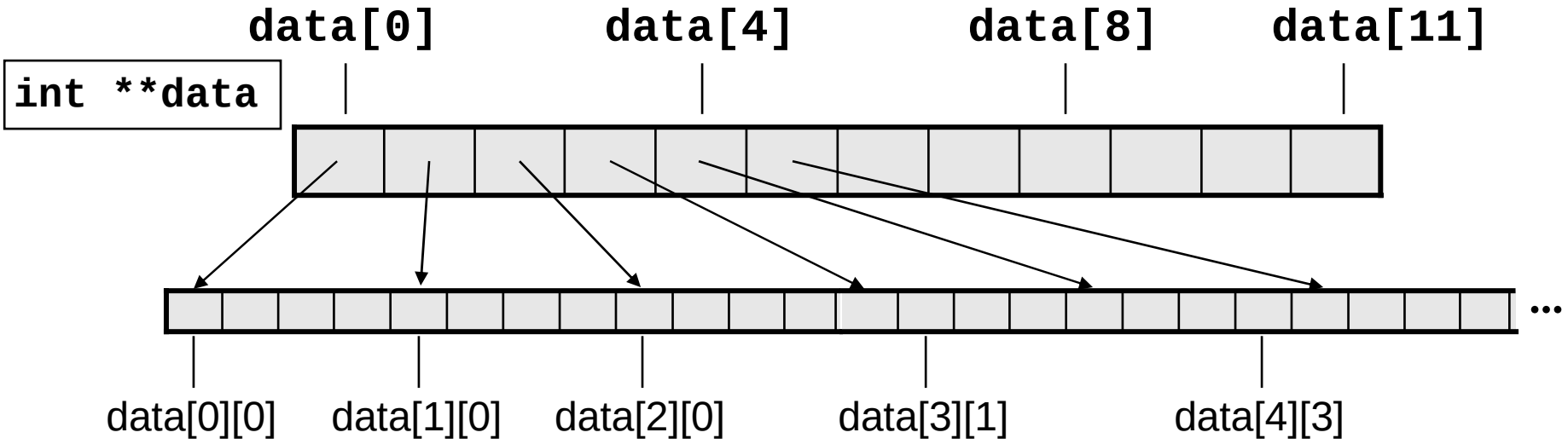
Similar to **data[12][4]**

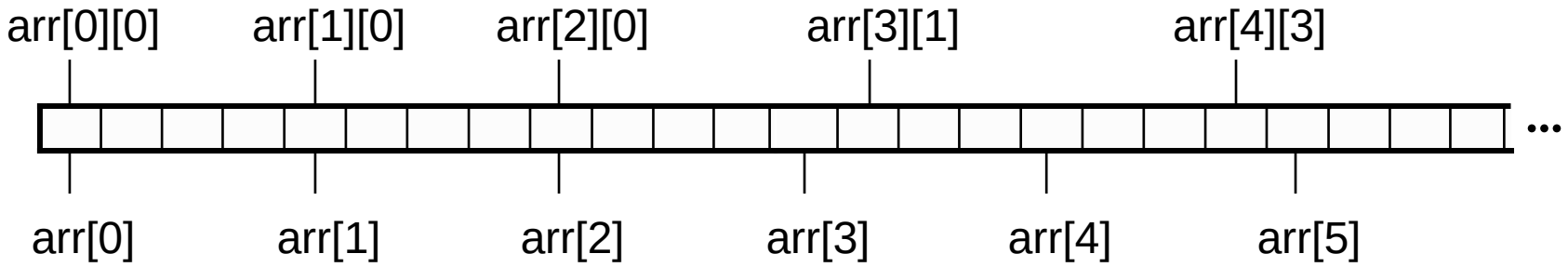
2D arrays: **data




```
typedef int *pint;
pint *data;
data = (pint *)malloc(12*sizeof(pint));
for (i=0; i<12; i++)
  data[i] = (int *)malloc(4*sizeof(int));
```

Same as previous slide (typedef makes it clearer)


data[0]
data[4]
data[8]
data[11]
int **data
...
data[0][0]
data[1][0]
data[2][0]
data[3][1]
data[4][3]


arr[0][0]
arr[1][0]
arr[2][0]
arr[3][1]
arr[4][3]
...
arr[0]
arr[1]
arr[2]
arr[3]
arr[4]
arr[5]

```
int arr[12][4];
```

- How many bytes will a 4x4 char array take up?

```
char arr[4][4];
```
← 16 bytes

```
char **arr;
```
← 32 bytes

|

16 bytes of addresses (4 pointers) + 16 bytes of data

Passing 2D arrays of any size

```
int **a,n,m;
scanf(“%d%d”,%n,%m);
a = (int **)malloc(n*sizeof(int *));
for (i=0; i<n; i++)
 a[i] = (int *)malloc(m*sizeof(int));
sum(a,n,m);

void sum(int **x,int n,m)
{
  // Use x[i][j] without problems
}
```

Passing 2D arrays of fixed size

```
int a[10][20],n,m;

sum(a,n,m);

void sum(int x[][20],int n,m)
{ // 20 must be a constant matching
  // the declaration in calling function.
  // Use x[i][j] without problems
  // but only x[][20]
}
```

- What's the value of **x**?

```
char arr[][2] = {{1, 2}, {3, 4}};
int x = (int)arr[1,1];
```

x is -1073994722 !!

Because [1,1] evaluates to [1] (remember the comma operator!)
So this is equivalent to

```
int x = (int)arr[1];
```

which sets **x** to the address of **arr[1][0]**

```
int main(int argc, char **argv)
```

or

```
int main(int argc, char *argv[])
```

- General declaration for **`main`** function
  - **`argc`** – argument count
    - The number of command arguments the program was invoked with
  - **`argv`** – argument vector
    - A pointer to an array of character strings, one for each argument

```
% myprog –l 32 –p /usr/local
```

```
argc = 5
argv[0] = “myprog”
argv[1] = “-l”
argv[2] = “32”
argv[3] = “-p”
argv[4] = “/usr/local”
```

```
% myprog –l 32 –p /usr/local
```

```
for (i=1; i<argc; i++)
{
  if (!strcmp(argv[i], "-h"))
    help = 1;
  else if (!strcmp(argv[i], "-l"))
    num = atoi(argv[++i]);
  else if (!strcmp(argv[i], "-p")) {
    filename = (char *)malloc(128);
    strcpy(filename, argv[++i]);
  }
}
```

Useful string utility functions (B.3 and B.5)

`strcpy`	**`atoi`**
`strncpy`	**`atof`**
`strcmp`	**`atol`**
`strncmp`	**`rand`**
`strlen`	**`exit`**
`strchr`	**`system`**
`strrchr`	**`abs`**

…and more…

Memory functions

`memcpy`

`memmove`

`memcmp`

`memchr`

`memset`

To copy a whole block of memory, don't copy byte by byte – use **`memcpy`**!

Math functions (B.4)

```
sin
cos
tan
asin
acos
atan
atan2
```

```
exp
log
log10
pow
sqrt
ceil
floor
fabs
```

…and more…